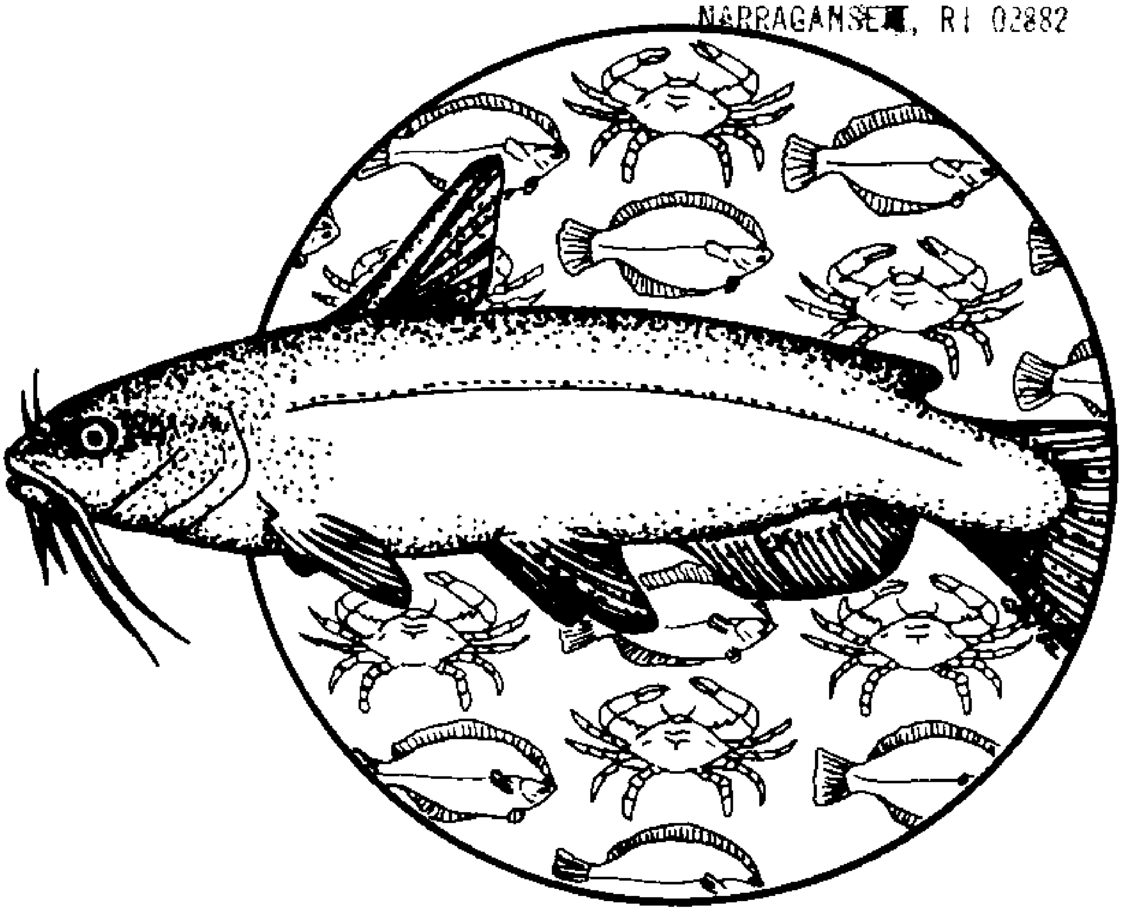
# Seafood Processing Wastes as Fish Meal Substitutes in Catfish Feeds





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# Seafood Processing Wastes as Fish Meal Substitutes In Pelleted Catfish Feeds

by

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Two significant problems face different sectors of the commercial fisheries industry. First, the scarcity of dependable, affordable supplies of high quality protein meals for fish feeds is a problem for fish-farmers. Second, the daily mass of wastes from seafood processing creates a disposal problem at seafood plants along the coast. This booklet describes a way in which these problems may be linked to the mutual benefit of aquaculturists and seafood processors.

## FISH CULTURE AND SEAFOOD PROCESSING

Fish culture in the southeastern United States generally means catfish farming. Production of catfish has increased from a few tons per year in the early 1960's to over 40,000 tons per year currently. Growing this quantity of fish requires about 70,000 tons of feed per year, making feed the major operating expense in catfish farming.

