WASHINGTON SEA GRANT PROGRAM

TOTAL UTILIZATION CONCEPT

Fish and Shellfish Processing Wastes

April 18, 1972

Report of a workshop
edited by Richard vanHaagen

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DIVISION OF MARINE RESOURCES
UNIVERSITY OF WASHINGTON 98195
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Sponsored by the Washington Sea Grant Program
and the National Sea Grant Office in cooperation
with Food, Chemical & Research Laboratories, Inc.
and the Oceanographic Institute of Washington

Division of Marine Resources
University of Washington
Seattle 98195

C O N T E N T S

The Washington Sea Grant Program is supported by the Office of Sea Grant National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

INTRODUCTION

A pilot plant operation for total utilization of fish and shellfish wastes is being established in Seattle by the Oceanographic Institute of Washington in cooperation with Food, Chemical & Research Laboratories, Inc. An award from the Washington Sea Grant program will help underwrite initial costs of this experimental venture.

In the plant, protein in fish wastes will be extracted for use in animal feeds and eventually, perhaps, for prepared human foods. Formerly wasted shellfish exoskeletons will be reduced chemically to chitin and chitosan, which are polymers of potential value to a number of industries.

It is hoped that experience gained from this pilot operation will provide the business community an impetus for developing economical products from fish and shellfish wastes as well as viable markets for these products. In addition to economic benefits, the project may help abate the fish processing industry's current pollution problem caused by casual disposal of processing wastes.

Although the pilot plant is not yet in full production, all parts should be operating by late July.

The total utilization concept (TUC) behind the pilot plant dates back to 1969 when Washington Sea Grant initiated two projects aimed at more complete utilization of marine products. One of these was started in the University of Washington's College of Fisheries under Dr. John Liston, Director of Food Science and Technology, and Dr. George Pigott, a professor in that institute. Their work was directed toward complete recovery of the protein in material remaining after fish processing, and they developed two methods of extracting this protein: in a brine solution and through enzyme hydrolosis.

The second sea grant project was started by Dr. Kyosti Sarkanen and Dr. Graham Allan, professors in UW's College of Forest Resources, and by Dr. Darrell Medcalf, a professor in the Department of Chemistry at the University of Puget Sound. This work centered around investigations of marine polymers including chitosan, a deacetylated derivative from the chitinous material of shellfish exoskeletons.

Studies showed that chitosan contained binding properties of potential value to the paper industry for improving wet strength of paper. Full-scale testing depended upon the availability of sufficient quantities of deproteinated shellfish wastes from which chitosan could be derived. Therefore, it was soon recognized that a conjunction of the two projects would provide cleaned shellfish for preparing chitosan as well as an effective means for further using shellfish wastes.

Concurrently, a Seattle firm, Food, Chemical & Research Laboratories, Inc., having completed a study for the Environmental Protection Agency and the City of Kodiak, was seeking assistance in establishing a semi-works scale pilot plant for producing chitin and chitosan from shellfish wastes. Seattle Rendering Works had provided the firm with a building and daily deliveries of shellfish wastes; however, additional facilities for cleaning and deproteinating the incoming shell were required.

Therefore, a mutually advantageous arrangement for combined pilot testing of the protein and polymer extraction operations has been set up at the rendering works. These combined operations allow student involvement in the actual operation of a pilot plant, and they permit interruptable operation since the rendering plant is capable of taking any and all aborted batches of material, thereby removing the pressure often found in a processing plant working with experimental equipment or processes. Moreover, the plant will supply products to the sea grant community for research and market development.

The processes under development and being tested in Seattle have possible applications elsewhere, such as the various New England fisheries, the Gulf shrimp industry, and perhaps such concentrated processing localities as Kodiak, Alaska.

How best to extrapolate and apply this information was the subject of a workshop sponsored by the Washington Sea Grant program on April 18, 1972, in Seattle. This publication summarizes some of the major discussions and questions addressed during that workshop by representatives from industry and sea grant programs across the nation.

HAROLD L. GOODWIN
Deputy Director
National Sea Grant Program

We have a very serious problem in seafood processing in the country, as I know all of you are aware. We have a problem of environmental maintenance and the requirements EPA is issuing about effluent control. We have a number of companies that are marginal. If they cannot dispose of their effluent in the environment, there are many that will have to go out of business. Sidney Upham, the Mississippi Sea Grant director, tells me that this is already beginning to happen with some of the smaller plants in the Gulf. Then also, there is the factor that in the stickwater from processing, in the chitin that we have been disposing of by dumping, there is a valuable resource.

The sea grant interest is to assist through bringing its facilities to bear on these problems and by revising the basis on which industry can structure the necessary methodology for extracting proteins and other elements from waste. If this can be done in such a way that the residues that we have been throwing away can be sold to users, either at the break-even point or for a slight profit, then this would make a great deal of economic difference. It also would have the effect of providing a strong incentive for cleaning up the environment by not dumping waste containing useable materials.

