INDUSTRY ANALYSIS OF WEST COAST FLOUNDER AND SOLE PRODUCTS AND AN ESTIMATION OF ITS ECONOMIC ADAPTABILITY TO RADIATION PROCESSING

by

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Working Paper No. 11
October 1969

BUREAU OF COMMERCIAL FISHERIES
DIVISION OF ECONOMIC RESEARCH

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(continued on inside back cover)

Industry Analysis of West Coast Flounder and Sole Products and an Estimation of its Economic Adaptability to Radiation Processing

by

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Prepared under

Memorandum of Agreement
with
U. S. Department of Agriculture
Economic Research Service
for
U. S. Atomic Energy Commission
Division of Isotopes Development

Abstract

Assessments of resource abundance for Pacific fisheries indicate that the harvest of Pacific sole could be doubled. More intensive use of the fishery, however, would have to be accompanied by an expansion of markets for sole, eastward. Current production is distributed, in fresh form, chiefly in the West Coast States.

Declining catches of East Coast species of fish, for which Pacific soles would be a suitable substitute, are creating a favorable climate for Pacific sole market expansion, especially for sole marketed in "fresh" form. Shelf life limitations contribute a formidable obstacle to market expansion, but improved preservation techniques can overcome this factor.

Low dosage irradiation preservation can add two weeks to the shelf life of Pacific sole, without alterring the "fresh" quality of the fish. Weighed against the apparent costs of irradiation processing, however, the benefits possible from expanded markets do not appear sufficient to justify commercial investment in irradiation facilities for processing Pacific sole. This conclusion is reached on the assumption that current production of Pacific sole is doubled and the gain in production is irradiation-processed and shipped to distant markets at f.o.b. plant price levels currently in effect.

Table of Contents

Page

Industry Analysis of West Coast Flounder and Sole Products and an Estimation of its Economic Adaptability to Radiation Processing

Pacific soles constitute a group of fish belonging to the Pacific demersal fish species inhabiting the Northeastern Pacific from California to and including the Bering Sea. Other Pacific demersal fish are halibut, flounder, cod, rockfish and Pacific Ocean perch. Halibut is the most important species of the group and is a separate fishery. The demersal fish referred to in this report do not include halibut.

For the past decade the Pacific demersal fisheries have come under increasing pressure from the Japanese and the Soviets. Each of these countries harvests several times the amount harvested by either the United States or Canada, whose catch has remained fairly constant since the end of World War II. The demersal fisheries of California, Oregon and Washington, however, are still fished mostly by U. S. fishermen.

Resource Potential

Pruter[1/] has estimated the standing crop and maximum sustainable yield of fishes in the northeastern Pacific Ocean. The standing

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1/ Pruter, A. T., Transactions of the Twenty-Ninth North American Wildlife and Natural Resources Conference, March 9, 10, and 11, 1964, Wildlife Management Institute, Washington, D.C.

crop is conservatively estimated at 200 million pounds of flounders, including soles, for the Oregon-Washington area. Additional resources exist off California, particularly in the northern area. Alverson[2/] has made standing crop estimates which generally corroborate these figures.

Maximum sustainable yield estimates are not given by species. Pruter[3/] compared the fishing grounds of the northeastern Pacific to those of the long-fished grounds of the northwest Atlantic and Europe. Based on comparative characteristics of the grounds it is estimated that the Pacific grounds are capable of providing a maximum of 10 to 20 pounds per acre annually on a sustained basis. At the present time, there are about 4.5 pounds per acre of demersal fish harvested annually from grounds off the Oregon-Washington coast. Halibut yield probably cannot be increased beyond its present catch. Therefore, any increase beyond 4.5 pounds per acre will come from the other demersal species. It seems safe to conclude that biological production will support a doubling of the current yield of any one of these species.

2/ Alverson, Dayton L., Conference on the Future of the U.S. Fishing Industry, "Fisheries Resources in the Northeastern Pacific Ocean," University of Washington, Seattle, Washington, March 24-27, 1968.

