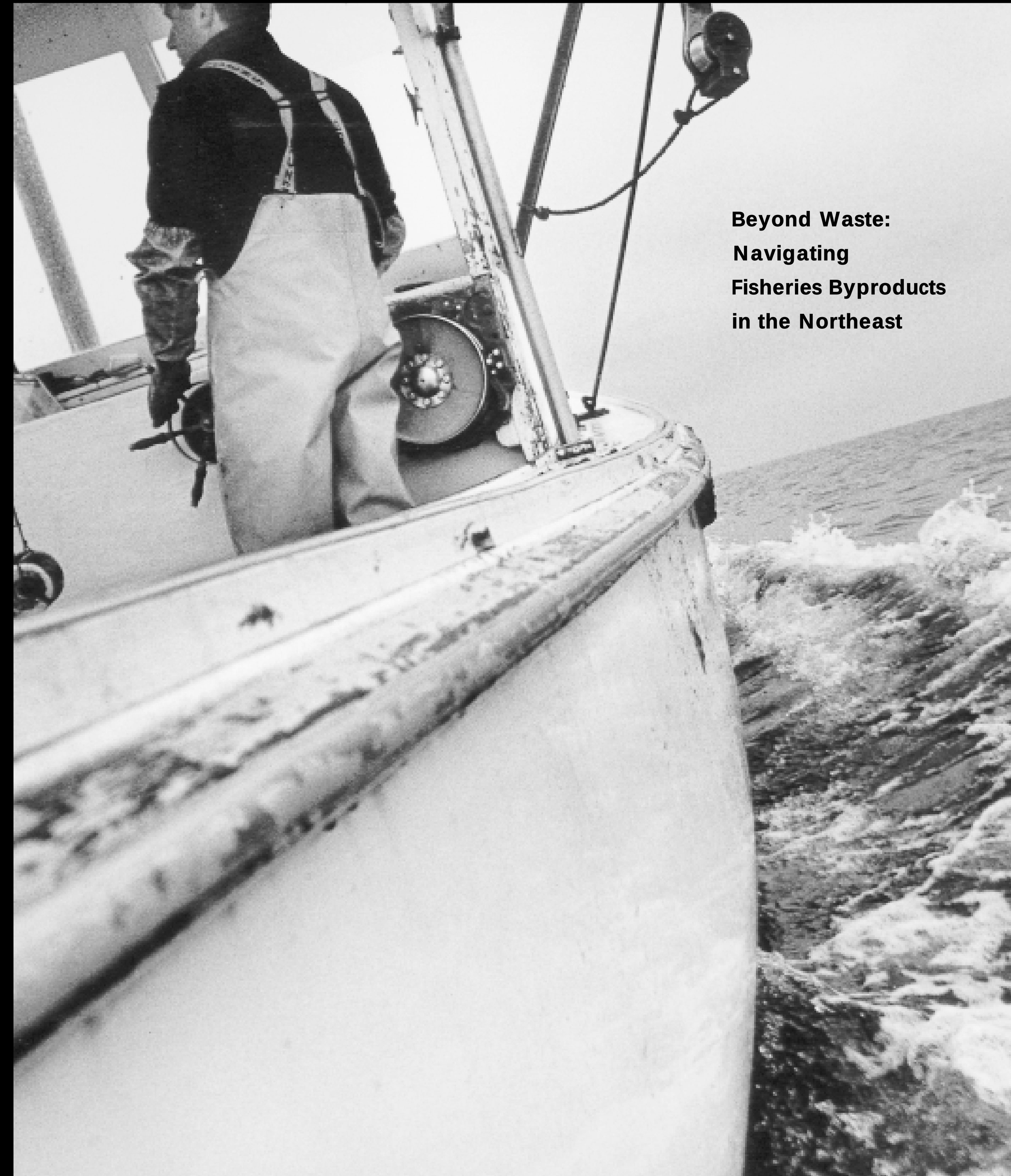

Beyond Waste: Navigating Fisheries Byproducts in the Northeast

Beyond Waste: Navigating Fisheries Byproducts in the Northeast

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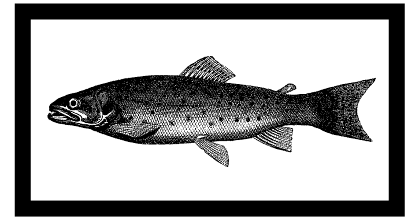
This publication has been funded, in part, by a grant from the National Atmospheric and Oceanic Administration. The views expressed herein, are those of the authors and do not necessarily reflect the views of NOAA or any of its sub agencies.

Front cover photo: Tommy Martin aboard the lobster boat, *Sue-Anna-Jean*, heading out to "The Southwest" near Cape Elizabeth. Photograph by Heather Newell. 1998.

Photo, left: The net of the groundfish trawler, *Julie D.*, never stops collecting monkfish, haddock, hake, cod and flounder in the Gulf of Maine. Photograph by Tom McCall. 1995.

Stormy seas make work aboard the 63 foot groundfish trawler, *Julie D.*, all the more trying in the Gulf of Maine. Kurt Brown and Milton Pelletier bring in the net. Photograph by Tom McCall. 1995.



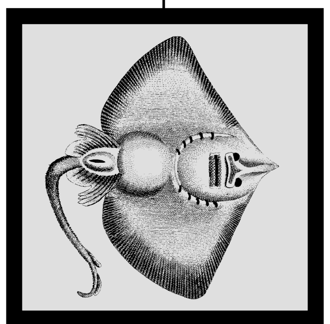
Introduction

This book was written for northeastern seafood processors wanting to utilize more of the raw materials entering their plants, and for those entrepreneurs interested in starting unconventional businesses based on seafood byproducts.

There are three good reasons for a renewed interest in byproducts at this time. First, fish stocks are down, and it makes good sense to squeeze as much product and as much profit out of every animal caught as possible. Second, certain market trends, such as that driving "nutraceuticals", have made some byproducts, such as fish oils, shark cartilage and chitin, look more attractive. Third, our region now has huge ethnic populations from nations whose eating habits vary considerably. Parts that we have consigned to the dumpster constitute delicacies to these groups. While we may not have enough of those parts to ship container loads to Asia or other regions, we do have enough to offer smaller quantities to local stores and restaurants. This book was written to fill you in on these emerging markets for byproducts and what they require.

Selling byproducts is rarely as easy or as profitable as it seems from the outside. A price that seems generous may turn out to barely cover the costs of processing, packaging, transportation and marketing.

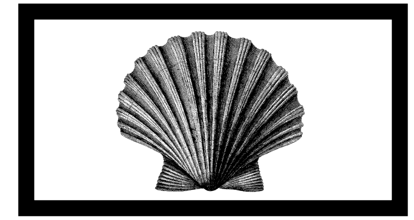
Or, a price that really was generous may drop quickly as newcomers glut the market. Some markets are stable, while sales of more trendy products swell like mushrooms after rain and disappear on the same time scale. We have tried to make this book truthful and balanced. While we hope that you will consider these products and enter markets that you believe might be lucrative and feasible, we also will consider ourselves successful if we forewarn you of ventures which are expensive and risky. If all of our research has uncovered no byproduct markets for a particular species, we will let you know that. Our job is to give you as much information as possible about as many markets as possible, so that you can make informed decisions. We can't tell you everything you need to know, but we have done our best to give you enough information to guide you in your own further research. We've tried to give you more information about byproducts that we think are likely to be successful, which means that some sections are long and detailed and others short and rough. We have also included information on less-known markets. We hope that this book will at least help you to get started on your own research. We've listed some publications, authorities and websites, but you will certainly find many more of your own.



Fourteen years ago, one of us (SG) co-authored the original book on New England seafood byproducts. (New Markets for Maximizing New England Fisheries Byproduct Values) We wrote this book because enough had changed that a new version was needed. This book is being written on the cusp of the Millennium. In ten years or perhaps less, enough will have changed that this book too will be only partially accurate. Keep this in mind, as time passes.

This book is organized in two sections. The first section lists the region's seafood species. The second section lists categories of products, which can be made from a variety of species; for example, chitin-chitosan or fish fertilizer or flavors. When you look up the species, you will be directed to the relevant product sections.

Good luck, and don't hesitate to call if you have further questions!



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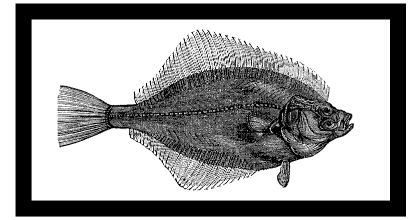
Milton Pelletier guts monkfish aboard the groundfish trawler, *Julie D.*, in the Gulf of Maine. Photograph by Tom McCall. 1995.



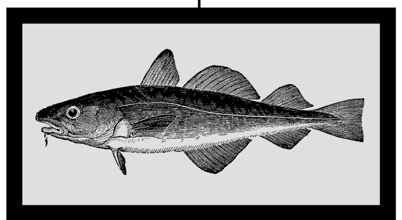
Species Listings

The number and diversity of species landed in the Northeast covers a wide range. This section identifies the kinds of products that can be manufactured or derived from byproducts generated by each species. To simplify navigation, the section is divided into two categories, fish and shellfish. Subsections within each section break down the listings of species even further: groundfish, flatfish, and so on.

Everyone knows that fish and shellfish are different, but even between cod and haddock, there is great evolutionary divergence. Knowing something about the biology and chemistry of the species you are working with can be very helpful. For example, scallops and clams, species that are biologically similar in composition, are equally good sources of meat and trimmings. But the fact that the scallop has the ability to move around makes a difference; since scallops swim, they may be contaminated with Paralytic Shellfish Poisoning (PSP, or red tide) and similar pollutants, even if they are harvested from clean areas. Clams and mussels are immobile – if they are harvested from a clean area, they are clean. The lesson is, if you know the biology of the animal you're working with, it will guide your decisions and steer you clear of pitfalls.

FISH

Flatfish: When we look into the dumpsters of flatfish processors, the two products that catch our eyes are **ribbons** and **roes**. Ribbons (aka “frills”) are the long strips of muscles that work the dorsal fins. They are unique products, not resembling other, more ordinary, muscles. Fish other than flatfish have ribbons, but the flatfish ribbons seem to be the most beautiful. The Japanese have traditionally been the market for ribbons. Turbot ribbons are said to be very valuable in Japan. (It’s worth noting that in order to get that value, turbot processors had to change their technique, so that the ribbons were taken first; not the fillets.) It might be possible to sell the ribbons of the smaller flatfish processed in this region to Japanese markets, sushi chefs, or the brokers that supply them.



For roes, see the section on Roe, p. 63.

For processors willing to get out there and talk to Asian buyers and sellers, there are some products which require relatively little processing and can bring increased returns. A **kirimi** cut, as described to us, requires leaving the roe (or milt) sac in the fish, and cutting off only the head and tail. Be advised that there are other cuts that are described by this same term.

For some markets, especially Asian and sashimi markets, flatfish can be bled using the “ike jime” procedure in which a cut is made toward the front of the flatfish, severing the main artery and the spinal cord. This paralyzes the fish. Placement of the cut is made to preserve the greatest amount of flatfish flesh. A second cut is made in the tail to hasten removal of blood. Flatfish are then chilled slowly to maintain circulation and facilitate the bleeding process. After the flatfish have been bled, they are transferred to a salt/ice water slurry and chilled to 12º Centigrade. Although flatfish are often packed in 13 kilogram cartons, more expensive species can be packed in 8 kilogram cartons to avoid compression. Special nesting, expanded polystyrene packing systems are also available. For many markets, product is best sorted by half kilogram increments.

Bleeding produces a desirable white color in the flesh and on the underside of the flatfish. When flatfish are not bled properly or are under stress, blood spots can appear on the white side of the fish during shipping. Because flatfish are graded depending upon the amount of blood spotting, careful handling to avoid stress and proper bleeding techniques can increase the price received for the product. Bleeding delays the onset of rigor and prolongs rigor once it has begun.

Another technique to avoid undue stress in flatfish while in transit employs a patented method of severing the spinal cord without severing the artery. This essentially prevents live flatfish from thrashing about in the shipping box.

Finally, there is a large Asian market for small, whole flatfish that can fit on a plate. The price may not be great (one price we heard was $1/kilo), but you don’t have to fillet, and it’s probably better than tossing it in the dumpster.

Groundfish: In the Northeast, groundfish are gutted at sea. In the Northwest and particularly in Alaska,

where the boats deliver them to the processing plants in the round, tons of cod and pollock roe, milt, maws, etc. are shipped to Asian markets, making extra money for the processors. **Cod roe** is also popular dried in local Middle Eastern markets. If you’re interested, read the section on Roe (p. 63). We don’t know if roes from the other local groundfish species would be acceptable, but it’s not a lot of work to do the experiment.

Cod skin makes a really beautiful **leather**, depending upon the size of the fish. See the section on Fish Leather.

Cod **maws** are popular in Asia. Korea may be the most likely market, but fish maw is often on the menu in Chinese restaurants. They are prepared by cutting the esophagus behind the mouth and then making the second cut behind the stomach. They need to be emptied of contents and washed. This may be done by turning them inside out or by slitting them. The one enquiry we received from an Asian importer interested in cod maws offered a price of $2/kilo. Maws of other groundfish species may also be acceptable.

Groundfish viscera are excellent sources of digestive enzymes. Cod enzymes, in particular, have been isolated in Norway and Iceland for commercial use. Groundfish frames are also good raw material for **fish fertilizer** (p. 42).

Cod livers are the source of probably the most famous fish oil in the world. Ironically, another consequence of gutting at sea is that we buy cod liver oil from Iceland, when we have our own cod fishery.

The **heads** of all groundfish are saleable to Asian markets; however, read the section on heads (pp. 13 and 68) before you cut them to show potential buyers.

Groundfish — especially cod, haddock and pollock are good candidates for **mince** production (see p. 53) or, alternatively, for using trim as chowder fish or for fish cakes, fish balls (see p. 70), etc. Haddock frames left after filleting often have large amounts of high quality muscle meat on them.

Monkfish: Monkfish processed on shore may provide trimmings that can be added to fish fertilizer or other bulk uses. There are also small amounts of monkfish livers that do not meet the standard for shipment to Japanese or American luxury food markets. Their high oil contents sug-

Beware!

Monkfish livers that we have tested have shown PCB levels too high to be legal as animal feed. Like other long-lived carnivores, monkfish are bioaccumulators. PCBs accumulate in lipids (fats and oils), and high fat monkfish, shark and ray products should all be tested for PCBs before you consider marketing them.

In some areas of the world, such as Eastern Europe, salmon caviar is ranked higher than that from sturgeon. It doesn't seem impossible (especially in the overcrowded and competitive world of salmon farming) that at some point farmers will find that it's worth raising their salmon to the spawning stage in order to produce high quality roe.

gest that they might be good candidates for either health food oil capsule markets or specialty aquaculture feed ingredient markets. Beware! Monkfish livers that we have tested have shown PCB levels too high to be legal as animal feed. Like other long-lived carnivores, monkfish are bioaccumulators. PCBs accumulate in lipids (fats and oils), and high fat monkfish, shark and ray products should all be tested for PCBs before you consider marketing them. See "PCBs" under "Analytic Laboratories".

Salmon: The salmon processed in the Northeast are all farmed. Salmon farmers don't want their salmon to become sexually mature; they'd rather direct energy out of milt and roe and towards growth of saleable muscle, so although roe exists in farmed salmon, it is rarely at the right stage. While some processors told us that farmed salmon roe was too immature to taste good, at least one had actually turned it into a product and sold it for $7 to $8 per pound. Norwegians produce and sell salmon roe from farmed salmon. In some areas of the world, such as Eastern Europe, salmon caviar is ranked higher than that from sturgeon. It doesn't seem impossible (especially in the overcrowded and competitive world of salmon farming) that at some point farmers will find that it's worth raising their salmon to the spawning stage in order to produce high quality roe. (See the section on Roe, p. 63.)

Sea Run Holdings Inc., in collaboration with the Maine Aquaculture Innovation Center, have conducted extensive research on the pharmaceutical uses of **salmon blood**. Surgical glues derived from salmonid plasma, when sprayed on wounds after surgery, help to form blood clots. Fibrinogen and thrombin extracted from salmon plasma eliminates the possibility of transmitting viruses to the patient. There is no crossover between salmonid and human diseases and salmonid plasma blood byproducts are compatible with human blood. Sea Run Holdings is selling a patented blocking reagent for laboratory diagnostics derived from salmonid plasma. They also produce and sell salmon red blood cells, used in cancer therapies.

Salmon **oil** (and particularly, salmon head oil) is a high value product in the nutraceutical market, but it is unlikely that the oil of farmed salmon would have as high a value as that of wild salmon. Unlike pro-

tein, which is totally broken down by the digestive tract before it is rebuilt according to the eater's genetic instructions, fats (oils are fats that are liquid at room temperature) tend to be laid down at least partly as they come in. Wild salmon eat a diet of fish and shellfish, rich in long-chain, polyunsaturated fatty acids. Farmed salmon are eating some fish meal, some soy and — depending upon the formulator — possibly some rendered products from meat animals or poultry. Their oils are likely to be less healthy and more variable than the oils of wild salmon. However, lack of healthiness and variability of product has not stopped many food supplement sellers from purchasing raw materials that they could get at a bargain price. And, we don't know the fatty acid analyses of all farmed salmon, so it is a possibility. For further information, see Fish Oils, p. 54.

Salmon **heads** are of interest to Asian buyers, but a significant amount of flesh must be left on the back end for the head to be of interest. (See photo)

Salmon **ribbons** are popular items in Japan, both fresh and dried. We have been quoted a retail price of $3/100 grams (a little under four ounces), but don't know whether this is for the fresh or dried ribbons. Whether a sushi chef or a sushi chef supplier or Japanese groceries in this country would be interested is not known. Smoked, scaled salmon **skins** (sometimes spiced, sometimes not) are very popular sushi items; however, most Eastern salmon is sold skin on, whether filleted or just gutted. Should you move to skinning, this is worth keeping in mind. One of the discouraging things about selling to Japanese clients in the U.S. is their strong preference for buying everything from Japan — even when the price is higher, and even when the item from Japan originally came from another country. However, it would be worth it to try to locate their suppliers and, since more and more sushi is being prepared in Korean-run restaurants, it might be even more useful to locate those suppliers. As the skins pile up, you might also want to read the section on Fish Leather, p. 50. Salmon skin leather is immensely strong (Northwest natives made boots out of it), and it is reasonably good looking. The problem, as with most fish leathers, is the small size of the pieces, but salmon is actually reasonably large and, like all farmed products, has the advantage of being predictable in size. Once the skin has been smoked, it may not be useable for leather.

There has been a Japanese market for canned salmon **bones**, as a calcium supplement. The canning process softens them sufficiently so that they can be crunched right up without breaking a tooth, and they are an excellent calcium supplement. Unfortunately, this seems to have been a passing craze. Whether finely ground salmon bones could be sold to Americans worried about osteoporosis is unknown, but might be worth consideration. Osteoporosis presents a serious health risk for a high percent of older women and a smaller percent of older men. One way health-conscious women have fought it, is with hormone replacement therapy. However, this is falling out of favor, since it is linked to an increased risk of certain cancers. One can buy a variety of mineral sources of calcium in tablet or capsule form, but it is quite likely that fish bones are a more effective and bioavailable source. Whether they would work better cooked or raw is unknown. If they are presented as whole bones, they have to be cooked to be softened. Ground and given as a pill is a different story, so some research would have to be done. The ideal way to approach this would be as a joint venture with a company manufacturing or distributing nutritional supplements.

Obviously the potential for fish bones as calcium supplements would apply to other species as well as to salmon. A **warning** however: Fish bones are generally high in fluoride. In fact, this may be one reason why they might be more effective against osteoporosis than mineral supplements or the bones of terrestrial animals; just as fluoride makes strong teeth, it makes strong bones. However, fluoride is also toxic (have you noticed the warnings against swallowing on toothpaste tubes?). The fluoride in fish bones seems to be nowhere near as toxic as that in toothpaste, since all of us eat canned sardine and salmon bones, and Asian treats include crunchy fish bone treats. However, fluoride is a point to be aware of and to take into consideration.

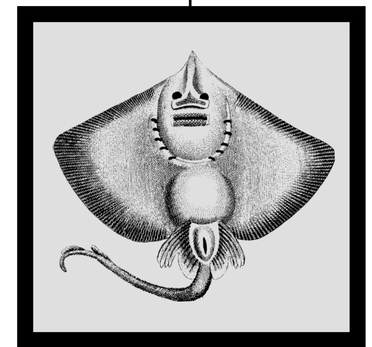
Novartis Pharmaceuticals Corp. markets a drug in the U.S. containing a product called **"Calcitonin-Salmon Nasal Spray"**, which significantly reduced fractures in women with osteoporosis as Miacalcin (R) Nasal Spray. We have not checked to find if this drug is actually isolated from salmon wastes or if it came originally from salmon but is now synthesized.

Salmon **trimmings** in good condition have value. These can often be sold to small businesses making specialty food products, or large processors might wish to hire a food product development specialist and make their own. Cheryl Doyle, of Out of the Blue (1313 Finaltown Road, Waldoboro, ME 04572), offers $2/pound for boneless, skinless meat (which can be mince, trimmings, etc). However, she doesn't want belly flaps, and the meat must be in good condition. *Warning:* Cheryl has had to terminate relations with at least one salmon processor who assumed that he could send her material in poor condition. Trimmings (and, in fact, all fish minces) are great raw material for fish pates, fish cakes, spreads and mousses, and the same goes for scraps from smokers. Chunks cut from trim are great for chowders. But, if it's going to be used for food, it has to be treated as food all through the line. You can't sweep it up off the floor and then sell it to a cook.

In the past, salmon **racks** with **viscera** were sold for lobster bait. The price wasn't high but you could get rid of a lot of poundage that way and make a little money off of it. At the time of writing this book, the use of farmed salmon carcasses as bait has been banned, for fear of spreading certain virulent pathogens affecting farmed salmon to wild fish. So, processors are suddenly faced with a disposal problem. Salmon waste can be turned into fish fertilizer (see Fish Fertilizer, p. 42) that would have a higher oil content than most such products, but it would be worth trying; particularly if it could be sold in small containers with attractive packaging. Salmon waste can be composted, but all the composters that we know require a tipping fee for taking wastes.

Sharks and rays: Among the sharks harvested in the Northeast is the spiny dogfish, *Squalus acanthias*, and as we write this, harvests are diminishing as management plans for this species are put in place. Dogfish wastes have been a serious disposal problem in

the past, with processors generally paying 4 to 6¢/lb. for landfilling or ocean dumping. Dogfish offal has been of particular interest to us in the past, because it has always seemed to have some particular value, and then further knowledge has turned out to negate or at least minimize that value. For example, one of us (S. G.) worked for some time to develop dogfish **liver oil** as a dormant spray. Dormant sprays are oils which are diluted with water and sprayed onto fruit trees (and others) before they leaf out in the spring. They kill mites and other pests by clogging up their breathing holes. Dogfish liver oil offered a chance to have an organic product for this quite lucrative market. In fact, in the Pacific Northwest, organic orchardists had already found that dogfish liver oil was ideally suited to this use (before petrochemicals, fish oil was the standard for dormant oil). The problem was that when we sent the product out for analysis, we discovered that the samples we sent out had 3.4 to 5.4 parts per million (ppm) PCBs. (See "PCBs" under "Analytic Laboratories", p. 87.) While it is quite likely that this would have ended up harmlessly in dormant oil use, it was hard to justify selling a product with a relatively high PCB level to organic farmers trying to produce cleaner crops. (This has not stopped some people from using dogfish offal in organic fertilizers.) At that time, we had also spent almost three years working to develop dogfish waste as a salmon feed ingredient, with funding from the Northeast Regional Aquaculture Center. We had solved all the technical problems and produced a concentrated liquid digest which, when added to feeds, was as palatable and supported as great growth as did high quality herring meal. This represented a surprising triumph since shark byproducts are generally considered to be of inferior nutritional value and palatability, and salmon are fussy eaters. However, the PCB analyses wiped out that project as well, since the legal limits in the U.S. for PCBs in animal feed are 0.2 ppm. Even though our feed product did not contain livers, and even when diluted with the other feed components, the final feed was over that limit.



On the following pages we provide two sorts of information about dogfish. One is to pass on some of the tricks of working with cartilaginous fish in case you come upon a miraculously uncontaminated source. The second is to give some information on dogfish byproducts which are currently looking hopeful.

Rays are biologically similar to sharks, and ray wastes can be treated similarly. Unfortunately, they are also similar in being bioaccumulators of pollutants. Skate (*Raja radiata*) liver oil which we tested had levels of PCB that were lower than those in dogfish, but still high: 1.1 to 2.9 ppm for our samples compared to 3.4 – 5.4 ppm for dogfish. However, skates may be less migratory than sharks, in which case there is a far better chance of finding clean local populations.

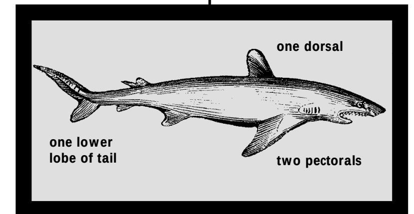
Despite their similarities, sharks and rays (at least *S. acanthius and R. radiata*) are not identical. For example, when the liver oils of both species were analyzed, most of the 26 fatty acids examined were present in similar quantities, but there was one major difference in the levels of the two most important polyunsaturated fatty acids (PUFAs). The dogfish liver oil was extremely high in eicosapentaenoic acid (EPA) – about a quarter of the total lipid – while skate liver oil was low (only about 4%); conversely, the skate liver oil was remarkably high in docohexaenoic acid (DHA) – over a quarter of the total lipid – while the dogfish liver oil contained about 8% of this important polyunsaturated fatty acid. Fatty acid analysis on dogfish revealed that their livers and eggs contained these two PUFAs in inverse quantities. While the dogfish livers were high in EPA, the dogfish eggs were high in DHA — in fact, DHA formed almost 10% of the total sample. Eggs were not analyzed. The dogfish eggs also had high cholesterol (showing that eggs are eggs, no matter who lays them): about 18 mg./gram of sample. If these animals had not been contaminated by the dumping of industrial wastes, their byproducts would have had great value; particularly as ingredients for aquaculture larval and fry feeds. For example, shrimp require cholesterol (most of the rest of us, including fish, can make our own), which gives cholesterol a value in shrimp feeds. All feeds for young cultured marine animals would benefit by the inclusion of EPA and, especially, of DHA.

Here are a few helpful hints on how to work with the wastes in dogfish or skates without significant PCB concentrations. (This section refers only to general wastes; guts, heads. etc., not to specialized wastes like oils and eggs.) These animals tend to have very strong digestive enzymes. (This was pretty much the subtext of "Jaws".) The bad aspect of this is that those enzymes tend to turn dogfish wastes into liquids, making them leak out of defective dumpsters and rendering them unfit for inclusion in products like fish meal. The good aspect of this is that since there currently are no fish meal plants in the Northeast, you might as well take advantage of their digestive enzyme content and make a liquid product. (For how to do this, see the section on Fish Fertilizer, p. 42.)

In addition to having strong digestive enzymes, cartilaginous fish are loaded with urea. Urea is usually an excretory product. When protein is digested, a common end product is ammonia. Ammonia is highly toxic; because it is so caustic, tiny amounts of ammonia in the body can lead to death. Large aquatic creatures turn that ammonia into urea, which is innocuous, and can be stored in the bladder or other parts of the body in high concentration, prior to excretion. However, in the case of elasmobranchs (cartilaginous fish), only a small fraction of the urea produced is excreted, and the rest is retained in the blood and tissue fluids. The reason it is retained is to raise the osmotic level of those fluids to the point where they have the same concentration of salts as sea water (without this, typical body fluids are about 1% salt and sea water about 3%), so that the animal doesn't become dehydrated by losing water or flooded by gaining water. It's an extremely ingenious mechanism. However, when the animal dies, the stored urea starts to turn back into ammonia. This leads to a very unpleasant smell and flavor.

The key to dealing with shark wastes successfully is to acidify them to the point where the ammonia is neutralized. This point turns out to be pH 6.1. As long as enough acid is added to keep the wastes below 6.1, the liquid will smell and taste mild. The acid can be added either before digestion (this will help keep the neighbors from complaining) or after. A pH of 6.1 is not, however, sufficiently acidic to preserve the

wastes; only to prevent the formation of ammonia. (Preserving liquid fish is discussed in the section on Fish Fertilizer.) When we made salmon feed out of dogfish waste, we learned that we had a narrow range of acidity to work with. In order to preserve the material, we had to take the pH down to 4.5. In order to get the salmon to eat it, we had to get the pH up to a minimum of 5.5. But, we couldn't get it higher than 6.1, or ammonia would form and the fish would reject it. So, our range of pH for feeding was 5.5 to 6.1. Once we had worked this out, we were successful in developing a palatable feed.



