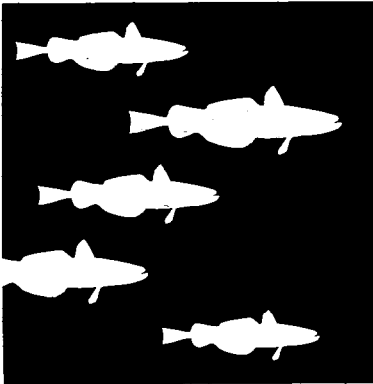


# PACIFIC WHITING

Harvesting, Processing,

Marketing, and

Quality Assurance



A Workshop:

March 30-31, 1992

Newport, Oregon

Edited by Gilbert Sylvia

and

Michael T. Morrissey

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# **PACIFIC WHITING**

## **Harvesting, Processing, Marketing, and Quality Assurance**

Edited by Gilbert Sylvia  
and  
Michael T. Morrissey



Oregon Sea Grant  
**Corvallis, Oregon**

Oregon Sea Grant, Corvallis, Oregon State University,  
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# PREFACE

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The domestication of the Pacific whiting fishery has resulted in an opportunity for significant cooperation between the fishing industry and research institutions. *Merluccius productus* has a number of behavioral and intrinsic characteristics that make controlling product quality a challenging problem. These characteristics include high recruitment variability, complex migration patterns, a relatively soft flesh, a fat layer associated with rancidity, the presence of myxosporidean parasites, and high levels of protease enzymes in the muscle tissue. These characteristics affect fishing practices, methods of processing, and market decisions. A number of ongoing research projects are designed to help us understand these relationships, including how different variables, such as time and temperature, affect product quality.

When we convened this workshop, our principal idea was to present information gathered from our ongoing research efforts as well as the efforts of others in the domestic and international hake/whiting fisheries. Our hope is that this information can be used to develop profitable quality-assurance programs and improve market opportunities. We were delighted with the response to the workshop in both at-

tendance and active participation of the audience during the discussions and question and answer periods. The workshop proved to be a two-way street, with considerable give and take between industry and researchers. Our hope is that this interaction will continue as product quality and market-related issues arise over the next several years.

The workshop was designed to cover a wide range of important topics in the Pacific whiting fisheries, including food technology, product quality, marketing, biology, and fisheries policy. As part of the newly formed Coastal Oregon Marine Experiment Station (COMES) at Oregon State University, we feel that this comprehensive approach to fisheries issues fits perfectly with the mission of the COMES program, which recognizes the need for interdisciplinary research in order to optimally manage the fishery resources.

Gilbert Sylvia  
**Hatfield Marine Science Center**  
**Newport, Oregon**

**Michael T. Morrissey**  
**OSU Seafood Laboratory**  
**Astoria, Oregon**



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Maureen Collson (Coastal Oregon Marine Experiment Station) and Georgia York (Oregon Coastal Zone Management Association) deserve special thanks for their yeomanly work in organizing the conference and attending to the 1001 administrative details. Sandy **Ridlington** (Oregon Sea Grant) edited the proceedings and oversaw their publication. Anne Shriver (International Institute of Fisheries Economics and Trade) summarized the discussions and the question and answer sessions. We also thank Bob Malouf and Sea Grant for publishing these proceedings. Finally, we would like to thank **Lavern** Weber (Superintendent, Coastal Oregon Marine Experiment Station) for his support of and commitment to all of the research devoted **to this effort** and to addressing issues related to the Pacific whiting

# OREGON'S WHITING FISHERY: A CASE STUDY IN COOPERATIVE DEVELOPMENT

*Barry Fisher*  
*Commercial Fisherman*

I am a trawl fisherman. A few short years ago whiting was to me, and virtually every other fisherman of all gear types on this coast, a trash fish. In fact we spent considerable time **trying** to avoid it during the summer months when whiting was prolific off this coast. In those days we fished primarily for soles, founders, lesser amounts of rockfish, and ling cod. We were often driven from the grounds we wanted to fish because of the presence of whiting.

There were good reasons in those days for the lack of interest in Pacific whiting. These reasons all added up to a "chicken and egg" situation. Our boats were too small and primitive to catch or handle the whiting effectively. The average trawler in those days here on the coast was a 50 to 65 footer with 175 to 350 hp. Our electronics and our fish preservation systems were primitive. We were a far cry from the modern trawlers that you see in the whiting fleet today: vessels ranging from 70 to 100 ft long, with horsepower ranging from 600 to 1200 and with a vast array of sophisticated electronics costing many hundreds of thousands of dollars. Above all, these efficient trawlers of today are pelagic trawlers that can effectively zero in on the whiting at any possible depth.

The plants in those days were neither capitalized nor equipped sufficiently to handle whiting. **They** had very limited ice-making and refrigeration capacity. The plants in general had a low capital intensity, and the fixed costs were low. Practically all of their costs were operating costs with a high degree of hand labor so that if you didn't handle much product it didn't **affect** your bottom line too much. The plants focused their attention on the traditional species of salmon, crab, and halibut (all species with high unit value), and increasing amounts of shrimp. Relatively small amounts of groundfish were bought from trawlers. Here was the chicken and egg situation. There were constant market limits on what the trawler could produce; hence, the vessel's capitalization costs and fixed and operating expenses had to be low. In other words, both trawlers

and plants were too small and inefficient to handle whiting, a low unit value species, in volume.

In addition to this set of obstacles, **Pacific** whiting also presented what were apparently other insurmountable **difficulties**. The fish had a soft fiber and delicate texture which rapidly became too mushy to fillet. **The** fish also contained a parasite, myxosporidia, whose enzyme caused the **fiber** to deteriorate in 5% to 15% of the fish.

**To** catch, process, and distribute whiting, therefore, would demand that a product be produced and processed in great volume at a low price into several product forms, all of which would require large investments in automated processing machinery, refrigeration systems, and cold storage capacity. The low capital intensity of the plants would have to change to one of very high capital intensity with considerable investments.

Correspondingly, it was obvious that the whiting would require larger and much more sophisticated vessels with greater horsepower and expensive electronics. In this period, 1965 to 1976, the first tentative experiments were being made in holding **fish** in refrigerated seawater or "champagne slush" seawater systems. It also must be remembered that the automated processing machinery that is much in vogue today was in its infancy in the 1960s and 1970s.

Yet interest in the development of the whiting resource was there. A few visionary fishermen were interested; we knew the stuff was worth something because the Soviet fleet was here in great numbers, taking huge amounts of fish every summer. There had to be a way to utilize this resource. This random interest was shared by a few plants that were constantly experimenting with whiting. There were ongoing efforts to market small lots of fillets or headed and gutted whiting to the traditional California trawl fish markets.

Throughout this period the Oregon State University Seafood Laboratory in **Astoria** was continuing to experiment with whiting with efforts primarily concentrated on the parasite and its destructive enzyme.

Of greater significance in other parts of the world, great strides were being made in **fish-**ing gear technology (in particular pelagic trawling and its associated requisite electronics, such as **sonars** and net sounders). A rapid profusion of automated processing equipment was being produced, and considerable progress was being made in preservation systems from the vessel to the retail store. This era also saw the beginnings of commutated products and analog products and a growing recognition that certain types of seafood lent themselves very well to the production of consumer-ready, fully manufactured seafood products.

But a further catalyst was needed to bring about a mode by which Oregon coastal boats could successfully enter the whiting fishery. The Fisheries Conservation and Management Act of 1976 provided the missing link. This "**200-mile bill**" gave Americans exclusive control of the fisheries resources within their **200-**mile fishery conservation zone. The Soviets recognized the priorities implicit in these controls and entered into a joint-venture company with American interests. The Soviet economy, even in those days, was very weak. **The** Soviets required continued access to our fish stocks, and they also needed a constant stream of hard currency for trade purposes since their own currency was inconvertible on the world money markets. A joint Soviet-American company could successfully reach both of these objectives.

In 1978, after exhaustive political battles within the American fishing industry, the new Soviet-American joint venture began operation. In August 1978, I purchased an **86-foot** trawler with 780 hp, pelagic trawl gear, and associated electronics. We began fishing operations off the central Oregon coast, and after a disastrous two weeks during which we taught ourselves how to **midwater** trawl, we hit "**pay dirt**" The pay dirt was modest. In a **24-day** period we harvested 958 metric tons (**MT**) of **Pacific** whiting, which was processed by two Soviet **BMRTs** into headed and gutted (**H&G**) **whiting** and some whiting block fillets. **That** first year we all lost money, but the concept of small catcher boats delivering transferable cod ends with tows of up to 25 tons to the processor vessel and the subsequent rapid processing and freezing of the fish was firmly proven. The joint venture would work.

In 1979 the Soviet-American joint venture fleet took approximately 11,000 MT of whiting. In 1980 approximately 48,000 MT were delivered, and by this time all of us involved-the independently owned American catcher boats,

the leased Soviet processing ships, and the Soviet-American joint-venture company-were making good profits.

An expansion of operations into the Alaskan area was planned to go **after** various flounders and cod fish. The first bottom fish joint venture also proved to be enormously successful. By this time other American fishermen were beginning to realize the potential the joint ventures offered for their efforts, even though American processing companies, by and large, were not interested in the enormous resources of whiting off the **Pacific** Northwest coast and the pollock, cod fish, and flounder resources in the Gulf of Alaska and the Bering Sea.

A stroke of fate provided the next impetus for a very rapid development in the **Pacific** whiting fishery. In 1979 the Brezhnev regime in the Soviet Union invaded Afghanistan. The U.S. government almost immediately canceled future allocations of any groundfish resources in the American fishery conservation zone to the Soviet Union. In one stroke of fortune the Soviets lost some 350,000 to 450,000 tons of direct allocations in the American zone. This fish had to be made up in some form, and the only vehicle remaining to ensure product for Soviet consumption was the Soviet-American joint venture. By the early 1980s the **Soviet-**American joint venture was taking over 100,000 MT of whiting off this coast and better than 260,000 MT of flounder and cod fish in Alaska.

**This** amount of fishing activity, as well as joint ventures between American vessels and Korean and Japanese companies, brought about a boom in vessel construction and conversion on the Oregon coast for vessels to fish in the new joint ventures. Almost overnight the economic potential for larger and more powerful trawlers could be realized, not only in the rapidly developing joint ventures with several nations, but because these same vessels could also harvest large amounts of **rockfish** in the winter fisheries off the Pacific Northwest coast. This sizable fleet was rapidly acquiring the experience necessary to fully prosecute the whiting fishery in great volume. One part of the equation necessary to develop this important fishery in the State of Oregon had been obtained: the catcher fleet was a reality.

Concurrently, considerable progress was being made in a number of contingent necessary areas. The 1980s witnessed an explosion of interest and **effort** in the production of surimi. The Japanese fishing vessels had been largely pushed out of the Alaskan pollock fishery by the joint ventures.

The Japanese continued to procure their surimi requirements from the pollock fishery by using surimi production factory ships as joint venture partners with American catcher boats. By the mid-1980s considerable effort was applied to the production of pollock surimi in Alaskan shore plants. After a few false starts, a rising volume of high-quality surimi products streamed from these plants. The requisite processing was highly automated, and it was recognized that this same automated equipment could be used to produce surimi from whiting if the characteristics of whiting would lend themselves to the production of surimi.

Intensive marketing efforts were also made in the United States for the analog products that were manufactured from the surimi base. The public acceptance of these products proved to be very positive.

Work at the Oregon State University Seafood Laboratory intensified. Great attention was being paid to efforts to counteract the effects of the parasite. Product forms were being tested and evaluated, and preservation systems were being studied in order to overcome the characteristics of whiting which led to short **shelf life** in the vessels, plants, and retail outlets. **From** all of these efforts, a quality surimi product from whiting began to be produced.

Simultaneously, small but important efforts were being made in northern California to produce round whole whiting, H&G product, and whiting **fillets** for the traditional California markets. Each year saw the production of some 1,660 to 2,099 MT, which provided some 'market reality experience.'

Economic greed can be an appreciable human behavioral dynamic. More and more shoreside processors were recognizing the simple lesson that a great deal of money could be made from whiting after all, the catcher boats were doing it. It was evident that vast quantities of this product were being consumed in the Eastern European community, the Third World, and of greater import, the Western European market. The domestic processors were also beginning to feel the pinch of reduced quotas in the traditional **groundfish** fisheries. Suddenly, as the markets expanded over more and more space and versatile processing machinery was being introduced, their access to resources was diminishing.

Whiting became more and more of a conversational topic on the waterfronts of Newport, Coos Bay, and Astoria. It became obvious to everybody that not only was the Oregon Sea-

food Laboratory heavily involved with whiting, but the National Marine Fisheries Service's seafood technologists were continuing their pioneering efforts, which had really begun in the late 1960s with **NMFS-sponsored** programs to process and manufacture fish protein concentrate, a fish flour, from whiting.

In August 1989, I requested a meeting with officials of the Oregon State University Sea Grant program, the Oregon Department of Agriculture, the Oregon Economic Development Department, and the Oregon **Trawl** Commission. During that meeting I quickly sketched the development of the Oregon trawl fleet into the whiting fishery and presented our catching capability. I described the effective automated processing machinery which was now available to process whiting. I reviewed the market opportunities for a variety of product forms that I felt could come from the whiting resource. I described improved refrigerated preservation systems that would allow the fish to be transported to shore and processed in shoreside plants.

I next described the status of the traditional **groundfish** stocks and pointed out that they would become overstressed if the new whiting trawler fleet had to revert to fishing upon those traditional stocks. I surveyed the successful Alaskan campaigns to produce surimi from pollock as well as pollock fillets and fillet blocks and stated that I felt the same thing could be done with whiting.

All of the vital components for shoreside processing of whiting seemed to be in place. I told the group that I felt that a catalyst was necessary to bring Oregon fully into the whiting business, from the fish in the ocean through product output from the doors of the processing plants. I felt that catalyst should be a detailed, thorough, and intensive study of whiting's potential. We should look at the strength and viability of the resource, competitive resources worldwide, the outlook and market opportunities for products that could be produced from these resources, an intensive study of both the domestic and international markets for whiting products in the form of H&G whiting, whiting **fillets**, whiting fillet blocks, minced whiting products, and, of course, surimi. Other areas that a study should cover were the requisite type and cost of capital for both vessels and shore plants to successfully produce these products, and all infrastructure requirements in terms of available utilities, water resources, labor, environmental criteria, permitting requirements, transport routes, and so on.

I felt that the study should issue from a single administrative source and that because whiting was such an important resource to the State of Oregon, the funding should come from (1) industry, (2) the Oregon State University Sea Grant program, which could provide the requisite seafood technology, (3) the Oregon Department of Agriculture (ODA), which was already engaged in the marketing of Oregon seafood product, and (4) the Oregon Economic Development Department (OEDD), which would be a potential source of demonstration grants and low-cost capital.

I then placed on the table my check for \$10,090 and made the remark that it was time to "ante up." The stakes were high and the Oregon coastal communities would benefit greatly if we could succeed in bringing ashore for processing and distribution the greater part of this enormous resource off our coast.

The response was overwhelmingly positive. By the time the meeting concluded, the director of ODA, the Sea Grant director, and the director of OEDD had signed on with concrete pledges of support. Within a very few weeks the monies had been secured. ODA and OEDD came up with approximately \$112,990 in direct support of the study. OSU committed an enormous amount of in-kind research capability from the OSU Seafood Laboratory, organizational services from the OSU Marine Extension program, and marine resource economic expertise from the Coastal Oregon Marine Experiment Station.

It was decided that the Oregon Coastal Zone Management Association (OCZMA) should be the administering agency for the study because of its long history of positive accomplishments on the Oregon coast and because the agency had the full support of the Oregon Legislature, from whom, of course, the funds would be obtained.

The first order of business was to decide that a policy-setting Whiting Steering Committee should be established to supervise the study. Accordingly the steering committee consisted of the director of OCZMA, the executive director of the Oregon Trawl Commission (a commodity commission to which all Oregon trawlers engaged in groundfish production belong and whose principal activity is the promotion of marketing efforts for Oregon trawl-caught product), a representative of the ODA, a representative of OEDD, and me, a representative of the Oregon whiting trawl fleet.

The various phases of the study were laid out, and appropriate consultants and institutions were given the authority and responsibility

to commence specific parts of the study. Each component had a well-defined scope of work, and critical relationships between the components were identified and established. Great care went into the design of the marketing survey, which proved to be one of the most comprehensive and well-designed marketing studies ever attempted in the seafood industry.

The Whiting Steering Committee met on an almost monthly basis to review progress. During the tenure of the study, key grants and low-interest loans were obtained for a Newport based processor who was enthusiastic about moving into the whiting market. We learned a great deal as the result of this plant's activities in handling whiting from the point of capture through processing and into H&G frozen whiting, fresh H&G product, and fresh and frozen whiting fillets.

The ODA began an immediate and effective campaign featuring whiting products and promotional activities nationally and internationally. Valuable marketing experience was a constant input from the ODA back to the study group.

The OSU Seafood Lab began an intensive series of research projects to produce fresh and frozen whiting surimi; continued effort was devoted to overcoming the effects of the myxosporidian enzyme. The Seafood Lab also concerned itself with experimental work on whiting protease and inhibitors to be used in the production of whiting surimi.

A related activity of the Coastal Oregon Marine Experiment Station was to establish computer modeling techniques regarding efforts and methods needed to extract the highest possible use of revenue from the whiting resource over time and space, from fishing vessels through to the consumer's plate.

The Whiting Steering Committee decided that a technical conference and seminar on Oregon whiting would be a desirable and useful activity. We wanted to tell the Oregon whiting story. We realized that the product was not popular in the marketplace, and indeed that market experience was limited. A conference was organized, and in August 1990, 400 invitations were mailed to an audience that consisted primarily of seafood brokers and wholesalers who had handled Pacific whiting and also great quantities of competing whiting products from all over the world.

The conference was a great success. Over 140 people attended from all segments of the seafood industry: fishermen, processors, institutional agencies, brokers, and wholesalers. The feedback from this conference provided

valuable information for the authors of the study. It **afforded** all of us a great slice of market reality. The experience engendered from this meeting provided not only feedback but cogent guidelines for the conclusion of the study and for industry, the ODA , OEDD and OSU.

The study was completed in February 1991 and was presented to the Oregon State Legislature and the industry. The study yielded great dividends. It clearly established for the **Pacific** Northwest seafood industry that there was now a body of considerable expertise that could be relied on to provide advice on any phase of what was now being called the whiting industry. The study and the conference also clearly established in the industry not only the need for interdisciplinary cooperation but a general climate of cooperation between fishermen, processors, and marketers of whiting products. Finally, the whiting study conclusively established a means of entry into the whiting business for several large outside firms desirous of obtaining or enlarging their presence in the seafood industry.

The cooperative planning and cooperative efforts also allowed the industry to speak with a concerted, positive, and definitive voice in the realm of fishery politics. It became obvious that the industry would have to procure a guaranteed allocation of the whiting resource over time in order for the industry to succeed. It was now able to go to the **Pacific** Fishery Management Council to seek guaranteed allocations on an annual basis of **sufficient** resources to develop the industry.

These political efforts to date have been successful, and a united coastal whiting industry is in the last stages of securing the requisite allocations. Here again, in the area of fishery politics, the whiting industry is accepted as just that, a coherent industry.

The United States Secretary of Commerce recognized in August 1991 the validity of the concept of guaranteed access to the whiting resource for catcher boats delivering whiting to shoreside processing plants. These guaranteed quotas established a priority over **at-sea** processors. Direct allocations proved to be the medium by which intensive investments would be made in both processing plants and the catcher vessels that would deliver the resource.

Enough market experience had been gained in 1991 to dictate that whiting products were competitive and would be broadly accepted, providing that a quality product could be delivered to these markets.

Landings of whiting to shore plants quadrupled and quintupled from August 1991 to

the end of the season in November 1991. The fall and winter of 1991 witnessed a rapid buildup of catching and processing capability and capacity. Several major plants on the Oregon coast decisively entered the whiting business with great emphasis being made on the production of surimi for the 1992 season. Industry surveys dictated that the plants' requirements for whiting in 1992 would approach 105,000 MT. Unutilized plant space has rapidly begun to **fill** with automated processing machinery. The shipyards on the **Pacific** Northwest coast have been full all winter long with trawlers converting to refrigerated seawater holding systems and undergoing all the requisite reconstruction necessary to preserve fish in this mode. Several vessels have acquired cod-end pumping systems to rapidly and safely bring the catch aboard and preserve it in adequate refrigerated seawater systems.

It was against this backdrop of energy and activity that the Whiting Steering Committee decided to schedule this conference.

I think we on the Oregon coast have learned some **valuable** lessons in the past two years. The resource has always been there. We **fishermen** were given a couple of breaks that allowed us to catch that resource. We were able to prove that very good profits could be made from a resource with low unit value, **providing that the resource could be harvested in great volume**. However, we were stymied in all attempts to progress beyond this point until such time as we recognized the other obstacles that must be overcome. We recognized that there was a lot more to the fish business than just catching fish. Markets had to be created. The market places worldwide had been undergoing great changes. Technology had brought us to the point where we could profit from these changes but only if we attacked our problems in a cooperative fashion and used a multitude of talents across a broad array of problems. A system was needed. A system was created. It was that system, enforced by a comprehensive study, that brought us to the point where we are today, on the threshold of a new industry.

No one group-fishermen, processors, managers, researchers, or government officials-could have succeeded alone in building this industry. Under the rigid discipline of a cooperative effort, we have achieved success. In 1992 and the years to come, the entire coast will profit from this new industry. Oregon whiting products are now ready to enter the domestic and **international** markets.



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# Seafood Technology

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# QUALITY ISSUES IN THE PACIFIC WHITING FISHERIES

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Coastal Oregon Marine Experiment Station

Gregory Peters  
Bioresource Engineering, Oregon State University

Gilbert Sylvia  
Coastal Oregon Marine Experiment Station

## INTRODUCTION

Pacific whiting (*Merluccius productus*) is the largest stock of trawl fish off the west coast of the contiguous United States. It has an average maximum sustainable yield (MSY) of approximately 200,000 metric tons (MT) per year. The fishery had been considered underutilized, since only a small proportion of the harvest was processed by the U.S. industry. Figure 1 shows the number of fishing sectors that have been involved in the Pacific whiting fisheries since the late 1980s (Radtke 1992). During the early part of the 1980s the fishery consisted of foreign fisheries (Korean, Japanese, and Russian) and joint venture (JV) operations between foreign mother ships and

coastal trawlers. The foreign fisheries were phased out by 1989. In 1991, there was sufficient interest by U.S. processors for Pacific whiting that JV operations with foreign processing vessels were also excluded from the quota. The U.S. shoreside plants increased their operations from 0.5 MT in 1983 to 22.6 MT in 1991.

There was a dramatic change in the domestic utilization of Pacific whiting last year. This was driven by (1) the high price of surimi in the global market and (2) technological advances in using Pacific whiting for surimi. These advances focused on the use of protease inhibitors in surimi that would slow the proteolytic breakdown of muscle proteins that

## Pacific Whiting Landings

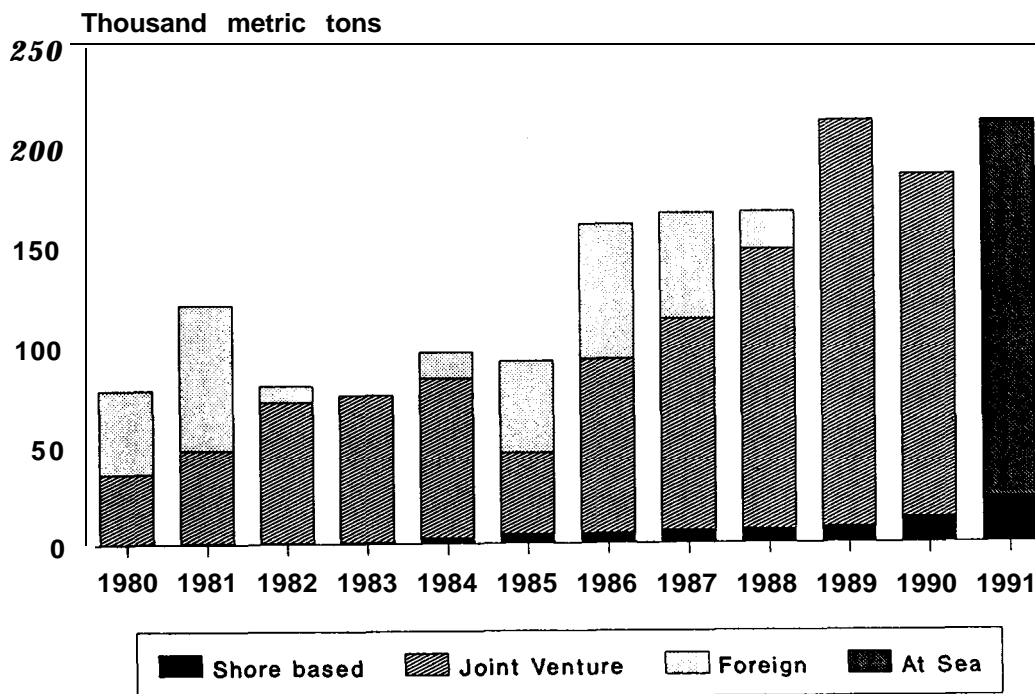


Figure 1. Description of Pacific whiting harvest 1980 through 1981.

lead to weak gel strength. Nonetheless, even with these advances it has become obvious to the fishing industry that **Pacific** whiting cannot be treated as other trawl-caught species. Intrinsic characteristics of the species, such as relatively soft flesh, the presence of a fat layer associated with rancidity, the infestation of Myxosporidean parasites, and the high levels of **protease** that rapidly break down the tissue, make it imperative that **the** fish be handled differently than other species. The Coastal Oregon Marine Experiment Station (**COMES**) has been awarded several grants to study the quality aspects of Pacific whiting and help the industry develop quality guidelines for the harvesting, handling, and processing of the fish.

Currently, there is a large variation in handling practices among fishermen and processors. Several of the processes required to produce a product with the quality characteristics necessary for generating profitable market prices may not be suitable or cost effective for coastal trawlers and processors (Sylvia and Peters 1990). Consequently, fishermen and processors must carefully consider the trade-offs between quality and cost in developing industry standards for Pacific whiting. To maximize profit potential, it may not be cost-effective to necessarily produce the best quality product. Quality guidelines must be based on optimizing the industry profits, rather than only on product quality. With this type of objective, dialogue between industry and researchers becomes easier and more productive. Data presented in the following sections represent the first phase of determining what some of the quality parameters are for **Pacific** whiting as observed in both the laboratory and local processing plants. **Over** the next several years, ongoing research will allow us to look at seasonal and regional variations. This data will

complement the research into how handling and processing **affect** quality in the **Pacific** whiting fisheries; the results will assist the industry in establishing profit-driven standards.

## METHODOLOGY

To relate quality parameters to handling and processing practices, we need to develop a standard method of measurement. In this study, both objective and subjective **evaluation** techniques were used. The subjective measurement used was a Descriptive Evaluation System (DES). The DES was developed from the Canadian **Groundfish** Guide (**Woyewoda** and Shaw 1995) and modified for **Pacific** whiting. This technique uses an observer in processing plants to subjectively determine quality parameters, such as relative texture, degree of discoloration, number of blood clots, and overall appearance. The objective measurements included the use of a **Torrymeter**, which is an instrument that measures electrical current along two points on the instrument in contact with the fish. Torrymeter values gradually decrease as the electrical properties **of the** tissue change after death. The values from this instrument are related to the quality **of the** fish and can be correlated to **specific** quality parameters such as texture.

Processing plants were visited on 35 different occasions during the 1991 season, and a total of over 1,500 fish were sampled. Random samples from each lot of fish were taken and each fish was analyzed and recorded. Table 1 illustrates the sample data collection sheet used in this research and shows the attributes measured. Figure 2 demonstrates the **DES** and standard methods for measuring the temperature and texture of the fish.

*Table 1. Sample data sheet for in-plant descriptive evaluation of Pacific whiting.*

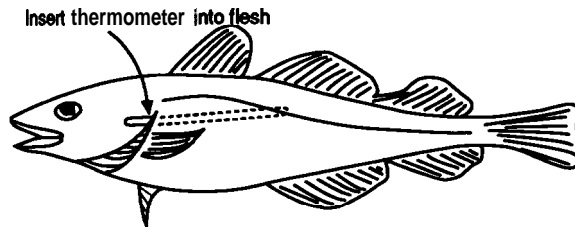
Whole Fish										
Weight										
Length										
Temperature (°C)										
Fish texture										
Fillets										
Blood clots										
Discoloration										
Fillet texture										
Black spots										
Torrymeter reading										

### 1. Record temperature

In order to assess whether fish has been properly iced at sea, determine its temperature. Insert a thermometer into the collar of the fish and push it through the flesh to a point midway down the flank.

Ensure that the tip of the thermometer is completely embedded in the flesh. Leave it in place for about 1 minute before reading and recording temperature.

Any accurate thermometer that can be inserted into the flesh is suitable. A dial or probe type may provide the least resistance. Accuracy of thermometer should be checked; temperature of ice and freshwater mixture is 0° C.



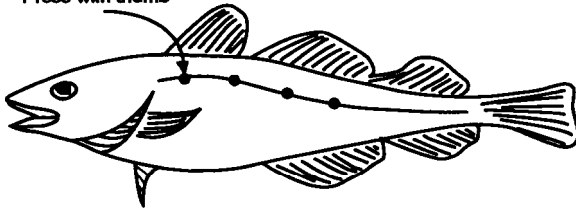
## PROCEDURE

## GRADE

### 2 Assess texture of fish flesh

Press thumb along lateral line for the anterior two thirds of the fish. Do not press along the tail section, as it contains little flesh and mostly bones, and will not give a true indication of texture.

Press with thumb



0 - flesh is firm and resilient, and springs back immediately when released.

1 - reasonably firm, some loss of resiliency, thumb indentations slowly fill out.

2 - moderately soft, thumb indentations may remain in flesh.

3 - excessively soft flesh.

*Figure 2. A sample instruction sheet for descriptive evaluation of Pacific whiting.*

Another objective evaluation technique, used in this study, was the torsion test. This test was developed by researchers at North Carolina State University (Kim et al. 1986). The torsion method evaluates the stress and strain of gels formed from the flesh of the fish. The stress gives a measure of gel strength. The strain is related to the protein functionality of the gel and measures the cohesiveness. A strain value of 1.8 is the lower limit for making a quality surimi product

The torsion test is useful not only in determining gel strength and functionality in order to make quality surimi, but also as a tool in determining the quality of fillets. To use the torsion test as a quality measurement, the researcher must mince the fillet and process it into a gel.

### Surimi Production

One potential use for Pacific whiting is the production of surimi. The texture problem prevalent in Pacific whiting can be circumvented in surimi with the addition of protease inhibitors (egg white, potato extract, beef plasma protein) mixed into the surimi. Surimi is basically a mince, and so the inhibitor can be mixed more uniformly and is more effective than in fillets. With the addition of protease inhibitors, Pacific whiting can be processed into a high-grade surimi. The color is white, and the gelling characteristics are similar to those of pollock surimi.

During surimi production, the fish were obtained from processing plants within 12 hours of capture. Fish were then transferred in ice to the Oregon State University Seafood Laboratory, where processing was immediately initiated. Fish were subsequently filleted and then minced to begin surimi production. The minced flesh was washed in polyethylene tanks (95-L capacity) with water and ice at a ratio of one part flesh to three parts water (W/W) and mechanically stirred for five minutes, then dewatered in a Sano-Seisakusho screw press, model SD-8 (Ikeuchi Tekkosho, Ltd., Japan). The washing and pressing procedure was repeated three times, with the final wash water containing 0.33% salt (NaCl). The first pressing was carried out rapidly to separate flesh and water. The press was operated more slowly during the second and third wash/press exchanges to produce the lowest possible moisture content in the flesh, approximately 75%. The dewatered flesh was refined with an Akashi strainer, remove impurities such as fat and small bits of

skin. Surimi was prepared by mixing the refined flesh with 4.0% sucrose, 4.0% sorbitol, and 0.3% polyphosphate in a Hobart Silent Cutter, model VCM (Hobart Manufacturing Co., Troy, OH) for two minutes. Beef plasma protein, a proven protease inhibitor in Pacific whiting surimi, was added at a 1% level. Product temperatures were maintained near or below 10°C. Aliquots of 600 g surimi were packed into individual plastic trays, vacuum packaged, and frozen at -30°C. Accurate weights of flesh were recorded throughout processing to estimate yield.

### Gel Preparation and Testing

Partially thawed surimi was used for the preparation of all gels. The formulation for the gel was adjusted to 78% ± 1% and 2% salt during the gel preparation stage.

All gels were blended under vacuum with a Stephan Universal Chopper (model UM 5, West Germany) for six minutes after the addition of each ingredient. Caution was taken to keep the temperature below 10°C to minimize protein denaturation. The batters were packed in stainless steel tubes (1.9 cm diameter and 17.5 cm long), sealed with rubber stoppers, and then heated at 90°C for 15 minutes in a Thelco Precision Scientific bath Model 83. Gels were tested for strain and shear stress by the torsion method. Shear stress is a measure of gel strength shown to correlate with sensory hardness; true strain, a measure of gel deformability, is shown to correlate with sensory cohesiveness (Hamann and Lanier 1987).

## RESULTS AND DISCUSSION

### In-plant Observations

An important part of our research during the 1991 season was to apply the methods we were learning in the laboratory to the fish-processing plants. DES results were obtained from more than 1500 fish evaluated in 35 plant visits during the summer and fall of 1991. Table 2 summarizes these results using analysis of variance tests (ANOVA) comparing seven different quality parameters to time. Using the statistical test, we related fish and fillet texture, the number of blood clots, and the Tonymeter reading to preprocessing storage time at a significance level of 95%. Discoloration of fillets was almost significant ( $p = .055$ ). This table illustrates the significant impact of time on quality attributes and restates the necessity which included factors such as gill color, skin

defects, and so on, was not significant with time nor was black spotting on the flesh. Black spotting refers to hair-like black striations which have been shown to be older cysts of **Myxosporidean** parasites (Patashnik et al. 1982). These are present in the flesh of the fish when captured and do not increase with time or appear to be related to other defects such as texture and discoloration. Our work has shown that they appear in 45% of the fish that are off-loaded. Although they present no health hazard, they are easy to see and are unacceptable for aesthetic reasons.

The Tormeter proved to be a **valuable** tool as a fast, nondestructive, objective measurement that could be related to quality. Tormeter values, in general, showed a steady decrease with time, as shown in figure 3. **Tormeter** values, however, can be quite variable between individual fish, and a suitable quantity (40 to 50 fish) must be tested to obtain a representative sampling of the lot.

The majority of fish sampled during in-plant testing were from lots maintained in slush-ice after capture. There is some concern about the use of the Tormeter and **Pacific** whiting with vessels that have refrigerated sea water systems for cold storage. It has been reported that the high salt content in these systems could make it difficult to obtain accurate results using the Tormeter. Additional research will be directed toward answering this question.

Attribute	P-Value
Fish texture	.007*
General appearance	.093
Blood clots	.044
Fillet texture	.005
Discoloration	.055
Black spots	.572
Tormeter reading	.002

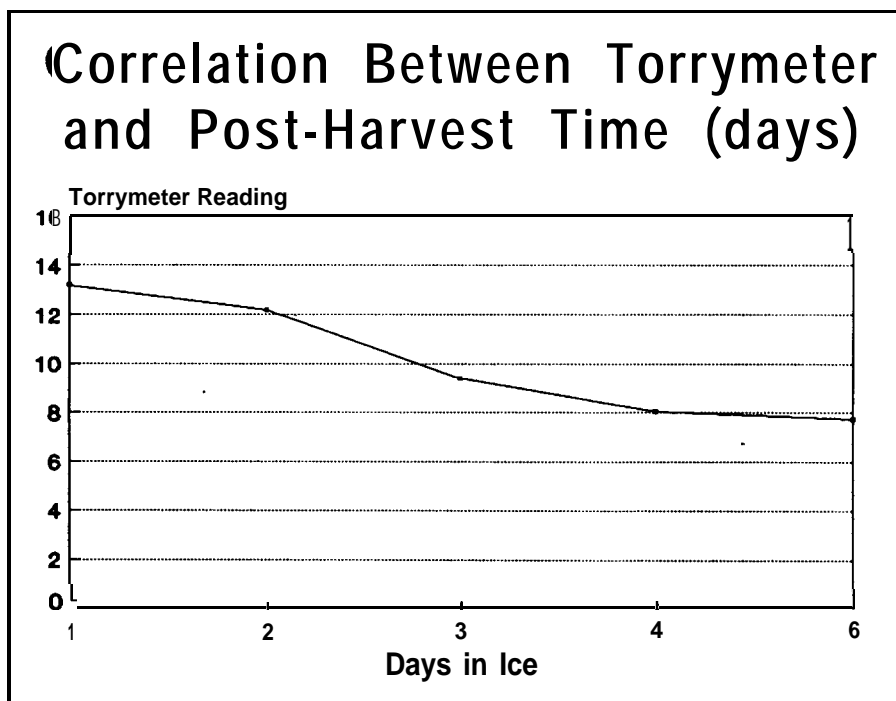
n = 1540

\*A p-value off .05 is significant at the 95% level.

