PRODUCTION AND MARKET DEVELOPMENT OF PACIFIC WHITING

(*Merluccius productus*)

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INTRODUCTION

There is a critical need for Pacific Coast producers of groundfish to maintain processing plant production levels so that existing facilities may be operated at a profitable margin. Recent increases in competition for groundfish and declining rockfish landings make it imperative that producers and processors alike seek new markets and supplies of fish. On the national level, there is a need to reduce a serious trade imbalance for fishery products. While U.S. fishery imports have continued to increase, reaching a record 5.1 billion dollars in 1983, export values in 1983 declined slightly to just over 1 billion dollars (U.S. Department of Commerce, 1984). The availability of a large Pacific whiting (Merluccius productus) resource close to the U.S. West Coast makes it a logical candidate for domestic exploitation to help Pacific Coast producers maintain profitable production levels and to offset the national trade imbalance. The objectives of this work were:

1. To report on available whiting marketing information from government documents.

2. To develop new whiting products and to investigate their acceptability in the marketplace.

3. To investigate potential whiting domestic and export markets.

4. To aid potential producers by developing information on whiting processing procedures, quality control, and marketing.

FOREIGN AND DOMESTIC MARKETS FOR WHITING

Whiting (hake) of the genus Merluccius is one of the most widely distributed fish in the world's oceans. There are seven major species, most of which are imported into this country as fillet blocks or individual fillets (Table 1). The Cape hake (M. capensis) and the New Zealand hake (M. australis) are preferred over other species. At times Cape hake brings prices similar to, or in excess of, those paid for cod in the European market. Pacific hake or whiting and Chilean hake (M. gayi) are probably the most similar in taste, texture, and general acceptability. All of these white fish species are good raw materials for battered and breaded portions, and for fish-in-sauce preparations.

Table 1. Major Whiting (Hake) Species of the Genus Merluccius.

Name	Species	Distribution
Cape hake	M. capensis	South Atlantic Ocean off South Africa
Argentine hake	M. hubbsi	South Atlantic Ocean off Argentina
European hake	M. merluccius	North Atlantic Ocean, Mediterranean Ocean, and Adriatic Sea
New England hake	M. bilinearis	North Atlantic Ocean off United States
Chilean hake	M. gayi	South Pacific Ocean off Chili and Peru
Pacific whiting	M. productus	North Pacific Ocean off United States
New Zealand hake	M. australis	South Pacific Ocean off New Zealand

U.S. Whiting Imports

Since the U.S. produces few whiting blocks, the amount of whiting imported is a good estimate of the size of the U.S. market for whiting. In 1982 and 1983, whiting imports amounted to over 24 million pounds. In 1982, whiting blocks accounted for 8.4 percent of the total volume of imported fish blocks, and 5.8 percent of the value. In 1983, these amounts decreased to 6.3 percent and 4.0 percent, respectively (Table 2).

Table 2. United States Imports of Cod, Pollock, and Whiting Slabs and Blocks for 1982 and 1983.[1]

Species	1982	1983
	(1,000 lbs.)	(1,000 lbs.)
Whiting (hake)	24,212	24,400
Pollock	61,018	79,493
Cod	149,092	197,979
Total (all species)	288,246	384,458

[1]Source: U.S. Department of Commerce, 1984

Argentina and Uruguay have been the major suppliers of imported whiting. Table 3 lists U.S. whiting imports for 1978, 1981, and 1982. In 1981 and 1982, 77 percent of all imported whiting blocks originated from Argentina (40%) and Uruguay (37%). Small amounts of whiting product came from the Republic of Korea (6.8%) and from Chile (5.3%). The remainder, accounting for less than 11 percent of all whiting block imports, came from 12 other countries.

Domestic Markets for Pacific Whiting

The total domestic catch of Pacific whiting from the U.S. West Coast was 15.6 and 17.4 million pounds in 1982 and and 1983 respectively (U.S. Department of Commerce, 1984). During both years more than 85 percent of the West Coast production was from Puget Sound, although a small amount of Pacific whiting was reportedly landed in Ft. Bragg and Eureka. The majority of the whiting landed on the U.S. West Coast was processed into meal, or headed and gutted for eastern U.S. and California markets.

The present size of eastern and midwest headed and gutted markets can only be approximated from data presented by Gendron (1980) on the 1976 utilization of silver whiting (*M. bilinearis*). He estimated a 1976 domestic production of headed and gutted silver hake of about 10 million pounds, and imports of about 6 million pounds. The recent collapse of the East Coast silver whiting fishery has resulted in an increased demand on the East Coast for Pacific whiting. It is not known how much West Coast product has been shipped east, but it is apparently taking up some of the slack in this market at prices very competitive with those paid for silver whiting.

California imports of unclassified whiting, including headed and gutted product, and the domestic California catch are reported in Table 4. The total California market for headed and gutted whiting cannot be estimated because product entering California from other states is not monitored. Since a large

part of the California catch is headed and gutted, the data in Table 4 represents only a portion of the California market estimated at 1.5 to 3 million pounds annually. The major California market for headed and gutted whiting is in the Los Angeles and San Francisco areas.

Table 3. U.S. Imports of Whiting Fillet Blocks Over Ten Pounds in 1978, 1981, and 1982.

Country	1978[1]	1981[2]	1982[2]
	(1,000 lbs.)	(1,000 lbs.)	(1,000 lbs.)
Argentina	17,433	10,233	11,369
Brazil	1,125		186
Canada	14	1,382	173
Chile	1,247	2,623	231
Denmark	205	472	458
Japan	2,532	555	79
Korea	3,092	1,686	2,021
Peru	1,422	22	87
South Africa	2,861	91	133
Spain	220		31
Uruguay	3,232	11,562	8,547
United Kingdom		102	233
Australia			123
New Zealand		1,014	541
Netherlands		1	
Belgium, Luxembourg		87	
Total	33,383	29,830	24,212

[1]Source: Gendron, 1980
[2]Source: National Marine Fisheries Service, Development Division, 300 Ferry Street, Room 2016, Terminal Island, CA 90732.