Shark cartilage is the most widely recognized dogfish byproduct. Sharks are cartilaginous fish; they form cartilage instead of bone, but anyone who has cut up sharks knows that their cartilage is as hard as bone. Interest in shark cartilage started more than a decade ago, with research that suggested that it contained an anti-angiogenic factor; that is, a factor that prevented the formation of blood vessels. This is important because solid tumors produce angiogenic factors to induce the body to make blood vessels form so that they can get fed. One still sees advertisements for shark cartilage anti-cancer pills, despite the fact that the science is out on this issue — there are studies that say that shark cartilage may help fight cancer and there are other studies that say that it has no effect. A larger market has opened for cartilage in the form of chondroitin sulphate in pills to help arthritis sufferers. However, this rarely if ever seems to be made of dogfish cartilage. It is almost invariably made of bovine tracheal cartilage collected from cattle slaughterhouses. However, this could change. Cartilage is a major component of shark fins, as well.

Other good sources are heads and backbones, and they must first be cleaned. Preliminary cleaning is generally done by the digestion referred to above; at the end of this process (see "Fish Fertilizer", p. 42, for more information on digesting wastes), the bones are clean. From a processor's viewpoint, the key is to find someone who will buy the cartilage and carry out the further processing, and that person will tell you what s/he wants and how it should be cleaned: it may be by digestion and it may just be by scraping off excess meat and freezing. There was a time when shark cartilage fetched a relatively high price, but at this time, the market is flooded and the price offered is relatively low. The way the market works is that a distributor who buys in shark cartilage makes sure that it is cleaned of flesh and dried, and sends it out to be ground. Grinding is done by custom grinders who first grind and then pulverize it to a fine powder. After that it's sent elsewhere to be sterilized and then it is sold. Some distributors only want to buy large volumes. Still, it pays to ask. One distributor in our region is Nutratech at 973-882-7773, and the person in charge is Bob Green. Also, for those who want to try to do it on their own, we can recommend a grinder: AllGrind Plastics, Inc. of Bloomsbury, NJ. The person in charge is Bill Willoughby, and the telephone is: 908-479-4400. (Note that AllGrind has ground not only dogfish cartilage, but also sea cucumber parts and chitin.)

Shark fins are used by Chinese cooks to provide a unique texture for a costly and prestigious soup.

Although the practice of finning and then discarding dogfish at sea was banned in the recently adopted dogfish management plan, the fins may be taken from dogfish that have been landed for processing.

Prices for shark fin fluctuate. Dogfish fins are not the most valued, but they are exported. One of the recent changes in the shark fin market is that poorer customers are starting to want them, and this has opened the market to smaller and lower quality fins. The only fins that are acceptable are the lower lobe of the tail (or caudal) fin, the first dorsal fin, and the two pectoral fins. The market may accept frozen fins, but generally prefers them dried; buyers may demand that they be cut a set number of inches from the body, or may want them in complete sets. You will need to find a buyer before accumulating fins, and be clear about the specifications your product must meet.

Tuna: The major tuna caught in northeastern waters is the giant blue fin (*Thunnus thynnus*), much of which is sent to Japan, headed and gutted, frozen in special, lightweight, metal coffins, to be sold there in the lucrative sushi market. (For those thinking about product development, it's entertaining and inspiring to think that these magnificent and delicious creatures were sold for a few pennies a pound into the cat food market until some enterprising Cape Cod fishermen found out about a mysterious Japanese market that would pay a hundred and, sometimes, a thousand times more for the same product.) The byproducts generated are the head and guts. **Tuna viscera** would probably make excellent fish fertilizer. The heads would do well also, but it would take a powerful and huge grinder to chop up those massive skulls. This is a seasonal (summer/fall) fishery, so one wouldn't want to make a big investment in a plant unless there were other species available at other times of the year.

One surprising byproduct that we all read about a few years ago was tuna **eyeballs**. As far as we know, the eyeballs themselves were not particularly valuable but the fat behind the eyeballs was particularly rich in docosahexaenoic acid (DHA), one of the long chain polyunsaturated fatty acids that makes fish heart-healthy. DHA is also what probably led to the old idea that fish is "brain food". In fact, DHA is key to the development of the brain and the nervous system. (It has been pointed out often that DHA should be a component in infant formula, but the FDA has been hard to convince on this point.) At any rate, the craze started in Japan for giving tuna eyeballs to school kids to help them develop better brains and get ahead in their academic careers. (Somehow, the idea of telling 12 year olds to eat their eyeballs is hard for most of us to stomach.) This craze then moved to Korea as the Japanese realized that they could give their kids DHA in more palatable forms. In fact, the Japanese diet gives kids plenty of DHA; it's the American diets that needs more of it.

SHELLFISH AND OTHERS

Clams: In the Northeast, several clam processors make flavors of their wastes and/or waste waters. The flavors are quite different from each other. One flavor is spray-dried to form a powder (this gets the highest price/pound). Another is composed of selected waste water streams from processing, and is processed by heating and evaporation, to form a slush. (This flavor is high in salt and it is the salt content that makes it freeze into a slush rather than an ice block.) A third flavor is derived from the clam bellies (technically, the

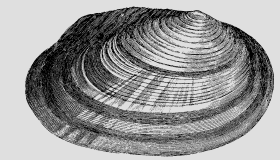
hepatopancreas). This flavor is also evaporated. Nearly all the components of clam processing waste - the liver, the meat scraps, and the process water - are rich in flavor. When we analyzed clam processing waste waters, different waters had different flavors, so that the water spewed out by the clams when they first opened was very salty and sharp flavored (this is what gets bottled as "clam juice"), while the water used to wash the clam pieces after grinding had a sweet, clam meat flavor with almost no salt.

We were able to make a delicious flavor out of the meat scraps left from clam processing by bringing them to a boil and then pressing them. If a market could be found for this flavor and the post-grind wash water (both of which could be used directly in chowders), the costs of disposing of waste and waste water would be significantly reduced. The post-grind wash water is not a huge volume, but for clam processors paying the municipality for waste water treatment on the basis of the organic load in their waste streams, this fraction represents the highest level of pollutants. (Note that in this case, pollution equals flavor.)

If your concern is reducing pollution, rather than developing a second product (flavor), you may be able to use your post-grind wash water as the liquid portion of your fresh or canned ground clam meats, rather than using fresh water. It will result in a better product for your customers, and dispose of a lot of your plant's total suspended solids (TSS) and biological oxygen demand (BOD). Canning will sterilize the water. For fresh packs, it is important to let the customer know that the product should be cooked; not eaten raw. This is true for the clam meats as well. Processors would produce a tastier product and greatly reduce pollution if they eliminated the post-grind wash. Whether the wash serves a real function, or whether it is there because of habit is debatable. It's a good idea to rethink all processes every five or ten years and ask why you did this to begin with, and if that need still exists.

We also found that we were able to concentrate the post-grind wash water by a process known as ultrafiltration. (Ultrafiltration is discussed in the section on Flavors, p. 58.)

Before jumping into the flavor business, read the section on Flavors, which discusses the form in which most industrial customers would like



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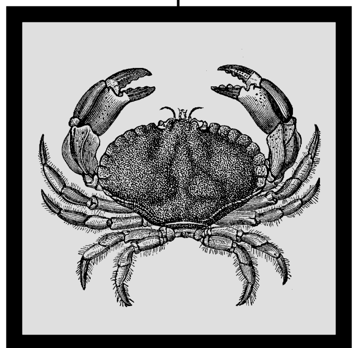
their flavors presented. If it is necessary to install an evaporator to meet these markets, the capital and operating costs are significant. On the other hand, if a local restaurant chain or food or cat food manufacturer will purchase your material as is, for use in chowders, stuffed clams, kitty treats etc., you could do quite well. **Clam belly flavor** is not only attractive to humans and cats; its is also attractive to fish. It can be sold as chum (it's too mushy to stay on the hook as bait). It would be of interest to aquaculture feed manufacturers, if it were dried — but the costs of this are probably prohibitive.



Clam shell: See under oyster, p. 21.

Crab: There are two anatomical parts of the crab that are of interest as byproducts: the liver (or hepatopancreas or brown meat) and the shells.

The **liver or brown meat** is of value because it is a source of flavor. As such it can be sold as a bulk item to a flavor company or, in smaller packages, to savvy chefs. One report we have seen cites a price of $1.75/pound for the product, sold frozen in 1 pound containers. The labor to extract it is about $0.90/pound. The depth of this market in the U.S. may not be sufficient to accept all brown meat; but the European and Asian markets may offer sales opportunities. Also, see Flavors, p. 58. Prior to offering it for sale, it would be a good idea to run a few analyses on it; particularly a chlorinated hydrocarbon screen (see PCBs, p. 88). Your potential customers may ask to see results from other tests, as well. Crab liver is sold in Japan (canned or jarred) as a consumer item.

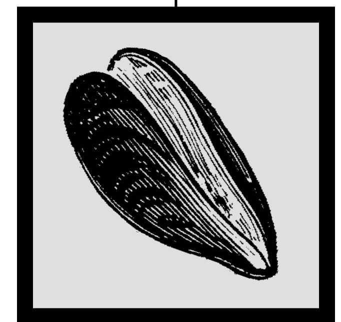
Crab **back shells** can be cleaned and sold to restaurants or high class ready-to-eat food manufacturers as containers in which to present crab dishes (just as some scallop dishes are presented in large scallop shells. This is more popular in the U.K. and Europe than here, and you may have to search for a customer. If you can find one, you'll have to decide if the special cleaning, drying, packing and shipping are worth what you'll get for it. There's a slim margin of profit.

The other use for crab shells is as a source of **chitin**. (See chitin, p. 32.)

In addition, since crustacean shells have been shown to have special value in **compost**, we suggest that you also look at that section (p. 34).

Lobster: (*Homarus americanus*) Like crab waste, lobster processing waste can be used for flavor, chitin production, or compost so you should read those sections of this book (pp. 58, 32 and 34). If you are interested in the **flavor** aspects of lobster bodies, another good place to start is by reading a recipe for the French classic, lobster bisque. The first step by which this rich and delicious soup is made, is taking the shells of boiled lobsters from which the meat has been removed, and cooking them with butter, flamed cognac, herbs, etc. The shells (and the innards) give flavor and color to the bisque. In fact, it would be interesting to produce either a bisque or a bisque base to which chefs could add flour, milk, cream etc. French

cook books also offer recipe for flavored butters and sauce bases which have been made by pressing the tomalley and roe through a sieve and blending with butter and other ingredients. However, keep in mind that Maine is now recommending against eating the tomalley, which has been shown to accumulate dioxin.



Mussels:

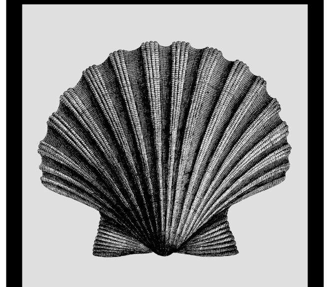
Shell: See below under oyster.

Oyster: Like clam and mussel **shells**, oyster shells are not of great value. They are composed of calcium carbonate (lime), and do not contain protein or chitin. (Actually, they do contain chitin but in such small quantities that it is not worth retrieving.) Crushed clam and oyster shells are often used in place of gravel to form walks and driveways in the mid-Atlantic region, so one way to get rid of the shells is to contact contractors and builders there. Another use is as cultch for new oyster beds.

Processors are sometimes misled by reading that oyster shells are used as calcium supplements for laying hens. This leads them to believe that their shell piles may have real value. The true story with regard to calcium and laying hens is as follows. There are two major sources of calcium in nutrition: "oyster shells", which sell at about $120 - 150/ton and mineral (mined) limestone, which sells at about $20 - 40/ton. The reason for the difference in price is that limestone must be sold as a finely milled or pulverized powder; while oyster shell is sold ground more coarsely. Somewhat counter intuitively, it turns out that the larger particles are more beneficial to the bird as a calcium source, possibly because they tend to stay in the gizzard for a while and are better absorbed over that longer time. It also turns out that the "oyster shells" fed to chickens are not simply ground shells left over from yesterday's chowder; they are shells mined from ancient oyster beds, now on dry land. The calcium in these ancient shells is said to be more bioavailable than the calcium in modern shells. The ancient shells are also softer and less likely to inflict cuts or scratches to the bird's throat or other portions of the delicate digestive tract. In fact, most modern bivalve shells, ground to the size of the ancient oyster shells, cause such cuts and subsequent death or illness. (We know at least one clam processor who killed off an entire experimental flock of turkeys this way.) Our major informant upon this subject has been Professor Kavous Keshavarz, Cornell University's specialist in laying hen calcium, who may be reached at 607-255-8143 or by email at: kk33@cornell.edu.

Oyster shell liquor, bled liquor, and some wash waters are rich sources of flavor, and can be utilized as soup or chowder base. Oyster processors should read "Characterization of Oyster Shucking Liquid Wastes and Their Utilization as Oyster Soup", by Shiau and Chai, J. Food Sci. 55(2): 374-378 (1990). In addition to making a separate soup product, more sanitary processing may make it possible to include at least some of this liquid in with the oysters, in cans or plastic packs. This will make it a better product for the consumer, in terms of flavor. Not only will any soup or stew have more flavor; the oysters themselves will have more flavor than if they are packed with water. This also goes for clam meats.

Scallops: (*Placopecten magellicanus*) The **skirts** (or lips or frills or mantles) are the thin strips of tissue that go around the perimeter of the scallop shell. They are separate from the scallop body. They have some market value, but it is extremely low. At the 1999 Boston Seafood Show, a California company called New Choice displayed scallop lips in brine imported from Chile, for about $2 per 15 ounce can. They also had seasoned scallop lips for a slightly higher price.



Cornell food scientists Robert Zall, L.F. Hood and Joe Regenstein developed a chowder recipe totally from seafood wastes. The chowder base was post-grind clam wash water. Some flavor as well as clam-type texture came from scallop skirts. Most of the protein and chunky bits came from groundfish trim mince. This was an interesting project but unrealistic for a processor, since it required wastes from three very different species. However, the concept might spark someone to collect wastes from several processors.

The **bodies** of scallops (currently discarded at sea) are rich in flavor, but also pose the problem of Paralytic Shellfish Poisoning (PSP, or red tide) and similar pollutants. This makes regulators extremely nervous. Scallop bodies would make a great fish feed ingredient, provided red tide could be avoided. (See the section on aquaculture feed, under Dried Products, p. 40.) A number of U.S. researchers have tried to show that scallop bodies are suitable foods for pigs. This has never worked; possibly because of storage methods, scallop bodies have tended to be too high in salt. Second, if any meat animal is fed a significant quantity of seafood wastes, the meat takes on a fishy taint, which is undesirable. The seafood would have to be withheld for the last few weeks prior to slaughter, and this complicates feeding.

The threat of PSP has also eliminated the most elegant and high value wild scallop byproduct, **roe on-scallops**. Anyone who has eaten scallops in France will probably have been served scallops where the whiteness of the muscle is enhanced by being next to the brilliant orange-red of the roe sac. Recently, some sophisticated American chefs have started to catch on to the fact that roe on-scallops are far more aesthetically pleasing than plain old white scallops. So far, however, the only roe on-scallops that have been sold are from cultured scallops, for a couple of reasons. One is that roe, like liver, collects pollutants. Another has to do with the seasons when scallop harvesting is allowed. The cultured product has the dual advantage that it is not allowed to swim around so that it can be kept out of red tide-infested waters, and that it can be sold at any time of year.

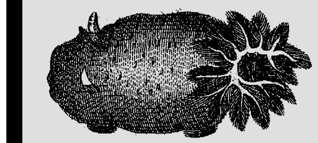
There is a market for large, perfect **scallop shells**. While these are not widely used in the U. S., French chefs (and, to some extent, those in the U.K. and Canada) like to present certain dishes, such as Coquilles St. Jacques, in the scallop shell.

And (this has nothing to do with byproduct) one way to maximize the value of high quality scallops is to refuse to "soak" them in tripolyphosphate, and to market them to quality-conscious chefs and high end shops as "dry" scallops, at a premium price.

Sea cucumber: The sea cucumber widely caught and processed in the Northeast is *Cucumaria frondosa*. There are (roughly) three parts to sea cucumbers: the wall, the body muscle, and the viscera, which includes all the internal organs. It's important to keep in mind that although *C. frondosa* is the only commercial sea cucumber in our region, there are hundreds of species world-wide. Some are too small or too toxic to enter the market (lucky for them), while others have either a large size or a special biochemistry that makes them particularly valuable. This means that when you read about a sea cucumber product selling for many hundreds of dollars per kilo, you should not necessarily assume that your sea cucumber product will fetch this price.

The major product sold world-wide is the **body wall**. Globally, it is often sold dried (after boiling, slitting, etc.) and is often called trepang or "beche de mer" (sea spade or sea shovel). Actually, every part of our sea cucumber is edible, so that there really shouldn't be a lot of waste. There is a market for the muscle, and one for the viscera, which may actually be the most valuable part of the animal. Although sea cucumbers are cultured in Asia, it is unclear that it would be worthwhile for our species. There are markets for live sea cucumbers; these may want the animals held in live tanks for two to three days to purge the intestinal content of sand and grit. If the animals are handled roughly they will purge themselves of their entire viscera, so gentle handling is a must. One old but highly recommended reference is "The fishery biology and market preparation of sea cucumbers", 1976, M. G. Mottet, Technical Report No. 22, Washington Department of Fisheries, Olympia, WA.

One big difference between Aisian and Western attitudes towards food is that Westerners (and particularly Americans) have always separated food and medicine. Even when we are told that a particular food has a health benefit, we would prefer to get the specific compound conferring that benefit in pill form, rather than eat the food. As a result, we lose much of the benefit, which often comes from the whole food. By contrast, Asians



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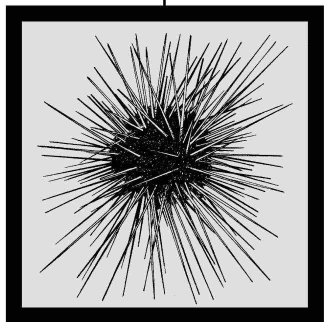
eat foods with an eye towards their medicinal value. Particularly high priced foods may derive their value from their deliciousness and/or rarity, or from their medicinal properties. (Whether these properties are real or imagined is another matter). The sea cucumber body wall contains chondroitin sulfate, one of the two major components in the pills Americans are taking by the million for arthritis. (If you log onto the Web, at: www.rxvitamins.com/nutriflex.htm you'll find a blurb for Nutriflex for Dogs and Cats, containing (among other ingredients) sea cucumber. It's not the local species (it's said to be *Pseudo-colochirus axiologus*), but it is claimed to provide joint relief, like bovine tracheal cartilage, another chondroitin sulfate-containing ingredient.



As far as we know, **muscle's** potential is simply as food. The viscera are not so simple. Sea cucumber **viscera** are an intense orangey-red in color, so it was natural to assume that they might be loaded with astaxanthin, that would have high value in salmon feed. However, in research done by Dr. Linda Kling at the University of Maine, Orono, when viscera were fed to salmon in a series of experiments, the growth of the fish was significantly retarded, and the higher the inclusion rate of viscera in the diet, the greater the retardation. That it is not a good pigment source may be due to the fact that the astaxanthin is bound to something that renders it unavailable to the salmon, or to the fact that the salmon whose feed contained the viscera, ate so little.

The viscera is not distasteful to humans, in fact, it's quite tasty. We don't know if it's a growth retardant, because none of us has eaten it as a high percent of our total diet. We can imagine a pate´with sea cucumber viscera as the main component, although typical American consumers reading the ingredients on the label might be put off. Sea cucumber viscera are a standard item in Asia, and the viscera often bring the highest prices of any part of the animal. However, that doesn't mean that our region's sea cucumber viscera are going to bring that high a price. First, to have high value, the viscera may have to undergo extensive processing. An example of this is "konowata" a product sold in Japan, which is fermented sea cucumber viscera. Alternatively, to have high value, the viscera may have (or be thought to have) special medicinal value. If you look up sea cucumbers on the Web, you'll see a lot about an extract called "Gamat". Gamat has high value and appears to be good for almost everything medicinal, but it's not found in all sea cucumber species, and almost certainly not in ours. It seems to be limited to *Stichopus* species. The most expert authorities on sea cucumbers in our region are probably Drs. Jean-Francois Hamel and Annie Mercier, who work for SEVE (Societe d'exploration et de valorisation de l'environnement) at 90 Notre-Dame Est, Rimouski, Quebec, Canada G5L 1Z6. They have written (personal communication to SG): "Regarding your question on the interest of the viscera for the Asian market, it is strange but true that, most of the time, viscera are forgotten in the processing of sea cucumbers. The processing of viscera (intestine, gonad, etc.) is not particularly difficult; it may involve drying the tissues,

or simply freezing them. The thing is that the demand for viscera exists but is less important than for other parts. Importers from China and Korea recently came to Canada and were quite interested to buy both the body wall and viscera. . . . sea cucumbers are almost 100% edible, making this avenue quite interesting to insure the profitability of such fisheries."

If you have sea cucumber waste, there is likely a higher use for it than garbage.

Sea urchins: Sea urchin processing is like eating an artichoke — more seems to be left at the end than you had at the beginning, when nature had it all packed into a neat little spheroid. In addition to generating a fair bit of solid waste, sea urchin processing also generates a lot of waste water which is high in organic load (a nice way of saying pollution).

Urchin shells are made of calcium carbonate, not chitin, so their value is not high. And, although there seems to be a lot of meat inside the urchin, not only is most of it gonad, but when you have the whole pile of waste analyzed, it turns out that the fertilizer value is not very high, because most of the remaining meat is water.

Urchin waste contains low percentages of useful elements: Nitrogen (N) was 0.82%; phosphorus (P) was 680 ppm; potassium (K) was 2347 ppm. Sodium (Na) which is NOT useful for plants was slightly over 1% (probably from sea water). Calcium was very high (about 33%), and Mg was over 1%. And strontium, which is in the same chemical family as calcium, and is taken up along with it, was very high. The dangerous elements, such as lead, chromium, mercury and cadmium, were at safe levels.

The ocean carries every chemical element that exists naturally. Creatures that live in the ocean take up all of those elements in proportions that reflect their genetic constitutions, but also, to a lesser extent, the amount of those elements in their surroundings. Calcium and strontium are in the same family, so if you're programmed to take up calcium, you'll also take up strontium, if that's available. Scientists have contemplated mining gold and other valuable elements from the ocean by finding or genetically engineering microorganisms that will take up that particular element and sequester it (Now there's a byproduct!). Unfortunately, organisms, including humans, also take up toxins that our genes never expected to encounter,

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...never expected to encounter, like DDT or PCBs. These molecules are devastatingly stable over time, and accumulate in the environment and, then, in the fatty tissues. Bioaccumulation is most dramatic in marine animals high on the food chain. Sharks, seals, walruses, etc. are considered by scientists to be indicators of toxic bioaccumulation. Humans who eat a lot of these animals, such as the Eskimos, are also highly contaminated.

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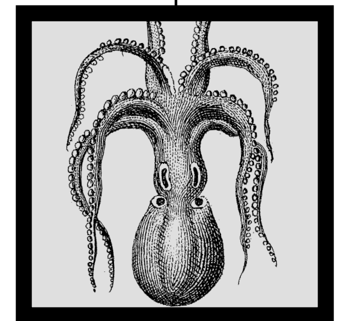
In hindsight, it would be interesting to analyze just the liquid wastes from urchin processing. They might be higher in those elements that are useful for fertilizer, in which case they could be preserved by acidification (See Fish Fertilizer, p. 42.) But they would almost certainly also be higher in sodium, because they would contain most of the sea water, as well. (This is probably only worth considering in those cases where the local water treatment authorities are giving the urchin processor a hard time about what's being poured down the drain.)

The drained solids should probably continue going where they are going now: to farms (preferably those with acid soil, since the calcium carbonate will replace some lime) or to composters, or back to the ocean. At least one report states that urchin shells are valuable as a source of calcium for apple growers.

Shrimp: Northern shrimp (*Pandalus borealis*) has a short winter season. Only a small portion can be sold fresh, so the rest is headed, shelled and frozen for year-round sales. Like eating artichokes or lobsters, visiting a shrimp plant gives the impression of generating an enormous amount of waste and a relatively small amount of product. Not only are the heads and shells discarded, but a tremendous volume of water is used in the processing and, when this is discharged, it carries with it heavy loads of flavor, roe, pigment and protein — all of which are lost. In fact, the processor may well incur heavy charges from the local waste treatment plant, which has to deal with this load of pollution.

In theory, shrimp byproducts have great value. But in practice, it is difficult to extract these byproducts in a way that maintains their value. The most attractive byproducts from shrimp are **pigment** and **chitin**. The pigment that gives shrimp its pink color is called astaxanthin. This is the same pigment that gives salmon and flamingos their distinctive color.

In the wild, all these animals derive the pigment, which is manufactured by tiny algae, from their natural food chains. Today, most of the salmon and an increasingly large proportion of the shrimp (currently about a third) that appear on our tables are farmed. In order for them to have the appropriate color, astaxanthin must be added to their feed. (Salmon that don't have it added to their feed have white flesh.) This can be added in the form of shrimp (or other shellfish) meal, or it can be added as a pure chemical, manufactured by Hoffman-LaRoche.



When you look at all the ingredients that go into feed, along with their prices, astaxanthin at about $40/pound is the most expensive. But it is added in very small quantities. If shrimp were headed as the first step in processing, and those heads were promptly made into meal, that meal would have value in the salmon and shrimp feed markets. (See Fish Meal, p. 51 and Dried Products, p. 40.) It is true that many (probably most) American feed manufacturers would prefer to use the chemical, with its consistent pigment content. However, there is an increasing market for "organically farmed" seafood, and some countries don't want to use synthetic colorants. If shrimp are soaked whole as the first step in processing, then significant amounts of pigment and other compounds leach out into the water. They are not only difficult to recapture, but they undergo chemical degradation, so that they are not worth recapturing. If shrimp were headed prior to soaking those heads might also have value for flavors and seafood soup/stew bases.

Shrimp, like many processed shellfish, seem to go through a long series of baths and washes. The first and longest soak is said to loosen the shell, so that it can be removed more easily. But each soak removes flavor and the glistening, pristine appearance of the freshly caught shrimp. American consumers have demanded cleaned, headed, and often precooked salad shrimp. But new consumers are flooding the country and they are often willing to pay more for less processing. Head on is the preferred form in most Asian markets. (The exception is Taiwan, which seems to prefer peeled product and also prefers coldwater shrimp, which they've been importing from Canada and Scandinavia.) The absolute best way to get money for byproducts in shrimp processing is to sell the shrimp whole and unprocessed. This saves money in processing, waste water treatment and waste disposal. Plus, a canny marketer can often get a premium price for the whole product.

Asian markets — especially Japanese — might also be willing to pay a premium for females with eggs. *Pandalus* eggs are a lustrous teal color, but after soaking become dull and gray. It would be well worth it to take some fresh (and, if possible, live) samples around to Asian restaurants and food purveyors. While most Asian countries are importing farmed warm water shrimp from their Pacific Rim neighbors, demand for shrimp has led to the importation of cold water shrimp for the first time. While shipping to Asia is difficult (although not impossible), it is worth exploring local ethnic markets and restaurants (plus upscale American or French restaurants) for interest in fresh or frozen, minimally processed, head on shrimp. Like minimally processed poultry or dry (unsoaked) scallops, shrimp that haven't sat in a bath for hours will be sweeter and more delicate. Also, some upscale Asian restaurants might pay a premium for whole live shrimp. This has been the case with larger, warm-water species; whether it will be extended to Pandalus is uncertain, but worth asking about. Note that maintaining shrimp alive will require different handling at every step, from catching onwards, so it will only be worth while if the premium is significant. (See also Live Product, p. 71.)

With it's slow releasing nitrogen from chitin, shrimp is a particularly interesting candidate for relatively high value **compost** (see Compost, p. 34). At least for large shrimp producers, the value of their product is high enough that they might be able to develop a joint venture with a composter to produce a specialty item during the winter months. In fact, from the composter's view, this could be extended year-round, since crab and lobster wastes would have similar value.

Chitin is discussed in a separate section (see p. 32).

Squid: The waste generated by squid processing consists of heads, viscera, pens, beaks and ink. Sometimes even whole squid go into the waste pile when they are too small for processing to be economical.

Squid ink is very difficult to collect, but can sell at prices as high as $100/lb., for the subtle flavor and inimitable shiny black color it imparts to pastas and sauces. Calamari Fisheries in Boston has practiced vertical integration by selling ink, black pasta made with ink, and running restaurants that offer an amazing variety of squid dishes.

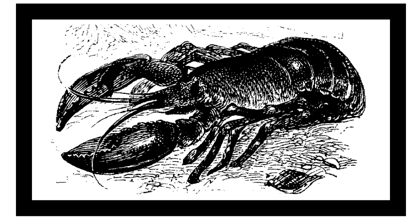
Squid beaks are said to be a popular snack food in Asia, and this would be worth investigating. We don't know if the northeastern squid species (*Loligo pealei* and *Illex illecebrosus*) would be acceptable to these markets, or what form the product should take. (Incidentally, the squid beak and radula contain alpha chitin.)