3/ Pruter, op. cit.

Alverson[4] warns, however, that fish populations often are not sufficiently concentrated to permit harvesting at a cost sufficiently low to attract commercial fishing. Also, concentrations often occur in areas unsuitable for trawl fishing.

Harvesting

There has been a slight upward movement in the U. S. catch of Pacific soles since the early 1950's. The average for the period is about 44 million pounds, with the record catch of 47.5 million pounds occurring in 1963. Table 1 shows the recent catch record for soles and for all demersal fish excluding halibut.

The sole fishery is not dynamic in the sense that it caters to a limited market. The chief market area for Pacific soles is on the West Coast, and there are only limited quantities exported from the region. Price stability at the harvest level is especially assured by advance pricing contracts. The fishermen's associations generally contract for prices with fish buyers a year or more in advance. The agreement bases the prices upon general movements in wholesale price indices. With this contracted price, buyers tend to purchase only those quantities which will clear the market at that price plus processing and handling costs.

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[4] Alverson, _op_. _cit_.

Table 1. Landings of Sole and of All Demersal Finfish (Excluding Halibut); Washington, Oregon and California, Annual Data

Year	Landings		Value	
	Sole	All Finfish	Sole	All Finfish
	(thousand pounds)		(thousand dollars)	
1950	45,245	80,239	2,249	3,717
1951	31,709	68,478	3,030	5,048
1952	44,621	86,549	3,269	5,627
1953	33,522	67,770	1,989	3,428
1954	43,190	93,785	2,532	4,564
1955	42,522	84,669	2,372	3,992
1956	46,240	96,094	2,442	4,242
1957	44,649	93,311	2,725	4,804
1958	43,773	92,070	2,555	4,606
1959	42,268	91,231	2,713	4,928
1960	44,194	85,694	2,929	4,879
1961	44,339	84,731	2,852	4,870
1962	46,955	95,298	3,127	5,530
1963	47,446	102,422	3,310	6,160
1964	43,644	90,346	2,974	5,327
1965	43,069	102,963	3,002	6,019
1966	43,555	100,921	3,377	6,368

Source: <u>Fishery Statistics of the United States</u>, Bureau of Commercial Fisheries, U. S. Department of the Interior

This fishery is highly seasonal. A peak is generally reached in August and September, followed by a rapid dropoff to a low in December. Table 2 shows these seasonal factors, with 100 being equal to the average monthly catch.

There is considerable price variation between varieties of sole. Table 3 shows price variations that were specified on a price agreement from Washington of the type described above. The lowest price is specified as 100, with the others showing the percent addition to this figure.

The average price paid for sole, dockside, in Washington in 1966 was $0.079.

Processing

Filleting plants which process significant quantities of sole extend from the extreme northern part of California through Oregon and Washington. These data are shown in table 4.

Humbolt County produced over 75 percent of the 5.6 million pounds of sole fillets in California in 1966. Very limited quantities are produced in other parts of the State with some concentration in the Los Angeles area. Consideration for supplying an irradiation plant can only be given to the production in Humbolt County as no other area has the necessary concentration or volume.

Table 2. Monthly Index of Catch of Pacific Sole

Month	Index
January	74.2
February	82.0
March	68.6
April	69.8
May	100.5
June	111.5
July	128.7
August	154.3
September	152.3
October	138.9
November	68.3
December	50.6

Table 3. Ex-vessel Price Comparisons for Various Kinds of Soles and Flounder

Product	Index of Price Variation
Petrale sole	
summer, first 10,000 lbs.	169.2
summer, all over 10,000 lbs.	153.8
winter	184.6
Sand sole	
summer	169.2
winter	184.6
English sole	
11 1/2 inches and over	130.8
specified size	146.2
Dover sole - 14 inches and over	103.8
Rock sole - 13 inches and over	107.7
Rex sole	100.0

Table 4. Processing of West Coast Soles, by States, Designating Leading County, 1966

