Final Report on the Characterization of Alaska Seafood Wastes

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EXECUTIVE SUMMARY

Waste management is one of the pressing problems facing the Alaska seafood processing industry. Currently, there are two alternatives for handling the large volumes of waste being produced, disposal and utilization. For most processors, the problem is avoided by grinding andf disposing of process wastes at sea. This is becoming an increasingly expensive operation and offers no economic return to the processor.

The other alternative to handling process wastes is through utilization and development of marketable by-products. This is being done to some extent at the three fish meal plants operating in Seward, Petersburg and Kodiak. Many other opportunities exist for creative fish waste by-products. Among these are development of animal and fish feeds, natural fertilizers and fish oil supplements. However, to develop successful products, compositional information on the raw materials is essential. In many cases, this data has not been readily available. This project was designed to provide the basic information on processing wastes to help processors understand the raw materials and help develop successful by-products.

Process wastes from cod and pollock filleting, surimi manufacture, halibut heading, salmon canning and freezing, crab butchering and flatfish filleting were collected and characterized for by-product potential. All materials were analyzed for proximate composition and amino acid and mineral profiles.

All wastes were acceptable as raw materials for some type of by-product development. The solid wastes had good protein levels, one of the major criteria for animal feeds. Fillet wastes (cod, pollock and flatfish) had high ash contents that could limit their application in aquaculture. Salmon and halibut heads were found to be excellent sources of fats and probably omega-3 fatty acids. The liquid wastes (bloodwater and washwater) had only nominal amounts of fat, protein and ash and have little use in by-product development.

Amino acid profiles of the solid process wastes revealed good concentrations of most essential amino acids necessary for animal and aquaculture feeds. The only exception was the flatfish fillet wastes which had very low amounts of methionine present.

Mineral contents were reflective of the amount of bone and cartilage present in the waste samples. Fillet wastes, salmon and halibut heads all had high calcium and magnesium levels, major components of bone.

The detailed information presented in this report can be used to assess the quality of a variety of process waste materials for potential application in animal and aquaculture feeds, natural fertilizers and as sources of omega-3 fatty acids.

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INTRODUCTION AND PURPOSE

The phenomenal increase in the production of Alaska whitefish and surimi in the past two years has been accompanied by large volumes of fish waste. In Kodiak alone, 45,000 metric tons of fishery wastes were produced in 1987. Of this volume, approximately 60% was processed to fish meal and oil by the local reduction plant. The rest was dumped at sea. This waste is a valuable protein source that has many potential by-product applications. Among the most promising is the production of feeds for aquaculture where a high quality protein is necessary for growth and survival. Other high value products produced from fish waste can include natural fertilizers and omega-3 fatty acids (the "fish fats" that can prevent heart disease).

While there is considerable potential for producing valuable by-products, information on the basic composition of various fish wastes has been scarce. Major fish waste studies conducted in the late 60's and early 70's were concerned with the control of environmental pollution. Wastes were characterized for their pollution potential rather than as a possible raw ingredient. This information, while necessary to control effluent pollution, was not sufficient to help in successful formulation of by-products.

This project was undertaken to evaluate the chemical composition of waste flows generated by Alaska seafood processing operations. The generated data would help provide baseline information that could be used to develop successful byproducts and further the utilization of fish wastes. Wastes from cod and pollock filleting, surimi, halibut freezing, salmon canning and freezing, crab freezing and flatfish filleting operations were sampled and characterized. Information was generated on proximate composition, amino acid and mineral profile for each waste flow.

APPROACH

The approach to the project was to sample and analyze various waste streams from Kodiak processing plants during the year. Samples were collected for all the major fisheries products produced in Alaska. These included salmon, cod, pollock, halibut, crab and flatfish. Wastes from surimi production were also included.

Samples were taken from waste flumes, totes, screens or other equipment that processing plants typically used to collect their wastes. Frequently, multiple samplings were taken during a production day to obtain representative samples.

Because each processing system was slightly different, sampling procedures varied. Specific procedures for each waste flow can be found in the findings section. In general, the samples were taken and immediately frozen for later evaluation.

Sample Preparation and Analysis

Frozen samples were thawed overnight at $50^{o}F$ and measured for proximate composition that included protein, ash, fat and moisture analysis. Protein content was determined using a modified Kjeldahl procedure (Association of Official Analytical Chemists (AOAC) method 2.055, 1984) with an Tecator digestion and automated distillation system. Moisture was measured using the standard AOAC method (24.033, 1984) of drying preweighed samples at constant temperature. Ash was determined by charring and ashing moisture samples (AOAC method 18.025, 1984). Crude fat was measured using an acid hydrolysis and an ethyl ether/petroleum ether extraction (AOAC method 18.022, 1984).

Samples for amino acid analysis were prepared by a sixteen to 20 hour acid hydrolysis (AOAC 43.263, 1984) and a pre-column dansylation derivitization procedure (Bongiovanni, 1981). Samples were subsequently filtered and analyzed using a acetonitrile/phosphate gradient high performance liquid chromatography (HPLC) procedure and Beckman amino acid analyser.

Samples for mineral analysis were prepared using ashed samples dissolved in 2% nitric acid (Teeny, 1984) and analyzed using atomic absorption spectroscopy. Mineral analysis was conducted by Dr. John Kennish of the Chemistry Department, University of Alaska, Anchorage.

Wastewater analysis measured pH, biological oxygen demand (BOD), chemical oxygen demand (COD), and soluble solids of flume and process waters for pollock and cod processing using standard methods (APHA, 1985). COD was measured using a modified standard method and the Tecator digestion system.

Solid/liquid ratios and expected waste volumes were measured for surimi processing. Measurements were done using the "bucket and stopwatch" method. Buckets of known volume were allowed to fill with wastewaters from various unit operations while fill time was recorded. Solid/liquid ratios were determined when the solids in the filled buckets settled and the volumes of both solid and liquid were measured. This method was repeated ten times to obtain an average flow rate.

FINDINGS

COD AND POLLOCK PROCESSING WASTES

Cod and pollock processing has become an important part of the shore based Alaska seafood industry. In 1987, X million pounds of cod and pollock were landed at Alaska ports. Much of this whitefish has been processed into fillets with an average recovery of 25 percent. The remaining 75 percent represents large volumes of waste material which have potential for by-product development especially with the current interest in aquaculture, omega-3 fatty acids and natural fertilizers. In order to properly develop useful by-products, composition information is needed on the raw material.

Sample Collection

Typical cod and pollock processing wastes were collected from five Kodiak seafood plants. Samples were collected in October 1986 when fish were in good condition and again in April 1987 during spawning season. Liquid and solid samples (Table 1) were collected from specific waste streams as well as composite samples representing the total waste profile. All solid samples were dewatered for three minutes, finely ground through a Hobart meat grinder and frozen for later analysis.

Table 1.
Cod and Pollock Samples

Hand Fillet Cod Wastes
Machine Fillet Cod Wastes
(winter and spawning)
Skinner Wastes
Trimming Table Wastes
Cod Roe
Machine Fillet Pollock Wastes
Pollock Bloodwater

Several samples of flume and process water were collected from two Kodiak processing plants for standard wastewater analysis. Samples were taken when the plants were at peak operation and the particulate matter in the wastewater would be at maximum levels.

Results

Cod Processing Wastes Proximate composition for all cod samples is presented in Table 2. Proximate analyses of the samples varied only slightly. The composition of spawning and non-spawning cod were very similar suggesting that most changes associated with spawning cod occur in the muscle (fillet) and not the waste fraction. Protein contents were very similar with the highest levels found in cod roe and skinner waste. Skinner waste was high in protein due to the levels of connective tissue or collagen present. Fat content in the spawning cod was noticeably lower than non-spawning cod. Higher levels of fat were found in cod roe and also the fillet wastes that included the cod roe. No difference in fat levels existed between machine and hand filleted waste. The levels of protein available in the cod fillet wastes make it attractive as a raw material for by-product development, although the high ash contents could pose problems for such applications as aquaculture feeds.

