PACIFIC HAKE (MERLUCCIUS PRODUCTUS) AS RAW MATERIAL FOR A FISH REDUCTION INDUSTRY

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ABSTRACT

Pacific hake can be processed successfully into fish meal and oil with carefully selected equipment of conventional design for fish reduction. High efficiency in harvesting and processing this resource will be essential to a profitable operation.

INTRODUCTION

GENERAL: Pacific hake (Merluccius productus) has been found in commercial quantit off the coasts of California, Oregon, Washington, and British Columbia. This fact can be in portant to the Pacific Coast fish-reduction industry which has been reduced to a small frac tion of its former size as the result of the decline in abundance of industrial species. The need to establish a productive hake fishery is emphasized even further by the fact that Unit States imports of fish meal have increased from 45 to 210 percent of domestic production i the past 5 years.

The Department of the Interior's Bureau of Commercial Fisheries is cooperating with the fishing industry in trying to fill this need. Development work with midwater trawl methods and equipment, and extensive but still incomplete survey work on the hake population, conducted by the Bureau's Exploratory Fishing and Gear Research Base at Seattle[1/], are beginning to provide a basis for a revived fish-reduction industry on the Pacific Coast. This report is an evaluation of what has been learned to date of the possibilities for Pacific hake for reduction by present commercial methods and supplying the existing markets for fish meal, oil, and solubles.

PACIFIC HAKE RESOURCE: Research on the potential hake fishery is being carried ou jointly by the Bureau's Exploratory Fishing and Gear Research Base and the Bureau's Biological Laboratory at Seattle. Information is being sought on the extent of the hake resource, its productive capacity, optimum fishing periods, and the best fishing practices for maximum sustained yield. Preliminary surveys indicate that Pacific hake (Merluccius productus) are found in commercial quantity from Baja California, Mexico, to British Columbia, Canada. Intensive but limited surveys off the coasts of Washington and Oregon in 1964 found some schools of hake numerous and large enough to sustain a fish-reduction industry of modest size. Available schools are defined for this article as being those found at depths of 40 to 60 fathoms that can be fished successfully with the Cobb pelagic trawl. The hake off Washington and Oregon appear to school sufficiently for commercial fishing from May or June through October or November, making this fishery a potential summer and fall operation.

Fig. 1 - Hake from Puget Sound being unloaded by pump.

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1/"Construction and Operation of Cobb Pelagic Trawl--1964," by Richard L. McNeely, Leonard J. Johnson, and Charles D. Gill, Commercial Fisheries Review, October 1965, pp. 10-17 (also Separate No. 743.)

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Large populations of hake are found to spawn off the coast of California in much deeper water. This apparently greater potential hake fishery off California is not included in this report since the required summer and fall surveys have not been made and the combination of effective gear and methods for harvesting has not been determined.

UTILIZATION: The possibility of using Pacific hake in both food and nonfood products has been the object of some preliminary investigation by the Bureau's Technological Laboratories at Seattle (Washington) and College Park (Maryland). The products being considered are fish or frozen fillets, frozen blocks of fillets, pet food, mink food, fish protein concentrate, and industrial products (fish meal, oil, and solubles). Since markets for the industrial products are established and strong at this time and, in our judgment, the meal, oil, and solubles from hake could be established in these markets in a short time, our first effort is in the direction of reduction.

HAKE REDUCTION

The reduction of Pacific hake into fish meal, oil, and solubles is being investigated in cooperation with the fish-reduction industry in Oregon, Washington, and British Columbia. That area was chosen because of the large concentrations of hake found there to date in available schools and because a relatively complete cross-section of the existing types of commercial reduction plants that might process hake are located there.

PACIFIC HAKE (MERLUCCIUS PRODUCTUS) AS A RAW MATERIAL: The characteristics of Pacific hake as a raw material for reduction are shown by the proximate analyses in table 1. In 1964, the hake caught in spring and early summer were low in fat content, in the range from 1 to 3 percent. In the late summer and through the fall, the fat content rose to a range of 4.5 to 6 percent. At about the same time, the crude protein rose slightly from about 14 percent early in the season to about 15 percent in the fall. This same pattern appears to be developing in 1965. Judging from the current meager data on composition and availability, August through November would be the most profitable months for processing hake, based on the increased oil and protein content. The termination date would depend on the dissipation of the dense schools of hake in the late fall. A more comprehensive article on Pacific hake as a raw material is in preparation at the Seattle Technological Laboratory.