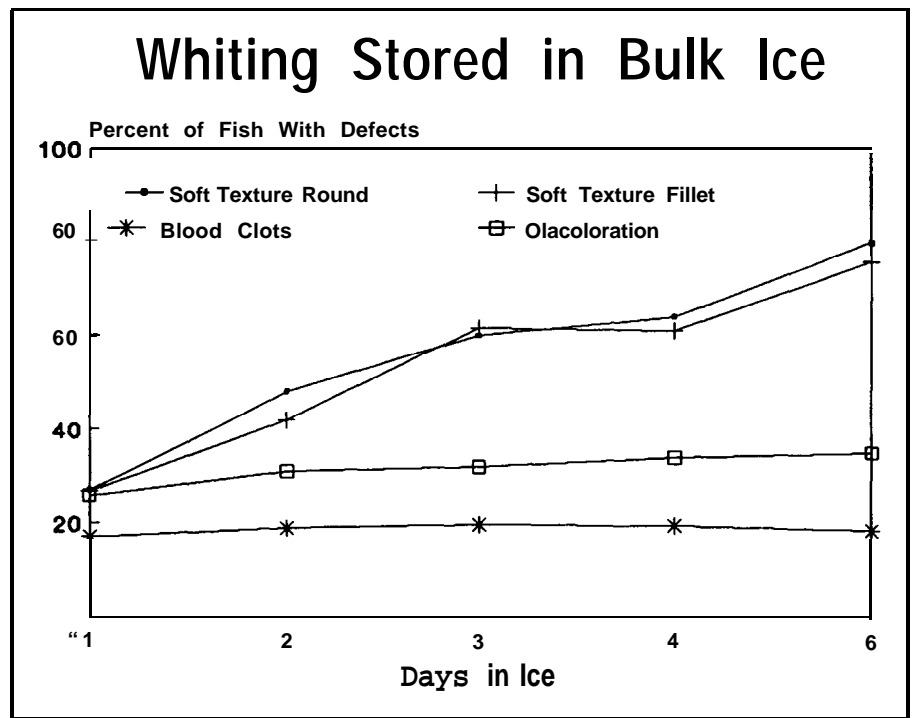
*Table 2. Results of analysis of variance tests performed to determine the significance of relationships between time and quality parameters for Pacific whiting.*

### Laboratory Experiments

The results of the DES analysis undertaken daily with fish kept in ice and daily surimi production and gel **evaluation** are shown in figure 4. These results correlate well with the results found during the in-plant observations. The results demonstrate that texture, measured in both whole fish and fillets, deteriorated rapidly with time. Pacific whiting, because of the presence of an active protease, has softer flesh than most ground fish, a factor which makes it important that the fish be landed and processed as quickly as possible. The percent of **fish** which had poor texture increased from approximately 27% after one day to over 70% after being held in ice for five days. This rapid decline in texture underscores the need for quick processing times. There was not a significant increase in blood clots or discoloration with time when the **fish** were kept on ice. **How-**



*Figure 3. The effect of preprocessing storage time on the tormeter value Of Pacific whiting.*



**Figure 4.** The effect of preprocessing storage time on quality parameters of Pacific whiting.

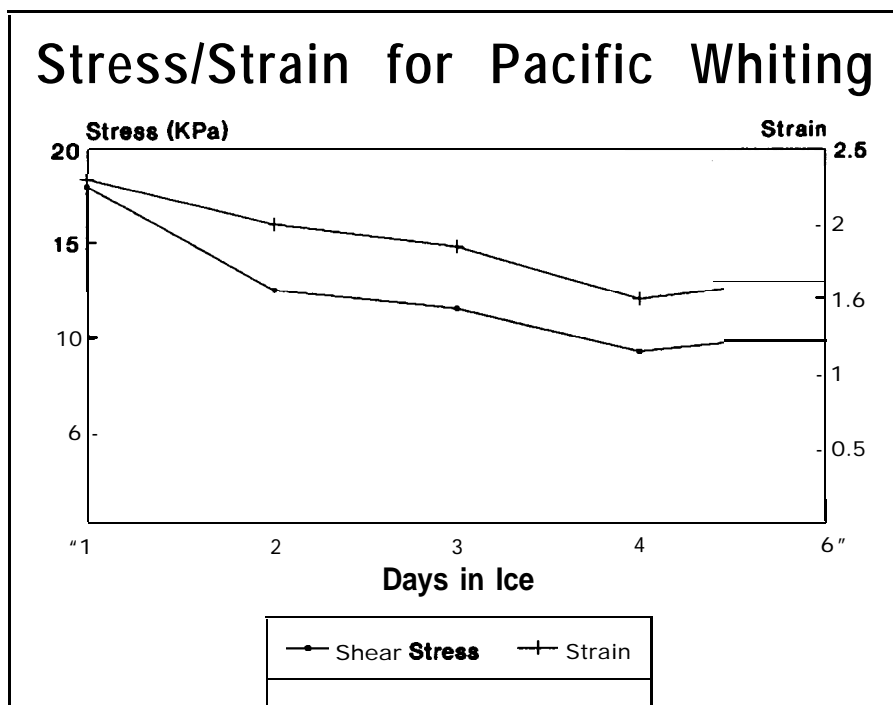
ever, as shown in the graph, the percentage of fish with defects in these categories ranged from 20% to 30% at day one. Similar results were obtained during the in-plant analysis as well. It is unclear whether these poor-quality fish are the result of capture methods, handling, or unloading practices, or whether problems were intrinsic to the fish and would be present regardless of capture or handling techniques. A preliminary study was conducted comparing vacuum unloading to bucket unloading, but there was no significant difference between the two methods. More research needs to be done on the **fishing** and handling practices in order to determine their actual effects on product quality.

The torsion test was run on surimi made each day from **Pacific** whiting kept on ice. These results are shown in **figure 5**. There was a **10-20%** decrease in stress and strain value with each day of processing up to day four of the experiment. On the final day there was a slight increase in the values. As mentioned previously, the torsion test is a newly developed method for determining protein functionality and can be used to objectively determine quality as well. During the 1991 fishing season, there was a great deal of interest in the use of Pacific whiting for **surimi**. **The use of protease** inhibitors during the production of surimi would allow for its use in this area. However, if whole Pacific whiting is stored for a number of **days**, the muscle tissue will dete-

riorate and surimi with inferior gelling properties will result. A critical question, especially for shoreside production, is how long the fish can be kept at refrigerated temperatures and still be processed into a good-quality product. If a strain of 1.8 (which is the minimum strain value that correlates with the traditional Japanese double-fold test for surimi) is used as a cut-off **point**, then our results show that **ap**-proximately two days may be the maximum time that Pacific whiting can be stored in ice before it is made into an acceptable grade of surimi. However, fish processed into surimi within 24 hours of capture possibly will yield stronger gels and a higher-grade product commanding higher market prices.

### CONCLUSIONS

The initial phase of this project was designed to provide researchers with insights into the quality parameters of **Pacific** whiting, especially as they pertain to onshore processing. Preliminary results suggest that time and temperature are the most critical parameters for maintaining good raw material for quality processed product. The **protease** activity in Pacific whiting muscle tissue warrants that the fish be captured, brought to shore, and processed immediately. A 24-hour delay in off-loading or processing could have a **significant** impact on the **final** product quality and be responsible for the rejection or low price of the



*Figure 5. The effect of preprocessing storage time on the stress and strain values for Pacific whiting.*

product. The texture of the flesh is the quality parameter that is the most significantly affected during storage time. This is especially evident in the production of surimi from Pacific whiting. Quality, as measured by gel strength, is reduced by 10-20% for each day of storage of the raw material. Since the surimi market is extremely sensitive to quality, one could assume that a reduction in quality would be accompanied by a reduction in price. Further, if the fish were stored for a period of longer than two days after harvest, there is a high probability that the final product would have low gel-forming abilities and ultimately be rejected as even a low-quality surimi product.

Handling may be an important factor for other quality parameters such as discoloration and blood clots. How these defects may affect quality and price is less clear. Future research is needed on the effect of tow sizes and length of tow on quality parameters of Pacific whiting. It is possible that large tow sizes or lengthy tows may crush the fish and could have an effect on parameters such as blood clots and discoloration and consequently final product quality. However, there is no question that an efficient and well-coordinated harvesting, off-loading, and processing operation is crucial in maintaining high quality and minimizing the number of defects. During the first phase of this project the Torrymeter has shown good potential as an objective measurement of fish quality. There is strong correlation between Torrymeter measurements, loss of surimi gel strength, and overall fish texture. Additional

work will be undertaken to determine if these correlations hold for other quality parameters. After the quality measurements are completed, economic analysis will be conducted to compare the costs of improving product quality with market prices. This information will then be used to determine which standards would maximize profits or market opportunities.

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# USE OF VARIOUS GRADES OF SURIMI WITH AN APPLICATION OF LEAST COST FORMULATION

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## INTRODUCTION

Least cost (LC) formulation is a computer-aided technique that has been used successfully for many years in the food industry, particularly in conjunction with formulated products such as processed meats. The technique is useful in allowing a manufacturer greater variability in the properties of the raw materials while insuring that the quality of the finished product consistently meets rigid standards. The computer selects the type and amount of each raw material in a formulation on the basis of raw material price, properties (compositional and functional), and targets of quality standards. In initiating use of the technique, we first have to determine the relationship between raw material properties and the quality of the finished products. We do this by accurately analyzing the properties of raw materials in current formulations of a product. Several batches should be examined to set up an acceptable range for each property, thus establishing a quality control "window."

## HOW TO APPLY IN SURIMI-BASED SEAFOODS

With respect to a surimi-based food, we must determine an acceptable range of values in color, flavor, and texture of surimi, since surimi forms the base protein matrix in which are imbedded all other constituents. Because surimi generally has a bland odor and is white, the flavor and color are generally derived from other ingredients. Therefore, the flavor and color are held to the minimum in most cases. The gel-forming ability of surimi becomes of prime importance in the acceptance of surimi seafoods. Textural properties can be measured by preparing a test gel from surimi, salt, and ice or water and determining the properties of shear stress (strength of gel) and shear strain (cohesiveness and rubberiness) of the gel, using a torsional test. The gel properties of the batter of the finished product can be measured in the same way. A window of acceptance constituting the upper level control and lower level control of each parameter for both a raw material (surimi) and a finished product can be

plotted on a stress vs. strain diagram, as shown in figure 1.

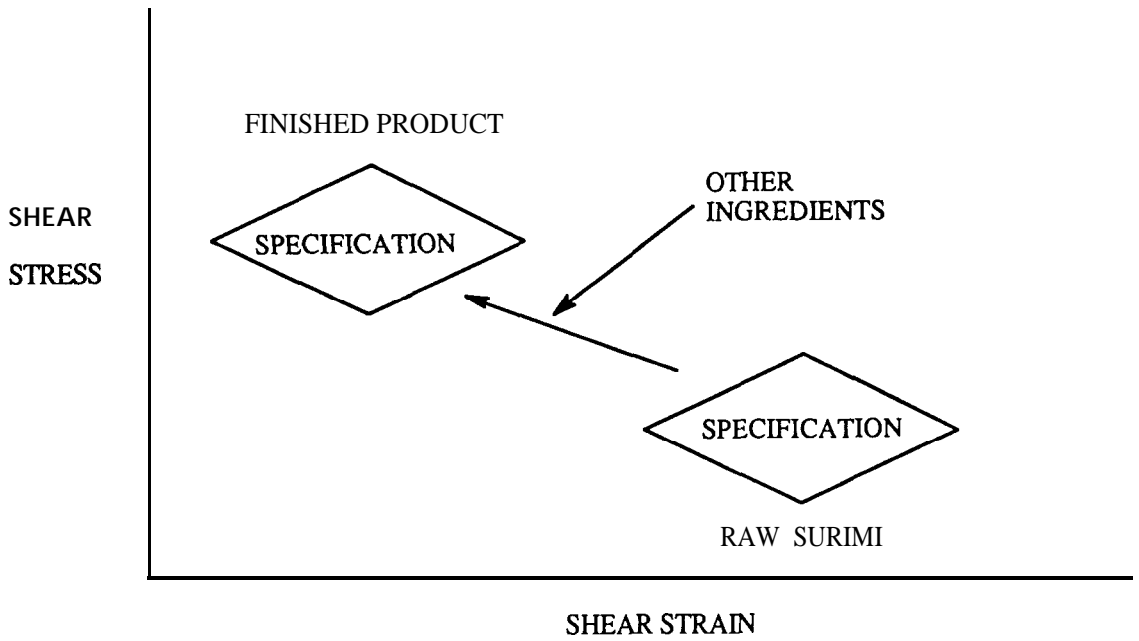
While this approach ensures a finished product of the desired quality, it follows that tight specifications for the raw material (surimi) may eliminate many available lots of surimi from consideration as an ingredient. This can not only present a challenge to the company buyer trying to locate sufficient raw material for production, but could also force up the price of that surimi which is in demand. The lower-cost surimi may not meet the specification; thus, surimi which does meet the specification becomes more expensive, and the cost of manufacturing the product goes up. Among commercially available low-to-medium grade surimi, certain quality parameters show the quality of high-grade surimi.

A more ideal approach for quality control would entail setting specifications on surimi to be used, but would allow for blending of other lots outside that specification in order to meet the target window (figure. 2). The selection of surimis for blending with the wide diversity of surimi qualities and price available will meet the desired objective of consistent product quality at least cost only when the quality parameters of all available surimis are analyzed accurately and applied properly.

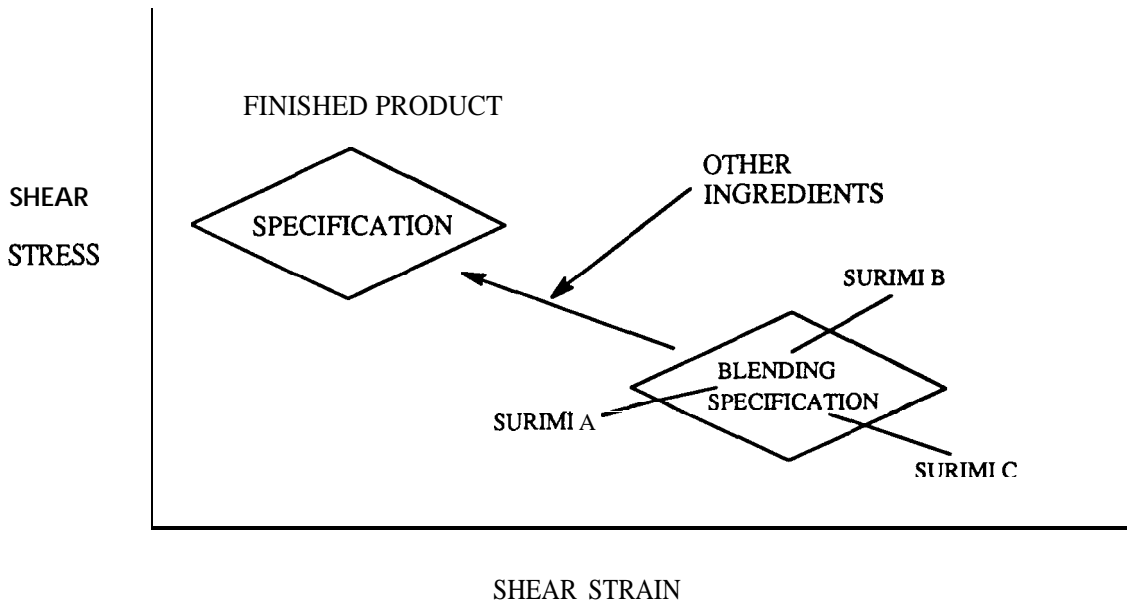
Optimum use of the LC formulation for surimi-based seafoods will be obtained when the linear program is allowed to select differing levels and types of functional ingredients in addition to surimi, such as starch and protein additives. Each ingredient must be tested at various levels in a surimi gel under standard conditions. The slope of the resulting plot of stress and strain values versus ingredient level becomes the factor, or constant, used in the LC equation to predict the effect of its addition on the product

## CONCLUSION

The LC formulation is an optimization technique. It is an effective means of controlling the quality of formulations while minimizing ingredient costs. Implementing a standardized testing procedure for all incoming ingredients is the first step. The various range of raw ma-



**Figure 1. Control of finished product specification using a single surimi.**



**Figure 2. Control of finished product specification using a blending technique**

terials (including Pacific whiting) can be used in surimi-based seafoods formulation with an adoption of the least-cost program approach.

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# CRYOPROTECTION OF SURIMI<sup>1</sup>

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## INTRODUCTION

The myofibrillar (muscle) proteins of most fish, being cold-blooded, are known to be more labile to denaturation than the contractile proteins of homeotherms commonly converted to meat for food, including beef, pork, and poultry (Connell 1961). For this reason, surimi, the refined **myofibrillar** component of fish muscle, requires the inclusion of a cryoprotective component prior to freezing to ensure long-term stability of the proteins in frozen storage. This in turn assures good **functionality** of the material in food manufacture, **expressed** primarily as **gel-forming** potential with its manifestations of **texture** formation and water-binding properties.

**Red** meat (mammalian) and poultry muscles are commonly stored frozen without cryoprotective additives and certainly suffer less deterioration in functionality than would

surimi under the same conditions. The former materials have greater stability, not only because of their homeotherm origin, but also because red meats and poultry are more commonly stored in whole muscle form, in which reactive components of the muscle are more compartmentalized from one another. Additionally in these materials, the **myofibrillar** proteins have not been refined from the **water-soluble** fraction, certain components of which are known to have a stabilizing **effect** on **myofibrillar** proteins during frozen storage (Jiang et al. 1987a, c; Loomis et al. 1989).

Figure 1 summarizes some of the changes which may occur in a muscle protein system during freezing and frozen storage (Haard In press; Shenouda 1980; Sikorski et al. 1976).

Muscle proteins express their **functionality** only when the **salt-soluble** proteins are fully

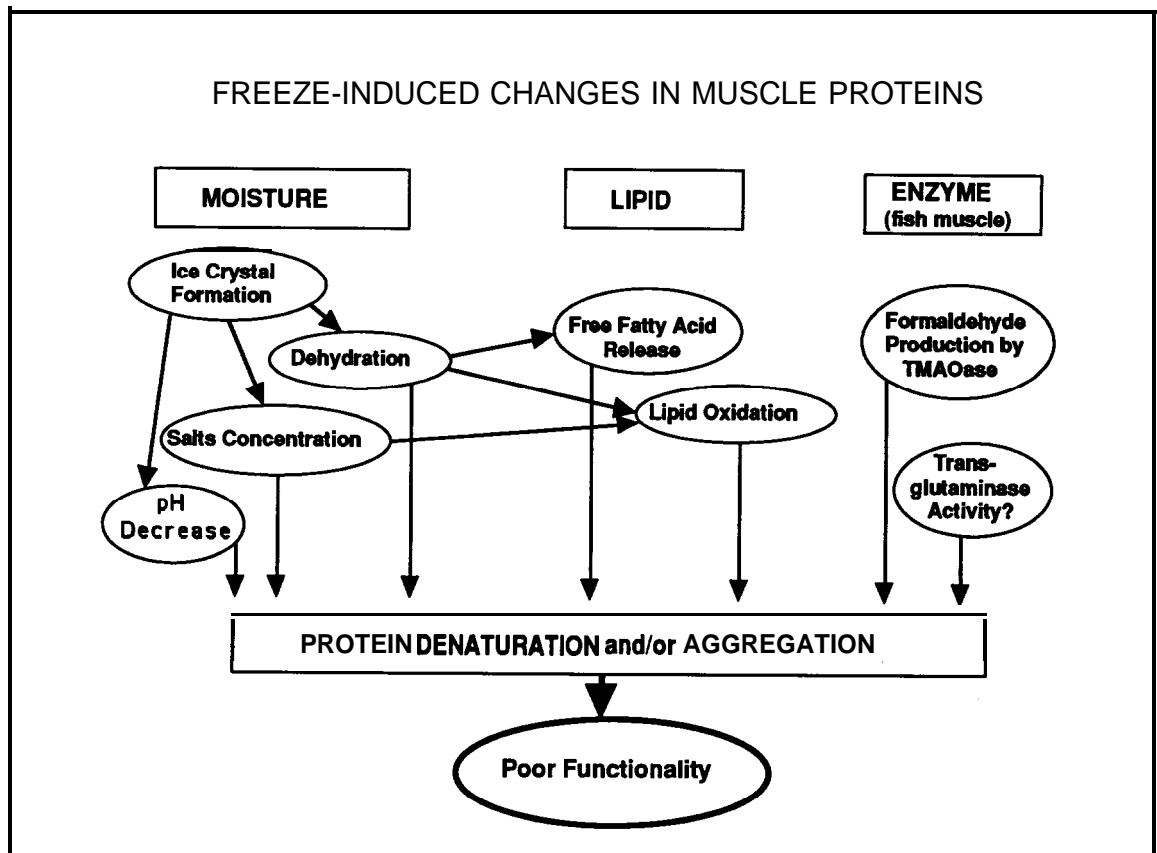


Figure 1: Factors that affect, directly or indirectly, muscle protein denaturation and consequent loss of protein functionality during frozen storage. Adapted from Shenouda (1980).

extracted (**solubilized**), and cryoprotection is possible only when intimate association of the cryoprotectant and the protein molecules occurs. Thus, both the expression and cryoprotection of muscle protein functionality will optimally occur in a minced or **commi-nuted** muscle system like surimi.

## CRYOPROTECTIVE ADDITIVES

**Noguchi** (1974) surveyed a wide variety of chemical compounds for their ability to maintain the **solubility** of carp **actomyosin** (muscle protein) in dilute solutions over brief periods of **frozen** storage. This model system was demonstrated to predict well the ability of compounds to cryoprotect the functionality of surimi during extended frozen storage. Besides a variety of carbohydrate compounds, including most of the mono- and disaccharides **evaluated** and several low molecular weight polyols, many amino acids and carboxylic acids were also found to be cryoprotective.

Other workers have also reported the cryoprotective action of a number of amino acids, quaternary **amines**, and other compounds with regard to the stability of various proteins and enzymes (Jiang et al. 1987a, b; Loomis et al. 1988, 1989).

The nucleotides ATP, ADP, and IMP have been shown to exert a protective effect on fish actomyosin stored at -20°C while the **nucleo-tide catabolites** inosine and hypoxanthine destabilized these proteins (Jiang et al. 1987c). This **finding** may help explain why fresh fish, with consequently higher concentrations of ATP, ADP, and IMP, are more stable during frozen storage than less fresh fish (Dyer and Peters 1969; Fukuda et al. 1984).

Watanabe et al. (1988) demonstrated the cryoprotective ability of certain surfactants, particularly certain **polyoxyethylene** sorbitan esters and sucrose esters, in preventing loss of gel-forming ability in surimi. These are common additives in many Japanese cryoprotectant formulas. A cryoprotective effect has even been attributed to triglycerides (fats), in that **free** fatty acids, which may be released through hydrolysis of phospholipids and react to denature proteins, are thought instead to preferentially react with triglyceride, thus indirectly protecting the proteins (Wessels et al. 1981).

Sucrose or sorbitol, typically alone or mixed 1:1 and added at 8% w/w to leached fish muscle, serves as the primary cryoprotectant in the manufacture of surimi from Alaska pol-

lock. Polyphosphate at 0.2-0.3% is also commonly added, ostensibly as a synergist to the cryoprotective effect of the carbohydrate additives, although its effectiveness in this regard is questionable in light of recent evidence (Park et al. 1988). These carbohydrates were chosen because of their relatively low cost, good availability, and low tendency to cause **Maillard** browning in the bright white kamaboko products typically enjoyed by the Japanese. However, these additives impart a considerably sweet taste to the surimi that many Western consumers have found objectionable for certain product applications. Thus, there has been some effort in the United States to select **nonsweet** additives with a **cryoprotective** effect equal to that of sucrose or sorbitol

Lanier and Akahane (1986) discovered and patented the use of **Polydextrose®**, a nonsweet, low calorie, bulking agent, for the cryoprotection of muscle proteins. They compared its effectiveness with that of sucrose and sorbitol and a **10-DE** maltodextrin (also having no sweetness) in maintaining the **salt-solubility** and gel-forming properties of Alaska pollock surimi. While the three additives maintained similarly high levels of solubility in the myofibrillar proteins at -28°C over several months compared to a control, the surimi containing the **10-DE** maltodextrin failed to form strong and cohesive gels (figure. 2). These results were interpreted as indicating that the 10 DE maltodextrin interfered with the gelation of the surimi myofibrillar protein, in much the same way as occurs with pregelatinized starch and certain gums (Lim et al. 1990; Foegeding and Ramsey 1986, 1987). A more recent study (Anderson 1990) indicates the potential of using higher DE starch hydrolysis products as effective cryoprotectants with less interference in the gelation process of the proteins.

Many other low-MW sugars and polyols that could be used as muscle cryoprotectants are currently or soon to be available. **Lactitol** and lactulose reportedly have low sweetness, the former having also been demonstrated to effectively cryoprotect surimi protein (Sych et al. 1990a, b). **Maltitol**, isomalt, and hydrogenated glucose syrups could also be considered for special applications (Sych et al. 1990a). Edible gums have been proposed to function as effective cryoprotectants, but tests have failed to demonstrate their effectiveness (da Ponte et al. 1985a, b, c). The reduced functionality of muscle proteins in the presence of gums may result from their competition for water with protein, or from interaction with proteins,

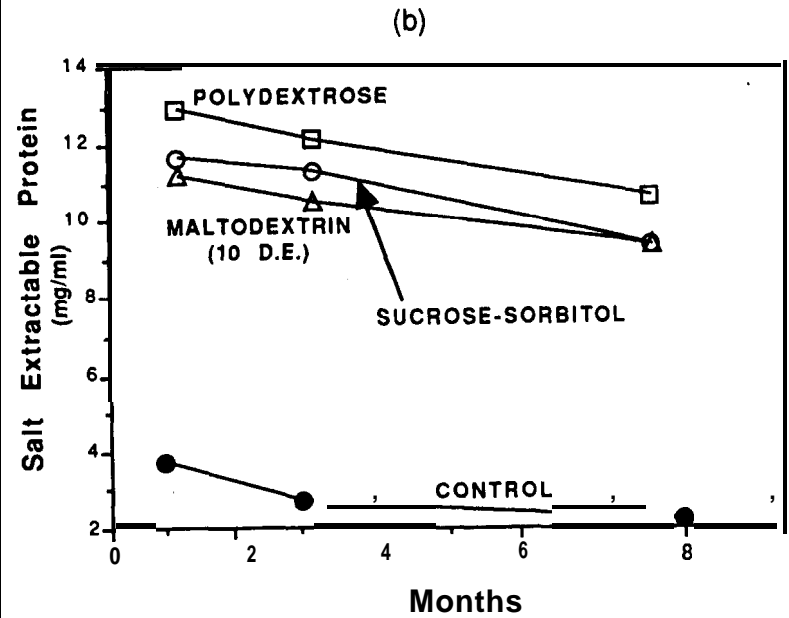
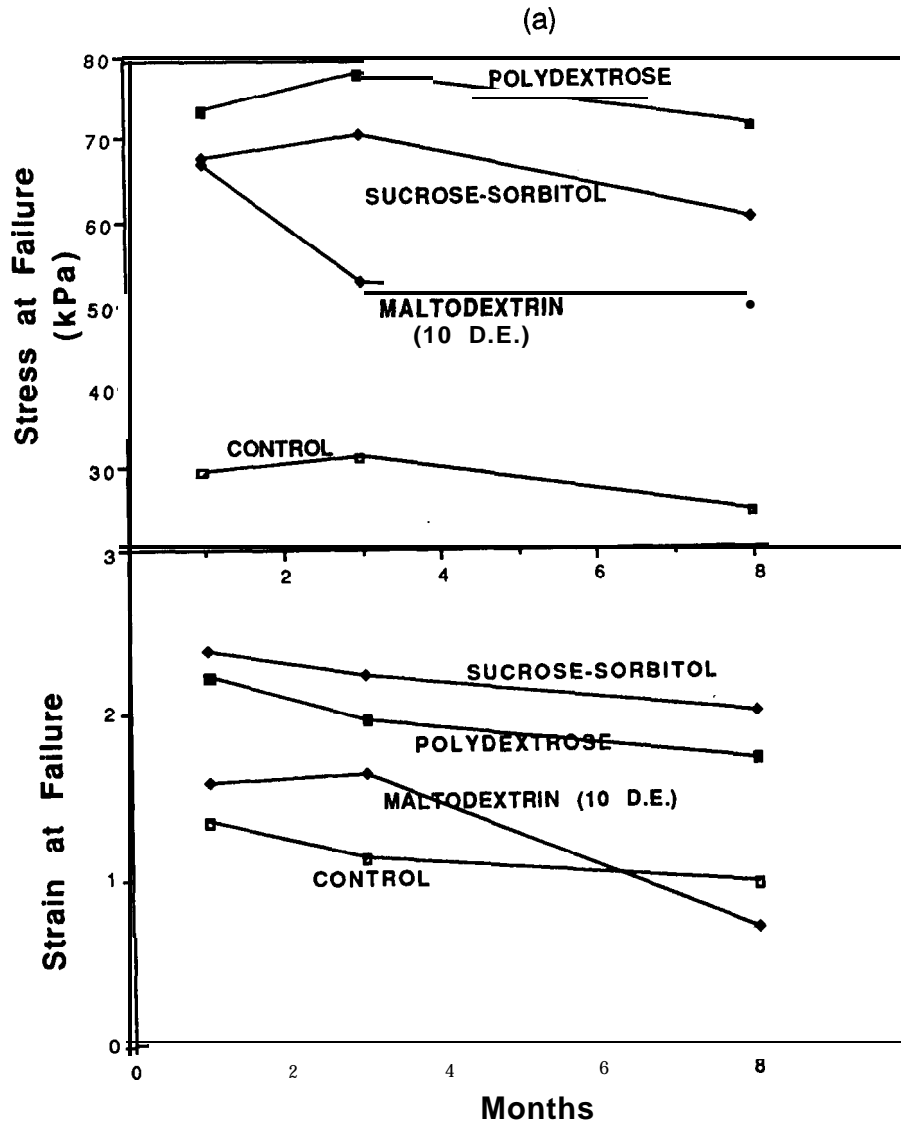


Figure 2: Surimi: Effects of added cyopmtectants on maintenance of (a) gel-firming properties and (b) protein extmctability during frozen storage. Stress and strain at failure correspond to the strength and cohesiveness, respectively, of heat set gels prepared from surimi containing 2% salt.

which results in poor protein gelation. Adding gums in the fully hydrated form without adding excess water, and attaining concentrations sufficient for cryoprotection are additional problems in the practical application of gums as cryoprotectants.

## MECHANISMS OF PROTEIN CRYOPROTECTION

The most commonly used cryoprotectants in the food industry have been low-MW sugars and polyols, such as sucrose and sorbitol used in surimi manufacture. While the mechanisms of cryoprotection by such molecules are not fully understood at present, it is known that they are able to stabilize proteins through their interaction with the surrounding water. Higher-MW carbohydrates seem to work by another, or additional, mechanism and will therefore be discussed separately.

### Low Molecular Weight Carbohydrates

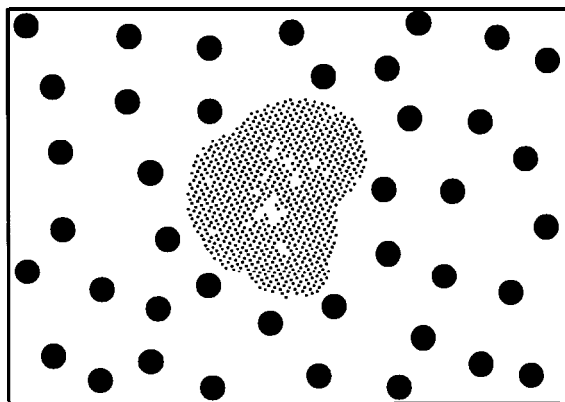
Sucrose and sorbitol not only act as cryoprotectants, but are also known to stabilize proteins to the denaturing effects of heat (Back et al. 1979; Park and Lanier 1987, 1990). Similarly, sodium chloride addition, which was found to promote freeze denaturation of beef (Park et al. 1987), has been shown to destabilize myofibrillar proteins to heat denaturation (Wu et al. 1985). Thus, the mechanism of heat stabilization by low-MW carbohydrates may also explain their cryoprotective properties.

By means of high precision densimeter measurements, Arakawa and Timasheff (1982) were able to show that the stabilizing solute molecules (sugars, low-MW polyols) were excluded from the surface of the protein molecule, thus 'preferentially hydrating' the protein (figure 3). While this "preferential hydration" of the protein has sometimes been identified as the primary protective effect of solute

exclusion (implying that the protein is thus protected against surface dehydration during freezing), the true protective effect is explained thermodynamically. The addition of protective solutes results in a positive (unfavorable) free energy change because the sugar is excluded from the protein surface. The magnitude of this unfavorable free energy shift is assumed to be in proportion to the surface area of the protein, that is, the volume of the cavity occupied by the protein and its hydration shell. Since the protein cavity is assumed to be greater when the protein is unfolded, this means that the native state of the protein is thermodynamically favored in a solution of sugar and low-MW polyol.

This explanation of the mechanism of cryoprotection by low-MW sugars and polyols is in direct contradiction to that forwarded by Matsumoto (1979), who envisioned a protective coating of the protein by cryoprotectant molecules. Arakawa et al. (1990) noted that certain compounds, such as DMSO, proline, PEG, and ethylene glycol, are known to be preferentially excluded from the surface of proteins at room temperature and are equally effective cryoprotectants. However, at temperatures above ambient, these compounds preferentially interact with the protein surface and as a result destabilize proteins at these temperatures. Crowe et al. (1990) noted that the protein denaturants urea and guanidine hydrochloride act by binding to the protein surface. They concluded that therefore "it does not seem likely... that stabilization of proteins during freezing involves direct interaction with the solute."

The preferential exclusion of solutes from the protein surface has been largely attributed to the effects of the solute in increasing the surface tension of water (Arakawa and Timasheff 1982; Carpenter and Crowe 1988; Arakawa et al. 1990). However, several cryoprotective compounds are thought to be



*Figure 3: Solute exclusion from the cavity occupied by the protein and its hydration shell (shaded area), the black dots signifying solute molecules.*



excluded by other mechanisms, such as by steric hindrance. Glycerol, which actually decreases the surface tension of water, is, however, excluded from the protein surface by an unknown mechanism.

That many of the **cryoprotectant** sugars and polyols do increase the surface tension of water may be important in other ways to protein stabilization. Back et al. (1979), from careful measurements, noted that "hydrophobic interactions between pairs of hydrophobic groups are stronger in sucrose or glycerol solutions than in pure water" and concluded that "this is the mechanism by which sugars and polyols in general may stabilize proteins to heat **denaturation**." Similarly, **Melander** and Horvath (1977) addressed the issue of why certain salts of the **Hofmeister** or lyotropic series have a stabilizing effect on proteins. They were able to demonstrate that such stabilization results from a strengthening of the protein intramolecular hydrophobic interactions in the presence of these salts and concluded that "the property of a salt that **affects** hydrophobic interactions is quantified by its molal surface tension increment."

Thus, it may be concluded that those polyols and sugars which do increase the surface tension of water may act to stabilize proteins dually by favoring solute exclusion **from** the protein surface and by enhancing the strength of intramolecular hydrophobic interactions.

Because several workers have shown that the addition of such sugars as sucrose and **trehalose** can stabilize proteins to the denaturing influences of drying (**Matusuda 1979, 1981**; **Carpenter et al. 1987a, b, 1988, 1990**; **Crowe et al. 1990**), it has been tempting to **ascribe** to both the **cryoprotection** and "**dryoprotection**" properties of these compounds the same mechanism. However, **Crowe et al. (1990)** and **Carpenter et al. (1990)** have demonstrated that, in the case of preserving protein structure in desiccation, it is a preferential **interaction** of solute with the protein surface that is required. Only certain disaccharides, among them sucrose, maltose, and trehalose, seem to meet the steric requirements such as to allow them to, in effect, replace water molecules on the surface of the protein and thus stabilize the native protein structure in the virtual absence of water. Many other compounds known to be effective cryoprotectants were found to be ineffective in protecting proteins from the denaturing effects of drying.

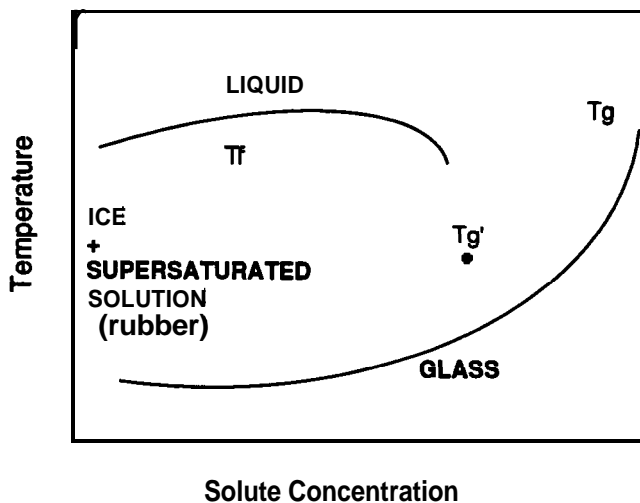
## High Molecular Weight Carbohydrates

**Carpenter and Crowe (1988)** theorized that certain high MW polymers, such as **polyvinylpyrrolidone**, polyethylene glycol, and dextran, are good **cryoprotectants** because they are **sterically** excluded **from** the protein surface by their size. However, an entirely **different** mechanism has been postulated by other workers to explain the cryoprotective effects of many high MW polyols and glucose polymers (starch hydrolysis products). This so-called "cryostabilization" theory is based upon the ability of **high-MW** solutes to raise the glass transition temperature (**T<sub>g</sub>**) of a solution (**Levine and Slade 1988a, b**).

**Figure 4** illustrates the glass transition temperature of a simple solution. At higher concentrations of solute, the **T<sub>g</sub>** occurs at temperatures above freezing. Thus, the mixture cools to form a "candy" glass directly from the liquid state. At solute concentrations below the point **T<sub>g</sub>'**, when the temperature falls below the freezing curve, the solution will exist either as a viscous supersaturated solution in the liquid state or more commonly as a mixture of ice crystals and supersaturated solution. Under these conditions, the system is termed a "rubber," exhibiting a high viscosity caused by the presence of ice crystals or strong, intermolecular solute interactions and entanglements. In the rubber state, ice crystal numbers and sizes may increase, the various chemical deteriorative processes of **figure 1** continue to proceed, and thus the stability of proteins under these conditions is poor. The rate of freezing and the constancy of storage temperature will of course influence ice crystal sizes and numbers, and likewise the solute concentration (**Pranks 1985a, b**). Thus, **T<sub>g</sub>** may be altered by time factors not shown in this two-dimensional phase diagram.

In contrast, the glassy state is a much harder solid, with viscosities near 10<sup>14</sup> Pa.s (**Franks 1985a**), in which reactions become **diffusion** limited as the result of immobilization of the water within a solute structure (**Treloar 1970**). This structure is formed when **solute-solute** interactions supersede solute-water attractions and occurs at the **T<sub>g</sub>** for the given solute and concentration. The structure is amorphous, like that of the liquid, with no **crystallinity** other than that of the enmeshed ice crystals.

Cryostabilization of proteins, then, involves addition of a solute to raise the **T<sub>g</sub>** to a temperature above that of the storage temperature, thereby ensuring that the system is in



*Figure 4: Schematic phase diagram for a binary system in which the solute component does not crystallize.*

the glass state. This effectively shuts down the deteriorative processes depicted in figure 1, including ice crystal formation, since the water is immobilized in the glass structure. Thus there are fundamental differences between the mechanisms of “cryoprotection” by low-MW sugars and polyols and “cryostabilization” by high-MW polymers: cryoprotectants function by altering the thermodynamics of the system to favor the native state of the protein, while cryostabilizers act to enmesh the protein in a glass wherein all deteriorative processes are greatly slowed.

The requirement in cryostabilization for use of polymers exhibiting relatively large MW arises from their ability to form glasses at higher temperatures. This is due to their propensity to entangle as well as to form hydrogen and other bonds, imparting a greater viscosity at any given concentration. Levine and Slade (1986, 1988b) published tables and graphs which indicate a generally direct relationship between molecular weight (or, inversely, dextrose equivalent, DE, for starch hydrolysis products) and Tg. Branching of the molecule will affect the solution properties of polymers, such that a strictly direct relationship between MW and Tg will hold only for a homologous series. Selection of the proper polymer thus effectively narrows the temperature range between Tf (on the freezing temperature curve) and Tg, in which the system exists as a less stable rubber.

Lim and co-workers (Lim et al. 1990; Lim 1989) recently attempted to demonstrate the principle of cryostabilization in the freezing of leached fish muscle (surimi). In model studies using salt-soluble protein to represent the surimi, they found that maltodextrin (Tg = -10°C) protected the solubility of the protein in a much more temperature-dependent fashion

than did sucrose. However, there was not a dramatic change in the stability of the maltodextrin-containing system when they compared the response to storage temperatures just above and below the Tg of maltodextrin at that concentration, as might be expected if a sharp glass transition took place in the system. Surimi also behaved similarly to the model system with respect to the stability of the proteins in the presence of these two carbohydrates.

Carboxymethylcellulose was also tried in these systems (Lim et al. 1990; Lim 1989), but it failed to protect the proteins and seemed to interfere with their heat-induced gelation. Thus, in practice, there may be limitations in applying the cryostabilization approach to maintain muscle protein functionality in frozen storage.

## PRACTICAL CONSIDERATIONS

Although several workers have attempted to employ cryoprotectant compounds in the freezing preservation of intact muscle, their efforts have not met with much success (Krivchenia and Pennema 1988a, b, Krueger and Pennema 1989). Obviously, either of the mechanistic approaches outlined in this article depends on intimate association of the cryoprotectant molecules and the protein, which is difficult to achieve in other than a comminuted system.

