Utilizing Scraps from Blue Crab and Calico Scallop Processing Plants

James C. Cato, Professor and Director
Florida Sea Grant College Program
University of Florida, Gainesville, Florida, U.S.A. 32611-0341

Processing scraps from blue crab and calico scallop processing plants in Florida have always been landfilled. Since these scraps are highly organic and putrescible, they have created an environmental landfill problem. Various options have been examined to deal with these and other seafood processing byproducts. These range from specific analyses including dehydration for use as meal along with other handling methods (1,5) and as a feed stuff for swine (9) to a complete overview of all seafood waste management problems nationwide (10).

Blue crab scraps produced in Florida annually range from 1,300 to 2,200 tons. Blue crabs yield 20 percent water when cooked, 12 to 14 percent meat, 35 percent shell (carapace) and 31 to 33 percent remaining body parts in scraps. Most of the waste management problem occurs in contiguous Dixie, Franklin, Taylor and Wakulla counties of northwest peninsular Florida. In Wakulla county, scraps from blue crab processing plants have represented about one-fifth of the total waste stream landfill volume and consumed about 25 percent of the solid waste budget.

Calico scallop production is normally highly concentrated in Brevard county on the Atlantic coast. Production on a daily, weekly, monthly and annual basis is inconsistent and unpredictable. Typical annual production ranges from 2 million to 15 million pounds (edible meat weight), with one recent year reaching 30 million pounds. Processing requires large amounts of water, with the waste product including bycatch from the vessels, processing effluents, shell and raw viscera. Solid waste can represent more than 80 percent by weight of the original vessel production. The shells from calico scallop plants have found potential use as oyster cultch and as fill in spoil areas, but the viscera and liquids have been a landfill and treatment problem. Waste alternatives examined included in-plant controls including waste restrictions and segregation, alternative screening and recycling; secondary and innovative secondary treatment facilities; and landfilling or ocean disposal, use as oyster cultch or animal feed, refining current ocean dumping operations and controlling odor, and sludge disposal from treatment facilities.

The Florida legislature in 1988 mandated that solutions to problems created by landfilling blue crab and calico scallop processing plant scraps be found. A number of demonstration projects were conducted after agreement by the Department of Environmental Regulation staff, county officials, seafood industry leaders, private consultants and university faculty (6). This paper presents an overview and results of these projects. Topics covered include:

- In-plant methods for blue crab waste control
- Wet extrusion
- Compacting
- Anaerobic bioconversion
- Composting
- Blue crabs
- Calico scallops
- Blue crab compost marketing
- Blue crab compost as a soil amendment
- Nematode control using blue crab compost

IN-PLANT METHODS FOR BLUE CRAB WASTES

Three methods were examined to improve in-plant handling of blue crab wastes. These included wet extrusion into a food pellet for aquaculture, compacting and grinding to reduce volume and moisture, and anaerobic bioconversion to produce methane gas.

Wet Extrusion

Blue crab processing scraps were used to produce two types of pellets (2). Crab scraps were mixed with soybean meal (48% TKN), potato starch and herring oil in two formulas to form a sinking feed pellet. One formula contained 45 percent crab, 41 percent meal, 10 percent starch and 4 percent oil, whereas the second contained 35 percent crab, 60 percent meal, 5 percent starch and no oil. Without herring oil, pellets did not form properly. The pellets using herring oil were accepted by spiny lobsters during feeding, but molded too quickly for feeding trials with shrimp and catfish. The moisture content of the pellets was high, and they tended to float following storage. There does not appear to be a potential use of crab scraps without additional tests.

Compacting

A custom-built compactor patterned after shrimp plant units was used in a crab plant to examine moisture, volume reduction and compactability of crab scraps as follows: with screens versus without screens; ground (using a hammermill) versus unground and at variable compression times. Fluids extracted were analyzed for COD, TKN and ammonia. Compacting was examined as an alternative to reduce waste volume leaving the plant and as a prior step to other handling uses. The volume reduction of crab scraps was highest via grinding alone, at 50 percent. Compacting without the screens achieved the best volume and weight reductions for ground (25.0 percent at six minutes) and unground (28.6 percent at five minutes) crab scrap. Ground scraps held their compressed form much better (2).