Table 4. California Production and Imports of Whiting in 1981 and 1982.[1]

	1981	1982
	(lbs.)	(lbs.)
California production (round weight)	1,442,424	2,215,096
California imports	100,520	527,715
Total	1,542,944	2,743,811

[1]Source: Data on California imports were obtained from the National Marine Fisheries Service, Development Division, 300 Ferry Street, Room 2016, Terminal Island, CA 90732; California whiting production data were obtained from California Department of Fish and Game preliminary 1981 and 1982 commercial seafood landing reports.

PACIFIC WHITING TEXTURE AND MARKET DEVELOPMENT

The soft texture of Pacific whiting is the major problem in market development. This is a problem for all species of hake, even for African Cape hake, believed to be the most desirable of all the hakes (Burt, 1974). Subtle differences in the extent and process of softening probably exist between the different hake species. For example, African Cape hake is commonly smoked for the United Kingdom market with good success, while Pacific whiting smoked during our work softened to the extent that it would be unacceptable for this market. These differences in texture degradation require different handling and marketing strategies.

Early in the exploratory phase of the Pacific whiting fishery, the texture problem was believed more widespread than observed in today's fishery. Improved harvesting techniques have reduced the occurrence of softness in whiting as well as in other fisheries (Dassow and Beardsley, 1974). Despite these improvements, Pacific whiting continues to have a bad reputation in some domestic and foreign markets because of its tendency to soften during thawing and slow-cooking procedures. However, it has been found that a firm whiting product can be achieved by rapid chilling and freezing of the fish, and by developing products that are designed to be cooked from a frozen state.[1] Fortunately, a large market exists for products cooked from a frozen state, and it is in this area that Pacific whiting marketing efforts should be concentrated.

Causes of Texture Degradation

Several researchers have investigated the nature of the chemical and physical process of softening in whiting. Patashnik et al. (1982) believed that enzyme activity, enhanced by temperature increases, caused tissue breakdown. It was thought that the enzyme was present in a myxosporidian parasite cyst found in whiting muscle tissue. Erickson (1983) confirmed that an enzyme was the causative agent of tissue breakdown, and located the enzyme in the muscle tissue fluid.

The enzyme-caused tissue breakdown can occur at nearly any temperature above freezing, but it is greatly enhanced at the warmer temperatures encountered in the handling facilities of fishery vessels and processing plants, and maximum enzyme activity occurs at 131°F to 149°F (Dassow, et al., 1970, Erickson, et al., 1983). Physical damage, such as bruising in the net, during bulk storage, and from handling, probably enhances enzyme breakdown because cell and tissue damage increases the surface area vulnerable to enzyme activity. Filleting may also have the effect of spreading muscle fluids in the tissue. A common observation is the development of a milky-pasty substance during filleting operations about three to four hours after fish are landed. This milky-pasty substance may be the result of enzyme activity.

[1]U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Utilization Research Division, "Weekly Activities Report," February 18, 1977.

Catching and Processing Techniques That Reduce Texture Problems

Observations of catching and processing techniques that produced superior tasting whiting were made in July, 1981, aboard the Canadian catcher/processor F/V Callistratus (Sabella, 1981). Net tows were limited to 15 to 20 tons to minimize bruising. When the unchilled fish were held on deck no longer than five hours, only ten percent turned mushy. By contrast, after ten hours of unchilled storage, as many as 30-34 percent of the fish were mushy. For this reason, every attempt was made to process the fish within four to five hours after being caught. The product was frozen within two hours in plate freezers.

Samples of whiting fillet blocks from the Canadian vessel F/V Callistratus were obtained from Mr. Gunther Elfert of Pacific Whiting, Ltd., Vancouver, Canada. Portions, 5/8 inch thick, were cut from the blocks, and fifty portions of whiting in butter sauce were prepared, repackaged, and then returned to frozen storage. All portions had good texture and a mild flavor after three months frozen storage. Portions were also battered, breaded, and deep fried, and grilled, and all samples retained good texture and quality after being cooked.

Fifty whiting samples, from fish handled by the same techniques used on the F/V Callistratus, were collected on the trawler Colintino Rose II in October 1982. All samples retained good texture and quality for two and one half to three months before off-flavors became apparent. On another occasion, whiting held one to two days in cold storage (mid to high 30°F range) could only be filleted with great difficulty, and even though there were no off odors or flavors, the flesh was definitely soft.

It is clear that the best whiting fillets are obtained by cutting and freezing within a few hours of catch. How much this time can be extended depends on a number of factors, including the method of preservation, freezing or storage in refrigerated seawater, or heading and gutting followed by storage on ice.

WHITING PRODUCT DEVELOPMENT

Handling of Raw Product for Product Development

Whiting samples for product development were obtained on the trawler Colintino Rose II of Coos Bay, Oregon. Deep skinned fillets were cut at sea within four hours of catch. Prior to cutting, fish were held in seawater at an ambient temperature of about 55°F. Fillets were washed and packed in plastic casings, 3, 4, 5, or 6 inches in diameter and approximately three feet in length. The weight of a three feet long 5-inch casing was about twelve pounds. Casings were shaken four or five times to prevent voids from occurring in the frozen product, and then the ends were tied. Few voids were observed.

In February 1983, a 140-pound sample of whiting was obtained at the Seafoods West, Inc. plant at Lynden, Washington. The fish were packed in ice and processed within one or two days of capture. The temperature of the fish was held in the mid to high 30°F range throughout the handling and processing cycle. Headed and gutted product was of good quality. However, filleting was almost impossible; fillets were either badly torn or could not be fully

skinned. When stored at 10°F, this product had a normal flavor for two to three weeks before off-flavors became apparent. The texture of the fish was fair to good.

A second sample of whiting was obtained from Seafoods West, Inc., within four to six hours of capture. A sample of skin-on fillets was prepared for the Australian market. Deep-skinned fillets were stuffed into casings for frozen portion samples using the methods employed on the Colintino Rose II, described above. These samples were stored at 10°F, and had normal flavor and texture for two months before off-flavors became apparent.