In surimi production, sucrose and sorbitol have been adopted as the primary cryoprotective additives for several reasons: relatively low cost, good availability, good safety record, broad legal status, good solubility, and beneficial functional effects (with only one minor exception, sweetness). There is currently no reason to suspect that cryoprotectants now used for pollock are not equally well suited for Pa-

cific whiting surimi. Much of the attention paid to alternative cryoprotectants for surimi has focused on sweetness reduction, with minor emphasis on caloric reduction. In this area of concern, cryostabilization by polymers such as maltodextrins or **Polydextrose®** could be viable alternatives, and **maltodextrins** are also less costly than sucrose and **sorbitol**. Dextrose is also a cheaper alternative, but **Maillard** browning reactions **from** reducing sugars may limit application in light or white-colored products of fish and poultry. More serious is the detrimental effect, discussed above, which certain high-MW polymers have on gelation properties of muscle proteins.

## CONCLUSIONS

Carbohydrates have generally been the most acceptable cryoprotectants for muscle applications (that is, surimi). New carbohydrates are becoming available which may be considered in order to achieve cost, sweetness, or caloric reductions. It is considered that all carbohydrates that are effective in protecting proteins from the denaturing effects of freezing and frozen storage act by at least one of two mechanisms: cryoprotection, in which the addition of primarily **low-MW** sugars and polyols thermodynamically favors the maintenance of the native protein state; and cryostabilization, in which primarily high-MW polymers **effectively** raise the glass transition temperature and ensure a less reactive glass state in the system at conventional freezer temperatures.

A future direction in cryoprotection may be to combine various compounds to create "**cryoprotectant cocktails**," which may be more effective than simple compounds alone. In this respect, it is interesting that the gall fly larva (*Eurosta solidaginis*) is known to generate **intracellularly** a **mixture** of carbohydrates and polyols to allow it to survive overwintering in cold climates (**Wasylyk** et al. 1988). Such an approach may prove to yield synergies, as may the exploration of interactions between carbohydrates and certain ions, organic acids, or amino acids.

Processors of surimi may as a result determine approaches for better maintaining the functionality of their raw materials in both frozen and dry forms, thereby realizing both cost savings in usage and more consistent quality control in production.

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# PRODUCT ALTERNATIVES FOR PACIFIC WHITING

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## INTRODUCTION

Several studies are currently underway at Oregon State University to evaluate whiting product alternatives. We describe three of them: fillets, fresh surimi, and **stabilized** mince. For frozen fillets, questions arise concerning shelflife, or storage stability, and how it changes with various conditions that might be controlled or optimized. A second alternative is fresh surimi: washed, minced fish that is made directly into analog products without **freezing** and therefore without a need for the customary 8% cryoprotectant ingredients. Whiting surimi is of particular interest because it enables effective application of **protease** inhibitors and creates a stable seafood product **from** a fish protein that is inherently less stable. Stabilized mince, a third alternative, involves a technology that would allow minced trimmings and some excess product to be frozen **with cryoprotectants**, and then later thawed to make surimi-based products.

## FROZEN FILLETS

Whiting were caught in August and hand filleted at an Astoria plant. A "K-value" of 15% indicated the fillets to be very fresh. Within 15 hours of catch, they were frozen in 750 g (1.7 lb) packages (four to six random fillets per bag) at the OSU Seafoods Labo-

ratory. Storage is currently ongoing at four carefully controlled temperatures:  $-8^{\circ}\text{C}$  ( $17.6^{\circ}\text{F}$ );  $-20^{\circ}\text{C}$  ( $-4^{\circ}\text{F}$ );  $-34^{\circ}\text{C}$  ( $-29.2^{\circ}\text{F}$ ); and  $-50^{\circ}\text{C}$  ( $-58^{\circ}\text{F}$ ). At various time intervals, two packages (1.5 kg) were taken from each temperature, mixed together, and tested. Our engineering goal was to describe (mathematically model) the quality change we might expect with time and temperature, and so be able to trade off quality with the increased costs of lower storage temperature. We measured protein denaturation, assuming it to represent the most significant quality change, associated as it is with toughening and a loss of succulence and water-holding capacity.

The results through five months of storage appear in figures 1-3, which picture three different means for measuring denaturation. (1) The most sensitive indication is the de-

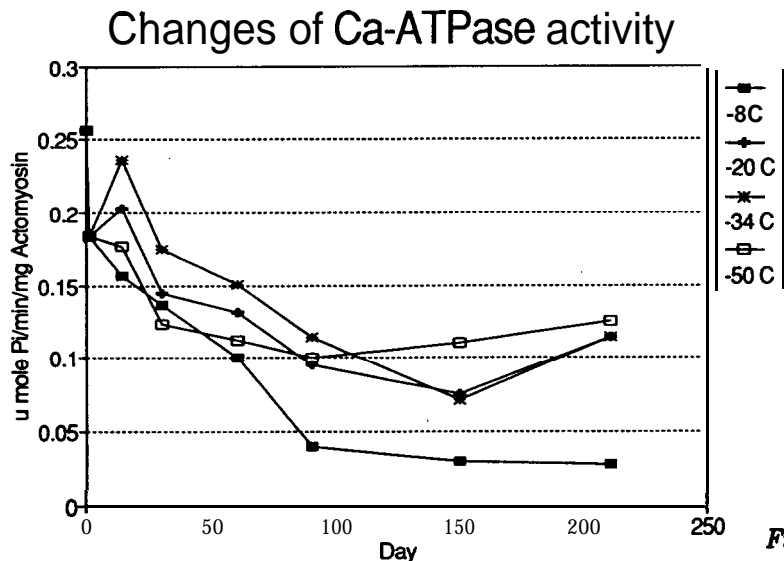


Figure 1.

## Changes of SSP in whiting

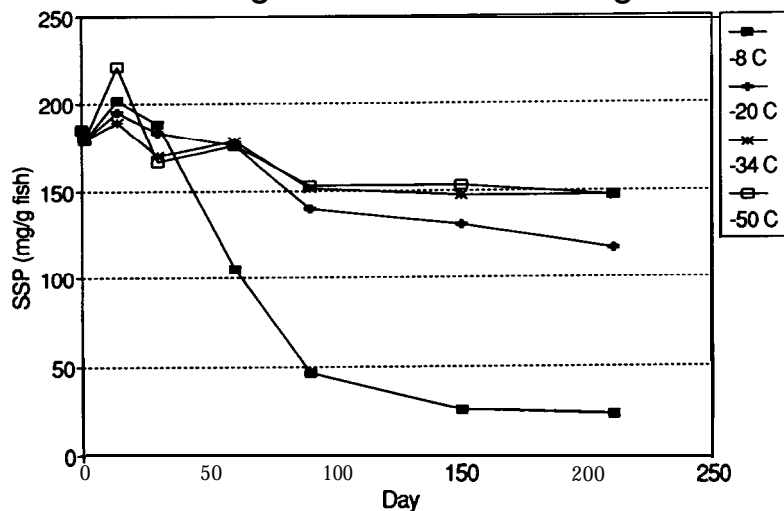


Figure 2.

## Changes of true shear strain in whiting

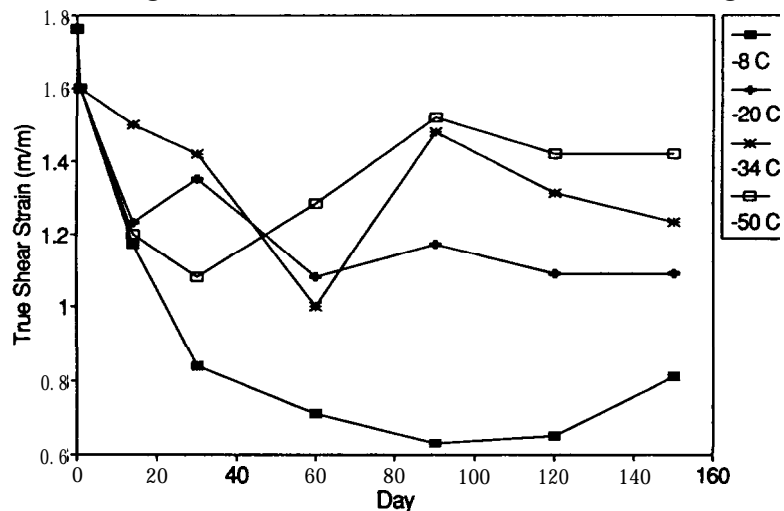


Figure 3.

crease in ATPase enzyme activity (figure 1). (2) Salt-soluble protein is a traditional measure of denaturation (figure 2). (3) Shear strain values indicating protein selling ability are determined by the torsion method (figure 3) commonly employed to measure surimi quality. The higher the torque angle of gelled cylindrical samples, the higher is the cohesive strength and the lesser the degree of protein denaturation. Although the numbers in each of these three graphs don't tell us when the product is no longer any good, we can make some general observations. Within one to two months at  $-8^{\circ}\text{C}$ , significant denaturation and quality losses have occurred compared to those at lower temperatures. Within the five-month period shown, texture quality at  $-20^{\circ}\text{C}$  has remained reasonably high, although lower temperatures appear to give slightly better results.

30

The  $-50^{\circ}\text{C}$  level holds no significant advantage over that at  $-34^{\circ}\text{C}$ .

A few additional notes or questions might be made from this and related work. (1) At one point (day 120), torsion tests were run on four different packages removed from each temperature level. A very large variation was found between packages (figure 4), explaining in part the scatter and nonsmooth curves shown, for example in figure 3.

(2) Results in both figures 1 and 3 showed a significant decrease in the quality value at day 0. These values were measured before and after freezing, raising a question about how important the freezing rate might be. These differences could also result from the package-to-package scatter, noted above. More work is needed to clarify this.

(3) In one related test over a three-month period, vacuum-packaged fillets were compared with those that were not vacuum packaged. No differences were found either in the denaturation values or in oxidation rates.

(4) Tests on whiting several years ago indicated SSP values that fell rapidly at a  $-20^{\circ}\text{C}$  storage temperature, in contrast to the relatively constant value shown in figure 2. This raises a question as to the significance of the uniformity of storage temperature used in our tests, or of the effects of fresh quality prior to freezing.

## FRESH SURIMI

There can be a considerable marketing advantage to developing a fresh surimiprodukt made from Pacific whiting. The major one is that there would be no need for the use of cryoprotectants, such as sorbitol and sucrose, which are viewed by most consumers as unwanted. The production of fresh surimi would

be very feasible for an on-shore processing plant, where the surimi can be shipped to an analog processor for quick production.

Our studies showed that fresh surimi can be made with gel strength comparable to that of good-quality surimi. Potato starch was used as a substitute for the normal cryoprotectants (sucrose and sorbitol) in an effort to control moisture content. In a five-day study, it was evident that the shellfish analog needs to be made within three days of making the fresh surimi.

After day three, the product quality suffered, especially color and odor.

Crab stick analogs were made from both fresh and frozen surimi at **Kyotaru** Oregon, in Salem. Although minor problems were encountered in the first run (too much starch in the fresh surimi), the overall results were promising. The personnel at **Kyotaru** responded favorably to the use of Pacific whiting. A production run of fresh surimi was made in early September 1991 with a new formulation and reduced starch content. Results were very satisfactory, with good gel-forming characteristics and sensory properties. Several samplers said that the fresh surimi without the cryoprotectants has a more natural seafood flavor.

## STABILIZED MINCE

Whiting can be held only a short time in chilled storage before it must be processed, this is especially true for production of good quality surimi. We are currently evaluating a technology that would enable minced whiting to be frozen, then later thawed and washed to form a fresh surimi that could be used for analog products.

Whiting were caught off Newport, chilled immediately, landed the same day, and trucked to Astoria. Fillets had a K-value of 8%, indicating a high degree of freshness, when they were processed and frozen approximately 24 hours after catch. Frozen headed and gutted (H&G), unstabilized mince (UM), and mince stabilized with 12% sucrose (SM) were all stored at -20°C (-4°F) and -50°C (-58°F). The cryoprotectant and temperature levels were selected to "bracket" conditions that might verify initial feasibility.

## True shear strain at day 120

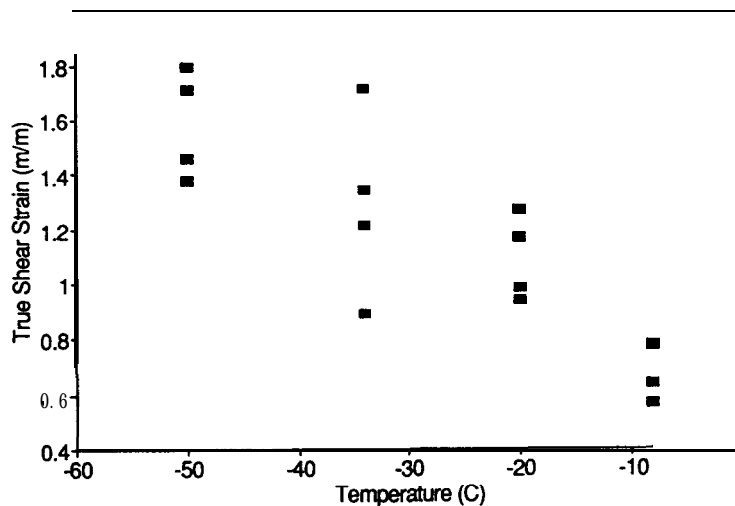


Figure 4.

Some of the whiting was initially made into surimi and stored at -34°C (-29°F) for a comparative control. At various time intervals, the H&G and mince were thawed, made into surimi (with the usual 8% cryoprotectants), and refrozen, so we could test it against the surimi that was already in storage. In all cases, 1% beef plasma protein was used as an enzyme inhibitor.

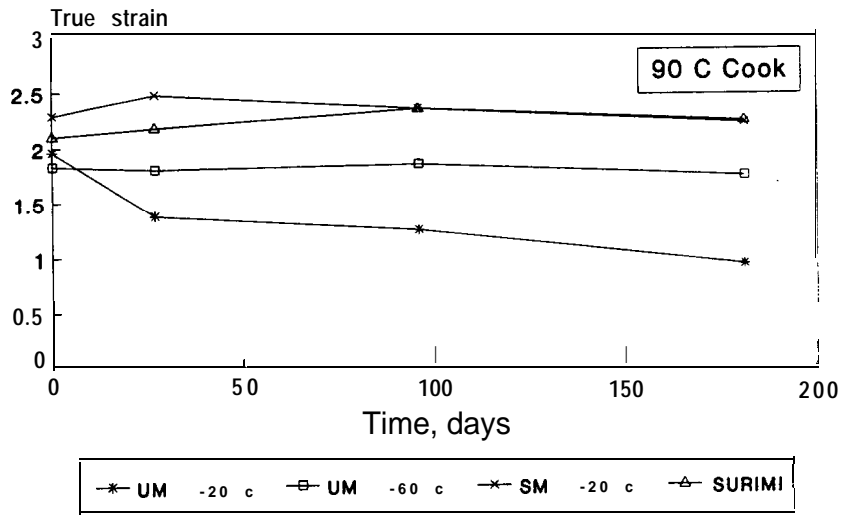
Figures 5 and 6 show some of the results for six months of storage. Torsion results giving strain at failure (figure 5) indicate that surimi made from -20°C UM was of poor quality, but with stabilizers (SM), it was good compared to the surimi control. UM at -50°C gave surimi with a relatively lower strain value (about 1.8). It did not vary much with storage time, indicating perhaps that the major reduction was caused by freezing without cryoprotectants. The following data were not shown in the figures: SM at -50 showed no improvement over SM at -20; and H&G at -20 and -50 showed roughly the same results as UM at the same temperatures.

Figure 6 gives stress values for the strain conditions of figure 5. These stress (strength) values are somewhat low.

These results show that whiting mince stabilized with 12% sucrose and stored at -20°C can potentially be used to make good quality surimi. Some significant questions remain. What kind of yields can be achieved with pilot-scale production? What optimum cryoprotectant, level, and storage temperature can be found? What freezer configuration can produce a continuous frozen product that will store well? These questions will be addressed following the start of the 1992 whiting season.

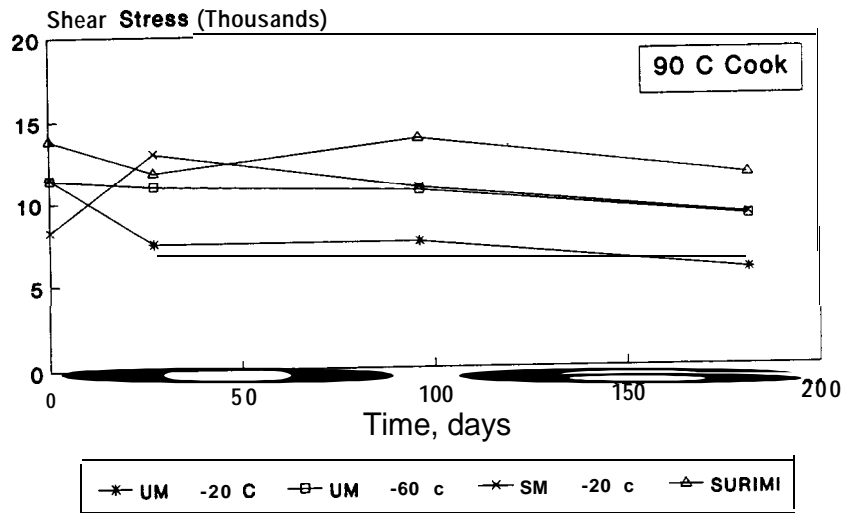


## Pacific Whiting Surimi Mince samples



**Figure 5.** Change in true strain at failure during storage.

## Pacific Whiting Surimi Mince samples



**Figure 6.** Change in shear stress at failure during storage.

# USE OF POTATO INHIBITOR IN PACIFIC WHITING SURIMI

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This laboratory has studied the problem of muscle softening in Pacific whiting over a several-year period and realized early that the softening was caused by **protease** enzymes in the muscle tissue (Patashnik et al. 1982; Kudo et al. 1987). Several studies have attempted to correlate the degree of softening with the incidence of myzosporean parasites *Kudoa thyrsitis* and *Kudoa paniformis*, but there does not appear to be a clear relationship.

Before any discussion of the use of inhibitors, it is helpful to look at a few basic principles regarding enzyme activity in Pacific whiting, outlined in figure 1.

- **Protease** enzymes are catalysts
  - are not consumed in the reaction
  - each **protease** enzyme molecule can act as long as conditions permit
- Rate of breakdown depends on several factors
  - enzyme concentration
  - temperature
  - **pH**
  - physical integrity of muscle tissue

Figure 1. *Protease enzyme activity in Pacific whiting muscle.*

Enzymes are catalysts and as such are not consumed in the reaction. Consequently, as long as conditions for activity permit (that is, temperature, **pH**, substrate availability), the enzyme will continue to degrade the muscle tissue. The rate of breakdown depends on several factors, such as **pH**, temperature, enzyme concentration, and the physical integrity of the muscle tissues. Some of these factors are outlined briefly in figure 2.

The physical handling of the round fish is extremely important to prevent smashing of the fish and crushing the tissue. This destroys the muscle integrity and natural compartmentalization of enzymes and substrates and thus accelerates softening.

- Physical handling of the round fish
  - abusive procedures crush tissue and destroy integrity and natural compartmentalization
- Time and temperature before and during processing
  - these two factors are inseparable: both must be kept to a minimum
- Enzymatic damage is irreversible

Figure 2. *Factors affecting enzymatic breakdown in Pacific whiting muscle.*

Time and temperature must be kept to a minimum before and during processing to retard enzymatic activity. These precautions are necessary because enzymatic damage to muscle tissue is irreversible and the use of inhibitors only prevents further degradation. It does not repair damage that has already occurred.

Freezing does not destroy the activity of the enzyme. It only retards the activity, which can resume again upon subsequent thawing of the product and a return to more favorable temperatures for activity. We have stored for eight years frozen **Pacific** whiting fillets that have retained much of their original activity. **This** suggests that anyone considering a twice-frozen product from Pacific whiting would be ill-advised to even contemplate such a product

**Figure 3** represents a **pH** vs activity curve of a crude enzyme preparation from Pacific whiting.

The muscle **pH** observed in Pacific whiting is around **pH** 6.8-6.9, which is above the optimum for enzymatic activity but in the range where considerable activity is still present. As would be expected, considerable variation in enzymatic activity occurs between various lots of Pacific whiting. **Figure 4** shows the temperature vs activity observed in two samples having large **differences** in activity. Inside Puget Sound, whiting does not have a **texture problem** and, as shown in figure 4, has considerably less enzymatic activity than Pacific whiting from the west coast of Washington. Pacific whiting taken from the coast is made up of a

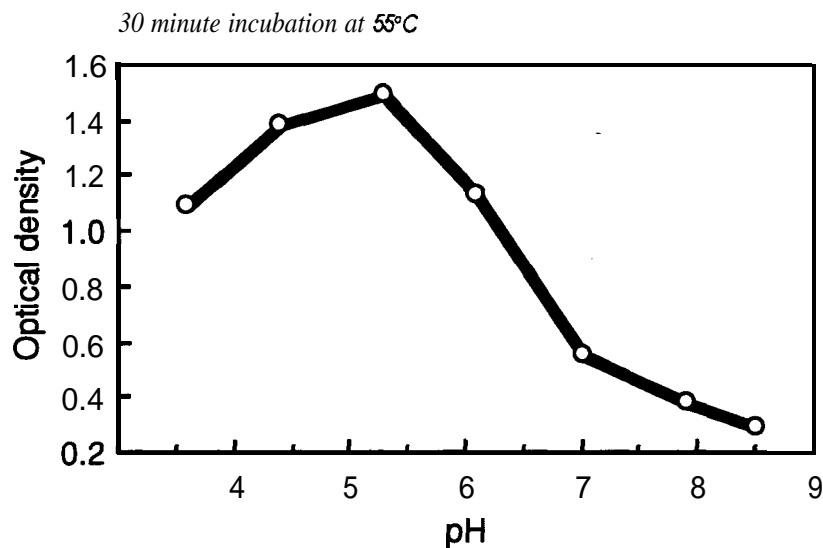


Figure 3. pH effect on protease activity.

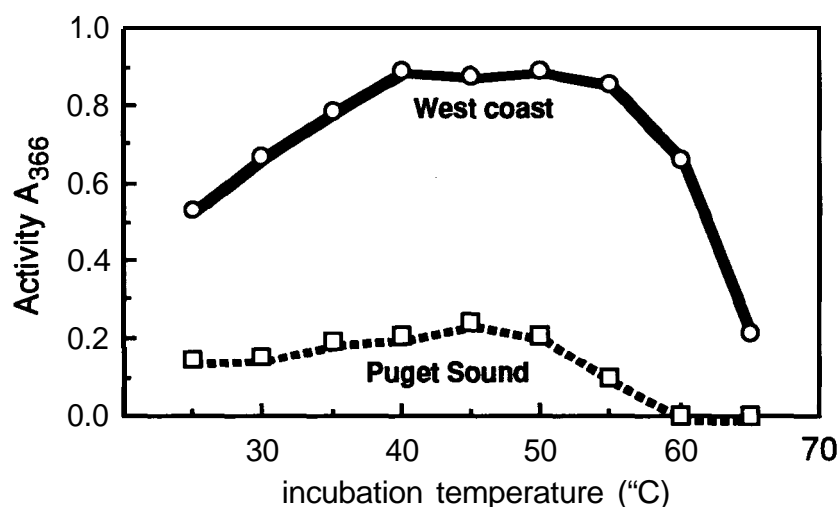


Figure 4. Temperature-activity curves for Pacific whiting extracts.

different stock and does have the softening problem. This gives an indication of the extreme ranges of enzymatic activity that can be found between lots of Pacific whiting. Also, it is clear that the enzyme is active over a broad range of temperatures.

I would like to re-emphasize the need for minimizing physical damage during handling and keeping time and temperature to a minimum between catching and subsequent processing and freezing.

There are several inhibitors which are effective against the protease enzymes in Pacific whiting. Among them are egg white, mammalian blood plasma, and potato inhibitor. Egg white and potato contain specific proteins that act as competitive inhibitors for the active site on the enzyme molecule, whereas mammalian blood is considered to trap the enzyme within one of the large molecular weight macroglobulin proteins, resulting in inactivation of the enzyme (Laskowski and Kato 1980.).

At the Seattle Laboratory of NMFS, we have done extensive research on the effect of potato inhibitor in preventing enzyme degradation in Pacific whiting surimi. I would like to remove any misconceptions regarding potato as an effective component and would direct attention to figure 5.

It is clear that the starch component of the potato has no inhibitory activity against the protease enzymes as shown by the fact that there is no improvement over the control surimi with no additives. The potato extract, which has the starch removed and contains a protein fraction from the potato, exhibits excellent gel characteristics. Also shown is the addition of dried whole potato to the same surimi to illustrate the efficacy of adding the inhibitor in this form. NMFS was granted a patent on the preparation and use of this inhibitor preparation, and it is being produced and marketed by Nonpareil Corporation of Blackfoot, Idaho (Porter et al. 1990).

<b>Additive</b>	<b>Percent added</b>	<b>Gel strength (GM-CM)</b>	<b>Force (GM)</b>	<b>Deformation (CM)</b>	<b>Fold test (3 mm slice)</b>
Control	—	20	77.0	0.26	1.0
Potato starch	3.0	26	98.8	0.26	1.0
Dried potato extract	0.3	569	517.1	1.1	5.0
Dried whole potato	3.0	564	594.0	0.95	5.0

*Figure 5. Evaluation of kamaboko from Pacific whiting treated with potato starch, dried potato extract, or dried whole potato.*

The potato ingredient, currently made from whole potatoes, is functional at the 3-4% level and should be blended with the cryoprotectants during surimi processing just prior to freezing. Pacific whiting surimi made with potato inhibitor levels of 34% has been used as the complete source of surimi in different analog processes with excellent results with respect to both processing characteristics and product quality.

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# PROTEOLYSIS OF PACIFIC WHITING AND ITS INHIBITION

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Gelation is a process in which a continuous network is formed by random cross-linking of proteins. The gel strength of surimi is closely related to the ability of component proteins to form an ordered, three-dimensional network. The main components of surimi are myofibrillar proteins, which include proteins participate in muscle contraction such as actin and myosin. Myosin, with a unique structure of two globular heads and a long tail, makes a significant contribution to formation of the gel structure. When heated, myosin loses its noncovalently stabilized structure of  $\alpha$ -helix followed by intermolecular association. Myosin then develops into a rigid structure held by strong covalent disulfide bonding and noncovalent interactions such as hydrophobic and ionic interactions.

Proteases are a group of enzymes that can hydrolyze a variety of proteins into shorter peptide chains. Proteases either present in the muscle tissues (endogenous) or introduced from other sources (exogenous) can degrade

myofibrillar proteins, including myosin, thus weakening network formation of surimi gel (figure 1). There are several types of proteases that can act to hydrolyze muscle fibers of fish: alkaline proteases (Lanier et al. 1981), calpains (Tsuchiya and Seki 1991), and cathepsins (Erickson et al. 1983). Pacific whiting shows high activities of proteases in comparison to other firm-textured fish species, and the activities are further increased when the flesh is infected with myxosporidian spores (Nelson et al. 1985). Therefore, unless properly handled and processed, Pacific whiting may suffer from severe quality defects caused by proteolysis.

Proteolysis of Pacific whiting can be controlled by the use of protease inhibitors such as beef plasma proteins (BPP), egg white, and potato extract. Generally, the gel strength of surimi is increased 20% to 30% by addition of these protease inhibitors during manufacturing. When BPP is added up to 1% in Pacific whiting surimi, gel strength increases substan-

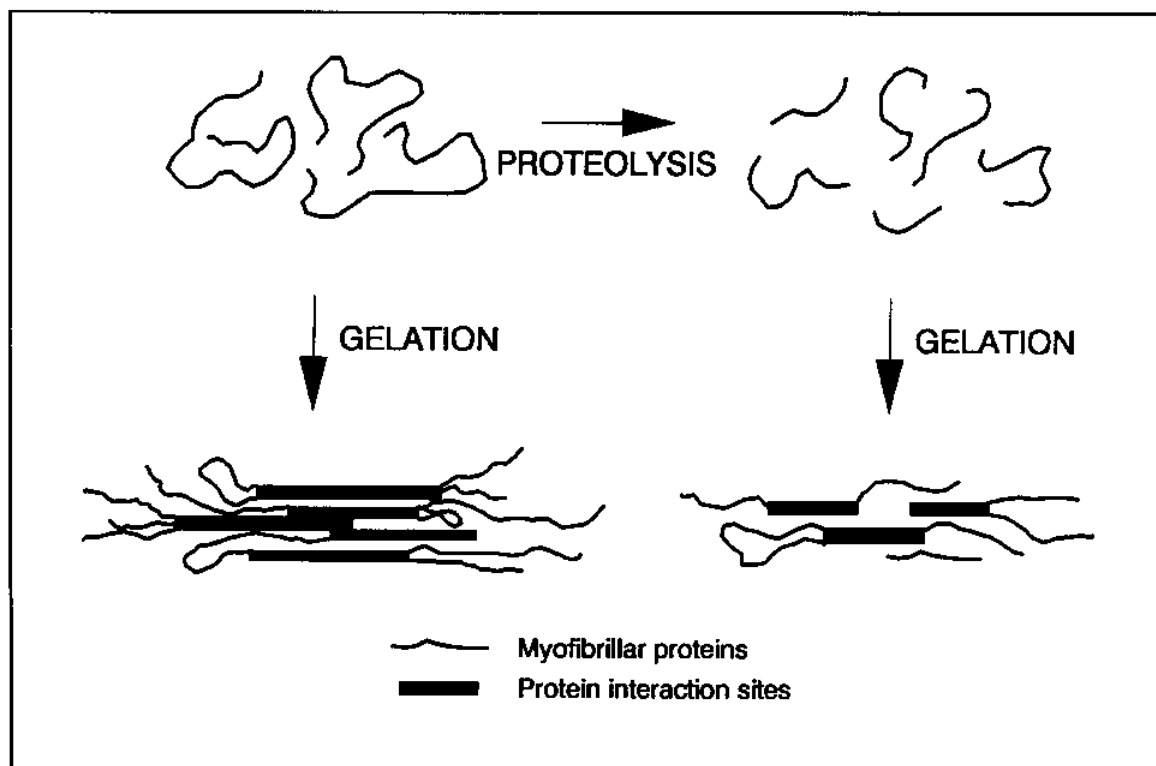


Figure 1. Effect of proteolysis on the gel formation.

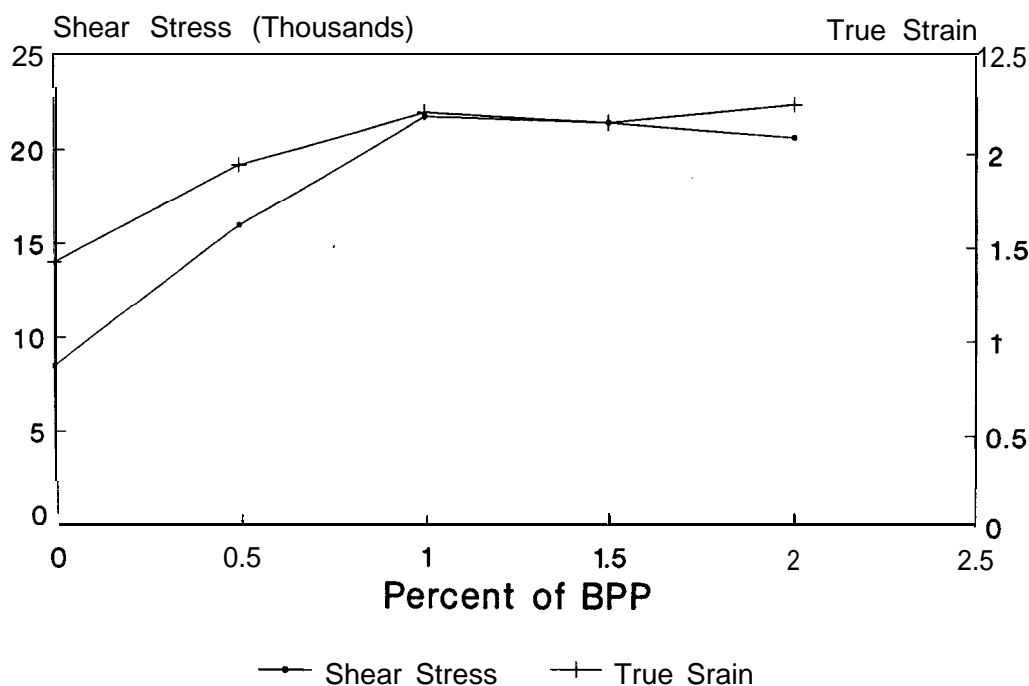


Figure 2. BPP effect on PW surimi.

tially as measured by true strain and shear stress. The highest true strain and shear stress values were observed at the level of 1% BPP with 1.58- and 2.67-fold increase, compared to that of surimi without protease inhibitors (figure 2). At the levels above 1%, there was no additional benefit, since true strain and shear stress leveled off. A true strain value of 2.2 or higher indicates good-quality surimi. These data indicate that good-quality surimi can be produced from Pacific whiting by adding protease inhibitors and practicing proper processing methods.

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# PANEL DISCUSSION OF SEAFOOD TECHNOLOGY

Session leader: *David Crawford*. Panel members: *Roy Porter, Haejung An, Larry Meyer (American Meat Protein Company) Jae Park, Edward Kolbe, and Tyre Lanier.*

**All questions were held until the panel / audience discussion period.**

**Q:** Michael Morrissey, from the audience) Could Larry Meyer, from the American Meat Protein Company, clarify the the FDA's current position on the "GRAS" (generally recognized as safe) status of the beef plasma product that has been found an effective **protease inhibitor** in OSU Seafood Laboratory's experiments and has been used by the Japanese for at least five years?

**A:** (Larry Meyer) A competitor of ours informed the FDA of the American Meat Protein Company's use of beef plasma, asking whether this use was permitted. The FDA responded that the product was not defined as either a food or a food additive, nor had it ever been accorded GRAS status by the agency. Since that time, the American Meat Protein Company has sought reconsideration of the matter and the FDA has agreed to rescind its previous determination, accepting the use of the plasma for this purpose. The FDA will be informing regional offices soon that its prior letter on the subject should be disregarded.<sup>1</sup>

**Q:** What are the current labelling requirements for the plasma product?

**A:** (Meyer) **The** labelling requirements depend on whether the product is intended for domestic consumption or international sale. This product has been used in a hydrolyzed form in meat products and **labelled** as "flavoring." In March 1991 the USDA changed its regulations covering flavorings. Now it appears that if the product is **to** be used in surimi seafoods for domestic consumption, it must be **labelled** "blood plasma protein" unless a hydrolyzed

formulation of the product is used, in which case it may be **labelled** "flavoring." For international trade purposes, it may be **labelled** "flavoring."

**Q:** Is there any advantage, in terms of shelf life, to the use of beef plasma vs. potato concentrate?

**A:** Morrissey reported that the Astoria Seafood Laboratory plans to study this issue. So far, over the six-month period the lab has held surimi containing the beef plasma, it has proven effective. Roy Porter further **stated** that both products have proven **effective** in NMFS laboratory tests for **10, 12**, and even 18 months. An audience member asked if gel strength would decrease over time, and Tyre **Lanier** answered that there was no reason to believe so.

**Q:** Could the panel clarify the meaning of the term GRAS (generally recognized as safe)?

**A:** (Meyer) Most substances are considered GRAS until questions are brought up about their use. Such substances can be used while the approval process for their use is going on. He claimed that it is currently legal to use beef plasma as long as the labelling requirements for domestic and international use are met.

**Q:** (Jae **Park**, from the audience) Is the dried potato extract used in inhibiting **protease** commercially available?

**A:** An audience member responded that his company had the patent to use this product, and it is currently available at **\$.95/lb.** FOE3 Idaho. The product is still being developed.

<sup>1</sup>On April 23, 1991, the FDA issued a letter stating that it "[does] not wish to contest ... at this time" the claim that beef plasma protein is a safe ingredient. This statement essentially gives the green light for use of beef plasma protein (it must be labelled) as an ingredient in domestic surimi. It should be noted that the FDA is leaving the door open for decision making in the future.





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# **Quality Assurance**

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# QUALITY ASSURANCE PROGRAMS FOR PACIFIC WHITING

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*Coastal Oregon Marine Experiment Station*

*Lisa Gaines*

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## INTRODUCTION

Improving and controlling product quality is possibly the greatest single challenge confronting the **Pacific** whiting (*Merluccius productus*) industry. The offshore stock of Pacific whiting is **characterized** by a complex set of product quality problems, including a relatively **soft** and delicate flesh, a high fat content, an **off-white** color, and varying levels of myxosporidea parasites and **protease enzymes** that degredate protein. These problems can result in a marketed product which is bruised, mushy, and rancid-and a product that can literally melt away during the cooking process.

Making decisions to control these problems is complicated by many factors. First, there is wide variation in the "**intrinsic**"<sup>1</sup> product characteristics of Pacific whiting, including variation in the level of **protease enzymes** and myxosporidea parasites. Although the dynamics of these characteristics are not well understood, they appear related to variation in biological, geographical, and environmental conditions? Second, the strategies used to address these problems will depend on the choice of product forms and market strategies. For products that undergo minimal processing and that are targeted for relatively "low-value" markets (for example, the retail domestic frozen headed and gutted [**H&G**] market) there may be less concern about product quality beyond reaching some minimum level of wholesomeness and product workmanship. For moderately processed products such as individual fillets and fillet blocks, there is greater concern about product quality, not only because market price for fillets is more dependent on the level of

product characteristics, but because there is a significantly greater degree of product handling, which increases quality control problems (for example, more exposure of surface areas and disruption of cellular walls). For more highly homogenized processed products, such as frozen minced blocks and surimi, **quality** is also important, but to some extent can be controlled by the addition of various additives to the minced product that can inhibit the **protease enzymes** or reduce rancidity and increase shelf life.

Research by seafood technologists has demonstrated that the most important way to reduce the product quality problems of Pacific whiting products is to control time, temperature, and pressure parameters during **all stages** in the production, distribution, and food preparation processes (Nelson et al. 1985). Individual **firms** or **industry** sectors which fail to adequately control these quality parameters can not only reduce their own benefits (in the form of lower prices, fewer sales, and poorer product reputation), but also the benefits of other whiting industry firms. Therefore, the activities of all industry sectors, from fishermen to consumers, need to be examined for the role they play in assuring some minimal level of predictable and acceptable product quality. The key issue for individual **firms** is deciding on the appropriate mechanisms to coordinate the activities of producers, processors, distributors, and government agencies in order to control product quality and **maximize** industry benefits and market opportunities.

The following paper concerns the marketing management concept known as "quality assurance" and its potential application for controlling the quality of Pacific whiting. In the first section of the paper, we discuss the concept of quality assurance and its use in production and marketing management. In the next section, we review issues that would be important in developing quality assurance programs for **Pacific** whiting. In the third and final section, we discuss specific strategies that individual

<sup>1</sup>**Intrinsic** refers to the preharvest characteristics of the product. See Love (1988) for a detailed examination of intrinsic variation in seafood.

<sup>2</sup>For a review of problems affecting the **Pacific** whiting fishery, including variation in product characteristics, see the special issue of Marine *Fisheries Review* 1985:47(2), devoted entirely to issues in the Pacific whiting fishery.

sectors of the industry could adopt as part of a comprehensive quality assurance program.

## QUALITY ASSURANCE, NOT QUALITY CONTROL

The U.S. seafood industry continues to be plagued by recurring concerns related to seafood safety and the need for development of mandatory seafood inspection programs. Currently, the Food and Drug Administration (FDA) has taken the lead in developing and testing a prototype quality control program using the concept known as **Hazard Analysis Critical Control Points (HACCP)**.<sup>3</sup> This program is designed to ensure an adequate level of seafood safety by setting safety standards and randomly inspecting "critical points" along the production and distribution chain where health-related problems have the highest probability of occurring. A major focus of the program is controlling microbiological contamination of seafood.

Most quality issues for Pacific whiting, however, are not related to seafood safety, but rather are related to sensory characteristics such as taste, texture, and appearance, that is, factors which affect consumer enjoyment and market demand. Intrinsic product quality characteristics such as proximal composition (for example, moisture, lipids, and protein), **protease** levels, and myxosporidea parasites can directly and indirectly affect sensory characteristics, **shelf life**, and the ability of the product to withstand the rigors of seafood processing.