Table 2.
Proximate Composition of
Cod Processing Wastes
(% wet wt)

Sample	Moisture	Protein	Fat	Ash
Hand Fillet[1]	79.5	14.3	1.7	3.9
Machine Fillet (winter)[1]	79.4	14.1	2.0	3.8
Machine Fillet (spawning)[2]	80.6	13.5	0.9	4.1
Skinner Wastes[1]	78.8	20.3	0.6	2.6
Trimming Table[1]	85.1	14.9	0.6	0.8
Cod Roe[3]	71.5	23.5	2.5	1.4

[1] n=6 [2] n=4 [3] n=2

Mineral content (Table 3) showed that sodium, potassium, magnesium and calcium were the predominant metals in all samples. The amount of calcium was indicative of the bone content in the fillet samples. Magnesium and calcium are common minerals found in the bone and cartilage while sodium and potassium are electrolytes used for osmoregulation. Cod roe had a different mineral balance compared to the fillet wastes. Significant amounts of zinc and iron were present while calcium and magnesium (found in bones) were at low levels.

The amino acid analysis is found in Table 4. Glycine and proline were found in the highest concentrations in the skinner waste indicative of collagen present in the sample. Machine fillet waste and cod skin had similar amino acid profiles. Trimming waste had lower glycine and proline, amino acids present in the connective tissue of skin. It appears that the fillet waste has a good balance of the essential amino acids needed for aquaculture feeds.

Results of the wastewater analysis (Table 5) were highly variable depending on sample collection and daily operating conditions. Ranges for COD and BOD varied more than 50%. However, the values for BOD, COD and suspended solids were within the ranges reported for typical cod processing operations (EPA, 1975).

Table 3.
Mineral Content of Cod
Processing Wastes
(mg/kg wet wt)

Sample[1]	Mineral							
	K	Na	Cu	Zn	Mg	Mn	Ca	Fe
	($x 10^3$)	($x 10^3$)			($x 10^2$)		($x 10^3$)	
Hand Fillet Cod	3.31	1.20	0.10	10.43	2.93	1.63	3.96	6.88
Machine Cut Cod	2.41	1.42	1.02	12.07	2.34	1.62	3.80	2.04
Skinner Waste	1.29	0.24	0.48	1.15	1.69	2.25	3.15	2.07
Trim Table Waste	2.35	0.51	1.57	6.49	1.82	0.28	1.89	3.11
Cod Roe	2.41	1.01	0.87	28.29	0.48	0.34	0.10	6.43

[1] n=3

Table 4.
Amino Acid Composition of
Cod Processing Wastes
(mg/kg wet wt)

Amino Acid	Sample[1] Machine Fillet Waste	Trimmings	Cod Skin
Alanine	8.6	6.9	8.9
Arginine	15.1	13.8	14.7
Aspartic Acid	9.0	9.1	7.8
Cysteine	1.7	1.8	1.5
Glutamic Acid	13.7	14.7	12.0
Glycine	15.9	6.9	22.2
Hydroxyproline	4.2	-	5.4
Isoleucine	4.7	5.2	3.9
Leucine	10.0	11.0	8.3
Lysine	12.2	15.6	7.8
Methionine	5.1	5.1	3.8
Phenylalanine	5.7	5.8	5.0
Proline	10.5	6.0	13.7
Serine	5.6	5.3	5.9
Valine	5.2	5.2	4.4

[1] n=3

Table 5.
Wastewater Analysis of Cod
Process Waters

Sample	COD (mg/l)	BOD (mg/l)	pH	Suspended Solids (mg/l)
Plant 1 - Hand Fillet Operation	800-1228	746-1145	7.28	437-705
Plant 2 - Machine Fillet Operation	723-867	--	6.91	643-938

Pollock Processing Wastes Proximate composition for the pollock samples are shown in Table 6. Little differences existed between spawning and non-spawning fish. The fat content decreased by one-third. This was accompanied by a small increase in moisture and a noticeable increase in protein in the spawning pollock. Protein levels of both winter and spawning pollock fillet wastes had good levels of protein which could be used in aquaculture or animal feeds. However, high levels of ash could prevent their utilization in certain instances without modification.

Table 6.
Proximate Composition of
Pollock Processing Wastes
(% wet wt)

Sample	Moisture	Protein	Fat	Ash
Machine Fillet (winter)[1]	81.3	11.3	3.0	3.6
Machine Fillet (spawning)[1]	82.0	12.5	1.9	3.7
Bloodwater[2]	98.5	0.9	0.2	0.3

[1] n=4 [2] n=2

Sodium, potassium, calcium and magnesium were the predominant minerals (Table 7) in the samples. This was expected with the high bone content of the sample.

Amino acid analysis (Table 8) revealed a profile different from cod wastes. All common amino acids were present in smaller amounts making pollock waste less desirable than cod waste as a raw material. Glutamic acid, glycine and lysine were found in the highest concentrations. Low amounts of all amino acids were found in the bloodwater.

Results from the wastewater samples (Table 9) were as variable as those from the cod samples. The variation was the result of plant and waste handling equipment as well as changes in daily operating conditions. However, the values for BOD, COD and suspended solids were within the range reported by the Environmental Protection Agency (EPA, 1975).

Table 7.
Mineral Content of Pollock
Processing Wastes
(mg/kg wet wt)

Sample[1]	Mineral							
	K ($x 10^3$)	Na ($x 10^3$)	Cu	Zn	Mg ($x 10^2$)	Mn	Ca ($x 10^3$)	Fe
Machine Cut (winter)	2.34	1.71	0.47	13.36	3.46	0.82	5.15	8.41
Machine Cut (spawning)	1.99	2.27	1.33	16.86	4.02	0.94	3.98	8.12

[1]n=3

Table 8.
Amino Acid Composition of
Pollock Processing Wastes
(mg/kg wet wt)

Amino Acid	Sample[1] Machine Fillet Wastes	Sample[1] Bloodwater
Alanine	6.1	0.18
Arginine	9.5	0.19
Aspartic Acid	5.2	0.12
Cysteine	1.3	0.09
Glutamic Acid	11.4	0.16
Glycine	11.4	0.19
Hydroxyproline	1.5	-
Isoleucine	2.1	0.09
Leucine	7.3	0.26
Lysine	10.5	0.49
Methionine	3.6	0.18
Phenylalanine	3.5	0.21
Proline	5.8	0.15
Serine	3.2	0.03
Valine	3.3	0.16

[1] n=3

Table 9.
Wastewater Analysis of Pollock
Process Waters

Sample	COD (mg/l)	BOD (mg/l)	pH	Suspended Solids (mg/l)
Plant 1 - Machine Fillet Operation	507-816	1047-1226	7.05	186-333
Plant 2 - Machine Fillet Operation	755-1569	--	7.38	543-694

SURIMI PROCESSING WASTES

Pollock surimi production generates large amounts of waste. Recoveries from round fish to minced, washed flesh for surimi range between 15 and 22 percent. Conversely, 78 to 85 percent of the whole fish is currently considered waste material. The bulk of the waste, approximately 60 percent, is generated by the filleting or splitting operation and consists of heads, backbones and viscera. Other significant waste flows include skin and bones removed by the mincing/deboning process (10-12 percent), soluble protein leached during the washing process (17-20 percent), and connective tissue and impurities removed by the refining operation (5-10 percent).

As with cod and pollock processing wastes, there exists good potential for development of useful by-products from surimi operations. As the first step to by-product development, baseline information (proximate composition, amino acid profile) is required to characterize the waste material.