State	Fresh (thous. lbs.)	Fresh (thous. $)	Frozen (thous. lbs.)	Frozen (thous. $)	% of Total Fresh	% of Total Frozen	Value Fresh	Value Frozen
California								
County								
Humbolt	4,536.2	1,679.6			39.0		34.5	
All Other	811.6	365.0	233.0	93.2	7.0	100.0	7.5	100.0
Total	5,347.8	2,044.6	233.0	93.2	46.0	100.0	42.0	100.0
Oregon								
County								
Clatsop	1,680.1	730.3			14.0		15.0	
All Other	1,886.8	875.1			16.0		18.0	
Total	3,566.9	1,605.4			30.0		33.0	
Washington								
County								
Whatcom	1,612.6	694.2			14.0		14.0	
All Other	1,082.8	508.3			10.0		11.0	
Total	2,695.4	1,202.5			24.0		25.0	
TOTAL	11,610.1	4,852.5	233.0	93.2	100.0	100.0	100.0	100.0

Processing in Oregon is concentrated along the northern and north-central coast. Nearly all of the production is within a distance which would allow for shipment of the fillets to an irradiation plant, located in one of the production areas.

Washington production of sole fillets is located along Puget Sound. A small amount is produced in Grays Harbor. Again most of the production of the State is within trucking distance to an irradiator.

Costs of fillet production other than that of the raw materials are are quite invariant (table 5). One of the principal sources of cost variation is the kind of sole. Fillet weight is about 29 percent of live weight. Thus, if there are no by-products from which to recover some of the costs, the fillet cost is 3.45 times that of the whole fish cost per pound. Added to raw material costs are labor, packaging, storage, marketing costs and overhead. As a general guideline, these services added to raw material costs give a total production cost of about 1.6 times that of the raw material cost.

Marketing

It is apparent that the price differential at the landings level by State is primarily due to a difference in the percentage makeup

Table 5 . Representative Production Costs for Fresh and Individual Quick Frozen (IQF) Flounder and Soles, 1967

Cost Item	Fresh			Frozen		
	Flounder	Soles	Rock Sole	Flounders	Dover Sole	Rock Sole
	(dollars per pound)					
Whole fish cost	.05	.0675	.07	.05	.0675	.07
Fish cost, fillet weight	.1786	.2328	.2414	.1786	.2328	.2414
Filleting labor	.06	.06	.06	.06	.06	.06
Other labor	.015	.015	.015	.025	.025	.025
Cartons and packaging	.003	.003	.003	.003	.003	.003
Taxes, insurance, depreciation, selling costs	.062	.062	.062	.0628	.0628	.0628
Total Production Costs	.3186	.3728	.3814	.3294	.3836	.3922

kinds of sole (table 6). The average price per pound is highest in California at the landings level, although the price of processed fish is lowest in California, among the States. The differential prices at processing are a combination of lower wage rates and distance from markets. California production is shipped to the population centers to the south or to Oregon and Washington cities.

Trial air shipments of fresh fillets from the West Coast to the Midwest were made in 1966 and 1967. These were accompanied with considerable promotion. However, no regularly scheduled shipments have been established. Consequently, the present market area is confined to rail and truck shipments along the coast.

Demand Projections

Based on the slow growth rate of this fishery since World War II and the limited market area, only a slight annual increase is projected through 1985. Table 7 shows the projections of the amount available for irradiation by State. A trend line of the form $y = a + bt$, where y is annual sole production and t is time was fit to the data from 1950 to 1966. This line was used to make the projections to 1985. The relative quantities among the three States is projected to remain the same as has been the experience of the recent past. Thus, in 1975 there is projected

Table 6. West Coast Sole, Quantity and Value, Landings and Processing Level, 1966

State	Quantity (thous. lbs.)	Value (thous. dollars)	Price (dollars per lb.)
Landings (Round Weight)			
California	19981	1664	.083
Oregon	13455	914	.068
Washington	10119	799	.079
Regional Total	43555	3377	.078
Processing (Fillet Weight)			
California	5580	2138	.383
Oregon	3567	1605	.450
Washington	2695	1202	.446
Regional Total	11843	4946	.418