In order to grow rapidly, fish must eat large amounts of protein, and feeds that promote rapid growth include fish meal as a major ingredient. In the 1960's, feeds contained high-quality fish meal made from the Peruvian anchovetta, a sardine-like fish that was abundant and inexpensive. The Peruvian fishery for anchovetta, however, collapsed in the early 1970's, creating worldwide shortage of high-quality fish meal for animal feeds. As supplies of fish meal decreased and prices increased (to more than $500 per ton in some cases), lower quality fish meals replaced anchovetta meal in catfish feeds.

Most fish meal used today comes from the menhaden fisheries along the Atlantic and Gulf Coasts of the United States. The cost of catching menhaden is high, the size of the catch is difficult to predict, and the quality of the fish meal varies considerably. Some fish meals are imported from Peru, Canada, and Norway, but their availability is as unpredictable as menhaden fish meal. Thus, the fish farmer is now faced with sharply higher feed costs and an undependable feed supply.

The seafood processing industry is plagued by the problem of waste disposal. In 1975 in the Chesapeake Bay area, Virginia fishermen caught about 17,500 tons of blue crab and 25,000 tons of finfish. Because about 80 percent of a blue crab is processing waste, 14,000 tons of crab wastes were produced. A similar estimate of finfish wastes is more difficult to make because different species are processed differently. Fish such as menhaden are completely used whereas fish such as flounder are about 70 percent waste. Assuming, however, that an average finfish is one-third waste, the amount of finfish waste produced in 1975 was about 8,000 tons. This means that seafood processing wastes in Virginia alone equal about half of the catfish raised in the entire U. S.

Disposing of these wastes is becoming more costly. Government regulations are becoming stricter and fines for violations are increasing. The Resource Conservation and Recovery Act of 1976, for example, was passed to encourage the recovery of valuable materials and energy from solid wastes through the cooperation of federal, state, and local governments and private enterprise. Future emphasis of the Act will include development of recyclable waste system plans by area planning commissions. This and other regulations will affect the future cost of waste disposal and seafood processing: The days of cheap, easy disposal are ending.

The problems of waste disposal for seafood processors and unstable supplies of costly fish meal for aquaculturists can be combined to the benefit of both groups. Seafood waste generally contains protein and may be a useful replacement for or supplement to current sources of fish meal. Although other types of processing wastes have been tried as fish meal substitutes with limited success, seafood waste is a more promising substitute because both fish meal and seafood waste are fishery products.

A study was conducted at Virginia Polytechnic Institute and State University to test whether or not various seafood processing wastes could be substituted for fish meals, specifically in pelleted feed for channel catfish. The overall study consisted of three major parts: (1) collection and analysis of seafood waste samples throughout a year; (2) experimental culture of channel catfish fingerlings in aquaria using diets containing either fish meal or seafood processing wastes; and (3) long-term culture of channel catfish in a pond using a commercial diet and diets containing seafood processing waste.

Nutritional Content of Wastes

Samples of finfish and blue crab wastes were obtained from selected seafood processors throughout 1980 in order to measure the potential nutritional value of wastes based on their chemical makeup. The finfish waste samples were separated into two types -- flounder frames and mixed finfish wastes. The crab waste samples also were divided into two types -- crab waste as furnished by the processors and crab waste without the carapace (back of the shell). The reason for removing the carapace is that it cannot be digested by fish and can be easily separated during normal processing.

The samples were analyzed for protein, fat, ash and water contents and compared to published results of menhaden meal analysis. Finfish wastes contained about 75 percent water, whereas crab wastes contained only about 60 percent water, probably because the crab shell contains almost no water. Higher moisture content of finfish wastes means that the time and cost of drying them would be greater than crab wastes.

Finfish wastes averaged about 60 percent protein, only slightly lower than fish meal (Table 1). Finfish wastes had slightly higher fat content than fish meal. This occurs because the fat content of fish meal is reduced during processing to remove fish oil. If the finfish wastes were processed to equal menhaden oil in fat content, their protein content would rise to over 64 percent. The crab wastes contained about 40 percent protein, about one-third less than finfish wastes and fish meal. But even this amount seems high since published values of protein in crab meal average about 30 percent. In comparison with finfish wastes, crab wastes are low in fat but extremely high in ash. Removal of the carapace had little effect on the nutritional content of the crab waste. This and the high overall content of ash indicate that the rest of the crab shell makes up the bulk of the ash content. Thus, removing the carapace would be of little use unless other shell parts also are removed.