Sample Collection

Surimi processing wastes were collected from a local Kodiak plant between October 1986 and March 1987. Samples included solid pollock waste (heads, viscera and frames) and wastewater (blood and process water) from a Baader 182 filleting machine, waste solids (skin and bones) from a Baader 695 mincer/deboner, solids from a Fukoko refiner and washwater from the rotary screens. Processing wastes were collected during an eight hour period to obtain representative samples. Solid samples were dewatered for three minutes, finely ground and frozen for later analysis.

Results

Proximate composition for the samples is presented in Table 10. All samples had high moisture contents (greater than 80 percent). The solid samples were a good source of protein indicating a potential for by-product development. Fat and ash content were the highest in the fillet waste, reflecting the high percentage of bone and viscera in the samples. The unacceptable washed mince from the refiner had a very low fat content as a result of the washing process. Blood and wash water samples had little protein, fat or ash.

Mineral content (Table 11) showed that potassium, sodium, calcium, and magensium were in the highest concentrations with lesser amounts of iron and zinc. High calcium and magnesium content was expected in the sample with bone and skin. Sodium and potassium were present in large quantities because they are used as osmotic regulators in the living fish.

Table 10.
Proximate Composition of
Surimi Processing Wastes
(% wet wt)

Sample[1]	Moisture	Protein	Fat	Ash
Fillet Waste	81.3%	11.3%	3.0%	3.6%
Bloodwater	97.9	1.3	0.4	0.3
Deboner Waste	86.1	10.7	0.8	0.7
Refiner Waste	86.4	12.1	0.7	0.4
Rotary Screen Washwater	98.8	0.8	0.2	0.2

[1]n=3

Table 11.
Mineral Content of Surimi
Processing Wastes
(mg/kg wet weight)

Sample[1]	Mineral K ($\times 10^3$)	Na ($\times 10^3$)	Cu	Zn	Mg ($\times 10^2$)	Mn	Ca ($\times 10^3$)	Fe
Fillet Waste	1.99	2.27	1.33	16.36	4.02	0.94	39.79	8.12
Deboner Waste	0.02	0.11	0.79	15.39	1.33	0.51	11.76	2.98
Refiner Waste	1.68	3.32	0.24	12.83	3.60	0.61	40.25	16.42

[1]n=3

Glycine, glutamic acid and arginine were the most abundant amino acids found in the samples (Table 12). Lesser amounts of alanine, aspartic acid, leucine and proline were also found. Hydroxyproline was found in all solid samples indicative of the presence of collagen protein in the waste material. And as expected, the amino acid composition of the blood and washwater revealed only small amounts present.

The solid/liquid ratios and expected volume from filleting, mincing and deboning, and refining are presented in Table 13. The solid/liquid ratios varied depending on water flow to the machinery, operation conditions and other factors. These values should be taken as time and plant specific and used as generalizations. Expected volume changed significantly depending on fish size and quality, operating conditions and employee performance. These values should also be used as approximations.

Table 12.
Amino Acid Composition of
Surimi Processing Wastes
(g/kg wet weight)

Amino Acid	Sample[1] Fillet Waste	Bloodwater	Deboner Waste	Refiner Waste	Washwater
Alanine	6.7	0.18	7.5	6.4	0.20
Arginine	9.8	0.19	10.5	11.0	0.21
Aspartic Acid	5.2	0.12	5.4	6.8	0.07
Cysteine	0.2	0.09	0.8	--	0.06
Glutamic Acid	10.8	0.16	10.2	15.2	0.10
Glycine	13.7	0.19	20.1	10.3	0.21
Hydroxyproline	3.0	--	4.5	1.5	--
Isoleucine	2.4	0.09	1.7	2.3	0.07
Leucine	7.5	0.26	5.3	7.4	0.22
Lysine	3.5	0.49	2.5	2.0	0.31
Methionine	2.9	--	3.1	2.7	--
Phenylalanine	3.9	0.21	2.8	3.2	0.17
Proline	7.3	0.15	9.4	5.7	0.11
Serine	4.1	0.04	4.7	5.1	0.05
Valine	3.6	0.16	2.7	3.3	0.12

[1] n=3

Table 13.
Physical Measurements of Surimi
Processing Waters

Operation	Solid/Liquid Ratio	Expected Waste Volume
Filleting	1:3	4200 lbs/hr
Deboning	4:1	600 "
Refining	10:1	750 "

HALIBUT PROCESSING WASTES

Processing halibut usually involves receiving dressed fish, removing the head, then cleaning and freezing the body. The head, accounting for 18 percent to 24 percent of the dressed fish weight, is the primary waste product. As a raw material for by-product development, halibut heads have several disadvantages. They are difficult to handle and frequently have fishing hooks imbedded in the mouth making grinding difficult. The current disposal method has been to barge and ocean dump whole heads in nearby waters. If handling systems could be designed to process the halibut heads, they could be another source for by-products development.

Sample Collection

Halibut processing wastes were collected over a three day period from local Kodiak plants during May 1987. Heads were taken at random to obtain a representative sample, dewatered for three minutes, finely ground and frozen for later analysis.

Results

Proximate composition is presented on Table 14. Halibut heads had a lower moisture content than other seafood waste flows analyzed. The lower moisture meant higher amounts of solids present, specifically protein and fat. Protein levels were similar to cod and pollock processing wastes and high enough to make halibut heads useful in by-product development. Of particular interest was the high fat content (16.2 percent), unusual for a lean whitefish species. Halibut heads have the potential as a raw material for fish oil/omega-3 fatty acid production. Ash content was high indicating considerable bone and cartilage present in the sample. The high ash content could be a limiting factor in utilizing halibut heads as a raw material in certain feeds.

Mineral analysis (Table 15) revealed moderate amounts of all measured metals in the sample. Calcium and magnesium from the bone and cartilage were present in the highest concentrations with lesser amounts of sodium and potassium from the muscle and connective tissue in the head. Small amounts of calcium and zince were also found.

Amino acid analysis revealed a well balanced profile (Table 16) necessary for halibut heads to be used in animal and fish feeds. Glycine, glutamic acid, aspartic acid, arginine, proline and alanine were present in the significant concentrations.

Table 14.
Proximate Composition of
Halibut Processing Wastes
(% wet weight)

Sample[1]	Moisture	Protein	Fat	Ash
Heads	65.5%	11.6%	16.2%	4.1%

[1]n=3

Table 15.
Mineral Content of Halibut
Processing Wastes
(mg/kg wet weight)

Sample[1]	Mineral K ($x\ 10^3$)	Na ($x\ 10^3$)	Cu	Zn	Mg ($x\ 10^2$)	Mn	Ca ($x\ 10^3$)	Fe
Heads	0.82	0.12	0.37	4.53	1.09	0.19	8.80	2.04

[1]n=3

Table 16.
Amino Acid Composition of
Halibut Processing Wastes
(g/kg wet weight)

Amino Acid	Sample[1] Heads
Alanine	10.5
Arginine	11.3
Aspartic Acid	11.6
Cysteine	--
Glutamic Acid	12.0
Glycine	21.6
Histidine	2.6
Isoleucine	4.3
Leucine	8.3
Lysine	8.8
Methionine	3.8
Phenylalanine	4.5
Proline	11.1
Serine	8.6
Threonine	5.4
Tyrosine	3.2
Valine	6.5

[1] n=3

SALMON PROCESSING WASTES

Salmon processing generates considerable waste volumes. In a typical salmon cannery, production wastes can account for 31 percent to 38 percent of landed weight. In freezer operations, processing waste may range from 10 percent to 25 percent of landed weight depending on product form. Wastes are primarily composed of heads, fins, tails and viscera. It is a very balanced raw material and has many uses. Whole salmon waste is the primary material for Alaska's meal plants. The viscera has very active enzymes that are useful in fish feed formulation. The heads and viscera are a good source of fish oil and omega-3 fatty acids. Ensilaged and acid stabilized, salmon waste becomes an excellent fertilizer or animal feed. Because there are so many potential uses for salmon wastes, compositional information becomes a useful tool in maximizing its utilization.