Table 7. Projected Processed Sole to 1985 Available for Irradiation

	California	Oregon	Washington
		(thousand pounds)	
1966	5047.2	3984.6	3054.9
1967	5102.3	4028.1	3088.2
1968	5146.3	4062.9	3114.9
1969	5190.4	4097.7	3141.6
1970	5234.5	4132.5	3168.2
1971	5289.6	4176.0	3201.6
1972	5333.7	4210.8	3228.3
1973	5377.8	4245.6	3255.0
1974	5421.8	4280.4	3281.6
1975	5476.9	4323.9	
1976	5510.0	4350.0	3335.0
1977	5565.1	4393.5	3368.4
1978	5620.2	4437.0	3401.7
1979	5664.3	4471.8	3428.4
1980	5708.4	4506.6	3455.1
1981	5752.4	4541.4	3481.7
1982	5796.5	4576.2	3508.4
1983	5851.6	4619.7	3541.8
1984	5895.7	4654.5	3568.4
1985	5950.8	4698.0	3601.8

to be 5.5 million pounds of fillets available in California, this quantity increasing to nearly 6.0 million pounds in 1985. Oregon is projected to have 4.3 million and 4.7 million in 1975 and 1985 respectively, while Washington will provide 3.3 and 3.6 million pounds respectively in the two years. These projections, it must be noted, are based on historic growth factors, and do not take into account the impact that new technology and unusual promotional efforts might have on the fishery.

Spoilage Loss and Irradiation

It can be assumed that spoilage losses of Pacific sole are average for all fishery products in the United States. Data are provided by Snead on spoilage and shrinkage loss at each market level from producer to retailer (table 8). It is expected that irradiation will take place after processing and before the product enters the distribution channel. Thus irradiation will inhibit spoilage beginning with the distributor. The cummulative losses from distributor through retailer total 7.6 percent by weight in the winter and 10.25 percent in summer. Approximately 54 percent of the product is marketed during the summer months by May through September, the remainder during the winter months. A weighted average loss for the year is thus 9.1 percent. Recognizing that only a part of this loss is skrinkage and only a

Table 8. Weight Losses in Shrinkage and Spoilage of Fresh Fishery Products

	Winter	Summer
	(percent)	
Producer	1.3	1.8
Processor	1.3	1.8
Distributor	1.7	2.6
Wholesaler	2.4	3.2
Retailer	3.7	4.8

Source: Larry L. Snead. Research Study Concerning Potential Effects of Radiation Processing on Market Supplies and Structure of the Domestic Fishing Industry, (unpublished). U. S. Department of the Interior, Bureau of Commercial Fisheries. January 1966. pp. 24-30 part of the spoilage loss could be curtailed by irradiation, a 3 percent savings by weight is assumed. At a wholesale price of $0.45 per pound and 12 million pounds annual production of fillets, this represents a yearly potential savings of about $162,000.

Market Expansion Possibilities

As noted above, the Pacific sole fishery is being utilized well below its potential. It is even possible that the annual catch could be doubled without deteriorating the resource. In this respect, the Pacific fishery contrasts sharply with similar fisheries in the Atlantic, which are being depleted, namely, Atlantic groundfish.5/ There is then some logic for assuming potential markets for Pacific soles--especially "fresh" soles--in

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5/ Charles Lyles, Bureau of Commercial Fisheries, U.S. Department of the Interior, reports in Fisheries of the United States--1968, that: The Atlantic fishery for groundfish (cod, cusk, haddock, ocean perch, pollock, and white hake) yielded a catch of only 192 million pounds--34 million pounds or 15 percent less than in 1967 and one of the poorest years on record. Haddock landings were only 71.3 million pounds--28 percent less than in 1967 and well below the 1929 record catch of 293.8 million pounds. The decline was due to decreased abundance not only from natural causes but also from heavy fishing by foreign fleets in 1965-66. The haddock fishery has been dependent almost entirely upon the 1963 year-class since very poor survival of spawn has occurred since then. Abundence decreased in 1968 and is expected to decrease in 1969-70 as the 1963 year-class passes out of the population as a dominant group.

the traditional Atlantic markets (which extend, in some cases, to the midwest). The Atlantic fisheries currently provide in the neighborhood of 50 million pounds of fresh processed groundfish and flounder fillets. This is four times the output of Pacific soles. Therefore, a modest drop in production in the east--5 to 10 percent--would create a potential for more than a 40 percent increase in Pacific sole production.