Squid pens are about 40% chitin on a dry weight basis (see the section on chitin, p. 32). They are an unusual form of chitin (beta-chitin), which is chemically different from that in the shells of shrimp, crabs or lobsters, and also differs in having no associated calcium carbonate or polyphenols. While squid chitin has been the subject of at least one Ph.D. thesis (V.F. Lee, 1974, University of Washington) , we know of no practical guide to marketing it. We believe that beta chitin could be marketed (Japan being the most likely target), but buyers will probably demand results from a series of tests. An advantage to squid pens as a chitin source is that they contain only chitin and protein, so the chemical process needed to purify the chitin is much gentler than that required for crustacean shells, which also contain minerals and polyphenols. This gentler process could mean a more intact and less degraded chitin, with a longer molecular chain length, making it a superior product. (In her thesis, Lee claims that squid chitin is superior to that from crab in strengthening paper.) Of course, one obvious problem is that a lot less squid chitin is available in the Northeast (or, for that matter, in the entire U.S.) than shrimp or crab chitin, since chitin is only about 0.2% of the weight of whole squid. So, if one were to look for a market for squid pen chitin, it would have to be a boutique market: small and reasonably high value.

There is a simpler application for squid chitin. Squid beaks and pens are great sources of slow release nitrogen for gardens. Dried and shredded or ground, and packaged attractively, they would be a unique product that might sell at a good price in a garden center or catalogue.

Squid scraps (viscera, heads, etc.) are generally dumped at sea or put down the drain at the plant. However, they have a surprisingly high value when dried; significantly higher than fish meal. **Squid meal** sells (at last glance) for $1/pound or higher. **Dried squid** is a valued ingredient in shrimp feeds for two reasons: it acts as an attractant for the shrimp, and it has an extremely high cholesterol content. Shrimp can't make their own cholesterol, and must have it supplied to them. An added advantage is that it probably won't have to be ground into a meal, since most buyers prefer to buy it as plain dried squid. (The reason is that at that price, they want to see what they're getting — a meal is too easy to adulterate with other, lower value ingredients.) See Dried Products, p. 42.

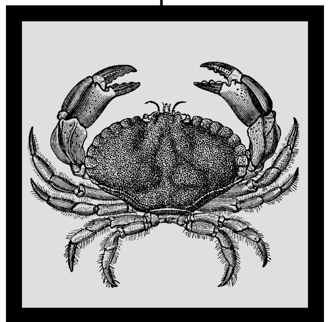
Tim Vacciano culling fish at the Portland Fish Exchange.
Photograph by Ayumi Horie. 1992.



Product Listings

This section might well include the subtitle "Better than Bait." For years, byproducts have sat spoiling on the dock as they waited to be tucked into a lobsterman's bait bag. These days, byproducts from the primary processing of nearly every species are finding high end uses, from a nasal spray to reduce bone fractures in women with osteoporosis, to fine crafted leather products fetching top dollar at up-market stores. Finding those uses takes time and ingenuity, something of which processors have precious little to spare. But in some cases the research pays off, either by reducing the waste stream (turning clam wash water into flavoring) or by increasing the value of the byproduct to the point where it becomes an asset, not a liability, as in the fast growing biotech and nutraceutical applications.

At least some processors we have spoken to have simply stated that they are too busy processing fish to go around looking for new markets for products such as ribbons which make up such as small percent of poundage. But if the per pound value were sufficiently high, and if there were other byproducts that could be sold to the same buyers, then it might be worthwhile for an entrepreneur to collect these parts from a number of processors, and market them. Be cautious: when using organs such as livers, beware of the toxic contaminants inside. And be smart: while it is always easier to spot a passing fad in retrospect, a little upfront scrutiny might steer you clear. Who could have known that the market for canned salmon bones as a calcium supplement, or tuna eyeballs as “brain food,” would ripple through Asia before simply evaporating into thin air?



Chitin-chitosan (aka polyglucosamine): After years of attention and the construction of several plants in this country and Canada, chitin — the second most abundant organic compound on earth — is still poorly understood and only minimally utilized in North America. Japan is a very different story.

Chitin is a polysaccharide carbohydrate (meaning large numbers of sugars hooked together). It is very similar to its cousin, cellulose (the winner of the most abundant organic molecule on earth contest). We know where all the cellulose is: in plants. When we see a forest, we understand instantly that huge amounts of cellulose must be in all those trees. But chitin is not as obvious. It's two major sources are the shells of arthropods — including insects as well as shrimp, crabs and lobster — and the bodies of fungi. A teaspoon of healthy lawn soil contains about three miles of fungal hyphae, or tentacles, and up to 30 nematodes. A teaspoon of compost could have much more – up to several hundred miles of fungal hyphae! The many tons of chitin that rain down onto the bottom of the ocean each year are decomposed by special microorganisms. Otherwise the ocean floor would be buried under old crustacean shells. (For those interested in learning more, we've recommended a couple of articles on chitin in the appendix.)

It's not just that chitin is produced in staggering quantities; it's also that it has so many proven uses that when you tell people about it they get that look of someone who is being sold a bill of goods. It's so useful in so many ways that it sounds like the proverbial snake oil tonic. A few examples:

- Chitin, unlike proteins and many carbohydrates, does not arouse our bodies' immune response. Since it can be spun into fibers and those fibers woven into cloth, it can be turned into biodegradable sutures or second skins for burn victims. It is used in Japan for both of these and also as intraocular lenses. Chitin can be woven into smart bandages having the ability to stop both bacterial infection and bleeding.
- Chitosan is just chitin which has undergone a simple chemical treatment which makes it soluble in dilute acids. It is one of the most versatile chemicals used in waste water treatment. Not only can it clean organic molecules such as protein or fat out of wastewater, it can remove heavy metals and even PCBs. In Japan, the government mandates the use of chitosan for food plant water cleanup.
- Since chitosan grabs hold of fats, if you swallow enough of it, it will carry fat out of your system so you can eat potato chips and still lose weight. Even better, taken orally, it reduces cholesterol with apparently none of the bad side-effects of the medically accepted cholesterol-lowering drugs.
- A simple chemical step turns chitin/chitosan into polyglucosamine which appears to be able to halt arthritis (especially in combination with chondroitin sulfate, which is made of cartilage).
- Thin films of chitin increase the shelf-life of meat, fruits, flowers and vegetables by a huge factor.
- Chitin is widely used in the paper and textile industries to create certain surface properties.
- And much, much more.

Given that every shrimp, crab and lobster shell contains chitin as a major component, why isn't every shellfish processor making chitin or at least selling their valuable shells to a chitin manufacturer? The answer is a long story, but here's the condensed version:

1. The highest value uses for chitin are medical, and it is extremely unlikely that the FDA will ever approve a product to be injected into the human body, that is made from shellfish waste. Chitin in crustacean shells is very tightly enmeshed with protein — so tightly that it is almost impossible to remove all the protein from the chitin. While chitin does not trigger our immune system's defenses, foreign proteins do. It's just too risky for approval.

The FDA recently approved a pad made of chitin to stop bleeding. The chitin is produced by a microorganism grown under sterile and highly controlled conditions. This venture was carried out by a shellfish dealer who got interested in chitin because of his shells, but then realized that the shells were not a realistic chitin source for a medical product. He became so interested in the medical potential of chitin that he left the shellfish company to his brother and went full-time into biotechnology.

2. Although the price for commodity-type chitin/chitosan may seem high (about $6 - 7/pound), so is the cost of producing it, while the yield per pound of shell is low. There is still competition from the high volume shrimp farmers of the Pacific Rim, who have cheap labor, consistent product, and a permissive regulatory climate.

3. Many companies, both domestic and foreign, have produced chitin, but very few have made money at it. Why? The main problem seems to be inconsistent product. Chitin and chitosan are notorious for batch-to-batch variability. With shellfish wastes, the raw material is variable (age, species, where it came from), it is held under variable conditions (both duration and temperature); even the process of turning it into chitin or chitosan can vary.

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Buyers who want to use chitin for a specific purpose don't want each batch behaving a little differently. Chitin and chitosan can do a lot of things, but most of the things that they do can also be done by other chemicals. Maybe not as well, but the buyer will frequently decide to give up chitin in favor of more consistent chemicals.

A new market for chitin/chitosan is in **nutraceuticals.** One of these is for healing arthritic cartilage. In this case the ingredient is called glucosamine, which is the name for the single units of which chitin is the polymer. Another is a diet aid for binding fat and carrying it out of the body. (It also binds cholesterol.) In the latter case, the ingredient is chitosan. It is too soon to predict how deep these markets are (it doesn't take much chitin to fill a capsule), and whether or not the manufacturers are looking for new sources of material. One manufacturer sources material from China.

In crustacean shells, such as lobster, crab and shrimp, the rough (very rough) rule of thumb is that one third of the shell is calcium carbonate, one third protein and one third chitin. In fact, the heavier shells like lobster or crab claws have more calcium carbonate. However, you can't weigh a pile of shells and assume that one third of that weight is chitin. You would need to scrape or digest off all the meat, and then dry the remaining shell. One third of that would be chitin.

The basic protocol for making chitin is to grind the shells to remove the protein with dilute (5%) sodium hydroxide (NaOH), to remove the calcium carbonate with dilute (5%) hydrochloric acid (HCl) and to dry the remaining material which should be chitin. Turning that chitin into chitosan requires a second NaOH treatment; this time with a much stronger (50%) solution. (Some people reverse this protocol, using the dilute HCl before the first NaOH treatment.) There is an enormous literature on chitin and before you start playing with dangerous chemicals to make some, we suggest that you do some more reading. (To learn more about working with acids, turn to p. 48. Strong alkalis require the same precautions as do acids, except that baking soda won't help.) There is also a ChitoScience Society which you might want to join.

Squid processors take note. The pen of squid is about 40% chitin. It contains no calcium carbonate; the other 60% is protein. And, it's a specific chitin called Beta chitin. There may be markets for this unusual form, but one would have to invest a fair bit of money in testing and defining the product. In the Appendix, we have reprinted an abstract of a research paper on the properties of chitin from squid pen (p. 96).

Compost: While very few seafood processors are going to become commercial composters, composting techniques are useful in unexpected ways, including to processors or retailers who are disposing of small amounts of waste and incurring odor complaints from neighbors. We have used composting in inner city fish dealers' trash cans to combat odor problems, in old pickle barrels to deal with small quantities of aquaculture morts, and for wastes generated by fish cleaning in sport fishing marinas. This section is designed to teach you some of the basics of composting, so that you can put it to work for you, if you need to.

Composting rarely creates a really valuable product, and large scale composting often creates really horrendous regulatory problems. But very small-scale composting can solve waste disposal problems. Composting is the only way we have found to deal with rotten wastes, contaminated wastes, and with

very small quantities of waste that don't justify investment in equipment.

Compost is a humus-like material created by the controlled, aerobic (oxygen must be present), thermophilic (refers to the microorganisms that carry out the process, which both generate heat and flourish in heat) decomposition of organic materials, containing the correct proportion of nitrogen (supplied by, for example, seafood wastes) and carbon (supplied by plant materials, such as wood chips, dead leaves, sawdust, peat, etc.). Compost has great value to gardeners and farmers and the more research that is done, the more valuable it becomes. Compost not only acts as fertilizer but also suppresses a wide spectrum of pests and diseases. It builds healthy soil and is almost a requirement for organic farming. Unfortunately, the value of compost is not always reflected in its price, which is relatively low. Usually, composters make only part of their income from sales; the other part is from tipping fees paid by waste generators, like seafood processors. On the other hand, farmers who use compost use huge amounts; one 600 acre vineyard in California uses three to four tons of compost/acre annually. Since organic farming is increasing, and the production of high quality compost is not keeping pace, the price may go up accordingly. While fish wastes can be composted successfully, shrimp, crab and lobster wastes (especially the first two) will create the most valuable compost, since the chitin in their shells increases the nitrogen content of the compost.

At one level, composting is so simple that anyone can do it. You may have done it. You throw all the garden leavings into a pile, add a little soil, turn it occasionally and within a year, the garbage turns into rich, black soil-like material. That's compost. Running a large composting operation is totally different. For one thing, the economics depend upon rapid manufacture and consistent product. For another, you have huge quantities of garbage coming in and if they aren't handled properly and rapidly, or if the composting process runs into difficulties, you can generate odors that will elicit complaints from neighbors miles away. There are potential problems with air and water pollution, you must get permits from federal and local agencies. The only people able to compost relatively simply are farmers, who are generally protected by special legislation, and they can usually take in at least some wastes from outside. But, commercial composting is to a great extent a materials handling business.

While there are numerous composting facilities in the Northeast, with several of them utilizing fishery wastes as major compost components, composting generally takes too much capital, time and expertise to be done as a sideline by a seafood processor. The one case we know of where a seafood processor did start a composting operation, to handle his own waste problem, turned out to be a disaster. And this was a processor with sufficient land, capital, knowledge and savvy to have a good chance at success.

The processor was Bill Jackson of Rockland, Maine. The Jackson brothers were running a large, successful dogfish processing business, and waste disposal was one of their biggest problems. They owned a significant parcel of land that was far from any neighbors. But when they tried to compost, they ran into one problem after another. We're not spreading gossip here; Bill Jackson has been generous about sharing his difficulties with all who might benefit from them.) Unfortunately, because the Jacksons were one of the very first to compost fish wastes in Maine, the State was probably

While there are numerous composting facilities in the Northeast, with several of them utilizing fishery wastes as major compost components, composting generally takes too much capital, time and expertise to be done as a sideline by a seafood processor... There is an enormous difference between a compost business started to dispose of a problem waste, and a compost business started with a marketing plan.

overzealous in its requirements, and demanded that the site be blacktopped. It was a huge site and a huge cost. (Afterwards, officials told Jackson that they would no longer require the hard top.) But the worst problem was odor. That was what made Jackson finally throw in the towel and buy a boat to dump waste at sea. People more than a mile away were complaining about awful smells. It undoubtedly had to do with the large quantities of dogfish waste being handled, but it also had to do with the wind and weather.

Several entrepreneurs who were not fish processors but interested in handling processing wastes, have operated successfully in the Northeast. Biorex, based in Rimouski, Quebec, handled shrimp processing wastes composted with peat moss. It was seasonal and specialized. The marketing plan was developed by Chris Jacques, a Quebec City-based consultant. Selling the special properties of this compost, including the excellent reputation of peat moss, and the high protein and (more importantly) chitin content of the shrimp waste, Chris developed premium markets in Asia and the Middle East. Chris Jacques' consulting company, *Comsortium*, can be reached at (418) 652-9988 or comstrat @webnet.qc.ca. There is an enormous difference between a compost business started to dispose of a problem waste, and a compost business started with a marketing plan.

Coast of Maine Organics primarily composts salmon residuals and mussel culls in addition to other marine and agricultural byproducts. After four years in business, they have converted these byproducts into a line of compost-based, premium priced products sold at lawn and garden centers throughout the Northeast. They are aggressively searching for new sources of raw marine and agriculture waste – or compost made from those materials – with which to expand their product line. You can reach Carlos Quijano at Coast of Maine Organics in his Portland, Maine office at (207) 879-1197 or carlosq@coastofmaine.com.

We will describe four basic types of composting here: agitated windrows, static piles, in-vessel, and worm composting. All of these are aerobic. There is anaerobic (oxygen-free) composting, but it plays a minor role and creates a product of less value.

Windrows are long piles with aisles between them for humans and

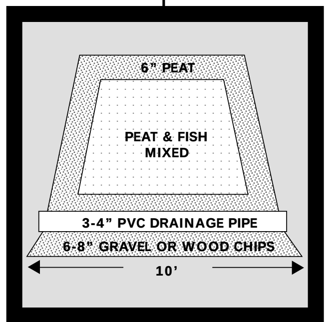
machinery to move along. An agitated or turned windrow is the standard method for large-scale, commercial composting. All the incoming material is piled in rows and, at frequent intervals (such as daily), specialized machines move along, stirring them up. Usually this agitation serves a few purposes. One is to move stuff around, from top to bottom and from inside to outside, so that everything composts equally. Agitation also tends to shred the softer materials so that the particles become smaller over time. (Harder materials, like wood, need to be shredded mechanically prior to being composted.) Small particles are good, because they have a high surface-to-volume ratio, which helps them to compost. On the other hand, small particles are problematic, because they tend to compact and minimize aeration, and the major reason for agitating windrows is to aerate the compost. Big chunks of material may compost slowly, but since they don't pack tightly they assist in keeping air trapped in the pile. When everything is very small, and the woody components are in a form like sawdust, the packing is so tight that within a few hours of agitating the pile, it's anaerobic again. For this reason, some composters like to use some large particles (like bark chips) in their compost. At the end the compost is screened to take out any bits of metal or glass, and the screening also removes the bark chips. These can be reused in the next pile, and the next, until they become small enough that they disappear into the compost.

When large amounts of seafood scraps have been composted in agitated windrows, the results have varied. Sometimes — especially when done far from neighbors — it has worked really well. One way it's been done is to build a pile of non-fish materials to be composted, with a hollow trough down the middle. The fish are dumped into that trough, and then covered over with more innocuous materials, and the agitation is not started until several days have passed. But even if the agitation starts the next day, many fish wastes disappear rapidly. For example, experiments in Maine showed that in summer, whole herring disappeared within two or three days. Problems tend to arise when fresh herring (or other species) are being added every day. Even if the odor from each batch only lasts a day or so, daily batches mean that every day is a smelly day.

The U.S. Environmental Protection Agency is concerned not only about air pollution from composting (actually, the neighbors are often more concerned about this than the authorities), but about water pollution from leachate (the technical term for dripping) from piles. This is why the Jacksons were forced to blacktop their site.

In agitated windrows, it's the turning that creates most of the odor, as fresh materials are exposed to the air. So it was probably natural for people interested in composting fish wastes to come up with the concept of the static (unturned) pile. Of course, the obvious question to ask about a pile that doesn't get agitated, is, how does it get oxygen? Well, nothing's perfect, but there are ways to get some oxygen to a static pile. (The original work on this subject was done by Sukhdev P. Mathur, Senior Research Scientist , Land Resources Research Institute, Agriculture Canada, Ottawa, Ontario, K1A 0C6.)

One way is by using PVC sewer and drainage pipes, with the holes turned up, at the bottom of the pile, to bring air into the pile. Another way, is by using large chunks of material (like wood or bark chips) in the pile to try to create air spaces, and prevent the pile from compacting into an airless mass. It's best to use both. Mathur introduced a way to prevent odor in a static pile using peat moss, which has an amazing ability to prevent the escape of smelly gases, on the outside of the pile. It's as if the pile were wrapped in a thick layer of peat. Here's a diagram to show what a static pile looks like, and here are a few notes. **1.** The wood chips on the bottom are to raise the pile up in case of excess rain. **2.** Note that the air pipe in the bottom is not in contact with fish at any point. **3.** The diagram shows fish and we've been talking about fish, but shrimp, crab and lobster waste would do just fine in compost. **4.** The seafood wastes have been mixed, prior to composting, with wastes containing carbon, such as sawdust, shredded cardboard, vegetable wastes, or more peat moss. (If you use all sawdust, remember the compaction problem and add some wood chips.) **5.** When you buy peat moss it has been dried, and is inactive in terms of stopping odor. You have to prewet it. This should be done a day or so ahead of time. It takes an unbelievable amount of water to prewet peat. You can pour the water on by the gallon, and then find that only the top inch or so is wet. The peat should be evenly moist. It should adhere together when you squeeze it in your hand, but shouldn't drip. 6. How do you know if your pile is composting, if you don't open it up and look at it? Well, you can dig in and look. The other way to do it is to measure the temperature. Remember that composting creates heat. Ideally, the temperature will go up as high as 140 - 150° F, but with a small pile and limited oxygen and a lot of fish waste, it won't go that high. Still, you can get a sense of how the process is moving along by sticking a thermometer in every two or three days and recording the temperatures. The best thermometer is one with a long metal probe and an easy to read face at one end.



The third type of composting — in-vessel — is exactly what it sounds like. It is composting in a container or in a dedicated building, using automated systems. This type of composting has high capital costs but uses less space (because it composts faster), and turns out a more uniform product. Odors are more contained. Industrial in-vessel composting is of no interest to us. However, there is an economical version of in-vessel composting that is interesting to retailers, processors, or aquaculturists that have a relatively small amount of waste to dispose of. You take a cheap, easily available small container, such as the plastic barrels that food ingredients get delivered in (and the company then needs to dispose of), or plastic or metal trash cans. You drill holes in the bottom and perhaps in the side, close to the bottom. You prop it up so the holes are available for air flow; for example, with bricks. You put some screening on the bottom and then a layer of moist peat. Then you add your waste mixed with a carbon source. Then you put another layer of mixed peat on top. You're basically making a sandwich with odor and leachate absorbing layers on the top and bottom. And then you leave it. After a few weeks, it will have shrunk. You can prepare a second barrel, with more moist peat on the bottom; pour in the contents of the first barrel to re-aerate and re-mix it, and put more peat on top. At some point, you should be able to put it into a plain old pile. You may ask why you shouldn't

use one of the many types of bins currently available for home composting. Those are unsuitable for meat or fish wastes because they have holes all over. The National Fisheries Institute has a video available on this sort of composting technology (done by Goldhor & Regenstein). Call: 703-524-8880.

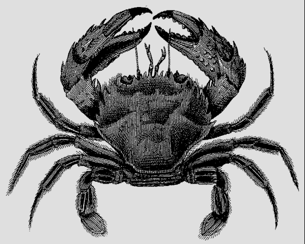
The oddball technology in this group is **worm composting**; more technically known as vermicomposting. Actually, worm composting isn't composting at all — it's actually a mini worm feedlot producing manure. Worm composting is the use of worms to eat wastes. The "compost" produced is the worm poop; often called "castings". (The second product is more worms.) Worm composting has a lot going for it. For small amounts of waste, it gets rid of the waste faster and creates less odor than any other low tech, low cost method. The product created, although smaller in quantity (which may be advantageous), is of higher value than regular compost. Globally, worm composting is widely practiced, and serious researchers and corporations are figuring out ways to do it on an ever larger scale. And, if you have children, this technology will be a source of endless fascination and learning for them. The best way to get started is to buy an inexpensive book by Mary Appelhof, called "Worms Eat My Garbage" (Flowerfield Enterprises, 10332 Shaver Rd., Kalamazoo, Michigan 49024, or email at: vermi@wormwoman.com or log on towww.wormwoman.com). The company also sells starter kits and worms.

One good thing about composting is that a lot has been written about how to do it (and how not to do it). If you are seriously considering composting, we recommend a subscription to **BioCycle**, the magazine of composting. BioCycle also organizes yearly conferences, both regional and national, on composting, which are good ways of learning a lot quickly. Subscription requests or questions go to: 419 State Ave., Emmaus, PA 18049. Tel: 610-967-4135. In addition, there are literally thousands of sites on the Web. Here are a few good ones to start your research:

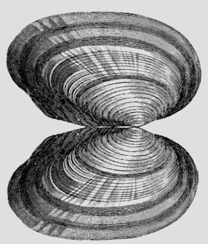
- The Cornell Composting Website: www.cals.cornell.edu/dept/compost/
- The California Integrated Waste Management Board: www.ciwmb.ca.gov/mrt/wpw/wporgncwporgan1.htm
- Environment Canada Atlantic Region: www.ns.ec.gc.ca/atlhome.html

Finally, if you don't want to compost but you're willing to pay a tipping fee to someone who does compost, and who will haul your waste away, here are some northeastern composters who accept seafood wastes:

- Agresource, Inc.
  100 Main Street, Amesbury, MA 01913
  (508) 388-5571
  has composting facilities in Ipswich, MA, Hopedale, MA and Eliot, ME
- ANJR (Association of New Jersey Recyclers)
  anjr@erols.com
- Coast of Maine Organic Products, Inc.
  (207) 879-1197 or (207) 726-9532
  office in Portland; facility in Marion Township (Washington County)
- Compost Connections, Bangor, ME (207) 947-1300
  compost broker, not actual composter
- Earthcare Farm, Charlestown, RI (401) 364-9930
- Gardeners Gold, Portland, ME (207) 799-9290
- Massachusetts Natural Fertilizer Co.Westminster, MA (978) 874-0744
- Sunrise Composting, Addison, ME (207) 483-4081



Crab meal is of low value, because of the high percent of shell and the low percent of meat. We believe that clam meal could be a fairly high value product, especially for shrimp feeds.



- Winter Wood Farm, Lyman, ME (207) 499-7886
  new composting facility in York County

Dried products / meal: Not everyone in the world owns a refrigerator. Dried seafood products comprise a huge spectrum, ranging from whole fish, small shrimp, squid, and scallops for Asian customers to salt cod, to products targeted to the livestock or aquaculture feed industries, such as fish meal. If you want to get a handle on dried seafood products, go to Asian supermarkets. Dried products are very often sold by herbalists so even as refrigerator ownership increases, market demand for dried products will remain. Animal feed products are a little harder to learn about and, in some ways, harder to produce but easier to market.

The rise of aquaculture has dramatically changed the market for fish meals. Twenty years ago, fish meal was used in feeds for pigs and chickens. It was generally included at low volumes (both because it was more expensive than corn and soy, but also because, if you included too much, the meat would be "tainted" with a fishy taste). But, it was almost always included because it contained unidentified growth factors (UGFs). As scientists eventually identified all of the growth factors, cheaper ways to present them were discovered. Aquaculturists use fish meal in large amounts in feed and they want their product to taste fishy. But, cultured fish are closer to wild animals than pigs and chickens, and fussier about their feed. Fish feed manufacturers demand higher quality fish meals than pigs and chickens. Attractants and feeding stimuli have gained an importance that they had never had on the farm. Think about shrimp, who are blind. What leads them to a feed pellet? Furthermore, fish – especially carnivorous species – had nutritional requirements that were difficult to meet except by feeding them seafood-based products. New products have entered the U.S. feed market, among them shrimp and squid meal. Crab meal is of low value, because of the high percent of shell and the low percent of meat. We believe that clam meal could be a fairly high value product, especially for shrimp feeds.

Drying scrap is different from drying whole fish, and has two advantages. First, scrap has a high surface-to-volume ratio, so it dries rapidly. Second, since appearance isn't important, you don't have to keep it flat

and treat it carefully. In fact, you can try mimicking the protocol followed in the manufacture of fish meal, and cook your scraps, press them, and then dry just the press cake. There are economical advantages to this procedure: both the size of the dryer and the energy costs of drying are a function of water content in the product. Squid or clam waste is about 80% water. Dryers are described in terms of how many pounds of water per hour they can remove. Things don't get absolutely dry in this kind of process; you're usually aiming for a final moisture content of around 10%, which means removing about 7.5 pounds of water for every 10 pounds of starting material. If you cook the scrap, it will lose water. This is because the water in muscle is bound to protein; as the protein is denatured by heat, the water becomes free to move. Usually, after cooking and either pressing or screening off the water, the squid will be 50% water rather than 75-80%. If this doesn't sound like a big reduction, look at it this way. Ten pounds of raw squid represents about two pounds of solids and eight pounds of water. When you cook the water content down to 50% solids, ten pounds of raw squid becomes two pounds of solids and two pounds of water. That's a four-fold reduction in water. (Actually, your raw material is somewhat reduced because a few percent of the solids have gone out with the water, but we're simplifying here to make the point.) There's another advantage to the cooking as well; it pasteurizes the waste, in case there's been any microbial buildup.

There are also two possible disadvantages to cooking prior to drying. The first is that you have now gotten rid of much of the soluble solids, and if you are selling your product for its attractant properties, they may be different (less) than those of the original intact raw material, even though nutritionally the material may be fine. Little research has been done on the effects of processing variables on the performance of seafood meals, so it may be necessary to test your finished product.

The second possible disadvantage to cooking down the waste before drying is the resulting waste water, which contains a high organic load. Depending upon the community you're in, this may be a serious problem or it may be no problem at all. It could also be an opportunity: the **clam water** we generated by heating clam meat scraps was a wonderful flavorant that would make a great chowder or seafood stew base. If you are going to try to use the flavor, you'll want to keep it as concentrated as possible, so cook the scraps using either no water or very little added water; say, 5%.

Drying seafood may be trickier than it sounds. The ideal way to dry seafood is at a low temperature. It isn't that you can't get a perfectly good product at high temperature; it's just that you have to watch it to make sure it doesn't burn, and low temperatures are a lot more forgiving. The drying temperature you choose is only important to you and your buyers. The type of dryer that you use, relative to its emissions into the atmosphere, is another matter altogether, since some municipalities are extremely cautious about dryers. Our un-warrantied advice is to use a refrigeration-based, closed loop dryer. These are not fired; they are basically dehumidification systems that work like air conditioners or lumber kilns. Warm dry air is pumped into the drying chamber. It leaves loaded with humidity. It goes through a heat exchanger which cools it (and conserves at least some of the heat), and then passes over refrigeration coils, which condense out the water. The condensate drips out, and the cold dry air goes back to a heat exchanger which warms it up again, after which it goes back into the drying chamber. These aren't the cheapest dryers per pound of water removed, but they have two big advantages. One is that they work very well at low temperatures. The second is that since the air doesn't leave the system, but just recirculates for the entire drying cycle, you don't put out odor.