While a **HACCP** type of program could be expanded to control product quality beyond microbiological contamination, there are many types of programs that could be applied toward "managing" Pacific whiting quality. Although most of these programs have been developed by scientists and engineers in Europe and North America, they have been most comprehensively implemented by the Japanese for improving product quality of a wide range of consumer and industry products. These programs are represented by an array of acronyms, including **SQC** (Statistical Quality Control), **TQM** (**Total Quality Management**), **QFD**

(Quality Function Deployment), **CIP** (**Continuous Improvement Process**), and **CB** (**Competitive Benchmarking**).<sup>4</sup> Regardless of their criteria or disciplinary focus (for example, engineering versus market versus management orientation), all of these techniques are based on statistically verifiable standards designed to reduce and control variation in final product quality.

Applying quality control concepts for seafoods in general, and Pacific whiting in particular, may be a more **difficult** problem than applying them to other food products. This is because, with the exception of aquacultural products, seafoods are "manufactured" from wild organisms that display a wide range of both "good" and "bad" intrinsic product characteristics. In addition, seafood tissue and muscle fibers are relatively more delicate than those in "terrestrial" animal products; "good" quality characteristics that enhance sensory enjoyment can be easily lost during the production, processing, and distribution process. The effects of "bad" product characteristics (such as **protease** enzymes), however, must be **minimized** or eliminated entirely. Control over quality characteristics, therefore, cannot be isolated at any one location or at any one time; rather it must be exercised at all "critical" points from ocean to plate. Comprehensive quality control programs designed to ensure quality seafood products at the point of consumption are known as "quality assurance seafood programs" (Gorga and Ronsivalli 1988).

The main objectives of quality assurance programs are sometimes perceived as intended to meet minimum government standards for hygiene and health. In other cases they may be perceived as designed to provide products that improve consumer satisfaction and confidence. Truly effective quality assurance programs, however, are designed with another goal—that of improving long-term benefits to the seafood industry in the form of higher profits, revenues, or greater shares in animal protein and seafood markets. **Effective** programs are not designed in isolation by food technologists but as part of an integrated system that includes production managers and marketing specialists.

Designing the most effective quality assurance program requires a careful analysis of the

<sup>3</sup>See Lee and Hilderbrand (1992) for a discussion of HACCP programs and application to Pacific Northwest fisheries.

<sup>4</sup>A description of these programs is beyond the scope of this work; however, see the October 15, 1991 issue of *Business Week* magazine for a concise review of quality control methods, especially the overview article by Port and Carey.

potential long-run costs and benefits of alternative programs. It requires vertically related industry sectors to estimate how such programs would affect production and processing costs and the demand for quality-assured products. It requires marketing specialists to determine how quality assurance programs could be effectively used in advertising aimed at improving consumer demand and consumer confidence. It requires an accurate estimation of the cost effectiveness of alternative warranty programs that would guarantee product quality.

Quality assurance also involves risk management. The variation in product quality characteristics must be unambiguously articulated, since unknown risks can lead to distrust and skepticism, especially to downstream users (for example, institutions, retailers, and final consumers). Therefore, a quality assurance program must use appropriate analytical tools, be statistically sound, and be able to clearly communicate its findings (Martin 1988). Strategic communication about risks which are equal to, or smaller than, risks associated with competitive products can help improve sales and expand market opportunities.

Developing a quality assurance program that is in the best interests of the industry, however, does not necessarily imply one grand industry or government scheme. Rather, it requires that each firm in the production and distribution process understand the long-run relationship between product quality and market price and then use this information to develop contractual arrangements, warranties, and price incentives consistent with controlling product quality and improving industry benefits.

#### **FACTORS AFFECTING QUALITY ASSURANCE PROGRAMS FOR PACIFIC WHITING**

Three important considerations that can affect the design and effectiveness of a quality assurance program are the name, label, and logo selected to represent the product.

*Merluccius productus* is harvested from only one geographic region in the world (that is, the Pacific Northwest). For most product forms, *Merluccius productus* is marketed under its legal common name, **Pacific whiting**. Before 1980 the product was marketed under its common name, **Pacific hake**, but the name was legally changed in order to overcome the product's poor reputation in domestic mar-

kets." Note, however, that this name change was not accompanied by improvements in product quality, and the market reputation which had characterized **Pacific hake** now characterizes Pacific whiting.

The other term in the name for Pacific whiting, that is, **Pacific**, refers to the geographical location. Labelling by geographical location or national origin is a feature of most of the **hake**/whittings that compete with **Pacific** whiting for market share, for example, Argentine hake (*Merluccius hubbsi*), Chilean hake (*Merluccius gayi*), and Peruvian hake (*Merluccius gayi peranus*). However, it should be noted that not all of the products processed from Pacific whiting are sold using the common name. For example, **H&G Pacific** whiting is sold retail under many brand names, usually with one or two brands representing each west coast **H&G** processor! Most products, however, especially at the wholesale level, will be associated with the common name, **Pacific whiting**. Using geographical identification as part of the name or label may be advantageous, especially if the regional name connotes some positive characteristic; however, regional identification also has disadvantages. Firms that do not adhere to quality standards not only reduce their own product quality and market opportunities, but also the opportunities of other regional firms targeting or processing the species. For Pacific whiting the name is especially problematic since the identity is already associated with poor product quality.

Individual firms planning to improve and control Pacific whiting quality must consider the potential costs and benefits of firm level and industry-wide strategies. For example, could individual firms which fail to improve product quality limit the potential rewards to firms which make major efforts to control product quality? Should new labels and logos be developed for firms which voluntarily agree to meet certain quality standards? Can a given state or region successfully market Pacific whiting products using its own regional identification? All of these questions need to be addressed before individual firms can decide on

<sup>5</sup>All hakes (*Merluccius* spp.) are known as whiting in the United States but retain the common name **hake** in all other national and international markets.

<sup>6</sup>The potential advantages of multiple brands may be offset by certain disadvantages. See Sylvia and Peters (1991) for a complete discussion.

the type of product quality assurance programs to develop.

Another important issue for developing quality assurance standards for Pacific whiting is related to market destination. Many of the intermediate and final products processed from Pacific whiting (including fillet blocks, minced blocks, individual **fillets**, breaded **fillets**, surimi, surimi-based seafoods, and meal) will be sold and distributed in global markets. As an example, a portion of the Pacific whiting which had been delivered to Polish mother ships during the **joint-venture** era of the fishery were processed **into** frozen blocks, shipped to plants in northern Germany for secondary processing into value-added products (for example, breaded portions), and then sold retail in northern and southern Europe.

The increase in trade of hake/whiting products also coincides with the establishment of economic trade zones. Examples include the consolidation of the European Economic Community (the world's largest market for **hake/whiting** products), the North America Free Trade Agreement, and the proposed consolidation of Argentina, Brazil, Paraguay, and Uruguay into a single economic community. As these agreements become finalized, economic communities will put into effect international product quality standards developed to protect the welfare of regional consumers and reduce the cost of business transactions (and in some cases protect regional industries from outside competition). Quality assurance programs will need to be designed in a manner consistent with these evolving international standards. This does not imply, however, that all quality characteristics for all product forms must be uniform. Rather, it suggests that quality assurance programs will improve market and trade opportunities if they are compatible with these standards.

### **STRATEGIES FOR PACIFIC WHITING QUALITY ASSURANCE PROGRAMS**

Given the product quality and market issues summarized above, the following strategies could be developed as part of a comprehensive quality assurance program for **Pacific** whiting.

(1) **The** National Marine Fisheries Service should evaluate how its regulatory strategies **affect** the variation in product quality characteristics of **Pacific** whiting. Research by seafood technologists and fisheries biologists has demonstrated that characteristics such as product

size and rates of parasitic infestation may vary seasonally, annually, and by geographic location (Dom 1990, Zabata and Whitaker 1985). Regulating where, when, and how the fish are captured can influence the spatial and temporal distribution of these quality characteristics. Even more important, **the** strategies used to control the fishery, and the industry risks associated with policy uncertainties, can constrain the level of investment necessary to profitably control product quality and improve marketing opportunities. These management strategies should be **carefully evaluated** to determine how they affect national, regional, and industry benefits.

(2) Fishermen should be encouraged to capture and handle **Pacific** whiting using methods which optimally control product quality problems. For example, fishermen may need to adjust the design of trawl nets and cod ends and reduce the duration of tows in order to minimize problems related to the relatively soft flesh of Pacific whiting and the presence of protease enzymes. Fishermen may also need to design on-board handling and cooling systems that ensure product quality and which meet national and international standards for hygiene and sanitation.

(3) Hake processors must develop control measures to ensure that the product that enters and exits their plant has a relatively high level of quality. This means developing contractual arrangements that reward fishermen who land quality product. It also means developing methods to off-load, process, inspect, package, and inventory products in a manner that ensures relatively high quality. Methods must be developed to minimize bruising of the **soft** flesh of Pacific whiting, detect parasites, and maintain near freezing temperatures until the product is frozen. Freezing units must be efficient and capable of lowering product temperatures at optimal rates. Processors must develop statistically verifiable performance standards consistent with assuring product quality while cost effectively **minimizing** variation in quality characteristics.

(4) **As a** minimum but necessary requirement, processors must develop production practices that conform to national and **international** standards ensuring product safety and wholesomeness. In the United States these standards will need to be consistent with the regulations being developed by the **FDA**. In Europe they will need to conform **to** the **FAO's** CODEX standards and the standards being developed by the Council of European **Communi-**

ties (1991). However, these guidelines and regulations provide only minimum standards designed to ensure that seafood products are safe and wholesome when they enter domestic or international markets. They do not ensure that the product will have maintained some minimum level of quality by the time it reaches the consumer. Providing this level of quality is a responsibility shared by the entire industry, from fisherman to retailer. It requires the development of product quality standards at every point of distribution and a concern by every firm and public agency that the product have a high level of quality when it is consumed.'

(5) Primary and secondary processors, distributors, and wholesalers must not only develop their own quality assurance programs, but must provide **information** to instruct institutional, food service, or retail sector buyers in properly storing, displaying, or preparing Pacific whiting in a manner which ensures quality products for consumers. In most cases this means minimizing product quality problems related to rancidity or softening of the flesh. Ensuring adequate **shelf life** to final users and consumers is especially important, given the shelf life problems of Pacific whiting compared to other ground&h products! In addition, retailers must provide adequate information to consumers on proper storage and food preparation and cooking techniques. All industry groups should work cooperatively to provide objective information regarding quality issues of **Pacific** whiting. Information about quality assurance programs and product warranties should be used to bolster the confidence of final users and to improve market opportunities.

## CONCLUSION

Given the intrinsic characteristics of Pacific whiting and their potential for **affecting** product quality during all phases of production, distribution, and food preparation, quality assurance programs could be of significant value for controlling product quality and improving mar-

**Note** that Iceland is now proposing to sponsor courses in Total Quality Management (TQM) for integrating the northern European **fishing** industry into a "modern technological society" and to meet and exceed evolving EEC seafood standards (UETP-INTERCOM 1992).

\*As one example, the state of Maine has instituted its own seafood quality assurance program for **groundfish** which incorporates expiration dates for all fresh **groundfish** products (Robert Beaudoin, personal communication).

ket opportunities. However, while there may be significant benefits to developing quality assurance programs, there may also be **significant** costs. Individual firms must develop specific strategies and determine the level of responsibility that will be addressed at the firm level and the industry level. For example, will it be in the industry's interests to develop general guidelines or enforceable but voluntary standards? How should the industry handle product quality issues given the diversity of product forms which are processed from Pacific whiting? Do new labels and logos need to be developed? What kind of fisheries regulatory structure is most compatible with assuring product quality?

Addressing these issues is a **difficult** but necessary task. Programs developed for controlling product quality of **Pacific** whiting, however, could provide new insights and opportunities for other fisheries. The industry should look at assuring the quality of Pacific whiting as not only a worthy challenge, but, if their efforts are successful, a model for developing programs for other Pacific Northwest seafoods.

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# HAZARD ANALYSIS AND CRITICAL CONTROL POINTS FOR ARGENTINE HAKE (*MERLUCCIVUS HUBBSI*) PROCESSING PLANTS

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## QUALITY ASSURANCE FOR SEAFOODS

For a number of reasons, it has not been easy to supply seafood products that are of adequate safety and consistent quality. (1) Too often, we rely only on end-product sampling and inspection. (2) Regulations are sometimes confusing or contradictory. (3) We often fail to link existing basic knowledge with sound operational measures at the production level. In addition, producers face the economic and managerial dilemma of trying to offer quality products in an increasingly competitive market at moderate cost. During the last few years, however, interest in seafood quality assurance has expanded into many new areas—the industry itself, government agencies, and consumers. As a result of this growing interest, it is time to redefine our directions and modify procedures in the industry.

The fish industry in many countries (for example, the European Community [EC], Japan, Mexico, and Uruguay) has initiated a new policy aimed at producing quality fish products by following quality assurance concepts. This innovation will affect the export of fish in developing countries and will regulate the fish imports of developed countries. Certainly, the wholesale and retail seafood market of every country will benefit

Quality assurance is not another inspection system; rather, it is a way of producing quality products, and it allows the industry to offer better and safer products while simultaneously improving the economy. Quality assurance is a preventive function that involves planning, organizing, and controlling operations to ensure that seafood products consistently meet requirements. It is an integral part of every management function. The implementation of quality assurance requires that producers establish systematic procedures for all activities necessary to guarantee the quality of raw fish and shellfish, in-process material, ingredients, additives, and finished seafood products. It also requires that harvesting, on-board handling, processing, grading, packaging, labelling, stor-

age, transport, and marketing comply with governmental regulatory requirements and industry and customer specifications. For the U.S. National Marine Fisheries Service (NMFS 1990), quality control is the establishment and maintenance of an optimum process and product through systematic and coordinated efforts, and quality assurance is the sum of all those activities in which one engages to ensure that the information and data generated are correct and reliable.

## HAZARD ANALYSIS AND CRITICAL CONTROL POINTS

Hazard analysis and critical control points (HACCP) is a specific, nontraditional, inspectional approach to controlling biological, chemical, microbiological, physical, and economic hazards in seafood (NMFS 1990). In 1977, J. Lee was the first to publish an account of how the technique could be employed for fishery products to decrease risk to consumers (Lee and Hilderbrand 1992).

Lee formulated an operational flow chart that listed each step of processing for a specific seafood commodity. To do this, he had to define the degree of hazard associated with a specific seafood product and with the intended use of the product. Designing an operational flow chart comprising each step of a seafood manufacturing process involves defining the hazards associated with each step and assessing their relative importance. It is necessary to identify the critical control point of the process and determine which preventive measures can be used to reduce the hazard to acceptable levels. It is also essential to monitor the procedures, either by observation or measurement, to determine when a hazard is under control. Careful records of the monitoring must be kept.

## HACCP FOR HAKE AND MARKETING OPPORTUNITIES

Hake is processed in different locations. Industries involved in exporting frozen hake to



# URUGUAYAN **H**AKE INDUSTRY

## TRAWLING FLEET—HACCP ON BOARD

FLOW SHEET	HAZARD	CONTROL
LIVE FISH	POLLUTION (1)	CCP 2: ENVIRONMENT MONITORING
CATCH	MECHANICAL DAMAGE (2)	CCP 1: TRAWLING TIME
HANDLING ON BOARD		
• SEAWATER WASHING		
• SPECIES SORTING	DAMAGED FISH (2)	CCP 1: REJECTION
• ICING AND CHILLING	FISH SPOILAGE (3)	CCP 2: TIME/TEMP.
• <b>TRANSPORT TO LAND</b>		
LANDING ON DECK	FISH SPOILAGE (3)	CCP 1: TIME/TEMP.

## HACCP IN FREEZING FACTORY

FACTORY ARRIVAL	FISH SPOILAGE (3) <b>FISH:ICE</b> RATIO (4) FISH <b>BOXES</b> LAID (2)	CCP 1: TIME/TEMP.
RAW FISH CHILLING STORE	FISH SPOILAGE	CCP 1: TIME/TEMP.
PLANT WATER SUPPLY	CONTAMINATION	CCP 1: CHLORINE LEVEL CONTROL
PLANT FISH SORTING	DAMAGED FISH (2)	CCP 1: REJECTION
FISH PROCESSING	<b>BACTERIAL GROWTH/</b> CONTAMINATION	CCP 1: TIME/TEMP. CCP 1: <b>PLANT/EQUIPMENT</b> <b>HYGIENE</b>
	QUALITY <b>HAZARDS</b> (5)	CCP 1: VISUAL INSPECT.
PRODUCT PREPACKING	<b>BACTERIAL/GROWTH</b> CONTAMINATION	CCP 1: TIME/TEMP. CCP 1: <b>PACKING MATERIAL</b> <b>CONTROL</b>
FREEZING	MINOR POSSIBLE <b>BACTERIAL</b> GROWTH	CCP 1: TIME/TEMP.
FINAL PACKING	MINOR POSSIBLE PACKING MATERIAL CONTAMINATION	CCP 2: VISUAL INSPECT CCP 1: LABORATORY CONTROL
COLD STORAGE	POSSIBLE QUALITY PRODUCT INJURY (5)	CCP 1: TIME/TEMP. CCP 1: VISUAL INSPECT CCP 1: LABORATORY CONTROL
OCEAN VESSEL LOAD	PACKING/PRODUCT MECHANICAL DAMAGE	CCP 1: VISUAL INSPECT
	POSSIBLE QUALITY PRODUCT INJURY (5)	CCP 1: TIME TEMP.

- (1) Government responsibility
- (2) Fresh hake mechanical damage
- (3) **Fish quality: spoilage bacteria/autolysis**
- (4) Temperature
- (5) Dehydration, rancidity
- (6) Quality losses

CCP 1: Complete control of hazard  
CCP 2: Complete control of hazard not possible

developed countries need to implement HACCP criteria to achieve a final product of high quality, to ensure its fitness for human consumption, and to reassure consumers. The European countries (EC, Iceland, Finland, Norway, and Sweden) have adopted the ISO (International Organization for Standardization) standards on quality management and quality assurance for the fish industry. Starting January 1, 1993, the EC official veterinary inspection will consist mainly of identifying critical points in the fishery plants of Third World countries on the bases of record keeping and of the processes used for manufacturing, monitoring, and sampling (in an approved laboratory). The U.S. Food and Drug Administration has proposed, with NMFS, a voluntary HACCP program that will be mandatory for imports from Third World countries starting January 1, 1995.

In Uruguay the HACCP program for the frozen Argentine hake (*Merluccius hubbsi*) export industry will be mandatory to ensure that hake processing plants meet with international sanitary and quality requirements. Compliance will be monitored by the National Fisheries Institute of Uruguay Ministry of Agriculture and Fisheries). In 1991 private industry in Uruguay exported more than U.S. \$60 million and 45,000 metric tons of frozen hake products (fishblocks, fillets, breaded, loins, and headed and gutted) to developed countries. Adhering to the HACCP program will improve marketing opportunities and prices for the producer. Regulatory agencies in the importing countries will spend less money on regulatory activities at ports of entry, and consumers will purchase the quality-controlled seafood products with more confidence.

The table on the opposite page shows the HACCP program for frozen hake plants in Uruguay.

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## Discussion

**Q:** What refrigeration system is used for South Atlantic hake by Uruguayan fishermen?

**A:** (Bertullo) Ice and the plastic boxes pictured on the slides shown are the only system currently used; we have not yet invested in RSW systems.

**Q:** Is South Atlantic hake the same as Pacific whiting?

**A:** (Bertullo) Although related to Pacific whiting, our hake has firmer flesh and fewer parasites.

# EUROPEAN QUALITY REQUIREMENTS FOR HAKE

*Joachim Werner*

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Some years ago we had different quality requirements in the European Community (EC), the Iberian Peninsula, and the Eastern European Countries. Now, with the integration of the Iberian countries into the EC and the dissolution of the Warsaw Pact, the influence of the EC is overwhelming. I think that the EC will establish its own standards for quality and that countries in a good economic position will adopt the EC system, or buy "European Standard," while poorer countries will have to buy substandard products or products from plants not approved by the EC. Consumption habits in Europe vary.

In the EC we principally find two different ethnic and religious groups: the northern part (Great Britain, Denmark, Germany, and The Netherlands), which is Germanic and mostly Protestant, and the southern part (France, Italy, Spain, and Portugal), which is predominantly Romanic and Catholic. Not only are race and religion important (for example, the Catholics eat by far more fish in Easter season than do Protestants). There are countries which have a sentimental relationship with the sea, like Spain and Portugal. In the Iberian Peninsula you can find a great variety of fish in the market and the highest consumption per capita (Spain 35 kg) in Europe. Homemakers in Spain still have more time to prepare sophisticated dishes, the family generally eats together in the evening (because of the climate), and the percentage of working women is lower than in the northern EC countries. Furthermore, Spain has more tourists per year than any other European country, even more than it has inhabitants. Many tourists return to the north asking for some exotic fish products like cuttlefish, squid rings, or even whiting.

In Spain whiting (hake) is the most important fish, the species to which the Spaniards compare all other white fish. Spain is the most interesting in its use of hake. It is the only country where the consumer enters a fish restaurant asking for whiting. Besides the normal fillet, the Spanish consumer looks especially for big size

H&G (headed and gutted). That's why South American producers separate the big pieces to gut and bleed thoroughly on board even if they bring all the rest of the catch to port ungutted. It is very important to gut the fish to impede the passage of the nematodes into the edible part of the fish.

In the South Atlantic nearly all big fishes have nematodes (of the Anisakis type) in the abdominal cavity, especially near the liver and the stomach. The presence in the muscle is very rare if you gut it on board. If you do not do this, the parasites attack first the belly flap. Very often these big fish are female. **This** allows you to separate the roe. In the case of hand filleting the whiting, you should cut the fish first on the upper part and then cut with care the lower part to harvest the roe. Each sack should weigh at least 1 1/2 or 2 oz to obtain a good price. The normal packing is **IWP** in 2-kg packages, and on a lower price level there is a market for broken sacks in blocks.

In Spain they defrost this product, put it in salt for some hours to dewater it, and then cold-smoke it (27-29°C). The resulting product is cut in slices and eaten like a snack. Spain is the only country that buys cocochas, which is the part underneath the jaw. The cheek is appreciated as the tastiest part of the fish. Because the H&G and the fillets have to compete in the fresh fish market, the merchandise should not have any odor and should be as white as possible.

In other European countries the best-known fish is cod, and the consumer compares everything with this species. In the northern part of Europe the percentage of working women is higher than in the south, reaching 50% in some countries. Here you can find the same situation as in the United States, which means that the housewife prefers convenience foods because she does not want to use her precious time to clean and scale fish. Because of pressure from trade unions, the shops usually close at 6 or 6.30 in the **afternoon**. **Thus**, buyers have only one or two hours to make their purchases. That is why the quality-minded cook chooses well-known brands.

Big companies usually establish their own quality level, trying to be better than their competitors. It is natural that in this system small companies can hardly survive, even when they have regional importance. Very often you can find blind loyalty to quality-approved brands. I would compare it to the confidence we placed in our mothers as they prepared the family's food in older times.

Nevertheless, the behavior of consumers is amazing; sometimes they even react hysterically to information about risks in their food. The majority have the opinion that fish is a healthy food, even when it doesn't have the same nutritional value as meat and even though, because of the pinbones, it could be dangerous, especially for children. In coastal areas the appreciation for fish is higher than in areas farther away from the coast. Approximately 15% of the consumers in Europe have an aversion to fish, fearing not only the pinbones but also the contamination with mercury, lead, cadmium, DDT, and so on.

Intellectual consumers in particular are very conscious of environmental contamination; they deduce that in contaminated water the fish will be contaminated, too. When in November 1980 an Italian laboratory found tetracycline in fish sticks, a district attorney prohibited the sale of all fish sticks and portions in Italy. This information spread all over Europe. Even when, some days later, this information was rectified, consumption decreased for several weeks, and even now you can find the original (false) information printed in books. In December 1983, a Dutch company imported from South East Asia cooked shrimp contaminated with *Shigella*. The shrimp caused 14 casualties. For years European consumers resisted buying shrimp from this area.

In the summer of 1987, German state-owned TV broadcast a film showing fish fillets infested by living worms (nematodes of type *Anisakis* and *Pseudoterranova*); the reaction of the consumer was tremendous. During the weeks that followed, fresh fish was nearly unsalable, and the government even had to save fish companies from bankruptcy. We are not used to closeups of small animals or insects (fleas, flies, mosquitos), but to see living animals in our food is really disgusting to us.

To kill the nematodes, you should use heat, salt, or acid or deep-freeze the merchandise for at least 24 hours at -18°C. In Western Europe it is not customary to eat raw fish, but anyway the parasites can survive cold-smoking (less than 30°C). They can also survive in mildly salted herring (*matjes*).

Even when there are only 10 to 20 cases of *Anisakis* infection per year in Western Europe (causing epigastric pains and vomiting), it seems that frequency of *Anisakis* infections is increasing, probably because of the protection of marine mammals. In Japan every year there are several hundred cases caused from eating raw fish. In the 1987 German case, German health authorities reacted quickly by publishing a regulation mandating how producers should handle the fish. The producers promised to remove all visible nematodes using candling tables (effective for the greater and colorful *Terranova*) and to remove the belly flap, where the majority of *Anisakis* can be found. The removal of the belly flap represents a loss of yield of 12-15% and even if your fillet is guaranteed parasite free and you deep-freeze it for one month (the time it takes for transport from the U.S. to Western Europe), you are practically obliged to remove the belly flap of interleaved fillets because the consumer is used to seeing the fresh fillet without it.

## DISEASES

There are several disease agents associated with seafood:

- a) bacteria, for example, *Vibrio parahaemolyticus* (and nowadays even *V. cholerae*), *Clostridium botulinum*, and *Listeria monocytogenes*
- b) virus, especially Hepatitis A, causing diseases
- c) toxic agents (like paralytic, amnesic, and diarrhetic shellfish poisoning)
- d) parasites, such as nematodes (*Anisakis* [whaleworm] and *Pseudoterranova* [seal worm]); trematodes (usually easily removable because you can see them outside the fish); and myxosporidium (*Kudua*)

## CHOLERA

Since the outbreak of cholera two years ago in Peru, more than 70,000 persons have fallen ill (50,000 of them in Peru), and more than 5,000 persons have died. To protect German consumers, the German government prohibited the import of fish and crustaceans from Peru (and later on from Columbia and Ecuador, too). The import is allowed only when the National Authority (in the case of Peru, CERPER) certifies that the production plant is under constant control and that the shipped merchandise is free of *Vibrio cholerae*. This year, responsible German importers have

started asking for a cholerae-free certificate issued by the Argentine authorities even though Argentina isn't under this obligation by law.

We know that cholera **bacteriae** are very sensitive to chlorine. That's why in the fish processing plant higher dosages should be used in your wash water (**10-15 ppm**), even though it may accelerate rancidity and shorten the shelf life of the product.

## **ESTABLISHING QUALITY STANDARDS**

You can see that there are several aspects to establishing quality standards:

1. public health aspect-protection of the consumer through inspection and control of fish products by food inspection authorities
2. the way fish are presented to the public
3. the competition among food companies, who offer guaranteed quality to gain a bigger share of the market

We know that the acceptability of fish is clearly related to price. Products can be replaced only by offering a better quality or a lower price.

Fish compete directly with red meat and pork, poultry and eggs, all products subsidized by the EC. That means that you can't raise fish prices while the prices of competing products are stable. Last year, at least until October, prices went up steadily, and when the producers of fish products tried to pass the increased prices on to the consumer, they noticed a strong resistance. The result was actually a decrease in business, for example, in Germany a decrease of around 20%. Some companies re-read their purchase conditions in order to pass claims back to the fish block producers, trying to bring down their high-value stocks **after** the prices went down again.

A good tool with which to pass claims is the condition of low plate counts, difficult to comply with in merchandise frozen on land. **The** easiest way to avoid those claims is to raise the chlorine level in the wash water with the consequence that the product, because of fat oxidation, has a shorter shelf life. **If** the quality department of a processing plant aims to find failures in order to reduce the price retroactively, it will **find** some **pinbones** or bloodspots it would not otherwise have mentioned.

In January 1993 the whole EC will function as a national market. there won't be controls at the national borders. Until now the national fish inspectors issued a certificate confirming

that the merchandise was produced under hygienic conditions. From 1993 on, every plant or factory ship that is in condition to produce good merchandise will get an official number and will be obligated to supervise production (this translates to self-monitoring by the fish industry). All products must have an official number to identify it in case of claims. The intention is to install an EC procedure for food inspection in Third World countries in the same way as it is planned for the EC, where competent authorities (that is, the central authorities of the member states) will carry out checks and inspections to ensure that the producers comply with the regulations. Each establishment must have responsible persons who carry out their own checks, especially at critical points, taking samples and keeping a written record.

Inside the EC, each member state will notify the commission of its list of approved establishments, and the commission will assign an official number. Commission experts-in cooperation with the national authorities-may **make-on-the-spot** checks to ensure the uniform application of this directive.

For imports from **Third** World countries, the directive foresees inspections carried out by commission experts to verify the conditions under which fishery products have been produced and stored.

Article 10 of the Council Directive **91/493** states that the provisions applied to imports of fishery products from Third World countries shall be at least equivalent to those of community products. This means that the EC urges the **Third** World countries to apply the same control system as the EC, to me a very reasonable viewpoint.

I'd like to explain a little the above mentioned directive. In chapter V (Health Control and Monitoring of Production Conditions) we find the following under special checks: **organoleptic** checks, carried out by the competent authority at the time of landing and after the first sale of fishery products. The **organoleptic** assessment of fish is the oldest quality control. Most quality control methods use the organoleptic control as a basis for verifying results. On the other hand, although each consumer has his or her own taste, when **qualified** persons give their opinion they represent thousands or even millions of consumers. This taste panel decides what the consumer has to like! We know that taste varies from region to region. For example, a German can't understand why a Spaniard prefers to eat hake, a fish he finds soft and insipid. It is true that hake is

highly perishable and fishing trips are **some-**times too long to guarantee a good product. On the other hand, codfish, which Germans like, has a far firmer texture, thanks to the high density of cell walls, which stop the bacterial spoilage for a while. Even for experienced **per-**sons it is very **difficult** to judge the total **qual-**ity of fish (in this case hake), especially **if it** refers to a defrosted fillet. Fresh fillets are easier to classify by a trained taste panel, but the **pro-**cess is quite expensive and there are always some members indisposed.

For fresh fillets-and, if you know the **his-**tory of the merchandise, for frozen fillets too **it is quite inexpensive to determine freshness** (as laid down in the directive) by measuring the quantity of total volatile basic nitrogen. With this test it is easier to find out "missing freshness" than different levels of freshness. If you have to judge hake fillets, you can hardly find sensorial **difference** under **21/22 mg %** TVB-N.

I **define** merchandise under 25 mg % as good and merchandise up to 30 mg % as acceptable. Even untrained consumers are able to detect off-odors in fillets with higher **TVB-N** levels than 30 mg %. With more than 50 mg %, the fillet is spoiled and smells like a stinky onion. But by measuring the total bases you can cover only one aspect of the quality.

The first impression, which means not only the color but also the total appearance, including the texture, is very important. It can **hap-**pen that the fillet is very **soft** and has gaping problems, but nevertheless is fresh and tasty. This is the case with big fillets (possibly after spawning) caught in summer in relatively warm water. On the other hand you can find firm fillets with an undefinable, "fatty" **off-**odor, even with low TVB-N levels, when the aliment&ion of hake consists mainly of **an-**chovy. In this case it is necessary to trim the fillet excessively and wash it much more than normal. Contrary to the principle "**first in first** out," fish like this should be used in the **pro-**cessing plant because it will develop a rancid flavor easily. Obviously, there are a lot of complementary data that **define** quality **be-**sides the official regulation or even besides the quality specification of the buyer (in this case the processing plant).

**Referring to** microbiological analyses, the commission will propose its measures by **Octo-**ber 1, 1992. Usually the national inspections apply a limit for plate count of **500,000/g** for good merchandise, admitting up to 1 million/g. Nevertheless many companies have their own

limits, not only for plate count but also for **col-**iforms, *E. coli*, and staphylococci. It is normal for the producer of fish blocks or **shatterpack** blocks to try to build up a special relationship with a group of buyers, offering a high-quality product able to satisfy the requirements of **ev-**ery potential buyer in this group. On the other hand, eccentric buyers should pay for their special wishes.

Normal requirements without any tolerance for hake blocks (16.5 **lbs**) are as follows:

1. weight at least 16.5 lbs (7.484 **kg**)
2. not more than 1 mm deviation of the **mea-**surements (482 x 254 x 63 **mm**), **absolutely** square edges and comers
3. not more than one **pinbone** or bone (like spinal chip) per kg
4. not more than one ice or air pocket per block
5. no packaging material imbedded in the block
6. TVB-N under 25 mg %
7. absolutely no rancidity, bitterness, staleness, off-flavors, or off-odors
8. no chemical ingredients, such as sodium polyphosphates

There is some tolerance in the matter of blood spots, bruised fillets, black membrane, skin, scales, water content, drip, and salt content.

I have some further suggestions:

1. No metal clip should be used to close the master carton.
2. The label should be big enough to identify the merchandise, even at a distance of 6-8 m (that means 5 or 6 pallets high). For this purpose the label should be on the side of the carton and not on the top, showing a combination of easily understandable letters or numbers.
3. Bed labels should be used for **pinbones** in merchandise and green labels for boneless fillets, symbolizing that these **fillets** can be eaten without any danger.
4. If you sell fish blocks, insist on two or three blocks per master carton. When you use a four-block master carton, it is too easy to staple the cartons with the blocks in a vertical way which separates the liner from the block. When merchandise is sent by container, each carton is handled at least **three times** (and up to seven times if a bulk reefer is used for transportation). The stevedores usually enjoy throwing cartons, causing fissures of the block, a serious handicap in the case of minced blocks.

5. If you sell defatted blocks, you have to define very accurately what the purchase manager means when he or she asks for **semidefatted** fillets. **If you** cut the fat (for example, with a Trio, Jensen, or a Baader machine), you could leave three lines. That means the very deep middle line and the two side lines, which are like waves parallel to the edge. If you remove more fat, you cut the outer lines and the fat will appear in spots. **If you** cut more deeply into the fillet, these spots will disappear, leaving only the middle line, which is nearly impossible to remove. The fat content usually fluctuates between 1.5 and 2%. A semidefatted fillet should bring the fat content under **1.0%**, and a one-line defatted fillet should be below 0.5% fat content.
6. Because of its fat layer, hake should be treated like a fat fish. This means you should cover the interleaved fillets by glazing them. You should not use oxidation enhancers like salt or water-containing metals (especially copper or iron), but use permitted drugs, like sodium erythrobate, to stop the oxidation. Hake has a far shorter **shelf life** than cod or other species with a low fat content
7. The block should always be packed with the fat layer inside, but that means that there will be two fat layers together in the middle of the block. To avoid this problem, you can "buffer" these layers with some defatted fillets. Minced hake has a lower fat content than normal fillets. For example, **if you** have 1.6% fat in the **fillet**, you can get down to 1.1% using only the V-cuts. But when you cut the part containing the **pinbones** a bit generously you can easily reach 1.3%. The reason is that near the neck you have a better relationship of relatively meager tissue to fat layer than near the tail, where it is nearly half and half.
8. To minimize the penetration of vapor, always pack the blocks with an additional PE-bag.
9. In the case of fillets IQF, apply an additional (to the net weight) glazing of 3-5%. Colored PE helps to identify **leftover** pieces of PE film. A blue-colored film emphasizes the white color of the fish. Quick-frozen (or even plate-frozen) fillets always have a whiter appearance than slowly frozen fillets, which have mostly a reddish color with even a hyaline impression.
10. Very often the producer mixes master cartons with plate and **blast-frozen** interleaved fillets, causing a real problem for the stevedores, because the cartons containing the blast-frozen fillets are usually 1 or 2 cm higher. Interleaved fillets should be well covered with PE with not more than two or three fillets per layer (depending on **the** size). The **fillets** should not touch each other, even after being frozen and pressed together in a plate freezer. Even here you should invest in an additional PE-bag. The experts of the joint **FAO/WHO Food Standards Programme** and Codex Alimentarius Commission deliberated more than ten years before publishing their standards. Nevertheless, each company has a lot of individual quality requirements that do not fit in any standard.

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## **Discussion**

**Q:** (Steven Freese, from the audience) When will the new European Community (EC) standards will go into effect?

**A:** (Werner) In January 1993.

Steven Freese added that the US government has a commission to develop a memorandum of understanding regarding these standards.

**Q:** Will the U.S. and less developed countries (LDC) be held to the same standards?

**A:** (Werner) In theory LDCs have until June 1, 1992 to apply for an exception, which would

allow them three years to meet the new standards.

**Q:** Aren't these standards so **difficult** to meet that the EC will have leeway to reject any block it doesn't want in an effort to bring down the price?

**A:** (Werner) This is a definite possibility; price or other factors may cause blocks to be rejected when they wouldn't otherwise be. For example, it is very **difficult** to meet the dual requirements of low bacterial counts and low chlorine levels in the fish, since chlorine is primarily used to keep bacteria down.



# THE IMPORTANCE OF QUALITY ASSURANCE FOR THE INTRODUCTION OF PACIFIC HAKE INTO TRADITIONAL FROZEN SEAFOOD MARKETS

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*Summarized by Ann L. Shriver*

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I would like to emphasize the importance of quality assurance in introducing Pacific whiting into new markets. Shelf life and quality issues make whiting a second- or third-level choice of buyers. Potential markets for this product include retail outlets, food service, and secondary processors, but each of these markets has specialized quality requirements that will play a role in the successful introduction of new products and species such as Pacific whiting.

Quality assurance involves the following functions:

1. preserving intrinsic quality
2. workmanship
3. meeting market and customer specifications

The most important function of quality assurance is the preservation of safety and wholesomeness. Unfortunately, Pacific whiting and whittings in general have gained a reputation for poor quality and short shelf life in the U.S. market. Overcoming this bias may require an extraordinary effort. Beyond maintaining product quality at its highest possible level, there are some additional considerations that will play a role in the successful marketing of whiting. Workmanship is important because, while it affects aesthetics more than safety, it will determine whether the product is able to meet a customer's specific needs. Workmanship is composed of the skill and accuracy used in the primary processing steps: filleting, boning, and skinning. It will enable the product to fit into particular weight, grading, size, packaging, and labelling niches.

Four primary market outlets exist today for seafood. Although once distinct, the divisions between these areas are now becoming somewhat blurred; however, for our purposes these markets are retail, food service, and secondary processors.

The retail market covers grocery stores as well as seafood specialty stores, including

single outlets, chains, and distributors. Appropriate product forms are those which can be sold either in self service or the fresh case; for the former, fish is trayed and over-wrapped and for the latter, thawed for the display. These product forms include fillets, whole, headed and gutted, steaks, and prepared foods. Quality-assurance concerns for this market focus on both intrinsic quality and workmanship, since visual aspects are important when the product is displayed. Specifications are more flexible than in other outlets. In this market, we accept seasonality and perhaps even expect it. The demand for U.S. Department of Commerce inspection is increasing, and we must pay attention to new requirements for nutritional labelling. In this market, prepared items are of increasing interest, and sauces, breading, and other treatments can be used to cover flaws in appearance.