Sample Collection

Pink and red salmon processing wastes were collected from local Kodiak plants (cannery and freezer operations) during July 1987. Samples were taken from two points in each seafood plant. Heads were taken from the iron chink indexers in the cannery and the pneumatic header in cold storage plants. Viscera was collected from the iron chink and butchering table. Species were mixed, dewatered for three minutes, finely ground and frozen for later analysis.

Results

Proximate composition for the samples is presented on Table 17. The composition of salmon heads was very similar to halibut heads. Heads had a high solids content composed primarily of fat and protein. The high fat content indicated that the head was a good source of fish oil. Low ash content indicated little bone or mineral in the sample. Overall, the profile of the salmon heads indicated a very balanced raw material for such by-products as fish meal, animal feeds and protein/fat supplements. The salmon viscera samples had higher moisture and protein levels and much lower fat and ash levels. Most noticeable was the low fat content in the viscera since it was expected that the liver would contribute significantly to the fat level. Again, the high protein levels indicated a good raw material for protein feeds.

Mineral analysis (Table 18) indicated calcium, sodium, potassium and magnesium were available in the highest concentrations while lesser amounts of iron and zinc were present. The viscera contained high levels of zinc and copper, probably indicative of the amount of blood present in the sample.

Amino acid analysis (Table 19) revealed a balanced mixture. Most amino acids needed for animal and fish feeds were available in measurable quantities. Both salmon heads and viscera had similar profiles. Glycine, glutamic acid, arginine, leucine and aspartic acid were available in the highest concentrations.

Table 17.
Proximate Composition of
Salmon Processing Wastes
(% wet weight)

Sample[1]	Moisture	Protein	Fat	Ash
Heads	67.3%	13.3%	15.8%	4.2%
Viscera	80.5	16.2	2.5	1.6

[1] n=3

Table 18.
Mineral Content of Salmon
Processing Wastes
(mg/kg wet weight)

Sample[1]	Mineral							
	K ($\times 10^3$)	Na ($\times 10^3$)	Cu	Zn	Mg ($\times 10^2$)	Mn	Ca ($\times 10^3$)	Fe
Heads	1.66	1.94	1.80	24.52	3.37	0.61	35.23	6.77
Viscera	0.96	0.26	44.30	176.28	2.07	0.54	13.37	6.88

[1] n=3

Table 19.
Amino Acid Composition of
Salmon Processing Wastes
(g/kg wet weight)

Amino Acid	Sample[1] Heads	Viscera
Alanine	8.8	8.7
Arginine	8.6	10.8
Aspartic Acid	10.5	12.0
Cysteine	--	--
Glutamic Acid	14.7	16.3
Glycine	16.1	8.8
Histidine	2.9	3.7
Isoleucine	4.3	6.2
Leucine	7.8	11.4
Lysine	7.9	11.9
Methionine	3.2	3.3
Phenylalanine	4.2	5.6
Proline	4.3	7.0
Serine	6.1	6.8
Threonine	4.9	6.5
Tyrosine	3.2	5.1
Valine	6.5	9.1

[1] n=3

CRAB PROCESSING WASTES

Tanner and king crab processing generates considerable waste volumes. In a typical cooked section operation, waste can account for 35 percent to 40 percent of landed weight. When meat is extracted from the shell, the amount of waste can be as high as 75 percent to 83 percent of landed weight. The bulk of the waste material is carapace or crab shell with smaller amounts of viscera and blood. Crab wastes have been used for several years. They have been dried and ground into meal for feeds and soil conditioners. Chitin has been extracted from the shell and used as a flocculant for precipitating solids from waste streams. In recent years, the value of crab meal has been so low that the best alternative to its use has been grinding and discharging.

Sample Collection

Tanner and king crab processing wastes were collected from local Kodiak plants between March and May 1987. The collection points for all samples were the butchering stations where the carapace and viscera were removed. The samples were dewatered for three minutes, finely ground and frozen for later analysis.

Results

Proximate composition for the samples is presented on Table 20. Small differences existed between king and tanner crab. The king crab sample had a lower moisture and higher protein levels. This was probably due to the larger percentage of viscera present in the king crab sample. Slightly higher fat and ash contents were also found in the king crab sample. As expected, the shell had high moisture and ash contents, lower protein and little fat. Protein and fat was derived from the viscera and blood while ash was a reflection of the amount of shell in the samples.

Mineral analysis (Table 21) indicated very high concentrations of calcium with lesser amounts of potassium, sodium and magnesium. Small amounts of zinc and iron were also present. The high calcium content was expected since a large percentage of the wastes samples were shell.

Amino acid analysis (Table 22) revealed the presence of the common amino acids although in low concentrations when compared to other waste streams. Very little differences existed between the king and tanner crab samples. Glutamic and aspartic acids were the most abundant amino acids present.

Table 20.
Proximate Composition of
Crab Processing Wastes
(% wet weight)

Sample[1]	Moisture	Protein	Fat	Ash
Tanner Crab	76.7%	8.9%	1.1%	9.2%
King Crab	71.7	13.8	1.6	10.3

[1] n=3

Table 21.
Mineral Content of Crab
Processing Wastes
(mg/kg wet weight)1

Sample[1]	Mineral K $(\times 10^3)$	Na $(\times 10^3)$	Cu	Zn	Mg $(\times 10^2)$	Mn	Ca $(\times 10^3)$	Fe
Tanner Crab	0.28	1.63	1.02	37.75	22.12	1.62	271.46	24.04
King Crab	1.54	4.93	2.21	22.92	23.09	2.15	229.16	11.94

[1] n=3

Table 22.
Amino Acid Composition of
Crab Processing Wastes
(g/kg wet weight)

	Sample[1]	
Amino Acid	Tanner Crab	King Crab
Alanine	4.3	4.9
Arginine	4.3	6.4
Aspartic Acid	7.3	9.5
Cysteine	--	--
Glutamic Acid	8.7	11.8
Glycine	5.3	6.4
Histidine	1.7	3.0
Isoleucine	2.8	4.1
Leucine	4.4	6.3
Lysine	3.4	4.8
Methionine	1.2	1.8
Phenylalanine	3.3	4.5
Proline	5.2	5.5
Serine	3.8	5.4
Threonine	3.7	4.4
Tyrosine	2.9	4.3
Valine	4.61	5.30

[1] n=3

FLATFISH FILLETING WASTES

The flatfish resource is one of the last underutilized fisheries in Alaska. Primary use of this resource will be as filleted product. Fillet recoveries from flatfish range between 18 percent and 25 percent depending on the species. The remaining 75 percent to 82 percent of the landed weight is waste material, primarily heads, frames and viscera. Because of the large resource of flatfish in Alaska waters, there is a great potential for by-product development especially with the current interest in aquaculture feeds, natural fertilizers and fish oil/omega-3 fatty acids.

Sample Collection

Flatfish processing wastes were collected from a local Kodiak plant in June 1987. Waste consisted of flatfish viscera and frames obtained from the filleting table. The samples were a mixture of rex, flathead and rock sole, and starry flounder. Samples were dewatered for three minutes, finely ground and frozen for later analysis.

Results

Proximate composition is presented on Table 23. The values are typical for fillet waste. There was high moisture content, lower protein levels and equal amounts of fat and ash. Moisture comprises almost 80 percent of the waste material. Protein levels appear to be high enough that there is a potential for by-product development using flatfish wastes. Ash content continues to be a potential limiting factor in utilizing these wastes for such products as aquaculture feeds.