Experimental Whiting Products

Whiting product development studies were conducted by Mrs. Geraldine Barton, P. O. Box 2651, Petaluma, CA 94952. Mrs. Barton has been involved in the seafood industry for the past 20 years in commercial fishing, seafood processing, and as a seafood cookery expert. Product liability insurance was obtained from SCJ Insurance Service, P. O. Box 9, Pleasanton, CA 94566 by Mrs. Barton. Prior to product development activities, whiting was prepared using a variety of preservation methods including smoking, canning and pickling.

1) Canned Whiting--On three occasions deep-skinned fillets were canned following procedures generally used for canning tuna (Groppe and Crawford, 1977). One batch was canned in oil and two batches were canned in water. The product had adequate texture and was very mild in flavor. The water-packed product was preferred by most evaluators. Canned whiting was mixed with grated tuna in a sandwich spread, and its presence could not be detected. A mixture of 20 percent whiting and 80 percent tuna was used in two fish casseroles and found acceptable, although bland.

2) Smoked Whiting--Deep-skinned whiting fillets were smoked for eight to ten hours at 120°F to 140°F at Noyo Pride, Inc., Fort Bragg, CA. About 20 percent of the fillets became jellied during smoking, and the flavor of non-jellied fillets was only acceptable.

3) Pickled Whiting--Pickled whiting were prepared using a herring pickling recipe. The flavor and texture of the pickled whiting was acceptable, but occasional soft or jellied portions discouraged further experimentation.

The effect of different methods of preparation on the texture, color, odor, and appearance of deep-skinned whiting fillets was also investigated. Product was obtained from the Colintino Rose II five months prior to preparation, using the handling methods described previously. Six fillets were thawed, and each was cut into six portions. Each portion was prepared by smoking, canning, boiling in a bag, pickling, or drying. The results of these experiments are summarized in Table 5. One fillet softened completely during all methods of preparation. All samples that were boiled-in-a-bag degraded in texture. Pickling and canning tended to effect texture less than the other methods of preparation.

Table 5. Grading of Whiting Product Forms By Appearance, Odor, Flavor, and Texture

		Scores for Whiting Fillet Samples[1]							
		#1	#2	#3	#4	#5	#6	Total	Average
Raw Fillets:	Appearance	1	1	1	1	1	1	6	1.0
	Color	1	2	1	1	2	2	9	1.5
	Odor	1	4	2	2	3	3	15	2.5
	Freezer Burn		3						
	Gaping		2						
	Texture	1	1	1	1	1	1	6	1.0
Whiting Products: (separation of fiber, texture)	Smoked	1	4	2	2	2	2	13	2.2
	Baked	1	4	2	2	3	2	14	2.3
	Canned	1	4	2	1	2	2	12	2.0
	Boil-in-a-bag	2	4	3	3	4	2	18	3.0
	Pickled	1	3	1	2	2	1	10	1.7
	Dried	2	3	3	3	3	2	16	2.7
Whiting Products:	Appearance	1	3	2	2	3	2	13	2.2
	Color	1	3	3	2	3	2	14	2.3
	Odor	1	4	3	3	4	3	18	3.0
	Flavor	1	4	2	2	4	3	16	2.7

[1] 1 = good; 2 = satisfactory; 3 = poor; 4 = unsatisfactory

Whiting in Butter Sauce

Whiting in sauce is a common method of preparation in Europe (McClane and deZanger, 1977). Mr. John Kline, Seafood Marketing Consultant, Novato, California, first introduced the Whiting Product Development Group to whiting in butter sauce. Whiting portions, 5/8 inches thick were cut from 4, 5, or 6 inch diameter whiting logs, prepared and frozen at sea. Butter Sauce For Fish (UC-1481, Griffith Laboratories) was rehydrated according to the manufacturer's instructions, heated to a boil, cooled to 40°F, and then poured over the frozen whiting portions. The whiting in butter sauce portions were individually vacuum packaged and frozen in a blast freezer. Samples were prepared by baking the frozen portions for 20 minutes at 375°F.

A florentine sauce and a almondine sauce were also prepared from the Butter Sauce For Fish. For the florentine sauce, frozen and thawed spinach was mixed into the heated butter sauce, using one pound of spinach per 20 pounds of butter sauce. For almondine sauce, sliced almonds were sprinkled on the butter sauce before the portions were packaged. The sauces did not separate during freezing or baking, if they were prepared correctly. One sample of butter sauce was not precooked, and developed an off-flavor and tended to separate during baking. The texture of the whiting remained firm, and did not soften during baking.

Nursing homes, hospitals, and other health-care facilities generally use tuna in preparing fish-in-sauce menu items. However, one of the largest nursing home chains in the U.S. has tested whiting-in-sauce products on several occasions. When good quality whiting was used, consumer acceptance was good. The positive results of these trials should encourage increased marketing efforts in health-care institutions.

Whiting-in-sauce prepared from shoreside processed fish has been test marketed on a limited scale. If quality and texture can be maintained, and the products are consumed before serious cold storage off-flavors develop, it may be possible to increase the use of Pacific whiting significantly by utilizing shoreside processing facilities.

Battered and Breaded Whiting

Mr. Jean Joaquin, Seafood Technologist and product development expert, was instrumental in convincing our Whiting Product Development Group that battered and breaded whiting can be acceptable to the domestic market. A whiting patty product was developed and tested.

Whiting portions, 5/8 inches thick were cut from five inch diameter whiting logs, prepared and frozen at sea. For each one pound of finished product, 0.31 pounds of water and 0.01 pounds of batter mix (#120 Adhesion Batter, Griffith Laboratories) were mixed until smooth with a wire whip. The frozen whiting portion was dipped in the batter and then coated with breading (#888 Breading, Griffith Laboratories). The battered and breaded portions were refrozen, vacuum packaged, and held at -30°F. Samples were prepared by frying in oil for five to six minutes at 355°F.