The amino acid content of the proteins in the wastes also was determined. In general, the proteins in both finfish and crab wastes are well-balanced (Table 2). Nine of the 10 amino acids that channel catfish need in their diet were found in the seafood wastes. Tryptophan, the tenth of these essential amino acids, could not be measured because it is destroyed in the preparation of the wastes for amino acid analysis.

Table 1. Percent Composition (Dry) of Menhaden Meal and Seafood Processing Wastes.

| Component | Menhaden Meal[a] | Flounder Frames | Mixed Finfish | Blue Crab (without carapace) | Blue Crab (with carapace) |
|---|---|---|---|---|---|
| Protein | 66.7 | 62.9 | 58.6 | 41.7[b] | 37.8[b] |
| Fat | 10.6 | 13.4 | 19.8 | 5.5 | 5.6 |
| Ash | 20.9 | 17.8 | 18.1 | 38.1 | 39.6 |
| Carbohydrate[c] | 1.8 | 5.9 | 3.5 | 14.7 | 17.0 |

[a]National Research Council. 1977. Nutrient requirements of warmwater fishes.

[b]Crude protein content corrected for chitin in crab shells.

[c]Calculated by differences; includes crude fiber and nitrogen-free extract.

Table 2. Essential Amino Acid Content (as Percent of Total Amino Acids) of Seafood Processing Wastes.[a]

| Amino Acid[a] | Flounder Frames | Mixed Finfish | Blue Crab[b] | Blue Crab |
|---|---|---|---|---|
| Arginine | 3.22 | 4.05 | 6.62 | 4.57 |
| Histidine | 1.06 | 1.30 | 2.13 | 1.92 |
| Isoleucine | 4.71 | 4.55 | 4.63 | 4.00 |
| Leucine | 8.70 | 8.00 | 8.00 | 7.41 |
| Lysine | 7.78 | 6.59 | 8.04 | 6.41 |
| Methionine | 1.32 | 2.88 | 3.08 | c |
| Phenylalanine | 4.61 | 4.38 | 3.70 | 4.82 |
| Threonine | 4.77 | 4.59 | 4.37 | 5.72 |
| Valine | 5.52 | 5.17 | 5.35 | 6.69 |

[a]Tryptophan was destroyed upon hydrolysis.

[b]Sample had small amount of shell material.

[c]Too low to measure accurately.

Growth of Fingerling Catfish Feeding on Wastes

A short-term laboratory experiment was conducted to measure the growth of fingerling channel catfish eating food containing seafood processing wastes as substitutes for fish meal. Twenty-five channel catfish were placed in each of 20 aquaria (30-gallon capacity). Five different diets were used, each fed to fish in four aquaria for 7 weeks.

The diets contained 10 percent menhaden meal or one of four types of seafood processing wastes (Table 3). The seafood wastes for the diets came from samples collected in 1980. The flounder and mixed finfish wastes used contained 60 percent protein and one type of crab waste (with shell) contained about 40 percent protein. Another type of crab waste (without shell), however, was ground, dried and sifted through a fine screen to remove a large portion of the shell fragments. This increased the protein content of the wastes to almost 60 percent, making the crab waste without shell equivalent in protein content to finfish waste. Other ingredients and proportions were identical in all diets. Because other ingredients also supplied protein, all five diets were similar in total protein content, ranging from 33 percent for the crab waste diet (with shell) to 35 percent for the other four diets.

Ingredients of the diets were mixed with water and made into pellets in a meat grinder (Figure 1). The pellets were then dried and fed to the fish at 3 percent of their body weight per day for 7 weeks (Figure 2).

The catfish ate all of the feeds readily, and less than one percent of the fish died during the experiment. Weight gain and feed conversion (gain in weight/feed eaten) were similar in catfish eating all five of

Table 3. Percent Composition of Diets Used in Laboratory Growth Experiment.

| Ingredient | Diet | | | | |
|---|---|---|---|---|---|
| | Menhaden Meal | Flounder Frames | Mixed Finfish | Blue Crab (without shell) | Blue Crab (with shell) |
| Menhaden Meal | 10 | - | - | - | - |
| Flounder Frames | - | 10 | - | - | - |
| Mixed Finfish | - | - | 10 | - | - |
| Blue Crab, sifted | - | - | - | 10 | - |
| Blue Crab | - | - | - | - | 10 |
| Poultry Meal | - | - | 5 | - | - |
| Soybean Meal | - | - | 45 | - | - |
| Corn | - | - | 25 | - | - |
| Carboxymethyl Cellulose (CMC) | - | - | 7 | - | - |
| Soybean Oil | - | - | 3 | - | - |
| Mineral Mix | - | - | 4 | - | - |
| Vitamin Mix | - | - | 1 | - | - |

