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COMMERCIAL PROFITABILITY OF OFFSHORE SAND AND GRAVEL MINING IN SOUTHERN CALIFORNIA: AN ANALYSIS FOR NEW ENTRIES

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ABSTRACT

Sand and gravel are primary resources used in many phases of construction and to maintain southern California's valuable beaches and harbors. Deposits of saleable-grade material under present political and economic conditions are becoming depleted. Although many land-based deposits are lost to competing land uses and mining of such deposits is generally opposed by urban communities, offshore mining of sand and gravel for use as construction aggregate is below the current rate of market interest (10%). The reduced profitability of offshore mining is chiefly due to high initial capital outlay and relatively high operating costs. Investment in land-based deposits may be profitable under specified conditions.

1. INTRODUCTION

In southern California, commercial sand and gravel is produced entirely by open-pit mining of onshore alluvial deposits. The requisite technology is well known to the industry. In recent years, increased socio-economic pressures have been imposed on producers in some areas, e.g. in Los Angeles County. The high rate of urbanization, limited reserves and increased operating costs as well as social and environmental concerns have encouraged some producers to seek new deposits for future exploitation. Commercial mining of offshore sand and gravel deposits for construction aggregate has been regarded as a possible alternative source for this commodity.

The following research was conducted to evaluate the economic feasibility of mining offshore sand and gravel deposits in southern California, particularly in Santa Monica Bay.

First, a brief description of the sand and gravel market in southern California and Los Angeles County will be presented. Secondly, a conventional onshore model will be discussed, and the rate of return in such a model will be estimated. Finally, the offshore mining case will be considered and compared to the onshore one.

2. SAND AND GRAVEL MARKET

In general, the demand for sand and gravel depends on the level of construction activity. Such activity follows a seasonal pattern and so does the demand for sand and gravel, which peaks in summer and declines in winter. Nearly 98% of the aggregate material used in southern California is consumed by the construction industry.

Due to the high unit storage cost, production of sand and gravel is geared to match the demand, and the market for this commodity is normally near the equilibrium at the given price level. The total available reserves of material in the major production districts currently supplying Los Angeles County is estimated to be approximately 620×10^6 tons. Average annual demand is estimated to be approximately 21×10^6 tons.[1] Thus under the current market conditions, known reserves will be exhausted in 30 years.

The market price of sand and gravel has been rising continuously through time; however, the real price has had sluggish upward or even downward movements. The market price in 1978 was over 111% higher than the 1965 level, but the real price had increased by only 3.2% in the same period. Table 1 presents the consumption, market price, and real price of sand and gravel in the Los Angeles area.

Transferring the material from the plant site to the consumption area is an important part of the marketing strategy. Transportation is normally done by trucks and trailers with a 25 ton average capacity. Minimum transportation rates are set by the Public Utility Commission on a zone to zone basis -- Tariff 17A. The rate for a 25 mile distance is $2.03 and for a 40 mile haul rises to $3.08 per ton. High unit weight, limited capacity and high transportation rate affects the producer's choice of locations.

3. ECONOMIC MODELING: FIRST APPROXIMATION

Suppose an entreprenure is considering (1) whether to invest in the sand and gravel production market; and (2) if the answer is affirmative, whether to invest in an onshore or offshore mining operation. The following economic models are offered for consideration.

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Table 1. Aggregate Sales, Market and Constant 1978 Prices of Sand and Gravel Los Angeles County

YEAR	MILLIONS OF TONS CONSUMPTION*	PRICES IN DOLLARS PER TON NOMINAL**	CONSTANT '78†
1965	25.3	1.09	2.23
1966	26.2	1.12	2.23
1967	22.2	1.12	2.17
1968	23.7	1.24	2.29
1969	22.9	1.10	1.96
1970	26.2	1.25	2.08
1971	21.7	1.32	2.10
1972	21.3	1.37	2.08
1973	22.2	1.49	2.14
1974	21.6	1.63	2.14
1975	19.1	1.79	2.14
1976	21.1	2.09	2.38
1977	21.4	2.20	2.36
1978	21.6	2.30	2.30

*Source: U.S. Bureau of Mines

**Source: 1965-1973, California Division of Mines

†Computed based on the general price level data from "Statistical Abstract of the U.S.," Department of Commerce, 1962-1979 Volumes.