Frozen whiting patties have been tested at several restaurants. The owner of the Captain's Broiler, Arcadia, California tested the frozen whiting patties with his own breading and batter. The owner indicated he would like to try this type of product in place of the fish sandwich he now serves. Unfortunately, only a single restaurant is involved, and storage is limited to a one- to two-week supply. The owner estimated that he would need about 20 pounds of frozen whiting portions per day.

A presentation was made to Sportsmen's Seafoods, a fish and chips restaurant in San Diego owned by Cosimo Busalacchi. Mr. Busalacchi indicated that our battered and breaded whiting product was good, but that he preferred to continue using the tuna burger he now sells.

Mr. Douglas Harbison, R. M. Sloan Company, San Pedro, California, presented our product at a "white tablecloth restaurant". The owner indicated that he didn't want a fish sandwich on the restaurant's menu, but that the product would be acceptable for a fast-food restaurant. The operators of a Jack-in-the-Box Restaurant in San Diego, California tested the product and indicated that they preferred the cod portions they were using.

Schools in Coos Bay, Oregon and Oakland, California commonly serve minced, battered, and breaded fish portions. A presentation of our breaded, baked, and frozen whiting portions was well received by elementary school children and kitchen staff in Coos Bay schools. Mr. Steve Martel of SAGA, Inc., Coos Bay, Oregon indicated an interest in purchasing frozen whiting portions that could be breaded and baked by the schools' kitchen staff.

The West Coast Fisheries Development Foundation conducted a tasting of our breaded whiting products at a reception they held for national and regional fisheries dignitaries, including their Board of Directors, members of the Pacific Fisheries Management Council, and directors of all regional offices of the National Marine Fisheries Service. The product was very well-received.

Battered and breaded products for oven baking were also developed. However, development of these products was discontinued when it was found that strong off-flavors developed during frozen storage after deep frying the portion briefly to set the batter. The development of this off-flavor is perplexing, since the same product frozen, and then cooked completely by deep frying had no off-flavor.

Most battered, or battered and breaded, fish portions in West Coast supermarkets are cod, pollock, or whiting. All of the pollock and whiting portions tasted were found to have off-flavors due to excessively long frozen storage or to poor handling. The market for these products probably could be expanded, if the products were handled better and they were consumed before off-flavors develop.

POTENTIAL MARKETS FOR PACIFIC WHITING

Headed and Gutted Pacific Whiting

The major market for Pacific whiting is for headed and gutted products for foreign markets. These products are produced in the Pacific Coast joint venture fisheries with Russia, Poland, and Bulgaria. Figures are not available on the product form produced by these fisheries, but it is believed that nearly all fish that are not put into meal are processed into headed and gutted products. We did not observe any Russian fillet operations on three visits to fishing grounds in 1981 and 1982 when approximately ten Russian processors were in operation.

Although present market tonnages for domestic headed and gutted Pacific whiting are well below production levels, probably less than 20 million pounds for all markets, domestic production is increasing. Headed and gutted whiting is produced on a small scale in California and Oregon, and to a greater degree in the Puget Sound fishery during the winter. Because the headed and gutted U.S. market is believed to be a small fraction of the total market available, market forms such as frozen fillet blocks, shatter-packed fillets, and canned whiting must be produced to fully exploit the Pacific whiting fishery.

Frozen Pacific Whiting Blocks

At least two sea-going fishing operations have experimented with Pacific whiting fillet block production in the past three years. The Offshore Factory Trawler Demonstration Project, sponsored by the West Coast Fisheries Development Foundation, was completed in 1980. They recommend that market development efforts be concentrated on the headed and gutted market and the institutional market for frozen fillet block products.

In 1981, Canadian fishermen experimented with block production in a private venture with the F/V Callistratus (Sabella, 1981). Blocks manufactured at sea in this operation were of very good quality. Unfortunately, prices for frozen whiting blocks decreased to about $0.70/lb before market acceptability could be established, and the project was discontinued after a single season. With the cost of production believed to be in the $0.80/lb. range, it is necessary to make value-added products, such as fish-in-sauce, to recover production costs, and to be less vulnerable to price fluctuations in the import block market.

The quality of imported frozen fillet blocks may not be as good as commonly believed. We evaluated battered and breaded whiting presumably of foreign origin and found off-flavors prevalent. In contrast, Pacific whiting of Canadian origin had virtually no off-flavors until after about three months of frozen storage. For this reason, locally-produced Pacific whiting may have a competitive edge on imported product that cannot be consumed within three months of production.

Off-flavors in imported whiting blocks may, in part, be the result of the high fat content of whiting fillets. Dassow and Beardsley (1974) reported that Pacific whiting fillets contained 2.5 percent fat, and that cod fillets contained only 0.6 percent fat. Off-flavors are known to occur from fat oxidation during frozen storage (Connell, 1975). The recent large decrease in whiting imports from 33 to 24 million pounds between 1978 and 1983 may be an indication of consumer resistance to foreign whiting products.

One California producer, Eureka Fisheries, has been processing Pacific whiting blocks on a pilot scale for at least three years. Fish are landed, stored in refrigerated seawater, and hand-filleted the following day. The fillets are then quick frozen in a plate freezer. There has been a gradual acceptance of this product reprocessed into whiting-in-sauce products. If quality standards can be maintained, and storage time kept to a minimum, it may be possible for Pacific whiting to compete successfully with imported products.

The Australian Market for Skin-on Fillets

The Australian market for skin-on whiting fillets is substantial and bears consideration. Table 6 presents data on the amount and price of whiting entering Australia from various countries in 1981. Over 20 million pounds of whiting were imported by Australia in 1981. Most of the product consisted of shatter-packed, skin-on fillets. Imports of whiting were from nine countries, but the Republic of South Africa provided just over half of the total, and Chile and Japan provided much of the remainder. It can be estimated from the data in Table 6 that the mean price of whiting imported into Australia is 0.77 Australian dollars per pound. By comparison, the mean price for U.S. imported whiting blocks in 1981 was 0.70 U.S. dollars per pound (Anonymous, 1981).