Table 1 - Proximate Analyses of Pacific Hake (Merluccius productus) Taken off the Coasts of Oregon and Washington

Season	Moisture	Oil	Protein	Ash
	(Percent)			
Spring 1964	81.5	1.5	14.3	3.2
Summer and Fall 1964	77.7	5.2	15.0	3.0
Spring 1965	80.3	2.4	14.0	3.2

Note: These data are seasonal averages based on 14 samples.

PROCESSING: Pacific hake can be converted to meal, oil, and solubles by conventional methods used for large-scale reduction of fish. This method is the wet-rendering process in which the fish are cooked by direct or indirect steam, pressed to remove oil and water, and the solid press cake dried in a rotary dryer. The mixture of oil and water removed after cooking is separated by centrifuging, and the water phase is evaporated down to 40 or 50 percent soluble solids (solubles). These solubles are added back to the press cake before entering the dryer.

Figure 2 shows a material balance approximating what one would expect in a conventional fish-reduction plant processing hake in the fall. In the spring and early summer, this chart would be altered by the lower fat content of the hake (around 2 percent) and the slightly reduced protein content. A typical operation on 1,000 pounds of the spring hake processed through the same plant would produce little or no oil and about 211 pounds of whole meal (solubles are dried as part of the meal) assaying 67 percent crude protein, 9.5 percent fat, and 10 percent moisture. This might permit the reduction of hake in the spring in a plant without equipment for removing oil. However, as the fat content of the hake rose above 2 percent, the fat content of the meal would rise above 10 percent. Consequently the meal would be degraded as an oily meal in the larger markets for fish meal. Equipment for separating, clarifying, and handling of oil is recommended for improvement of the meal quality and as a source of income from the oil.