We received the proposal from the University of Washington in concert with the Oceanographic Institute of Washington to produce chitosan. This proposal was based in part on work that had been conducted in Puget Sound under the Washington Sea Grant Program by Dr. Graham Allan, who had been looking at additional uses for chitosan beyond those that Dr. Peniston will describe. This proposal tied in beautifully with George Pigott's Total Utilization Concept for the extraction of proteins from seafood wastes.

Even with these two systems working, the situation poses many, many problems; and it is these problems that I wish you would consider during this workshop, and think of them in terms of potential solutions. For example, it is perfectly clear that the situation does not allow for the shipment of shrimp and crab wastes over long distances--they are too highly perishable. So, this means that there must be localized protein extraction in order to produce a dry exoskeleton.

If we develop markets for chitosan or other chitin products, there is a problem of supply because the exoskeletons would have to be shipped to a central processing point, and there is at present no system for this. I don't think the problem is insoluble, but we certainly have to think about it.

With the many potential uses of chiotsan, we have to arrive at those that are most highly marketable. Chitosan, after all, is a marine polymer, and it is competitive to a degree with the alginate products from kelp and the carrageenin products from the red seaweed. On this problem we may have a handle within the Washington Sea Grant program.

What I would like to ask you at the end of this workshop is: Where do we go from here? How do we apply the work that has been done here? How does this relate to work that has been done in other places? For instance, Tom Meade at the University of Rhode Island has been concerned; and Art Novak at Louisiana State University has been working with shrimp processors for a long while on this problem. You participants were invited to this workshop to bring your own thoughts and experiences to bear on these problems. So keep in mind that the ultimate question after the workshop will be: "What do we do to help solve this national problem?"

QUINTIN P. PENISTON
President
Food, Chemical & Research
Laboratories, Inc.

To bring us up-to-date: after several discussions with Dr. Stanley Murphy, John Dermody, and others in the Sea Grant Program last Spring, Food, Chemical & Research Laboratories, submitted a proposal in August 1971 whereby Sea Grant would purchase certain quantities of chitin and chitosan at a price, and Food, Chemical & Research Laboratories would produce this material in a semi-works plant to be located in Seattle. This (after discussions last fall and so on) culminated in a purchase contract which was signed in mid-March 1972, and we are currently getting this plant ready to produce chitin and chitosan.

The plant will be located at a rendering works--the Seattle Rendering Company which is located south of Seattle in Tukwila, near the Long Acres Race Track on the bank of the Green River. Seattle Rendering has been located there for many years and has facilities for handling all animal wastes such as are usually handled by a rendering plant. They process crab shell for a couple of the local crab packers, notably Odian Sea Foods and New England Fish Company. These plants have been processing local crab for a number of years and lately they also have been bringing frozen whole crab from Alaska and processing them here to make canned crab and frozen legs, etc.

There is now available in the Seattle area, both King crab and Dungeness crab waste. Seattle Rendering, as I said, has been handling this material, making crab meal from it, for a long time, and this was one of the reasons for locating the plant there. We can operate on any scale we want to up to the total production of crab waste in Seattle and any that we don't need for immediate production, we can by-pass to Seattle Rendering who will use the material in their usual way. Also, Seattle Rendering can take care of by-products that we may produce and have no immediate need for.

For example, we will make about as much protein as we will chitosan from this crab waste, but we don't have any immediate market for this protein. Rather than spend money to purify, precipitate, wash, and spray-dry, we will turn that protein back to Seattle Rendering who will put it into their rendering process for meat meal. Therefore we won't have a disposal problem--that was one of the reasons for locating there.

We have a large part of the equipment for the plant on order and we are planning on starting up soon to meet the requirements of the Sea Grant contract. We were supposed to begin supplying in January 1972, 1,000 pounds of chitosan a month. We are to deliver to Sea Grant 12,000 pounds during the year, so we are going to start producing somewhat over a ton of chitosan a month in order to meet the annual requirement for 12,000 pounds. This also will give us perhaps a third of that needed for private market development work.

We are building the plant so that it can be increased in capacity by a factor of four without additional equipment. What we plan to do is to operate with about three batches a week on an 8-hour shift, 5 days a week. We can increase that to five batches a week or even six and operate with two shifts if we have to and could quadruple the production of this plant.

The main private users who we feel are going to take the immediate production of this plant, are in the field of water clarification and treatment of domestic and industrial waste. We have done quite a bit of work in this area and we find that chitosan is the equivalent of some of the best of the cationic polyelectrolytes for use as a coagulant. We also hope that a market can be developed quite rapidly for the use of chitosan in underwater exploration work and perhaps in repair work on ships, piers, and all aspects of underwater activity where turbidity in the water ia a problem. We find that chitosan is effective in causing rapid coagulation of silts and sediments and in clarification of water. We have also found that chitosan is effective in the coagulation of organic matter from industrial wastes and domestic wastes.

Are there any questions?

Is chitosan a coagulator or a coagulant aid?