Specifications for skin-on whiting fillets obtained from SAFCOL Holdings, Ltd., 30-46 Wright Street, Adelaide, S. Australia, 5001, were as follows: the fish must be scaled; the pin bones should be kept in and all other bones removed; the fish should be white in color; splitting or gapping must be kept to a minimum; shatter packs should be graded by size in 2-4, 4-6, 6-8, 8-10, 10-12, 14-16, and 16 ounces and up; and fillets should be shipped at -20°C.

Table 6. Imports of Whiting into Australia in 1981.[1]

Country	Tons	1,000 Lbs.	$ Aust./Ton	$ Aust./Lb.
Argentina	65.1	143,220	1,046	.47
Canada	16.3	32,000	1,795	.82
Chile	2,244.5	4,937,000	1,876	.85
Japan	1,706.1	3,753,420	*1,441-1,930	.66- .88
Korea	490.9	1,079,980	*1,780-1,905	.81- .87
S. Africa	4,738.8	10,425,360	*1,491-1,706	.68- .77
New Zealand	121.7	267,740	*2,325-1,192	.54-1.06
Peru	36.0	79,200	724	.33
USA	21.0	426,200	*1,970	.81

* Prices for packs less than 1 Kg.
[1]Source: SAFCOL Holdings, Ltd., Adelaide, Australia

It is likely that any exploitation of the Australian market by U.S. suppliers would require machine filleting operations. A sample of 60 pounds of frozen, whole whiting was sent to A&W Manufacturing in Gladstone, Michigan to test the performance of their Lapine M-45 filleting machine for meeting the Australian specifications for whiting listed above. Fish, 3/4 to 2-1/4 pounds each, were machine filleted. The fish were individually quick frozen round whiting that had been thawed for 24 hours. The machine did not stall or jam, but fresh fish would probably work much better on the standard M-45 filleting machine. The backbones appeared to remain intact upon removal. The ribs were removed in two, separate 20-pound trials. The yield of untrimmed, unskinned fillets was approximately 45 percent for both trials. The heads were v-cut by hand. Cutting the heads straight to remove all four fins also worked well. Forty round fish made 60 pounds of product.

Ben Brower, who did the testing for A&W Manufacturing, commented that hake ribs are heavy bones, horizontal from backbone to skin, and that the machine sometimes leaves portions of ribs. He noted that since the ribs are in the same position as the pin bones, removal of the pin bones would also remove rib bones. He recommended the following settings for filleting of whiting using the Lapine M-45: back spacer setting -.250; belly spacer heading -.187; light spring pressure.

It is unclear from these trials whether or not the Lapine M-45 filleting machine can be used to produce skin-on fillets for the Australian market. The occurrence of rib bones is unacceptable, and the problem would seem to be whether or not the Lapine machine can remove enough of these bones to meet market specifications. Optimal performance from the machine seems to require fresh fish caught within a few hours of processing. Since the occurrence of gapping, or muscle fiber separation, is another major problem in meeting specifications, it may be that only fish filleted within a few hours of catch can be used to produce the quality needed. Future tests should be designed to study the problems of rib bone removal and gapping. In addition to using fresh fish to reduce the incidence gapping, Burt (1974) suggests that immersion for two minutes in six percent salt solution, followed by a half to two minute immersion in 12.0 percent sodium tripolyphosphate before freezing should also reduce gapping.

In March 1983, a sample of skin-on fillets from Puget Sound was sent to SAFCOL Holdings, Ltd. in Australia for market evaluation. Fillets were cut by hand at the Seafood West, Inc. dock in Everett, Washington and transported to Lynden, Washington, where they were packed in a five pound container and blast frozen. Except for the method of cutting, which left the rib bones in the fillets, SAFCOL found that the product was acceptable, with good color and little splitting or gapping. Assuming the use of the proper fillet cut, a price of $1.30 (U.S.) per kilo was quoted for fillets CIF at an Australian port. Two steamship companies, Columbus Line and Pacific Australian Direct Line, were suggested for shipments from the San Francisco area.

A second sample of skin-on fillets for the Australian market was prepared by Mr. Charles Eickhoff, 7314 Sand Dollar Street, Coos Bay, Oregon, 97420. A seven pound sample was filleted within four hours of landing offshore from Coos Bay. Mr. Andrew Williams of SAFCOL Holdings, Ltd., evaluated the samples as follows:

> "Fillets are cut properly, but they are generally dark in color. A chalky white is preferred. There is a tendency for these fillets to mush when thawed out. Our market requires thawing and cutting fillets into smaller portions. Large, firm fillets, six to eight ounces, are preferred for this trade. Your samples averaged about five ounces. Samples should also be double wrapped, since they are beginning to dry out. At first glance, we expected fish would have to be scaled, however, upon thawing, it appears that Pacific whiting has very small scales which probably will be acceptable."

On the basis of these evaluations, we conclude that the texture breakdown of offshore-produced Pacific whiting and the small size of Puget Sound whiting make further exploitation of the Australian skin-on fillet market a low priority. However, it is worthwhile to monitor the Australian market for any possible changes in requirements, such as an apparent trend to use product cooked from a frozen state.

Although occasional skin-on fillets are observed in California supermarkets, unless this product can be delivered for cooking from a frozen state, it should not be sold domestically. Negative consumer reaction to softening upon thawing, and texture breakdown in the fresh fish counter could have serious implications for other whiting marketing ventures.

Preparation of breaded, skin-on fillet portions designed to be cooked from a frozen state should be evaluated for domestic as well as Australian markets. The positive aspect of selling skin-on fillets is economic. It is possible to achieve yields from skin-on fillets reaching 40 percent of the whole fish. This is double the yield expected for deep-skinned fillet operations. In the Australian market, skin-on fillets bring about the same price as deep-skinned fillet blocks. The negative aspects of skin-fillet marketing should be examined. The effect of retaining the ribbon of fat along the lateral line just beneath the skin may limit potential markets to consumers that prefer a "fishy" flavor. Consumer acceptance studies and product development work are needed to confirm this.