Whatever type of dryer you buy, test it prior to purchase and ask to speak to customers already using it on seafood. We know of two manufacturers of such dryers:

- Nyle Corporation, Bangor, Maine (800) 777-6953
- Southwind Manufacturing, Ltd.
  Waverly, Nova Scotia (902) 865-4700

Fish fertilizer: Ever since Squanto showed the pilgrims how to put fish into their mounds of corn, fish has been used as fertilizer in North America. Fertilizers are labeled according to the nutrients they contain, and these are divided into macro-nutrients and micro-nutrients. Macro-nutrients (which plants need in large doses) are generally nitrogen, phosphorus and potassium (respectively, N, P and K). Micro-nutrients (needed only in tiny quantities) comprise a much longer list of elements, including iron, boron, and selenium. N, P and K are so important that every fertilizer label, by law, must state how much of each of these elements is in the fertilizer. This is true, even if one or two of these elements are totally absent from the fertilizer. For example, you might see a label on, say, urea (a nitrogen-containing molecule which can be easily and cheaply synthesized) that says 30 - 0 - 0. This means that this fertilizer is 30% N, and contains no P or K. Usually, very high analyses, such as the one for urea, or something like 12 - 12 - 12 mean that it's a chemical rather than an organic fertilizer. Organic fertilizers are more likely to have analyses like 4 - 4 - 4. Or, in the case of liquid fish fertilizer, the analysis might be something like 2 - 4 - 0.

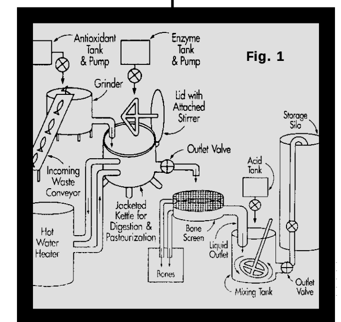
Fertilizer labeling is not totally clear upon first glance, and one frequently asked questions is: If all the percents on the analysis add up to relatively small numbers, what is the rest of the fertilizer made of? The answer to this is that when the label says “N” or “P” it means the chemical element nitrogen or phosphorus. But it's rare to have a solid compound that consists of one single element. Plus, most dry fertilizers contain inert carriers (such as sand) of one type or another. An organic fertilizer, such as dry fish meal, might contain 10 to 12% N.

Unlike fish meal, most fish fertilizer is sold wet, so most of the contents of the bottle will be water. If a fish is about 15% protein, 2 - 3 % ash, and 5% lipid (oil), then the rest (about 77%) will be water. If we divide the protein (15%) by 6 to get the N, we come up with about 2.5 % N. So a typical wet fish fertilizer will have an N analysis of between 2 and 3. (In fertilizer analyses, you are allowed a variability factor of 0.5 in your labeling to account for batch-to-batch variability. Some manufacturers sell concentrated fish fertilizer, which they've put through an evaporator (a lot like concentrated orange juice), so that they don't have to ship, package or store such vast quantities of water. Their N analyses can be as high as 6 or 7.

Two Northeast processors are making liquid fish fertilizer. Both processors (Steve Connelly and Ocean Crest) are in Gloucester, MA. Their products are sold under the trade names of, respectively, **Squanto's Secret** and **Neptune's Harvest**. You will be surprised at how many brands and versions of fish fertilizer you

can find in your local garden supply shop or in gardening catalogues.

Liquid fish fertilizer is made by grinding fish processing waste (heads, frames, skins, viscera), and digesting it with enzymes that attack protein. The digestion causes the fleshy parts to liquefy; the bones, scales and any other undigested parts can be screened out, and the resulting liquid is kept from spoiling by adding acids. The acidified liquid is fish fertilizer, also known as fish protein hydrolysate (or hydrolyzed fish protein) or fish emulsion. Claims about whether the digestion has been hot or cold and what constitutes a fish emulsion versus a fish hydrolysate or digest have more to do with sales than science. Fig. 1. shows a diagram of the process and the type of machinery needed to produce this product on a modest scale.



Concentrated fish solubles are a byproduct of fish meal manufacture (see Fish Meal, p. 51) and are different from liquid fish fertilizer in that all the fleshy components in fish digest or fish hydrolysate are liquefied and become fertilizer, while in concentrated fish solubles, only the soluble proteins and other soluble components go into the liquid product. Although few if any scientific studies have been done comparing the benefits of the two types of products the assumption is that fish digest is a better product and it's to our advantage to believe that, because there is no doubt that solubles can be produced far more cheaply and in far greater quantity. Plus they are concentrated, whereas few of the smaller producers who make liquid fish can justify the purchase and operation of an evaporator. Fish meal manufacturers must believe that the digested product is better because one or two or them have started to turn out that product.

Liquid fish commands a high price in the marketplace: typically $5 to 6 per quart. Assuming that there are lots of bones, perhaps three or even four pounds of waste has gone into producing those two pounds of fertilizer –a high price for three or four pounds of waste! Of course, it has been processed with expensive machinery; labor has gone into it, some chemicals have been added, it's in a fancy bottle with a nicely printed label and, occasionally, producers will get really serious about it and spend significant sums to advertise and distribute it. But if the scale is right, and you have enough capital to back the venture, it's one of the more profitable things to do with plain old filleting waste. Remember that it takes one and a half to two pounds of waste to make a pound of fish fertilizer, and it takes five to seven pounds of fish to make a pound of fish meal. The difference is that fish fertilizer is wet and meal is dry. So, if the price of meal looks tempting, keep in mind the far higher capital cost of producing that, and how much raw material has gone into each pound of product.

How do you make liquid fish fertilizer? Following the figure above, the steps are as follows:

1. Grind
2. Digest (requires heating and stirring)
3. Pasteurize
4. Screen to remove bones, scales, and any undigested materials
5. Preserve by adding acids and antioxidant
6. Store or package

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Here is how to implement these steps on a small scale. Each large plant will have its own engineering drawings and machinery specifications. Second, and this is impossible to say strongly enough, start out by doing it on a kitchen level, working with maybe a few quarts of waste and working up. This will allow you to learn the process and even do some marketing, before investing major capital in a plant. If you can get someone to do the grinding for you, you can hydrolyse hundreds of pounds per day, in restaurant-scale double boilers, investing only in some good stirrers. If you have a friend who teaches biology or chemistry at a local school, you might be able to convince that person to help you. This might be a great summer project for one or two students.

1. Grind: Large-scale grinders can be very expensive, and small-scale grinders can't handle the larger bones in fish heads or dogfish skin. For learning the process, we've used blenders for soft tissues or sometimes just cut them up with a knife, and used saws or hammers on the hard ones. If necessary, crush the head before putting it in the grinder; you can also put the skin in whole. The point of grinding is to increase the surface-to-volume ratio to speed digestion, and also to release the digestive enzymes from their casing in the intestines. Novices can expect to deal with a slower or a less perfect digestion. The biggest danger of whole skins and whole heads is that they will wrap around or clog the stirrer and impede its movement. At best, this will slow the process down further; at worst, it will burn out the stirrer motor, so keep an eye out for this. When you get to the point where you are ready to scale up, you'll need to decide between a grinder and a deboner. Our advice is to stick with the grinder. Deboners waste a lot of tissue. The only reason to use a deboner is for making mince. Also, the process of digestion cleans bone off extremely well, so that should a market open for bone, you're ready for it.

2. Digest: The structure of animal tissues is largely formed by protein, so the best way to liquefy solid flesh is to digest that protein with enzymes. An enzyme that attacks protein is called "proteolytic", which means protein-breaking.

Seafood wastes can be digested either by purchasing commercially available proteolytic enzymes or by using those in the wastes themselves. If you are purchasing an enzyme, you want a relatively cheap "random, endo-peptidase". This means that the enzyme will cut more or less randomly through the inside of the protein molecules. You want one that works at either neutral or acid pH, because you don't want to spend money raising the pH of your fish only to have to spend more money later lowering it. You'll need to ask the company how to use their enzyme; for example, what is the best temperature for digestion, what concentration to use, etc. Most enzyme companies offer multiple grades of the same enzyme. While purity is not a big issue in making fish fertilizer, you should be aware that the cheapest grades of enzymes will usually have less enzyme per pound than the better grades. Find out not only the price per pound, but also how much of that enzyme you'll have to use per ton of waste. If they offer the enzyme in both liquid and powder forms, we would advise starting out with the liquid. It will be less concentrated and will probably have a shorter shelf life, but you won't have to mix it up beforehand, and you won't have to worry about inhaling the powder or spraying it around. Many companies will give you free samples of their products, to get you started. Many only sell in huge quantities and it's easier for them to simply give you a few ounces than to make up a package and price.

Proteolytic enzymes are often categorized by the type of organism that produced them. For example, papain gets its name because it's made from papaya. There are also a number of microbial proteases, made by fungi and bacteria. We like papain because it's cheap and effective; the problem is that every now and again, the papaya crop fails and papain becomes expensive and rare. There are many companies that sell enzymes. Here are the names of two:

- Skidmore Sales & Distributing Co., Inc. Tel: (800) 468-7543.

They sell papain produced by a German company called Rohm, which has the irritating habit of calling all of their proteases by the same name (Corolase), differentiating only by number. Talk to a sales representative

- Novo-Nordisk (919) 494-3000

They make their own enzymes and sell a protease that works well on fish called alkalase, as well as many other proteases (despite alkalase's name, you don't have to make your product alkaline for it to work). They don't sell papain.

It is much cheaper to use the free enzymes already present in the waste. Fish viscera are full of enzymes that the fish use to digest their food

It is much cheaper to use the free enzymes already present in the waste. Fish viscera are full of enzymes that the fish use to digest their food. However, there are certain limitations on these naturally occurring enzymes. First, some fish have more powerful enzymes than others. Second, digestive enzymes usually don't survive freezing, so only fresh wastes will work. Finally, many northeastern processing wastes don't have viscera; for example, cod and haddock, which are gutted at sea.

(which is usually fish). However, there are certain limitations on these naturally occurring enzymes. First, some fish have more powerful enzymes than others. Second, digestive enzymes usually don't survive freezing, so only fresh wastes will work. Finally, many northeastern processing wastes don't have viscera; for example, cod and haddock, which are gutted at sea.

When you are making a liquid product that will be fed to animals, flavor is of paramount importance. Since the enzyme used will affect the flavor, the choice of enzymes becomes a major concern. Flavor is irrelevant in fertilizer, so economics can be your deciding factor. If you are making a fertilizer that is going to be sold to large operators who may apply it as a spray, particle size becomes important, since large particles clog spray nozzles. All digests get screened before bottling, but if your enzyme is relatively weak, you may lose so much material in the screening process that it will pay you to buy a better enzyme. There is no way to learn this sort of thing other than by experience.

Proteolytic enzymes seem to work best at relatively high temperatures. For example, endogenous enzymes (those already in the wastes), generally digest at about 160° F. That's the temperature where many proteolytic enzymes work fastest, and fish gut enzymes are no exception. This is surprising because in live animals (for example, in fish), the enzymes never see a temperature this high. But the price paid for this very rapid digestion is that the enzyme molecules have a shorter life. This doesn't matter to you — once the digestion is complete you actually want the enzymes to die. But it would matter to the fish, who can't pay the metabolic price of manufacturing new enzymes every few hours.

When you digest, heat the ground material and stir continuously. Start experimenting with a double boiler, a paddle (or a big spoon), and a good thermometer (preferably one made of metal with a long stem and an easy to read dial on top). Put water in the bottom pot; ground fish waste in the top, heat it up over a stove or hotplate (for big pots, we've used two or three hotplates pushed together), stir and watch what happens. If you use a commercial enzyme, there are a few safety precautions that you need to follow. Remember that you are made of protein, too, and that if you breath in enzyme molecules, you may cause serious irritation of your nasal passage, throat and lungs. Wear safety glasses. Wash any exposed skin promptly and, if you spill dry powder, wipe it up with wet towels or vacuum it. Don't try to sweep it dry. If your enzyme comes in powder form, carefully stir the correct amount into cold water before you add it to the fish. Don't form air bubbles (that's to protect the enzyme; not you), and don't make this solution up ahead of time, since most enzymes lose strength rapidly in water.

The first thing that will happen is that you will get tired of stirring, particularly if your pot is large. At that point, you'll want to invest in a stirring motor. You'll want one that can turn very slowly, that can take the high product viscosities at the start of the process without burning out, and — this is really difficult — that stirs the entire mass of fish. If you can only get two out of the three, give up the last and give it an occasional good stir by hand.

There is no complex scientific criterion that you are striving for in digestion – it's ready when the fish turns to liquid. This will be a function of time, temperature and how much enzyme is present. There may be tremendous batch to batch variability with visceral enzymes, depending on when the fish last fed, the fish species, and season of the year. Keep notes on each batch, writing down every variable that you can think of.

3. Pasteurize: Pasteurization refers to killing microorganisms by heat. There is no set temperature for this process; pasteurization is actually a variable time-temperature relationship. The hotter the temperature, the shorter the time necessary to achieve pasteurization. Since you will be working with an ordinary pot, you can't get higher than boiling, and you don't want to actually boil your material. If you can get your material up to 200° F, five minutes at that temperature will be sufficient. This temperature will not only kill most microorganisms; it will also kill the enzymes. This is good — you don't want them to continue to work once you've completed your process.

In an industrial plant making liquid fish, the temperature of a huge mass of fish can be raised rapidly; for example, by steam injection. But in your experiments, the temperature will go up very slowly — especially if you are using a large pot. So, you may actually get most of your liquefying action while you are heating up to the digestion temperature. You may also experience significant digestion while you are raising the temperature from digestion to pasteurization, before everything gets hot enough to kill the enzymes.

4. Screen: At the start, just squeeze the material through the window screening that you can buy in the hardware store, or line a colander with window screening. You may eventually want to invest in a vibrating screen or other large-scale, mechanized means of separating liquid from undigested bones, scales, etc.

5. Preserve: In order to preserve liquid fish, you need to protect against three types of spoilage: rancidity, bacterial spoilage, and mold. Each one requires a different sort of protection.

Rancidity, aka oxidative rancidity, happens when oxygen interacts with oils (a reaction which goes much faster when heated). The long-chain, polyunsaturated oils in fish are particularly vulnerable. Chemicals which protect against oxidation are called antioxidants, and the antioxidant of choice for fish oils, when you are making a feed or fertilizer product is ethoxyquin. (Ethoxyquin would not be used in a human food product.) Protecting your product against oxidation is simple: prior to heating the fish in the digestion step, just add 0.025% of ethoxyquin. (That is one quarter of a tenth of a percent. Not much.) If you were making a ton of product, you'd add half a pound of ethoxyquin. If you're making a pot full, just add a few drops. If you're working with very low fat wastes, such as cod or haddock racks and cuttings, you don't need to worry. Otherwise, it's a good idea to use antioxidant. Because you're using so little, it's often helpful to dilute the ethoxyquin. Ethoxyquin is thick, oily, and is hard to measure and pour. You can dilute it with an oil such as corn oil, or you can purchase it as a water soluble emulsion, which is worth the extra cost. Ethoxyquin can be purchased from a number of sources. Here are two:

- Amerol Corporation, Farmingdale, NY
  (516) 694-9090
- Summit Pharmaceuticals, Attention: Gene Reed
  (501) 834-3817

Summit offers a dry ethoxyquin, called Abiquin. (You may have to add more of a dry product, since only some percent of that product will be ethoxyquin.)

The major way in which liquid products are protected against **bacterial spoilage** is by adding acid to

Caution!

Acids are dangerous. They can burn you and blind you. You should not use them without wearing safety goggles and some kind of coat that you can take off quickly, if necessary. Don't use acids when you are wearing sandals, and don't use mouth pipettes to suck them up.

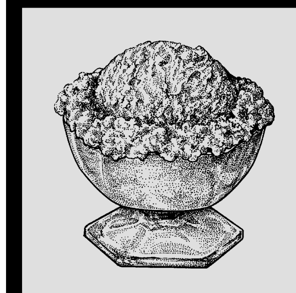
lower the pH, which is the unit by which acidity and alkalinity are measured. The pH scale goes from 0 to 14. (It actually goes higher and lower, but only a small number of specialists ever get to those points.) On the pH scale, 7 is neutral. Pure water is 7. Anything below 7 is acidic, and anything above 7 is alkaline. One of the interesting things about pH is that it's logarithmic: as you go down (or up) past 7, reaching the next unit requires ten times as much acid (or alkali) as the one before. So if you start out at a pH of 7, and you want to acidify to a pH of 4, it might take you only an ounce of acid to get to pH 6. But it would then take you ten ounces of acid to get to 5, and a hundred ounces to get to 4. So, as you make something more acidic, it takes more and more acid to get there.

The **acid** most commonly used for fertilizers is phosphoric acid, since it is not only cheap, but it also adds P (phosphorus) to your fertilizer analysis. If you used a different acid, your N - P - K analysis might be 2 - 0 - 0. If you used 4% phosphoric acid to stabilize your fertilizer, that would probably push your analysis up to 2 - 4 – 0, which looks a lot better to consumers. The correct amount of phosphoric acid is more or less 4%, but you'll need to measure. A good pH for stabilizing fish fertilizer is 4.

Buying acids from a scientific supply house will be more expensive than from industrial sources, and probably purer than you need. Even from an industrial source, your acids will be expensive because you will be buying in very small quantities. To work out your final economics, ask for prices for large quantities. You will probably want feed or agricultural grade. One northeastern supplier we have used is Monson, telephone: 800-262-5446. There are others as well. Try the Yellow Pages under "chemicals".

Caution! Acids are dangerous. They can burn you and blind you. You should not use them without wearing safety goggles and some kind of coat that you can take off quickly, if necessary. Don't use acids when you are wearing sandals, and don't use mouth pipettes to suck them up. If you can work wearing protective gloves, so much the better, but keep in mind that a glove with a hole in it may be worse than no glove at all; acid can seep in and it will take longer to become aware of it and wash it off. If you ask an employee to work with acids, make sure s/he understands the dangers and is adequately protected. ALWAYS keep a lot of water close

by, in case of a spill to wash it off your skin. We're talking about a hose here — not a bucket. This water needs to be really close and really easy to turn on — remember that the person needing it may be blinded, and have to get to water fast, to keep from suffering permanent injury. You may also want to keep baking soda nearby to neutralize spilled acid on floors or surfaces.



How do you measure pH? The cheapest, simplest way is to buy litmus paper. This is like a roll of tape. You tear off about an inch and touch one end to the liquid whose pH you want to measure, and the tape will change color. pH paper comes with a color chart so you compare the color on the paper with that on the chart to see what the pH is. The paper comes in wide and narrow ranges, so you can buy one tape that goes from 0 to 14, or you can buy tapes that covers only one or two pH units. Generally, it's a good idea to have one wide range one, and one narrower one that covers the pH you want to reach. You can buy pH paper fromGallard-Schlesinger. Call (516) 229-4000.

Although phosphoric acid will protect your fertilizer against bacterial growth, it won't protect against **mold**. Mold protectants (called antimycotics) are usually organic acids. Phosphoric acid, which you are using to protect against bacteria, is a mineral acid. One widely used organic acid for protecting against mold is propionic acid. You'll see it on a lot of food labels. Though expensive, you only need about 0.25% — a quarter of a percent.

6. Store or package: In choosing from the many options for packaging, be sure to check with the manufacturer to make sure that the plastic you purchase can stand up to the level of acidification you've used. Never put fish fertilizer into a glass bottle; stick with plastic. That's in case the preservation is imperfect, and some microorganisms grow in it and generate gases. If it's in plastic it will swell up or maybe develop a leak, but if it's in glass, it could explode, shooting out dangerous glass shards.

Fish gelatin Although fish are quite different from mammals, their skins and bones can be used as a source of gelatin, just like the skins and bones of cows and pigs. The major difference is that fish gelatin melts at lower temperatures than mammalian gelatin. Unlike mammalian gelatin which can be used to make an aspic which will be solid at room temperature, most fish gelatins melt at room temperature but stay solid in the refrigerator.

Fish gelatin, made largely from North Atlantic groundfish, has been manufactured for many years by Norland Products Ltd. of North Brunswick, NJ. Norland also has a plant in Port Saxon, Nova Scotia. This gelatin had multiple markets but the major part was sold to the printing industry as a photoresist base. With the shrinking of the groundfish stocks in the Northeast, this business has sourced its skins elsewhere.

Fish gelatin has an intriguing potential use in the food industry, which derives from its relatively low melting point. The gelatin of some species melts at room temperature which gives it the appropriate "melts in your mouth" mouth feel for use in frozen and refrigerated foods, such as ice creams, yogurts, etc.

Fish gelatin has another interesting selling point for the processed food industry. Almost all mammalian gelatin is unacceptable to the kosher Jewish and the Moslem halal communities because, even when it is made of pure beef, the beef has not been slaughtered under kosher/halal conditions. Although kosher Jews make up only a small percent of the nation's consumers, a varied and significant number of consumers like to buy foods labeled kosher. Therefore, food manufacturers try to get kosher labeling for their foods. If fish gelatin is made from skins and bones coming from a plant that handles only kosher fish (fish with scales — this means that fish like catfish, monkfish, eels, sharks and rays are not kosher), then that gelatin is kosher. But, not every fish that is kosher is suitable for gelatin. For example, Atlantic salmon skins yield a gelatin which although viscous, simply doesn't gel.

Due to diminished stocks, it does not seem likely that a fish gelatin business will be started in the Northeast at this time. The capital investment required to outfit a processing plant and market the product can only be justified by a very large and constant flow of raw material. However, things change. If you are thinking of starting a kosher fish plant, the world's expert on kosher/fish gelatin is easily accessible. He is:

- Professor Joe Regenstein
  Department of Food Science
  Cornell University, Ithaca, NY 14853-0315
  Tel: (607) 255-2109 email: jmr9@cornell.edu

Fish leather: Although few people realize it, fish skin makes extraordinary leathers. They are beautiful, varied in texture, accept dyes well, and amazingly strong. The native peoples of Alaska made boots of salmon skin, which were waterproof and tough. The most common fish skin for the leather trade is shark. As early as the 17th century, shark skin was treated and tanned to form shagreen, an immensely strong leather with a granulated texture, which was used to cover boxes, furniture, sword handles and scabbards, etc. (Antique shagreen items have recently become trendy for collectors.) Shark and ray skins are sometimes used for cowboy boots. Because of its rough texture, sharkskin also makes a pickpocket-proof wallet. (Of course you can't get it out of your pocket, either.) Slime eel (hagfish) skins are commonly used in making wallets and belts, although these are hampered by the narrowness of the individual skins which must be sewn together to form any item larger than a key case. This exemplifies the greatest problem for fish leathers, which is that the pieces are relatively small. It's true that most fish leather pieces are small compared with, say, cow hide, but not compared to snakes and lizards, whose skins fish skin resembles. Many of the items made out of leather, like shoes, watch bands, wallets, patches, etc. don't need to be cut out of giant hides. In fact, at one point larger hides were also used by an Australian decorator to cover bar stools and throw pillows. Fish hides have even been made into bikinis; an ideal use for small pieces!

Although fish leather has never become a major item, small scale uses continue. In 1989, the Government of Newfoundland and Labrador carried out a market study and estimated that there were between five and ten commercial scale fish tanneries in the world, with another ten to twenty operating at pilot scale. To quote a report by Canadian Fishery Consultants Limited, "The majority of these ventures are operating at well below maximum production levels, averaging ten to thirty percent utilization. The tanneries are currently 'jockeying' for market position but do not have sufficient financial capacity to promote their product effectively."

Among the local fish which have been tested for leather production are cod (the finished product could replace endangered snake and lizard skins), Atlantic catfish, and Atlantic wolffish, as well as sharks and rays. This should not be taken to mean that other species won't work; only that they may not have been tested.

The best route for anyone interested in the potential of fish leather is to find a small, experimentally-minded tanner interested in working with you. Experience with fish skin leathers is definitely a plus, but small-scale equipment is even more important. Call the Leather Industries of America (an industry organization) for their annual membership directory: (202) 342-8086.

Turning the skins into leather is the easy part of this venture. The hard part is to market those skins to manufacturers or to develop a product which will utilize the skins. Start out by thinking which skins you generate on a regular basis, which are reasonable in size. Have samples of those tanned and dyed, and then let the skins assist you in deciding what markets might accept them. You might be lucky enough to get a shoe or wallet manufacturer interested. But it would probably be easier to talk to local craftspeople, who might be able to use them in a variety of ways, including jewelry, sculptures, clothing and souvenir items. You might also think about specific sale places for such items, like aquarium gift shops, fishing town souvenir stores, and local crafts shops.

Fish meal: Fish meal is made as follows: fish or fish waste is cooked, ground, pressed and dried. After drying, the press cake is milled into a meal with the consistency of sand. The press water is usually put through a decanter to separate off the oil, and the non-oil fraction is then concen-

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> **In Alaska there are... fish meal plants handling processing wastes... {in} municipalities like Kodiak and Dutch Harbor, where hundreds of tons of wastes may be generated daily. They are often owned by a consortium of processors as a way to make a little money out of their wastes. So, if the quality is lower than optimal and the price received is lower than optimal, the processors will accept this in a way that an independent entrepreneur would not.**

trated by evaporation (it's known as stick water or concentrated solubles) and is either sold in that concentrated form, preserved by acidification, for fertilizer or feed or it's added back to the fish meal, which is then put through the drier a second time. A few decades ago, there were meal plants — also known as dehy (short for dehydration) or rendering plants — all up and down the coast. New England had fourteen. Most of them handled mixed materials, taking in poultry, meat and fish processing wastes. The product was poor in quality, often having been made of semi-rotten materials, and was frequently over-cooked or burnt. The plants stank to an extent that most of us can hardly imagine, and polluted entire neighborhoods, but the odor was accepted by communities that were dependent upon the businesses that these plants serviced and that couldn't imagine another way to operate. Times changed, and so has fish meal! In the most general terms, there are two types of modern fish meal plants: on land and at sea. On land, the plants carry out the same process as outlined above. The difference is that they are almost odor-free. They are designed to produce a consistent, high quality meal and to be cleaned in place. The process is computerized; in short, they are like any modern food plant. The equipment required for the process (and which makes them odor-free) is extensive and costly. Since there are big economies of scale in processes like evaporation, they tend to be enormous (one relatively recent plant in Norway is capable of processing 40 tons of fish per hour). They do not handle processing waste. Not only would they be unable to find the appropriate amounts of waste, but processing waste collected from multiple plants would be varied in type, would contain high amounts of bone and viscera, and would not be fresh. What fish meal plants really want is high amounts of muscle meat. Stale raw material would lower both the yield and the quality of the final product, and would make it harder for the plant to be odor-free. The large, modern on-shore fish meal plants operate with raw material from directed fisheries such as anchovetta, capelin and menhaden.

Fish meal plants that utilize processing wastes are found almost solely on board factory trawlers. In Alaska there are also on-shore fish meal plants handling processing wastes, but these are limited to municipalities like Kodiak and Dutch Harbor, where hundreds of tons of wastes may be generated daily. They are often owned by a consortium of processors as a way to make a little money out of their wastes. So, if the quality is lower than optimal and the price received is lower than optimal, the processors will accept this in a way that an independent entrepreneur would not. In this country, on board fish meal plants on factory trawlers are only found in Alaska. These trawlers are capable of bringing up more than 100 tons of fish with one set of their nets and their catch is usually a single species. The fish are processed on board, with shifts working round the clock, so the wastes are actually fresher than those delivered to onshore plants from directed fisheries. The unique thing about these onboard plants is that they don't need to evaporate. They decant the press water, separate out the oil (fish oil can actually be used for up to 20% of the fuel for a vessel), and dump the rest overboard. It doesn't harm the environment and saves the considerable investment required for an evaporator. This makes a relatively small plant cost-effective. The other things that makes it cost-effective are that it operates 24 hours a day, and that it doesn't have to make any investment at all in air pollution control technology, since it has no neighbors. And, since the material going in is the freshest possible — fresher than any on-shore plant can command — the product fetches a premium price in the aquaculture market. It seems unlikely that fish meal will ever be produced in the Northeast again, so our section is brief. Anyone wanting more information should contact the International Association of Fish Meal Manufacturers, located in England at: Hoval House, Orchard Parade, Mutton Lane. Potters Bar, Hertfordshire EN6 3AR.

Fish mince: Mince is the British word for ground meat, and fish mince (from now on called "mince") is ground fish. For very large producers, such as Alaskan factory trawlers, mince is produced from the huge quantities of trim generated. It is also possible (although less frequent) to make mince from the flesh left on the frames. Although very large producers may make mince as an end product commodity to be purchased by users who will turn it into a fish cake, etc., smaller producers, such as those in the Northeast, will probably be forced by economics to turn their mince into a value-added product, which will command a higher price.