Well, it works both as a coagulant aid for use with ferric chloride or alum and as a primary coagulant in itself. For example, in the treatment of domestic waste for phosphate removal, we find that where alum is used alone, a very accurate control of pH is needed in order to get good phosphate removal. The range for good phosphate removal with the addition of chitosan seems to be broader, so it is not quite so critical a process. Also, we feel that settling is faster and that phosphate removal is better using chitosan than with the alum alone. But in other applications such as the clarification of sea water, chitosan would be used as a primary coagulant because what we want there is a very rapid coagulation and our feeling is that the amount used is not quite so critical. That is, a commercial diver is getting several hundred dollars a day for his activity; if we could improve his efficiency by 50 per cent we can afford to use quite a bit of chitosan to accomplish this.

Do you have any control of the molecular weight?

We do, yes. We have means for controlling the average molecular weight. We have no way except random breakage of bonds, but we can control the average molecular weight.

What is the pH range for use of chitosan?

Chitosan precipitates at a pH of about 5 1/2 - 6 and it is necessary to have a pH below that. Of course, in these coagulation usages for waste treatment, we add chitosan as a slightly acidic solution in acetic acid. If the pH goes above 6, chitosan would tend to precipitate by itself.

Does chitosan precipitate by itself?

Chitosan appears completely soluble at normal concentrations except where there is an impurity that can be flocced out. A floc is not noticeable when chitosan is first added unless there is some material like silt, or clay or organic matter that can be flocced, even at pH 8. Something we should do is establish what these solubility relationships are for instance in purified sea water: how many parts of chitosan can we get into it at different pH levels.

Does chitosan form films?

Chitosan is used in films--chitosan will form films and fibers. It can be spun from a solution in dilute acetic acid; it can be spun into air or into a solvent such as alcohol or acetone; it can also be applied as a coating to fibers or paper and it forms quite tenacious films. Films can be caste from a solution in acetic acid by casting onto glass plates, or something of that nature and then peeled off. The films are insolubilized as they dry. They lose the acetic acid. That is, the acetic acid is held as an amine salt, but becomes volatile as the chitosan dries, and when the acetic acid evaporates, the material is quite impervious to water and water vapor.

In fact, one of the earliest uses proposed for chitosan was as a coating for cellophane to make moisture-proof cigarette packages. Chitosan as a film has been proposed for treatment of glass fibers to make them accept dyes. To make a glass facric accept dyes, it is necessary to treat the glass some way to make it hold the dye, and chitosan is an excellent medium for this.

What is the nitrogen content of chitosan?

We have been able to make chitosan with a nitrogen content higher than 8.3 per cent--theoretical is 8.7 per cent.

Do you get a turbidity in solution?

Yes, a little tindle cone, but it's substantially clear to the eye.

What are the impurities?

In the chitosan? I think mostly artifacts of degraded chitin and deaminated residues lower in molecular size. Of course, if the demineralization is not done completely, there will be some calcium salts. It is pretty hard to see how any protein can survive the deacetylization treatment with 50 per cent caustic soda at 150°C.

What will be the cost of production?

In our pilot plant, it is going to be in the neighborhood of $2 per pound. We have a new process for producing chitosan which will eliminate the use of hydrochloric acid and permit recycling of all the processed chemicals. We feel that with a large scale installation of this process, we should be able to get the cost below 50 cents per pound.

How do you eliminate the hydrochloric acid--are you using calcium chloride?

We are not using an acid for demineralization. We are doing it by an alkali process.

TOTAL UTILIZATION CONCEPT

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Institute of Food Science and Technology
College of Fisheries
University of Washington

George Pigott, Associate Professor
Institute of Food Science and Technology
College of Fisheries
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George Pigott:

I am not going to say too much this morning because I will get a crack at you when we go over to the University. Other than laying out the ground work for our program, I would like to turn it over to Dr. Liston for a few comments. He is on his way to Chile this morning and maybe he could add a few words of wisdom before he goes since we might never see him again!

Basically we started this program about 4 or 5 years ago with the idea in mind of solving several problems at one time. It is always a rather sizeable chore to tackle such a program, but we wanted to come up with a process that would handle both whole fish and waste--particularly in our area, the Northwest and Alaska--and that would also close the processing cycle so we wouldn't have a pollution problem. The first phase of the research was to produce what I call a non-functional sand-type protein by an aqueous process using an acid-brine extraction. We wanted a process that was cheap enough to be utilized in small plants in areas that do not have an extensive volume of products and that could be carried out by rather simply trained technicians.

The capital investment on the part of the producer was also a major concern. We did not start this program with the idea of initially coming up with the so-called tasteless, odorless, wonderful cure-all protein. Our attitude was that we would come up with something that could be sold for a profit and then go on to more grandiose schemes.

The second phase was to improve enzyme hydrolysis by shortening the processing time to produce a functional protein.