Canned Whiting

Flavor and texture evaluations of canned whiting were generally positive. Malabar, P.O. Box 129, Bodega, California, 92923, prepared a plan for a canning line to process fifty tons of product per day for potential foreign and domestic markets. The Malabar project has been recently discontinued. Information on potential markets for canned whiting is lacking.

Speciality Products

Technological advances in the development of poultry products in the U.S. and the manufacture of fish jelly in Japan have added greatly to our ability to supply the consumer with a myriad of new, ready-to-eat products. Fish jelly is the name given to a fish base formed from washing the fat from deboned fish and adding sugar, salt, seasonings, and other ingredients. The jelly-making potential of Pacific whiting was recently evaluated by Okada and Noguchi (1974). It was considered low to moderate in its jelly-forming capability because of the tendency for tissue degradation caused by enzyme activity. If the enzyme could be deactivated in some manner, another potential product for this fish might be possible. Because of the American preference for bland fish with a moderate texture, it is felt that a product with the neutral flavor of fish jelly and the texture of canned Pacific whiting might be the specialty product most likely to attract U.S. consumers. Research should be encouraged to investigate speciality as well as traditional canned fish markets.

The Domestic Armed Services Market for Pacific Whiting

The domestic market for Pacific whiting can be expanded if whiting receives certification by the U.S. Armed Services; certification is presently under consideration. A description of the product, its acceptability, and background information is given in Appendix 1. This description was developed by Mr. Chris Toole, University of California Sea Grant Marine Advisor in Eureka, California, in conjunction with the Eureka Fisheries, Inc. Because of the positive consumer acceptance information obtained from this work and that of others, it is likely that product specifications can be negotiated to allow use of Pacific whiting products by military installations.

Whiting Fish Meal Production and Marketing

Some whiting fish meal is now produced on Soviet joint venture processors, and there are several plants in the Washington Puget Sound area that utilize either whole fish, offal, or both when available in the winter whiting fishery. As the headed and gutted whiting market develops, more offal will be used to make meal. The idea of utilizing whiting for meal is not new. There is considerable information about the use of whiting in the 1960's exclusively for meal. Acceptability of whiting meal as poultry feed has been studied by L.R. Berg (1970). He found that whiting meal promoted good growth in broilers when added at the five percent level. Nelson and Dyer (1970) discussed technical problems of meal making and looked at market potential. Operations in the 1960's were not profitable because of the low prices paid for meal at the time (in the range of $3.00 per unit, or per cent of protein content). With current prices approaching $6.00 a unit, it is now more feasible to produce meal from

whiting. The increased use of poultry in U.S. diets makes the outlook even brighter.

A supply of whole fish is often available from the Soviet joint venture fishery for whiting. Small whiting and overcatches of fish are available to U. S. catcher boats on a fairly regular basis. Meal could be made from fish as they become available during normal operations. Meal production is not labor intensive and, in most cases, existing crew could do the job. Fish holds in the larger catcher boats (those in the 100-foot range) could easily provide the space needed for a meal plant capable of producing four or five tons of meal per day. Local fish meal equipment suppliers are the Beaverton, Oregon representative of the Stord-Bartz Company of Bergen, Norway and J.R. Townsend Company, P.O. Box 1638, Carmel, California, 93921.

Domestic fish meal supplies probably do not meet local demand on the U.S. West Coast. Present sources of fish meal for poultry producers include anchovy meal from southern California and Mexico and herring meal from Canada. One domestic poultry producer, Foster Farms of Modesto, California, indicated a need for seven to eight thousand tons of whole fish meal per year. Their specifications are as follows:

1. Steam dried meal preferred, with less than 10 percent moisture content.

2. Seller must guarantee a minimum protein content for bulk shipments.

3. Antioxidant - ethoxyquin - to be added at the rate of 750 ppm.

4. After testing, will purchase one 25 to 50 ton bulk load for more testing.

5. Prefer to work with 600 ton contracts, with 150 ton-per-week deliveries.

Poultry feed is not the only use for fish meal. Feed for trout and salmon also has large requirements for fish meal, and producers should explore this market as well. A market for white fish meal for feeding eels was identified in Taiwan. Product specifications were stated only approximately, with the buyer indicating that acceptable meal should contain 68 percent protein, 7-8 percent each of moisture and fat, and 15 percent ash. The quantity needed is two to four thousand tons per year. A U.S. contact for more information about this market is Mr. Ken Takayama, WESCON International, 380 Swift Avenue, South San Francisco, California, 94080.

SUMMARY OF INDUSTRY APPLICATIONS

Guidelines for product development were based on recommendations of the National Marine Fisheries Service (Patashnik et al., 1982). Sea-frozen product was used, and it was not allowed to thaw from the time it was first frozen on the boat until it was cooked from a frozen state by the prospective consumer. A method of preparing frozen portions was developed that consisted of stuffing polyethylene casings (sausage-type casings) with deep-skinned fillets, freezing, and cutting to the desired thickness with a band saw. This use of casings made it possible to work with the product without the need for costly equipment to manufacture fish blocks at sea.

Test marketing of whiting-in-sauce was conducted by the Meredith Fisheries Company in Sacramento, California and the Western Sea Treat Company of Marysville, California. The target market was health care facilities, such as nursing homes, and senior citizen centers. To date, about 10,000 pounds of whiting in sauce have been sold in pilot acceptance programs. The potential for this market is growing as the average age of the U.S. population increases. Acceptance of this product could greatly increase domestic use of Pacific whiting. Western Sea Treat Company recently discontinued the Pacific whiting project.