Figure 1. Processing of experimental diets for catfish in aquaria

Figure 2. Feeding of catfish in flow-through aquaria

the diets (Figure 3). Fish grew well on all diets, more than doubling their weight in 7 weeks. Feed conversion showed that 1.7-1.9 ounces of food produced 1.0 ounce of weight gain in fish. These results showed that flounder frames, mixed finfish wastes, and blue crab wastes work as well as menhaden meal at 10 percent of the diet in catfish feeds.

Growth of Catfish in Cage-Culture

We followed the laboratory experiment with a longer test of the seafood waste diets under actual fish-farming conditions. Two hundred and fifty fingerling channel catfish were stocked into each of nine identical floating cages (about 1 cubic yard each) in a pond at the Reynolds Homestead Center, Critz, Virginia (Figure 4). Fish were stocked in May, 1981, and were fed 3 percent of their body weight per day until harvest in October. Fish were weighed at approximately 2 week intervals to measure growth and adjust feeding levels.

Fish in each of three cages were fed either a commercial fish feed containing whole fish meal, an experimental diet containing finfish waste, or an experimental diet containing crab waste. This experiment required several hundred pounds of finfish and blue crab wastes. Wastes for the finfish diet came from herring wastes of a canning plant in Maine rather than finfish wastes from the Chesapeake Bay area (at the time of our experiment, no local wastes were available). Crab wastes were made at a Chesapeake Bay crab meal plant without further processing.

The experimental diets were comparable to those used in commercial catfish feeds, except for the intended replacement of fish meal with wastes (Table 4). Wastes comprised 15 percent of the experimental diets