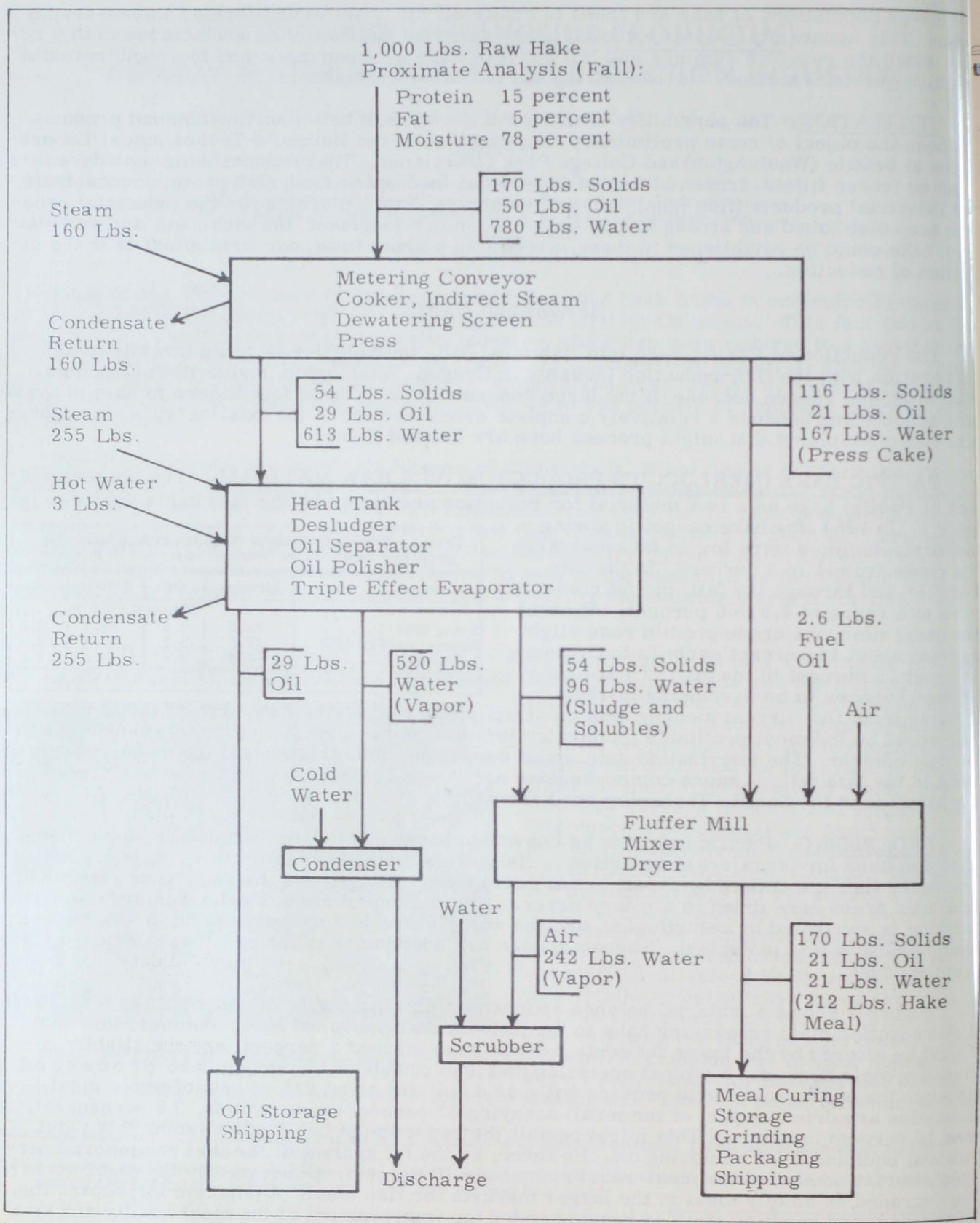

Fig. 2 - Material flow diagram for reduction of Pacific hake in the fall.

One characteristic of Pacific hake is its tendency to cook to a soft mushy consistency in an industrial cooker. This was a cause of concern on our part and led to a series of plant tests to evaluate the resultant problems in pressing and in processing in general.

COMMERCIAL PLANT TESTS: A series of cooperative plant tests have been run in the reduction plants in the Pacific Northwest with the hake being supplied by the Bureau's exploratory vessels. The amount of fish was too small in relation to plant capacity to produce reliable quantitative yield information. However, the information developed on process characteristics is included here because it is the best we have on Pacific hake.

Hake requires cooking at a lower temperature than is normal in fish reduction. Overcooking produces a press feed material of mushy consistency. This mushy material has a severe tendency to jam the press. Under even the best cooking and pressing conditions we have observed so far, the fish press cake has been pressed to a moisture content no lower than 63 percent. Thus we have much to learn before the cooked fish can be pressed down to normal 50 to 55 percent moisture, or it may develop that hake is one of those species so difficult to press that a wetter press cake must be accepted. Certainly, any press equipment installed should be selected for maximum efficiency on moisture-retentive material and should have the best possible provision against jamming. Hake may present a challenge to the ingenuity of equipment manufacturers.

Another problem expected in production of hake meal will be the curing after drying. The iodine value of hake oil is high enough (around 160) to lead one to expect heating of the meal after drying. This heating may be severe enough to require special curing facilities such as equipment for addition of antioxidants and for turning and aerating the fish scrap. So far none of the test runs have produced large enough volumes of meal to permit us to check this question.

The recovery of soluble protein from the press liquids is essential in the processing of hake. In the semiquantitative tests run so far, the proportion of fish solids found in the press water (stickwater) after desludging was about 22 percent of the solids content of the raw fish. This proportion will probably increase as press efficiency is improved. This represents too much of the raw fish to be lost. Also, recovery of solubles will eliminate a serious water pollution problem. The usual recovery system for solubles from press liquor, the triple effect evaporator, works well on acidulated stickwater from hake. With current market conditions, provision should be made for mixing the fish solubles back into the press cake ahead of the dryer for the production of "whole" meal. Oil-yield data were particularly unreliable in these tests because of the small percentage of fat in the relatively small plant runs. However, in one case where oil was not removed in a late summer test, the resultant meal assayed 21 percent fat. The conclusion is that the separation of oil is essential in such cases.

In general, the plant tests run to date indicate that conventional fish-reduction equipment carefully selected for application to the processing characteristics of hake will work reasonably well on hake reduction. Since hake is one of the more difficult fish to process, this same equipment should work well on herring, tuna scrap, sardine, and "scrap" fish. Although plant tests run so far have not been sufficiently quantitative to supply reliable yield data, the reduction products have been a source of reportable data.