Grinding using a hammermill appears to be the best method for volume reduction at the plant level and could be implemented immediately using existing plant manpower. This does not eliminate the waste stream but changes its form and makes storage easier. Compacting creates excess fluid that could be a problem if discharged into septic systems or wastewater treatment systems. The liquid fraction of the waste stream contained 256 grams per liter of COD, compared to standard sewage wastewater that contains 300 milligrams per liter of COD.

Anaerobic Bioconversion

The characteristics of blue crab scraps for use as an anaerobic bioconversion feedstock in the production of methane gas was also studied. The investigation focused on physical and chemical analyses of the waste and assessment of the ultimate conversion and rate of conversion via biochemical development, along with optimization using bench scale digesters. Sample analysis indicated an average total solid concentration of 33 percent for the total waste stream and a volatile solids concentration of 50 percent dry weight for the total solids (7). This indicates a very high average ash content (50 percent) for the waste stream. For the liquid function, comparable results were 10 percent and 70 percent, respectively.

COMPOSTING

Composting projects were conducted to test and implement an alternative to continued landfilling of scrap byproducts from blue crab and scallop processing plants.

Blue Crab

Open Windrow: A large-scale demonstration project for composting blue crabs was conducted at the Taylor County landfill utilizing all crab wastes from Taylor, Wakulla and Leon counties for a two-month period (3). Eight windrows of material were composted using a WILDCATTM turning machine powered by a large tractor. A total of 1,067 tons of material were composted, of which 380 tons (36 percent) were crab scrap. Cypress sawdust (431 tons), wood knots and shives (148 tons), and pine bark (42 tons) were the principal sources of carbonaceous material. The eight windrows of materials were formulated using the following six combinations:

- fresh cypress sawdust and crab scraps
- fresh cypress sawdust and crab scraps treated with phosphate
- aged cypress sawdust and crab scraps
- pine bark and crab scraps
- knots and shives and crab scraps
- yard trimmings, wood chips, crab scraps and manure

All materials tested, with the exception of knots and shives, appeared to have qualities which in the context of a proper mix would be useful or desirable for composting. All compost windrows were analyzed on a scheduled basis to document changes taking place during the composting process. Initial mix moisture content, pH, organic matter content, carbon-nitrogen ratios and ammonium content were monitored.

Core and surface temperature measurements were recorded every other day throughout the composting term. Fresh cypress sawdust windrows sustained the longest period of active heating, although aged cypress windrows showed higher earlier average temperatures. Heating was measured for 125 days, but the cypress windrows completed active composting in about 60 days. Pine bark windrows lost heating ability in about 50 days as did the knots and shives windrows, although the latter had some of the highest recorded temperatures of all windrows and a higher-than-ambient temperature for 100 days. Windrows with yard trimmings maintained the lowest temperatures of all windrows, and heated for only 50 days. Periodic rainfall may also have affected the heating times and levels of some sites. All windrows ranged from 21 to 36 days above 55 C except for the yard trimmings, which had only three days above this temperature. On the average, the composts appear stable after approximately 75 days.

All windrows were sampled at the end of composting. They differed from the initial compost in color, odor and texture. Each was darker, humus-like and fine-crumbly. Average moisture content across all piles was 44 percent, similar to the initial compost. Even with some rainfall occurring, the compost lost water, a desirable result to yield a marketable product. Finished compost data on water content, pH, organic matter content, TKN percent, C:N ratios, NH_3, P, K, Ca, soluble salts and CO_2 were also provided (3).

Analysis on the average composition of all the blue crab composts indicated several important facts. A total of 53 percent of the organic matter was decomposed or 28 percent of the total solids. Total nitrogen loss was 46 percent, and 49 percent of the compost volume was reduced, based on initial versus final volume measurements.

Traditional disposal costs have risen so significantly that a new framework is now available to assess the economic feasibility of composting. A composting operation (in contrast to landfilling) that exists on a break-even basis may be justified. The concept of composting as "value added" and the potential of using compost as a soil amendment gives rise to new support for the composting option. A limited economic analysis for a proposed compost operation in Taylor County was also provided (3). Economic factors considered were site preparation costs, required equipment, operating costs, sources of raw product, transportation costs, tipping fees, proposed markets and land requirements. Based on the assumptions outlined in the report, total annual costs of a compost operation to produce 5,000 tons of final product would be $103,000, or $29.49 per ton of crab scrap handled. Revenues that would be generated from a nominal tipping fee and bulk and bagged compost sales were estimated at $107,000, yielding a net revenue of $4,000. Composting of blue crab scrap appears to be a feasible alternative for the area in which the demonstration project occurred.