Marketing of a battered and breaded whiting portion has not yet been achieved. SAGA, Inc., an Oregon food distributor, and a school lunch administrator in Coos Bay, Oregon have indicated interest in purchasing two-ounce frozen whiting portions that could be breaded by kitchen staff. A test of this product was carried out by Mrs. Kathryn Vanderpool in March 1983 in two Coos Bay schools, and the product was enthusiastically accepted by students and kitchen staff.

Exploitation of the large Australian export market for skin-on fillets may be possible if certain product specifications change in the future. The magnitude of this market is approximately 20 million pounds annually. The tendency for Pacific whiting to soften when thawed precludes its use in the Australian fish and chips market. However, if present methods change and fish are cooked from a frozen state, development of this market would be possible.

The use of whiting in fish meal is another potentially important area for product development. Production of fish meal could provide needed supplementary income for some whiting producers.

RESEARCH NEEDS

The most pressing research need is to determine the handling techniques required to supply a quality whiting in sauce product for the senior citizen trade. Preliminary work indicates that shore-side processing techniques may be adequate. However, potential texture problems need monitoring. The taste preferences of senior citizens need to be better defined, particularly in regards to cold storage off-flavors.

Although a headed and gutted market for Pacific whiting is developing, consumer acceptance studies are lacking. In addition, little work has been done to determine how this product should be stored or prepared. The skin-on fillet market should also be explored for possible development of breaded fillet products to be cooked from a frozen state. Consumer acceptance information for such products is also needed. The response of Pacific whiting to various cooking methods is another important area for future research. Taste and texture information is needed, particularly regarding the relationship between time in cold storage and the development of off-flavors and texture problems. More work is needed to define the enzyme degradation reaction, its timing, and how it might be controlled by handling or fishing techniques. The effect of bruising on enzyme activity may be more important in quality control than currently recognized.

In the two hake processing operations we observed at sea, the fish were generally not chilled before processing. Information is needed on the effects of different temperatures of liquid and ice-chilling systems on enzymatic breakdown at the time of processing, before and during freezing, and when cooked in different ways.

Information is also needed on enzymatic tissue degradation in different stocks of Pacific whiting. Puget Sound stocks are believed to be less effected by enzymatic tissue breakdown than other stocks.

Finally, more work is needed in the area of product development. Because of the American consumer's preference for bland fish with a moderate texture, it is likely that a product with the neutral flavor of Japanese fish jelly and the texture of canned Pacific whiting would attract the attention of the U.S. seafood consumer.

CONTRIBUTIONS

The following industry, government, and university individuals aided greatly in providing information and various kinds of aid to complete this report:

Eureka Fisheries, Mr. Jerry Thomas, P.O. Box 217, Fields Landing, California 95537; provided samples for skin-on machine fillet demonstration, provided samples for sauce products, and tested sauce products in a restaurant.

Pt. St. George Fisheries, Les Amundsen, Tony Delima, 8 Sebastopol Road, Santa Rosa, CA 95401; provided freezer space, cut and packaged samples and provided information.

Meredith Fisheries, c/o John Kein, 1811 Novato Blvd., Novato, CA 94947; began early work to develop whiting in sauce market for senior citizens.

Western Sea Treat, Mr. Andy Rosen, P.O. Box 251, Marysville, CA 95901; engaged in processing Pacific whiting sauce products for senior citizens centers.

Noyo Pride Fisheries, Mr. Gene Mattiuzzo, 32410 N. Harbor Drive, Fort Bragg, CA 95437; provided smoker, space, and numerous samples for product development.

Pacific Whiting Ltd., Gunther Elfert, 1899 Layton Drive, North Vancouver, British Columbia, Canada, V7H 1Y1; supplied samples for product development and hosted a trip to observe sea processing on the F/V CALLISTRATUS.

SAFCOL Holdings Ltd., Peter Edmonds, Andy Williams, Bill Froiland , 30-46 Wright Street, Adelaide, South Australia 5000; evaluation of samples for Australian market.

MALABAR Fisheries, P.O. Box 129, Bodega Bay, CA 94923; provided information on canning whiting.

Seafood West Inc., Mike Parks, P.O. Box 846, Vashon, WA 98070; provided plant space, samples for Coos Bay school lunch program, and skin-on fillets for Australian market, SAFCOL Ltd.

Ouest Trading Co., Nancy and Charles Eickhoff, 7314 Sand Dollar Street, Coos Bay, Oregon 97420; provided skin-on fillet samples for Australian market, and aided with work at sea.

R.M. Sloan Co., Doug Harbison, 150 W. 7th Street, Suite 204, San Pedro, CA 90731 provided product testing.

Winkelman Bros. Meat Co., 12830 Valley Ford Road, Petaluma, CA 94952, provided product testing and storage.

Foster Farms, Mr. Dale McDaniel, 1000 Davis Street, Livingston, CA 95334; provided information on utilization of fish meal in poultry feeds and completed feeding trials indicating whiting meal is a viable poultry feed for their operations.

Sportsman Seafoods, Cosimo Busalacchi, 1617 Quiviva Road, San Diego, CA 92109; prepared whiting for consumer acceptance opinion.

Allied-SYSCO Co., 30977 San Antonio Street, Hayward, CA 94544; Mildred Hipkiss, Merchandiser provided information of Oakland school lunch program.

Durkee Foods, Ken Martin, 3706 Diablo Blvd., Suite 310, Lafayette, CA 94549; provided deep-frying oils for cooking samples.

A. W. Manufacturing, Inc., Mr. Trevor Wastell, P.O. Box 268, Gladstone, MI 49837; ran skin-on fillet trials.

Griffith Laboratories, Mr. John Weinrich, Pelman Sacks, Robert McMahan, Leo Krebs, 33300 Western Avenue, Union City, CA 94587; provided about 50 pounds of sauce products, a variety of breadings, batters, liquid smoke, and other ingredients, also use of their test kitchen for deep frying trials.

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National Marine Fisheries Service, Joe Farrell, P. O. Box 1668, Juneau, Alaska; provided all types of information about marketing.

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Keller, Mathew, 13290 Dupond Road, Sebastopol, CA 95472; provided information on marketing troll-caught Pacific whiting.