HAKE MEAL: Whole meal and oil produced from Pacific hake in commercial reduction plants have been examined by this and other cooperating laboratories. The proximate analyses of the meal are shown in Table 2.

The quality of the protein of Pacific hake meal was evaluated by the Bureau's Technological Laboratory at College Park, Maryland.

Table 2 - Analyses of Hake Meal from Plant Tests

Date	Proximate Composition			
	Moisture	Oil	Protein	Ash
	(Percent)			
September 1964	9.1	21.8	63.7	9.3
	5.4	15.0	68.7	13.4
October 1964	8.5	9.7	70.2	11.6
May 1965	9.2	10.2	65.0	18.1
	9.0	10.7	70.0	14.0
July 1965	7.1	13.5	67.5	15.3
	9.1	17.2	61.9	15.0

Note: Analyses were by the methods of the Association of Official Agricultural Chemists (1960).

They report that two samples from commercial plant test runs were fed to chicks on a comparative basis with four other proteinaceous materials of various qualities. The chicks we fed for 21 days on the test materials as a sole source of protein to supply a 15-percent lev of protein in isocaloric diets in which calcium and phosphorus contents were kept constant 1.50 and 0.88 percent, respectively.

Table 3 - 21-Day Chick Test Showing Protein Quality of Hake Fish Meals in Comparison with Different Fish Meals

Protein Test Material	Relative Growth Response	Average Body Weight
	Percent	Grams
Reference Protein Source No. 1 1/	100	354
Hake fish meal (B)	88	313
Fish meal "VP"	87	309
Hake fish meal (A)	81	286
Fish meal X	67	238
Reference Protein Source No. 2 1/	48	171

1/ The reference test diets and the fish meal test diets reported here are special diets each containing 15 percent protein from a single source. Thus, the data in the table are useful in determining the relative quality of the fish meals with each other and with the reference standards. However, the data have no value in determining the relative quality of proteins from fish meal and proteins from cereals when added to a practical high-efficiency ration in which the proteins are from mixed sources. Reference Protein Source No. 1 was soybean meal with 0.3 percent methionine added; Reference Protein Source No. 2 was soybean meal.

Soybean meal with and without the addition of 0.3 percent methionine was used as standard for indicating protein quality of th extremes--that is, the superior versus the ferior. In addition to the two hake meals, a sample of fish meal identified as "VP" was tested. These three products were less tha 2 months old when tested. For comparison, another fish meal "X," which had been kept ambient room temperature for 12 months, w also included in this test. The results show ing the 21-day average weight obtained from 30 chicks for each of the test materials are listed in table 3. Since the soybean meal die containing the addition of 0.3 percent methionine was expected to and did result in the maximum growth (354 grams), it was set arbitrarily at 100 percent. All other groups were rated on a relative growth basis. On such a relative rating scale, Hake Meal A is average for a fish meal while Hake Meal B is very good.

The protein fraction of three samples from test runs was assayed for amino acid composition. The results (table 4), show the ranges of concentrations found in these limited studies.2/

Solubles are produced from hake stickwater by conventional acidulation and multiple effect evaporation techniques. Since current economic factors dictate inclusion of the solubles in the whole meal, the solubles were not evaluated separately.

HAKE OIL: The oils produced to date from short-run hake reduction tests were dark reddish (number 12 or 13 on the Gardner '53 scale). Their iodine values have assayed around 160. Saturated fatty acids comprise from 26 to 33 percent and polyunsaturated fatty acids (with 4, 5, or 6 double bonds) comprise about 15 to 19 percent of the total fatty acids according to gas-liquid chromatographic analyses. These preliminary data indicate that the use of hake oil in organic coatings would be worth investigating.

Table 4 - Amino Acid Analyses of Protein from Pacific Hake Meal

Amino Acid	Percent Range 1/	
	Minimum	Maximum
Lysine	7.9	8.6
Histidine	2.0	2.3
Arginine	6.3	6.8
Aspartic acid	9.7	10.3
Threonine	4.1	4.5
Serine	4.0	4.1
Glutamic acid	14.3	14.8
Proline	4.3	4.9
Glycine	6.6	7.8
Alanine	6.1	6.7
Valine	5.0	5.5
Methionine	3.0	3.3
Isoleucine	4.5	4.9
Leucine	7.4	8.0
Tyrosine	3.1	3.7
Phenylalanine	4.1	4.4

1/ Ranges from analyses of 3 samples of Pacific hake meal reported as percent of total protein.