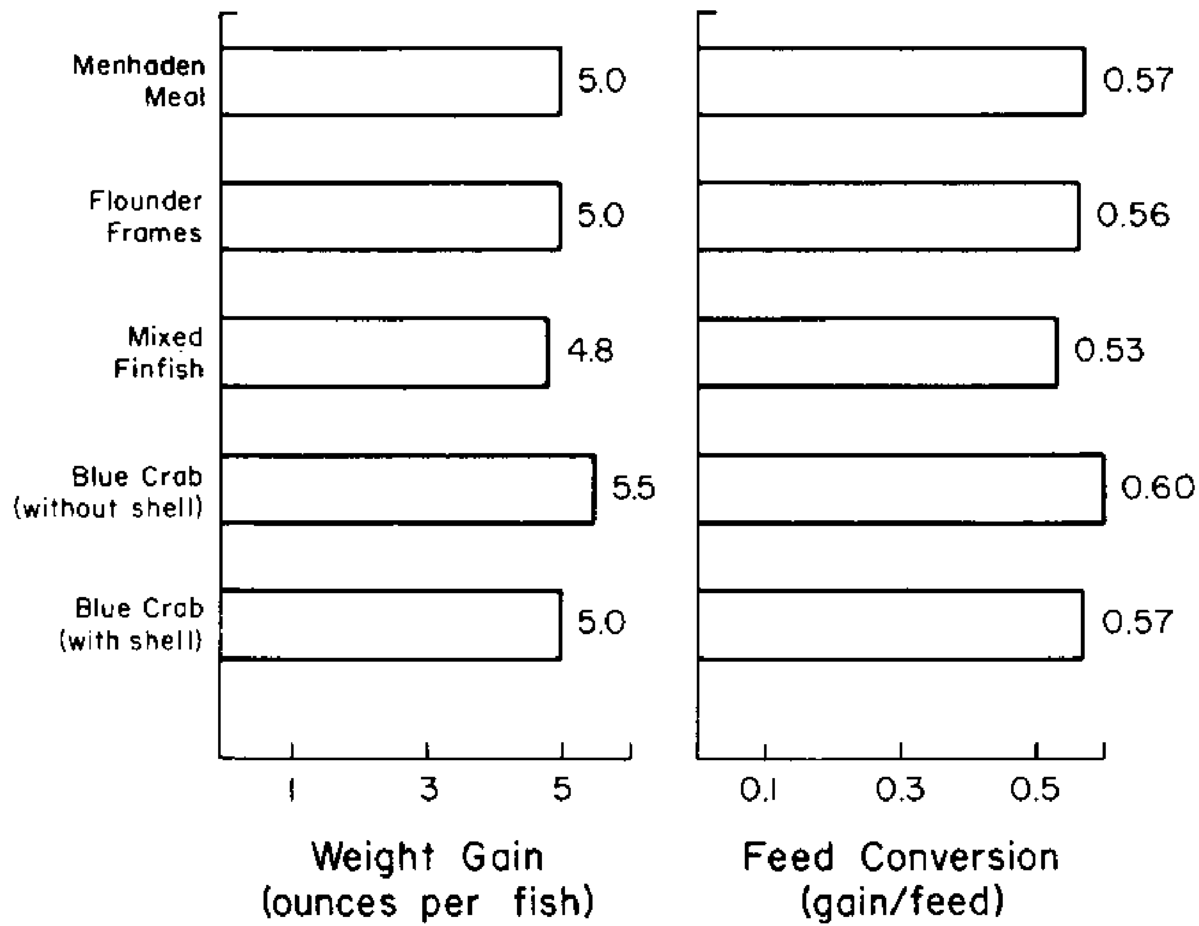


Figure 3. Response of fingerling channel catfish in aquaria fed diets containing menhaden meal or seafood processing wastes.

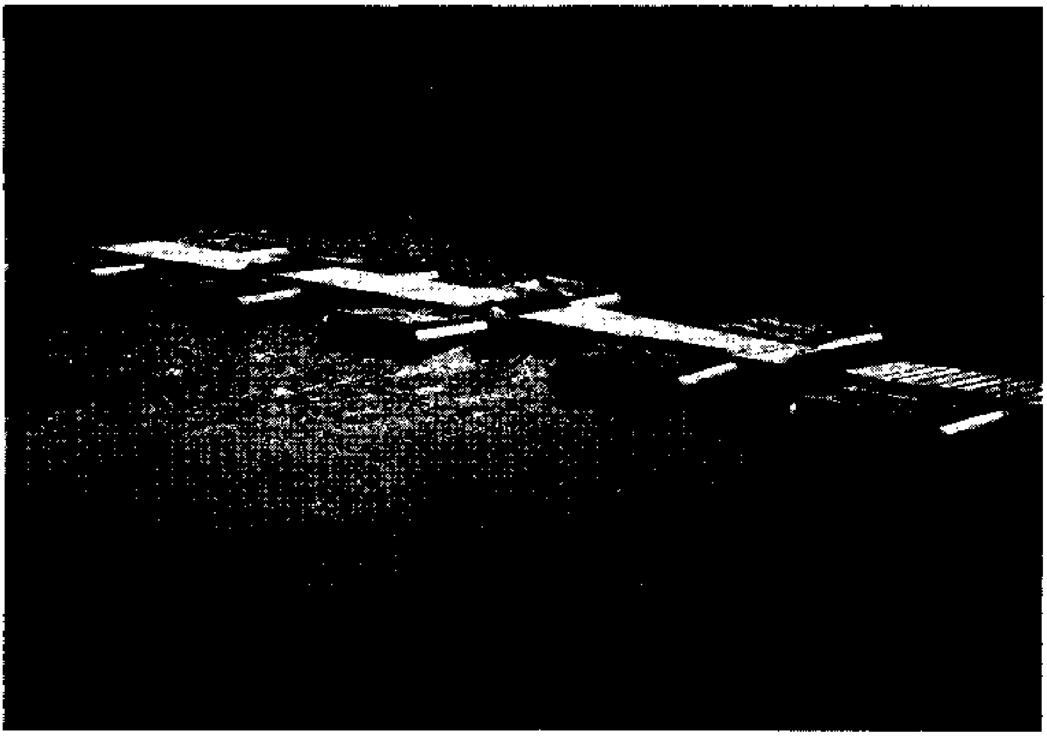

Figure 4. Layout of cages used in field experiment

Table 4. Composition of Diets Used in the Cage-Culture Experiment.