The final phase of the project was to do something with the effluent waste. Most of the effluents in these processes, whether you are talking of organic solvent extraction or aqueous extraction, contain in the neighborhood of 50,000 parts per million on up of BOD or COD. Obviously we have to reduce this to maybe 100 or less if we are going to reinject it into the environment. In sequence we have developed a procedure for precipitation of proteins, floculation, carbon absorption and ultrafiltration. Basically, this is our program and, as we proceed today, we will point out the places where we figure we have made substantial progress and the places where we need help and redirection in the future. So, John, would you mind saying a few words, particularly associated with the pollution aspect.

John Liston:

Well George has briefly outlined the purposes of the program and today you will see the results to date, which I think are quite good--quite encouraging. One point that I think will be obvious to you is that the protein extraction process can fit very nicely with the chitin-chitosan process which was described and this is one of the objectives of the Total Utilization Concept: to put a number of things together so in processing fish we end up with nothing but the whistle, as they say in pig factories. George asked me to talk briefly about something that was mentioned earlier--where do we go from here?

We have a working system, I think, for enzyme digestion of waste which gives us a good clean protein; we have the working system for aqueous precipitation of protein from waste or from whole fish which gives us a reasonable product; and we end up as he pointed out in both of these processes, particularly the second one, with an aqueous waste which has a significant amount of nitrogen in it. One way of dealing with this as he described is to clean it up by various precipitation and filtration processes, using carbon. Another one, of course, is to utilize this material in some way.

One project, which we are going to be looking at in the next few months, is taking this waste and putting it together with another local waste, pulp mill effluent, and using this as a basis for single-cell protein production. This is in an experimental stage at the moment. It looks good on paper. The sugar requirement is provided by the pulp mill waste; the nitrogen requirement is provided by small molecular waste from the aqueous process. So this is a project for the future that we are doing.

Another project is related to the enzyme process where we end up with a pleasant substance, which is, however, deficient in tryptophane. We would like to put tryptophane back in here and we are looking at a process that has come to life in recent years known as the plastein reaction whereby one can add amino acids onto peptides to produce essentially synthetic proteins. The enzyme process as it presently exists produces hydrolysate composed not of amino acids but a hydrolysate composed principally of peptides. This has good promise or being used in plastein type reaction to improve the protein quality. Also, I may say, to reduce the slight bitterness which is found typically in hydrolosates--enzyme hydrolosates.

These are two directions that I think we are going to go in the future. We still have a lot of work to do on the existing processes, and we would like to tie them in at the producing end with the catching process. One of our objectives originally was to come up with a system which could be used on shipboard. I know the National Marine Fisheries Service are doing a great deal of work on another area that we are interested in and that we think we can tie in with and that is the separation of fish flesh using the Japanese type flesh separators. This leaves a waste material of skin and bones, etc. which would fit, we think, either the digestion process, using enzymes or the first stages of the brine process.

Ultimately we would like to try to develop a shipboard system utilizing the Yanagya type machine which would separate the flesh on board the ship and channel the rest of the material into a digestion process of some kind, so that the ships instead of landing whole fish, or as in the case of factory ships, fillets, would land frozen blocks (which I think is what John Dassow's group are looking at now) and some kind of extracted material. This would put the whole fishing operation on to a much more technical base and would eliminate the necessity for ships carrying ice and taking up a lot of space with things of that kind.

So this is the forward end of the process which we are looking at--the other end, the waste recovery, we are trying to fit into a complete recovery of all of the material so that the end product is more or less pure water. I think that is mostly what I wanted to say.

<u>What micro-organisms do you propose to use?</u>

John Liston:

Basically we are thinking of growing yeast on it--yeast or fungi. We know we can go yeast--this has been done locally, using pulp mill effluent to produce alcohol. One of the companies is producing alcohol by a yeast fermentation of pulp mill waste. Most everywhere in the Northwest and Alaska, where we have major pulp mill plants, we have major fish installations which is probably peculiar to our area.

We also have other food plant wastes of course, but this is not actually of concern to the Sea Grant Program. I think, in looking at the total picture of waste utilization, we have to consider situations. For example, in Bellingham Bay, where we have pulp mill effluent going into the bay, we have fish plant wastes and also we have freezer and canner wastes from food processors. All of these wastes taken together provide an excellent medium for micro-organisms and it is a matter of determining if they can be used economically.

I think possibly most of you are aware of the fact that there has been a tremendous amount of work on this recently and we have heard from Max Milner, secretary of the PAG of the UN, the other week that the Russians, for example, are pinning nearly all of their hopes for future protein production on single-cell protein. They are making this the largest item in the budget for non-conventional proteins. The French and British are investing I don't know how many millions of francs and pounds respectively in petroleum plants which are in production status--not any longer just pilot plant operations. Now there is obviously an economic difficulty here, in that we in the U.S. have a net surplus of protein at the moment, whereas, in Europe and on other areas, they do not. So we are not looking for this protein production as single-cell protein to produce an immediate large profit for industry, but it would be a net gain over paying for purifying the environment.