The food service market includes cafeterias, restaurants, and institutions. This was a steady market throughout the 1980s and has remained strong through the last several years as well. The needs of working couples drives this increasing trend towards eating out, eating school lunches, using cafeterias, and so on. Product forms demanded include fillets, shatter packs, and prepared items (such as breaded portions). Intrinsic quality is less important here than in the retail market; there is a broader range of tolerance for second or third levels of quality. Portion control is relatively more important, since it determines profits, and workmanship will determine how well this is accomplished; weight grades of plus or minus a half ounce are not uncommon. Cooking instructions are often based on cost-control principles. In some areas, such as school lunches, nutritional information is very important. Additional considerations in this market are the need for packaging flexibility, the ease of preparation, and dealing with the seasonality of supply.

Secondary processing markets include breaders, entree preparations, and other converters (such as soup and chowder manufacturers). Product forms of most interest here are fillets, blocks, and surimi. This market has the most demanding product requirements. All quality-assurance factors, including intrinsic quality, workmanship, and contractual specifications, are crucial, since manufacturing systems can tolerate only a small degree of variation in the input product to be efficient. Detailed specifications often include bacteriological tolerances and even pesticide or mercury levels. An additional consideration is the desire for a year-round supply to reduce purchasing costs, including costs associated with switching labels to meet federal requirements when alternative species are used. Shelf life issues become very important in this market, where a **shelf life** in excess of **12 months** is **often** required.

Although this presentation has only scratched the surface of potential market opportunities, I hope I have shown that over and above the classic quality-assurance concerns, the quality-assurance function may be required to tailor processing or other aspects of a processor's operations to specific market needs. For processors investigating a potential market, I advocate an approach which includes the following steps:

1. Identify potential markets, customers, and products.
2. Determine customer quality requirements and product specifications.
3. Match these requirements to your **processing** capabilities.
4. Match the customer requirements and your processing capabilities to species characteristics.

Once this has been done, you should undertake test marketing and sampling and feed the results back into step number 1. Too often, this process is reversed. Following these steps in this order may take longer and cost more, but will result in markets for Pacific whiting that are stable and longer-lasting.

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## Discussion

**Q:** (Gil Sylvia, from the audience) Does the technology exist to use extruders on fresh fish, and if so, what could the impact be on whiting?

**A:** (Daniels) Currently the technology is underdeveloped but there are opportunities in that area, for example in the marketing niche of making fish sticks in shapes attractive to children. Using fresh mince instead of frozen block for this might cut out a middle step and lower costs. However, the use of fresh product would entail much closer matching of opportunities between primary and secondary processors because of the shorter time horizon required.

**Q:** (Sylvia) Can we really take advantage of seasonality in the way you pointed out in your talk, by giving the product a closer association with the fresh fish market? Hasn't much of our effort been toward reducing the seasonality imposed on the industry by the way fisheries operate?

**A:** (Daniels) **Seasonality** may be something only the fresh market can really play to its advantage by associating certain products with certain seasons of the year and playing on the freshness aspect. In **the** frozen market we need to increase **shelf life** in order **to** assure higher quality.

**Q:** (Barry Fisher, from the audience) Can whiting really be a product going directly into grocery stores, given their emphasis on revenue generated per square foot and cash flow?

**A:** (Daniels) The costs of developing and introducing a new processed product are so high (**my company** estimates \$7 million) that a better bet for whiting might be **to** try to position it for the fresh counter within the grocery store.

**Q:** What about the problem of consumer unfamiliarity with seafood; should we attempt to counter this by developing and distributing simple, easy recipes at the seafood counter?

**A:** (Daniels) Yes, this is a potentially useful strategy. Also remember that the easy-to-fix, processed product appeals to the consumer who is unfamiliar with fish and intimidated by the prospect of cooking it.

## PANEL DISCUSSION ON QUALITY ASSURANCE

Session leader: *Kenneth Hilderbrand*. Panel Members: *Gilbert Sylvia, David Jincks, Enrique Bertullo, Jaachim Werner, Jim Daniels*

Q: (Session leader) What are the most important elements of quality assurance or quality control for Pacific whiting?

**A:** Each panel member responded to this question. David Jincks emphasized the need for fishermen to keep the product as cold as possible up to the processing phase, and for processors to follow up by doing their part to keep temperatures down so as not to waste the fishermen's efforts. Jim Daniels highlighted the related problems of rancidity and **whiting's** high fat content, to enable whiting to compete with cod, pollock, or other hakes that have lower fat contents and longer **shelf life**. Enrique Bertullo responded that the problem of competition with cod is resolved through price. Joachim Werner discussed handling problems that can be resolved with a bit of special care. For example, some frozen block sold to Germany had been packaged with the fat side out, increasing the danger of oxidation of the fat and leading to rancidity. Had the simple measure been taken of packing the block with the fat side of the fish inward, this problem could have been reduced. Only two or three boxes should be packed per carton. Metal clips should not be used. On the other hand, extra polyethylene packing should always be used.

Gil Sylvia responded that management **affects** the **quality** of a product. **The** fact that the Pacific whiting fishery is currently a "pulse" fishery, with all of the product being caught in a very short period of time, makes it risky for the industry to invest in the capital equipment needed for optimally controlling product quality. The current **management** scheme allows fishing early in the season, when intrinsic product quality may be relatively low (postspawning condition results in high moisture and low fat ratios). For surimi, as prices rise, higher-priced fish will become relatively more attractive as ingredients. However, as supplies build, prices begin to decrease. Therefore, it may be wisest to develop a whole portfolio of product forms that allows the producer to switch between pro-

cessed products as prices fluctuate. Contracts are another important factor; they should be written so that improved handling is reflected by a better price. Finally, there is the need for additional research, especially on the variability of product attributes. **The** entire industry needs to have a philosophy of improving quality, to improve the reputation of this fish.

Werner emphasized that when one seller makes an inferior product, the whole industry suffers. Sylvia observed that it is interesting that hakes on the whole are identified by geographical location, so that the problem becomes one of inferior fish being associated with an entire region. Ken **Hilderbrand** summed up by remarking that a bottom-up approach was needed in the industry; you can't produce a superior product with poorly trained, temporary labor. Quality control people should be management, not production people.

Q: (Session leader) What is the effect of seasonal closures on a company like Mrs. Paul's? How much of the year must a product be available for it to be feasible to use in a processed product?

**A:** (Daniels) It is not as much a question of the length of the availability as it is of the volume available. That being said, a six-month availability might be adequate and a two-month availability probably would not be.

Q: (Session leader) What treatments are available to solve oxidation problems?

**A:** (Daniels) My company has used a water soluble treatment that had to be dropped because it colored the fish. **They** switched to sodium **erythroate**, but this is **difficult** to distribute in a frozen block unless it is minced. My company is currently receiving Polish whiting products and has been surprised at the good quality of the seven-month-old product.

Q: (Session leader) What is the market for mince, and would it help to develop a stabilizer that could be used in mince?

**A: (Daniels)** The consumer says that mince is as good as fillets; and yes, a stabilizer would make the product more usable. Using sugars, Mrs. Paul's has been able to reduce **formaldehyde** formation, too; there may be other options as well.

**A:** Daniels observed that this hasn't proven feasible because a several-month inventory of stocks is needed. Sylvia suggested that **contract** arrangements could be adjusted to implement such a system for whiting and reduce the need for long **shelf life**.

**Q:** (Gil Sylvia, from the panel) Has Mrs. Paul's experimented with management methods such as "**just in time**" delivery?

# PANEL DISCUSSION ON THE COOPERATIVE EFFORTS OF FISHERMEN AND PROCESSORS TO IMPROVE PRODUCT QUALITY OF PACIFIC WHITING

Session leader: *Bob Jacobsen (OSU Sea Grant Extension)*. Panel members: *Terry Rosaaen (Castle Rock Seafood)*, *Kurt Cochran (commercial fisherman)*, *David Jincks (commercial fisherman)*, *Tom Libby (Point Adams Packing Company)*, *Jerry Bates (Arctic Alaska Fisheries Company)*, and *Barry Fisher (commercial fisherman)*.

*No formal presentations were made by this panel. Members responded to a set of questions from the session leader and from the floor.*

**Q:** (Session leader) How can fishermen and processors cooperate in assuring consistent quality in Pacific whiting products?

**A:** The responses of the panelists can be collectively summarized as follows. Some of the most important issues related to maintaining the highest quality in this product revolve around communication and coordination between fishermen and processors. The more that fishermen understand what will happen to their fish on shore, and how it is turned into the final product, the better they will handle the fish at sea. Handling is more important with this product than with any other; processors need to take a stand and refuse product from fishermen that is handled improperly. It is necessary to match catching activity with freezing activity so that fishermen can turn over their landings every day. Even those who own both catching and processing facilities find this challenging, and it is even more difficult when ownership is separate. Radio communication between fishermen and processors is important to ensure that facilities are available at the dock for immediate unloading of catch. Processors need to be ready to process and freeze catch within a few hours of landing. There are also a number of catching and handling procedures which need to be followed on board with Pacific whiting to ensure that the flesh does not begin to soften. They include using champagne ice or refrigerated seawater systems, constant monitoring of storage times and temperatures, shortening the length of tows so that the amount of fish in the cod end when emptied is less, reducing fish, and using cod ends with zippers in the

bottom rather than dumping fish on board. A storage time of 12 to 16 hours is acceptable; anything longer than 16 hours on board results in softening of the fish. On the plant side, careful handling will include using pumps rather than manually offloading, and freezing as quickly as possible. The headed and gutted form can take the most abuse.

Barry Fisher turned away from technical issues to address institutional concerns. He pointed out that the Oregon Department of Agriculture, at the urging of the fishing industry, has done a good marketing job, making use of the Coastal Oregon Marine Experiment Station (COMES) and its economist to gather and analyze market data. Grants and low-interest loan programs have also been provided. Fisher introduced the concept of a fishermen's association for Pacific whiting, which would have certain voluntary standards. Everyone interested should be involved in the planning, needs of an economic, technical, and political nature could be identified, and the potential members would have to agree on a framework they could all live with. The Oregon whiting industry is fortunate that the Astoria Seafood Lab began to work on whiting characteristics when it did. Fishermen could organize to have input into this process. Such a group or institute could coordinate the efforts of various government groups. Alaska had a hard time with the Alaska Fisheries Development Foundation and the Alaska Seafood Marketing Institute until industry began working together. With all of its problems, whiting needs an organized industry. The primary issue is voluntary standards with some kind of quality label, to establish some kind of discipline in the market. Fisher asked for responses to this concept from the other panel members and the audience. Terry Rosaaen responded that such an organization is a good idea; the industry

needs a lobbying group given the current activities of the Pacific Fishery Management Council. He pointed out, however, that even though he owned both boats and processing facilities, it was a big challenge to get them to work together. How can we get such a contentious industry to work together? It would require a great deal of cooperation, for example, in determining which quality of fish can be used in which product form. Kurt Cochran agreed with the need for an industry standard, but wondered how it would be policed. The industry should not limit itself to aiming for a lower-quality product such as that required by surimi. David Jincks commented that this is the year to set standards; the industry needs them but he wasn't sure how they could be set. Tom Libby also agreed to the need for standards from the moment of catch through all processing levels. If the market comes to perceive whiting as a low-quality product, the Oregon fisherman and processor will be in serious trouble. Much of the data needed to establish the parameters are probably available from the Astoria laboratory; they would include temperature ranges, acceptable tow lengths, mesh size, and cod end sizes among other things. Processors will have to take a firm stand to ensure that the quality standards are met. Jerry Bates pointed out that although the idea for standards is a good one, the market really establishes standards, through pricing. The market will push you right out of business if you don't comply, and each market has its own standards.

Fisher responded that what he had in mind were voluntary standards, developed from, by, and for industry. How are we going to get into EC markets, he inquired? Answering his own question, he replied: only with a set of unified and very strict standards. He claimed never to have gotten a dime for delivering "premium" fish, and that the factory trawler fleet had no internal standards and delivered a lower-quality product; no price premium currently exists based on quality. The cod shortage won't last forever, he emphasized, and we live in a very competitive world.

A suggestion came from the floor that a state agency could establish a quality seal of approval with some set of standards attached to it. Another individual pointed out that the rapid change in the industry argues for denied the possibility of shoreside production

of surimi a very few years ago and now it is commonplace. Discussion continued around the concept that if a certain quality of product wasn't good enough for one product form, it could be used for other forms. Some felt that minimum standards should be set and others felt there should be a range of different qualities, perhaps grades. It was proposed that a set of standards be drafted with input from the group, and assistance from both COMES and the Astoria Seafood Lab. Suggestions for the standards included that they begin as guidelines, be profit driven, establish a range of different qualities, take advantage of price and quality market information being developed from the whiting study done by Gil Sylvia, and use data from processing firms which use time and temperature monitors on the boats delivering to them.

The discussion turned to the issue of who should be in charge of developing and enforcing the standards. Dalton Hobbs, from the Oregon Department of Agriculture, offered to help. Bob Jacobsen nominated Gil Sylvia to gather the information needed and function as coordinator for this effort, suggesting that anyone who wanted to be involved "sign up with Gil."

With this, the group returned to a technical issue: the problem of inadequate ice supplies. Ken Hilderbrand asked why processors could not simply provide ice to fishermen who supply them, directly from the plant. It was pointed out that the quantities needed are enormous and that first priority was usually given to the shrimp boats. Some fishermen had switched over to RSW systems because of the irregularity of the ice supply. This provides yet another area where cooperation and coordination between fishermen and processors would be to their mutual benefit, particularly with this species and its special handling requirements.

At the end of the session, the following question was put to the audience: would it be worthwhile to hold another such conference next year? The response was positive, with the suggestion that the next conference focus more on fish buyers. It was also suggested that a quarterly newsletter on whiting would be useful, and Mike Morrissey agreed that this would be an appropriate task for the



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# Marketing

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# SURIMI MARKET—BOOM OR BUST

**Ron Jensen**

**Arctic Alaska Fisheries Corporation**

In this paper, I would like to get away from academia and talk about the real experience of producing and marketing surimi.

Arctic Alaska Fisheries has pioneered the production of surimi. We were the first to produce pollock surimi aboard a U.S. vessel (in 1986 on the U.S. **Enterprise**, a surimi factory trawler). And this year, we will be the first to operate a hake surimi shore plant, here in Newport.

Producing surimi in the past has not **been easy** for us. We made our mistakes and paid for them dearly. **On** our first surimi factory trawler, we thought we knew surimi enough to do it the "American Way"; we didn't listen to our Japanese partners or their technicians. We were wrong.

Through our mistakes, we have learned a lesson and have gained experience. As far as **Pacific** whiting utilization goes, we have studied this potential for a few years now.

We have watched with keen interest, and assisted whenever we could, as dedicated scientists such as **Roy** Porter have painstakingly labored to develop methods of inhibiting the troublesome **enzyme**. We have devoured the series of informative reports prepared by the Oregon Coastal Zone Management Association. In addition, we have worked with local processors and fishermen to learn the important fundamentals of quality handling of this fragile species of fish. The dedicated work of these people and countless others (such as Ken Hilderbrand) has resulted in an information pool from which we have drawn to make the very **difficult** decision to help pioneer the shore plant surimi business in Oregon.

The people of the Arctic Alaska Fisheries Corporation are proud to be working with local contractors, fishermen, and processors in pioneering the domestic utilization of Pacific whiting on a scale only dreamed of as recently as last year.

We are installing a surimi factory which processes 350 metric tons (**MT**) of round fish per day under a joint venture agreement with Jerry and Sheryl Bates of the Depoe Bay **Fish** Company. We expect to process in excess of 40,000 MT of round fish this year.

We are building a state-of-the-art, **320-MT**-rated (incoming raw material) Atlas fish meal plant adjacent to the International terminal area on the bay front in Newport. This plant will provide a critically needed disposal site for local processors and will ensure 100% use of the raw product in Newport. The plant is currently under construction and is scheduled for completion on April 15.

We are working closely with the Oregon Department of Environmental Quality and the Oregon Department of **Fish** and Wildlife in monitoring both the water quality and the animal life forms in the estuary. We hope these ongoing studies will help promote continued positive interaction between industry and the habitat caretakers as we together continue to promote ecologically and economically sound methods of processing fish.

We also look forward to further work with scientists and private industry who continue to develop more advanced forms of the **enzyme** inhibitor that will be acceptable to all markets.

To discuss surimi business, we must **first** discuss pollock surimi, since it has been and still is a dominant force in the market.

Until the **1950s**, surimi was an exclusively Japanese-produced, Japanese-marketed product. Through the Magnuson Act, the **first** U.S. production of pollock surimi took place in 1986 on the U.S. **Enterprise**. Since then, U.S. production of surimi in the Bering Sea has grown to 140,000 MT yearly.

Until U.S. production became dominant in the past few years, the surimi market in Japan was very oligopolistic, controlled by a few Japanese fishing companies. From 1939 to 1990, because of the unknown and unproven quality of U.S.-produced surimi and the breakup of traditional Japanese distribution channels by the new U.S. producers, the market became confused and prices plummeted.

The drastic increase of surimi prices in the last six to nine months is most likely temporary, caused by a reduction of surimi production in the Bering Sea and Donut Hole last year. However, extremely high prices are discouraging the demand for pollock surimi and encouraging substitute production from less

expensive fish species, such as Pacific hake, southern blue whiting, and sea bream.

The reason pollock surimi was preferred in the past was the high gel-forming capacity of the meat and its relatively high whiteness value. Pacific whiting, used as a substitute for pollock surimi, is usually blended with pollock surimi by kamaboko makers to strengthen the gel-forming capacity. Pacific whiting surimi has a very favorable white color and thus is a very attractive alternative to pollock surimi if priced reasonably. However, as pollock surimi in Russia increases, and as other substitute surimi production occurs in Argentina and Indonesia, it faces increasing competition

We estimate the world supply of surimi in general in 1991 to be approximately 390,000 MT, of which Japan produces about 200,000 MT and the U.S. 120,000 MT. In 1992, this number could be as much as 480,000 MT, an increase of 26%. Of course the production could change in the latter part of the year, but the estimated increase of surimi mainly comes from countries such as Thailand, Argentina, Chile, and Indonesia that produce sea bream or southern blue whiting surimi. Russia also will double its pollock surimi production through joint venture this year.

Demand for surimi totals about 460,000 MT worldwide, of which Japan consumes approximately 80%, or 380,000 MT. The Japanese demand is said to be on a slight decline because of a general change in consumer taste. Demand in Korea, which consumes about 50,000 MT yearly, and Europe, 5,000 MT, is on the increase. However, these markets are still young and small compared to the Japanese market.

Considering that the world demand is relatively stable at 460,000 MT, surimi supply can easily be at surplus condition this year if we include all the surimi made out of various species. Therefore it is certain that Pacific whiting surimi must meet the challenges from the rest of the world.

Between 1980 and 1990, the price of top-grade pollock surimi in Japan was relatively

stable, ranging anywhere from ¥400 to ¥520 wholesale. This converts to roughly U.S. \$1.00 to U.S. \$1.40 FOB Alaska price after freight, cold storage, and other expenses. So you can see how unusual the last year's radical price increase was.

Potential producers of Pacific whiting surimi should be aware of the historical surimi price levels and be ready to compete with worldwide surimi production in a cost-efficient manner. The important task we have as producers of pollock and hake surimi is to try to maintain reasonable price levels for the longer health of the industry and to avoid this boom and bust nature of pricing strategy.

We also discourage gambling all the production capacity on surimi. Rather, we highly advise diversification into other products, such as fillets and blocks, to balance the impact of anticipated market fluctuation.

The quality of surimi plays a very important role in making the surimi business a success. Kamaboko producers must trust the suppliers to give them a consistent quality and supply of material to produce the analog products for consumers. "Quality" includes the market acceptance of the surimi that a particular company or vessel produces. There is no perfect surimi; the processors prefer a variety of different characteristics of surimi within the same quality parameters. In the same way, there's no perfect steak that pleases everybody. Some like T-bones, some like rib eyes. Market acceptance also takes time. When we first began producing surimi in the United States, the Japanese markets didn't trust the quality of surimi that the Americans produced. In the past five years, we have developed loyal customers who prefer the products off our vessels. The general taste of Japanese consumers also changes. We now produce specialized surimi, with all sorbitol or all salt surimi for gourmet markets.

In summary, it is the balanced combination of accepted quality, supply and demand, and right pricing that creates success for surimi producers.

# GLOBAL MARKETS FOR SURIMI-BASED PRODUCTS

Joseph Zalke  
Nichirei Corporation of America

Global markets for the production of surimi-based products grew to over 2.3 billion pounds in 1990. Long dominated by the Japanese and Korean markets, surimi-based products are starting to **find** acceptability as a protein source in many global societies.

Table 1 **illustrates** the best estimates of the global production of surimi-based products. Japan is the obvious leader in this production, representing 85% of the total, or approximately

total production, 53,500 MT, or 117.9 million pounds, were consumed domestically; the balance was exported to the countries shown in table 2.

Japanese exports of crab-style surimi seafoods to the U.S. reached their zenith in 1985, **totalling 129,000 MT**. By 1991, the annual exports decreased to slightly over 10,000 MT, representing a decrease of 93%. Appreciation of the yen, Korean production, and **expan-**

*Table 1. Global production of surimi products.*

Annual Estimates—1990		
Country	Metric Tons	Pounds
Japan	915,000	<b>2,013,000,000</b>
Korea	103,800	228360,000
U.S.	50,000	<b>110,000,000</b>
Europe	4,000	<b>8,800,000</b>
Russia	4,000	<b>8,800,000</b>
Thailand	2,000	<b>4,400,000</b>
China	1,000	<b>2,200,000</b>
Totals	<b>1,079,800</b>	<b>2,375,560,000</b>

Source: Nichirei Best Estimates

2.0 billion pounds. Surimi-based products are a staple of the Japanese consumer. A wide variety of **finfish**, including **salmon**, is used in surimi production. Kanikama products, which typify the style of products consumed in the U.S. and European markets, account for approximately 20% of the total surimi-based products processed in Japan. In 1990 Japan processed approximately 70,000 metric tons (**MT**) of kanikama, or 154.0 million pounds of crab-style surimi seafood products. From the

sion of the **production** of U.S.-based surimi seafood contributed to the steep decline.

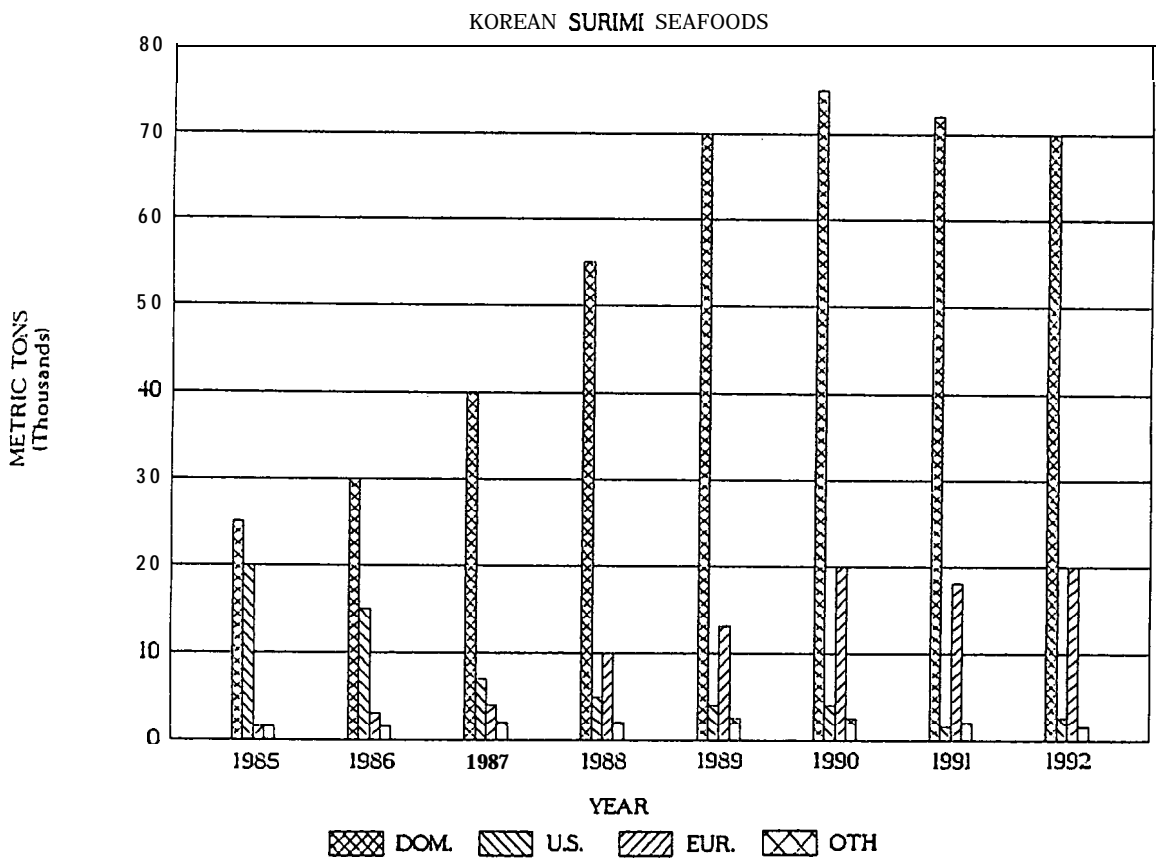
Korea's domestic consumption of **all** surimi-based products has almost tripled since 1985. In 1985 the consumption was 25,000 **MT**; in 1991 it had risen to 72,000 MT.

The actual estimated 1991 production of surimi-based products was 50% of their total capacity. The artificially supported prices of raw material resulted in plants operating at 60% **of capacity** in the latter **half** of 1991. **Be-**

**Table 2. Japanese exports of crab-style surimi seafoods.**

(Annual Estimates-1990)		
country	Metric Tons	Pounds (000 omitted)
Australia	1,680	3,696.0
Canada	453	<b>1,007.6</b>
Europe	9,215	<b>20,275.0</b>
U.S.	4,060	<b>10,120.0</b>
Others	1,300	<b>2,860.0</b>
<b>Totals</b>	<b>16,713</b>	<b>36,770.0</b>

Source: Japan Frozen Food Inspection Services



**Figure 1. Korean surimi seafoods.**

cause of the high prices of raw material, **traditional** ham and sausage users of raw surimi have switched to turkey meat as an **alternative**. The expected use of raw-material surimi in 1992 **will** decrease to 40,000 MT.

There are currently 16 major surimi seafood processing companies in Korea. Throughout

the country there are over 1,000 **small processing** companies producing the traditional fried kamaboko products.

Figure 1 **illustrates** the growth of **all** surimi-based products in Korea and exports to the U.S., Europe, and other countries.

**Table 3. European annual surimi seafood consumption**

Estimates in Thousands				
country	1990		1991	
	MT	LBS	MT	LBS
France	8,000	<b>17,600.0</b>	4,000	<b>8,800.0</b>
<b>Italy</b>	2,000	<b>4,400.0</b>	2,000	<b>4,400.0</b>
Spain	4,500	<b>9,900.0</b>	4,500	<b>9,900.0</b>
U.K	4,000	<b>8,800.0</b>	4,000	<b>8,800.0</b>
Others	2,500	<b>5,500.0</b>	2,000	<b>4,400.0</b>
Totals	21,000	<b>46,200.0</b>	6,500	<b>36,300.0</b>

Source: Nichirei's European office

Europe has replaced the U.S. market as the dominant recipient of surimi seafoods processed in Korea, with exports increasing more than tenfold in the last eight years. Europe will continue to dominate Korean exports. Demand by the EC countries for surimi products, strong markets, currency strength, and an absence of an infrastructure in EC counties for processing surimi seafood will continue to make Europe an attractive export customer.

Surimi seafood consumption in Europe is a combination of imports and an infant domestic processing industry. Table 3 is an approximation of European consumption of surimi seafoods.

Information on surimi consumption in Eastern Europe is not available at this time. However, we are aware of sales being made to countries in this region. Moreover, within the new Russian republics, surimi seafoods are now being processed at plants in four locations, operating a total of five processing lines.

At present, six surimi processing lines are operating in EC countries: U.K—one, **France—four**, and **Italy—one**. The total estimated production for 1991 was 4,000 MT, or **8,800,000 lb**.

My company, Nichirei Corporation of Tokyo, has established a new joint venture with **Angulas Aguinaga**, S.A of Spain, to create *angulas de surimi*. The product resembles the size, shape, texture, and flavor of wild angulas (baby eels).

The following is a brief profile of the EC countries.

#### **France**

- The market expanded in 1988 because the use of additives was permitted by the federal government.
- Domestic production is sold primarily **refrigerated** because the domestic producers cannot compete with Korean frozen imports.
- The retail market is larger than the food service market. The most popular style is sticks (sold in 250-g packs).
- Consumption volume declined dramatically in 1991 because of unusually high prices.

#### **Italy**

- *The* market is largely undeveloped because of federal restrictions on food additives.
- Domestic production started in 1991 as a joint venture with a Korean company.

#### **Spain**

- Spain is one of the more mature surimi markets. Sales started approximately eight years ago.
- The market is segmented into the high-price, high-quality product of Japan, and the **low-price** product of Korea.
- Retail is the primary market for surimi.

#### **U. K.**

- **Surimi sales** started ten years ago.
- The food service market is the most mature of the EC countries.
- Volume is stable at **4,000-5,000 MT** annually.

- One major Japanese surimi company has established a domestic processing plant specifically for the retail market.
- Korean imported products dominate the U.K food service market.

The German market is nonexistent because the use of phosphate in surimi seafoods is prohibited, just as it is for sausage production.

The EC has the potential to annually consume approximately 30,000 MT. There is room for expansion in the market with product form. At present, EC consumers prefer the sticks over the salad packs or flake packs.

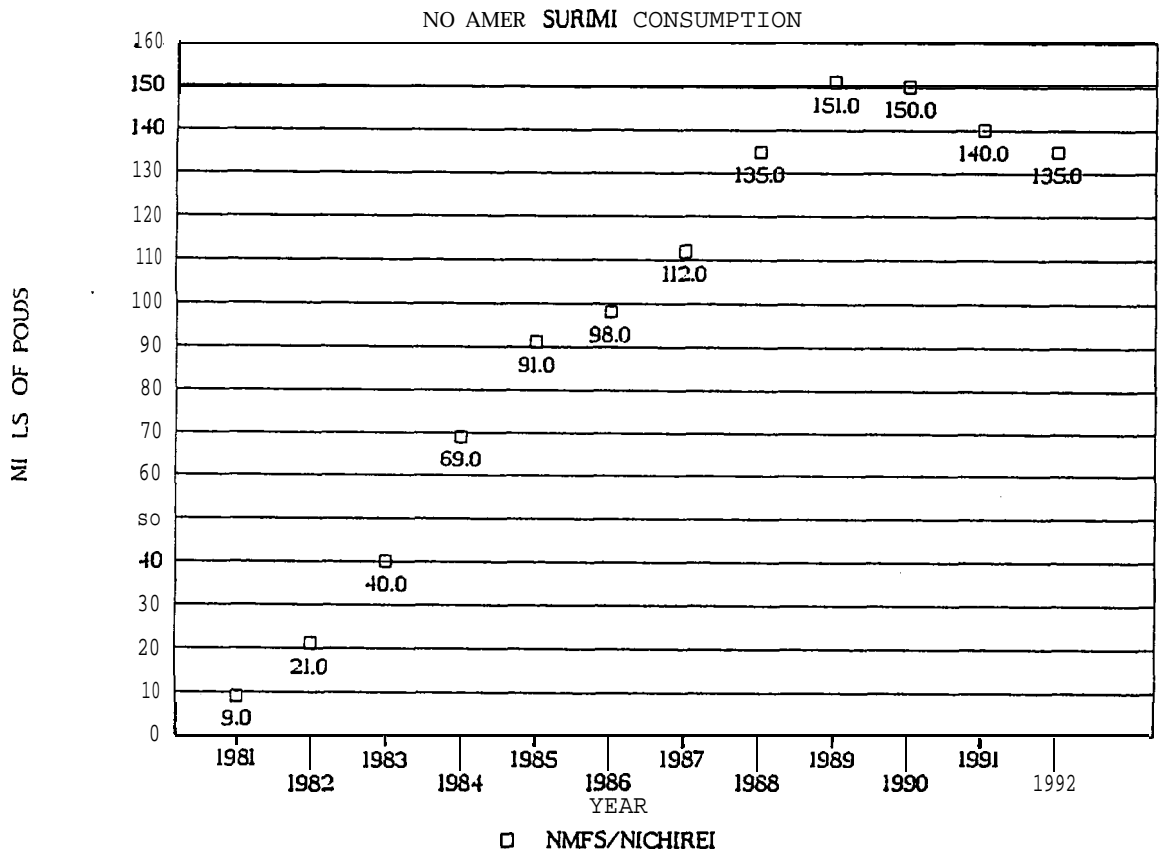
North American surimi consumption reached its pinnacle in 1990 when an estimated 150 million pounds were consumed. As we know, there is no **definitive**, quantifiable data which measures surimi consumption in North America. Any data that is accumulated is **based** on conjecture and supposition. Data gathering in this market is based on the grass roots method of multiplying the number of processing plants times the number of surimi processing lines, and multiplying this figure by the estimated number of pounds per hour. The final figure is an aggregate sum of estimated production capacity in North America.

Estimate the pounds consumed by major restaurant chains; add the purchasing volume of the **major** supermarkets and food service chain **distributors**; to this, add the volume used **by** the major salad manufacturers, and any major industrial customers plus a pinch of "blarney," common sense, and intuition, and you've just measured the size of the North American surimi market.

**Figure 2** provides a tracking device for the estimated size of the North American market. **From** its infancy in 1981 of 9.0 million pounds to its current estimated size of 140.0 million pounds, the surimi market has grown 15.5 times.

**The** production capacity in North America is estimated at 225 million pounds **from** 17 processing facilities. During the peak consumption year of 150 million pounds, 66% of the plant capacity was used. **If** the estimated 1992 consumption rate does slip to 135 million pounds, the plant capacity rate will decline to 60%.

Explaining this downward trend in surimi consumption is complicated and disconcerting. Between 1988 and 1990, we witnessed a classical thrust of several factors:



**Figure 2.** North American surimi consumption.

- market assessments that supported the additional major capital expenditures in new processing equipment,
- new processing companies coming on line, and
- a **frenzied** expansion of line capacity.

All this took place in response to the prediction that surimi consumption would reach a level in excess of 175 million pounds.

Market activities supported these management decisions:

- Major restaurant chains offered a variety of surimi products.
- Salad manufacturers expanded their distribution patterns to satisfy consumer demand for light foods. Surimi seafoods became a key ingredient in salad combinations.
- Supermarket chains expanded their merchandising of surimi products to multiple locations in the stores: deli, seafood counters (both service and self service), salad bars, and frozen food cases. Supermarket operators found a new major profit contributor in surimi to offset the decline they were experiencing in other seafood items. Last, surimi afforded the supermarket operators a profitable promotional vehicle at \$1.99 a pound.

The surimi seafood processors actively supported this demand through formulation manipulation to satisfy the requests for **lower-priced** products. As long as the raw material costs of pollock surimi remained low, this strategy was not only feasible, but profitable.

Surimi seafood consumption of 175 million pounds was a sight worth setting.

We all know what occurred in the winter of 1990. **Raw** material prices started to accelerate, and processors were faced with the inevitable fact—the price of finished goods would have to increase. The reality of the situation became apparent, not at first, but shortly after the beginning of 1991: the underpinnings of the structure of the surimi seafood industry were weak.

**Overcapitalization** became the nemesis for the industry: too many processors were chasing a market whose growth curve was maturing. Price rather than quality concerns took priority in the buying decision.

Because surimi seafood is one of a number of ingredients in most preparations, discerning quality features are often masked by other ingredients.

No one surimi seafood processor enjoys a position of leadership from which to direct the market or provide a stabilizing influence.

The symptoms of a declining, mature market heated up:

- Buyers began to perceive surimi seafood as a commodity.
- Companies tried to grab the market share through price reductions.
- Consumption stagnated or declined.
- The food service industry suffered menu burn out.
- Surimi seafood was no longer “new.”
- **The** introduction of any new product was met with limited success.

Surimi seafood will have to take on a new dimension. For it to remain a viable product category, everyone even remotely connected with this industry will have to start with repositioning the product

The stigma of **“imitation”** must be erased. In hindsight, initially positioning surimi as a “crab substitute” was an error in judgement that we are still living with. The five- to **six-**year battle with the FDA must be resolved, and “imitation” must be dropped from the descriptive nomenclature.

New market niches are being untapped by many of us and must be pursued. This will require new product forms and uses. We must retain the confidence of the current heavy consumer and encourage the casual user to consume more. There are many nonbelievers in the market. They are not convinced that engineered foods have a place in their diet; continuous exposure and trial usage will convert some of this group.

Surimi seafood as an ingredient in many products is viable. In my view this is the next important direction for surimi.

My concern for the future of surimi seafoods is the adulteration of the seafood formulas to achieve a viable, profitable product matrix. **Reducing** the percentage of raw material surimi in a product in order to compete in the market is tantamount to ordering our own destruction.

We must establish identification standards for surimi seafoods to provide a buyer’s guide. At present, the quality of surimi seafood is left to the subjectivity and discretion of the buyers.

**Pacific** whiting, as an ingredient in surimi seafood, is not a problem. As matter of fact, the **Pacific** whiting we used in test runs produced an excellent product Using this species as a blend with other species is not a problem in the market. Keep in mind that in the early days of



surimi processing, turbot was blended with Alaskan pollock. If my memory serves me correctly, Gulf croaker was one of the first **finfish** to be considered for surimi.

However, until we resolve the issue of the enzyme inhibitor, we cannot proceed further with whiting surimi. Once a **definitive** ruling is made and agreed upon by the government, we can move forward.

I am **confident** the surimi seafood industry will evolve to the next plateau. The “surimi shock of 1991” has made us realize that the elements of survival are quality, product attributes, and product benefits. We live in a world of food that offers instant, substitutable gratification. No one product is insulated from this fact. All of us who are involved in the surimi industry, whether through ingredients, packaging, boat ownership, fishing, processing, or marketing, must continually do our part to ensure that when the chefs, menu development personnel for restaurant chains, supermarket merchandisers, or consumers think of protein, surimi comes immediately to mind.

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## **Discussion**

**Q.** (Susan Hanna, OSU Department of Agriculture and Resource Economics) What is your company, and the industry in general, doing about the problem of the high levels of sodium in surimi products? Is this level of sodium necessary? Are there any alternatives?

**A.** Zalke responded that Nichirei is planning to introduce products with 42% less sodium. The company does think that this is important to consumers. Jae Park also remarked that it's an important issue, and Tyre Lanier expressed the hope that with new developments in his research, they may be able to reduce sodium levels another 25% or so from there.

**Q.** What about quality standards? Are they needed?

**A. (Zalke)** Absolutely. I would make a plea for the development of these standards, which buyers in the marketplace are asking for. Up to now, brands have not been an important way of identifying product because of the many small suppliers. As the competitiveness of the industry heats up, smaller firms will be driven out of the business, which will consolidate down to fewer, larger suppliers. As this happens, brand association will become more important.

Tyre Lanier followed up with the comment that the problem is not the lack of standards but the lack of brands. Zalke replied that they are hoping for stability in the raw materials so that they can make quality more important than price in determining which raw materials to buy.

**Q.** (Gil Sylvia) When banana suppliers attempted to standardize the product to improve the overall quality of bananas delivered to consumers, they lost a lot of the variety available in the product. How can we standardize without losing variety in surimi seafoods?

**A. (Zalke)** There are two ways surimi has gone to the market: through retail brands in such products as “Sea Legs,” and through seafood menu items in restaurants. **Restaurants** began by putting the product into their menus using many different formulations; this causes a vast proliferation of surimi types and formulas. This situation made restaurant surimi users overly concerned with price and not concerned enough with quality. Gil Sylvia commented that good chefs could train consumers **to** use surimi, which would improve demand at the supermarket. Zalke replied that Nichirei has been working with some home economists and chefs, but to date there has been no **industry-wide** effort. He had worked with the surimi committee of the National Fisheries Institute (**NFI**), but it has a very small budget, which they have used mostly to work with newspaper food editors. Barry **Fisher** recommended working with the Chefs de Cuisine group of Oregon, which is committed to pushing underutilized species.