The basics of mince production are covered in a chapter from "Improving the Profitability of Finfish Processing Waste", by Susan Goldhor and Joe Regenstein (New York Sea Grant, 1991) reprinted in the Appendix. Since this publication is quite old, prices are inaccurate; however, the basics of the process are still valid..

Note that of the four major deboning manufacturers, Baader, Bibun, Beehive, and Paoli, the first three make machines that are more or less similar to the diagram shown in the reprint, where you can control the size of the flesh chunks by the hole size, while the Paoli machine makes a mince that is less like hamburger and more like a paste. Which type is better depends upon what you want to do with the product.

The U.S. government controls which species may be used in mince blocks, but any species may be used in a value-added food product for which mince is the starting ingredient. We have a few comments to add to the reprinted article.

First, don't buy a deboner until you have gotten a demonstration from the manufacturer and have a reasonable idea of yield (you'll need this for any economic

...fish mince is a great way for people who think they don't like fish, and don't want to eat novel foods, to enjoy the health benefits of fish. School lunch programs or nursing homes might not want to buy fillets, but they might like to buy products that offer fish in recipes that are acceptable to their clients' tastes.

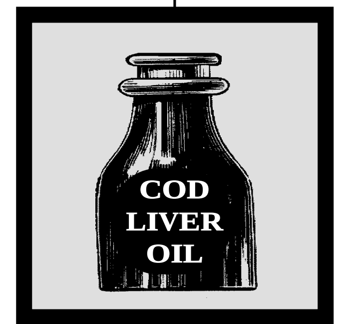
projections), and of how the material produced by that deboner works in your product(s). Make sure that you test the species that you plan to work with or at least a very similar species. You could probably substitute cod for haddock, but neither would be a good substitute for flatfish, which tend to have a very different, mushier texture and a different body conformation..

Second, if you have a great concept for a fast-selling product but are worried about producing enough and producing it steadily, you may be able to negotiate with other processors for their trim, etc., and you may also be able to purchase frozen blocks for part of the year. The problems you'll encounter with the first possibility are largely those of quality control; with the second, your problems are more likely to be economic.

Third, what sorts of products make sense? All of the products mentioned in the reprinted article are reasonable ones, and we would add one more: fish balls for the Asian market. (See the section on fish balls, p. 70.) Surprisingly, fish mince — especially that from the firmer meated, mild flavored fish, such as cod or haddock — can be a good substitute for red meat. In a strongly spiced and red-colored dish, such as spaghetti or chili, mince could fool most people into thinking that they were eating hamburger. We're not advocating false labeling and fooling people, just suggesting that fish mince is a great way for people who think they don't like fish, and don't want to eat novel foods, to enjoy the health benefits of fish. School lunch programs or nursing homes might not want to buy fillets, but they might like to buy products that offer fish in recipes that are acceptable to their clients' tastes. Try some different species: for example, would skate or dogfish, which have firm, chewy flesh, work in this context? Try mince in a spicy, tomato-ey recipe where you would normally use hamburger. Just chop some trim or even some fillets up by hand or by pulsing for a short time in a food processor. You can cook it exactly as you would cook hamburger, or you can sauté it and add it closer to the end of the cooking time. We can't tell you what will work best in your recipe. We're just asking that you experiment before you reject the idea.

Fish oil: The history of fish oil in America is closely linked to our region but, at present, the Northeast produces essentially no fish oil. This often

leads us to believe that fish oil is a minor product. But globally, this is not the case. Fish oil has traditionally been number 12 on the list of the 17 most important world fats and oils (an oil is just a fat that is liquid at room temperature) — right behind olive oil and ahead of corn oil, at between one and one and a half million metric tons per year. The mid-Atlantic and more particularly the Gulf regions are large producers of menhaden oil, a secondary product of fish meal manufacture. The largest world-market for fish oil is in human food, using over a million tons per year up until ten years ago. While this is not the case in this country, Northern Europe, South America and Japan utilize huge quantities of fish oil, mostly for salad oil, frying fat and margarine production. Since the menhaden fish meal industry received FDA approval for partially hydrogenated menhaden oil for food, this oil is being used more widely in such products in the U.S. Fish oils are also used for a wide variety of industrial uses. Since the growth of aquaculture, the feed market for fish oil has grown greatly, using more than a quarter of world production, and raising fears of a fish oil shortage. Fish oil is also in increasing demand from the pet food industry. However, the need for it is greatest in feeds for marine aquaculture species, since it will be difficult to tout the health benefits of a salmon that has been fed on soy or meat, and whose fatty acid composition resembles that of a soybean or a cow.



There is a relatively small market for medicinal fish oil, seen in capsule form in the health food stores. Since food supplements are unregulated, these capsules are of varying quality and often contain less or more (occasionally, none) of the key ingredients than advertised.

Oils can be derived from fatty fish, such as menhaden or herring or salmon. Alternatively they can be derived from the livers of fish with dry flesh, such as cod or haddock. In the past, shark liver oils were highly valued, but that day is past, not only because of the PCB issue, but also because fish liver oils, though wonderful sources of certain vitamins, have been replaced by manufactured vitamins. Although there are now alternate sources of vitamins, fish oils remain our major sources of long chain, polyunsaturated fatty acids, which are believed to offer multiple health benefits. (*Warning:* this too may change, as microalgae and fungi, major primary producers of these fatty acids, become increasingly cultivated.) Before reading texts giving the oil content of different tissues and/or species, be aware that oil content of fish (like fat content of humans) is widely variable, changing especially dramatically with season and reproductive status. And, muscle oil, roe oil and liver oil may all have quite different fatty acid compositions even in the same species.

Since there is no fish meal manufacturing in this region, extracting fish oils would require a special effort and dedicated equipment. The oils which might justify such an effort would be salmon head oil and liver oils.

Oils have to be rendered out and, unless you are good at putting together used machinery components, any single producer might find the cost of rendering prohibitive. However, it might be a good investment for someone who collected waste from several processors, provided they could control the quality of the waste. Alfa-Laval is an established manufacturer of fish render-

Those of us who were forced to swallow cod liver oil prior to the introduction of modern processing methods are convinced that it underwent every possible form of deterioration. Cod liver oil is actually a good arthritis medication but the stories of what was necessary to enable early patients to get it down are horrendous. ...this is probably why it gets little attention today, despite the fact that very high quality product is now available.

ing equipment. Their North American specialist in fish products is Chris Pook, telephone (Vancouver): 604-290-5097. Or log onto www.alfalaval.com.

In other sections of this book we've warned about the buildup of PCBs in liver oils of long-lived bottom fish, such as dogfish, skate and monkfish. Supercritical extraction is an oil separation technology that could clean these oils up, but it is very costly and technical. Supercritical extraction uses carbon dioxide in a "supercritical" state which is somewhere between a gas and a liquid. In this state, it acts like a solvent but unlike the traditional oil solvents, such as hexane, it is neither toxic to humans nor hazardous to the environment. Several companies manufacture supercritical extractors, including Phasex in Lawrence, MA and Applied Separations, Allentown, PA. There is a lot of interest in removing or destroying PCBs, and new, economical technologies may emerge.

Warning: Before investing in any equipment, make small-scale samples of the oils and have them analyzed, to make sure that there are interested buyers. You don't want to set up a plant to extract, say, salmon head oil only to find out that the head oil of aquacultured Atlantic salmon doesn't meet the specifications of buyers used to wild Pacific salmon. Your potential buyer will tell you which analyses s/he wants.

The special value of fish oils lie in their long-chain, polyunsaturated fatty acids, particularly docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA). These not only contribute to the ability of a fish's membranes to remain elastic in cold water, but they are believed to have multiple benefits for human health (and for the health of other animals, as well). They are probably the major reason that fish can be labeled "heart healthy". On the other hand, they also have a major downside for processors: the longer the chain and the more unsaturated the fatty acid, the more easily they can be oxidized. Oxidation, which is usually caused by the presence of oxygen (especially at higher temperatures), leads to off-flavors (typically characterized as rancid), off-odors and turns a healthy product into an unhealthy one. Fish oils can deteriorate before, during, and after processing, and during storage.

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arthritis medication but the stories of what was necessary to enable early patients to get it down are horrendous. In fact, this is probably why it gets relatively little attention today, despite the fact that very high quality product is now available.

The best way to insure a high quality product is to process fish while they are still fresh, to add antioxidant as soon as possible in the process, and to flush the product thoroughly with nitrogen gas prior to storage. For animal feeds, ethoxyquin is generally regarded as the antioxidant of choice, but human foods (and sometimes pet foods) require other antioxidants. There is abundant scientific literature on fish oils; a recommended source is "Fish Oils in Nutrition" by Maurice Stansby, 1990. Van Nostrand, Reinhold, NY.

Fish scales: Fish scales are probably best known for producing **pearl essence**, the lustrous component in some nail polishes, artificial pearls, and lacquered surfaces. Before it lands in these products, it's the component that gives fish their lustrous and pearly, reflective appearance. It is a result of one compound: guanine, which is highly insoluble, and is deposited as a crystalline substance in the scales of many fish. Windsor and Barlow, authors of the classic "Introduction to Fishery Byproducts" say that pearl essence is produced from the scales of most pelagic fish, such as herring, sardines, salmon and menhaden. Pearl essence is made by several fairly heavy-duty chemical processes. Most people probably won't choose to make it, but it is possible that a manufacturer might want to take your scales, provided they are the right type.

The following summary of an article was published in the June, 1990 issue of Monthly New Food Products in Japan 15(6): 35: "Functional food: Fukuei Hiryo Co, Japan, an organic fertilizer maker, has introduced Calpro Esta, a functional food obtained from fish scales. Fukuei has used crushed fish scale for fertilizer for years, and has now succeeded in processing fish scale into a tablet form that can be blended into biscuits, fish paste or health foods."

While we doubt that fish scales would have much success in this country as a health food (and we don't know how the product fared in Japan), fertilizer seems an excellent application for fish scales. If guanine is present, it offers slow-release nitrogen, and even if it is not present in meaningful amounts, the scale itself is largely protein, and would offer slow release nitrogen on its own. The scales would have to be washed and dried, and the market might also want them to be ground. If anyone was making a fish bone meal, the scales would make a good addition to the product, or they could stand on their own.

Another potential use of scales is trickier and further from commercialization than the two uses listed above. This is the use of dried ground fish scales as a coagulant to remove dispersed solids from waste waters. This concept was first tested in a Cornell Masters thesis ("Fish Scales: A Coagulating Aid to Recover Colloidal Solids in Food Processing Wastewater", 1978. Frank Ward Welsh.) In this thesis Welsh tested the scales of carp and porgy, and found that they were surprisingly effective at cleaning food processing wastewater. Prior to use the scales were dried at 120° F for 24 hours, and then ground in a small grist mill until they would pass through a 0.5 mm screen. They were tested against standard flocculants, such as ferric chloride and alum as well as against chitosan. The scales and the chitosan performed about equally, with the carp scales outperforming the porgy. Later work by Welsh's thesis advisor, Robert Zall and his co-workers, extended the research to other species of fish, comparing porgy with flounder and cod, and also looked at removal of different metals, comparing the results to those obtained with chitosan. Not only did scales from different species of fish vary, but they performed differently on different metals. For example, cod did as well as porgy in removing lead (all fish scales did better than chitosan in lead removal), but both flounder and cod performed worse than either chitosan or porgy scales in removing copper, cadmium or chrome from solution. While it is interesting to recognize that the scales of different fish may have very different abilities to remove particular metals or compounds from wastewaters, it is unlikely that a fish scale wastewater cleanup product is going to come to market. Still, the coagulation properties of fish scales makes one wonder if they could capture fat and cholesterol the way chitosan does, and find a home in the nutraceutical market.

Flavors: Seafood flavors — fish, clam, shrimp, crab, lobster, and mussel — have deep markets and are used by chefs, food-service companies and food manufacturers. Flavors command high prices, but the highest prices tend to go to the most highly processed and concentrated flavors. There is a much bigger U.S. market for clam flavor than for mussel, although the opposite might be true in Belgium or France.

Many processing wastes are extremely rich in flavor. For example, livers or other organs have very high flavor contents (although the flavor derived from those organs may not be precisely what the consumer considers typical of that species). Reading French recipes for fish or shellfish soups and stews, one discovers that most of the recipes start by having the cook make a stock or base from what processors throw out: racks, heads, shells, organs, etc. Making this takes time and effort, so more and more restaurant chefs and soup manufacturers are buying either complete soup bases or at least pre-made flavors that can be blended into a soup base.

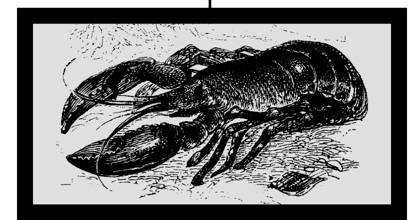
There are a number of ways in which processors can approach this market. The simplest is to contact local chefs and ask them if they are interested in purchasing any heads, racks, shellfish bodies, etc. This approach probably won't get rid of more than a small portion of your waste and it probably won't bring in very much money, but the market research is quick and simple.

The next simplest approach (which should be taken only after you've talked to the chefs and determined interest) is to make the soup base yourself from your byproducts and sell it to local chefs.

The next step up is to make an actual soup for restaurant or retail sale. This was the approach taken by an Australian company, highlighted in the April, 1999 issue of INFOFISH International. George Muer, a fisherman-cum-restaurateur, wanted to find a way to add value to the tons of fish heads he handled each year. The first product his company introduced was Mures Smokey Chowder, followed by a Provencale style soup. The soups come in one liter, foil lined cardboard packs and do not need refrigeration. Now, the head of every premium deep sea species landed at Mures is used. The company has its own boat, processing plant, wholesale and retail fish sellers, two restaurants and sushi bar and employs 150. Note, however, that the company carrying this out has government support from the National Seafood Center, and

substantial resources.

The easiest way to make soup would be to partner with a restaurant chef whose restaurant could use the soup. Getting a new product into supermarket chains is expensive and difficult, requiring special packaging, labeling, stocking fees (fees paid by food manufacturers to the supermarket for shelf space) and advertising campaigns to build customer recognition. Forget this. On the other hand, making a soup for a local restaurant or specialty shop is a reasonable goal.



Flavors can sell for as much as $10 to $15/pound, and that looks awfully attractive; especially if you're paying money to dispose of waste. They can be sold to food companies, chefs or flavor companies who offer an entire line of flavors to food manufacturers and chefs.

The bad news is that flavor users (such as restaurant chain buyers) want a flavor which is concentrated, so they don't have to store huge amounts of material, and easy to use in small amounts. In other words, the ideal flavor for them would be a dry powder. It would be shelf-stable and if they needed to make one gallon of soup that day, they would just take as many spoonfuls as they needed out of the jar and add water. The next best form of flavoring would be a highly concentrated frozen slush similar in consistency to frozen orange juice concentrate. They want a slush, not an ice cube so that they can dig a spoon in and take out just as much concentrate as they want. It's slushy because it's concentrated; the process of evaporation has removed so much water that the solids have lowered the freezing temperature significantly. This sort of flavor is sold by some clam processors; in this case it is salts rather than the sugars in oranges which help form the slush.

Flavors are sufficiently valuable that some entrepreneurs form partnerships with processors and do nothing but make flavors out of the processors' waste materials. Some products are straightforward meat type flavors, some are derived from selected waste water streams, such as cook waters; some are manufactured from organs, and some are very highly processed, with the final product having been cooked, enzyme digested, evaporated, etc.

Enzyme digestion can intensify flavors enormously — depending upon the enzyme used and the conditions, this intensification may make the flavor more desirable or it may make it unbearable. This technology is widely used to enhance palatability in pet foods. Choosing the right enzymes and controlling the reactions are complex tasks, and the equipment can be quite expensive. Isnard-Lyraz, a company in Brittany, France specializes in concentrated seafood flavors made by careful enzymatic digestion of a variety of processing wastes. The quality of the wastes is strictly controlled, and the flavors are preserved by freezing and sell for high prices to chefs and food companies.

An experimental approach to flavor uses ultrafiltration. Ultrafiltration works by pumping the water around and around a loop, one portion of which consists of a plastic or ceramic membrane which is perforated with millions of tiny holes of a particular size. The water and salt and some very small molecules go through the holes and down the drain; the flavor molecules, which are larger, are retained. Each time the water goes around the loop and through the membrane cartridge, the part that is retained (called the retentate) gets more concentrated. The part that goes through the holes and flows out of the system (called the permeate) is often quite pure water, and this water can be reused in the plant. It might be possible to have a setup where one relatively clean type of process water, such as clam post-grind wash water, goes through an ultrafilter, where the retentate is stored to be sold as flavor and the permeate goes back, through a chiller, to be reused in the same process.

Note that "clean" here is defined as having a relatively low pathogen count; not as having a low organic load. To the municipal water treatment plant, this water would be considered dirty, but all of that "dirt" is flavor. However, the low pathogen load is important because in this case, the ultrafilter will not only retain flavor molecules; it will also retain bacteria, molds, etc., since those are also too big to go through the holes. Both pathogens and flavor will be concentrated, so this is a process which is good for waste streams that are relatively low in pathogens and where the flavor concentrate will ultimately be cooked.

Ultrafiltration is very widely used in the food industry for a variety of purposes. It's used to clean up certain waste streams, and it's also used to separate streams into more than one fraction. For example, in the cheese industry, the liquid whey has two major components: protein and milk sugar (lactose), each with separate markets. Since sugar is a small molecule and protein is a huge molecule, it makes sense to use a membrane with holes large enough to let sugar pass through, and small enough to retain protein.

Ultrafiltration is part science, part art. Each type of process water is different, and deciding which types of membranes will work in a particular situation requires experimentation. A good example is our work with clam post-grind wash water. We used a spiral wound cartridge with a 30,000 molecular weight (mw) pore size. That means that the pores were designed to retain molecules of 30,000 or greater molecular weight. Flavor is composed of small molecules, not large ones. One of the problems with multiple washings of clam meats and certain other seafoods is that the flavor goes down the drain and the remaining meat has texture but no flavor. (That's how surimi is made — the minced fish flesh is washed until all flavors, pigments and oils are gone and all you have is a bland, white, fish background against which 3% crab meat will show up.) The molecules that carry flavor, such as free amino acids, are much smaller than 30,000 mw. Theoretically, they should wash out through the pores and only relatively flavorless chunks of protein should be retained. But now we come to the art part of membranes. What happens in a membrane is that for the first second or so, everything happens the way theory predicts. Then a film forms over the membrane, composed of the organic molecules in the water that is being filtered. The film then becomes the true membrane. The holes in the membrane may be large, but the film may only let through very small molecules. This is why you need to experiment.

We believe that ultrafiltration has a future in seafood processing; particularly where there are cook waters or wash waters carrying large amounts of flavor. As of now, we know of no one using this technology in this industry. When we showed our ultrafiltered clam flavor to some flavor companies, they loved it. They mentioned how clean and how unique it was.

However, they also asked if they could purchase the flavor in a more concentrated form. Ultrafiltration concentrates, but not really enough for the marketplace. What it does is take a watery flavor, which has no use, and concentrate it to about a 10 to 20-fold concentrate, enough for chefs to use with relatively little dilution. We hired a product development specialist who used our flavor in both a chowder and in a stuffed clam. In the chowder, our product was added as 10% of the total recipe . In the stuffed clams, our product was added as 21% of the recipe (along with 40% water to dilute it). In both cases it made for delicious dishes.

Even if the flavor produced from wastewater is of relatively low value, you might clean up that waste water stream sufficiently to relieve your surcharges from the local waste water treatment facility. For example, the post-grind wash water at most clam plants, although a relatively small quantity, contributes the most BOD to the plant's waste water. Similarly, the tiny amount of cook water generated by most sardine plants may contribute way more than its share of pollutants to the plant's effluent. If the plant is under pressure from the municipality to clean up its effluent, the fact that the flavor produced from these small but very polluting waste streams is of low value may be irrelevant. Sometimes you can save more money cleaning up your waste water than you could possibly make out of a flavor. If this is the case, you may be better off selling the flavor for very little or even giving it away.

Here are the names of three companies manufacturing seafood flavors in our region (even the one in Illinois has at least one facility in New England) who might be willing to work with processors or their raw materials. These are not seafood processors who turn their own wastes into flavors, since we assume (perhaps incorrectly) that those would not be interested in assisting the competition.

- Coastal Creations, Inc., Stuart A. Littlefield
  369 King Street, Oxford, ME 04270 (207) 743-6444
- Ocean Cliff Corporation
  P.O. Box 417, Glenview, IL 60025-1552 (847) 729-9074
- St. Ours & Co.
  P.O. Box 566, Norwell, MA 02061 (781) 331-8520

Safety note: If you use organs such as livers or roe for flavor, please note that

Even if the flavor produced from waste-water is of relatively low value, you might clean up that waste water stream sufficiently to relieve your surcharges from the local waste water treatment facility. Sometimes you can save more money cleaning up your waste water than you could possibly make out of a flavor. If this is the case, you may be better off selling the flavor for very little or even giving it away.

Nutraceuticals are hybrids between foods and drugs, and the marine world is rich with chemicals which are of potential high value either as drugs or as nutraceuticals. Nutraceuticals have been a minor boom to seafood processors and a major boom to the entrepreneurs who make and market the supplements.

these organs tend to accumulate toxins and pollutants. One reason why clams have been so popular for flavor manufacture is not only that Americans like clam flavor; it is also that the clams processed for meat (usually ocean quahogs or surf clams) are harvested from deep waters, sufficiently far out to sea to be free both of industrial pollutants, such as dioxins and PCBs, and of natural pollutants, such as red tide. At least some deepwater species of crab, such as Jonah crab, are equally clean, and the livers can be used for flavor. This is not true of shallow water dwellers, whether they be crabs, lobsters, fish, scallops, or mussels. Since mussels stay in one place, it is easy to test their waters or to test a small sample of product to make sure that they are safe. But mussels are the only ones on the list which are immobile. Remember that the muscle meat of the species listed above may be safe to eat year round, while their organs may be contaminated by seasonal toxins such as red tide, or by other pollutants. To prevent illness, one should not start a business based on the organs of these animals without talking to experts on seafood product safety and setting up a regular testing schedule for the material you hope to use.

Pharmaceuticals and nutraceuticals:
Nutraceuticals are hybrids between foods and drugs, and the marine world is rich with chemicals which are of potential high value either as drugs or as nutraceuticals. Nutraceuticals have been a minor boom to seafood processors and a major boom to the entrepreneurs who make and market the supplements. Shark cartilage, chitosan, and fish oils (discussed in other sections) are sold as food supplements, which means that they fall neatly between foods and drugs and are not (currently) overseen by the FDA. This is not great for consumers, who pay high prices for supplements which can be useless, of unpredictable strength, or even toxic. This is not to say that there are no effective chemicals in seafood which can powerfully affect human health. Each year dozens of papers are written by serious researchers who have isolated chemicals with potential for fighting cancer, offering pain relief or anesthesia, or activity against specific pathogens from marine creatures. These creatures are more likely to be invertebrates than vertebrates, they are more likely to be tropical than temperate, and most of them are highly unlikely to appear in a Northeast processor's dumpster. While there's no doubt that the seas (like the land) are full of curative compounds, what are the chances that something that is in your dumpster will turn out to be an important drug?

One promising and exciting new drug has been isolated from dogfish livers and stomachs. This is called **squalamine**, and it is currently undergoing clinical trials testing it against ovarian and breast cancers, as well as other solid tumors. And, it may have potential in macular degeneration, rheumatoid arthritis and psoriasis. But, to quote from email we received from one of the researchers (at: info@magainin.com), "Squalamine was initially isolated from the livers of *Squalus acanthias* for preclinical studies. We obtained it from discarded livers (kept cold) from fisheries on both East and West coasts. The material we are now using is synthetic… However, we have just published an article in the Journal of Natural Products describing the presence of other active molecules related to squalamine in dogfish liver. I suspect that the article might stir up some interest from those interested in studying those molecules, since purification of these substance is a far easier task than synthesis, in the short run."

Researchers may want to purchase byproducts over the short run, but for high quality, high priced medical products — particularly those that will be injected into the body where absolute purity is a must — they will always be looking for ways to synthesize them. In fact, one of the triumphs of modern chemistry is considered to be the greatly reduced time between the discovery of a new molecule and its synthesis.

An extract from the blood of horseshoe crabs, LAL, is an important molecule for human health. The crabs are returned to the ocean, where most survive, and the LAL is used to detect toxic substances produced by certain bacteria, either in human body fluids or in pharmaceutical products. LAL is not used inside the human body; this may be why FDA is willing to go with a product coming directly out of an animal. Or, it may be a really tough molecule to synthesize. Or, the market price for LAL may not justify synthesis.

To return to the nutraceutical markets, there is an annual meeting on dietary supplements, natural medicines, and food for vitality, called the Vitafoods International Exhibition and Conference. Information on upcoming meetings is available at www.vitafoods.co.uk or by emailing vitafoods@cornwall.net. There are probably meetings in the U.S. as well; the Vitafoods International Exhibition is worldwide, and gets good reviews.

Roe: Compared to other nations, Americans are relatively uninterested in roe. America is now filling with immigrants from nations who have kept their taste for fish eggs, and each nationality (and sometimes each region) has its own way of preparing roe and its own favored species of roe fish. Americans, and particularly northeasterners, assume that caviar — "real" black caviar from sturgeons — is everyone's favorite. But, in fact, many nations prefer red caviar from salmon. In the Alaskan salmon roe season, different regions of a single country like Japan, may each send their own technicians to work in processing plants preparing roe to their region's specifications. At the risk of grossly oversimplifying this subject, here is a general overview.

Roes are either prepared whole in their membrane or taken out of the membrane and processed loose. The process used is sometimes a function of the type of fish and of roe sack thickness. If the sack is too thick for salt or drying to penetrate, the eggs must be taken out for treatment. It is also a matter of taste. For example, sturgeon caviar is processed loose. Salmon roe destined for Eastern European tastes is always loose, while Japanese markets take the same roe both loose and in the skein.

Roes can be dried, salted, smoked and canned, although generally, only canning really safely preserves the product. Other roes are frozen, or refrigerated if the holding time will be short. Roes are also often dyed, a fairly rare process in seafood. Low quality jars of lumpfish roe usually have eggs that have been dyed either black or red; presumably, because these colors are more acceptable to customers than the true color of this roe. Flying fish roe (known as tobikko in sushi parlors) is often dyed the kinds of colors that would appeal to a punk rocker, with a bright chartreuse being the most popular. Because this is a fairly bland roe (it's the crunchy texture that is appealing), it is often flavored and the color may signify the flavor. For example, chartreuse tobikko is often flavored with wasabi — the Japanese horseradish that is also usually dyed green.

The seasonality of roe development makes caviar more complicated to deal with than organs like skin or muscle. Not only is the roe of each fish species different, the roe of each species goes through a cycle of maturation and may only be at its peak for a short time. Wild salmon roe is popular not only because it is beautiful and delicious, but also because the time-table that each species follows as it swims up rivers to spawn permits humans to grab them at that specific point in the river where the roe is optimal. At first the eggs are small and not so tasty. Later, at maturity, the eggs develop a hard shell, which makes them less pleasant to eat. But in the middle they are just right. For this reason, connoisseurs of salmon caviar will request the eggs of chum salmon taken halfway up the Yukon river.

For the American market, processors usually use 3.0 to 3.5% salt. The Japanese market wants 2% salt or less. The Russian market will accept higher salt but prefers the roe of pink salmon. Shrewd marketing is often the key to success. One Alaskan processor of Yukon chum roe, faced with a poor market in Japan, hired his own rabbi for kosher certification, and peddled his roe profitably in New York, Miami, Jerusalem, Kiev and Paris.

Alaskan processors also sell **salmon milt** (the sperm sack of male salmon), although Americans in the lower 48 states are less likely to have seen that product.

That northeastern processors discard roe is wasteful, but realistically, unless you can develop a specific ethnic market that accepts the roe with minimal processing, the complexities of roe handling are simply too much for small processors to take on. On the other hand since well-processed roe offers a big profit margin for a product that sells by the ounce, roe presents an opportunity for a small specialty business. To get an idea of the type of business that can be built from roe, visit the website of Carolyn Collins Caviar at www.collinscaviar.com. This Chicago-based business handles fresh water domestic caviars, and presents them as deluxe items at very high prices.

Another potential stumbling block is the fact that

our roes are so under-exploited, no one knows their value. Here are a few suggestions which interested processors might use as starting points.

Korean markets are interested in roe-in whole flatfish. The head and tail are cut off, leaving the roe in the body cavity. This is called a **"karimi"** cut. The price will vary with the ripeness of the roe, but even non-ideal roe may bring a premium. Find a buyer and ask him/her to show you how to cut it.