1974-1978 estimates based on the U.S. Bureau of Mines Publications and on industry survey.

Onshore Model I

An average producer in Los Angeles County produces from 1.5 to 2 million tons of aggregate per annum. Here, we consider both production levels. The work schedule is assumed to be 8 h/day, 5 days a week, and 50 weeks a year. If 90% of the material is usable as final product, a maximum of 160 tons/h should be mined to satisfy the maximum production of 1,000 tons/h. A 6 yd^3 bucket size electrical shovel and a dragline are used for mining. Trucks and belt conveyors transfer material to the plant for further processing. The total capital outlay for such a plant and equipment is estimated to be approximately 8.95 million dollars invested as a lump sum in the beginning of the project. The lifetime of the equipment is taken to be 20 years. Depreciation is computed on a straight line basis and the scrap value of equipment is zero at the end of the twentieth year. A 55% tax rate on the net taxable income is imposed by the federal, state and local authorities. F.O.B. price of sand and gravel is estimated to be about $2.60/ton.[5]

Under the above conditions, the operating cost is estimated to be about $1.75 per ton/year, and the gross operating income remains the same for twenty years. Operating costs include labor, energy, supplies and maintenance, insurance, total taxes and royalties. The internal rate of return for the 1.5 million ton annual production case is 7.9%, and for the two million ton annual production case is 10.9%

Offshore Case: Santa Monica Bay Model I

Santa Monica Bay deposits have several economic advantages which make this an area worthy of modeling (Fig. 1).

1) Large deposits of sand and gravel occur in the offshore area from Kings Harbor to Santa Monica. An offshore deposit extending from Marina del Rey to the Santa Monica pier contains from 18×10^6 yd^3 to 66×10^6 yd^3 of sand and gravel, of which approximately 72% is suitable for construction aggregate. Collectively, other deposits contain from 99×10^6 yd^3 to 214×10^6 yd^3 of dominantly sand, of which 80% is suitable or marginally suitable for beach restoration and nourishment.[2, 3, 4] 2) The deposits are close to shore, which reduces the transporting cost and capital outlay requirement. 3) Water depth in this area is relatively low (5 to 15 fathoms), which decreases the initial capital outlay requirement. 4) The quality of the material reduces the operating costs of mining and production. 5) The district is close to Los Angeles County markets, and is particularly close to Los Angeles city markets. This provides producers some price advantages over operations located farther from these markets.

The level of production and work schedule is assumed to be the same as in the onshore case. The desired combination of sand and gravel is assumed to be 45% and 55% respectively. The deposits have been estimated to carry 65% sand and 35% gravel and the maximum dredging depth is assumed to be 15 fathoms.

Dredging should vary between 1,200 and 1,600 tons/h to satisfy 1.5 to 2.0 ton annual production. Dredging is done by a hopper dredge, equipped with a 22 in diameter pipe. The horse power required for the dredging is about 2,000 bhp. The material is transferred to shore using barges equipped with self-discharging facilities. The distance to shore is about 4 mi and each round trip takes a maximum of 60 min. For a continuous production, three barges with the total capacity of 2,500 tons are required. A belt conveyor transfers the material over the 0.2 mi distance from the shore to the plant for normal processing and stockpiling. The total capital outlay for such equipment and normal size plant is estimated to be about $14.8 million invested as a lump sum in the beginning of the project. The operating cost is estimated to be about $2.00/ton. Under the same market conditions as in the onshore model, rate of return will vary from 1.9% to 3.85% depending on the annual production level of 1.5 to 2 million tons.[5]

4. ECONOMIC MODELING: SECOND APPROXIMATION

In the previous models for onshore and offshore production, it was assumed that the operating income (price less operating cost) remains constant throughout the length of the project. In this part, this assumption is modified by allowing both price and operating cost to change from year to year.