<u>Static Pile</u>: This demonstration used a "low technology" approach that has been used for fish scrap composting in Wisconsin. It was examined because of its lower cost and less frequent handling characteristics. Overall, the low technology system of blending coarse chips with crab scraps worked extremely well. Where little turning is done, the mix ratios must be adjusted upwards to reduce the potential for poor aeration and to guard against odor generation (4).

Each day crab scraps were dumped off trucks directly onto the ends of an active compost windrow and blended into the windrow. A mixer was used for large volumes and a bucket loader for smaller amounts. For this method, the proper ratios of coarse bark and chips to crab scrap appear to be 2 volumes wood to 1 volume crab scrap. At the end of the process, the compost passed through a tub-grinder which produced a dark humus-like product. This final step was not necessary in the open-windrow procedure because the compost was turned daily.

Laboratory analysis was conducted on the crap scrap compost to provide information on water content, pH, organic matter content, TKN percent, C:N ratios, N, P, K and other measures (4). This product should not be viewed as a fertilizer since the N, P, K ratio was .9:.5:1 but as a low-grade soil amendment. The final C:N ratio was 25.

Calico Scallops

A total of 96 tons of scallop viscera were composted in early 1991. Complementary materials used included 1,200 cubic yards of pine bark, sawdust and tree trimmings; 128 tons of seaweed; 24 tons of rejected citrus pulp; 25 tons of water hyacinth weed; and 14 tons of horse manure (4). The viscera was of two principal forms: raw viscera and viscera/shell mix. The principal wood products used were log bark and log chips from a home manufacturing plant and cypress sawdust from a mill.

A mechanical-lift SCATTM compost turner was used to turn the windrows. This process does not chop to any extent like the WILDCATTM machine, but this did not pose a problem due to the scallop viscera. The compost piles showed a quick rise in temperature after the scallop viscera was added, but did not reach temperatures over 120 F, probably because water became a limiting factor. The SCATTM turner oxygenated the piles well, which reduced odors, but the intensive lifting and air-exposure of the compost means a lowering of the temperature, which fell by 30 degrees after each turning.

The beginning nitrogen content of the viscera was very high at 14.2 percent. The viscera shell mix was one fourth that level. The final compost seemed somewhat course because of wood fragments, so the final product was screened. The coarse yard trimming piles performed the best, resulting in more than 70 percent fine material, which is preferred for use as a soil amendment and for potting mixes. The course materials are best for mulch-type landscaping operations. The nutrient composition was also changed after screening. The density increased, nitrogen content increased and C:N decreased, resulting in a more stable product. The final analysis for four scallop viscera piles using various sources of the organic materials gave N, P, K values ranging as follows: N, .3 to .5; P, .07 to .13; K, .08 to .9.

Scallop viscera, with and without cracked shells and by-catch, can be readily composted and converted into a soil-humus product. Because of the high BOD of viscera, frequent turnings are needed or a course fraction of wood is necessary. The SCATTM machine-turning technology used provided excellent aeration of the piles and controlled composting adequately.

COMPOST MARKETING

Blue Crabs

A marketing program also was developed for the blue crab compost produced by the open windrow method (8). Potential uses such as garden and farm centers, nurseries, greenhouses, landscapers, farmers, organic farmers, golf courses and contractors were examined. A pilot marketing program was established in six north Florida counties and sales of the compost have occurred in bulk form and bagged for retail outlets. Fourteen retail outlets and several public service organizations were involved in the test sales project. By the end of 1990, compost sales totaled $8,558 (wholesale value). They sold 311 bags (40 pounds each), primarily through farm and feed supplies at a wholesale price of $3 per bag. The retail price was $6 per bag. Bulk sales have been 305 cubic yards at $25 per yard. An estimated 200 cubic yards and 100 bags remain to be sold, but the supply has been controlled to maintain a constant supply to the market (C. Greenfield, 1991, Suwannee River Resource Conservation and Development Council, Live Oak, FL, personal communication). Adequate demand exists in the six-county north Florida area to annually sell the entire compost production possible from the blue crab scraps of Taylor, Wakulla and Leon counties.

Other forms of use for the static-pile crab compost and for the calico-scallop compost are being examined. A free compost day was held for the static-pile compost as a way to measure product acceptability. In four hours, 63 vehicles loaded 85,060 pounds of compost which homeowners and gardeners used as potting soil and as a soil amendment (12).