Some Asian and Middle Eastern markets sell dried whole roes still in the sack, often encased in wax. Middle Eastern buyers refer to this as "butarga", "boutargue", or "batarekh". Claudia Roden, who is regarded as the foremost contemporary authority on Middle Eastern food, writes about making butarga in her 1972 classic "A Book of Middle Eastern Food" (Alfred A. Knopf, Inc.) and in the more recent "The Book of Jewish Food" (Alfred A. Knopf, Inc. 1996). She recommends either fresh or smoked whole roes of cod or gray mullet. Gray mullet was the preferred species but has now been mostly supplanted by cod. The roes must be intact within the skin. If smoked, they are simply air-dried. If fresh, they should be rolled in salt and dried on absorbent paper until they stop exuding liquid, then air-dried. Obviously, since Northeast cod are gutted at sea and the organs dumped, you would have to arrange with fishermen to save the roe and bring it ashore. Or, interested fishermen, with limited fishing days at sea, might want to try to sell roes of any species caught. Roe — even as butarga — has a sufficiently high value that it might be worth investing in a home low-temperature air dryer. Since the roe season is short, it might be possible to freeze and thaw the roes prior to drying. Test this for each species before freezing vast quantities.

In Alaska, where cod are brought into processing plants in the round, both the whole roes and the milts (sperm) of cod and pollock are exported to Asian markets, without drying. The milts are sometimes called "soft roes". In the Northeast, where little market research has been done on any of these organs, it would be worth testing samples from all groundfish species in Asian markets. These markets might also buy maws, stomachs and other products of the same species, so if you visit a buyer, take a variety of organs.

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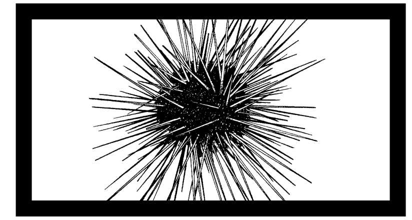
Rubber work gloves of sea urchin worker on the Portland waterfront. Photograph by David Gavril. 1993.
© Salt Institute for Documentary Studies, Portland, Maine, 2000.



Specialty Markets

Asian immigrant populations in North America have increased significantly in the last ten years and many have settled in northeastern US and Canada. Unlike the old Chinatowns, the new Asians are of diverse origins and backgrounds.

We have Vietnamese, Cambodians, Chinese Hong Kong expatriates, Japanese, Korean, and Filipino immigrants of all classes, and many more. The two things that they all have in common is that they tend to settle in communities together, and they love seafood.

This opportunity brings challenges. Selling into Asian markets may present a language barrier. Words may not have the same meaning to both sides. Whenever possible try to see a sample or at least a picture. Retailers or brokers may know what they want to sell, but they may not be able to tell you how to process that product and, in fact, they may not know how to process it. A good example of this is fish sauce.

Another challenge in selling to Asian clients in the U.S. is their strong preference for buying everything from their home country – even when the price is higher, and even when the item from the home country originally came from another country. However it would be worth it to try to locate their suppliers. The main point about products with potential for

Anyone who wishes to sell to Asian markets must be prepared to do their homework, and should be warned that what will sell to one nationality — or even one region — will not necessarily sell to another. Although exporters need to know exactly what each country wants, in this country, many markets sell to mixed Asian populations.

Asian markets is that no one of them alone may be worth spending the time required to make the contacts needed to sell them, but there are many of them, and all together they may be well worth your while.

ETHNIC MARKETS (Including Live Product)

In processing plants in Alaska, parts of cod are processed for sale to Asia which New Englanders normally throw into the dumpster. Maws, stomachs, roes and milts are all shipped. In the Northeast, shipping costs are higher and catches are lower, so it is probably unrealistic to expect to export these products. But there are Asian markets in the Northeast available to those who are willing to take the trouble to seek them out and learn their eating and buying patterns. The challenge is that Asian markets are diverse — as diverse as the many peoples who compose them. Anyone who has gone to both Chinese and Japanese restaurants knows how different they are; Korean or Vietnamese or Thai or Filipino restaurants are all different, as well. In fact, not only is a vast country like China composed of regions with different eating habits; even a small country like Japan has regions with different eating habits due to centuries of difficult travel and insularity. Those who wish to sell to Asian markets must be prepared to do their homework, and should be warned that what will sell to one nationality — or even one region — will not necessarily sell to another. Although exporters need to know exactly what each country wants, in this country, many markets sell to mixed Asian populations.

Heads: Heads only sell if they have a fair bit of meat at the collar. The back of the head should look like a steak — not like cut away bone (see photo), The more meat the better. If you can get 50¢/lb. for the entire head, maybe it's worth leaving meat on it, and making the fillet a little shorter, or maybe it's not, but at least you now know what is meant by "head".

Fish sauce: Any Asian grocery store will sell many varieties of fish sauce. That doesn't mean that they can say how it's made. Fish sauce is a mix of whole and partial fish or fish and crustaceans, which has been mixed with 20% of its weight in salt, and left to digest and ferment. The digestion comes from enzymes in the raw flesh, heads and viscera; the

fermentation comes from microorganisms present in the mix. Like wine, the unique and varied flavors of fish sauce come from the raw ingredients, from the process, and from aging — fish sauce usually sits around for six to twelve months before the liquid portion is poured off and bottled for sale. It doesn't spoil because of the high salt content.

Fish sauce is estimated to occupy a $50 million annual market in North America, possibly a comparable market in Europe, and a far larger market in Southeast Asia where it actually provides a significant fraction of the protein in the diets of poor people. Almost all of what is sold in the U.S. is imported from Southeast Asia; however, Asia is running short of fish, which might present some interesting opportunities. Two Asian immigrant entrepreneurs are manufacturing fish sauce in Vancouver and Atlantic Canada, with mild success; there are no U.S. manufacturers. Fish sauce poses pitfalls for potential manufacturers. First of all, it's the kind of product (full of wastes, guts, mixed species, uncooked) where the FDA might give you a really hard time. Second, in it's Southeast Asian homeland, it's entire aging period can take place out of doors; our climate would necessitate indoor storage and this would increase production costs enormously. Third, like wine, there are certain flavors that manufacturers aim for and that take some expertise to achieve. Finally, when housewives shop for it, they look for brands they recognize. The safest way to embark on a fish sauce venture is to form a relationship with a well-known brand running short of raw material, and supply that raw material (which could include wastes from a variety of processing plants), ground and mixed with 20% salt as a preservative.

The retail price for fish sauce (for a 660 ml bottle) ranges from about $4.00 for a premium product with lobster to about $2.50 to 3.00 for a more ordinary product.) The initial stages of the process could take place as the material traveled East, and when it returned West, it would bear the label and brand name of a known commodity. You would need the services of a broker who could make that connection for you, and we list one experienced and reliable broker with excellent language skills here

- Howard Yip, General Manager
  2075 Warden Avenue, Unit 25
  Scarborough, Ontario, Canada M1T 3R1
  Tel/Fax: (416) 321-8959 Cell: (416) 720-8829

Fish paste is actually a complex category of products, and their manufacture is varied. Fish paste can be made by grinding salted/marinated fish and shellfish (usually small fish and small shrimp) and letting them ferment, but not to the point where the liquid and solid fractions separate, as they do in fish sauce. Or it can be made of the solid fraction left behind in fish sauce manufacture. Other fish paste products are cooked/fried fish and shellfish, where the ground material would be salted and mixed with various spices and other aromatic ingredients. Although the standard shellfish is shrimp, squid can also be used. Fish paste products come in jars, cans and bottles. Like fish sauce, fish paste is generally marketed under brand names that are traditionally recognized in their countries of origin. The retail price per pound is about $4.50.

Fish balls: A simpler product with huge markets that is widely produced in North America is fish balls. If you visit Asian markets, you will find fish balls, usually unbranded and minimally labeled, in both the refrigerated and the frozen sections. Look for fish balls of about one inch diameter. In the United States, the FDA has certain basic requirements for the food label. There is, however, an exemption from nutritional labeling for small businesses. This information is available at the FDA website: http://vm.cfsan.fda.gov_ Fish balls can be made of fillets or fillet trim (maybe of frame mince) of a variety of fish and non-fish seafood (such as squid), mixed with carbohydrate fillers, such as rice flour. The ball shape is molded in a machine. Fish balls generally sell in 200 gram (about half a pound) packages for about $2.25 retail, which amounts to about $1.10 to the manufacturer.

Fish balls are not exactly like the fish cakes that we are used to. Fish cakes in the West are nothing but flakes or bits of fish, held together with egg or other binders, and mixed with spices and — according to tastes — potato or other starches. Asian fish balls are at least partly gelled (in fact, they are often referred to as fish jelly products), and the way they are manufactured is either from surimi or, if they are made from mince, that mince is put partway through a surimi-type process. In surimi, minced fish is extensively washed to get rid of the soluble protein, lipid, flavor and pigment, so that what is left is a bland, white protein which will form a strong gel. The ideal fish ball would be made of surimi, but since surimi is an expensive starting material, most fish balls are still made of minced fish. Fish ball manufacture is nowhere near as demanding as surimi manufacture, but the mince needs to be moved at least partway towards gel and whiteness.

The classic procedure for making fish balls is first to take the mince and, if it is insufficiently fine, to put it through a second mincing with a finer mesh size. The fine mince is then mixed with water, salt (3 - 5% of the weight of the mince), and taste enhancers, then put through a mechanical mixing process. Different countries have developed different mixing machines for this stage. The mix must be kept cold. When mixing is complete, the product is formed into balls, cakes, etc. This is usually done by machine. To encourage gelation, the product then sets; usually in water, either for two to three hours at 28 - 30° C, or for twenty to thirty minutes at 40 - 45° C. It is then cooked, which also serves to pasteurize the product. Cooking is usually done in water at 90° C for at least 20 minutes (depending upon size); the temperature of the water is kept below boiling to keep the balls' surfaces smooth. It can also be steamed. In this classic procedure, the product is helped to gel by the addition of the large amount of salt and by the mixing and subsequent soaking. However, in some more modern factories, the manufacturers have added a leaching step (washing the mince in cold water) to increase whiteness and gel formation. Check www.np.ac.sg/~adp-nitec/showcase/AFball.html for a description of a modern fish ball plant in Singapore. In this case, the starting material is surimi.

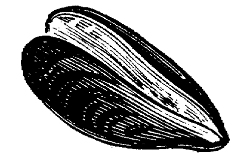
Live product: Chinese, Vietnamese, Malaysian and Thai immigrants like live fish/seafood and will pay about double the price for live product. Since live product is more costly for the market to hold and display, this is not a guarantee that you will receive double for live fish, but even if you got just a fraction more, you are getting it for the entire fish, head, guts and all. The Japanese, however, tend to prefer chilled, except for the sushi/sashimi markets.

The live seafood market in the U.S. and in the Northeast is expanding, thanks mostly to upscale Asian restaurants. The difficulties are capturing, transporting and maintaining the seafood alive, and locating the best markets. Some sorts of seafood are trickier to keep alive than others. Most shellfish are pretty easy to keep alive; at least for a while. (It's harder if you're planning to ship them to Japan.) Finfish are more difficult, but an increasing number of fishermen and brokers are doing it. For example, the Cape Cod Commercial Hook Fisherman's Association, in Chatham, MA, is currently completing a large live fish holding facility, and an increasing number of their members are outfitting their vessels with live tanks.

Globally, there has been a huge increase in interest in shipping live seafood — often over great distances. The first (and free) thing to do to begin researching the live market is to join an email group called "Livesea". The person running it has been Brian Paust of the University of Alaska, who can be contacted by email at ffbc@aurora.alaska.edu. Livesea has run an annual conference on shipping and marketing of live aquatics, and proceedings from prior conferences are available. INFOFISH, published out of Malaysia, offers their Technical Handbook No. 3, entitled "Transportation of Live and Processed Seafood" for $6 (it's easiest to contact them by email at: infish@pc.jaring.my). Also, read the three (relatively) recent articles on this subject in the Suggested Reading list.

The technology used varies, depending upon the species and the distance shipped. Keep in mind, however, that a number of northeastern products have traditionally been shipped live long distances, ranging from elvers and sea urchins going to Asia, to lobsters going to Europe during the winter holiday season, so that this is not a totally new concept. What may be new is the extension of this concept to less familiar species, ranging from shrimp to flatfish. While the technical challenges of keeping the animals alive and well are often paramount in the beginner's mind, the venture can also be wiped out by the same problems that every exporter has to deal with: customs (live animals present more of a threat to the health of local stocks than frozen fillets do), shipping schedules and unexpected holdups, and making sure that the distant buyer is both honest and solvent.

Coast of Maine's *Penobscot Blend Organic Compost* made with composted salmon and mussel shells.
Photograph by Kate Philbrick. 2000.



Starting a Byproduct Venture

People usually get interested in byproducts for somewhat unpredictable (although often perfectly good) reasons. It's rare that someone looks at all the great stuff in their dumpster and says, "Hey! That's all potential product! I'm going to do something about that." It's more common to see 16 ounces of fish fertilizer selling for $7.95 at the garden center, or meeting an immigrant who tells you how much s/he's missed eating roe or maws or livers. So you get interested, and you start poking around, and you make a bit of the product and before you know it you're hooked. You're into byproducts.

The first time you try out a new process in the processing plant, don't worry about the time it takes. The first few times your workers take out roes intact, or cut maws, they'll probably mess up the product, and take a long time doing it. That's when most people decide that it doesn't make sense to produce this new item and that they should keep their lines running the way they always did. Well, every process goes slowly and poorly at the start. Remember the first time you cut a fillet? When your workers get used to the new process, they will work as fast and be as productive on the new products as they are on the old ones.

Once you decide to turn your wastes into byproducts you need to maintain an acceptable level of quality control. For organs such as roes or livers, destined for human consumption, that level of control may actually be more rigorous than what you use now for your primary products. The first question you need to ask...is, can you keep it in good shape for the length of time it will take you to process/stabilize/distribute it?

Byproduct quality: As long as you look at the materials we're discussing as wastes, you don't have to worry much about quality. You may have to keep the dumpster in cold storage over the weekend in July, if the pet food guy is going to pick it up on Monday, but it's basically his problem, not yours. If the neighbors don't complain, you're okay. Once you decide to turn your wastes into byproducts, however, you need to maintain an acceptable level of quality control. For organs such as roes or livers, destined for human consumption, that level of control may actually be more rigorous than what you use now for your primary products. In the case of fertilizer or gelatin, you can probably be a bit more lax. However, any odor or decay will lower the value of your product and may actually ruin it. One of the biggest gripes about fish fertilizer is that it smells, and many current distributors would switch brands in a heartbeat if you could guarantee an odorless product. There is only one use for rotten material, and that is compost. The first question you need to ask yourself about the byproduct you are considering is, can you keep it in good shape for the length of time it will take you to process/stabilize/distribute it?

Quantity: Marketing and market research play big roles in determining what customers want and whether there's some reasonable fit between what you are offering and what they are demanding. Another problem is that many products are seasonal, while the demand is year-round. One of the reasons why the fish produced by aquaculture are so successful is that they can be supplied to restaurants year-round in whatever size they want. Many potential byproducts end up in the dumpster because they are seasonal and in such (relatively) small quantity that processors decide that it's just not worth their while to market them. That's why so much byproduct development is done by independent entrepreneurs. They can collect the material from many processors, thus getting more quantity and — where it's useful — more variety.

Quantity may be the least of your worries. Ultimately, quantity counts, but at the start, the primary concerns are whether there's a market, what that market wants, how deep is the market, whether they are satisfied with what you're producing for them, what will they pay and what are the startup costs for large-scale production. If it's good enough, either you'll start to specialize in the species that generates that byproduct, or you'll buy the byproduct from other processors, or you'll team up with someone who will take what you've developed and run with it. You'll need to start small anyway.

Scaling up: The best way to learn about and develop byproducts (except for compost) is to start out in the kitchen. And, you can produce sufficient product to send to potential buyers, have analyzed for nutritional value and/or pollutants, and test for shelf life, storage conditions, and so forth. The problems come when you scale up. One problem that wipes out a lot of startup byproduct ventures is the failure to think of the costs of each step of a process. For example: you decide that you'd like to make fish fertilizer. You do your first small batches in a double boiler over a stove burner, and you figure that you can afford a jacketed kettle and a hot water heater, so you decide to scale up to the next level. You forget that in your small batches, you were chopping the fish up with a knife and that now you'll have to buy a real grinder. You learn that although hot water heated the batch in the pot pretty well, now that you have more than a hundred pounds of cold ground fish in the jacketed kettle, it's taking so long to heat up to digestion temperature that you'll have to buy a steam generator. The steam generator turns out to require an electrical hookup that your system can't support, so you have to shell out to the electrician. You find that you need a pump to get the material out of the kettle and to the deboning screen, and then to where it will be acidified, and you need some sort of mechanized screening device, because your initial method of screening, which was just to put it through some window screening, is no longer adequate. You need to choose a bottle and have labels designed and printed. After you get your little processing line hooked up, with pumps and hoses, etc., you realize when it starts to smell that you didn't design it for cleaning in place, and that there's liquid fish caught in all the crevices and it's rotted, and now you're going to have to pull the whole thing apart and redo it with higher grade materials and attachments. This is just one example, but you get the idea. The real problem is that if you could instantly sell thousands of gallons of the stuff, you could probably justify the costs of a large scale system. But very few people can increase their sales so rapidly. And, if you were to put in a large scale system without having worked the bugs out in a smaller one, you might waste hundreds of thousands of dollars instead of just thousands. So, despite the costs and problems, we would advocate for gradual scaling up. But we also suggest that, in any process, you try to envision each step of that process, no matter how simple, and think about what it will take to carry it out with larger amounts of material.

Unforeseen hazards: In addition to equipment costs and space, you may have to think about neighbors, regulations and permits. For example, if you process fish and keep your dumpster indoors and covered until the last minute, you are probably not creating too much odor. If you suddenly start cooking fish — whether it's for a human food product or fertilizer — you're going to generate a lot more odor. It may not be a bad odor, but the neighbors may object. A byproduct may also change what you put down the sewer. For example, all your solid waste may have been going into the dumpster. Now you've decided to

Be very clear about what you mean when you say something like, "good quality". You may wish to define conditions such as how old the product can be and how it must be kept and packaged. Your contract should include the right to return product that does not meet your specifications. Both parties, need to clarify each others' responsibilities: if the processor keeps it cold, but a third party transports it to you in a warm truck, whose fault is it?

make liquid fish fertilizer. You have some bad batches and you can't put liquid in the dumpster so you pour it down the drain. If the batches are big enough and you live in a community where the waste water treatment system is on the verge of inadequacy anyway, your material may drive it over the edge and you may find yourself not only unpopular, but paying heavy fines. This kind of problem can happen any time you change your operation. For certain processors, drying is an excellent method of producing saleable byproduct. But each state has different laws about air pollution caused by dryers. New Jersey, which has squid and clam processing wastes that would be perfect for drying, makes it so difficult to get a permit to install such a piece of equipment (and, worse, so easy to be shut down after installation), that it's easier for processors to just continue to throw out potentially valuable material. One can only hope that regulators will eventually recognize the ecological and economic benefits of byproducts and start working on ways to assist their manufacture rather than on ways to stop it.

Byproduct quality (the entrepreneur's side): Everything written above applies to processors, as well as to independent entrepreneurs. Independent producers of products that depend on processors' wastes avoid some problems but add others. One is guaranteeing supply and another is guaranteeing quality. There is, of course, a third, related problem, and that is guaranteeing price.

There are three ways that you can get wastes from a processor: you can charge to take them away; you can pick them up for nothing and save the processor disposal costs, or you can pay for them. Your choice depends on the price you expect to get for your product, and how much you're going to depend upon and demand from the processor. If you're a composter, and you have plenty of suppliers of raw material, and you're the only game in town accepting rotten or unconventional wastes, and you're producing a low value product, you'll have to charge a tipping fee.

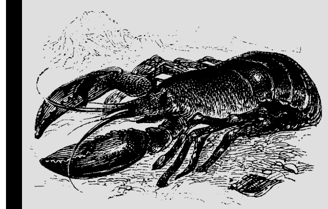
Free pickup may be financially advantageous to both parties, but it may be difficult to get processors to keep product in good condition or to give you a long range commitment, if they don't actually make any money on it. Unless you're saving them from a significant outlay, and you don't

expect anyone else to make them an offer on those wastes, your situation could be precarious.

Be very clear about what you mean when you say something like, "good quality". You may wish to define conditions such as how old the product can be and how it must be kept and packaged. Your contract should include the right to return product that does not meet your specifications. Both parties, need to clarify where each one's responsibilities end: if the processor keeps it cold, but a third party transports it to you in a warm truck, whose fault is it? Also, if you are getting product from several processors, you need a clear way of identifying each processor's containers. A number of companies manufacture inexpensive temperature abuse tags, which can be stuck onto each processor's container. These usually offer some time-temperature mix and will tell you if the product has warmed up unacceptably, but not when. There are also more sophisticated temperature recorders which will provide a printed and/or computerized record of when the abuse occurred and what temperatures were reached. A good place to look at what is available is the International Boston Seafood Show.

A few warnings: Entrepreneurs who become fascinated with a marine byproduct, but have not previously worked with seafood need to understand some important points before starting. Seafood is different from almost any other type of food in its:

Variety. Slaughterhouses process three types of animals; poultry processors handle another three. Big deal: they are all warm blooded vertebrates, and while some may have fur and some feathers, they are pretty interchangeable. Seafood comprises four phyla of animals. (A phylum is the next largest systematic category after a kingdom.) The four phyla included in seafood are chordates (of which vertebrates, including all the fish, sharks and rays, are a subphylum), echinoderms (such as sea urchins and sea cucumbers), molluscs (which includes clams, oysters, whelks, mussels, squid, and octopus), and crustacea, which includes shrimp, crabs and lobsters. The biochemistry and anatomy of the more or less 100 species comprised under the general heading of "seafood" is highly varied. No wonder that researchers keep finding extraordinary molecules in this zoo that show promise of curing every possible disease. Depending upon how you look at it, this variety can be either a dreadful stumbling block or a



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vast opportunity.

Fragility. To return to the meat analogy, seafood must be held at a lower temperature than meat, and spoilage is more rapid. One reason for this is that meat-producing animals maintain very high internal temperatures: close to 100° F. If their flesh is cooled to, say 40° F, all of their biochemical processes slow down enormously. But seafood — especially seafood from cold oceans, such as we have in the Northeast — consists of mostly cold blooded creatures whose body temperatures are close to that of the waters they inhabit. For some, putting them at 40° actually warms them up. Others are cooled, but not a lot. Their biochemistry (including the reactions of decay) goes chugging along. The flesh of most fish is softer than that of meat animals, more easily bruised and torn, providing entry for microorganisms. Some fish have a specialized biochemistry of decay, where extremely smelly compounds are formed over relatively short periods of time.

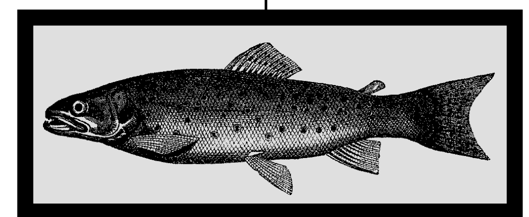
Potential for toxicity. Although many people act as though eating raw fish was a particularly bizarre form of Russian roulette, fish flesh is less likely to cause salmonella or other common types of food poisoning than poultry and even some vegetables. However, fish and particularly fish byproducts do pose some potential problems. Humans have polluted the oceans with very long-lived toxic wastes, and these have polluted creatures living in the oceans; particularly long-lived bottom dwellers. Maine has issued a health advisory on dioxin in lobster tomalley (livers) and Northeast dogfish, skate, and monkfish livers are very likely to contain PCBs. Fish viscera and other processing wastes from the Great Lakes may contain not only PCBs but also Mirex and other toxic agricultural chemicals. Shellfish can be contaminated with neurological poisons produced by algal blooms. Paralytic shellfish poisoning (PSP) from red tide is common but luckily is rarely lethal. Domoic acid produced by algae and then taken up by mussels has caused severe neurological symptoms and then long lasting (perhaps permanent) memory loss in Canadian consumers. Most bivalves like clams and oysters can be dangerous, but scallops are not associated with any possible danger in most peoples minds, since we only eat a scallop's adductor muscle. If other portions of the animal are eaten, then they must be tested regularly for PSP, etc. Some animals that might be expected to be contaminated turn out to be clean. For example, the large, deep water clams seem to be clean, and these are the ones that undergo processing during which byproducts are generated.

Before investing in a facility to process a novel byproduct, send samples of it out for a battery of tests, including heavy metals and a chlorinated hydrocarbon screen. This latter test will pick up PCBs as well as the DDT family and several major toxic agricultural chemicals. Remember that with transient toxics like red tide, the fact that an animal is clean once doesn't mean that it will always be clean. Animal feed doesn't allow a higher inclusion rate of toxics than human food; in fact, the law allows a ten times higher level of harmful chemicals like PCBs in human food than in

animal feed. All of these chemicals are invisible to the naked eye and don't affect flavor. Test your product if you want to avoid litigation.

Transient fisheries. We are living in an age when overfishing and water pollution have led to boom and bust fisheries. In the nineteenth century, one could have made a huge investment in cod byproducts (in fact, many people did), knowing that cod were here to stay, and the investment would be amortized over decades of use. Unfortunately, this is no longer the case. The traditional fish of our region – groundfish, redfish, scallops – are now being harvested in small quantities, while less traditional species are going from underutilized to overfished in record time. In addition, many fisheries are seasonal. A plant that does nothing but process Northern shrimp or sea urchins will be idle most of the year. And, finally, the animals themselves change as they go through their annual cycles of spawning and of plentiful versus scarce food.

Note that many of these warnings apply only to wild as opposed to farmed fish. However, most of our seafood species and most of our seafood tonnage in the Northeast is still wild.



Appendix

A Canadian Perspective on Asian Food Markets

Consultant:
Nilo Cachero, NC Info Management
1503 Michaelsem St.
Orleans, ON K1C7C3, Canada
(613) 837-6958
nilo@compuserve.com

a) Common names

The table contains a list of byproducts resulting from traditional processing of various species, along with their Latin and common names.

There are no other common names for the species on the list since they are all from North Atlantic. Asian consumers who actually are familiar with the species (e.g., the Japanese, Koreans, etc.) normally refer to them by either using the North American common names or some generic names in their own specific languages. For example, UNI is the Japanese generic name for sea urchins.

b) Market potential of byproducts

Except for fish heads, the byproducts listed in the table **do not have direct market potential in the Asian food markets**. In their original forms, as they come out of the processing plants, these byproducts or even their equivalent from Asia, are not normally sold in the these markets. Although there may be odd individuals willing to purchase some of the products, the "market" would not likely be feasible at all from the businessman's point of view, whether as a processor or a marketer.

It follows, therefore, that among the existing importers, brokers or distributors of seafood or any food products for the Asian markets, none would likely be interested in buying the products. In other words, they would not qualify as "ready buyers" for the byproducts under consideration in this report.

The market potential of the byproducts, except again for fish heads and perhaps even fish cheeks, would only exist as **raw material** substitutes for producing products normally found in the Asian food market. It is suggested that, as far as the Asian food market is concerned, there are only three product types for which these byproducts could possibly qualify as raw material - namely, **fish sauce, fish paste and fish balls**.

The byproducts and their market potentials are summarized in the chart below.

The potential buyers for these

By-Products	End-Products for Asian Food Market			Other End-Products
	Fish Sauce	*Fish Paste*	*Fish Balls*	
Jaws, strips, cuttings, trimmings, ribbons, frills	Yes	Yes	Possible	
Entrails, viscera, ground paste, skirts, liver, bellies, ink, beaks, guts	Yes	Yes		
Racks, bones	Yes	Yes		
Fish roe				Could be sold to "specialty processors"; not typically consumed by Asians
Crustacean shells				Could be used to produce chitin, chitosan fertilizer, etc. Processors ar not easy to find, and marketing is a big challenge due quality problems originating from the "waste" nature of the raw material
Fish skins				Existing leather producers are potential buyers

byproducts could be found among the processors themselves who are mostly located back in Asia. If northeastern US seafood processors were to pursue these potential buyers, they should target those that already have well-established brand names and distribution network. This was one conclusion of a recent feasibility research on fish sauce and fish paste which this writer conducted on behalf of a seafood processor in New England and another one in Atlantic Canada. Their interest was, and perhaps still is, to find a way of producing a line of fish sauce and fish paste products in partnership with a major producer in the Philippines.

Fresh or frozen fish balls are already being produced in North America. However, there is only a slight possibility that current fish ball producers in the USA or Canada would be interested to use some of the byproducts as raw material, the reason being that they normally use top-quality fish meat. It remains to be seen if the byproducts under consideration in this project would meet such standard.

Some of the end-products listed above (e.g., shells) are not of particular significance to the "Asian food market" as defined in this report, and are therefore mentioned only in passing. They are sold to the "general" consumer market under different product categories, e.g., fish leather for leather accessories or fish oil, chitin/chitosan and other marine extracts under food supplement, pharmaceutical or "nutraceutical" product categories.