# THE SITUATION OF GLOBAL SURIMI, WITH SPECIAL EMPHASIS ON THE JAPANESE MARKET

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## THE GLOBAL SUPPLY SITUATION

According to industry estimates, the current world surimi production (1991) is 390,000 metric tons (MT), down by 130,000 MT from the 1988 peak of 520,000 MT (table 1).

current operations in Japan are not as efficient as those in the U.S. Thus, a further reduction in the number of production facilities will be expected in the foreseeable future in Japan.

		1985	1986	1987	1988	1989	1990	1991
Japan	vessel	240	240	220	240	150	80	30
	plant	180	170	170	160	150	140	140
	subtotal	420	410	390	400	300	220	170
U.S.	vessel	-			30	80	150	110
	plant	-		20	30	30	40	50
	subtotal	0	0	20	60	110	190	160
Rep Korea	vessel	20	20	30	30	30	20	10
Russia	vessel	-		-	-		-	10
Argentina	vessel					10	10	10
Thailand	plant	10	20	20	30	20	20	30
<b>Total (vessel + plant)</b>		450	<b>450</b>	460	<b>520</b>	470	460	390

\*Table 1 is based on industry estimates.

Table 1: Global Surimi Production (1000 MT).\*

Japan has significantly reduced its share from 93% (420,000 MT) in 1985 to 43% (170,000 MT) in 1991. Meanwhile, the U.S. has rapidly increased its share to 40% (160,000 MT) in 1991. In addition, the number of producing countries has expanded to six in 1991.

The major portion of Japan's production used to be made on board (57% in 1985); however, onshore plants dominate current production (82% in 1991). In contrast, U.S. production is mainly made on board (69% in 1991). Thailand is the third largest surimi producer. Thai surimi production from itoyori, or threadfin bream (*Nemipterus spp.*), is entirely made onshore, while others' production is all made on board.

During the 1987-91 period, the number of U.S. vessels and plants increased from 3 to 24 and from 3 to 7, respectively. Meanwhile, the number of Japanese vessels and plants has come down from a high of 41 in 1988 to 31 in 1991 and from a high of 40 in 1985 to 36 in 1991, respectively, as production volume came down. By comparison, it is quite obvious that

When looking into the supply demand balance in the three major players of surimi in the world-Japan, the U.S., and the Republic of Korea-we see the following facts. Japan is largely dependent on imports (81% in 1991) and hence is the largest net importer. On the other hand, most U.S. production is exported (78% in 1991). This makes the U.S. the largest supplier of surimi. As in Japan, the end product manufacturers in Korea are largely dependent on U.S. surimi supply (77% in 1991).

## THE JAPANESE MARKET

Table 2 shows the origins of surimi coming to Japan. The total supply has greatly diminished, from the 1988 peak of 447,000 MT to 324,000 MT in 1991. This is a 28% decrease in three years. Pollock surimi is mainly from U.S. vessels and plants (60,000 MT and 22,000 MT, respectively, in 1991), whereas Japanese joint-venture operations with other countries have almost terminated (only 1,000 MT from a joint venture with Russia in 1991). Furthermore,

Table 2: Japan:  
Surimi Supply by  
Source (1000  
MT).\*

On board	1986	1987	1988	1989	1990	1991
<b>Imported pollock surimi</b>						
U.S. vessels	-	3	11	43	100	60
U.S. plant	-	2	4	20	20	22
Korean vessel	10	10	6	3	-	-
Russian vessel	-	-	-	1	1	13
Subtotal	10	15	21	67	121	95
<b>Domestic pollock surimi</b>						
U.S. Gov. to Gov.	62	-	-	-	-	-
U.S. joint venture	114	125	105	32	-	-
Russian joint venture	9	15	13	8	5	1
DPR Korean joint venture	-	-	2	2	-	-
High seas operation	42	55	85	63	45	17
Subtotal	227	195	205	105	50	18
<b>Pollock surimi total</b>	<b>237</b>	<b>210</b>	<b>226</b>	<b>172</b>	<b>171</b>	<b>113</b>
<b>Other species surimi</b>	<b>10</b>	<b>20</b>	<b>36</b>	<b>48</b>	<b>40</b>	<b>43</b>
<b>Hoki surimi</b>						
New Zealand	10	19	26	25	18	10
Argentina	-	-	2	1	-	-
Subtotal	10	19	28	26	18	10
<b>Southern blue whiting surimi</b>						
New Zealand	-	-	1	2	2	1
Argentina	-	-	2	3	6	13
Subtotal	0	0	3	5	8	14
<b>Pacific whiting, etc., surimi</b>						
Argentina	-	1	1	3	-	-
U.S.	-	-	2	10	11	18
Canada	-	-	-	2	3	1
Subtotal	0	1	3	15	14	19
Flounder surimi (from U.S.)	0	0	2	2	0	0
<b>Other species surimi total</b>	<b>10</b>	<b>20</b>	<b>36</b>	<b>48</b>	<b>40</b>	<b>43</b>
<b>On-board surimi total</b>	<b>247</b>	<b>230</b>	<b>262</b>	<b>220</b>	<b>211</b>	<b>156</b>
<b>Onshore</b>						
Domestic pollock surimi	170	173	160	155	140	140
Imported itoyori surimi (from Thailand)	20	20	25	18	20	28
<b>Onshore surimi total</b>	<b>190</b>	<b>193</b>	<b>185</b>	<b>173</b>	<b>160</b>	<b>168</b>
<b>Grand total</b>	<b>437</b>	<b>423</b>	<b>447</b>	<b>393</b>	<b>371</b>	<b>324</b>

\* Table 2 is based on industry estimates.

the production from Japanese high sea operations has declined from the 1988 peak of 85,000 MT to 17,000 MT in 1991.

As for hoki (*Macruronus novaezelandidae*) surimi, New Zealand is a major supplier. However, supply to Japan has come down from the 1988 peak of 26,000 MT to 10,000 MT in 1991.

Southern blue whiting (*Micromessistius australis*) is another surimi source. The major supplier is Argentina (13,000 MT in 1991), and the market is expanding. Pacific whiting (*Merluccius productus*) is another hope. The dominant supplier is the U.S., at 18,000 MT in 1991.

	1990		1991		1992	
	Shore processed	Sea processed	Shore processed	Sea processed	Shore processed	Sea processed
January	1.8	3.5	2.1	3.6	4.1	4.5
February	1.8	3.5	2.1	3.6	4.1	4.5
March	1.7	3.3	2.1	3.6	3.9	4.3
April	1.8	3.2	2.1	3.7	3.9	4.3
May	1.8	3.2	2.1	3.6	-	
June	1.9	3.3	2.1	3.6	-	
July	1.9	3.3	3.8	4.1	-	-
<b>August</b>	1.9	3.3	3.8	4.1		
September	2.1	3.6	3.9	4.3		
October	2.2	3.8	3.9	4.3		
November	2.2	3.9	4.0	4.3		
December	2.2	3.8	4.1	4.5		

Note: Price figures on the table indicate the high side of price range.

Source: *INFOFISH Trade News*, 1990-92

Table 3: Japan: Prices of Alaska pollock surimi of domestic origin at Tokyo wholesale market (U.S. \$/kg).

Surimi supply from warmwater species such as itoyori, or **threadfin** bream, is also growing. The major supplier of this surimi is Thailand, at 28,000 MT in 1991. Surimi from other species, which are not identified in the table but which are not necessarily **insignificant**, is also growing markedly, from 10,000 MT in 1986 to 43,000 **MT** in 1991.

To sum up, the following trends in surimi supply for Japan can be safely identified:

1. Total supply is declining.
2. Pollock surimi supply is declining.
3. Other surimi supplies are **rising**.
4. Currently, species with good potential are southern blue whiting, Pacific whiting, and **threadfin** bream.

## PRICE TREND

Table 3 shows a steadily rising trend in surimi price. Prices have increased from U.S. **\$1.8/kg** for shore surimi and U.S. **\$3.5/kg** for sea surimi in January 1990 to U.S. \$4.1 and U.S. 84.5, respectively, in January 1992. These figures represent increases of 128% and 298, respectively, in just two years. In addition, the following points can be made with respect to prices:

1. Sea surimi costs more than shore surimi because of quality, but the price **difference** has been reduced **significantly**. In March 1992, it was only 10%.

2. Prices are seasonal. That is, toward the end of the year, prices tend to go up.
3. The price of pollock surimi still **influences** the price of surimi from other species because of its large **volume** and excellent quality. The price of itoyori surimi is lower than that of pollock, and the price of surimi from other white-meat **fish**, such as hoki and Pacific whiting, is presumed to be slightly lower. The only exception, which has emerged recently, is southern blue whiting surimi. Because this surimi is white, elastic, and tastes better than pollock, it fetches the highest price.
4. Manufacturers still prefer domestic surimi of higher grade to imported surimi, such as U.S. surimi, because the quality of imported surimi is not consistent. The representative of the manufacturers' association says that there are few instances in which the quality of shipped products is equal **to** that of the samples provided.

Wholesale prices of **surimi-based** products are also rising, reflecting a hike in surimi price and other production costs. For instance, wholesale prices were up by 10% between 1989 and 1990 and 7% between 1990 and 1991 when compared to February prices, which are usually the lowest prices of the year (table 4).

The hike in retail prices for the past year was more significant. Retail prices of traditional surimi products, such as kamaboko

**Table 4: Japan.- Wholesale prices of kneaded products at six largest city central wholesale markets (¥/kg).**

	1989	1990	1991
January	417	427	476
February	401	440	472
March	403	442	481
April	416	442	488
May	422	444	507
June	422	450	524
July	414	450	522
August	420	460	520
September	410	464	521
October	411	456	526
November	497	457	518
December	551	618	682

Source: Fisheries Products Marketing Statistics, Ministry of Agriculture, Forestry and Fisheries

(boiled fish paste), chikuwa (tube-shaped fish paste), and **satsumaage** (fried fish paste), were raised three times in succession, in August and November 1991, and January 1992. Last year, retail prices of some products were up by 50% over the same period in 1990. Major manufacturers are worried about the likely impact of a rapid hike in prices on consumption, saying "Because of the price rise, consumers may move away from surimi products. Consequently, surimi products may shift their position from necessary to luxury items." Currently in Japan, there are said to be 3,100 manufacturers processing consumer products worth ¥ 500 billion, or U.S. \$3.8 billion. However, the average size of the factory is small,

with only 16 employees. There are a number of giant companies; the rest are small-scale operators. The price hike of last year has hit the industry at this end especially hard. An estimated 50 small-scale companies, or double the number in the 1990, went out of business in 1991.

### PACIFIC WHITING PERSPECTIVE

Although Alaska pollock is still a major source for surimi, other coldwater white-meat fish, such as hoki, southern blue whiting, and Pacific whiting, have been claiming more and more of the Japanese market. The 1991 figures were 6% for Pacific whiting, 4% for southern blue whiting, and 3% for hoki.

The use of Pacific whiting surimi is not specified by the manufacturer, although it can be assumed that the high grade goes to the production of high-grade kamaboko whereas the low grade goes to products at the other end, such as chikuwa, satsumaage, and **hampen** (floating-type boiled fish paste). The different grades of **kanikama**, or crab leg analog, are made from various grades of surimi; thus, high-grade surimi is used in high-priced products and low-grade surimi in low-priced products.

Manufacturers usually prefer white-meat surimi to nonwhite meat since the former can be processed into various end products whereas nonwhite surimi has limited use because of its color and smell. Thus, the price of white-meat surimi is usually higher than that of nonwhite. Surimi from Pacific whiting is obviously white; thus, it can sell well at prices close to those of Alaska pollock. To sum up, we

**Table 5. Japan.- Main fish species used for surimi production.**

Market rank	Species	Comment
<b>A</b>	Alaska pollock	Commonly used for all surimi-based products
<b>A</b>	Polar cod	Best whiteness; it can produce high-quality surimi-based product.
<b>A</b>	Yellow croaker	Excellent gel strength
<b>B</b>	Pacific whiting	Started to produce in 1988; surimi has good gel strength.
<b>B</b>	Hoki	Good whiteness and gel strength
<b>B</b>	White croaker	Good gel strength and whiteness
<b>B</b>	<b>Merluccius</b> spp.	Good whiteness; quality similar to hoki and pollock.
<b>C</b>	Threadfin bream	No black membrane and tissue
<b>C</b>	Chilean mackerel ( <b>scad</b> )	Good taste, white-grey meat color

Note: A = excellent; B = good; C = fair

can say that there is good potential for Pacific whiting surimi exports to Japan, provided that (1) there are ample resources to ensure steady supply, (2) production cost, and hence price, is low enough, and (3) the quality of the surimi is as good as that of Alaska pollock surimi or at least close to it (table 5).

## FACTORS TO BE MONITORED

Although domestic demand is stagnant because of declining domestic production, more imports of nonpollock surimi, including Pacific whiting, can be expected in this decade. However, the following factors need to be closely monitored when we develop a plan for a new species like **Pacific** whiting.

1. Domestic consumption of the end product, which is currently stagnant, may decline further, for the following reasons:
  - a. Prices are high compared to those for other seafood or nonseafood products. In particular, a rapid price hike may scare consumers away from surimi products, as actually happened in 1991 when end-product manufacturers collectively raised the retail price of their products substantially twice in one year and again once in 1992.
  - b. Consumers may become a little tired of eating products that have similar looks and similar tastes. They may want more variety. Although manufacturers are trying hard to invent new products, like kanikama, they have not yet developed a product that rivals kanikama in its enormous popularity.
  - c. Today's consumers are becoming more and more health oriented. The end product from surimi contains various additives that may not be considered good for health. In addition, consumers may be developing an orientation toward natural foods, which they prefer to artificial or processed foods.
  - d. As long as end products like kanikama are analogs, they will never win over the seafoods they imitate. In short, there is a growth limit to analog consumption. This is especially so when the price difference is less and consumers' disposable income is growing. The technology of processing surimi into

kanikama has progressed to **the** extent that, according to the industry, the latest high-grade product is almost like the one it imitates in terms of looks, texture, flavor, and taste. Hence, it is easy for ordinary consumers to mistake the analog for the real thing. However, even though the species imitated by surimi analogs are getting scarcer, the imitation product will seldom gain a respectable position in the future.

2. The production cost of the end product has already become prohibitively high in Japan so that a number of Japanese manufacturers are already operating overseas as part of joint ventures. Thus, demand for surimi in Japan will further fall. This trend will continue as more countries begin processing an end product. However, other countries with a growing demand for surimi, such as the Republic of Korea, Thailand, Singapore, and Malaysia, can be the next markets for U.S. surimi.

**The Republic of Korea.** Korea is the next largest buyer of U.S. surimi with a good potential. Although Korea **itself is** trying to ensure a constant surimi supply, domestic production is likely to be stagnant, according to industry sources. A number of manufacturers, anticipating a good European market, are in full swing in their kanikama production. Thus, a scarcity of surimi is anticipated.

**Thailand.** At the moment, Thailand is known to be an exporter of surimi made from warmwater species, with insignificant amounts of surimi imports. However, we anticipate that in this decade Thailand, in joint ventures with Japanese and Korean firms, will increase production of surimi-based products, targeted for Japan, Europe, and so on. **Furthermore, itoyori** resources reportedly are quickly dwindling. In light of these two projections, the surimi industry should not be surprised to receive a substantial number of orders from Thailand in a few years.

**Other countries.** At the moment, Singapore and Malaysia, in addition to Thailand, are considered good overseas production bases by the Japanese and Korean surimi industry. In fact for the past few years several plants have

started and increased the capacity of production of kanikama products for the European as well as the Japanese markets. Since both countries have little capacity for producing surimi, they will inevitably import surimi for their kanikama products. Other countries in Asia which may follow a similar path in the near future are Indonesia, Vietnam, India, and China. In Europe, France has had three plants in operation since 1991, and Russia reportedly plans to start a plant in the near future.

3. The supply to Japan of nonpollock surimi, except for Pacific whiting, may rapidly increase to the extent that it affects the import volume and price structure of other surimi, including Pacific whiting. The probable candidates are
  - itoyori, or threadfin bream, surimi from Thailand
  - horse mackerel surimi from Chile (from 1991)
  - Indian surimi of local species (from 1992/93)
  - Malaysian and Indonesian surimi of local bream species (in a few years)
4. According to industry sources, the Central Fishery Research Institute of Japan has recently developed a pilot plant which could process 3 MT a day of sardine and mackerel into surimi with a quality as good as that of Alaska pollock. With a few additional technical problems to be solved, this will open for the industry a huge opportunity for commercial production. No other surimi could beat sardine surimi once its quality has reached the point where it is as good as that of Alaska pollock since the resources are ample and the unit material prices are among the cheapest. Furthermore, this technology will be applied to other abundant nonwhite-meat species.
5. Apparently, the global catch of Alaska pollock has a major impact on surimi price. Therefore, a change in various restrictive measures, such as catch and import and export quotas, needs to be closely monitored. In 1990 the U.S. acknowledged the de facto cartel formation of the United States Surimi Commission, which was given authority to control the volume and price of exports.
  6. Faced with a shortage of surimi, Japanese surimi buyers are not sitting idle. Rather, they are looking for alternative surimi sources. The following will be the major developments of 1992:
    - a. More purchases of southern blue whiting from Argentina (over 20,000 MT from 11,000 MT in 1991)
    - b. More itoyori and nonitoyori surimi to come from Thailand—at least over 30,000 MT. However, the resource seems limited.
    - c. More jack mackerel surimi expected from Chile (10,000 MT against 2,000 MT in 1991). This can become a major surimi source in the years to come since the annual landing of jack mackerel is over 2 million MT. However, industry sources are afraid that the **El-Niño** phenomenon may affect the catch this year.
    - d. More pollock purchased from Russia this year—nearly 140,000 MT, more than **triple** that of 1991. As long as resources are ample, the industry will be increasingly geared to this channel. Furthermore, the Russians are eager to sell.
    - e. In considering the rising price of surimi in 1991, the industry, especially small-scale makers in western Japan, is coming back to the production of surimi from local warmwater species of relative abundance. Two such species are **hairtail** and **lizardfish**. And, in case of scarcity, the industry will import these fish from neighboring countries to supplement the domestic catch.

In Hokkaido, in northern Japan, the federation of fisheries cooperatives has started surimi production out of fall salmon (local salmon), which seem relatively abundant. The federation expects that this will, in turn, solve the problem of the falling

Across the Pacific, Japanese manufacturers have been in a sort of crisis in the past few years. To get themselves out of it, manufacturers may begin to consider some concerted effort, probably led by the manufacturers' association or the public sector concerned. This kind of development, though political, should be carefully monitored.

price of salmon. Reportedly, the surimi has a slight salmon flavor, so it may sell well, even **if it** is priced higher than pollock. The federation has processed over 10,000 MT of fish into surimi, and major fisheries companies have also joined the production in 1991. Thus, the industry estimates that 10,000-15,000 MT of salmon surimi was produced in 1991.

7. Last, when we market Pacific whiting, we need to seriously consider two factors:

- Whether Pacific whiting should go to surimi-processing or not depends on the market prices of frozen fillet, block, or other forms. For instance, when the price of fillets are high, raw material should go to filleting, not to surimi processing.
- Supplying to a number of U.S. manufacturers is always a good alternative **to** exporting. In anticipating the increasing production capacity of surimi-based products in the U.S., we need to study this fact, as well as export markets.

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# MARKET PROMOTION OPPORTUNITIES AND CHALLENGES FOR PACIFIC WHITING

*Dalton Hobbs*  
*Oregon Department of Agriculture*

Because of the rapid development of the Americanized Pacific whiting fishery along the coasts of California, Oregon, and Washington, a unique set of promotional opportunities as well as challenges has been served up to the fishermen and processors of whiting in these states. During the joint venture period of the west coast whiting fishery, U.S. fishermen were more often involved with the production and negotiation of price, leaving the details of marketing the whiting products to their offshore partners. I would like to explore what we feel are the significant opportunities for fishermen and processors, how they may be challenged, and what strategies they can use to develop export and domestic markets for whiting.

There are currently three major markets for Pacific whiting: (1) Japan, which imports a large percentage of Pacific whiting surimi products, (2) the EC, which is essentially a fillet and to a lesser extent a headed-and-gutted (H&G) market, and (3) the United States, which is characterized as a mature H&G market, with growing opportunities for new product categories.

An important marketing strategy for developing and expanding these markets is participation at major trade shows. These shows provide efficient access to key buyers, wholesalers, distributors, and processors in targeted market areas. However, participation in trade shows can be very expensive and requires graphic expertise. Too often, past generic or governmental efforts have been lackluster when compared to the displays of competing products. For Pacific whiting marketers, it is critical to mount a world-class effort at trade shows. To do less will result in less than hoped for results.

Another important tool for reaching importers and buyers of whiting in offshore markets is trade missions to targeted industries. In the last 12 months the Oregon Department of Agriculture has mounted three such missions to Japan alone. The purpose of these missions is to introduce suppliers and their products to prospective buyers. The missions have proven to be effective in attracting new buyers and dispelling misconceptions in the marketplace.

Last November (1991) an eight-member mission was in the seafood processing area of Ishinomaki, talking to surimi manufacturers and processors. These were very experienced Japanese seafood product managers, with a very high level of sophistication and knowledge about fish.

Midway through the presentation, they brought out for the group's examination two whole-frozen whiting that had been eviscerated. The viscera were beside the fish with evidence of a liver nematode. The Japanese processors told us they had heard of the parasite problem with Pacific whiting and asked if the liver worm was an example. The technical members of the Oregon mission relayed that while visually disturbing, the live worm was not the problem. There then ensued a long technical discussion of the "real" Pacific whiting parasite problem. This example points out the importance of face-to-face information exchange. Although expensive, technical marketing meetings of this kind are absolutely critical to any long-term market development program for Pacific whiting.

Certain product forms of Pacific whiting may lend themselves to in-store promotions. The efficacy of this tool, however, will depend greatly on the relative value of the **Pacific** whiting product to be promoted. It is unlikely that a lower-value H&G product will be able to sustain in-store promotion. Promotion of this kind of product will most likely be consigned to programs funded by the government or by trade associations. However, higher-value branded products, such as **Pacific** whiting surimi analogs, may have enough selling margin to support in-store promotion. These promotions could include such tools as **point-of-sale** materials, recipe cards, product demos or joint promotional programs with compatible product categories. All of these marketing efforts should be supported by trade-press and vernacular press publicity and editorial support. Food editors should be targeted to continue to raise the market profile and consumer awareness of the range of whiting products. Media efforts should be coordinated with **in-**

store or trade-show promotions to maximize their benefits.

A major constraint is **finding** a focused, single-purpose entity to carry forward these marketing strategies. In the last year, for instance, we have seen the demise of the National Seafood Promotion Council. More than any indicator this has demonstrated the trend towards national seafood promotion generally.

On regional or state levels, however, things are looking up. **The** Alaska Seafood Marketing Institute has secured more than \$8 million in USDA marketing dollars to promote salmon in Japan, France, and the **U.K.** California has a new, industry-supported seafood council. Oregon has attracted federal dollars for seafood promotional work in the **EC** and Japan but the money must be spent on a variety of species and is not focused solely on whiting. In the same way, the Oregon Trawl Commission does some promotion of whiting, but it must also promote the other variety of products the trawl fleet harvests. A more focused approach to developing markets for Pacific whiting should be explored by fishermen and processors working in concert.

I want **to** make a few comments on branded identities and quality and grade standards for **Pacific** whiting products. When discussing these subjects, it is instructive to **analyze** one of the most successful examples of an integrated inspection, quality control, and branding program for seafood—the Norwegian farmed salmon.

The Norway example is a model for how to do it right. Because Norway is a small, **homogeneous** country with a rich socialist tradition of working together towards a common goal, the Norwegian **salmon** farmers were in an excel-

lent position to implement such a program. They instituted strict, government-controlled, quality guidelines that insured that only the finest product they produced was shipped to market. They carried this program forward with serial lot controls, pack dates, **size** and product form, and processor establishment numbers on wholesale packaging. Gill tags were placed on each fish, and point-of-sale materials supported the product with the consumer. At the peak of their promotional efforts, as much as \$25 million a year was spent by Norwegian salmon producers to maintain existing markets and develop new ones. Farmers dispatched technical representatives to work in the major wholesale markets throughout Europe and Japan to answer questions of buyers and report back to the producers with quality control information.

It was a well-thought-out program that propelled the Norwegian **salmon** industry to nearly 150,990 metric tons of production during their peak year of 1990. Since that time Norway has fallen on hard times with more than one-third of its product declaring bankruptcy in 1991. Other, larger market **forces**—such as increased harvest of wild **salmon** in Alaska and increased farm-raised fish from Chile—caused a collapse of the world salmon market and brought down with it the highly capitalized **salmon** farms of Norway.

**The** important lesson is that even with a well-thought-out and well-executed product standards program, linked perfectly with an aggressive promotional and merchandising program, the vagaries of international seafood markets can still wreak havoc. The producers of Pacific whiting can, however, profit **from** the lesson of Norway when developing standards for product inspection and branding.

# PRODUCT CHARACTERISTICS AND MARKET DEMAND FOR PACIFIC WHITING

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## INTRODUCTION

Industry, state government, and fisheries management agencies must develop fisheries-related strategies that are in their individual and collective interests. For Pacific whiting (**Pacific hake**, *Merluccius productus*), **this is** a considerable challenge because of the difficulty in controlling product quality **characteristics—characteristics which affect product market demand**. Industry and government, therefore, must determine how their behavior **affects** certain product characteristics, while also evaluating how product characteristics influence production and management decisions.

For example, fisheries management agencies must decide how their regulations ultimately affect **intrinsic** (preharvest product) characteristics and **extrinsic** product characteristics (characteristics affected by harvest and postharvest activities). In turn, fishermen must negotiate contracts with processors and develop cost-effective harvesting and handling practices consistent with these contractual arrangements. Processors must select a portfolio of product forms and develop production strategies consistent with controlling risks and reducing variation in product quality. First receivers must negotiate product quality warranties with processors and then develop sales and inventory strategies consistent with product quality limitations. State agencies must determine the degree of industry support, including promotion and market development. And the industry must collectively determine the degree **to** which it will assure product quality.

Industry and government agencies need different types of information to make these decisions. The degree to which each industry sector could **affect** and control product characteristics needs to be understood. This information would be provided by fisheries biologists, food technologists, and food engineers. Information is also needed to help evaluate the degree to which individual firms and agencies **should** control product quality. This requires analysis

by economists, marketing specialists, business managers, and policymakers.

**This** second type of information can be broken down into two categories: (1) information showing the relationship between product quality and production and management costs, and (2) market information showing the relationship between product quality and market demand. Biological, technical, and economic information can then be combined within production and policy models **to** help industry and government agencies make decisions about controlling product characteristics. These models may range from simple spreadsheets to relatively complex bioeconomic policy models.

In this paper we **summarize** the results of a survey we undertook (Sylvia and Peters 1991) that was designed to provide one of the types of information needed for making decisions about controlling product quality of **Pacific whiting—**the relationship between product characteristics and market demand. In the **first** section we review issues related to market demand and product characteristics. In the second section we summarize some of the results from the market survey. We conclude with a **brief discussion** of how industry and government sectors could use this information **to** optimally control product characteristics.

## ISSUES AFFECTING DEMAND FOR PACIFIC WHITING

Many supply and demand factors have affected the development of markets for Pacific whiting. These factors are (1) the supply of and prices for competitive whiting products and groundfish species such as Atlantic cod (*Gadus morhua*) and Alaskan pollock (*Theragra chalcogramma*), (2) **growth in** world population and national incomes, (3) improvement in seafood technologies, and (4) political and institutional changes.

The development of many whiting fisheries has occurred only during the last decade in response to rising prices for cod and cod **substi-**

tutes. These price incentives have motivated whiting industries to adopt improved seafood technologies to cost effectively improve and standardize product quality characteristics. As a result, global whiting production has increased from 2.2 million metric tons (MT) in 1982 to over 3 million MT in 1988 (Natural Resources Consultants 1990).

Individually, and as a group, whiting species (*Merluccidae*, *Merluccius* spp.) demonstrate wide variation in biological, geographical, and product quality characteristics. The wide range in characteristics is reflected by the range in prices received for different whiting stocks. For example, Antarctic queen (*Merluccius australis*), which is larger, firmer, and whiter than most other whittings, has been sold in Spain as a fresh, whole, unprocessed product for wholesale prices exceeding U.S. \$10.00 per kg (L. Gaines, personal communication). In contrast, Peruvian stocks of Chilean whiting (*Merluccius gayi peranus*), which have fewer desired characteristics, including soft flesh, small size, and an off-white color, may sell as a frozen headed and gutted (H&G) product in Europe and the United States for as little as U.S. \$0.55 per kg. Most whiting species, however, fall between these two extremes. The differences in product characteristics is one reason that the whittings are processed into a wide variety of product forms, including whole product, H&G, individual fillets, and frozen fillet and minced blocks (which may be further processed into breaded sticks or portions). Some whiting may also be processed into surimi (washed minced products).

While various factors have influenced differential development of whiting fisheries, one of the primary factors has been intrinsic product characteristics. Whiting display great inter- and intravariation in product characteristics—characteristics which may be valued to different degrees by different markets. These characteristics include, but are not limited to, such attributes as product size, texture, lipid composition, parasite infestations, and levels of protease enzymes (that is, enzymes which break down protein). For example, for most product forms, whiting between 1.5 and 3.0 pounds are more highly valued on a per unit weight basis than whiting which are smaller. This differential demand is due to size-dependent texture characteristics, size-related processing yields, and consumer portion control.

One especially important intrinsic product characteristic is product texture. Many stocks of whiting have a relatively soft texture that

decreases their value relative to groundfish, which have a firmer texture. Not only does soft texture reduce consumer enjoyment, but whiting with soft texture bruises more easily. This problem has compelled fishermen and processors to adopt techniques that reduce bruising, such as redesigning cod ends, reducing tows, and using wet pumps for off-loading.

In addition to shifts in market demand and improvements in seafood technology, the globalization of whiting markets has provided opportunities to fully exploit whiting across a wide variety of product forms. Today, processors have the option of either specializing in a single product form or diversifying risks and processing a wider variety of products. A portfolio of product forms allows processors to take advantage of changes in market conditions for alternative products or to match markets and product forms with inter- and intraseasonal variation in intrinsic product characteristics such as product size, lipid composition, and texture. This allows processors to compare market dynamics with information on supply availability and intrinsic product characteristics. Given their access to capital and their aversion to various risks, processors can then determine the optimal mix of capital equipment for producing a range of product forms.

Although information on individual firm behavior is generally not available, aggregate information shows that individual whiting stocks are used proportionately more for certain types of product forms. In general those species or stocks with excellent quality characteristics (for example, larger than two pounds; white-colored flesh; firm, flaky texture; relatively small fat layer; and few parasites) command not only the highest prices but tend to be used more as a fresh whole or fillet product for white tablecloth restaurants (especially in Europe), or for retail as a relatively expensive and specialized product. For species which have good quality characteristics, such as the Cape hakes (*Merluccius capensis*, *Merluccius paradoxus*), the products may be used in a wide variety of product forms, from fresh, whole product and fresh fillets to frozen fillet blocks. Moderate to lower-quality whittings, such as Argentine whiting and North Pacific whiting, are used for production of "commodity items," such as frozen blocks H&G or frozen fillet or minced blocks destined for further processing into battered and breaded products sold to food service, institutional, and retail sectors in Europe and the United States. Increasingly, however, improvements in food

technology have allowed these products to be processed into other product forms, including minced products (for example, surimi) and individual quick frozen fillets (IQF).

### PRODUCT CHARACTERISTICS AND MARKET DEMAND—A MARKET SURVEY

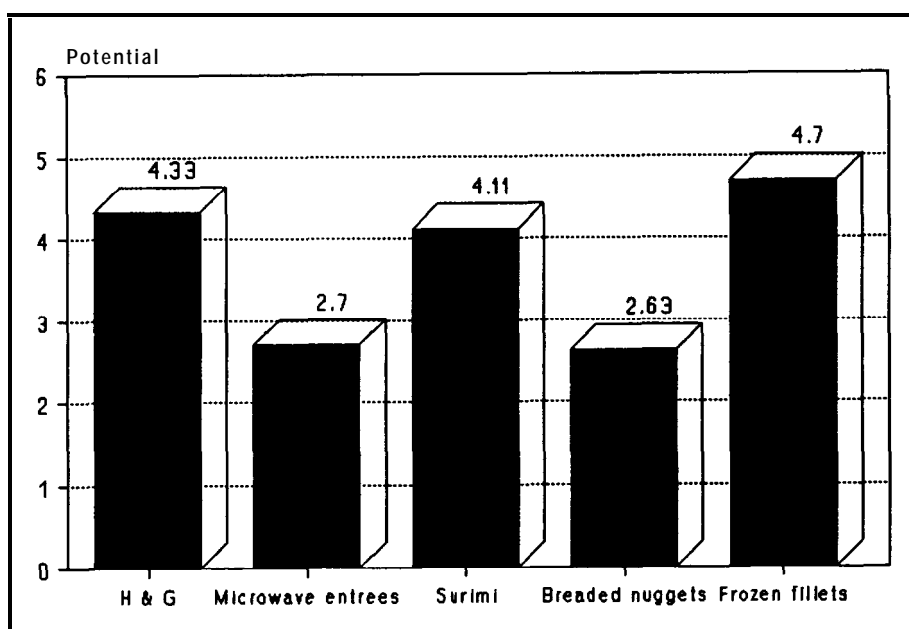
We conducted a survey of 125 domestic wholesalers and brokers of whiting products and surimi seafood producers in order to develop market information for the Oregon seafood industry (Sylvia and Peters 1991). We used various qualitative and quantitative survey methods to develop information on optimal product forms, the importance of product characteristics, market demand, and the value of

alternative contractual arrangements. The following section briefly summarizes a subset of these findings.

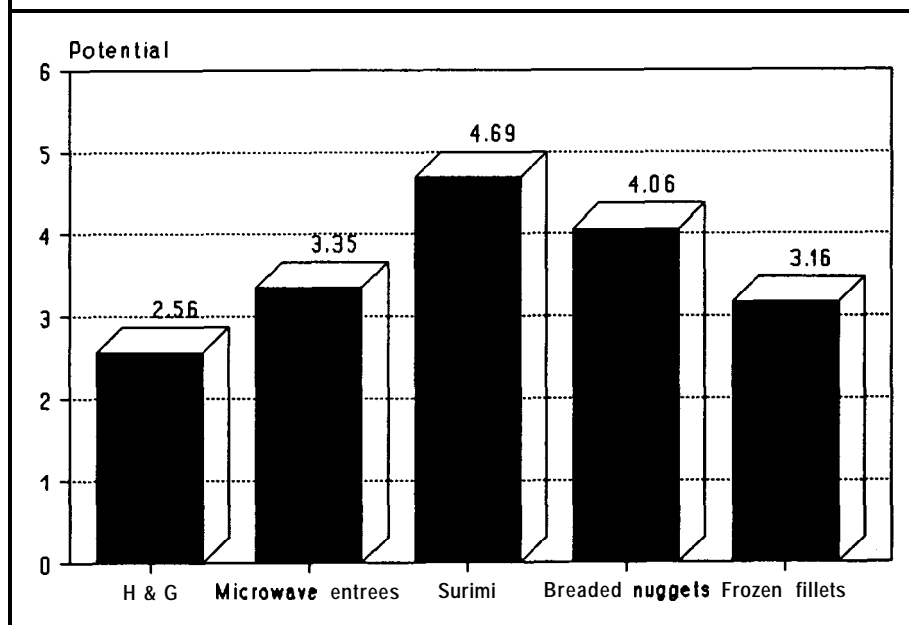
Figures 1 and 2 show the relative potential for various products as perceived by firms which predominantly handle H&G or fillet whiting products. Firms which primarily handle H&G product perceive Pacific whiting to have a moderately good potential for continued production of H&G product and even higher potential as fillets. The fillet industry, however, perceived relatively greater potential for value-added products. Both groups of firms believed that Pacific whiting had relatively high potential as a surimi product.

A significant portion of the survey focused on the relative value and importance of various

*Figure 1. Relative potential for Pacific whiting products as perceived by firms that predominantly handle H&G whiting (0 = no potential, 6 = high potential).*



*Figure 2. Relative potential of Pacific whiting products as perceived by firms that predominantly handle whiting fillets (0 = no potential, 6 = high potential).*



*Table 1. The values of various product characteristics for frozen whiting fillets for first and second receivers and small and large wholesalers (Sylvia and Peters 1991—derived from table 5.5, page 127).*

<b>First Receivers</b>			
<b>Base Attributes</b>	<b>Value</b>	<b>Improved Attributes</b>	<b>Value</b>
Base price	<b>\$.57</b>	Base price	<b>\$.57</b>
Skin-on	<b>\$.00</b>	skin-off	<b>\$.10</b>
2-4 oz fillet	<b>\$.07</b>	4-6 oz fillet	<b>\$.12</b>
2-month supply	<b>\$.02</b>	7 month supply	<b>\$.06</b>
No marketing support	<b>\$.00</b>	Marketing support	<b>\$.06</b>
<hr/>			
Total price for small first receivers	<b>\$.66</b>		<b>\$.90</b>
Total price for large first receivers	<b>\$.62</b>		<b>\$.86</b>
<hr/>			
<b>Second Receivers</b>			
<b>Base Attributes</b>	<b>Value</b>	<b>Improved Attributes</b>	<b>Value</b>
Base price	<b>\$.66</b>	Base price	<b>\$.66</b>
Skin-on	<b>\$.00</b>	skin-off	<b>\$.15</b>
2-4 oz fillet	<b>\$.10</b>	4-6 oz fillet	<b>\$.16</b>
2 month supply	<b>\$.03</b>	1-month supply	<b>\$.08</b>
No marketing support	<b>\$.00</b>	Marketing support	<b>\$.09</b>
<hr/>			
Total price for small second receivers	\$.79		\$1.14
Total price for large second receivers	<b>\$.73</b>		<b>\$1.08</b>

product characteristics of H&G, fillets, and surimi products. For H&G and fillets these product **quality** characteristics included price, product size, product form (fillets only), texture, species, **shelf life**, flesh color, package size, supply availability, product uniformity, product line, marketing support, and payment terms. The characteristics of surimi included water-holding capacity, gel strength, moisture content, protein content, color, flavor, contamination, source, price, supply availability, delivery volume, and product uniformity.

In general, it was found that for H&G, price was **significantly** more important than other product characteristics. Other important characteristics were texture, supply availability, product **uniformity**, and product size. For fillets, price was also the **highest-scoring** characteristic but was not statistically more important than product form, **shelf life**, product size, texture, supply availability, and product uni-

**formity**. For surimi, the price characteristic also scored highest but was not statistically more important than water-holding capacity, gel strength, supply **availability**, and product **uniformity**.

One example of the importance of product characteristics, contractual arrangements, and the characteristics of wholesalers is shown in table 1 (for methodological details see Sylvia and Peters 1991). This **table** shows how **break-even** prices for first and second receivers and for small firms and large firms (revenues greater than \$10 million) are **affected** by changes in characteristics of a frozen whiting fillet product with the following **fixed** characteristics: **shelf life** of 12 months, slightly off-white color, moderately firm texture, 95% uniformity in product attributes, "ideal" package (for example, **5-lb** frozen blocks), and terms of net 30 days.

Supplying a **4-6-oz**, skin-off fillet, seven months a year, accompanied by marketing support, increases market price by **\$.24** over the basic product. Large first receivers offer **\$.04** less than small first receivers in exchange for larger purchase volumes. Second receivers offer approximately 26% more at break-even prices than **first** receivers and not only pay a higher base price but offer a higher absolute premium for improved attributes.