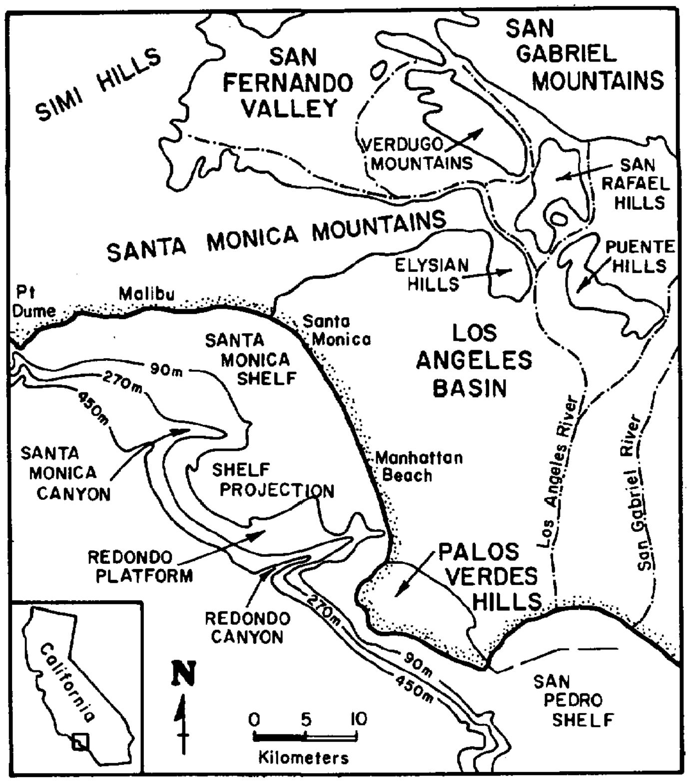

Figure 1. Location map showing the bathymetry and physiography of the study area. Note position of depth contours.

The price of sand and gravel is assumed to be governed by the following equation:

(1) $P_t = Ae^{\alpha t}(P_{t-1})^{\beta}$

or taking the logarithm of both sides:

(2) $Ln(P_t) = a + \alpha t + \beta Ln(P_{t-1})$

where P is the price level of sand and gravel, and a, α, and β are the parameters of the equation that should be estimated, and t represents the time indicator.

The ordinary least square method was employed to estimate the coefficients. The price equation then can be written as:

(3) $Ln(P_t) = -0.0478 + 0.0308t + 0.5861 Ln(P_{t-1})$

or:

(4) $P_t = 0.9533e^{0.0308t}(P_{t-1})^{0.5861}$

R^2 for the equation is 0.9. Data for the period from 1965 to 1979 was used to estimate the coefficients.

Using equations (3) or (4), the price of sand and gravel was forecast for the future. The base year for this forecast is 1981. The price of sand and gravel was estimated to reach $2.60/ton in 1980. The operating cost for the onshore case was estimated to reach $1.75/ton and for the offshore case to be $2.00/ton in 1980.

Operating cost was assumed to increase at a rate approximately equal to the rate of inflation of the producers price index. This rate was estimated to average 7%/annum.

Table 2 represents our predictions or price and operating costs for the next 20 years.

Rates of Return for Onshore and Offshore Models II

Given all the conditions described in the onshore model I, with the new price and operating cost estimates, the internal rate of return for the 1.5 million ton production would be approximately 10% and for the 2 million ton production case it would reach the 12.5% level.

Under the same conditions specified for the offshore model I with the new price and operating cost levels, the internal rates of return are 4.2% and 6.7% for the 1.5 and 2.0 million tons of production respectively.

5. PROJECT EVALUATION

We started the modeling procedures by putting the entrepreneur in a decision making position facing two questions: 1) Whether to invest in the sand and gravel production market, 2) if yes, which one to choose, onshore or offshore.

The answer to (2) is simple. As the study shows, in all cases, rates of return for onshore models are greater than for offshore models. This obviously implies that onshore mining has comparative economic advantages to offshore production, and therefore is more profitable. The answer to the first question is not as clear as the second. Rates of return, which were referred to in this

Table 2. Price and Cost Predictions

YEAR	PRICE LEVEL	OPERATING COST ONSHORE - $/TON	OPERATING COST OFFSHORE - $/TON
1980	2.60	1.75	2.00
1981	2.65	1.87	2.14
1982	2.74	2.00	2.28
1983	2.86	2.14	2.45
1984	3.03	2.28	2.62
1985	3.23	2.45	2.80
1986	3.45	2.62	3.00
1987	3.70	2.80	3.21
1988	3.97	3.00	3.43
1989	4.26	3.21	3.68
1990	4.66	3.43	3.93
1991	4.96	3.68	4.20
1992	5.30	3.93	4.50
1993	5.68	4.20	4.82
1994	6.09	4.50	5.16
1995	6.55	4.82	5.52
1996	7.02	5.16	5.90
1997	7.54	5.52	6.30
1998	8.08	5.90	6.76
1999	8.59	6.30	7.23
2000	9.30	6.76	7.73

paper and which were calculated for different models and under different assumptions, are basically rates at which the discounted future income stream of a project equals its cost. This rate alone has little practical significance for an entrepreneur unless it is compared to some other economic indicators. The reason is that the investor not only wants to know if a certain project is profitable in absolute terms, but also wants to find out if it is profitable relative to other investment opportunities available to him.