Mineral analysis (Table 24) indicated that calcium, potassium, sodium and magnesium were present in the highest concentrations with lesser amounts of zinc and iron. Measurable amounts of manganese were also present. Calcium and magnesium levels were high because of the large percentage of bone in the sample.

Amino acid analysis (Table 25) revealed the most common amino acids were present in the protein component of the waste. Glutamic and aspartic acids were present in the highest amounts. The amount of the amino acid methionine, one of the necessary amino acids for animal and fish feeds, was very low. If flatfish were to be used as a material for feeds, it would have to be supplemented to balance the amino acid profile.

Table 23.
Proximate Composition of
Flatfish Processing Wastes
(% wet weight)

Sample[1]	Moisture	Protein	Fat	Ash
Flatfish	79.4%	13.8%	3.8%	3.2%

[1] n=3

Table 24.
Mineral Content of Flatfish
Processing Wastes
(mg/kg wet weight)

Sample[1]	Mineral K ($\times 10^3$)	Na ($\times 10^3$)	Cu	Zn	Mg ($\times 10^2$)	Mn	Ca ($\times 10^3$)	Fe
Flatfish Waste	2.28	1.34	0.57	22.17	2.97	3.89	34.13	7.94

[1] n=3

Table 25.
Amino Acid Composition of
Flatfish Processing Wastes
(g/kg wet weight)

Amino Acid	Sample[1] Flatfish Waste
Alanine	7.8
Arginine	8.1
Aspartic Acid	11.6
Cysteine	--
Glutamic Acid	16.5
Glycine	9.3
Histidine	2.6
Isoleucine	5.3
Leucine	9.4
Lysine	9.7
Methionine	0.8
Phenylalanine	4.5
Proline	6.7
Serine	5.5
Threonine	5.0
Tyrosine	4.0
Valine	6.9

[1] n=3

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EVALUATION

Project Goals and Industry Benefits: The project goals and objectives were: 1) the characterization of waste flows from different seafood processing operations through detailed chemical and physical measurements, 2) update information on pollution potentials of various seafood waste flows and 3) sponsor waste utilization workshops in Alaska to provide the industry with the results of this study and discuss by-product development. It was expected that the project would help provide industry with information necessary to develop marketable fish waste by-products.

The goals of the project were measured by the data generated through the detailed chemical and physical analysis of the various waste flows. Proximate composition data was the most important information generated that could be directly applied to assessing by-product development potential. The detailed amino acid and mineral profiles provided technical information that is important in producing specific waste by-products. Some of the physical measurements helped individual plants understand their waste flows, but had little general application.

Several modifications to the goals were made during the course of this project. Detailed microbiological analysis was dropped from the project when the bacteriologist resigned her job and a replacement was not available for several months. Many of the environmental and physical measurements were dropped after initial analysis because the information generated was plant specific and would not apply to the industry. There were too many variables in such things as water flow to make broad generalizations.

Most of the goals and objectives were met by the end of the project. The major waste flows had been characterized for their potential for by-product development. The update on the pollution potential of the seafood waste flows was incomplete due to the plant specific nature of the information and lack of generalization that could be made from the data. Industry workshops were held in conjunction with other activities of the University of Alaska Marine Advisory Program throughout Alaska and a special workshop was held in Kodiak to discuss by-product development.

Specific Accomplishments: The specific information generated by this project that would have interest to the Alaska seafood processing industry included:

1. Proximate composition information on wastes from all major seafood species being processed in Alaska. These included cod and pollock halibut, salmon, tanner and king crab and flatfish processing.

2. Detailed composition information on the major waste flows from surimi manufacture.

3. Detailed amino acid and mineral profiles for wastes from all major seafood species processed in Alaska.

4. Physical measurements to characterize cod and pollock filleting and surimi manufacture.

The information generated during this project met the goals and objectives found in the original proposal and will help meet the future needs of the Alaska seafood processing industry as waste management becomes more important. Some of the information generated has little direct interest to the Alaska seafood industry. It is information that technologists and scientists can use to assess the quality of the waste material for very specific applications such as animal and aquaculture feed development. The information from this project is valuable in serving as baseline data for future development of by-products. By providing this information, interested processors can more clearly define their needs and tailor product development projects along closely focused efforts.

Benefits to the Seafood Processing industry: The Alaska seafood processing industry has had access to the information generated by this project through the following:

1. Information published in the Alaska Fisheries Development Foundation's newsletter the "Lodestar".

2. Information in the "Alaska Marine Resource Quarterly", published by the University of Alaska Marine Advisory Program.

3. As topics in workshops presented by the University of Alaska Marine Advisory Program in Juneau, Ketchikan, Kenai and Petersburg.

4. Formal presentation at the Pacific Fisheries Technologists meeting in Anchorage, February, 1989.

5. Interim reports submitted to the Alaska Fisheries Development Foundation.

6. Individual consultation between investigators and interested industry personnel throughout the project.

7. Workshops given in Kodiak on pollock waste utilization and by-product development in 1987 and 1988.

The information generated by this project has been used by researchers in fish feed development and others looking for alternatives to ocean dumping of waste. The application of the project data is still somewhere in the future, at such time as the Alaska seafood processing industry becomes more involved in by-product development.

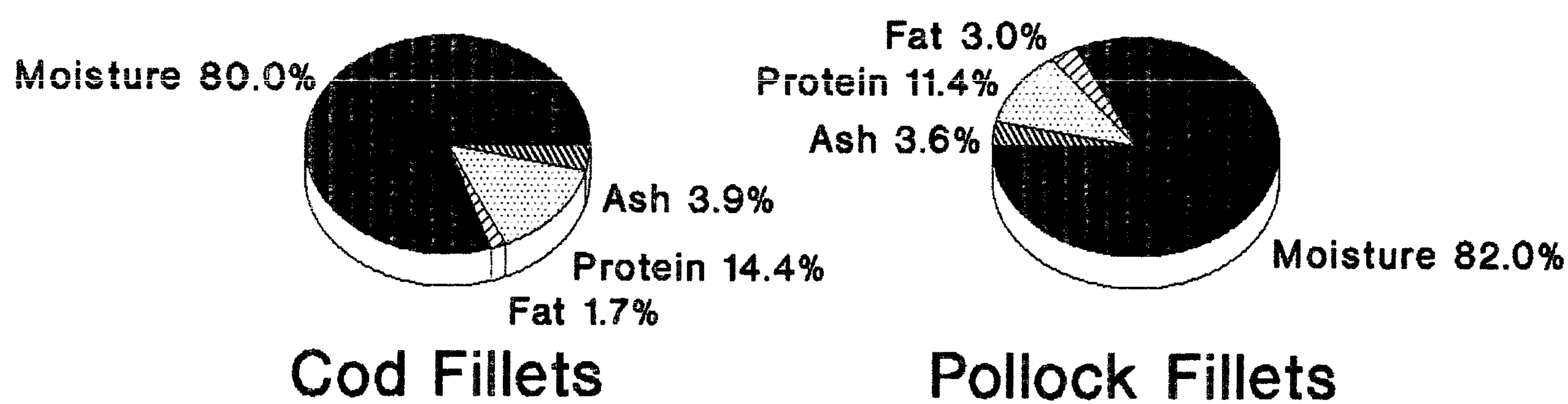
It is difficult to assess economic benefits from this project since the Alaska seafood processing industry has not come to grips with waste management. Economic benefits from this project lie in the future when the industry becomes interested in producing aquaculture feeds, natural fertilizers or omega-3 fatty acids. At that time, this basic data could be used for decision making and guiding development strategies. Any increase in the utilization of wastes in the state of Alaska will have positive economic impact.