Laboratory experiments have established that low dosage radiation preservation will add at least two weeks to the shelf life of west coast sole fillets. It was also found, through taste panels and field testing, that irradiated sole fillets were highly acceptable, as regards taste and texture.[6/] Assuming that the transition can be successfully made from laboratory to plant, irradiation processing of sole fillets could be an important marketing tool for extending the markets for Pacific sole varieties, which as noted, are sold chiefly in the area of catch.

Commercial Feasibility of Radiation Processing

Radiation processing requires somewhat elaborate facilities. The required investment in plant and equipment would be too large (probably in the area of one-half million dollars) for the typical individual processing plant to consider. Moreover, operating costs would be prohibitively expensive where facilities were used for the relatively small throughput of an individual

6/ Miyauchi, D., J. Spinelli, G. Pelroy, and M. A. Steinberg, "Radiation Preservation of Pacific Coast Fisheries Products," Isotopes and Radiation Technology, Vol. 5, No.2, Winter 1967-68.

plant. The outputs of several plants, therefore, would have to be channelled through a single facility, to keep costs within reason.

Based on the geographic concentration of west coast sole processing plants, three separate radiation facilities would have to be constructed, one each in California, Oregon and Washington. This would give most processing plants access to a facility within 75 miles.

Based on current trends in production, and allowing for seasonal peaks, irradiation plants capable of processing at a rate of 1,400 pounds per hour would meet the requirements for each of the three areas. This capacity would allow an annual throughput of up to 6 million pounds, with the plant operating on a 6 day per week, 2 shift basis. Irradiation processing costs for the 6 million pounds would average nearly $0.04 per pound. Added to this would be the transportation and handling costs--estimated to be $0.015 per pound--incurred in moving the product between the fish processing plant and the radiation plant. Thus, total irradiation processing costs would be about $0.055 per pound (table 9). This would amount to between 12 percent and 15 percent of f.o.b. plant prices for sole fillets.

Table 9. Breakdown of Investment and Operating Costs for an Irradiation Plant Processing a 6 Million Pound Annual Throughput, at .2 M Rads 1/

Operating Days Per Week - 6
Shifts Per Day - 2
Annual Throughput - 6,000,000 lbs.

	Dollars	
Investment Requirement		
Source	35,416	
Plant	432,429	
Total	467,846	
Operating Expenses		
Labor (direct)	29,654	
Labor (indirect)	29,654	
Operating Supplies	2,162	
Maintenance	21,621	
Source Replenishment	4,958	
Depreciation - Source	3,541	
Depreciation - Plant	50,450	
Utilities	4,324	
Taxes and Insurance	8,648	
Third Party Liability	21,621	
Total Operating Expenses	176,637	
Allowance for Return on Investment of 12%	56,141	
Total Operating Expenses and Returns	232,779	
Irradiation Cost Per Lb.		.03880

1/ Assumes source cost at $0.45/curie, and 30% efficiency.

The most likely benefits from irradiation processing would be elimination of spoilage loss. As noted above, our best estimate of spoilage loss was 3 percent of total production. What with irradiation costs running as high as 15 percent of the average wholesale price of sole fillets, it is apparent that elimination of the spoilage loss problem, itself, would not provide economic justification for using the process.