The indicator used in cost-benefit analysis is the expected future rate of interest. If the rate of return of a project is higher than the expected future rate of interest, the project is economically profitable and should be chosen. Hence, an important step in the evaluation of a project is to estimate this rate. In this study, the following steps were taken to accurately estimate this rate: 1) A lower bound, and upper bound and a mid-range value for the money market interest rate were defined. 2) Using the time series data, and models similar to equation (1), the future trends of the low, middle, and high values for the interest rate were forecast. 3) Using the forecasted values, the average expected future low, middle, and high values of the interest rate were computed. These values are: low - 8.73%; middle - 9.28%; and high - 10.55%. Allowing 0.5% for estimation and/or calculation error, the average expected rate of interest is approximately 10%. Having the rates of return and the expected rate of interest permits one to address question (1). Table 3 summerizes our analyses.

Table 3. Project Evaluation and Summary

Models	Production Rate 10^6 Tons/Year	Rate of Return %	Project Evaluation: Rejected (R), Accepted (A), Accepted with Low Risk (A*)				
Onshore I	1.5	7.9	R	R	R	R	R
	2.0	10.9	A	A	A	A	A
Onshore II	1.5	10.0	A	A	A	A*	R
	2.0	12.5	A	A	A	A	A
Offshore I	1.5	1.9	R	R	R	R	R
	2.0	3.9	R	R	R	R	R
Offshore II	1.5	4.2	R	R	R	R	R
	2.0	6.7	R	R	R	R	R
Interest Rate Low-Average-High			8.75	← →	9.25	← →	10.55
			Low		Average		High

5. CONCLUSIONS

The results of this study indicate that although investment in an onshore sand and gravel operation might be economically advisable under certain conditions, high initial capital outlay and relatively high operating costs argue against offshore mining for construction aggregate under present economic conditions. Utilization of known reserves, socio-economic conditions and changing environmental attitudes may make offshore production for construction aggregate more attractive in the future.

6. REFERENCES

1. Evans, J. R., Anderson, T. P., Manson, M. W., Maud, R. L., Clark, W. B., and Fife, D. L., Aggregate in the Greater Los Angeles Area, California, California State Division of Mines and Geology Special Report 139, 1979, 96 p.

2. Osborne, R. H., Scheidemann, R. C., Jr., Nardin, T. R., Harper, A. S., Brodersen, K. L, Kabakoff, J., and Waldron, J. M., Potential sand and gravel resources in Santa Monica and San Pedro Bays, southern California: IEEE Proc. Vol., Oceans '79, San Diego, 1979, p. 590-597.

3. Osborne, R. H., Scheidemann, R. C., Jr., Nardin, T. R., and Harper, A. S., Quaternary stratigraphy and depositional environments, Santa Monica Bay, southern California, <u>in</u> Field, M. E., Bouma, A. H, Colburn, I. P., Douglas, R. G., and Ingle, J. C., eds., Quaternary depositional environments of the Pacific coast: Pacific Section, S.E.P.M., Los Angeles, California, 1980, p. 143-156.

4. Osborne, R. H., Scheidemann, R. C., Jr., Nardin, T. R., Harper, A. S., Brodersen, K. L., Kabakoff, J., and Waldron, J. M., Occurrence and sedimentological characteristics of offshore sand

and gravel bodies in Santa Monica and San Pedro Bays, and their suitability as a source of material for beach nourishment and construction aggregate: Univ. Southern California Sea Grant Publication, in preparation.

5. Saghafi, Massoud, and Osborne, R. H., An economic appraisal of mining offshore sand and gravel deposits, Santa Monica Bay, southern California: Univ. Southern California Sea Grant Publication, in press.

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