The information presented in table 1 is useful for developing long-run management and marketing strategies. The information allows processing firms to compare the costs and benefits of providing various sets of product attributes. Note, however, that some of these characteristics (for example, fillet **size** and supply availability) would be controlled by not only the industry, but regulatory fisheries agencies. Note also that improvements in product characters provide greater absolute and relative value to second receivers, a result consistent with other survey findings, which showed that the further downstream the buyer, the more important product quality characteristics become. These findings raise interesting issues related to managing product quality, developing sales strategies, and increasing the profits of industry.

#### CONCLUSION

Not all hake or whiting are created equal or treated equally. As a result, market prices will show **significant** variation as a function of product characteristics. Product characteristics also **affect** industry's choice of product forms, level of capital investment, selection of quality control programs, nature of contractual ar-

rangements, and marketing and promotional strategies. The **Pacific** whiting industry must decide to what extent product quality **can be** controlled (**by** fishermen, processors, distributors, consumers, regulatory agencies) and then determine how much it **should** be controlled

The type of information presented in this paper can help the industry address this issue by showing the relationship between product characteristics and market demand. **This** information can then be combined with cost data, biological information, and information on food technology and food engineering to explore issues ranging **from** developing profit-driven, quality assurance standards to determining how fisheries regulatory policy affects market opportunities and the benefits of regional and national fisheries. Integrating market information with other elements is one important step toward improving our understanding and management of the Pacific whiting fishery.

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# PANEL DISCUSSION ON MARKETING OF PACIFIC WHITING

Session leader: *Ann Shriver*. Panel members: *Joseph Zalke, Ichiro Kano, Dalton Hobbs, Gilbert Sylvia*

**Q:** (Session leader) Please describe **what** the U.S. and global surimi seafood market will look like five years from now.

**A:** Each panel member responded separately to this question. Joseph Zalke responded that surimi is more of an ingredient in foods than a commodity in and of itself. As a commodity, surimi-based seafood has reached a peak, but there is potential for expansion in niche markets. For example, Mexican food is growing in popularity. There is potential for the use of surimi-based products in that area. Gil Sylvia added that more species would be used worldwide, reductions would be made in salt and sugar additives to answer consumer reservations about the healthfulness of surimi, and a larger variety of products and ingredients would be developed. Dalton Hobbs commented that additional segmentation of the market would probably occur, focusing on, for example, the institutional food sector and take-out and deli type of outlets. The new variety in products will support the development of these market segments. Ichiro Kano warned that surimi markets will grow at a very slow pace with some ups and downs; probably no market breakthrough will be experienced.

**Q:** What are the current labelling requirements for surimi-based products?

**A:** Chuck Herrick, another audience member, answered that you are permitted to use the term *surimi*, which must be followed in parentheses by the ingredients of the surimi, or you may simply list the ingredients of the surimi. Jae Park followed up from the audience to clarify that the use of the term *surimi* by itself is not permitted; you must list the ingredients, including the species of fish used. Zalke added that the National Fisheries Institute (NFI) is working with the U.S. Food and Drug Administration to get the nomenclature approved so that *surimi can* be used by itself. He stressed that it was important to get rid of the concept

of surimi as “imitation” food and to have it accepted in its own right Park pointed out that the U.S. is the only country where surimi is stigmatized this way. Another audience member mentioned that if you blend different species, you must give the percentage of each species used. Gil Sylvia asked why you couldn’t just list several options, as is done in labelling frozen packages of fish sticks or breaded portions.

**Q:** (Session leader) Where is the promotion dollar best spent? **NFI** says that its constituents do not support generic promotion if they have to pay for it. Is this smart?

**A:** Each panel member responded separately to this question. Zalke responded that the question is very complex and difficult to rationalize. **NFI** resembles a political organization representing many diverse factions, including regional interests, importers, domestic market producers, and shrimp, halibut, salmon and other species, among others. The “seafood” producer does not produce a homogeneous product as, for example, the poultry industry does. How do you get salmon producers to agree to support the surimi committee? This explains the limited budgets and willingness to contribute to promotional campaigns. There are also personal and business egos which want the market to be more brand oriented, so that is where the advertising dollar goes. From his perspective, however, it would be good to continue a generic “eat seafood” campaign.

Gil Sylvia added that sometimes the current average level of seafood consumption-15 pounds per person per year-is viewed as an upper bound. The seafood industry worries that one segment’s gain would be another’s loss. In fact what must be done is that the 15-pound limit must be pushed up as a whole, enlarging the pie so that all different kinds of seafood producers will have a larger share. The consumer needs to be educated that seafood is



healthy, easy to prepare, and tastes good; this also argues for more generic advertising.

Dalton Hobbs gave the Oregon perspective, mentioning that this state has a tradition of generic promotion. The same problem exists between, for example, advertising for cheese and milk as does between shrimp and **flatfish**. He agreed with Sylvia that the fundamental problem is that we do not consume enough seafood. This was seconded by Kano, who pointed out that compared to seafood consumption in Asian countries, **15 pounds** is not much. Promotion should be used to counter this limit.

From the audience, Joe Easley of the Otter Trawl Commission revealed the results of some polls the commission has undertaken in this state. The polls revealed much ignorance on the part of the public. Most of the information the consumer gets about seafood comes from the server behind the seafood counter, and these people are sometimes woefully ignorant. Training and educating handlers of seafood so that they in turn can educate the public should be a priority. **Safeway** has started a training program using a videotape out of a manual developed by Easley's organization; if you can't get to the level of the market chain which is selling to the **final** consumer, then your advertising is worthless.

**Q:** (Session leader) Does fresh surimi have market potential?

**A:** Park replied that the Japanese used surimi in that form until the **1960s**, when they began to add sugars as preservatives to extend surimi's **shelf life** and began to be able to extend frozen storage times as well. For **Pacific** whiting, the fresh form is a good idea; it can enhance quality and reduce the need for additives. Having fewer additives would make it easier to improve the percentage of protein in the final product.

Zalke demurred, **emphasizing** that the economics of a fresh product as an input to be used in large quantities would have to be studied. Sylvia mentioned that they had addressed this issue in their marketing survey. From the surimi industry's perspective, having a limited supply is a problem, and shrinkage is a problem. He asked a question of his own: Is market research on fresh surimi needed?

One audience member argued that concern over additives such as salt and sugar is not a major issue to 90% of consumers. **This** would indicate that the interest in a fresh surimi product would be very limited. Another pointed out that given the level of processing done to surimi products, **frozen** or not, they could never be **labelled "fresh,"** and therefore any marketing advantage would be lost. The increased cost of using a **nonfrozen** surimi product would not be justified in an increased price in the final product.

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# Biology and Management

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# HOW THE BIOLOGY OF PACIFIC WHITING MIGHT CONSTRAIN THE DEVELOPMENT AND STABILITY OF THE FISHERY

Mark E. Wilkins

National Marine Fisheries Service, Seattle, WA

## INTRODUCTION

**Pacific** whiting, *Merluccius productus*, is currently the most abundant commercially harvested groundfish off the Pacific coast of California, Oregon, and Washington. It is a **codlike** species found over the continental shelf and slope from southern Baja California in Mexico to the Queen Charlotte Islands in Canada. The exploitation of the coastal stock of Pacific whiting was developed by foreign **fishing** fleets beginning in the mid-1960s. Through joint ventures with foreign processors and recent improvements in processing technology and innovative products, the U.S. industry is increasing its domestic exploitation of this species. This review will discuss the basic characteristics of the biology, **life** history, distribution, and abundance trends of Pacific whiting. Biological constraints on the development and stability of the fishery will also be discussed. Other reviews of the biology of Pacific whiting have been reported by **Stauffer** (1985), Bailey et al. (1982), and Francis (1983).

## BIOLOGY AND LIFE HISTORY

Within its range, Pacific whiting consists of four reproductively isolated stocks. The major stock, and the one to which I will limit my remarks, is the coastal stock found off central Baja California (27°N lat.) to the Queen Charlotte Islands (52°N lat.).

Male and female Pacific whiting both mature at a length of approximately 40 cm, when they weigh about 0.4 kg (**Stauffer** 1985). **This** means that some three-year-old fish and most four-year-old fish are mature. Fecundity appears to be approximately 200 eggs per gram of female body weight (MacGregor 1966).

Pacific whiting spawn from December through April, with peak spawning occurring during January and February. Spawning takes place in the southern end of their range, between Baja California and San Francisco. Observed spawning concentrations of whiting are **scattered sparsely throughout** a wide expanse of ocean.

Spawning occurs as far as 400km off the coast in dense, well-defined aggregations between 100 and 400 m below the surface.

Pacific whiting undertake a significant annual migration from their spawning grounds in the area between Baja California and San Francisco to their feeding grounds off Oregon, Washington, and British Columbia (Bailey et al. 1982) (figure 1). **They** arrive over **the** continental slope off the coast of Oregon and Washington by the third week in April and off Vancouver Island by late May, **travelling** about three to six nautical miles per day (**Stauffer** 1985). **The** fish move onto the shelf in June and remain in these feeding grounds until **fall**. Whiting stratify by length, age, and sex along the coast. Older, larger fish migrate farther north, and females, because they grow to a larger size, dominate the earlier arrivals and more northerly residents of the summer feeding grounds. Whiting also exhibit a diurnal vertical migration, apparently in pursuit of their main prey, euphausiids. At dusk whiting ascend to the top 20 m, returning abruptly to 100-250 m at dawn.

Ages of **Pacific** whiting are determined from **annual** rings on the surfaces and cross sections of their otoliths. The surface ageing method has been found to be accurate through age 11, by which time most growth has been completed (Dark 1975; **Beamish** 1979). Whiting complete about 75% of their growth in length and 50% of their growth in weight by 4.5 years of age. Following maturation, females **outpace** males and grow to an average **maximum** size of 61 cm (1.3 kg) while males grow to only about 56 cm (1.0 kg) (figure 2).

**Pacific** whiting feed primarily on euphausiids and fish. **They** also eat shrimp and squid. Apparently little or no feeding takes place during their winter spawning. The diet of larger whiting includes a higher proportion of fish, including smaller whiting, sand lance, Pacific herring, and deep-sea smelt (Livingston and Bailey 1985). Within a season, whiting gain weight on the feeding grounds and lose weight during migration and spawning.

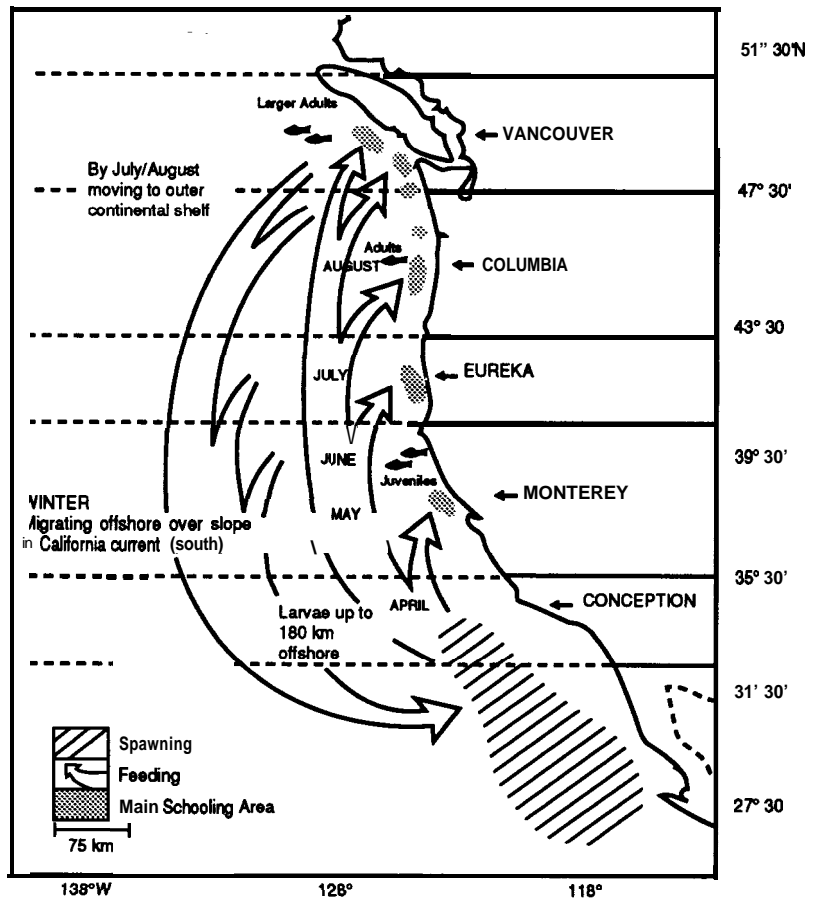


Figure 1. Migratory patterns of Pacific whiting (from Bailey et al. 1982).

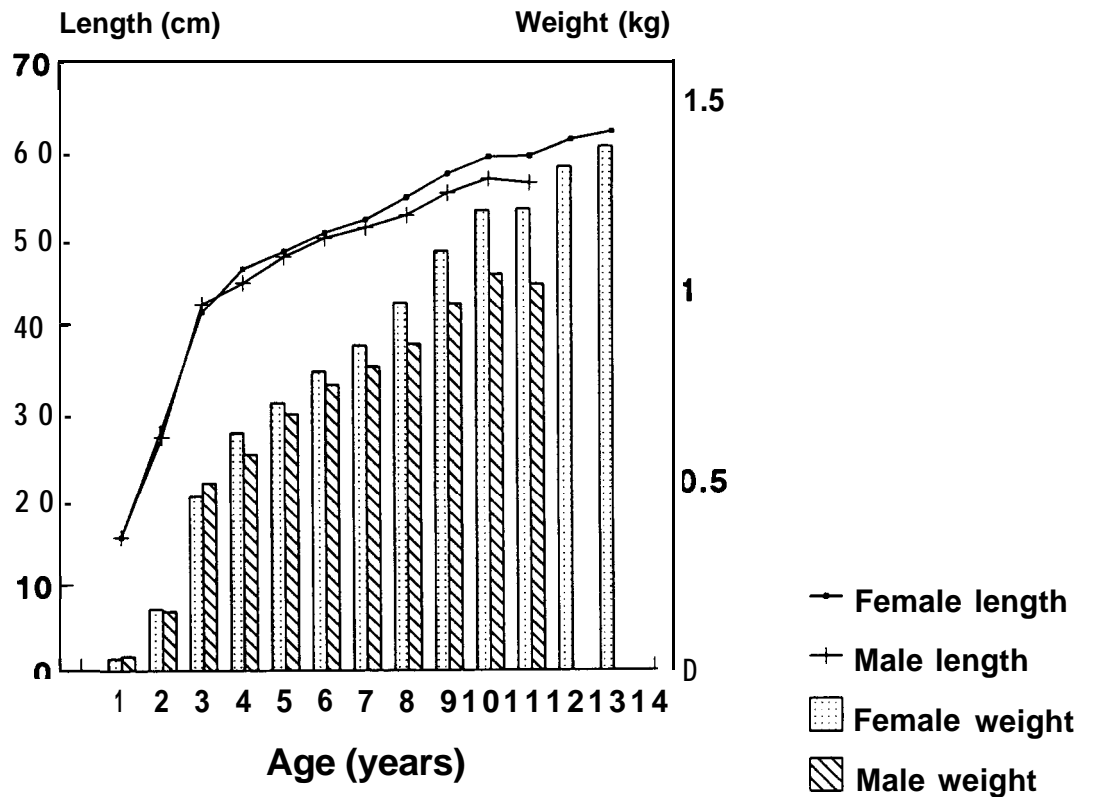
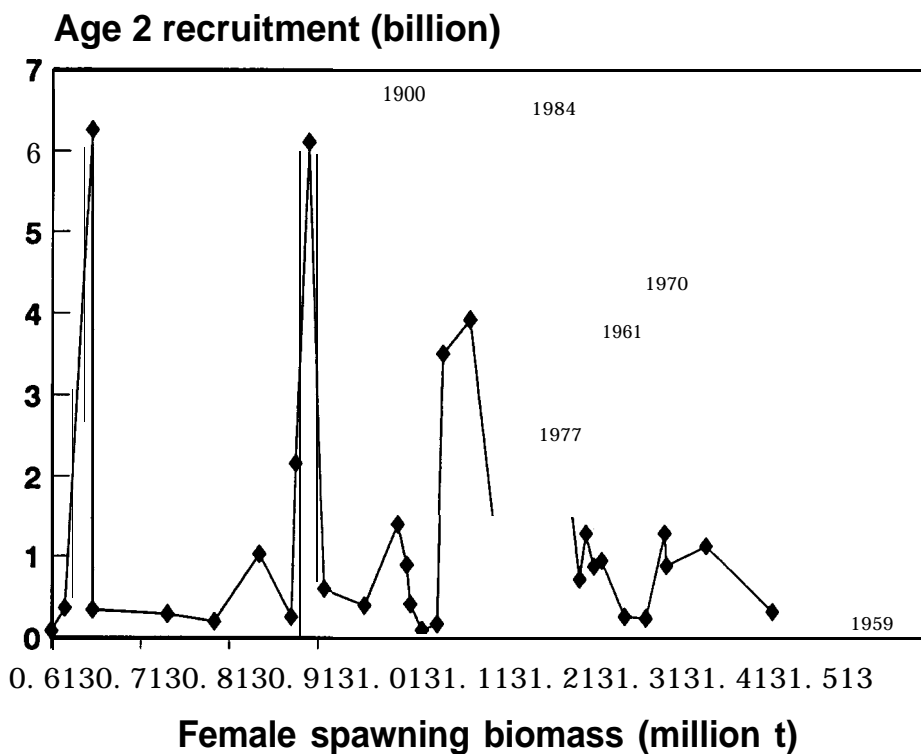


Figure 2. Pacific whiting mean length and weight at age by sex.



**Figure 3.**  
**Recruitment**  
**history of**  
**Pacific whiting,**  
1959-1987.

The coastal population of **Pacific whiting** exhibits a high rate of infection with a protozoan parasite of the phylum Myxosporea (Nelson et al. 1985). This parasite enters individual muscle fibers, forming pseudocysts. While there is no evidence that these infections cause any harm to consumers, they have a significant effect on the texture of fillets and other products from infected fish. Proteolytic enzymes are produced by the parasite as natural **metabolites**. While the host fish is alive, its excretory system can eliminate these chemicals. Upon capture, the **enzymes** accumulate in the muscle fibers and start to break down the flesh, resulting in a soft, mushy texture that is unsuitable for marketing.

Pacific whiting begin to recruit to the fishery at age three years off northern California. They are nearly completely recruited to the Oregon-Washington summer fishery by age five. The extreme recruitment variability of Pacific whiting (**figure 3**) has a major influence on the population dynamics of the stock. The population is typically dominated by one or two large year classes, with other year classes contributing very little to the biomass. Recent large year classes have occurred in **1973, 1977, 1980, 1984, and 1987**. The occurrence of large year classes has been correlated with years of weak upwelling conditions and warm coastal surface temperatures (Bailey and **Francis** 1985).

One explanation is that strong upwelling pushes larval whiting offshore into a less productive habitat, reducing their survival rates.

#### **ABUNDANCE AND STOCK ASSESSMENT**

The biomass of Pacific whiting is measured every three years by **NMFS** with concurrent bottom trawl and echo integration (**hydroacoustic**) surveys, designed to assess both the demersal and **midwater** components of the stock. **Figure 4** presents these combined estimates for the five triennial surveys. **The** dynamics of the population are more comprehensively **modelled** by including information regarding the magnitude and biological composition of the catches each year using stock synthesis (**Methot** 1989). The results are issued annually as a stock assessment document through the Pacific **Fishery** Management Council (**Dorn** et al. 1990; Dom and **Methot** 1991). The effects of variable recruitment can be seen in the history of biomass estimates. Years when only one or two strong year classes were present (1977-1983) can be contrasted with 1986, when three large year classes were present. Currently, the 1980, 1984, and 1987 year classes are supporting the fishery, but the latter one is only moderately strong.

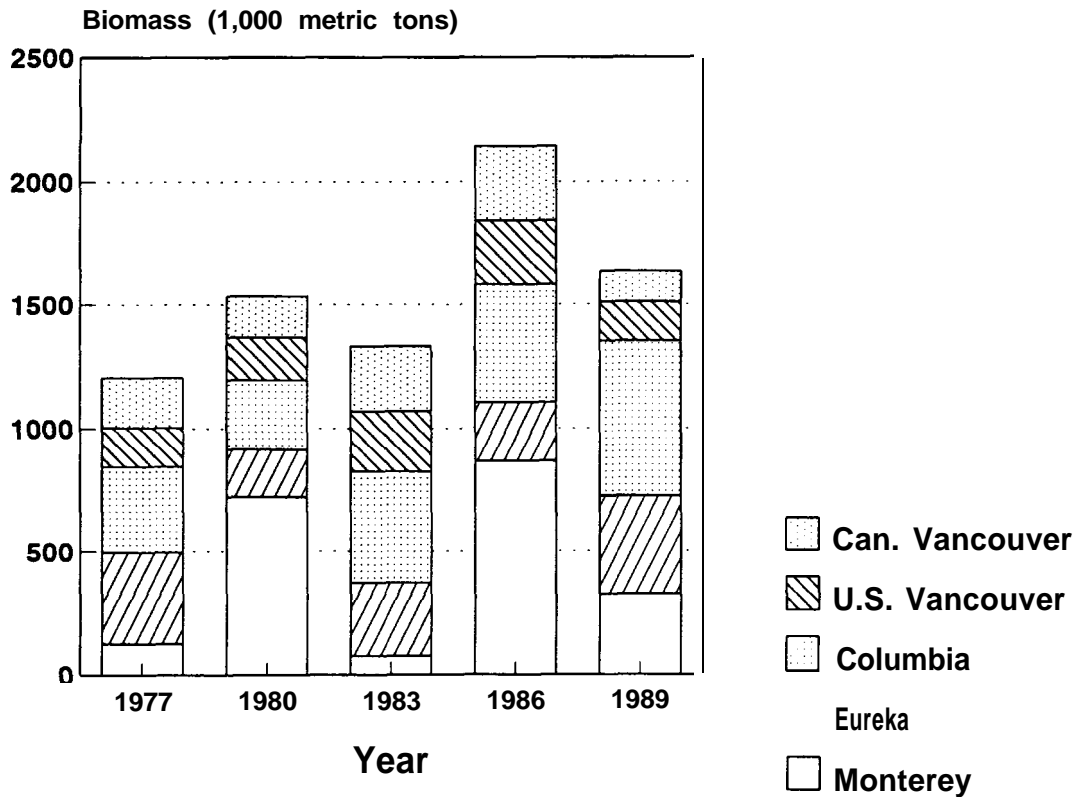


Figure 4. Pacific whiting research survey biomass estimates by year and INPFC area.

### IMPLICATIONS FOR FISHERY DEVELOPMENT AND STABILITY

The three most critical biological characteristics, in terms of the ability of the coastal Pacific whiting population to sustain a fishery, are (1) its annual migratory pattern, (2) its high rate of parasite infection, and (3) its extreme recruitment variability. Since larger fish, and consequently females of an age class, arrive in the area of the fishery earlier than the males and stay longer before migrating back to the south, the availability of certain components of the stock vary with the timing and location of fishing. For example, a fishery occurring in the INPFC Monterey area would catch mostly immature fish. Such differential vulnerability can contribute to the instability of the population.

The marketing problems caused by the Pacific whiting's parasitic infection have been an impediment to fishery development in the past, but appear to have been overcome with innovative products and processing.

The "boom or bust" nature of Pacific whiting recruitment seems to be the most difficult problem facing the development of this resource. The dependence on strong year classes for the yields from the population means that the long-term stability of the yields is always in doubt. Because of a lack of strong recruitment since 1984, the current age structure of the fishable Pacific whiting population is rela-

tively old. If recruitment continues near average levels, the outlook for the immediate future is for a continuing slow decline in the annual yield. Recruitment of a strong year class would substantially increase the projected yields.

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## Discussion

**Q:** (Barry Fisher, from the audience) Your presentation seems to indicate that the variation in the population of whiting is not exclusively due to overfishing. Has research on their cannibalistic pattern indicated anything about management methods?

**A:** (Wilkins) The cannibalistic nature of the fish means that a large year class will eat more members of a younger year class, making the population of the younger year class lower. The cannibalistic pattern is partly mitigated by the stratification of the species [tendency of different year classes to feed in different places], so the cannibalistic pattern is not a dominant part of their predation. Therefore, there would be no strong reason to base management strategies on this factor.

**Q:** Does the spawning pattern of whiting make them susceptible to fishing pressure?

**A:** (Wilkins) As fishing has not been permitted in the spawning areas, this hasn't been a problem.

**Q:** What environmental conditions favor recruitment? Do these conditions affect survival at spawning or later? Could you clarify the spawning pattern?

**A:** (Wilkins) Years when there are low upwelling or El Niño conditions are high recruitment years. These environmental conditions affect the fish at spawning. During April, spawning fish are off the Northern California shelf; they move farther north in May or June.



# POTENTIAL YIELD FROM THE PACIFIC WHITING FISHERY

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## INTRODUCTION

Unlike their counterparts in other scientific disciplines, fisheries scientists rarely can use controlled experiments to test hypotheses about the dynamic behavior of wild fish populations. **Artificially** manipulating the populations or their environment takes too long to produce results, or it is impossible, impractical, or too costly. As a consequence, fisheries scientists usually must base their conclusions and recommendations on results from experiments with theoretical models of fish populations. Although fisheries models are often viewed with skepticism by the fishing industry, the models can provide insight into the processes that control the **productivity** of a fish resource and they can suggest alternative strategies for harvesting that productivity.

This paper describes and examines one relatively simple model for the long-term average behavior of an idealized fish population. The model combines a traditional yield-per-recruit analysis with a spawner-recruit relationship; as a consequence, it is able **to** portray simultaneously the effects of short-term growth overfishing (catching fish before they have attained a favorable **size**) and long-term recruitment overfishing (catching fish before they have produced enough offspring). Beverton and Holt (1957) originally developed and used this model in their classic analysis of the North Sea stocks of plaice and haddock. Although it has not been widely used by fisheries scientists, this model, or variants of it, appears in **Cushing (1973)**, **Shepherd (1982)**, **Sissenwine and Shepherd (1987)**, and **Clark (1991)**.

## YIELD FROM A COHORT

**First** consider the total weight (the biomass) of a collection of fish (a cohort), all of which were born at the same time. As time passes, two processes operate on this cohort and cause its biomass to change: some individuals die; the survivors grow and increase in size. Together these processes cause the biomass **to** rise to a maximum and then decline. For Pacific whiting, the age at which a cohort attains its maximum biomass is about four years. If

we could harvest all the fish simultaneously, we could obtain a maximum catch by taking all the fish when they reach this critical age.

With Pacific whiting, as with most other commercially exploited species, we cannot catch all the fish **simultaneously** when they achieve a particular age. Instead we harvest a portion of the fish available over an interval of time. The upper panel of figure 1, for example, illustrates how fishing might **affect** the biomass of a cohort of Pacific whiting in which initially there are 1000 one-year-old fish (the recruits). We begin harvesting when the **fish** attain an age of four years, we cease fishing when they reach an age of twelve years, and at each instant of time we catch 30% of the available fish. The hatched area represents the total weight of the fish caught (the yield) during the **eight-year** span. In this example, we get a yield of about 186 kg. In the lower panel the fishable lifespan extends from age 3 to age 12, and the yield is about 201 kg.

The lower panel of figure 1 illustrates another phenomenon. Harvesting reduces the biomass of the mature portion of the stock (the spawning stock biomass). In this panel we begin fishing before the fish attain maturity (at age 3.5 years), and fishing reduces the biomass of the mature population to about one-third of its **size** in an unexploited stock. In the upper panel we begin fishing after the fish attain maturity, and our fishing reduces the spawning stock biomass to only 4.4% of the virgin level.

If we halve (or double) our rate of fishing to 15% (or **60%**), **the** yield will not be **half** (or double) the values shown in the figure. Changing the rate of fishing alters the shape of the biomass curve. The greater the rate of fishing, the more rapidly the biomass declines.

The age at which we first begin capturing fish, in combination with the rate of fishing, determines how much yield we will take from a cohort and determines how many adults will be left to produce future generations.

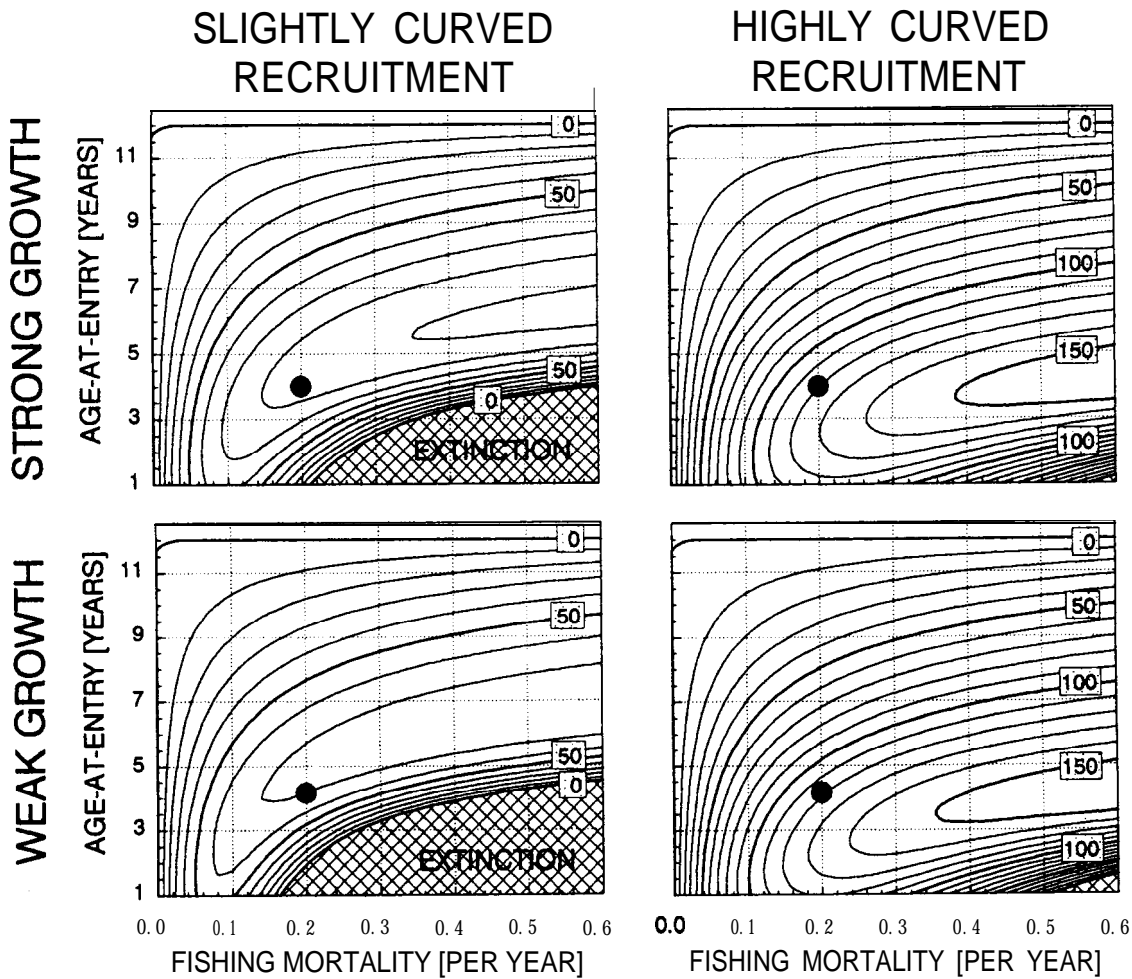


Figure 1: Biomass, yield, and spawning biomass from a cohort of Pacific whiting.

### RECRUITMENT AND SPAWNING STOCK BIOMASS

In order to gauge how today's fishing affects the fish stock that will be available in future years, we need to relate reproduction with the subsequent recruitment of offspring. Fecundity is proportional to body weight in many species of fish, therefore it is reasonable to assume that the number of eggs produced by a cohort is roughly proportional to the cohort's total biomass over its reproductive lifespan. However, it is almost certainly unrealistic to assume that a cohort's production of offspring is proportional to the number of eggs laid by the cohort. Over the generations a strictly linear relationship between the number of eggs and the number of reproductively successful offspring would lead either to extinction or to a population that was infinitely large. The fact that fish populations remain reasonably stable over time suggests that the relationship between egg production (that is, spawning stock biomass) and recruitment is curved and that there is relatively less recruitment at high levels of egg production.

Establishing with reasonable certainty the relationship between stock size and recruitment is a central and unresolved problem in fisheries science. Uncontrollable environmental factors apparently have a strong effect on the relationship (for example, Hollander and Bailey 1989). Furthermore, the high imprecision in our estimates for spawning biomass and recruitment makes the relationship difficult to measure. One method for dealing with our uncertainty about the stock and recruitment relationship is to use a range of alternatives and investigate how they affect the results.

### SUSTAINABLE YIELD FROM PACIFIC WHITING

If we combine the relationship for the yield from a cohort with the relationship between spawning stock biomass and recruitment, we can derive a model that predicts the average yield that we can harvest annually on a sustained basis. We cannot control the biological factors—such as natural mortality, growth,

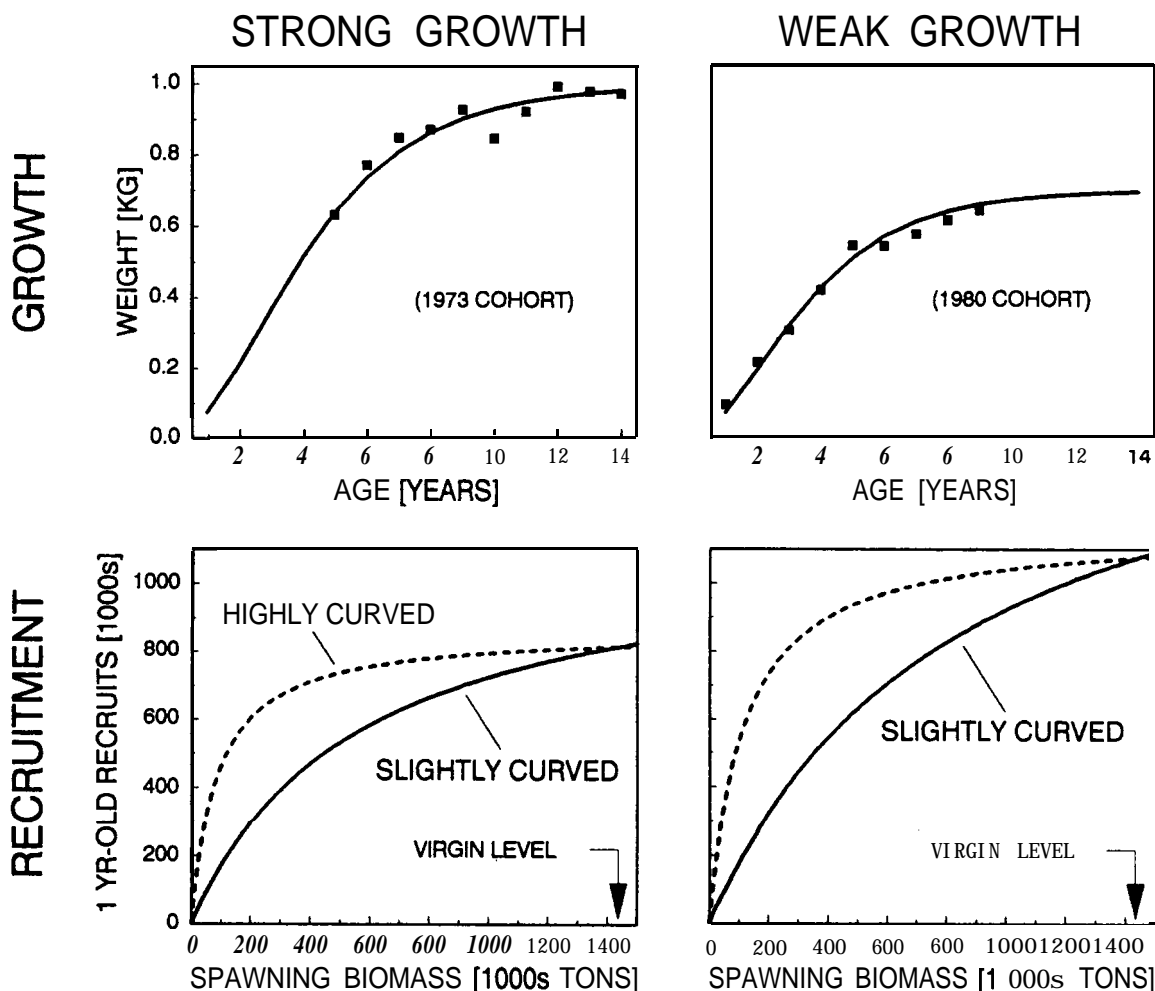


Figure 2: The growth curves and recruitment relationships that produce the sustainable yield relationships shown in figure 3.

and the recruitment relationship—that determine the sustainable yield. However, we can manipulate the rate of fishing (the fishing mortality) and the age at which fish are first harvested (the age-at-entry). The objective in applying this type of model to the stock of Pacific whiting is to evaluate whether there are combinations of fishing mortality and age-at-entry that will produce larger yields or that will more economically produce a given yield.

Previous studies of Pacific whiting have established that cohorts born in different years sometimes follow separate growth schedules (Hollowed, Methot, and Dom 1988; Dom and Methot 1989). In order to see how differences in growth affect the potential yield of Pacific whiting, we can compare the results derived from two growth schedules, one for strong growth and one for weak growth (shown in the upper panels of figure 2).

Over the observed range of values for spawning biomass, researchers have been unable to detect any clear relationship between spawning stock biomass and recruitment (Dorn et al. 1990). This may be due to the scar-

city and high degree of variability in the data. Alternatively, the absence of a pattern suggests that the relationship may be like the highly curved ones shown in the lower panels of figure 2. In those relationships there is little change in the average number of recruits produced by levels of spawning biomass greater than 500,000 metric tons. In order to see how differences in the recruitment relationship affect potential yield, we can compare the results from two sets of recruitment relationships, one that is highly curved and one that is only slightly curved (shown in the lower panels of figure 2). Different curves apply, depending on whether growth is strong or weak. In order to keep the relationships on the same relative scale, we must choose the recruitment curves so that for an unexploited stock they all produce the same spawning biomass.

Figure 3 shows how potential yield varies with fishing mortality and age-at-entry for the different combinations of growth and recruitment. The contour lines trace out the combinations of fishing mortality and age-at-entry that on average produce a particular annual yield.

The large dot on each graph represents the current position for the Pacific whiting fishery; the rate of fishing is about 20%, and fish are first vulnerable to capture at about four years of age. In the hatched regions, in the lower right portion of each panel, the rate of removals by the fishery exceeds the stock's biological productivity, and extinction results.

If we compare the upper and lower panels, we can see that changes in growth do not have much effect on the sustainable yield of Pacific whiting. However, if we compare the panels on the left with those on the right, we can see that the amount of curvature in the recruitment relationship has a pronounced effect. For example, if growth is strong and the recruitment relationship is only slightly curved (shown in the upper left panel), the current fishing strategy (indicated

by the large dot) produces a sustainable yield of about 84,099 metric tons per year. However, if the recruitment relationship is highly curved (shown in the upper right panel), the current strategy produces a sustainable yield of about 119,009 metric tons per year.

If the true relationship between spawning stock biomass and recruitment is the slightly curved one, then the current 20% rate of fishing is very near the level that produces the maximum sustainable yield for an age-at-entry of four years. We

could achieve a modest increase in yield by increasing the rate of fishing to about 35% if we coupled this with an increase in the age-at-entry to about 5.5 years. Note that if we increase the rate of fishing without raising the age-at-entry, then the sustainable yield will decrease! If the true recruitment relationship is the highly curved one, however, then we are currently **underfishing** this stock. By doubling our rate of fishing, we could significantly increase the annual yield.