Consumer-ready fish roe products are not significant food items found in the Asian food retail market. Those that appear in stores usually have been processed in very specialized manner, e.g., salted, marinated, etc. They would account for very small part of the seafood segment.

On the other hand, Japanese-style fish roe preparations are seldom sold in retail stores but are mostly consumed in Japanese restaurants or fast-food counters serving sushi. This is a highly specialized market. Some of these sushi products may actually be prepared fresh in North America, but it is believed that most are air-shipped daily from Japan. Shipments are normally in mixed containers consisting of fish roes and so many other sushi products. In talking to Japanese chefs and distributors, it would be a big, and probably impossible, challenge to supply salmon roe as single item to the restaurants or food-service distributors. In other words, importers, distributors and retailers do not buy sushi items individually but in predetermined mix packages.

c) Volumes, seasons, and prices of byproducts commonly found in Asian food markets

Fish heads

The volume of fish heads sold in these markets is virtually impossible to estimate. Some fresh fish heads sold in the stores are leftovers from the live/fresh fish counters. Others are delivered to the retail stores in plastic containers by fish wholesalers. Frozen fish heads, e.g., cod heads, salmon heads, are starting to appear up in some retail stores, but the volume is very small.

While the market size for fish heads is difficult to estimate at this point and may in fact be relatively small, it was apparent from talking to one major importer/distributor that there is potential to develop the market if supply can be organized.

Retail prices for fish heads range from C$1.00 to C$1.50 per kilogram in Toronto. This is equivalent to about U$ 0.70 to U$ 1.00 per kilogram. Generally speaking, similar price range can be expected in the USA. Assuming an average mark-up of 100% from importer to distributor/retailer, the expected price range to a US supplier could be U$ 0.35 to U$ 0.50 per kilogram.

Fresh fish heads could be packed in Styrofoam boxes with ice, just like shipping fresh whole fish or fillets.

Frozen fish heads are now sold IQF and delivered in 10 to 20-lb boxes.

It is important to note that a typical fish head sold in the market includes a considerable portion of the nape, whereas, a typical fish head "by-product" that comes out of a US fish processing plant may contain very little nape meat. This implies that to be able to supply the product, US processors may have to adjust their cutting process. Most importantly, this may add to the "yield cost" in processing their primary products.

Fish sauce products

In a study conducted by this writer in 1992, it was estimated that the market for fish sauce of all types in North America was worth about U$ 25 million

in import value. It is now estimated to be worth about U$ 40 million.

It is also estimated that about 99% of all fish sauce products are imported from Asia. To date, this writer is aware of only one fish sauce producer in North America using its own brand name, i.e., Atlantic Fish Sauce based in Newfoundland.

In the USA and Canada, the biggest hindrance to producing fish sauce products to replace or compete against imports is the HACCP, GMP and other processing and product regulations. Either the regulations or the inspectors/regulators themselves are not flexible enough to accommodate the processing of fish sauce. It has been suggested that to create a new fish sauce industry in North America, an extended pilot project should be conducted for the purpose of developing processing protocol to satisfy the HACCP, GMP or other requirements, as well as determining the commercial feasibility of such an industry.

It is worth noting that the current fish sauce market in Europe may be about as big as in North America. As well, indications from distributors and retailers are that supplies of fish sauce in Asia are starting to be tight due to a general depletion of resources and the changing weather patterns. Historically, the fish sauce industry in Asia was created as one way to make use of "excess" fish during peak fishing season. Today, there is not much "excess" fish to talk about even during peak fishing periods, and the long-term trend for fish prices is generally up. One major fish sauce producer sees a possibility of bringing fish sauce in bulk from overseas for further processing and bottling in Asia. All this implies a great market potential for a new fish sauce industry in North America, given the availability of the so-called "underutilized" species (e.g., excess herring and other pelagic species) as well as waste byproducts.

Fish sauce products are sold in glass or plastic bottles of virtually all sizes. There are numerous brands in the market with a few dominant ones. Asians from the Philippines, Vietnam and Thailand are the largest consumers of fish sauce.

From the processing point of view fish sauce products can be classified into "premium" and "standard" and "specialty" groups. These classifications, along with packaging and brand identity, are factors that determine relative prices. The following comments are based on what the producers would "claim" to justify price differentiation.

- ***Premium fish sauce***

Premium fish sauce would come from "good quality species" or "fresh fish only". Or, at the end of the fermentation process, only the top layer of the liquid (usually most clear, and free of solids) is used for bottling.

Most premium products are still sold in traditional glass bottles. Although more expensive, glass bottles are still more popular than plastic ones

In Canada, premium 725-750ml glass bottles retail at roughly C$ 2.50 to C$ 3.50 per bottle. C$ 1.30-C$ 1.75 would be the price range for 350-400ml bottles.

- ***Standard fish sauce***

Typically, this type of product would sell at 10-30% less than the premium products.

Theoretically, the raw material for this type could be "any fish" or "any condition."

- ***Specialty fish sauce***

In addition to using regular finfish species (e.g, anchovies, mackerels, herrings, etc), the "specialty" products would contain other "high-value ingredients" such as lobster, squid, crab, etc. Whether the product contains only the "aroma" of these high-value species, their extracts, or actual fermented animal like small shrimp is anybody's guess.

Prices for the specialty products could be as high or even higher than the premium products. Brand name recognition is a big factor for these specialty products. Normally, only the large companies are able to venture into developing new higher-return products.

Fish paste products

Most of the comments made regarding fish sauce also apply to fish paste products. The main difference is that the fish paste category is even more complicated and varied in terms of processing and market presentation.

Some fish paste products are produced through fermentation, but not to the point where the liquid can be separated from the solid sediment. Fish paste products can, in fact, use the sediment by-product of fish sauce processing.

Fish paste can also be produced by grinding salted/marinated fish (anchovies or similar small fish) and shellfish (typically small or baby shrimp).

Other fish paste products consist of cooked or fried fish and shellfish. Typically the ground material would be salted and mixed with various aromatic ingredients and species.

Fish paste products are packaged in jars, cans and bottles - all in various sizes and shapes.

Like the fish sauce products, the marketing of fish paste products are mostly based on brand names that are traditionally recognized in the "home" countries.

Following are retail price examples for fish paste products:

- C$ 4.99 - C$5.40 per 500gr glass jar containing cooked and "sauteed" shrimp paste:
- About C$ 3.69 per 340gr glass jar of cooked and "sauteed" shrimp paste
- About C$ 2.99 per 340gr glass jar of salted shrimp (not cooked)
- C$ 1.99 - C$2.50 3.40gr glass jar of for mackerel fish paste

d) Marketing structure

Live and fresh fish and shellfish

Large supermarkets "source" some products directly from producers or from local importers/distributors. Examples of these products are:

- Live mussels from PEI
- Live and fresh salmon from New Brunswick
- Various live/fresh fish from small freshwater fish harvesters all over the Eastern and Mid-western parts of Canada and the USA
- Live crabs and other shellfish from British Columbia and California.
- Live fish and shellfish arrive by air or by land.
- All the other live/fresh fish retailers source their products through importers/distributors. A list is provided.

Fully-processed seafood products

These products account for a large part of seafood consumption of Asian consumers in North America. They are sold almost exclusively in retail stores.

Aside from the fish sauce, fish paste and fish ball products, the other common marine-based products found in the markets are:

- Cured, fermented and salted small fish and shellfish in jars or cans of varying shapes and sizes
- Canned fish and shellfish of varying shapes and sizes
- Dried (salted or not) fish and shellfish in whole or in parts, usually in poly-bags, but sometimes sold unpacked in open bins (shipped in bulk)
- Various products belonging to the "surimi" category

Typically, each processed product type is marketed under numerous brands. For each type, there are numerous producers in the "home countries". There are very few dominant brands, and these are normally associated with large food corporations already very popular in the home countries, e.g, Thailand, Hong Kong, Vietnam and Philippines.

A typical processor produces a wide range of products. Brand or company recognition, rather than price, seems to be the key to marketing.

Most imports of fully-processed products arrive in "mixed containers". In some cases, large "consolidated" shipments of specific products first arrive in major ports such as San Francisco and Vancouver, where they are typically broken into smaller lots which are combined with other products as they are transported in mixed containers to other parts of the continent. In effect, the majority of products found in Toronto Asian food stores, or any stores throughout Eastern Canada for that matter, may come from New York and California.

Most retailers buy strictly from distributors/importers. Very few, if any, are large enough to import their own mixed shipments.

Most importers/distributors carry very wide line of products but they tend to specialize along national market segments, e.g., the Chinese, the Filipinos, the Vietnamese, etc. Traditionally, "home" country cultural affinity, family ties and loyalty are key to the entrepreneurial style of Asian food distributors, importers and retailers. However, a new trend is emerging whereby growing number of importers and retailers are serving customers of different nationalities at once.

Selected Fish & Seafood Product Buyers (Importers and Wholesalers) in Ontario, Canada

All Seasons Fisheries
3595 St. Clair Ave. E., Unit 15
Scarborough, ON, M1K 1L8
Tel: 416-265-7900 Fax: 416-265-1278

Allseas Fisheries Inc.
51 Six Points Road

Species	*Latin Name*	*Common Name*	*By-Products*	*Potential End-Products*
Salmon	*Salmo salar*	Atlantic salmon	Head	Fresh, frozen whole head with neck meat
			Jaws, belly strips, trimmings	Fish balls, fish sauce, fish paste
			Roe	Frozen and/or salted specifically for Japanese consumers; Fish sauce, fish paste
			Smoked cheek	Vacuum packed but not a normal Asian food product; Fish sauce, fish paste
			Skins	Leather material but not specific to the Asian market
			Canned bones	Fish paste
			Entrails, ribbons	Fish sauce, fish paste
Herring	*Clupea harengus*	Atlantic herring	Cuttings	Fish balls, fish sauce, fish paste
			Ground paste	Fish sauce, fish paste
Cucumber	*Cucumaria frondosa*	Northern sea cucumber	Viscera	Fish sauce, fish paste
Shrimp	*Pandalus borealis*	Northern prawn Cold-water shrimp Pink shrimp	Shells	Chitin/chitosan, protein concentrate, colorant
			Cook-water	No identifiable end-product
Haddock	*Melanogrammus Aeglefinus*	Haddock	Racks	Fish paste
Pollock	*Pollachius virens*	Pollock	Roe	Frozen and/or salted specifically for
			Boston blue fish	Japanese consumers; Fish sauce, fish paste
			Skins	Leather material but not specific to the Asian market
Cod	*Gadus morhua*	Atlantic cod	Ribbons, racks, entrails	Fish sauce, fish paste
Flounder	*Glyptocephalus cynoglossus*	Witch flounder Grey sole	Racks	Fish sauce, fish paste
White hake	*Urophycis tenuis*	White hake Red hake	Roe	Fish sauce, fish paste
			Racks, entrails	Fish sauce /paste material
Dogfish	*Squalus acanthias*	Picked dogfish Spiny dogfish	Cartilage	Freeze-dried powder usually encapsulated
			Liver oil	Encapsulated or bottled
			Entrails	Fish sauce, fish paste

Scallops	*Placopecten magellanicus*	American sea scallop	Skirt, frills	Freeze-dried powder, fish sauce, fish paste
Urchin	*Strongylocentrotus droebachiensis*	Green sea urchin	Shells	No known product
Crabs	*Cancer borealis*	Jonah crab	Liver	Fish sauce, fish paste
	Cancer irroratus	Atlantic rock crab		
			Shells	Chitin/chitosan, protein concentrate, colorant
Lobster	*Homarus americanus*	American lobster	Shells	Chitin/chitosan, protein concentrate, colorant
			Oil	Lobster sauce material
Clams	*Mya arenaria*	Soft shell clam	Bellies	Fish sauce, fish paste
		Sand gaper clam		
	Spisula solidissima	Atlantic surf clam		
		Bar clam		
			Shells	No known product
Squid	*Ilex illecebrosus*	Northern squid	Ink, beaks, guts	Fish sauce, fish paste
			Short-fin squid	
Mackerel	*Scomber scombrus*	Atlantic mackerel	Trimming	Fish sauce, fish paste
Mussel	*Mytilus edulis*	Blue mussels	Shells	No known product

Toronto, ON, M8Z 2X3
Tel: 416-231-1043 Fax: 416-239-5273

APO Products Ltd.
50 Dynamic Dr., Unit 1
Scarborough, ON, M1V 2W2
Tel: 416-321-5412 Fax: 416-321-0614

Aquastar
4600 Highway #7, Suite 255
Woodbridge, ON, L4L 4H7
Tel: 905-850-8740 Fax: 905-850-8684

Cana Foods Inc.
3080 Yonge St., Suite 2000
Toronto, ON, M4N 3M1
Tel: 416-480-8914 Fax: 416-480-8950

Central Smoked Fish Limited
63 Mulock Avenue
Toronto, ON, M6N 3C3
Tel: 416-763-1151 Fax: 416-763-1153

Clouston Foods Canada
3800 Steeles Avenue West
Woodbridge, ON, L4L4G9
Tel: 905-851-6771 Fax: 905-851-5703

Export Packers Company Limited
250 Summerlea Road
Brampton, ON, L6T 3V6
Tel: 905-792-9700 Fax: 905-792-7421

Feature Foods Limited
15 Meteor Drive
Rexdale, ON, M9W 1A3
Tel: 416-675-7350 Fax: 416-675-7428

Federated Foods Limited
2121 Argentia Road, Suite 102
Mississauga, ON, L5N 2X4
Tel: 905-567-1900 Fax: 905-567-1918

Finley Greenwood Inc.
PO Box 2665, LCD 1
Hamilton, ON, L8N 3M3
Tel: 416-362-8316 Fax: 578-5303

Groupe La Mer
6080 Indian Line Road
Mississauga, ON, l4V 1G5
Tel: 905-678-9353 Fax: 905-678-9129

Harbord Fish & Foods Inc.
61C Research Road
Toronto, ON, M4G 2G8
Tel: 416-467-5648 Fax: 416-467-5844

Jako Fish Inc.
250 Summerlea Blvd.
Brampton, ON, L6T 3V6
Tel: 905-791-7227 Fax: 905- 791-7740

Janes Family Foods Ltd.
2160 Highway 7
Concord, ON, L4K 1W6
Tel: 905-669-1648
Fax: 905-669-6027

Jost Kaufmann Import-Export Co. Ltd
47 Capital Drive
Nepean, ON, K2G 0E7
Tel: 613-226-3887 Fax: 613-226-3907

Macgregors Meat & Seafood Ltd.
265 Garyray Drive
Weston, ON, M9L 1P2
Tel: 416-749-5951 Fax: 416-740-3230

McCormack Bourrie Sales & Marketing
1080 Tristar Drive, Unit 3
Mississauga, ON, L5T 1P1
Tel: 905-670-3663 Fax: 905-670-2277

Mediterranean Fish Import
Export Co. Ltd.
39 Townsley Stree
Toronto, ON, M6N 1M7
Tel: 416-656-2948 Fax: 416-656-9955

Midland Seafoods Inc.
138 St. Helens Ave.
Toronto, ON, M6H 4A1
Tel: 416-536-5050 Fax: 416-536-7808

Mina Seafoods Central Limited
20 Goodrich Road
Toronto, ON, M8Z 4Z8
Tel: 416-252-3375 Fax: 416-252-7043

Morton Wholesale Limited
5188 Walker Raod
Windsor, ON, N0R 1L0
Tel: 519-737-6961 Fax: 519-737-1836

North Atlantic Fisheries
170 St. Helens Avenue
Toronto, ON, M6H 4A1
Tel: 416-536-5316 Fax: 416-531-3106

Oceancrest Seafoods Ltd.
151 Superior Blvd., Unit 10
Mississauga, ON, l5T 2L1
Tel: 905-670-0770 Fax: 905-670- 5445

Oceanfood Sales Ltd.
27 Taber Road
Rexdale, ON, M9W 3A7
Tel: 416-740-6441 Fax: 416-740-8055

P.J.B. Marketing & Sales Ltd.
3397 American Drive, Unit 10
Mississauga, ON, L4V 1T8
Tel: 905-673-2244 Fax: 905-673-8656

Tai Foong International Ltd.
2900 Markham Road
Markham, ON, M1X 1E6
Tel: 416-299-7575 Fax: 416-299-5556

Toppits Foods Ltd.
3 Director Road, Suite 201
Woodridge, ON L4L 4S5
Tel: 905-850-8900 Fax: 905-850-8910

Analytic Laboratories

Several laboratories are listed below. This is not an endorsement; it's just to get you started. Laboratories can vary greatly in what they charge for any given analysis; it pays to comparison shop. The closest lab may not be the cheapest. In addition, local universities or government labs may offer analytic services. University labs may charge less but their results may not be certified analyses which you can show other people, and may be in a form which is harder to understand. Call the labs and request a catalog and price list of services. Ask questions. And, check your Yellow Pages under “Laboratories, Testing”.

Woodson-Tenent Laboratories, Inc.
Memphis Tennessee *(one of several locations)* (901) 272-7511

Agway Analytical Services
Ithaca, New York (607) 257-2345

Shuster Laboratories, Inc.
Quincy, Massachusetts (800) 770-8705

Cornell University
ICP Analytical Laboratory
Ithaca, New York (607)255-1785
(especially fertilizer or compost analyses)

Important

Special material handling: Even if you are not ready to send off your material, ask the lab how it wants it handled BEFORE you start collecting samples. For example, certain analyses, such as those for PCBs, are more accurate if the material has not been in contact with plastic, so that if you've stored it in the freezer in a plastic container, you may have compromised the accuracy of the analysis. In some cases, such as analyses of some materials in water, the material should not have been frozen. The laboratory will tell you how to preserve it at room temperature. Since this may require purchasing a particular chemical, you need to know this before you start collecting samples.

Presentation of results:
Another question to ask in advance is how the results of the analysis will be presented. For example, we have gotten very inexpensive elemental analyses from the Cornell fruit and vegetable lab compared with a commercial lab's cost. (This is an analysis that tells you the concentration of different atomic elements present in a sample. This is useful for getting N - P - K for a fertilizer label, or for testing materials for heavy metal content, such as lead and chromium.) Some university labs may send clear data on letterhead stationary, while others present the data in a form which is difficult to interpret, or send the printout from the computer, so there is no letterhead. If it's important for you to have a formal analysis on letterhead stationary, and for the key results to be interpreted so that they are easy to read, it may be worthwhile to pay a commercial laboratory.

PPM and percent:
Everyone knows that a percent is one part per hundred. Certain analyses are for materials present in very small quantities; for example, PCBs. The results of these analyses will usually be in ppm: parts per million. One percent is equal to ten thousand ppm. Conversely, one ppm is equal to 0.0001% or a ten thousandth of a percent. The legal limit for PCBs in animal feed is 0.2 ppm or 0.00002%.

PCBs:
The legal limit for PCBs in human food is 2.0 ppm; the legal limit in animal feed is 0.2 ppm. While it may seem illogical to allow humans to eat food with ten times higher concentration of a toxic material than is allowed for animals, it actually makes good sense. Animals are fed the same food day in and day out; if there is a toxic component to that food they will accumulate it and — when they are slaughtered as food — that toxic component will end up being eaten by us.

The human food limit refers to the food itself. For example, if a monkfish liver has a PCB content of 3 ppm, it is illegal to sell that into the human food market. The animal feed market refers to the finished compounded feed. So if the material in question has a PCB content of 1 ppm but will only be used as 5% of the feed, it would be legal to sell it into that market. However, if you knew the PCB level, you would be morally obligated to tell the manufacturer what that was, so that s/he wouldn't use it at too high a level. And, once they knew that it contained measurable PCBs, they would probably not use it.

Many laboratories offer PCB screens. Note that there is a family of PCB compounds so you want to get a test that screens for the entire family. One laboratory that we have used and found reasonable for this screen is Woodson-Tenent (address and telephone number listed above). The lab will analyze PCBs for one price, and for a reasonable additional fee, they will add on analyses for 15 additional chlorinated hydrocarbons, including the DDT family and Mirex.

Do-it-yourself analyses:
The range of simple, quick diagnostic tests is increasing rapidly. The value of these kits is both in their lower cost compared to a professional lab, and the speed with which the results are received, since time is of the essence when fresh product is involved.

The best way to learn about which kits are available and how difficult they are to use is to go to the International Boston Seafood Show, where a sampling of both kit manufacturers and analytic laboratories exhibit. Also check for advertisers in magazines oriented towards fish processors.

Below are listed a few sources for kits. When ordering, be sure to ask if anything is needed beside the kit itself, so that you don't buy an inexpensive assay only to discover that you need a $15,000 spectrophotometer to read the result.

PSP — for years, the test for paralytic shellfish poison (aka red tide), has been a difficult and expensive one where the presumed toxin is injected into mice who then either live or die. It's not fun to do and it costs about $300/test. Now a Nova Scotia-based scientist (Joanne Jellett) has started a company to produce do-it-yourself rapid tests for PSP. The company is called Jellett Biotek and the tests are called MIST (for Maritime in Vitro Shellfish Test). The company can be reached by telephone at: (902) 424-8670 (ext. 147).

Histamine, sulfites, salmonella, E. coli and Listeria — Neogen, a Lexington, Kentucky-based corporation produces test kits for these. Telephone: (800) 477-8201 www.neogen.com.

E. coli 0157 — GEM Biomedical has a rapid test (for several strains of E. coli), as well as for other major classes of bacteria, and it has a generalized kit called FishCHECK, which gives a rapid general quality assay. Telephone (in Hamden, Connecticut): (800) 551-1415.

*Listeria and Salmonell*a — Vicam, located in Watertown, Massachusetts, offers tests for these. Tel: (800) 338-4381.

PCB, and other long-lasting herbicides and pesticides — J. T. Baker has kits available for these. Telephone (Headquartered in Phillipsburg, New Jersey): (800) 582-2537.

Hand-held fat meters and freshness meters are in development. When these will be ready for market is uncertain.

Further Readings and Literature Cited:

Literature in the world of fishery byproducts is not on the best-seller list. Most of the research is published in technical journals and is difficult to read, and not always applicable to the real world. Most of the publishing has been done by government agencies — often by Sea Grant in the U.S.. You'll note that much of the work cited here was published about ten years ago, when interest in waste disposal was at its peak. With declining fisheries, waste disposal has become less of an issue (although squeezing the last penny out of each fish caught has become more important). Many of the works cited here are out of print. However, Sea Grant will lend out-of-print works out for one month. Contact: National Sea Grant Depository, Pell Library Building, University of Rhode Island, Narragansett, RI 02882. In addition, the list of Sea Grant programs in each state, with telephone numbers, email addresses, etc. is appended (p. 100). Although Sea Grant libraries and offices are located in universities, Sea Grant is a public program — not a university program. Sea Grant libraries are open to the public, even when the other libraries at the University are not. It's a good idea to go and explore the library nearest you. Remember, it's your program. Your tax dollars paid for it. You should benefit by it.

Another source of useful information is INFOFISH International, a truly global magazine. Started by the U.N.'s Food and Agriculture Organization, it is now independent. You can probably find it at your Sea Grant library, and you can contact them in Malaysia, their home, at: infish@tm.net.my.

Unfortunately much of the information on the Web is irrelevant, inaccurate and repetitive. One helpful tool is a good search engine. The ordinary ones like Yahoo and Netscape are not great at distinguishing between useful information and trash. Two that we've found useful are NorthernLight.com and google.com. You'll undoubtedly find others for yourself.

Try to make some contacts among researchers working in byproducts at Sea Grant or other university and government departments. Tell them that you want to be notified about upcoming meetings relevant to byproducts. Many of the works cited below are proceedings of conferences, and those conferences are where you really want to be.

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Fish Oil Production and Potential in Atlantic Canada. 1986. James H. McClare & Associates, Ltd. Paper No. 115 for the Program Development Division, Fisheries Development Branch, P. O. Box 550, Halifax, NS B3J 2S7

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Improving the Profitability of Finfish Processing Waste: Options for Fish Processors with an emphasis on Mechanical Deboning (Mincing), Hydrolysis (Liquid Fish Fertilizer Production), and Composting, 1991. Susan H. Goldhor & Joe M. Regenstein. New York Sea Grant publication NYSGI-T-91-001.

Industrial Prospects for Chitin and Protein from Shellfish Wastes, 1977. MIT Sea Grant Program, Report No. MITSG 77-3.

Introduction to Fishery By-Products. 1981. M. Windsor & S. Barlow. Fishing News Books, Ltd., Marston Book Services, Ltd., P.O. Box 269, Abingdon, Oxon OX14 4YN, U.K.

The Live Revolution. Fitzgerald, Roger. Seafood Leader, July/August 1998. p. 62-72

Live Fish – handling and transportation. Subasinghe, S. INFOFISH International. February 1997. pp. 39-43

Live food fish, Technical Q&A on. INFO-FISH International. February 1996 pp. 67-68.

Market Study for Underutilized Species: Focusing on the Asian Ethnic Market in North America, 1991. A study conducted for the Canadian Association of Fish Exporters, under the Seafood and Marine Products Sector Campaign of Industry, Science & Technology Canada. Tel: 604-387-3498.

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The Australian government puts out a series of useful reports, many of which are relevant to the topics discussed here, such as "An analysis of Asian markets for seafood products", "Development of a process to manufacture powdered shark cartilage", "Development of live fish transport techniques", "Food processing concepts for the Australian beche-de-mer industry" and so on. Even if Australian species are quite different from ours, you might want to log on to their website and have a look. www.dpi.qld.gov.au/cft/ssaust/Reports.html

The following is reprinted from:
Improving the Profitability of Finfish Processing Waste, 1991
Susan Goldhor and Joe Regenstein
New York Sea Grant (NYSG-T-91-001)

Fish Mince

In the meat industry, small scraps and bone scrapings are ground into hamburger and sold at a relatively high price. The advent of deboning machines has made possible a burgeoning supply of minced poultry, which has been developed into a wide variety of products. Deboning equipment, similar in concept to that used for poultry, has been developed for use on fish and may be used to produce a hamburger-like product called fish mince. Although fillets of whole fish may be used to produce fish mince, there is little economic incentive to do so except possibly in the case of surimi manufacture, where an extremely white product is required for certain applications. The true value of mincing is that it enables the processor to utilize some of the fish flesh trimmed off of the fillet during processing, or left on the frame after filleting, as a human food ingredient of reasonable value, rather than treat it as offal.

Deboning machines are manufactured by a number of companies; the brands most used in this country for fish are Baader (German) and Bibun (Japanese), although the U.S brands Beehive and Paoli are gaining popularity. The Baader and Bibun machines require the operator to place the fish on a rubber belt which carries the fish to a revolving, perforated, stainless steel drum. The drum's perforations (holes) may be anywhere from 1 mm to 10 mm in diameter. In general, 3 mm to 5 mm seems to be used for fish, with 3 mm being the preferred diameter. The rubber belt is thick and inelastic and forces the fish against the drum. The flesh, fat, and blood, which are the softer components of the fish, pass through the holes and accumulate inside the drum, while the bones, scales, and skin remain on the outside surface. As the drum rotates, one point on its external path is continually in contact with a scraper, which removes the adherent bones, scales, and skin. Figure 1 schematically represents the basic operation of the drum-type machine.

The variability in the diameter of the holes in the drum permits the processor to produce a paste-like material (using small perforations) or a more chewy and chunky material (using large perforations). The tension on the belt is also variable; the greater the tension, the more pressure will be exerted on the fish and the more flesh will be pushed through the drum. In other words, the higher the tension, the higher the yield. At first glance, the highest possible yield might seem desirable; however, this is not always the case, for reasons which will be explained below. (Machines like the Paoli do not have adjustable tensions, but do have the advantage of being far easier to clean.)

Mince is classified by the species of fish from which it is taken, and is further divided into various types in order of decreasing quality: fillet mince, "V" and "J" cut mince, whole fish mince, trim mince, frame mince with the backbone removed frame mince, and rackmince (which includes the head). Fillet mince is made of whole fillets. This is generally the economic equivalent of grinding up a steak to make hamburger. The "V", mid "J" cut minces are almost equivalent to fillet minces in quality. Groundfish contain small bones, called "pinbones," in one part of the fillet. In making a boneless fillet, pinbones are some times removed (using either a “V” or “J” shaped cut) and these pieces become the starting material for “V” and “J” cut minces. Following filleting, fish are usually trimmed for blood spots, badly gaping pieces, uneven fillet edges, belly flaps with black membranes, etc. The trim mince prepared from these materials will be somewhat darker and more strongly flavored than the higher-quality minces since it will contain blood and pigments. Frame mince is even stronger in flavor and redder in color than the trim mince since it contains nerve tissue as well as more blood. If the backbone is not removed, frame mince may also contain kidney tissue, the amount depending upon belt tension. Increasing the belt tension will thus increase the color and flavor components of the frame mince. Rack mince is similar to frame mince, but would not be acceptable for human food use in this country because of the presence of gill and eye tissue.