Market extension for fresh sole products is another potential benefit available through irradiation processing. These benefits, to industry, would be in terms of "new" earnings. Assuming processors' margins at 15 percent, we calculated the rate of return on investments in radiation facilities, from the potential added earnings that would accrue from expanded markets. Only the expanded production would be irradiation-processed. We assumed the limits of this expansion would be an amount equal to current production levels, on the basis of estimates that the resource was only being 50 percent utilized. The irradiation plants, then, would be built to process a 6 million pound yearly throughput, on a 6 day per week, 2 shift basis. The assumed price was the f.o.b. plant price in effect for west coast soles. (The price in distant markets, would of course, reflect considerable transportation charges, but these would not likely price the west coast soles out of competition with the eastern varieties of fresh fish).

The method used to determine rates of return was a discounted cash-flow rate of return analysis. This computes the "internal" rate of return on an investment, which is the percentage rate that discounts the flow of earnings over the life of the project to an amount equal to the present value of the investment. An analysis was made for each of three proposed irradiation plants, with plants being built in 1975 and becoming operational in 1976. The investment life was taken at 10 years. The calculated rates of return were as follows:[7/]

Plant (1) California - 21.6%

Plant (2) Oregon - 20.2%

Plant (3) Washington - 3.3%

It is immediately apparent that the Washington plant represents a questionable investment. This is due to the fact that the area is not projected to attain sufficient fillet production to allow economical irradiation processing. Irradiation processing operations are characterized by high fixed costs. Unit total costs, therefore, drop sharply with increases in output (or rise sharply with decreases), at a given plant capacity.

The expected rates of return are considerably better for plants located in Oregon and California, although they are likely not high enough to attract risk capital. The irradiation investments

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7/ See appendices 1, 2 and 3 for summary tables of analysis.

represent a high order of risk. They concern in effect, the marketing of a new product--"radio-pasteurized fillets"--for which there may be unusually high consumer resistance. Moreover, the irradiation plant is of specialized construction, and not easily adaptable to other uses, in the event of unfulfilled expectations. A minimum return would have to be in the order of 25 percent, but considering the special problems involved in irradiation processing of fishery products, e.g., consumer resistance and uncertain resource limit, it would take a much higher expected rate to attract investments. Gordon and Shillinglow write, "The minimum acceptable rate of return, often referred to as the cost of capital, will vary from company to company, depending on the market's evaluation of the degree of risk. The greater the risk, the less the stockholder will be willing to pay for a dollar of anticipated earnings. . . . If 20 percent before taxes is deemed adequate on an equipment replacement proposal, 15 percent may be adequate on a general purpose warehouse, and 25 percent may be required on the investment needed to put a new product on the market."[8/]

Another way to evaluate the feasibility of commercial irradiation investments for Pacific soles is by examining the ratios of

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8/ Gordon, M. J. and G. Shillinglow, Accounting a Management Approach, Homewood, Illinois: Richard D. Irwin, Inc., 1964, p. 745.

benefit to costs, discounting both to present value (1975, in our analysis) at various assumed discount rates. This is done in table 10, in which it will be noted that at discount rates of 9 percent (which is in line with the current cost of money) benefits connected with investments in irradiation plants in California and ~~Washington~~ Oregon are in the neighborhood of 1½ times the costs, and anticipated benefits in Washington are well below costs.

Epilogue

The Pacific sole processing industry is operating well below its potential, from the standpoint of resource availability. The industry is geared to limited regional markets and future growth will be dependent upon market expansion. The climate for market development, nationwide, is especially favorable, what with the declining abundance of east coast groundfish varieties.

The shelf life extension features of irradiation processing permit sufficient time for surface shipments of sole products to distant markets, and assure quality maintenance. However, substantial investments would be required for constructing and developing irradiation facilities (assuming FDA approval), and operating costs per unit of output would be relatively high at the expected levels of output. Assuming current price levels, the expected additional earnings from expanded markets do not appear sufficiently attractive for risk capital. The risk of

Table 10. Expected Benefit/Cost Ratios for Commercial Investment in Radiation Processing Plants for West Coast Sole Varieties--10-year Project Life, 1975-1985, By Area