<u>What do you think the cost structure will be?</u>

George Pigott:

That is why we are building a pilot operation and initially are going to extract out of Tukwilla. Every time anybody comes out with an estimate it is always less than the actual production costs and everybody criticizes you for premature publicity. We believe for several cents a pound we can clean up effluent--total effluent--but at the same time, recover, essentially quantitatively, the protein that is in the waste water. This in turn could be used for an animal feed.

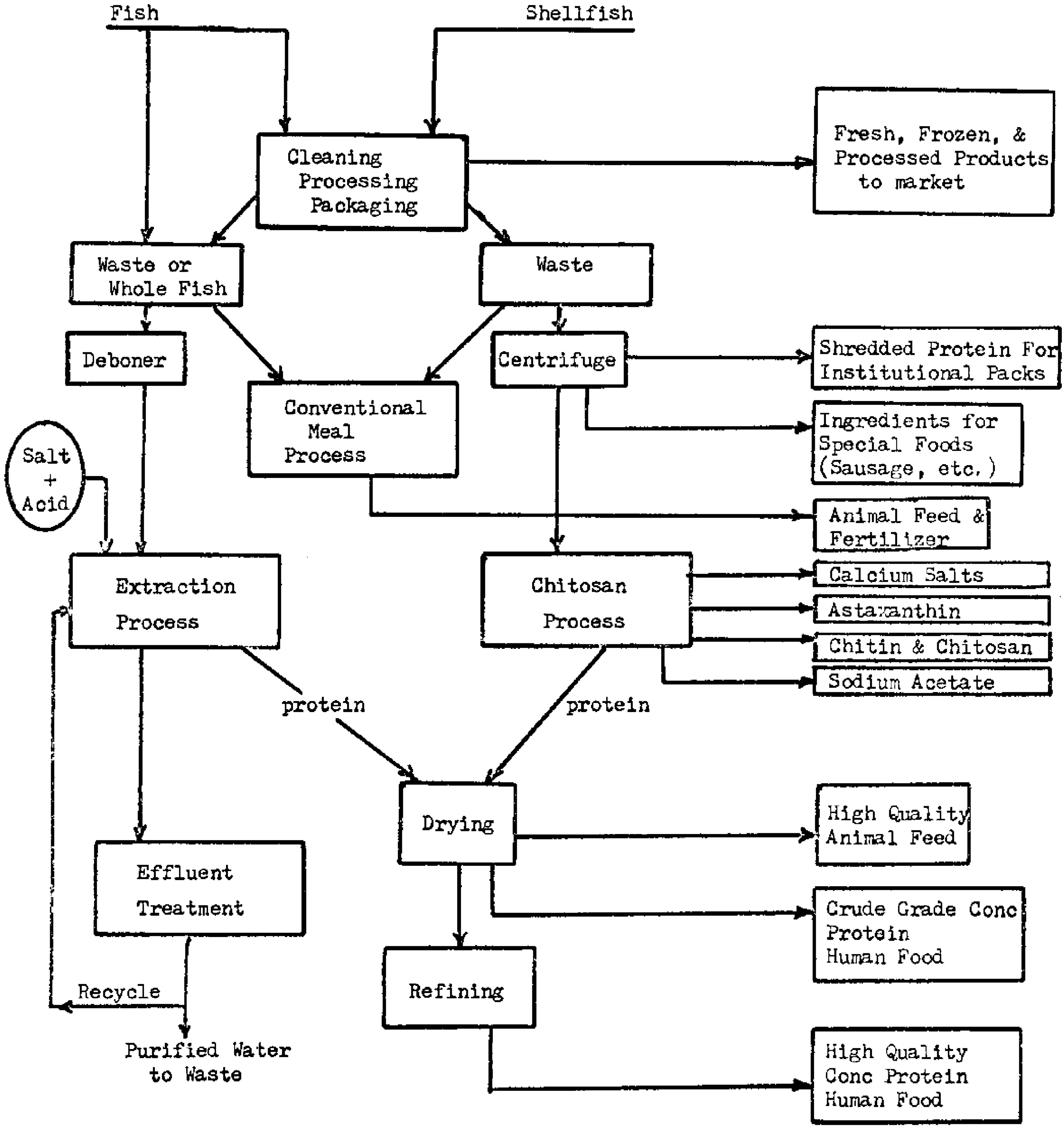
We should have some accurate cost figure by next September or October. We should also have the processing procedure and sequence well worked out. For example, if you use a brine process, you get a little salt in the product, or you can get a lot of salt depending on which of the various schemes is used.

We are having some rather interesting results in putting the effluent through an ultrafiltration cell in order to concentrate to the point where we can spray dry. If you can concentrate 30% solids you can spray dry very inexpensively--maybe a half cent a pound. If you have a five or ten percent moisture, the economics is most questionable. So we are looking at the economics of using ultrafiltration where we take out chloride at the same time we are concentrating. Using this same scheme, with our enzyme process, preliminary runs have resulted in the removal of a tremendous amount of the low molecular weight bitter component.