CONCLUSIONS

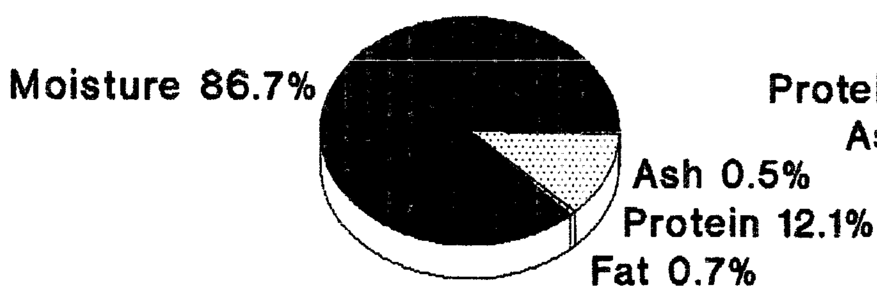
This project has provided the baseline information on wastes from all the major fish species processed in Alaska. It has shown that most of the waste flows have potential for by-product development. The project was successful in providing data that will help the Alaska seafood processing industry understand the nature of the raw materials that can lead to fuller utilization of the resource.

However, this is only the first step in by-product development. Further work needs to be done in the practical application of waste utilization. Avenues of research can include development of new methods to handle waste, specialized animal and aquaculture feeds, natural fertilizers and omega-3 fatty acids.

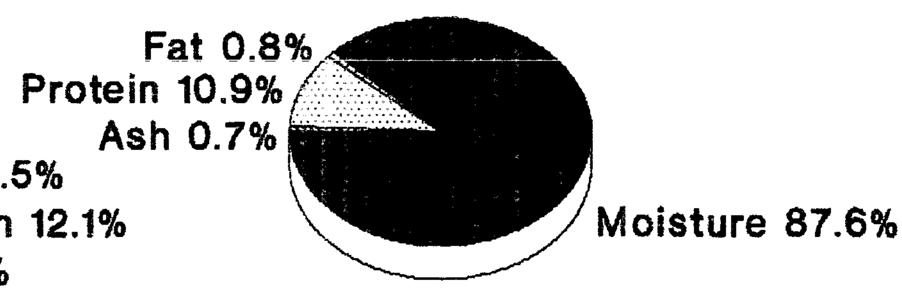
Proximate Composition of Cod and Pollock Wastes