Discount Rate (%)	California	Oregon	Washington
	Benefit/Cost Ratio 1/		
2	2.28	2.17	1.07
3	2.16	2.06	1.01
4	2.06	1.96	0.96
5	1.96	1.86	0.92
6	1.86	1.78	0.87
7	1.78	1.69	0.83
8	1.70	1.62	0.79
9	1.62	1.55	0.76
12	1.43	1.36	0.67
15	1.26	1.21	0.59
20	1.06	1.01	0.49
25	0.90	0.86	0.42
50	0.49	0.47	0.23

1/ Discounted Benefits divided by Discounted Costs

Source: Appendices 4, 5, and 6.

introducing a new food product, or process, is always high; it would be even higher for irradiation processing for three reasons: (1) possible strong consumer resistance; (2) immobility of capital investment (plant and equipment could not find other uses); and (3) the possibility that FDA approval of the process, once gained, could be summarily removed (which was done in the case of radiation-sterilized bacon and ham).

In brief, the expected volume of output of Pacific sole is simply not large enough, at expected prices, to produce sufficient net benefits from irradiation processing.

Appendix 1. Discounted Cash Flow Rate of Return Analysis for Investment in Pacific Sole Radiation-Processing Operations in California *

Year	Annual Throughput (thous. lbs.)	Investment Plant	Investment Source	Operating Expenses (thous. dollars)	Operating Revenue	Net Cash Flow
1975		-432				-432
1976	5,510		-35	-206	316	75
1977	5,565			-207	320	113
1978	5,620			-208	323	115
1979	5,664			-209	325	116
1980	5,708			-210	328	118
1981	5,752			-211	330	119
1982	5,797			-212	333	121
1983	5,852			-213	336	123
1984	5,896			-214	338	124
1985	5,951			-215	342	127

Marginal Efficiency of Capital (Rate of Return) = 21.6%

* .2 M Rads Dosage
35% Efficiency
$0.45/Curie Source Cost

Appendix 2. Discounted Cash Flow Rate of Return Analysis for Investment in Pacific Sole Radiation-Processing Operations in Oregon *

Year	Annual Throughput	Investment		Operating Expenses	Operating Revenue	Net Cash Flow
		Plant	Source			
	(thous. lbs.)	(thous. dollars)				
1975		-432				-432
1976	4,350		-35	-188	294	71
1977	4,394			-189	296	107
1978	4,437			-190	300	110
1979	4,472			-191	302	111
1980	4,507			-192	304	112
1981	4,541			-193	306	113
1982	4,576			-194	309	115
1983	4,620			-195	312	117
1984	4,654			-196	314	118
1985	4,698			-197	317	120

Marginal Efficiency of Capital (Rate of Return) = 20.2%

* .2 M Rads Dosage
35% Efficiency
$0.45/Curie Source Cost

Appendix 3. Discounted Cash Flow Rate of Return Analysis for Investment in Pacific Sole Radiation-Processing Operations in Washington *

Year	Throughput	Investment Plant	Investment Source	Operating Expenses	Operating Revenue	Net Cash Flow
	(thous. lbs.)			(thous. dollars)		
1975		-432				-432
1976	3,335		-35	-172	223	16
1977	3,368			-173	225	52
1978	3,402			-174	228	54
1979	3,428			-175	229	54
1980	3,455			-176	231	55
1981	3,482			-177	233	56
1982	3,508			-178	235	57
1983	3,542			-179	237	58
1984	3,568			-180	239	59
1985	3,601			-181	241	60

Marginal Efficiency of Capital (Rate of Return) = 3.2%

* .2 M Rads Dosage
35% Efficiency
$0.45/Curie Source Cost

Appendix 4. Expected Benefit/Cost Ratios for Commercial Investment in Radiation Processing Plants for Pacific Sole in California*

Discount Rate (%)	Present Value Benefits ($000)	Present Value Costs ($000)	Benefit/Cost Ratio
2	1,063	466	2.28
3	1,008	466	2.16
4	957	466	2.06
5	910	465	1.96
6	866	465	1.86
7	826	465	1.78
8	788	464	1.70
9	753	464	1.62
12	661	463	1.43
15	588	462	1.27
20	487	461	1.06
25	413	460	0.90
30	356	459	0.78
35	312	458	0.68
40	276	457	0.60
50	224	455	0.49

* Plant capacity, approximately 1,400 lbs. per hour; dosage, .2M rads; 30 percent efficiency; source cost @ $0.45/curie.