I should emphasize all of our present work is with the heads, tails, guts and fins. We are not using whole fish anymore. We know with both of these processes a fillet gives a very acceptable product. In my opinion, we are crazy to carry out reduction research with raw materials that have a high demand for human food. We sometimes get a little carried away talking about cheap proteins when we have such a tremendous gourmet market at our finger tips. However, by using only the waste products coming out of plants we are definitely getting more off-flavors and discoloration, but we feel these are the things we must solve.

John Liston:

I would like to make one comment--looking at the whole field of non-conventional proteins. The successful operations, and I think probably the petroleum people are the best example of this, apparently have been directed ultimately to producing a human grade product but economically have been aimed at an animal feed market. I think as far as fish waste is concerned, the waste recovery, this is the way we should go because ultimately if you feed the animals you are feeding people. On the other hand, it is necessary to set your sights just a little higher than an animal grade product to reach the ultimate goal. I think that goes along with what you were saying. If you aim at economic production of a very purified human food grade product right from the beginning, I think you are going to fall on your economic fanny, if you'll pardon the expression.



Total Utilization Concept

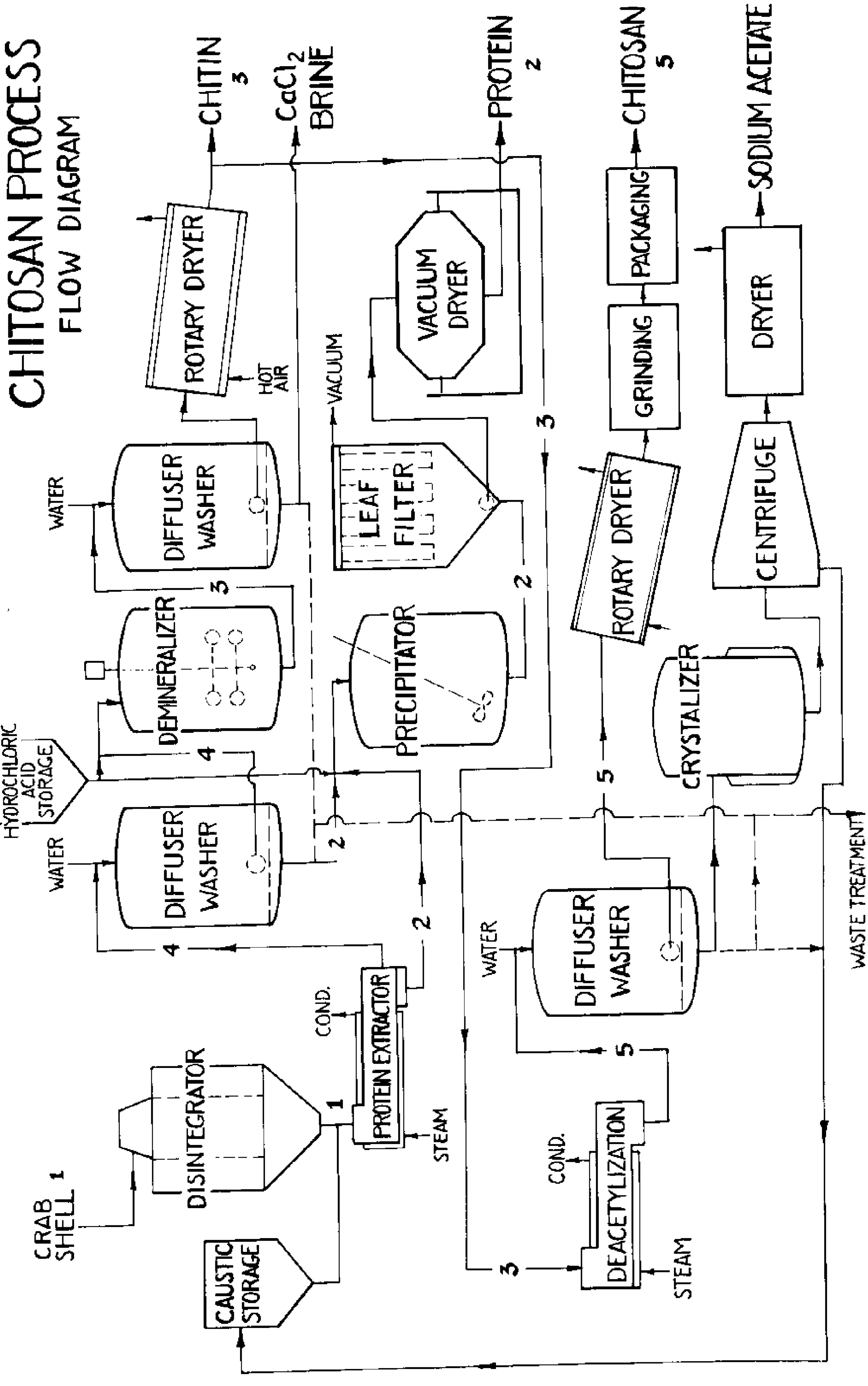
WASTE TREATMENT

PILOT PLANT

at

Seattle Rendering Company

Tukwila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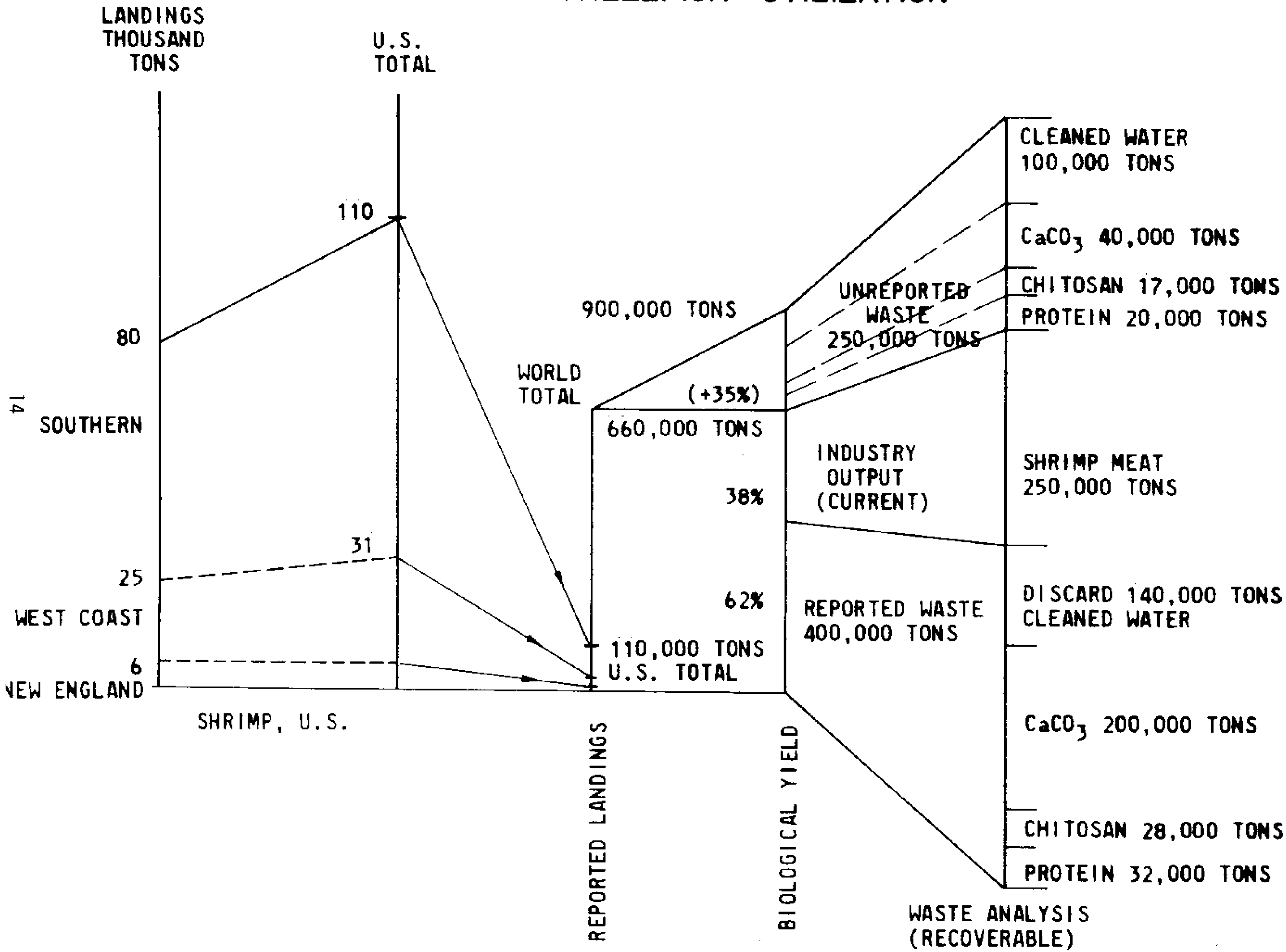

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Three projects may help solve pollution problem

By HILL WILLIAMS
Science Editor

The Sea Grant office brought a handful of experts to Seattle last week for advice on a program aimed at stopping a serious source of pollution by making the waste too valuable to throw away.

The idea is to take the waste produced by fish and shellfish processing plants and extract valuable industrial materials as well as protein for food. It would be a closed-cycle process, with purified water the only "waste" entering the environment.

There are still technical problems but they appear on the way to being worked out. The big question mark is economics: Cost of extraction. Availability of markets. Costs of transporting waste to central processing plants.

That is why Sea Grant, which is providing matching funds to the project, assembled a dozen government, university and industry experts from across the country.

Harold L. Goodwin, deputy director of the Sea Grant office, told the group: "We're going to be asking you, 'Where do we go from here? What do we do now to solve this national problem?' I hope you have solutions."