The appendix gives the full details of the parameters and equations of the model for the potential yield of Pacific whiting.

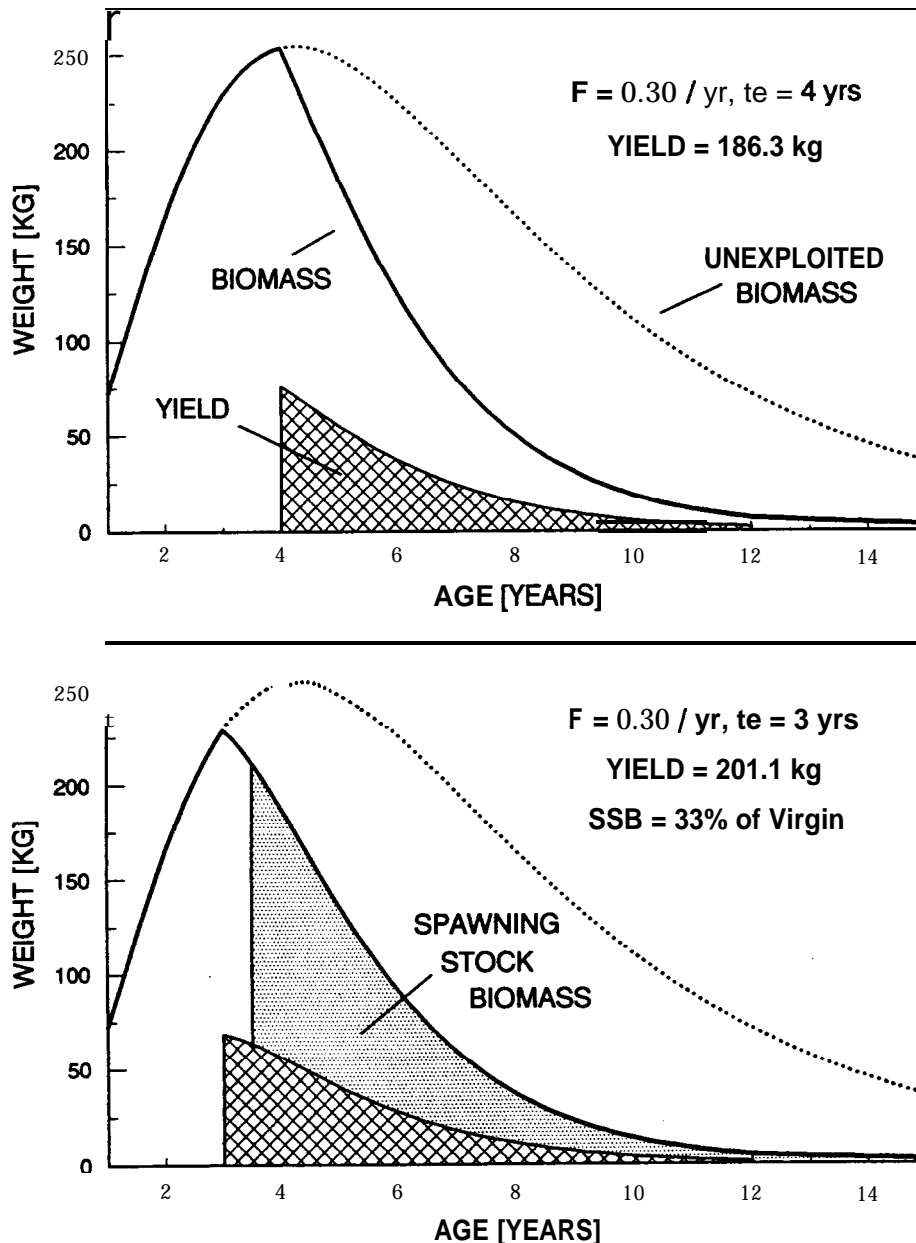


Figure 3: Contours Of sustainable yield (thousands Of metric tons per year) from a fishery for Pacific whiting.

## DISCUSSION

Most fishermen and fisheries managers are familiar with the concept of maximum sustainable yield (MSY, the largest average rate of catch that can be taken on a sustained basis). However, they are probably unaware that MSY varies with the age-at-entry. For example, examine the upper left panel of figure 3. The lowest point on each contour line represents a combination of age-at-entry and fishing mortality that produces an MSY. For an age-at-entry of two years, we obtain an MSY of about 70,000 metric tons per year with a fishing mortality rate of just over 0.1 per year. If we increase the age-at-entry to 5.5 years, we can obtain an MSY of about 90,000 tons per year with a fishing mortality rate of about 0.36 per year.

Figure 3 also illustrates that we can lessen the risk of causing a year-class failure if we make the age-at-entry large enough to allow young fish to spawn. Pacific whiting reach maturity at about 3.5 years of age. If we regulate the age-at-entry in the whiting fishery to be 5 years or greater, then even extremely high rates of fishing will not reduce the spawning biomass to dangerously low levels. With Pacific whiting it should be possible to manipulate the age-at-entry with mesh-size regulations or with time and area closures.

The greatest uncertainty about how much Pacific whiting we can take on a sustained basis lies in the shape of the recruitment relationship. If we gamble that the relationship is highly curved and then increase the rate of fishing, we will attain higher yields if we are correct and lower yields if we are wrong. With our current policy and its conservative fishing rate, it will take a very long time to collect enough information to establish the recruitment relationship. Perhaps we should adopt a policy of deliberate overfishing for a few years so that we can determine more accurately the shape of the recruitment relationship.

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APPENDIX: The Equations of the Model for Whiting Yield

In the following equations the variable  $t$  denotes age in years.

GROWTH: 
$$W(t) = W_{\infty} \cdot [ 1 - e^{-k \cdot (t-t_0)} ]^3$$

$W$  is the average weight-at-age of a fish.

	$W_{\infty}$	$k$	$t_0$
Strong Growth	1.0 kg	0.36 /yr	-0.5 yr
Weak Growth	0.70 kg	0.42 /yr	-0.5 yr

SURVIVAL: 
$$N = N(t, F, t_e)$$

$$N = \begin{cases} R \cdot e^{-M \cdot (t-t_r)} & \dots t \leq t_e \\ R \cdot e^{-M \cdot (t_e-t_r)} \cdot e^{-(F+M) \cdot (t-t_e)} & \dots t_e < t \leq T \\ R \cdot e^{-M \cdot (t_e-t_r)} \cdot e^{-(F+M) \cdot (T-t_e)} \cdot e^{-M \cdot (t-T)} & \dots T < t \end{cases}$$

- $N$  is the number of living fish.
- $R$  is the number of one-year-old recruits.
- $t_r$  is the age at recruitment:  $t_r = 1$  year.
- $t_e$  is the age at entry to the fishery.
- $T$  is the age at which fish cease to be vulnerable to fishing;  $T = 12$  years.
- $M$  is the instantaneous rate of natural mortality:  $M = 0.237$  per year.
- $F$  is the instantaneous rate of fishing mortality.

BIOMASS: 
$$B(t) = W(t) \cdot N(t, F, t_e)$$

$W$  is the total weight of the surviving fish.

YIELD: 
$$Y(F, t_e) = \int_{t_e}^T F \cdot N(\tau, F, t_e) \cdot W(\tau) d\tau$$

$Y$  is the total weight fish caught over the fishable lifespan from age  $t_e$  to age  $T$ .

SPAWNING STOCK BIOMASS: 
$$SSB(F, t_e) = \int_{t_R}^{\infty} N(\tau, F, t_e) \cdot W(\tau) d\tau$$

$SSB$  is the total weight of fish over the reproductive lifespan from age  $t_R$  to final senescence.

RECRUITMENT: 
$$R(F, t_e) = \frac{SSB(F, t_e)}{1 - a \cdot [ 1 - SSB(F, t_e) / \beta ]}$$

$R$  is the number of one-year-old recruits produced by the given spawning stock biomass ( $SSB$ ).

		Strong Growth	Weak Growth
Slightly Curved	$\alpha$	0.5	0.5
	$\beta$	567,720 mt	856,420 mt
Highly Curved	$\alpha$	0.9	0.9
	$\beta$	776,610 mt	1,244,090 mt

All four recruitment relationships produce 1.438 million metric tons of unexploited spawning stock biomass (Fig.2).

#### EQUILIBRIUM SPAWNING BIOMASS:

$$SSBeq(F,te) = (\beta/\alpha) \cdot [ SSB(F,te)/R - 1 + a ]$$

SSBeq is the long-run average spawning stock biomass.  
SSB/R is the short-run spawning biomass per recruit.

#### EQUILIBRIUM RECRUITMENT:

$$Req(F,te) = SSBeq(F,te) / [ SSB(F,te)/R ]$$

Req is the long-run average one-year-old recruitment.

#### EQUILIBRIUM YIELD:

$$Yeq(F,te) = Req(F,te) \cdot [ Y(F,te)/R ]$$

Yeq is the long-run average weight of fish caught from a cohort over its fishable lifespan.  
Y/R is the short-run yield per recruit.

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## **Discussion**

**Q:** How does it **affect** your predictions if we don't really know what foreign vessels are catching in our waters?

**A:** (Sampson) This wouldn't affect these models because the models consider total catches, including foreign ones.

**Q:** (Barry Fisher, from the audience) The data we used to get from the observer program on the foreign fishing fleet could have been useful. Why don't we use the fishing fleet to gather more data if it could improve the projections used for management of stocks?

**A:** Sampson answered that what we need to be able to do is to predict environmental changes like El Niño, but this ability seems unlikely. The session leader interjected that what the questioner was implying is that we need to improve our projections with better data, such as weather cycle data, to improve management decisions. Fisher added that

looking at one species alone is a mistake; we need to examine the interactions in a multispecies fishery, as part of the overall ecology.

**Q:** What about the economics of this situation? How do you include supply and demand in the model?

**A:** (Sampson) These factors can be included. To do so, we need to attach likelihoods to each recruitment scenario, then do the economic analysis based on the situation we think is most likely to occur.

Several additional comments were made in summing up. Mark Wilkins commented on the idea of trying to **analyze** the whole system rather than one species alone; this is already happening up in Alaska and they have fallen behind down here. Fisher added from the audience that the scientists need to let the industry help them where possible, both in gathering data and in raising funds to support the research.



# A MULTIPLE-OBJECTIVE BIOECONOMIC POLICY MODEL OF THE PACIFIC WHITING (*MERLUCCIUS PRODUCTUS*) FISHERY

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## INTRODUCTION

Modern fishery management embraces a broad range of biological, economic, and social objectives (benefits). The emergence of the concept of optimum yield as the legislative principle of fisheries management in the United States explicitly recognizes the multiple-objective nature of fishery management (Healey 1984). The fundamental problem with multiple-objective management, however, is the need to reconcile conflicting objectives. Bailey and Jentoft (1990) point out the necessity of making difficult choices among policy objectives in fishery management.

Traditionally, the analysis of fishery policy has centered on single objectives. For example, much of the analysis has focused on the issue of biological conservation. Although this focus has been essential for maintaining the long-term productivity of the resources, as mandated by the Magnuson Fishery Management and Conservation Act (MFMCA), it has neglected the economic and social aspects of the fishery. In contrast, economists have tended to favor traditional cost-benefit analysis, which focuses on the single objective of maximizing the present value of net revenues. Although this approach provides valuable insight, it does not fully account for the effects of policy regulations on other objectives, such as regional employment and income.

Economic analysis based on a single objective is not consistent with the nature of the political process in fisheries management, nor does it comply with the MFMCA, which mandates an integrated consideration of biological, social, and economic objectives. To overcome these problems, Cohon (1978) has suggested a modified and refined methodology for the analysis of multiple-objective decision problems. This methodology is known as multiple-objective programming, a branch of operations research that allows the consideration of multiple objectives explicitly and simultaneously.

The purpose of this paper is to summarize the recent developments of a multiple-objective bioeconomic policy model of the Pacific whiting (*Merluccius productus*) fishery. This model integrates biological, marketing, and industrial data with economic impact and regulatory policies. In particular it draws heavily from Pacific whiting stock assessments, especially the results of the stock synthesis model by Dorn and Method (1991 and 1989), Dorn et al. (1990), Method (1989), and Hollowed et al. (1987). The study also draws from several other sources, including a market survey by Sylvia and Peters (1991). To illustrate the potential use of the model, we present the results from one application and briefly discuss them.

## CONCEPT, SCOPE, AND LIMITATIONS OF MULTIPLE-OBJECTIVE MODELS

Traditional (single-objective) methods of fishery policy analysis are designed to search for policy regulations that will potentially yield the highest value for the objective under consideration. In contrast, multiple-objective analysis recognizes that since fishery policy consists of noncomplementary objectives, a solution that simultaneously maximizes all the objectives does not exist. That is, a management strategy that maximizes one objective does not necessarily maximize the other objectives. Multiple-objective models attempt to identify policy alternatives representing full utilization<sup>1</sup> of the resource. A policy alternative represents full utilization if, given the objectives, the time horizon, and the constraints, there is no other possible alternative that will produce an increase in one objective without causing a degradation in at least one other objective. Since there are many objectives, and

<sup>1</sup>These solutions are called, alternatively, nondominated, noninferior, or Pareto efficient.

many ways to value these objectives, there may also be many possible ways to fully utilize the resource. The principal characteristic of full utilization alternatives is that, in moving from one alternative to another, we must trade-off the objectives. It must be emphasized that full utilization refers to all of the objectives selected for the analysis. Multiple-objective analysis systematically **identifies** full utilization alternatives and the trade-offs implied by the selection of these alternatives.

The principal disadvantages of multiple-objective analysis are the large information requirements and the high computational cost, which increase exponentially with the number of objectives under consideration (Willis and **Perlack** 1980). As the number of objectives included in the analysis increases, the number and complexity of the solutions also increase, making the policy information more **difficult** to be **evaluated**.

Multiple-objective models, as with other kinds of mathematical models, are useful only if their limitations are clearly understood by analysts and decision makers. The essence of mathematical modelling is abstraction; therefore, models provide only a limited view of real systems. Given the complexity and uncertainty involved in fishery management, the numerical solutions of mathematical models must be interpreted with caution. Nevertheless, multiple-objective models, **if used** in combination with other sources of information, including the experience of the policymakers and "common sense," can be **valuable** tools for the decision-making process.

## **AN EXAMPLE: GEOGRAPHICAL DISTRIBUTION OF EFFORT**

### **The Policy Problem**

**Pacific** whiting exhibit an extensive northerly migration to summer feeding grounds off the coasts of Northern California, Oregon, Washington, and British Columbia (Bailey 1981). The extent of the annual migration is age and size dependent. Older fish and larger fish within a given age class tend to migrate farther north. Because the behavior and success of the **Pacific** whiting fishery depend on the migratory behavior of the species, geographical shifts of effort can not only complicate stock assessment, but can **affect** long-term yields (**Dorn** et al. 1990) and therefore the levels of other policy objectives.

**Dom** (1990), using catch and observer data from the period 1978-1988, identifies three ar-

reas of high **Pacific** whiting catches in the U.S. zone: (1) the Eureka and Monterey regions (**EUR**), consisting of the area south of latitude **43°00' N**; (2) the area from latitude **43°00' N** to latitude **46°45' N**, corresponding to the southern part of the Columbia region (**SCOL**); and (3) the area north of latitude **46°45' N** to the U.S.-Canada border, consisting of the northern part of the Columbia region and the U.S. portion of the Vancouver region (**VCN**). Because of their migratory behavior, Pacific whiting harvested from the different areas have different age, sex, sexual maturity and **weight-at-age** compositions, with the northernmost regions having, on average, larger, and older fish. In addition, because of their larger size, fishes from the northernmost regions have, depending on product form, potentially higher value per unit weight (Sylvia and Peters 1991). The northernmost regions are also likely to have a higher proportion of sexually mature females.

The following policy problem considers a situation where the **Pacific** whiting fishery in the U.S. is divided, for management purposes, into three subfisheries according to the regional classification described in the last paragraph. **The** main purpose of this exercise was to analyze the effects of regional distribution of effort on the level of benefits.

### **The Policy Objectives**

Consider a policy decision problem where the objectives of management are the **revenues**<sup>2</sup> accruing from each of the three regions (**subfisheries**). In addition to revenues, maintaining the long-term productivity of the resource is also considered an objective of management. This policy problem, therefore, consists of four conflicting objectives. The policy instruments (or decision variables) for this problem are the harvests allowed from each subfishery.

### **Methodology, Model Structure, and Assumptions**

A dynamic (**time-dependent**), multiple-objective mathematical program was used to analyze the policy problem just described.<sup>3</sup> The biological dynamics of Pacific whiting were

With the additional assumption that **costs** are independent of the geographical pattern of effort, gross revenues approximate changes in fishery rent.

\*For a full description of the model, see **Enriquez**, unpublished manuscript.

simulated by a generalized age-structured submodel, with an exponential (Baranov) catch equation accounting for the effect of the fishery on the stock. The model divided the **fishery** into four subfisheries: three in the U.S. zone (as described above) plus the Canadian fishery. The Canadian fishery in this version of the model was treated as an **external** variable. For a detailed description of the model see Enriquez (unpublished manuscript).

The procedure used to **find** full utilization solutions consists of the following steps:<sup>4</sup> (1) Assign a set of arbitrary weights (that is, relative values) to the various policy objectives; (2) search for the geographical pattern of fishing yielding the **maximum** level of benefits given the weights assigned; and (3) repeat steps (1) and (2) for different sets of weights. The solution of each of these parameterizations represents a full utilization solution.

Because of the high computational cost, the large number of possible full utilization solutions, and the limited scope of this work, we restricted ourselves to the identification and discussion of only three solutions. For the sake of simplicity, the biological objective (that is, securing the long-term productivity of the resource) was incorporated into the model as a constraint. The spawning biomass was not allowed to fall below the cautionary level of 457 thousand tons (the biological objective was not subject to weighing.)

The analysis considered a **20-year** time horizon and used the parameters estimated by the stock synthesis for the 1991 assessment of the Pacific Coast **groundfish** fishery (Dom and Method 1991; in particular, see tables 10 and 11). The model assumed a 3.5 oz (.1 kg) average individual fish weight difference between the southernmost and northernmost segments of the U.S. fishery. This estimate was based on the 1990 Pacific whiting stock assessment report (Dorn et al. 1990). Each solution was the result of 25 replicate runs each with a randomly generated **20-year** time series of **recruitment**.<sup>5</sup> To keep catches within observed levels, we restricted fishing mortalities in the U.S. subfisheries ( $F_{US}$ ) to an average of no more than  $F_{US} = 1/2$ .

We considered two product forms in the analysis--fillets and surimi. Total fishery **pro-**

**duction** was considered too small to **affect** the level of prices in the market. However, the model considered price variations for **fillets**, according to product size and supply availability, given by

$$\text{PRICE (\$/LB)} = .71 + .0095 \text{ FILLET SIZE (oz)}$$

This relationship was obtained from a market survey by Sylvia and Peters (1991). The price of surimi was considered constant at \$1.28 per lb. The simulation used a 0.25 recovery rate for fillets and a 0.14 recovery rate for **surimi**.

Three solutions representing full **utilization** alternatives were generated. In the first solution called, Option 1, a high relative weight (see table 1) was assigned to the **EUR** region. This was done to force the model to concentrate effort in the southern region. In the second solution, Option 2, all the three regions in the U.S. received similar weights so as to distribute harvest throughout the three U.S. regions. In the third alternative, Option 3, a high relative weight was assigned to the northern (**VNC**) portion of the fishery. In all runs, the Canadian fishing mortality ( $F_{CAN}$ ) was **fixed** (at  $F_{CAN} = 0.15$ ). The results of the analysis are shown in table 1.

The policy options shown in table 1 represent three different ways of using the resource to its full capacity given the objectives, constraints, and time horizon considered in the analysis. **Basing** the results only on the levels of revenue shown in the table (and displayed graphically in figure 1), we could not prove that any one solution was absolutely superior to the others. That is, none of these solutions provides more revenues from every **subfishery**. For instance, Option 1 provides the highest level of revenue from the **EUR** region but no revenues **from** either the **SCOL** or **VNC** regions. Option 2 gives more revenues from the **SCOL** and **VNC** regions than Option 1 but provides \$231.6 million less of discounted revenues from the **EUR** region. Similarly, Option 3 provides more revenues from the **VNC** region but very low levels **from** the other two regions. These results show the nature of the trade-offs involved in fishery decision making: increased benefits from one region can come only at the expense of other regions.

A typical multiple-objective problem has many full utilization solutions, all of which are equally desirable from the standpoint of multiple-objective analysis. However, only one alternative can be actually implemented. A **deci-**

<sup>4</sup>This procedure is known as the weighing method for generating noninferior solutions (see Cohon 1978).

<sup>5</sup>Variability in recruitment was simulated by randomly selecting with replacement from the time series of recruitment for the period 1958 to 1989 (see table 18 in Dom et al. 1990).

	Option 1			Option 2			Option 3		
	EUR	SCOL	VNC	EUR	SCOL	VNC	EUR	SCOL	VNC
Weights	90%	5%	5%	32%	36%	32%	5%	5%	90%
PV Revenues	726	0	0	494	147	277	14	0	722
St. Dev.	400	-		220	20	61	14	-	178
Catches	2967	0	0	1999	546	1005	76	0	2803
St. Dev.	1289	-		783	12	170	94	-	540

Revenues for each option represent the average (mean) over the 25 replicate runs and are discounted to the initial period using a 5% interest rate. Catches (totaled for the 20-year period) represent averages over the 25 replicate runs and are measured in nominal weight. Revenues are in millions of dollars and catches are in thousand tons. All figures are rounded to the nearest unit.

Table 1. Results of the multiobjective analysis as described in the text

sion has to be made as to which full utilization solution is **best** for the **region** or nation. In the multiple-objective approach used here, such decisions are not incorporated as part of the model, but are **left** entirely to the decision makers.

**Comparing Policy Alternatives**

In principle, full utilization solutions can be compared only by introducing **value** judgments regarding the social importance of the **objectives**. Although these value judgments should be **left** to the decision makers, the analysts can still play a role in the process. One **thing** the

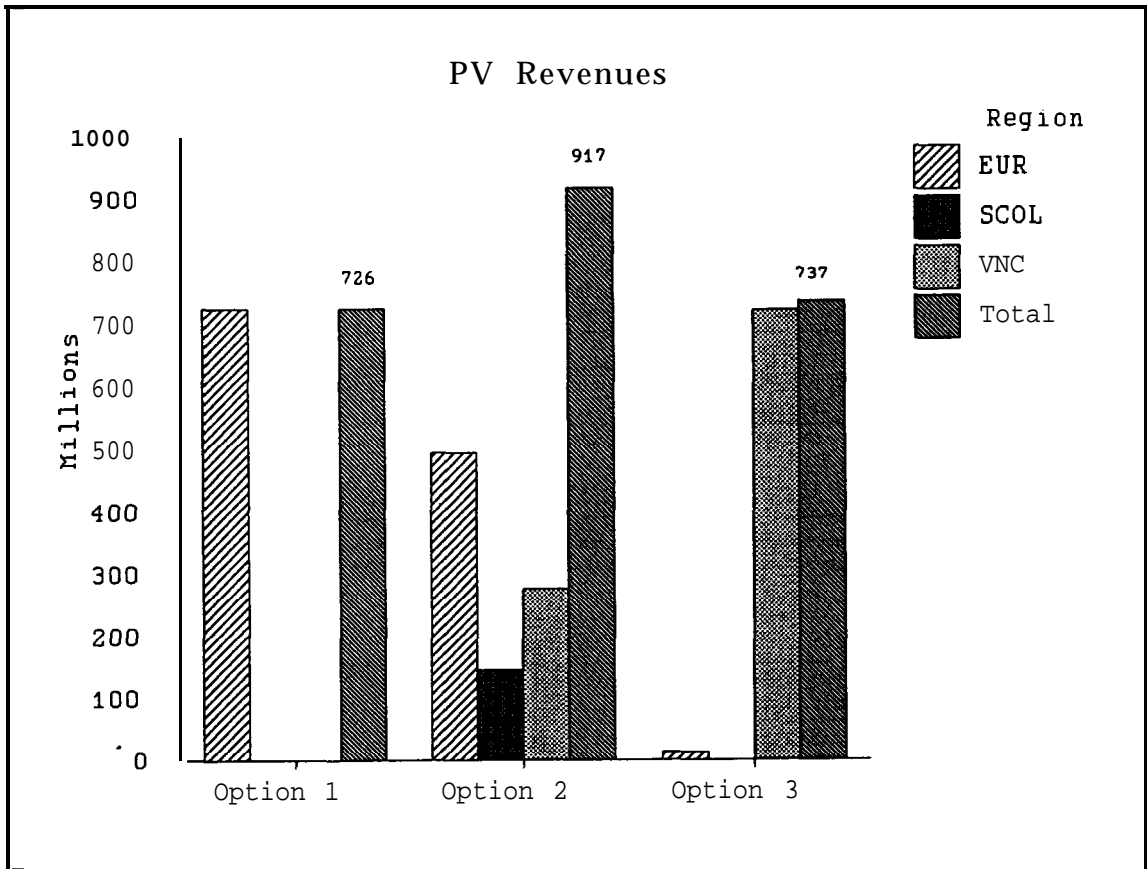


Figure 1. Discounted revenues for the three full utilization solutions as described in the text.

analyst can do is to provide additional criteria for evaluating policy alternatives. These criteria can take many forms; for our example we use aggregate revenues and variability.

Figure 1 shows aggregate levels of (discounted) revenues across subfisheries for each option. Aggregated revenues from the fishery are potentially larger in Option 2, that is, when the effects of the fishery are spread out geographically. Option 1 is the alternative that provides fewer overall revenues because it takes a larger proportion of smaller, less valuable fishes (see figure 2). When effort is concentrated in the northern region (Option 3), catches are likely to consist of larger fishes (figure 2). However, catches from this region probably also will have a higher proportion of mature females. This is likely to affect negatively the level of spawning biomass. To avoid this effect, the model, by constraining the level of spawning biomass, restricts the levels of catches allowed from the northern portion of the fishery. This, added to the effects of natural mortality, explains the lower level of revenues from Option 3 relative to Option 2.

Variability of discounted revenues is another attribute that can be used as a criterion for evaluation. Figure 2 shows the coefficient of variation associated with discounted revenues and yield for the three policy options. The coefficient of variation measures the variability in potential revenues and can be used as a crude measure of economic risk. Option 1 has the highest level of variability of the options considered. This is because catches in the southern subfishery have a larger proportion of recently recruited individuals. Therefore, yields from this area are more directly affected by variability in year-class strength. As expected, Option 3 possesses the lowest level of variability.

An interesting aspect that surfaced from this analysis is the fact that yields from the Pacific whiting fishery are less variable than the level of discounted revenues. The reason for this is that the timing of strong year classes (that is, whether they occur earlier or later in the period of analysis) affects the discounted level of revenues. Therefore variability in revenues can be expected to increase as the rate of

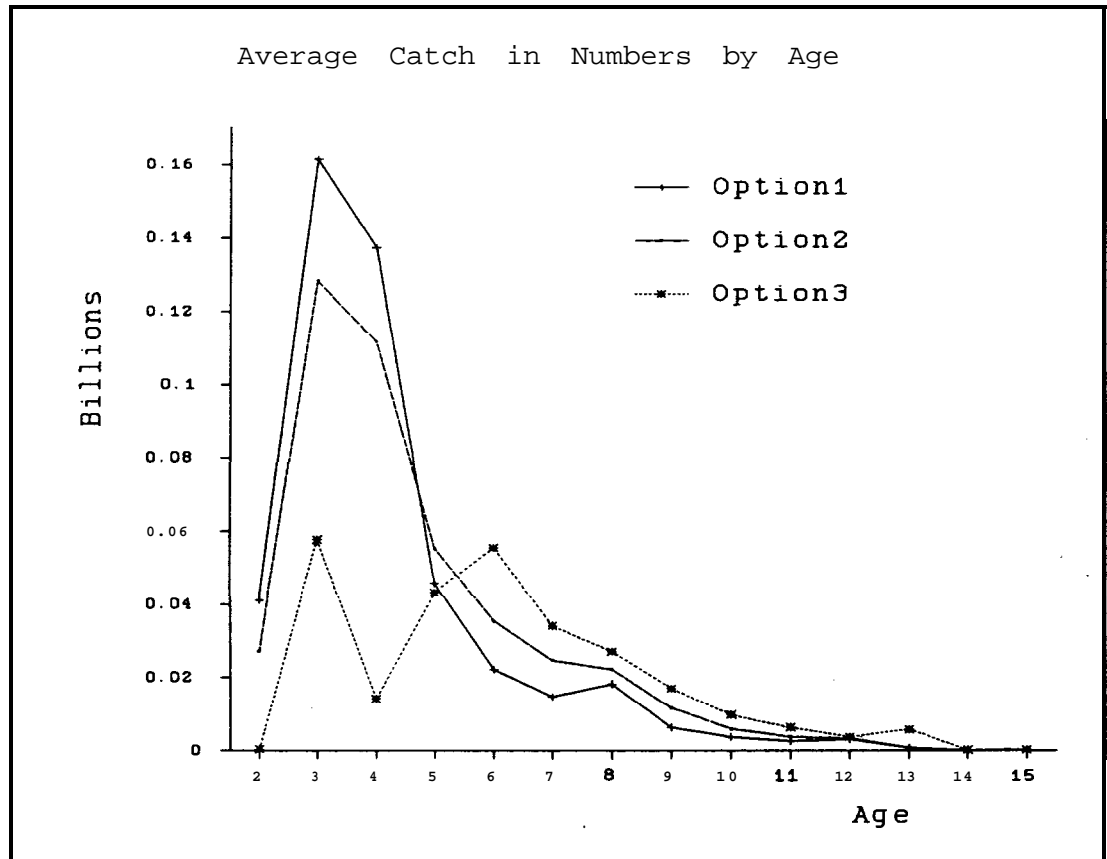


Figure 2. Average catch in numbers for the three full utilization solutions described in the text.

\*The standard deviation as a proportion of mean.

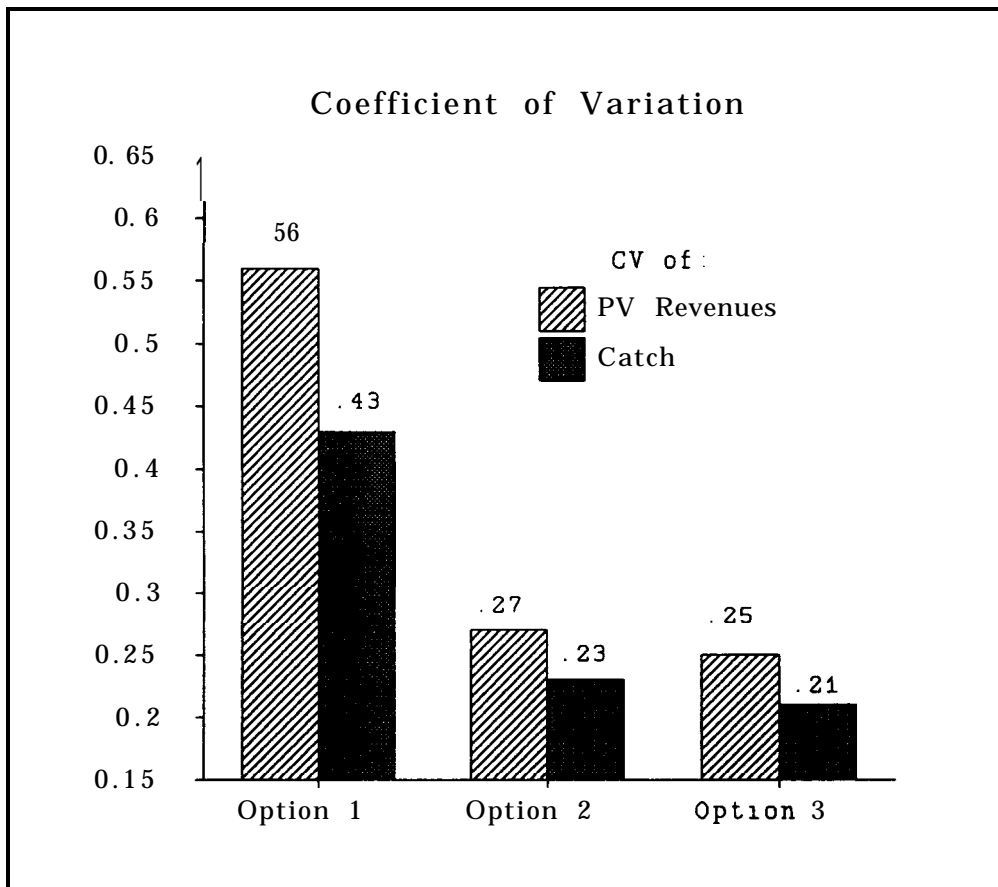


Figure 3. *Coefficient of variation of discounted revenues and yield for the three full utilization solutions described in the text.*

discounting is increased. In contrast, the level of yield is less dependent on the timing of strong year classes.

The policy options presented here are but three of many full utilization possibilities. Yet, the comparison suggests that the geographical distribution of **effort** could have important effects on the level of benefits expected from the fishery. Future research using multiple-objective programming techniques will address a wider range of issues affecting the Pacific whiting fishery, including onshore and offshore processing, seasonal shifts in **effort**, community impact, and assessment of biological and economic risk.

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## **Discussion**

**Q:** (Barry Fisher, from the audience) **If** you stretch the fishery out (lengthen the time over which the fish are caught), will this result in an increase in the number of product forms?

**A:** (Enriquez) Yes, because then larger fish will be caught on average, and we assume larger fish give more product form options.

**Q:** (Fisher) Does this mean that an **“olympic”** fishery (one where all the fish is caught in a

very short period of time) will actually provide less revenue?

**A:** (Enriquez) My analysis was not intended to address this question specifically, but it does indicate this result, since an earlier fishery will be further south and take smaller fish.

**Q:** (Fisher) Later in the season, more females are caught. Is this fact accounted for in your model?

**A:** (Enriquez) Yes, it is implicitly included in the spawning and biomass variables. What is missing so far is a consideration of how different costs are **affected**; that is being done now.

**Q:** When you talk about spreading out the fishery, are you talking about spreading it out over time or area?

**A:** (Enriquez) Both.

Gil Sylvia **interjected** here that this model provides information which can be used for management by making assumptions about demand for various product forms with different product quality characteristics. When combined with the information from the marketing study done by Sylvia and others, price effects can be included, and the researchers will be able to draw conclusions on how regulatory systems affect price. The concept of inventorying the fish in the ocean, that is, letting fish grow in the ocean rather than paying to freeze it, is among the many reasons for spreading out the fishing season over time. One extension of this analysis would be to look at the change in risk of a lower female biomass, vs. the change in risk to fishermen, of different management systems.

**Q:** (Steven Freese, from the audience) **The** management councils will be looking at **longer-term** models; what kind of long-term data and information will be needed to improve this model for use by the councils?

**A:** (Enriquez) **The** cost information needs to be included in the model.

Sylvia added that this approach allows you to test different economic scenarios using sensitivity analysis. You need to limit the sensitivity analysis to a reasonable range of assumptions about what is most likely. The data requirements increase exponentially as more factors are included in the analysis.

# PANEL DISCUSSION ON BIOLOGY AND MANAGEMENT OF PACIFIC WHITING

Session leader: Neal *Coenen*. Panel members: *Mark Wilkins, David Sampson, Roberto Enriquez*.

**Q:** (Session leader) What about the use of interdisciplinary teams to provide information for management of this species, given the special economic and biological **difficulties** involved?

**A:** Each panel member responded separately to this question. David Sampson replied that using interdisciplinary approaches is a good idea, as many of the problems have both economic and biological aspects. Mark Wilkins mentioned that this type of analysis is beginning to happen, but needs to be emphasized more. Barry Fisher, from the audience, interjected that it is important to use English rather than technical jargon to communicate. Gil Sylvia remarked that Pacific whiting is a classic case where an interdisciplinary approach is needed; **NMFS's** approach to the problem has used different disciplines sequentially, but not together. Steven Freese of **NMFS** responded that the system stretches too few people in too many directions; tasks need to be more limited. Fisher praised the scientists who have had the courage to insist that an interdisciplinary approach is needed, and to criticize the council's approach, which tends to say "Let's hear from the biologists" and then, "Let's hear from the economists." As long as people are stretched too thin, management problems will continue.

Joe Easley, of the Otter **Trawl** Commission, commented that it would be a mistake to look at whiting in isolation; we need to examine the whole trawl fishery, which is economically, socially, and biologically integrated.

**Q:** (Session leader) What kinds of regulations are consistent with decreasing risk?

**A:** Each panel member responded separately to this question. Sampson responded that the recommended mesh **size** of three inches should be checked and re-analyzed, as this was only an estimate when it was originally set. Fisher remarked from the audience that this is not enough; we need to look at double bags, chafers, and **knotless Kevlar** net, which would provide better escapement. Wilkins added that a prohibition against fishing in the southern areas or the use of other seasonal or area exclusions could be as effective as regulating mesh size.

Easley, from the audience, commented that the management issues between the U.S. and Canada need to be settled. Sampson added that science says we shouldn't focus on Canadian fish, as they are older year classes, and the Canadians claim that we in the U.S. underestimate the biomass. Wilkins responded that we are now beginning to work out our scientific differences with the Canadians.

We must get a handle on the catch by at-sea processors, because the current measure is not reliable, Fisher added. Easley then commented that many of the council's management problems rest in Washington, D.C. It seems as though many issues work their way up through the system and then get stuck somewhere in Washington, D.C. As a result, they never get resolved.



# CLOSING REMARKS

*Barry Fisher*  
*Commercial Fisherman*

*Summarized by Ann L. Shriver*  
*International Institute of Fisheries Economics and Trade*

We have been exposed to a great deal of information over the last two days, all of which helps us answer the question, What do we need to do to help to develop the whiting fishery? Among the important conclusions that we can draw are the following:

- Quality assurance is crucial to developing markets for this product Organization is necessary in the industry to accomplish this, as well as to work on related issues, such as marketing and establishing quality standards or guidelines.
- There is a need to improve communication within the industry. Fishermen and processors need to communicate with each other, the rest of the industry, and the markets. Some suggestions to improve communication that have come out of this conference include the establishment of an industry newsletter, which the Astoria Seafood Laboratory has agreed to undertake, and holding more meetings like this one, in future focussing more on buyers. Government bodies and fishery managers need to be drawn into these activities.
- Continuation of the work done by the Astoria Seafood Laboratory and OSU in food technology, and in the marine resource economics research done at the Coastal Oregon Marine Experiment Station, is imperative.
- We can and should focus on the advantages of Oregon in our marketing and development

efforts. Because we live in a small state, we have the **luxury** of knowing one another, as people in larger states such as New York and California do not. We have the Oregon Department of Agriculture, Oregon State University, Oregon Sea Grant, the Coastal Oregon Marine Experiment Station, and the Seafood Laboratory, which can all provide useful input. The Oregon Department of Fisheries and **Wildlife** has a much more practical, cooperative attitude than do similar departments in Alaska and Washington, and we should be able to work with them too.

- It has been suggested that we should form some sort of a whiting group. We need an industry grouping of processors and fishermen, with liaison to the Oregon Coastal Management Association, the Coastal Oregon Marine Experiment Station, and the Oregon Department of **Agriculture**.
- My advice to fishermen: Get out and find out more about your product and its international markets. For example, you might subscribe to **INFOFISH**, a publication described by Mr. **Kano**. Continue to be politically astute and kick in financial support when needed. We need to change our attitude and accept the kinds of changes in gear and handling procedures mandated by the market. We can no longer say, "That's the way my grandfather did it and it's good enough for me."