Proximate Composition of Surimi Wastes

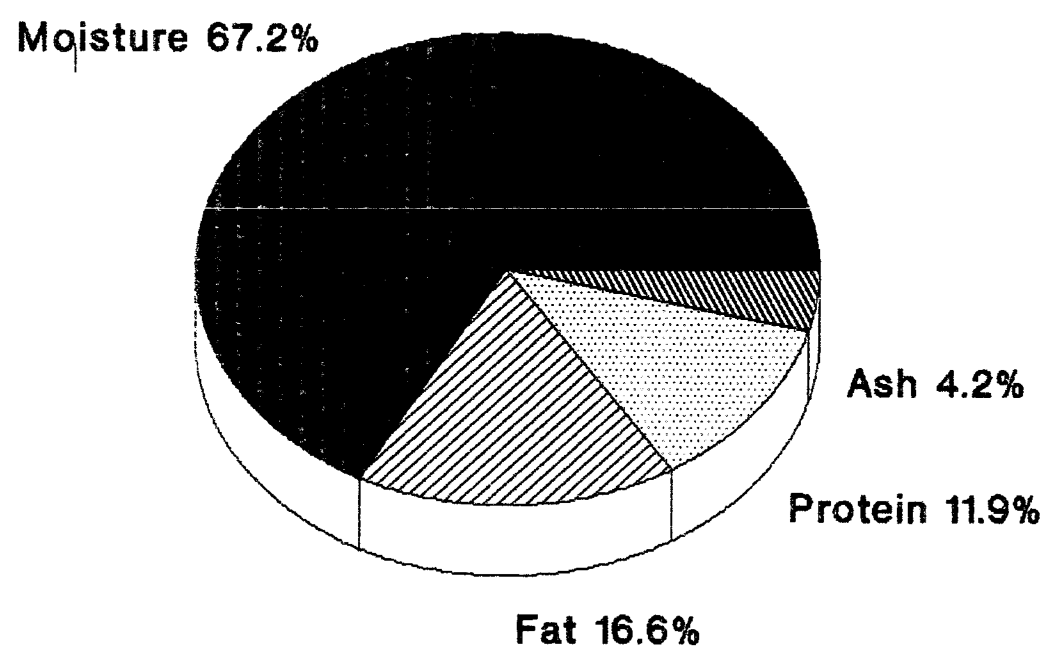


Refiner Waste



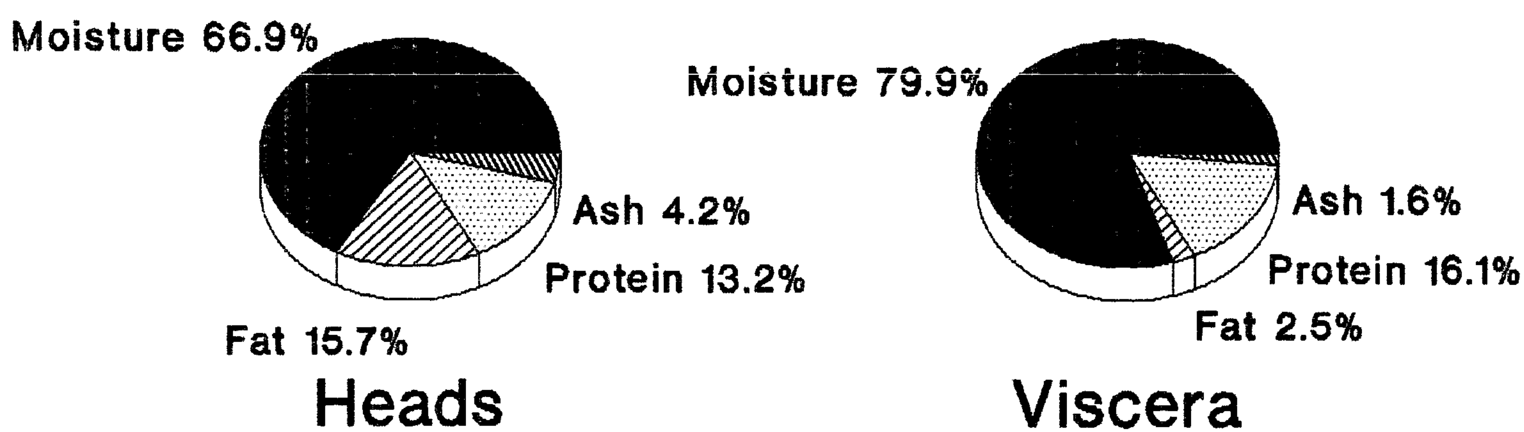
Deboner Waste

Proximate Composition of Halibut Wastes

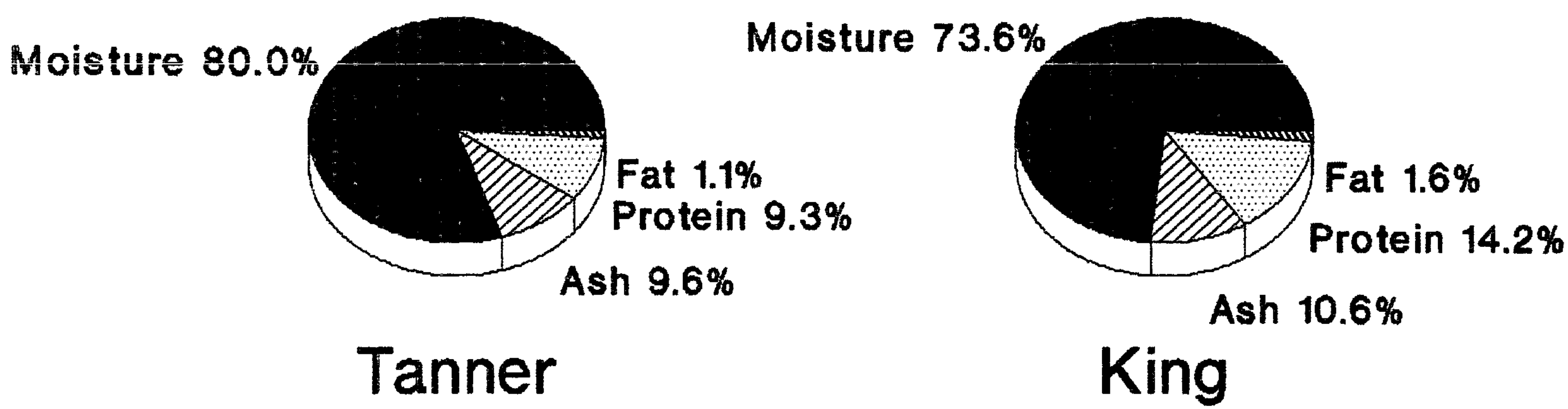


Heads

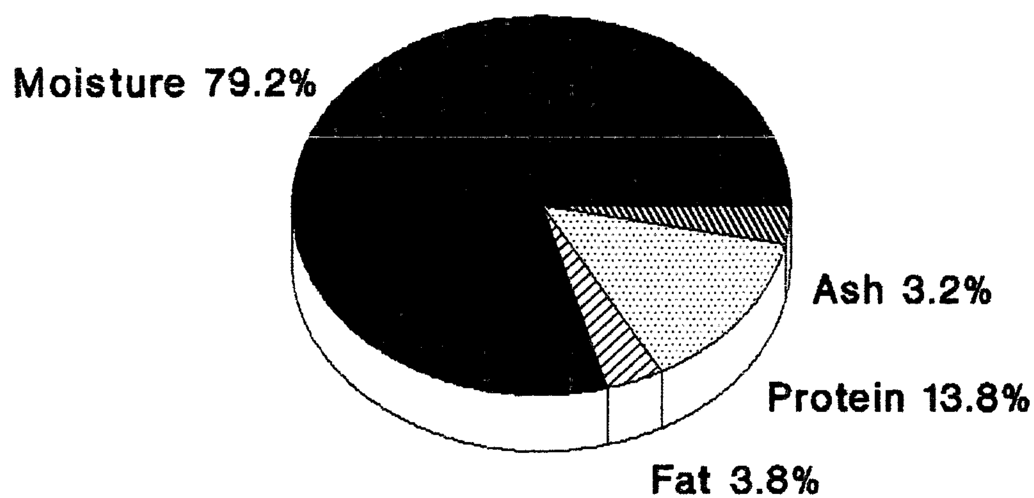
Proximate Composition of Salmon Wastes



Proximate Composition of Crab Waste



Proximate Composition of Flatfish Wastes

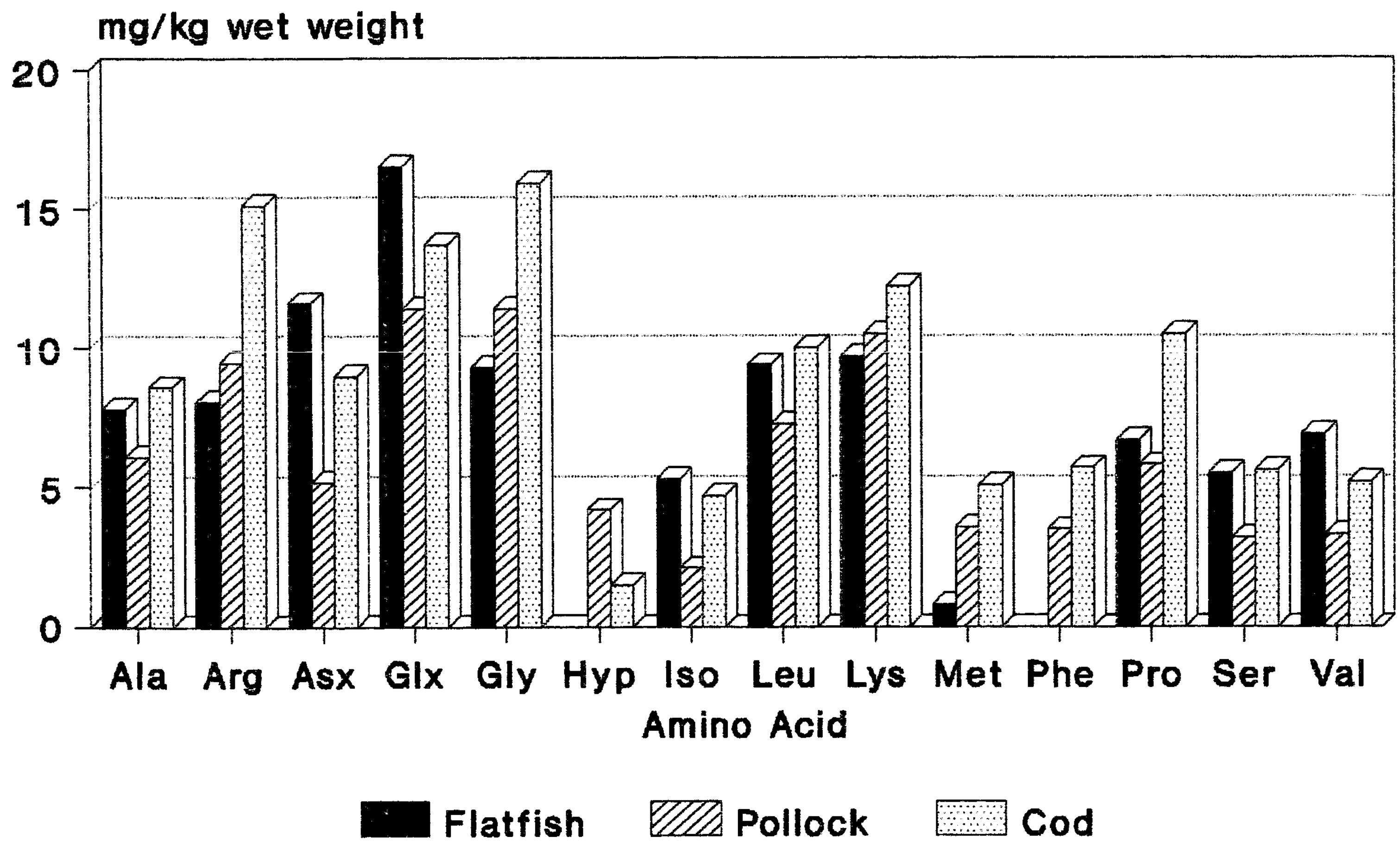


Flatfish Fillets

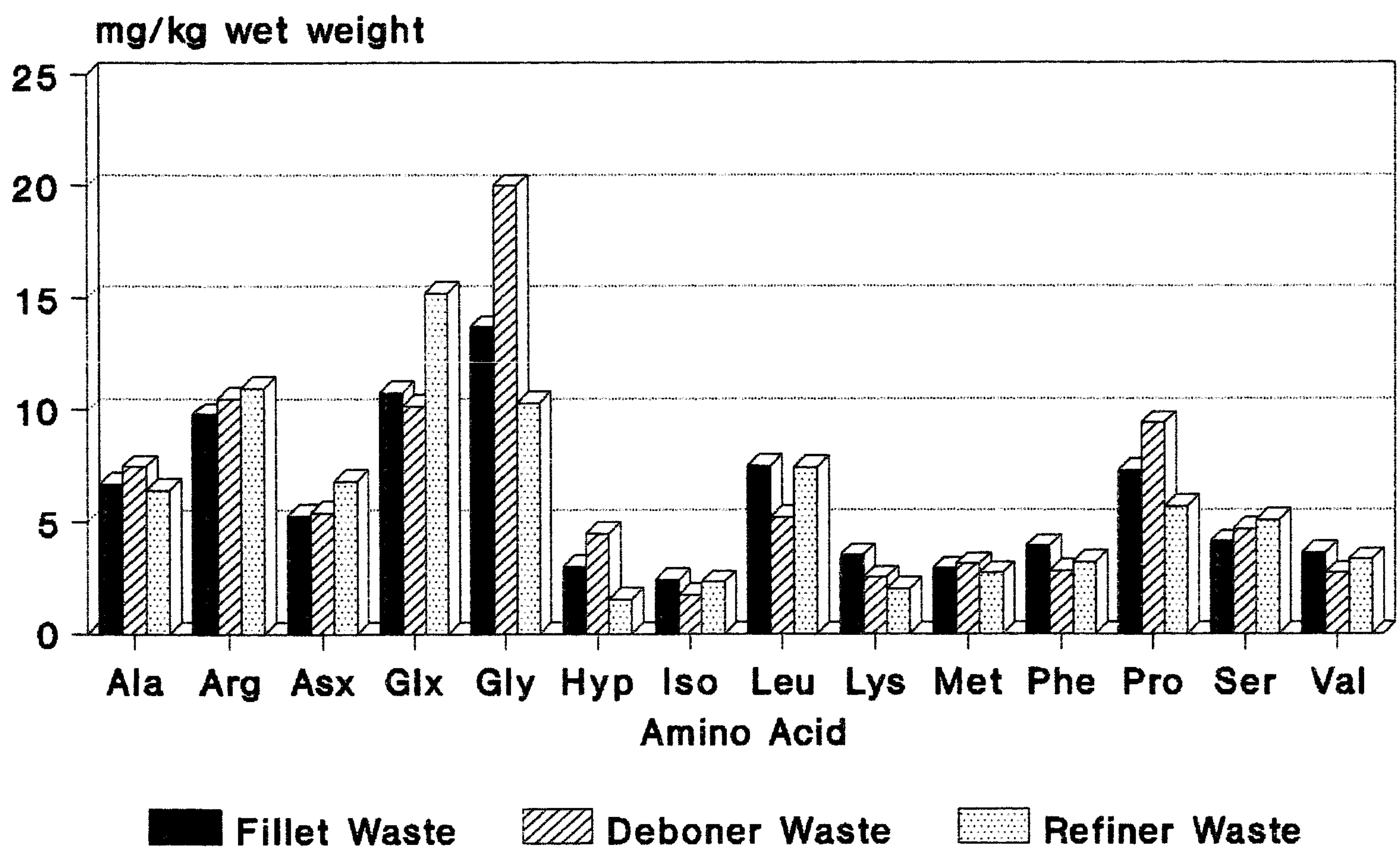