Barton, Geraldine, P. O. Box 2651, Petaluma, CA 94953; developed six different whiting products with two basic formulations, carried out cooking trials evaluating different cooking methods, developed vacuum packaging technique for various samples, and provided most of the samples for consumer trials.

Townsend, J. R., P.O. Box 1638, Carmel, CA 93921; provided information on fish meal marketing procedures and equipment.

Toole, Chris, Marine Advisor, Foot of Commercial Street, Eureka, CA 95501; obtained samples for product development, wrote specifications for Pacific whiting use in military markets.

Vanderpool, Kathryn, Rt. 2, Box 679, Coos Bay, Oregon 97420; conducted a series of seafood preparation workshops on methods of cooking whiting. Developed an oven-baked breaded whiting and demonstrated its use in Coos Bay, Oregon schools.

Joaquin, Jean, Seafood Technologist, 420 Yosemite Court, Petaluma, CA; was instrumental in formation of a group to work on Pacific whiting and he convinced members of this group that Pacific whiting products have good potential in the market place. Joaquin opened his home and demonstrated various products using locally-caught fish.

Klein, Richard, P.O. Box 1840, Sausalito, CA 94965; provided many suggestions on our project including suggestions on restaurant marketing.

Pigott, George, Inst. for Food Science and Technology, College of Fisheries, University of Washington, Seattle, Washington 98195; provided laboratory apparatus for making fish meal.

Flechsig, Art, former Marine Advisor, San Diego County; provided market contacts and consumer trials.

Klein, John, 1811 Novato Blvd., Novato, CA; aided with formulation of sauce, market contacts on sauce, aided with formulation of canned product, information on packaging.

Strong, Dick, Marketing Consultant, 8 Madronal Way, Orinda, CA 94563; provided marketing ideas and contacts, and general consultation.

Abbott, Robert, Aquaculture Consultant, San Francisco Foundation, Paradise Drive, Tiburon, CA 94920; aided with fish meal proposal, general consultation.

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APPENDIX 1

Military Market Statistics

DESCRIPTION OF PRODUCT

Pacific whiting (Merlucclus productus) is a fish that is closely related to Atlantic whiting (Merlucclus bilinearis, also known as "silver hake"), a species that is currently sold to the U.S Armed Forces. It is found from the Gulf of Alaska to the Gulf of California, but most is caught between British Columbia and central California.

Pacific whiting is a white-fleshed fish which, when kept at low temperatures after catching and when processed rapidly, has a firm texture and mild flavor. The product is available from Eureka Fisheries in 18-1/2 pound blocks of deep-skinned fillets. These are dipped in a commercial preparation of Brifisol D 510 to retard oxidation and rancidity. The product is usually prepared as a battered and breaded portion, which can be served alone or with a variety of sauces, as an inexpensive and quickly-prepared main dish.

ACCEPTABILITY

For the past 20 years, Pacific whiting has been fished heavily by eastern European countries. The fish are either headed and gutted or filleted and blocked and are a popular food item in Europe and other parts of the world.

Eureka Fisheries has been selling Pacific whiting in California and other western states for the past three years. We have witnessed a steady increase in demand for our product during this time. Most of the product is sold headed and gutted through supermarkets but approximately 20 percent is sold as IQF fillets and a very limited amount as deep-skinned fillet blocks.

Recently a "Product Development and Marketing Group for Pacific Whiting" has been formed through the West Coast Fisheries Development Foundation. They have test marketed Pacific whiting in several forms and have found the most acceptable products are breaded and battered and sauce products. Favorable responses to this product have been obtained from nursing homes, schools, and restaurants in California and Oregon.

PACKAGING INFORMATION

Deep-skinned fillets are formed into 18-1/2 pound blocks and measure 19 x 11-3/8 x 2 1/2 inches. They are transported to a major breader to be portioned and breaded. They are then packaged according to military standards.

AVAILABILITY

The maximum sustainable yield is 175,500 mt per year and less than 5,000 mt per year is currently processed domestically. Domestic fishermen currently harvest over 60,000 mt, which are delivered to foreign processing vessels in joint venture operations. Pacific whiting is available from March to September.

STABILITY or SHELF LIFE[1]

Untreated fillet blocks of Pacific whiting will maintain their quality for 3 - 4 months if stored at 0°F and for 6 months if stored at -20°F. Fillet blocks treated with an antioxidant will maintain quality for 6 months if stored at 0°F and 9 - 12 months if stored at -20°F.

PREPARATION INSTRUCTIONS

For best quality, battered and breaded portions should be no more than 3/8-inch thick and should be kept frozen until cooked, preferably by deep fat frying at 385°F for three minutes.[2] The portions you are receiving were cut and prepared by personnel from the NMFS Utilization Research Division, Northwest and Alaska Fisheries Center. They will be in contact with you to describe any specific preparation instructions and to answer any questions.

The "Product Development Group for Pacific Whiting" has found that there is a strong consumer acceptance of breaded and battered whiting and whiting served in various sauces.[3]

NUTRITION

Pacific whiting has the following characteristics per 100 grams: [4]

Calories	91.0
Protein	16.1%
Fat	2.5%
Minerals	1.1%

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[1] Information From: Harold Barnett, Utilization Research Division, Northwest and Alaska Fisheries Center/NMFS, 2725 Montlake Blvd. East, Seattle, WA 98112, (206) 442-4431.

[2] Patashnik, M. et al. 1982. Pacific whiting, Merluccius productus. I. Abnormal muscle texture caused by myxosporidian-induced proteolysis. Marine Fisheries Review 44(5):1.

[3] Butter Sauce for Fish UC-1481. Available from: Griffith Laboratories, USA, Inc., 33300 Western Avenue, Union City, CA 94587

[4] National Marine Fisheries Service. 1980. Nutritional values in north Pacific fish and shellfish. Utilization Research Division, Northwest and Alaska Fisheries Center, NMFS, Seattle, WA 98112. 8 p.