Appendix 5. Expected Benefit/Cost Ratios for Commercial Investment in Radiation Processing Plants for Pacific Sole in Oregon*

Discount Rate (%)	Present Value Benefits ($000)	Present Value Costs ($000)	Benefit/Cost Ratio
2	1,012	466	2.17
3	960	466	2.06
4	912	466	1.96
5	867	465	1.86
6	826	465	1.78
7	787	465	1.69
8	751	464	1.62
9	718	464	1.55
12	630	463	1.36
15	558	462	1.21
20	464	461	1.01
25	394	460	0.86
30	340	459	0.74
35	298	458	0.65
40	264	457	0.58
50	214	455	0.47

* Plant capacity, approximately 1,400 lbs. per hour; dosage, .2M rads; 30 percent efficiency; source cost @ $0.45/curie.

Appendix 6. Expected Benefit/Cost Ratios for Commercial Investment in Radiation Processing Plants for Pacific Sole in Washington*

Discount Rate (%)	Present Value Benefits	Present Value Costs	Benefit/Cost Ratio
	----------($000)	-------	
2	498	466	1.07
3	472	466	1.01
4	448	466	0.96
5	426	465	0.92
6	406	465	0.87
7	387	465	0.83
8	369	464	0.79
9	352	464	0.76
12	309	463	0.67
15	274	462	0.59
20	227	461	0.49
25	193	460	0.42
30	166	459	0.36
35	145	458	0.32
40	129	457	0.28
50	104	455	0.23

* Plant capacity, approximately 1,400 lbs. per hour; dosage, .2M rads; 30 percent efficiency; source cost @ $0.45/curie.

List of Tables

List of Appendices

(continued from inside front cover)

14. A Price Incentive Plan for Distressed Fisheries by A. A. Sokoloski and E. W. Carlson.

15. Demand and Prices for Shrimp by D. Cleary.

16. Industry Analysis of Gulf Area Frozen Processed Shrimp and an Estimation of Its Economic Adaptability to Radiation Processing by D. Nash and M. Miller.

17. An Economic Evaluation of Columbia River Anadromous Fish Programs by J. A. Richards.

18. Economic Projections of the World Demand and Supply of Tuna, 1970 - 90 by F. Bell.

19. Economic Feasibility of a Seafood Processing Operation in the Inner City of Milwaukee by D. Cleary.

20. The 1969 Fishing Fleet Improvement Act: Some Advantages of its Passage by the Division of Economic Research.

21. An Economic Analysis of Policy Alternatives for Managing the Georges Bank Haddock Fishery by L. W. Van Meir.

22. Some Analyses of Fish Prices by F. Waugh and V. Norton.

23. Some Economic Characteristics of Pond-Raised Catfish Enterprises by J. E. Greenfield

24. Elements Crucial to the Future of Alaska Commercial Fisheries by D. Nash, A. Sokoloski, and D. Cleary.

25. Effects on the Shrimp Processing Industry of Meeting the Requirements of Wholesome Fishery Products Legislation by D. Nash and M. Miller.

26. Benefit Cost Analysis of a Proposed Trawl Systems Program by M. Miller.

27. An Economic Analysis of Future Problems in Developing the World Tuna Resource: Recommendations for the Future Direction of the BCF Tuna Program by F. Bell.

28. Economic Efficiency in Common Property Natural Resource Use: A Case Study of the Ocean Fishery by D. W. Bromley

29. Costs, Earnings and Borrowing Capacity for Selected U. S. Fisheries, by Sokoloski, Carlson, Noetzel

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