| Ingredient/Component | Percent Composition | | |
|---|---|---|---|
| | Catfish Chow[a] | Finfish Waste | Crab Waste |
| Herring Meal | | 15 | -- |
| Blue Crab Meal | | -- | 15 |
| Soybean Meal (hi-protein) | | 30 | 30 |
| Wheat | | 25 | 25 |
| Corn | | 19 | 19 |
| Feather Meal | | 5 | 5 |
| Corn Oil | | 3 | 3 |
| Limestone | | 1 | 1 |
| Dical. Phosphate | | 1 | 1 |
| Salt | | 0.5 | 0.5 |
| Vit./Trace Min. Mix | | 0.5 | 0.5 |
| Crude Protein | 39.62 | 33.56 | 30.67[b] |
| Crude Fat | 2.65 | 3.65 | 3.58 |
| Acid Detergent Fiber | 5.53 | 3.71 | 4.68 |
| Ash | 10.34 | 7.75 | 11.24 |

[a]Control diet [Purina Catfish Cage Chow (FR) (W)]; contains fish meal, meat and bone meal, soybean meal, wheat middlings, corn, brewer's dried yeast, dried whey, animal fat, minerals and vitamins.

[b]Crude protein content corrected for chitin in crab shells.

to raise the protein content close to that of the commercial feed. About one ton each of the finfish and crab waste diets was milled at Kansas State University (Figure 5). The waste diets were manufactured so that they would float and would be similar in texture, color, and water stability to commercial feed (Figure 6). The diets, however, did differ in protein content. Crude protein level was about 40 percent in the commercial catfish feed, 34 percent in the diet containing finfish wastes, and 30 percent in the diet containing crab meal.

As in the laboratory experiment, the catfish ate all three feeds vigorously, and the survival rate was high and equal in all cages. This suggests that the diets containing seafood wastes were as palatable as commercial feed and caused no harmful side-effects.

Weight gain was largest in fish eating the commercial catfish feed, slightly lower in fish eating the finfish waste diet, and lowest in fish eating the crab waste diet (Figure 7). Body weight increased 8-, 7-, and 5-fold in fish fed the commercial, finfish waste, and crab waste diets, respectively. The patterns of feed conversion among the three groups of fish were basically similar to those of weight gain, but the differences were smaller because the slower growing fish weighed less and, therefore, were fed less. If the lower protein content of the diets containing wastes is considered, however, all three diets were similar in their conversion of dietary protein to fish flesh.

These results indicate that the growth of catfish is proportional to the amount of protein in the diet and that finfish and crab wastes are suitable sources of protein. One problem, however, is that crab meal could not directly replace menhaden meal because the protein con-