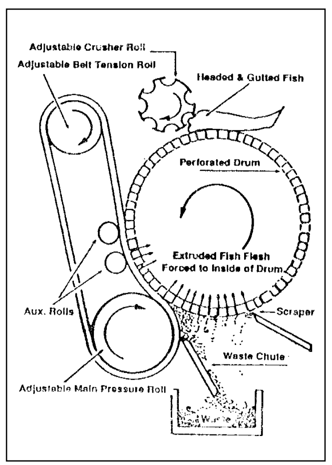

Figure 1. Basic operation of the drum-type deboning machine

The National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration of the Department of Commerce has put out proposed U.S. Standards and Labeling Requirements for Minced Fish Meat (see the Federal Register, Vol. 49, No. 27, Feb. 8, 1984, pages 4804 to 4806). This document attempts to establish standards of identity and recommended methods of handling such product, with the understanding that participation in the NMFS seafood inspection program is strictly voluntary. These standards are perhaps overly strict with regard to species currently allowed (only four are permitted: Atlantic cod, silver hake [whiting], walleye [Alaska] pollock, and red hake), while at the same time they may not be strict enough with regard to storage temperatures for frozen product. This will be discussed below.) Since the standards place great emphasis on whiteness of color, it is clear that they are not designed for frame minces but only for trim minces at best.

Almost all mince enters the market frozen. Frozen mince is available in blocks of various sizes, with the 16-pound block being most common. Alternatively, mince may be laminated at a set percentage into fillet blocks, where it may actually improve the appearance and quality of the blocks by filling up any empty spaces between the fillets. The percent of mince acceptable in laminated cod blocks varies according to country of origin. The U.S. market has accepted imported frozen laminated cod blocks but is not producing any at this time. Production of frozen minced blocks or fillet blocks is not yet common in the United States, but at least one New England producer is manufacturing frozen blocks of minced cod, pollock, and haddock. All of this plant’s mince production is made from trim; frame mince is not sold in these forms at this time in the United States, presumably because of its unacceptable color and flavor. At least one plant in the United Kingdom is preparing frame mince for human

While the gadoid species, such as cod and haddock, appear to be the most desirable candidates for mince in terms of availability and name recognition, they exhibit undesirable changes in flavor and especially texture if improperly frozen. These changes are caused by an enzyme which appears to be inactivated when the temperature is sufficiently low. The Torry Research Station (Aberdeen, Scotland) recommendation (J. N. Keay, Minced Fish, Tony Advisory Note No. 79) is that good quality cod and haddock can be stored for at least six months at -30ºC (-22ºF), or for three months at -20ºC (-4ºF). Hake and Alaska pollock have much shorter shelf lives in frozen storage. The U.S. labeling standards mentioned earlier recommend -18ºC (0ºF) as suitable for six months frozen storage for all species discussed. Research by J. M. Regenstein has shown that undesirable texture changes can be created in about one month if gadoid minces are stored at -I4ºC (7ºF). Therefore, the U.S. recommendations could result in a very poor product. With respect to U.S. production of minces, it is a serious problem that most U.S. cold storage facilities are not designed to go down to -30ºC (-22ºF), where the reaction causing the gadoid texture changes does not seem to occur.

One possible alternative for frozen storage has been suggested by J. M. Regenstein, whose laboratory has shown that if mince is stored at an extra-cold temperature (around -40ºC [-40ºF]) for several months, changes appear to occur which stabilize the mince. If mince production were to become a major regional effort in this country, a municipality or even a region could build a suitable freezing facility in which mince could under go the first few months of frozen storage. Stabilized mince could then be released into the standard U.S. cold store chain with the expectation that the rate of degenerative changes would be much slower. An extra-cold freezing facility might also benefit the storage of regular frozen fish products, and cause a significant improvement in the overall quality of frozen fish in the United States.

Less attention has been paid to flatfish as a source of mince than to the gadoid species. While mince from flatfish does not undergo gross textural changes upon freezing, its initial fresh soft texture is regarded as less desirable in mince than the firmer texture of the gadoids. Nevertheless, at least one New England processor is selling fresh flounder mince, and this product offers a number of options for further processing. This leads into what we believe to be a second and perhaps simpler approach to handling and storing both trim and frame minces. This is to turn them into cooked products destined for immediate consumer sales. Cooking extends the shelf life of fresh (unfrozen) mince and, in the case of gadoid minces, destroys the enzymes responsible for negative texture changes in frozen storage.

The finished products that may be made from mince are enormously varied, ranging from sausages to salads. Trim mince could be used for traditional fish dishes, such as chowders, seafood Newburgs, and salads, where a white appearance is valued. lf the fish is of good quality, no odor or off-flavor will exist. Frame mince can be an excellent red meat substitute in a variety of preparations where the strong color and flavor of the food itself will mask any in the fish. Spaghetti sauce, sloppy joes, taco mix, and sausage have all been tried with success. Products such as these can be sold fresh-cooked, frozen, precooked and frozen, or canned, and can be marketed through a variety of channels.

What kind of yields should be expected from mincing? At least one worker has reported that frozen pollock yielded approximately as many pounds of mince as it did fillets (Babbitt, S. K. et al., Observations on reprocessing frozen Alaska pollack [*Theragra chalcogrammal*] J. Food Sci. 49: 323, 1984). However, this may be unrealistically high for many operations.

You can determine yields on trim mince in your operation by weighing a given number of fish (for example, twenty) as they enter the processing line, and weighing the trim mince derived from those fish as the trial exits the line. The trim should be broken down by categories, e.g., worms, blood spots, black membranes, gaping pieces, etc., so that it is possible to identify which materials are available for which end uses; unsuitable pieces should be discarded before weighing. The experiment must be done separately for each species, and should be duplicated at least once. Fish of different quality should he studied separately. Often the poorest fish can be found on Monday!

In our experience, trim waste will comprise approximately 4% to 5% of the weight of whole (gutted) haddock in which the pinbones were left in place. About 80% of this 4% to 5% is recoverable as mince. This is far lower than Babbitt’s experience with pollock, where a yield of over 20% trim mince was obtained. Whenever “V” or “J” cuts are done, yields presumably will be significantly higher than what we found. Babbitt's estimate on frame mince from backbones was that almost two-thirds of the weight of the backbones could be recovered as mince, and that the backbones were almost 20% of the weight of the original fish. Thus, about 12% of the original weight of the fish could be recovered as frame mince. In our experience with haddock, the frames were also very close to 20% of the weight of the whole (gutted) fish. However, while a yield as high as 66% mince from frames may be achievable, it is not always desirable.

Obtaining a better color, flavor, or texture may be more important. An estimate of 40% to 50% of the weight of the frame for high quality mince might be more realistic. This would amount to 8% to 10% of the weight of the original fish. Thus, based on work with gutted haddock, our personal experience suggests that 11% to 14% of the weight of the original fish is a realistic estimate for combined trim and frame mince. We would expect the yield for cod to be somewhat higher, because of the "V" or "J" cuts.

If mince were to become a really profitable item, processors might consider looking into a new machine developed in Iceland (the Kwikk 205 Fish Head Splitter), which is said to be able to remove mince from heads, yielding 5% of the landed weight. The U.S. patent for this device was issued in 1986 and has been assigned to Bander U.S. Patent Number 4,583,265). This machine would be of even greater use to any processor with an ethnic market for checks and tongues (see pages 8-9).

Another possibility, if mince were to become popular, would be a two-stage mincing operation. In the first stage, processors would use the traditional fish deboners to produce a good-quality frame mince for use in traditional products. The second stage of deboning would use the higher pressures and smaller hole sizes of the equipment currently being used by the poultry industry, for use in producing products that could accept a lower-quality mince; that is, a mince with more pigment and stronger flavor. These second stage machines operate on somewhat different mechanical principles from those designed for fish and described earlier. They work either by augering the meat to the inside of a deboning head from which the meat is expelled through small holes (see Figure 2), or by using a hydraulic ram that forces the meat out through a screen. The hydraulic ram deboners, although using high pressures, have the advantage of subjecting the raw material to only one pressure cycle.

One further word of caution should be added for processors working with cod or other species with heavy parasite loads. Deboning machines are designed for getting rid of bones, Worms pass through most of intact and are quite visible in the finished mince, both fresh and frozen. Needless to say, this is unacceptable. Cod destined for mince, like cod fillets, must be candled over a light table and dewormed.

Indeed, for any processor considering moving into mince production, it is important to recognize at the outset that mince is a human food product and must be treated as such at every stage of its production. This may require a reeducation of the work force.

Evaluating Fish Mince Production

In order to consider making mince, a company would have to invest in a Baader 694 or a similar piece of deboning equipment. The price of such machines is in the range of $15,000 to $20,000, although used equipment is obtainable.

The choice of whether to freeze

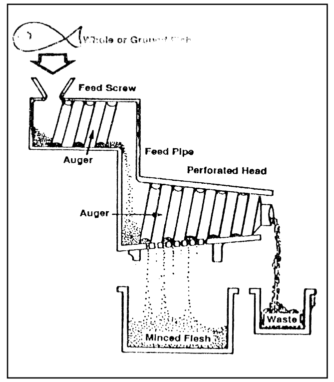

Figure 2. Basic operation of the auger-type deboning machine

mince or go directly to fresh product depends on a number of considerations, including freezing facilities, quality, quantity, and expertise.

Freezing Facilities. The production of stable gadoid (e.g., cod, haddock, whiting, hake, cusk, and pollock) mince requires block-freezing facilities (i.e., vertical plate freezers) at -40ºC and cold storage facilities at -30ºC or lower, capable of storing a significant quantity of material.

Quality. NMFS-proposed standards for mince emphasize whiteness and uniformity of color. Mince prepared under this standard is presumably for use in traditional fish products such as fish sticks and portions, and fish cakes. This means that only the highest quality "V" or "J" cut mince will be acceptable.

Only a very large output could justify capitaI expenditures for new equipment, including freezers.

Expertise. Processors with no cooking equipment and no experience in the area of prepared foods may wish to stick to very miniinal processing and to

limit initial sales to fresh or frozen "chowder fish" or "fish nuggets," as a way of utilizing high-quality trim waste and damaged fillets without doing any mincing at all. At the other end of the spectrum are those processors with significant experience in prepared foods (or the desire and funds to hire a person with such experience) and good links to suitable markets. For these people, given the current increase in away-from-home and heat-and-eat seafood consumption, the sky is the limit. Quenelles, sausage-type products, smoked pates, and so on are all high-priced products that can utilize minced fish. In between these two extremes are more moderately priced prepared foods.

The processor wishing to manufacture human food products from mince would also have to select the proper marketing arrangements, i.e., wholesale, retail, or institutional. Generally it is easiest to break into the institutional market.

Making Human Food Products from Mince

There are three major points to be made about mince, whether it is derived from trim or frames.

First, if trim or frame minces are to be utilized, then these streams may no longer be treated as waste. Instead, they must be treated as human food at every step of the way. Indeed, they should be treated with even more care than whole fish or fillets. This is for three reasons:

- Like hamburger, the mince has a high surface-to-volume ratio, providing an enormous growing area for microorganisms.
- No portion is protected from bacterial invasion or oxidation by skin or belly membrane.
- Both trim and frame mince are from the most fragile pans of the fish, which are most prone to spoilage, odor, and off-flavor development. In addition, frame mince is high in blood, pigment, kidney tissue, etc., all of which can develop off-flavors and support microbial growth particularly rapidly.

For these reasons, frames and trim destined for food use should be collected immediately in clean containers and sorted, minced, and cooked, as rapidly as possible. If frames and trim must be kept for any length of time at all between steps-even half an hour-they should be put into cold storage. They should not be kept overnight. Raw material should be sorted and chosen early enough in the day to be processed into frozen or cooked food products prior to shutdown. Product should not be held, but should be distributed as quickly as possible.

Second, it is important to remember that not all trim and frames are suitable for human food use. We would recommend against production on Monday from fish which has been stored all weekend. We also would suggest that trim waste be sorted by hand, so that severely discolored or damaged material may be discarded. (Ideally, the trimmers might be trained to separate food-grade from nonfood-grade trim.) Similarly, in making frame mince, material with off-odor should not be used at all, and even with frames in good condition, the mincer should not be set at the highest pressure. High quality should take precedence over high yield.

Third, we suggest using only certain species for mince. In particular, we would warn against cod, because of worms. lf cod trim is to be used for mince, it must be put on a light table and dewormed. Cod frames also ought to be candled prior to deboning, although this is more difficult since the bone blocks out some light.

Finally, in selling minced product, the producer will have to decide upon a price and marketing strategy. The price structure will depend partly upon the value assigned to the raw material. We would suggest that values of about $0.40 for frame mince and $0.60 to $0.80 for trim mince would be reasonable at the present time (1991), based on the value of related poultry and fish materials.

If the producer has made the decision to sell processed food products incorporating mince, the question of product choice and development arises.

As a first value-added processed food product, we would recommend something relatively simple such as a fish salad or a chowder. Subsequently, more challenging products could be developed. The producer will wish to consider products on the basis of complexity of preparation, shelf life, potential local markets, and profit margins. The producer may also wish to consider products on the basis of whether they lend themselves to manufacture from white, mild-flavored trim mince or from the redder, more strongly flavored frame mince. The salads and chowders mentioned above will generally require trim mince. So will a variety of other possible recipes, including fish fingers, croquettes, nuggets, etc., which could fit into markets ranging from institutional meal plans to restaurant happy hours.

Frame mince may be successfully utilized in red meat analog products, such as taco fillings, chilies, sloppy joes, or spaghetti sauces. While these are unconventional uses of fish, the end results, when properly formulated, are surprisingly conventional products in appearance, flavor, and texture. The strong flavors and tomato based sauces cover up any color or flavor in the mince, and the texture of the mince provides a hamburger-like chewiness, provided the proper hole size has been used in the deboner. The red color of frame miince is largely due to blood, and this supplies a meat flavor to these foods, as well as a higher iron content than trim mince or fillets would provide. If these products are properly labeled and marketed, they can offer consumers who do not like fish a way to enjoy the health benefits of fish. They are also appropriate for institutional sales, where they offer an attractive combination of irnproved nutrition and favorable economics.

Processors interested in producing and selling mince in any form can request a copy of *Minced Fish*, by J. M. Regenstein, from the author. Those interested in formulating either trim or frame mince into processed foods can also request a copy of *Choose Your Title: Kosher Minced Fish Cooking/ Fish Cooking with a Food Processor International Fish Recipes*, from the authors, J. M. and C. E. Regenstein. While the recipes given in this latter pamphlet are small-scale and aimed at home cooks, they are a good introduction to the possibilities of minced fish use, and some are suitable for commercial production and sale.

References

In addition to the sources cited above, those interested in minced fish may want to read the following:

- Agnello, R. 1983. Economic potential for utilizing minced fish in cooked sausage products. *Marine Fisheries Review*, 45 (7,8,9):21.
- Regenstein, J. M. 1981. Minced fish: a critical examination of the Cornell experience. *Seafood America*, 2(l):18.
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The following is reprinted from:

Physical Properties of Chitin Sheet from Loligo Pen

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The crystal structures of chitin (King crab shell or tendon) and chitin (Loligo pen) are already well known. Their x-ray diffraction patterns and IR spectra can be distinguished from each other. In the present work, the swelling properties of chitin, Loligo pen, was noted and related to a possibility of direct sheet preparation to use a biocompatible material, especially, an artificial skin. While the inability of chitin, King crab shell or tendon, to swell on soaking in water is explained by the crystal structure of extensive intermolecular hydrogen bonding. Thus, in the chitin, we should firstly prepare a fiber from the chitin dope and then make nonwoven sheet from the short cutting fiber. Obviously the process is economically more disadvantageous than that of chitin, and also somewhat trouble with the residual organic solvent.

At first, purified Loligo pen was disintegrated in small amount of water (3g sample on dry base/50ml H_20) and then poured into large amount of water (one third of the gel/ l000ml H_20) to suspend them and to make testing sheets by evacuated papermaking process for reason of considerably low freeness of the gel. Physical properties were measured by TAPPI standard methods. Static or dynamic Young modulus was calculated from stress-stain curve and vibrating reed method. As shown in Table 1, chitin sheet from Loligo pen shows a high bursting factor of 5.0 and breaking length of 6.6Km, compared with those of chitin sheet from crab shell, 1.0 and 3.0 Km. While the static Young modulus of the pen sheet is $2.0x10^{-3}$ Kg/mm^2, which is one fifth of that of the shell sheet. Tearing factor of the pen sheet is about the same as that of news paper in the machine direction. The pen sheet has fatigue property of folding endurance superior to that of the shell sheet, in addition, relative low permiability of air, water or vapor, 27mgH_2O/cm^2.hr. Furthermore the sheet has a good biological properties which has a strong affinity for blood proteins (adsorption %; albumin 67.5%, fibrinogen 78.6%, globulin 69.5%) and slow biodegradation by lysozyme. The SEM observations clearly showed the difference in morphology for both chitin sheets. The shell sheet has a well developed and very pronounced microfibril structure of about l00nm width.

In contrast, the pensheet shows a scaly lamellae structure at high magnification regardless of observing a straight array of the fiber at low magnification . These morphological differences may result in the different physical properties as mentioned above. Thus, the pen sheet seems to be more suitable for an artificial skin.

The following is reprinted from:

Chitin from Shellfish Waste – Health Benefits Overshadowing Industrial Uses!

S Subasinghe

Infofish International, March, 1999

Chitin, starch and cellulose belong to the group of compounds chemically known as polysaecharides - large molecules consisting of smaller sugar molecules strung together, like pearls on strand. In nature, among polysaccharides, its abundance ranks only second to cellulose. Cellulose and starch have widespread use and a similar potential is evidenced for chitin. Chitin is a very light, white or yellowish coloured, powdery/flaky product, which can be processed into many derivatives. The most readily available being chitosan, is formed when chitin is chemically treated. Unlike most polysaccharides, chitin has a strong positive charge which allows it to bind to negatively charged surfaces.

Chitin was first found in mushrooms in 1811 by Professor Henri Braconnot, Director of the Botanical Gardens at the Academy of Sciences in Nancy, France. In the 1830s, it was isolated in insects and named chitin. Discovery of chitosan by Professor C Rouget in 1859, led to extensive research on chitin and chitosan compounds. Interest in new applications of these products grew in the 1930s and early 1940s leading to over 50 patents. However, commercialisation of these products was hampered by the lack of adequate manufacturing facilities and competition from synthetic polymers. Renewed interest in the 1970s was encouraged by the need to better utilise shellfish shells. Since then, numerous research studies have been undertaken to explore the different uses of these materials. The present day chitin/chito-san industry primarily depends on shrimp and crab processing waste as raw material. Chitin is manufactured by deproteinising and demineralising cleaned shell material. De-acetylation of chitin using alkali produces chitosan.

Nearly 10% of the global landings of aquatic products consist of species rich in chitinous material. These include species such as shrimp, crab, squid, cuttlefish, oyster, clams, etc. At present the annual production of these species is around 9 million mt. Chitin is a major constituent of the exoskeletal material of crustaceans, cuttlefish and squid. The processing waste of these species contains approximately 10-55% of chitin on a dry weight basis, depending on the processing method.

Even though the availability of chitin rich species is quite considerable there are practical difficulties in gaining accessibility to waste from such species for commercial scale chitin/chitosan extraction. The seasonality of the resources and the scattered location of the processing industries in many countries can restrict the availability of a regular supply of raw material. The relatively bulky nature of waste and its high perishability are factors which can make sourcing the raw material difficult. The need for coordinated collection and transport of carefully collected waste from several sources would also add to the cost of the raw material.

About 35-45% by weight of shrimp raw material is discarded as waste when processed into headless shell-on products. Peeling process, which involves the removal of the shell from the tail of prawn, increases the total waste production up to 40-45%. Environmental implication of traditional disposal methods of

Specifications for various grades and forms of chitin and chitosan

Specifications (Food Grade)	*Chitin (Food Grade)*	*Chitosan (Pharm. Grade)*	*Liquid Chitosan (Tech. Grade)*	*Chitosan*	*Chitosan*
Appearance	white/yellow flake	White/yellow powder or flake	clear/yellow liquid	while/yellow powder or flake	white/yellow powder
Moisture content	<10%	<10%	—	<10%	<10%
Residue on ignition	<2.5%	<0.2%	<0.5%	<0.2%	<0.5%
Protein content	<1.0%	<0.3%	<0.5%	<0.3%	<0.3%
De-acetylation	70-100%	70-100%	> 90%	70-100%	70-100%
Viscosity (0.5% solution)	600 cps	<5 cps	50 cps	<5 cps	50-100 cps
Insolubles	<1.0%	<1.0%	<0.5%	<1.0%	<1.0%
Heavy metals -					
Arsenic	<10ppm	<10ppm	<10ppm	<10ppm	<10ppm
Lead	<10ppm	<10ppm	<10ppm	<10ppm	<10ppm
pH	7-9	7-9	<5.5	7-9	7-9
Odour	no	taste	or	smell	

such waste, coupled with the strengthening of environmental regulations in many countries, has created an interest in alternative methods of disposal and also the potential economic benefits of such waste.

Only waste produced by large scale processing facilities serve as a reliable, regular source of good quality waste. On a global basis, over 90% of frozen shrimp are exported, only less than 10% is used for domestic consumption. In many developing countries almost all the production of frozen shrimp is exported. Thus, an assessment of shrimp waste availability, from frozen shrimp export, estimated at nearly 580 000 mt, can be considered as the prime source of quality waste. Other sources are the shrimp canning facilities and facilities producing value added shrimp products. Nearly, 80% of the global canned shrimp production comes from Thailand, whereas the USA accounts for most of the peeled frozen and peeled battered and breaded production with estimated waste productions of 60 000 mt and 80 000 mt respectively. Thus on a global basis the shrimp processing industry produces over 700 000 mt of quality waste.

The annual landings of crabs and crab like species are estimated at 1.35 million mt. Over 70% of the raw materials are discarded as waste during processing. Most of the crabs landed are marketed in the shell-on form. Crab waste mainly occurs during the production of frozen or canned crab meat. The annual world production of crab waste from such facilities can be estimated at around 480 000 mt. Annual landings of squid amounts to nearly 2 million mt with the potential for 400 000 mt of waste. The most reliable sources of regular supplies of large quantities of quality waste are from processing frozen squid. Total global production of frozen squid has been estimated at 497 655 mt. Assuming a 30% recovery of body meat during processing, the above quantity of squid will have a total waste potential of 99 531 mt.

The global chitin production potential has been variously estimated at 118 000 mt and at 150 000 mt. However, based on the assumption that the centralised large scale processing facilities, which are almost 100% export oriented in many developing countries,

as the major reliable suppliers of quality raw material, we have to accept a more conservative global chitin production potential of around 76 000 mt. This figure is arrived at assuming a 100% conversion of waste into chitin. Even if half of the waste are made available for chitin production we can arrive at a more realistic global production potential of around 38 000 mt.

Markets for chitin, chitosan and chitin derivatives

Japan and USA are the main producers of chitin and chitosan. Other less important producers are India, Italy and Poland. The total sales of chitin/chitosan, which was estimated at US$50 million in early 80s, is expected to surpass US$2 billion by the turn of the century.

There are various grades of chitosan marketed globally, catering for various requirements. Accordingly the market price too varies widely, from around US$5.00 per kg for the crude grades used in agriculture to around US$200.00 for ultrapure grade used in health care industry.

Food and biomedical uses

Over the past decade, researchers in Japan, Europe, and the United States have tested chitin and its derivatives in biomedical applications. Researchers also have focused on the food and nutrition arenas, including edible films and coatings to preserve the quality and texture of foods. In 1992, Japan's Health Department approved chitin and its derivatives as a functional food. To be considered a functional food, it should contain two of the following 5 functions: fortification of immunity, prevention of illness, prevention of aging, recovery from illness, and control of biorhythm, chitin is identified to have most of the attributes.

According to researchers and promoters of health benefits chitosan, it is found to attach itself to fat in the stomach before be metabolised, thus trapping the fat and preventing its absorption by the digestive tract. It is believed that the fat binds to chitosan fibre thus becoming a large mass which the body cannot absorb, and hence eliminated unabsorbed. Chitosan fibre posesses a positive ionic charge flora and stimulates lactose digestion in animal intestines. It has also been reported that chitini chitosan oligosaccharides, when intravenously injected, enhances lysozyme activity in animal blood, and enhances the anti-tumor activity by activating the macrophages. The sulfated derivatives of chitin and chitosan have the anticoagulant and lipolytic activities in animal blood. 0-Sulfated derivativ Qf chitin and CM-chitin inhibit the tumor metastasis. 5'-Methylpyrrolidinone chitosan promotes the dental osteoconduction. N-Hexanoyl and N-octanoyl derivatives of chitosan have an antithrombogenic activity, and are highly compatible with animal blood and tissues. Chitosan has antibacterial and anti-fungal activities, and prevents their infection. Chitin is digested in animal tissues, and metabolised into animal connective tissues. Chitosan implanted in animal tissues heals wound and haemostatic activities.

The last few years have witnessed a marked growth in the dietary chitosan preparations with therapeutic and health attributes, now available in the market. Most of these preparations are in tablet or capsule form while a small fraction is presented in powder form. The composition may vary from pure food grade chitosan to a mixture of chitosan and some vitamins and minerals. For example the US product "Chitosan Plus" contains 500 mg chitosan per capsule and 20 mg esterified vitamin C, 5 mg CoQ10 and 5 mg manganese. Some others have dietary supplements such as lecithin, garlic, beta-carotene as well as vitamins C and E incorporated into the product.

Most of these products are promoted as fat trimmers or as cholesterol lowering agents, highlighting the ability of chitosan to absorb up to 12 times or more its weight of fats and lipids. The dietary capsules have to be taken 5-10 minutes before meals with adequate amount of water to disperse the chitosan material in order to facilitate maximum absorption of fat. The dosage recommended for most products vary depending on how fatty the diet is, 2-4 capsules at a time for most low-medium fat diets while 6-8 capsules, or 750-1000 mg, or more for high fat diets.

Conclusion

It is interesting to note that in spite of the considerable progress in chitin/chitosan research and the large number of potential applications of chitosan and its derivatives, their commercial applications are somewhat limited, except for the recent growth in interest globally, on its health benefits. Hence, it could be safely assumed that at the present level of industrial usage of chitini/chitosan, the shrimp and crab processing industries world over would be capable of satisfying the raw material requirements for decades to come.

The slow growth of the industry has been attributed by some to the negative role of patents, which have tended to slow down market development. It is also believed that instead of examining ways of using chitin/chitosan as a substitute for ingredients already in usage in agriculture and industry, more research on identifying specific uses and the advantages, would help expand the spectrum of commercial applications of chitin, chitosan and their derivatives. In this respect specific dietary/biomedical applications have good prospects for successful commercialisation. One may wonder whether the producers and promoters of dietary chitosan products have given the industry the right direction in this respect.

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Fish Waste Composting:
www.cfe.cornell.edu/compost/fishwaste.html

Fish fertilizer
Seafood Waste Management Bibliography
http://www.seafood.ucdavis.edu/Pubs/compost.htm Site has bibliography of reports under these categories: composting; hydrolized fish/fish fertilizer; and waste management.

Fish meal / feed
USDA's Alternative Farming System Information Center
http://www.nal.usda.gov/afsic/afsaqua.htm
A comprehensive aquaculture listings site offering links to other aquaculture related websites, faq's, aquaculture related publications and topics, US federal government agencies, and other web sites' lists of links. The page "Aquaculture-Related Internet Sites and Documents" provides hundreds of links to aquaculture sites of companies, organizations, and associations, listed alphabetically.

SAB
http://www.ingvar.is/
A manufacturer of an all-purpose fish meal plant.

Roe
North Carolina SeaGrant Research
http://www2.ncsu.edu/ncsu/CIL/sea_grant/frg1998.html
North Carolina Seagrant (Northern Region) funded a $22,500 research project entitled "Use of Scallop Roe in the Manufacture of Value-Added Seafood." Project #: 98ST-04. Principal Investigator: Joey Daniels

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Acknowledgements

We would like to express our genuine appreciation to each of the fishermen, processors, dealers, scientists, owners of byproduct businesses, restaurateurs and retailers who responded to our inquiries, provided valued information and permitted us to peer into their dumpsters.

Special thanks to Linda O'Dierno, a great colleague who expanded our definition of the Northeast beyond Maine and Massachusetts, to Bob Moore who actively chased leads, provided photos and editorial acumen, to Bob Ross and Ken Beal, Saltonstall-Kennedy Program Administrators for their patience and support for this endeavor, to Nilo Cachero who introduced us to the world of Asian markets and to Bob Peacock of RJ Peacock Canning Company for his generous in-depth plant tour and Downeast hospitality. Finally, to the memory of Bob Curren of Yarmouth, Maine whose dedication to moving beyond waste continues to animate and inspire efforts to turn waste into products.

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