THE PROBLEM stems from industry practices of using only the flesh from the fish and dumping the rest, as much as 80 per cent of the weight of some fish.

One researcher said the harbor at Kodiak, Alaska, where most of the Alaskan crab and shrimp catch is processed, sometimes has a "putrid layer of waste seven feet deep in places."

The Environmental Protection Agency has begun to tighten regulations, threatening the existence of marginal operators who can't afford to dispose of the waste by other means.

And, Goodwin reminded, "there are valuable resources in what we've been dumping."

Seattle is the center of this research because of three separate research projects that have been brought together by an interesting combination of offices.

THREE YEARS ago, two studies began at the University of Washington into ways to utilize marine products more completely.

Two professors in the College of Fisheries, Dr. John Liston and Dr. George Pigott, were working on a more complete recovery of the protein in the waste left after the flesh is removed from fish and shellfish.

And in the College of Forest Resources, Dr. G. Graham Allan and Dr. Kyosti Sarkanen, along with Dr. Darrell Medcalf of the University of Puget Sound, were investigating whether another material extracted from shellfish waste would be useful in paper-making.

The material needed by the forestry project had to be extracted from shellfish waste from which protein had been removed, something the fisheries professors were doing.

SOON, WHEN the pilot plant begins operation, the fisheries professors will be working on their project to extract protein from fish waste and Food, Chemical and Research Laboratories will be using the leftover from that process to produce chitin and chitosan for possible industrial use by the forestry project.

Chitin is the structural material of shellfish skeletons, the material that holds them together. Chitosan is derived from chitin. (The words are pronounced kitin and kitosan, by the way.)

Liston and Pigott are trying to be realistic in their protein-reclaiming process. Although their product would be suitable and nutritious for human food, they aren't talking about that for now.

Unlike much of the world, the west has a protein surplus. There appears little point in competing with established food.

"Our main idea was to get rid of the wastes for a profit," Pigott said. "All we're using is fins, heads, tails and guts. It seems crazy to talk about processing the whole fish when the world will accept the flesh as it is.

"As a result, we're having more trouble with taste, smell, color and so on. But this is the problem that has to be solved."

And, about the same time, a Seattle firm, Food, Chemical & Research Laboratories, Inc., was looking for funds to set up a pilot plant to produce the material the forestry project needed.

THE NEEDS and objectives of the three projects fit together beautifully. This was recognized by the university's division of marine resources, which administers Sea Grant funds in the Northwest.

But the university is not legally set up to operate pilot plants and to buy and sell products. The Oceanographic Institute of Washington was able and willing to manage the project.

So Sea Grant, the university and the Oceanographic Institute put together a contract covering research into "total utilization" of finfish and shellfish.

The program this year is operating with about $41,000 in Sea Grant funds and 25,000 in local matching funds.

Food, Chemical & Research Laboratories expects to put a pilot plant into operation next month at Seattle Rendering Works in Tukwila. The site was selected because the rendering works has been processing crab wastes from the Seattle area for years.

Liston added: "We think we should aim at animal feed because if we feed animals we ultimately feed humans.

"If we try for high-grade human feed at the beginning, we're going to fall on our economic fannies."

Liston and Piggott are developing a portable processing unit to try out in Alaska next summer, and later aboard a ship.

THEY ALSO are considering another study, that of combining nitrogen-rich fish wash with sugar-rich pulp or cannery waste to provide a growth medium for single-cell protein.

On paper, the idea looks good. Again, costs will be the big question mark.

The wastes would still have to be cleaned up after being used for growing protein, but Pigott pointed out they would be easier to handle. The protein would have used up certain oxygen-demanding chemicals.

The College of Forest Resources investigators want to learn whether chitosan can make its way commercially as an additive to increase strength of paper.

Experiments already have shown that chitosan is a much more efficient paper strengthener than the additives now used by the paper industry. The question is whether the price will make it competitive and the price won't be known until the pilot plant operates for a while.

The forestry program also has learned that chitosan, combined with a herbicide, would be useful in a controlled - release pesticide, where one application would keep down unwanted plants in a forest for a long period with less pollution of the environment.

Dr. Quinton Peniston, president of Food, Chemical & Research Laboratories, said chitosan has possibilities as a coagulant for use as a water clarifier in industrial and city waste - treatment processes.

"I also hope that a market will develop rapidly in underwater exploration, ship and dock repair or in underwater photography where turbidity of the water is a problem," Peniston said.

"Chitosan has been found effective in coagulation of silts and sediments for rapid clarification of water."

One reason that chitosan is so little known and little used is that the supply has been scarce and expensive.

PRODUCT SAMPLES

Qualified researchers desiring chitin and chitosan produced by the pilot plant should submit their requests to:

Office of Sea Grant
National Oceanic and Atmospheric Administration
U. S. Department of Commerce
Rockville, Maryland 20852

To make direct purchase of these materials, please write:

Food, Chemical & Research Laboratories, Inc.
4900 - 9th Avenue NW
Seattle, Washington 98107