Figure 5. Processing of experimental floating diets for caged catfish

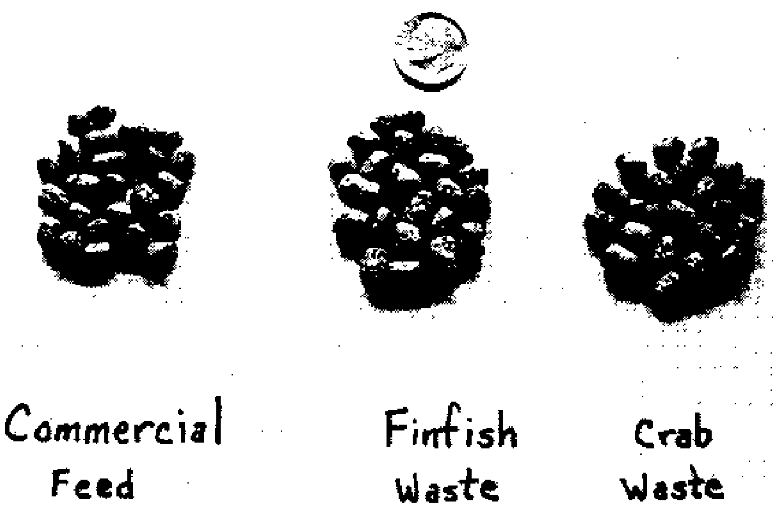


Figure 6. Floating pellets used in field experiments

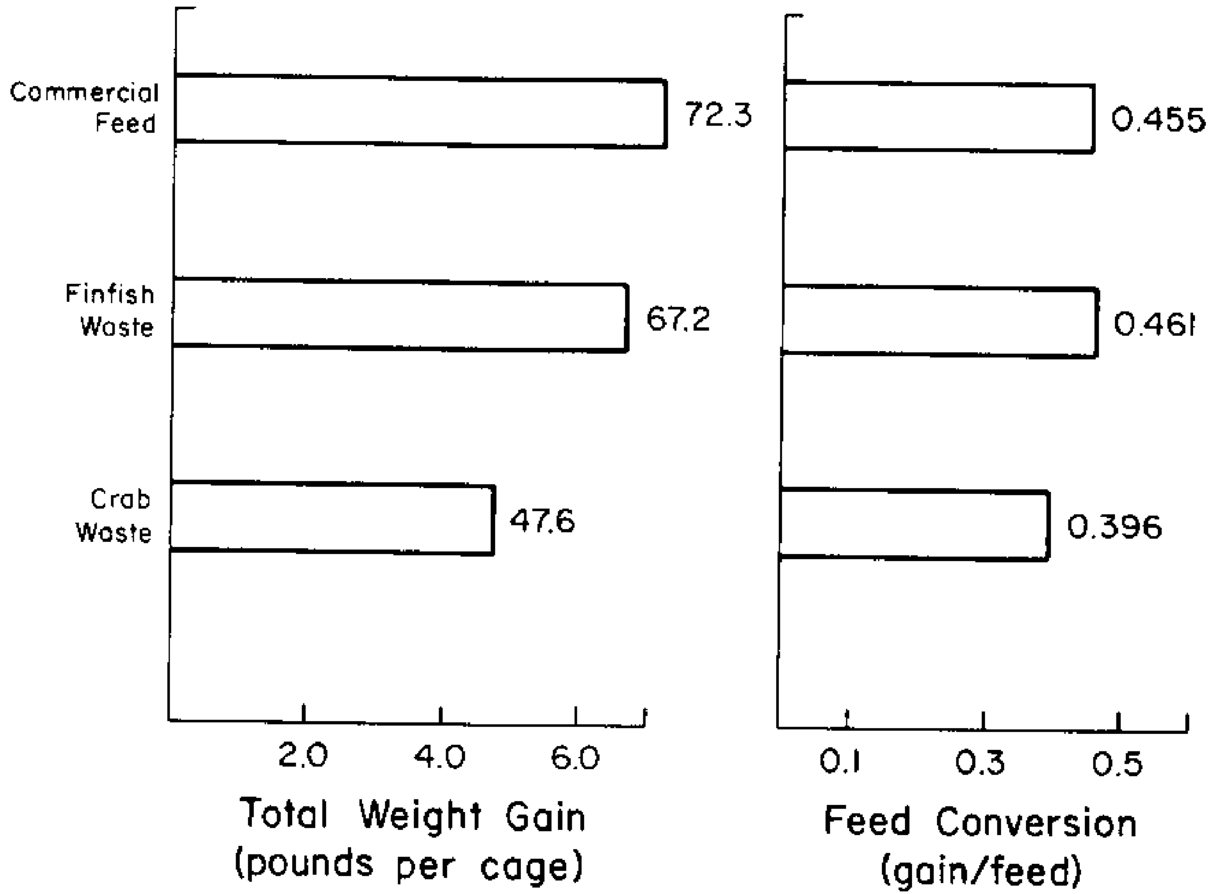


Figure 7. Response of caged channel catfish fed a commercial feed or experimental diets containing either finfish waste or crab waste.

tent of crab meal is too low. Probably the best way of increasing the protein content of crab meal is to remove shell fragments from the ground crab meal.

Summary

The combined findings of this study indicate that the use of Virginia's seafood processing wastes as fish meal substitutes in pelleted catfish feeds is feasible. Several points support this conclusion:

1. The supply of seafood processing wastes is large and stable. The supply also is localized, so that transportation, storage, and processing could be handled efficiently.
2. Finfish wastes are similar to fish meal in composition and in effect on fish growth. They require drying and grinding but no special processing.
3. Crab wastes have potential as a replacement for fish meal if shell fragments are removed. The removal of shell fragments increases protein content and lowers ash content, making the crab meal similar in nutritional value to finfish wastes.

Processors and aquaculturists could work together for their mutual benefit. Seafood wastes could be easily collected and processed into meals suitable for use as fish meal replacements or supplements in fish feeds. The waste meals could be priced low enough to encourage use by fish and poultry feed manufacturers and yet be profitable enough to offset seafood processing costs. Thus, waste disposal problems could be reduced and valuable resources could be conserved--a wise choice ecologically and economically.