Amino Acids

Ala = Alanine
Arg = Arginine
Asx = Aspartic Acid
Glx = Glutamic Acid
Gly = Glycine
His = Histidine
Hyp = Hydroxyproline
Iso = Isoleucine
Leu = Leucine
Lys = Lysine
Met = Methionine
Phe = Phenylalanine
Pro = Proline
Ser = Serine
Thr = Threonine
Tyr = Tyrosine
Val = Valine

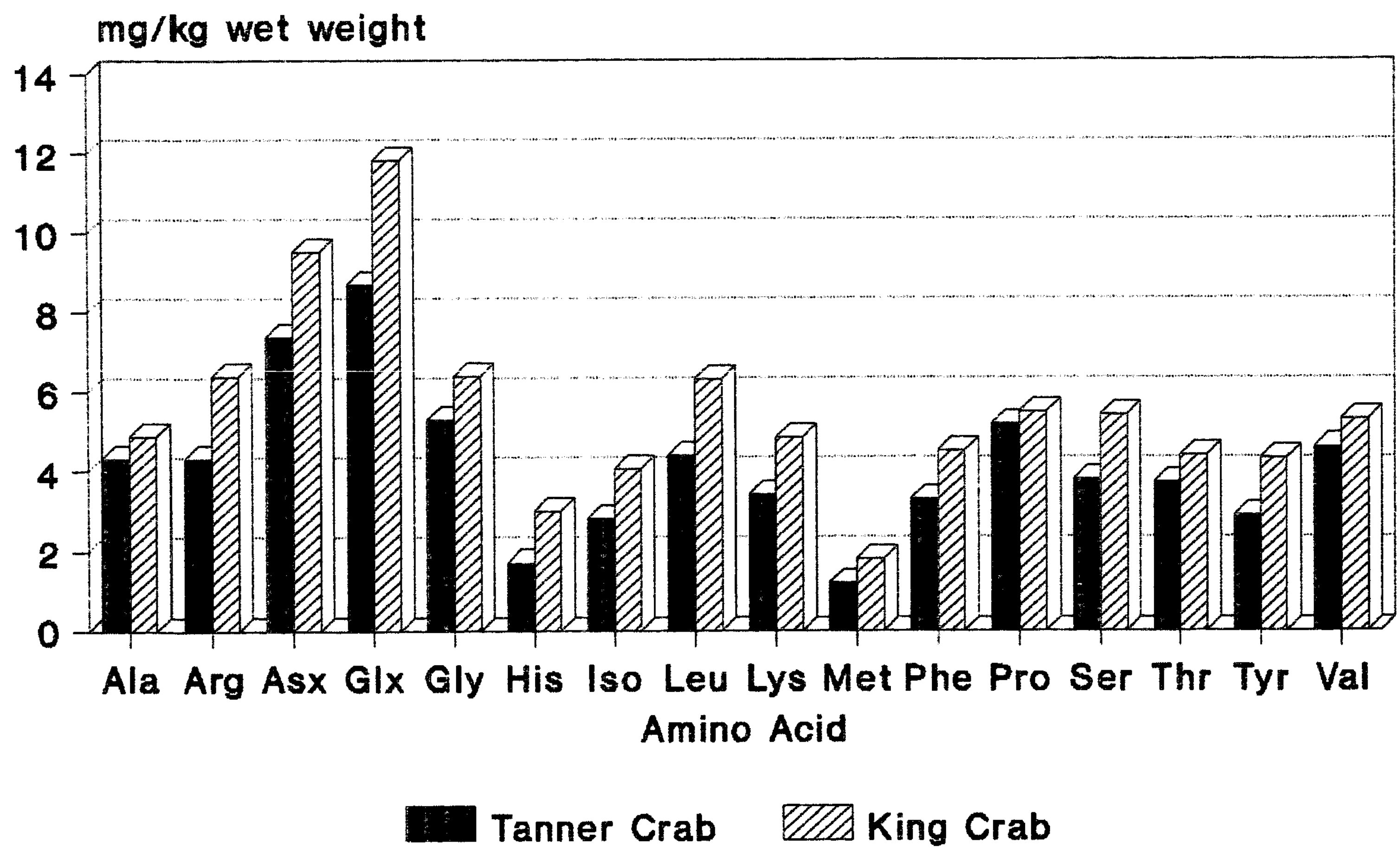
Amino Acid Profiles of Flatfish, Pollock and Cod Wastes



Amino Acid Profiles of Surimi Waste



Amino Acid Profiles of Crab Wastes



Amino Acid Profiles of Salmon and Halibut Wastes