Calico Scallops

The calico scallop compost will be used in demonstration projects as a soil amendment for roadside wildflower projects, in home gardens and as a possible amendment to mixes used to start young citrus trees (B. Mahan, 1991, Brevard County Sea Grant Extension Agent, Cocoa, FL, personal communication). This will help establish demand and uses for the compost.

BLUE CRAB COMPOST USED AS A SOIL AMENDMENT

Blue crab scraps have interesting chemical/biochemical properties, including a high chitin content that may prove effective in immobilizing not only those metals (including Fe, Al, and Cu) contained in the scraps but also associated trace metals from other compost constituents including sewage sludge. A study to characterize the responses of sorghum/sudan grass to varying applications of raw and composted blue crab scraps, in comparison to fertilized and non-fertilized control treatments in field and greenhouse tests, was conducted (11).

The field plot portion of the test was an unreplicated demonstration effort, comparing the growth, relative yields, and plant composition of traditionally fertilized, raw crab scrap amended and compost amended plot areas. The greenhouse study was a replicated variable-rate study in which soil and plant composition, and plant yields were compared for various rates of raw crab scraps, crab compost, traditionally fertilized and unamended/unfertilized plots. The greenhouse studies included an analysis of the soil and plants for resultant values of N, P, K, Ca, Mg and B for all treatments and soil sample and plant analyses for P and N. Plant yield increases were made for the field tests (11).

Raw crab scraps offer considerable potential as a soil amendment for crop production at sites where the initial odor and fly problems from unincorporated portions are tolerable. They would seem to be acceptable, for example, in relatively remote sites (removed from human residences) where crops of a low-input, low-maintenance nature are being grown. This would include pine plantation replanting areas, which are common in Taylor County. The compost product, though more desirable from an aesthetics standpoint, is of limited value as a nutrient-supplying amendment. Long-term effects on soil organic matter levels and adequacy of nutrient supply for more slow-growing crops, including pine plantations, are other considerations which may be of value but which could not be evaluated via the current studies.

NEMATODE CONTROL USING BLUE CRAB COMPOST

Chitin amendments significantly reduce populations of the soybean cyst nematode, the southern and peanut root-knot nematode, and the citrus nematode. Chitin is contained in several materials used to control nematodes and in crustacean exoskeletons such as blue crabs. Tests were conducted to determine the effect of compost made of blue crab scrap and cypress sawdust on the reproduction of Javanese root-knot nematodes(13).

Two greenhouse pot experiments were conducted using the "Homestead" tomato, along with field microplot tests using the "Rutgers" tomato. All tests used various levels of the Javanese root-knot nematode for inoculation to determine the effect of various levels of blue crab compost on nematode control. In both greenhouse tests, crab scrap compost had a significant effect on the foliar and root weights of tomatoes compared to the control treatment. The observed increases varied depending on the rate of nematode inoculation and percentage of compost added to the soil. In the field microplot study, no significant differences between compost levels and the control treatment were observed for plant top weights, although a trend toward greater yield was observed in the compost treatments (13).

In both greenhouse tests, the 20 percent compost application rate was the lowest level of compost that produced large reductions in root galling and nematode reproduction. Pure chitin produces results at extremely lower levels (less than 1 percent). The depletion of nitrogenous compounds and reduction of energy sources through composting probably reduced chitin concentrations and the nematode suppressive characteristics of the crab scrap as well. The 20 percent level of crab scrap compost represents an application rate of more than 200 mt/ha, which would not be economical for nematode control in commercial agriculture. The crab scrap compost has the same limitations for nematode control as many other materials containing low C:N ratios. The greatest potential for crab scrap compost for nematode suppression would be for container grown plants and organic home gardens, where higher loading rates are common.

BLUE CRAB COMPOST AND WATER QUALITY

Agricultural areas in Florida are commonly underlain by sandy, well-drained soils that have low organic matter and low moisture retention capacity. Thus, ground water is highly susceptible to contamination from applied insecticides, herbicides and fertilizer nutrients. Compost made from crab scrap may impact the quality of the ground water in two ways: decomposition of crab scrap may add organic compounds, chemical residues or trace elements to ground water; and crab scrap compost may provide a means of enhancing the retention and/or degradation of pesticides and nutrients in the upper portion of the soil profile. Early data indicate that arsenic, selenium and manganese in the crab compost could be at significant levels to create a potential hazard, although the work has not been completed (14).

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