ECONOMIC FACTORS

The economics of hake reduction should be considered in terms of spring and fall operations because of the change of chemical composition during the summer as discussed earlier. In the present early stage of our knowledge of the hake resource, the crude indications are that the hake school into fishable concentrations in May and disperse about November. The fat and protein content appear to rise through July and August and remain high through the rest of the season.

2/ Correspondence from Dr. Donald Snyder, Department of the Interior's Bureau of Commercial Fisheries Technological Laboratory, College Park, Maryland.

A reduction ratio (weight of raw fish processed to the weight of whole meal produced) of a t 5.5 to 1 appears to be commercially practical from well-drained hake throughout the y e. With calculations based on the average prices over the past 8 years of $2.20 per ton u of protein in the meal and 7.5 cents per pound for oil, a ton of spring hake should yield a t 12.3 ton-units of protein at $27.10 and no oil. (We are aware of the higher prices for f meal and oil at the time of this writing but do not recommend judging a long-term in- v ent on the basis of spot prices, particularly during or after a period of a steep rise in p .) In the fall, a plant with a good oil extraction system and solubles recovery should y about 12.7 ton-units of protein worth $28 and about 54 pounds of oil worth $4.05 for a t product value of $32.05. This low gross sales value of the products of reduction of a t f hake calls for the utmost in efficiency and business management to cover sales and p uction costs such as brokerage fees; packaging; handling; plant operation and mainte- n e; unloading; amortization of plant equipment, building, and dock facilities; as well as a c petitive price to the fisherman for the hake and, hopefully, some profit. Experimental f ng during the 1965 season indicates that like any other fishery, the hake fishery can have i ean periods. The size of the fishery is still open to conjecture, but based on the preliminary s eys by the Bureau's Exploratory Fishing and Gear Research Base, Seattle, and preliminary p ulation studies by the Bureau's Biological Laboratory, Seattle, the schools of hake found c he coasts of Washington and Oregon are sufficient to support two reduction plants of 20- t -per-hour capacity on a sustained yield basis. This estimate is subject to revision, since i based on only five months of operation and an incomplete survey of the hake resource. H ever, this is the best information available at this early stage of the investigation.

SUMMARY

At the present stage we can see no great bonanza in a hake reduction industry; yet there s good possibility for a paying operation. We have observed that a well engineered conven- n al fish-reduction plant will process hake in a satisfactory manner. This is still a pioneer- g period in which risk of capital is high. On the other hand, one waiting the years neces- y for more complete development of information may find the fishery saturated with proc- s capacity already established to or beyond the sustained yield potential. The only help we n give to management on whether and when to go into the hake-reduction business is for us c ontinue research where it is needed most, and to disseminate information as early as s sible along with our evaluation of that information according to its stage of progress. Oth- r considerations are: (1) the great hake populations off the coast of California at greater p ths may become available through continued development of the midwater trawl techniques i more survey information; (2) research is underway on the evaluation of Pacific hake for t edible fish market in the forms of fresh fillets, frozen fillets, and frozen fish blocks; (3) n siderable interest has been shown in hake by the manufacturers of frozen and canned ani- l foods; and (4) Pacific hake, because of its low fat content and excellent amino acid bal- c e, is attractive as a source material for the manufacture of fish protein concentrate.

Any of the above potential uses for Pacific hake, if developed, could outbid the fish-re- t tion industry for the raw fish, so their progress should be watched. On the other hand, e market for fish meal and oil is here now and being supplied largely through imports; h reas, the other markets are either undeveloped or the suitability of hake for those mar- t s is still in doubt. Consequently the reduction of hake into meal and oil would be the only r te open into a seller's market at this time.

ACKNOWLEDGMENT

We wish to acknowledge the cooperation of members of the reduction industry in making e plant tests possible. The management and personnel of Bioproducts, Inc., Warrenton, r egon; British Columbia Packers, Ltd., Steveston, British Columbia; and Grays Harbor e dering, Elma, Washington, made their plants and skills available to us for test runs and b servations on commercial processing of hake. The staff of the Department of the Interior's r anch of Commercial Fisheries Technological Laboratory at College Park, Maryland, made e protein evaluations reported here.