Market Incentives that Starve Our Beaches: Gainers and Losers

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Abstract

This paper is an extension of previous work (Magoon et al., 2004) wherein the authors offered a preliminary estimate of the sediment losses and the value of sediment losses from engineered interferences that impact the sediment supply along the Pacific Coastline of California, Oregon and Washington. Based on an array of secondary sources, in the Pacific states nearly 28 million cubic meters of material is lost annually to engineered interferences. Preliminary estimates of cumulative losses since 1950 total 1.4 billion cubic meters. In this paper, we examine the activities (that produce goods and service) causing these losses to the coastline and estimate the increase in cost of the good or service to avoid or mitigate the sediment loss. The engineered interferences considered, in order of importance are (1) sand and gravel mining, (2) dams and flow regulation, (3) subsidence related to fluid extraction, (4) dredging, (5) debris basins and (6) harbor deepening. This paper examines sand and gravel mining and dams and flow regulation that together result in about 95% of the sediment losses. Corresponding cost increases to mitigate and/or reduce the sediment losses are examined for goods and services including sand and gravel, flood control, hydroelectric power, and water supply.

Background

Prior estimates (Magoon et al., 2004) indicate that the leading cause of sediment losses from engineered interferences is sand and gravel mining. The authors estimated that of the nearly 28 million cubic meters lost to the shoreline each year, more than 21 million cubic meters relate to sand and gravel mining. Figure 1 shows the relative share of annual losses by type of activity. Each of the activities is conducted in support of an economic interest separate from consideration of shoreline losses. For example, sand and gravel is used primarily in construction, but the cost to purchase these construction inputs does not reflect the cost of the loss of these sediments to the coastline. Losses to the coastline result from losses to the beach profile and include losses in recreational values when beaches erode, losses in property values relating to both the loss of beach and the degrading of the coastline and reductions to the quality of life in coastal areas. A generic estimate of the cost to replace sand on the beach is $12 per cubic meter (Magoon et al., 2004), a cost that is not reflected in the market price of sand and gravel for construction, from $4.61 - $8.51 per metric ton in 2002 (USGS, 2002) which equates to $7.79 - $14.38 per cubic meter.

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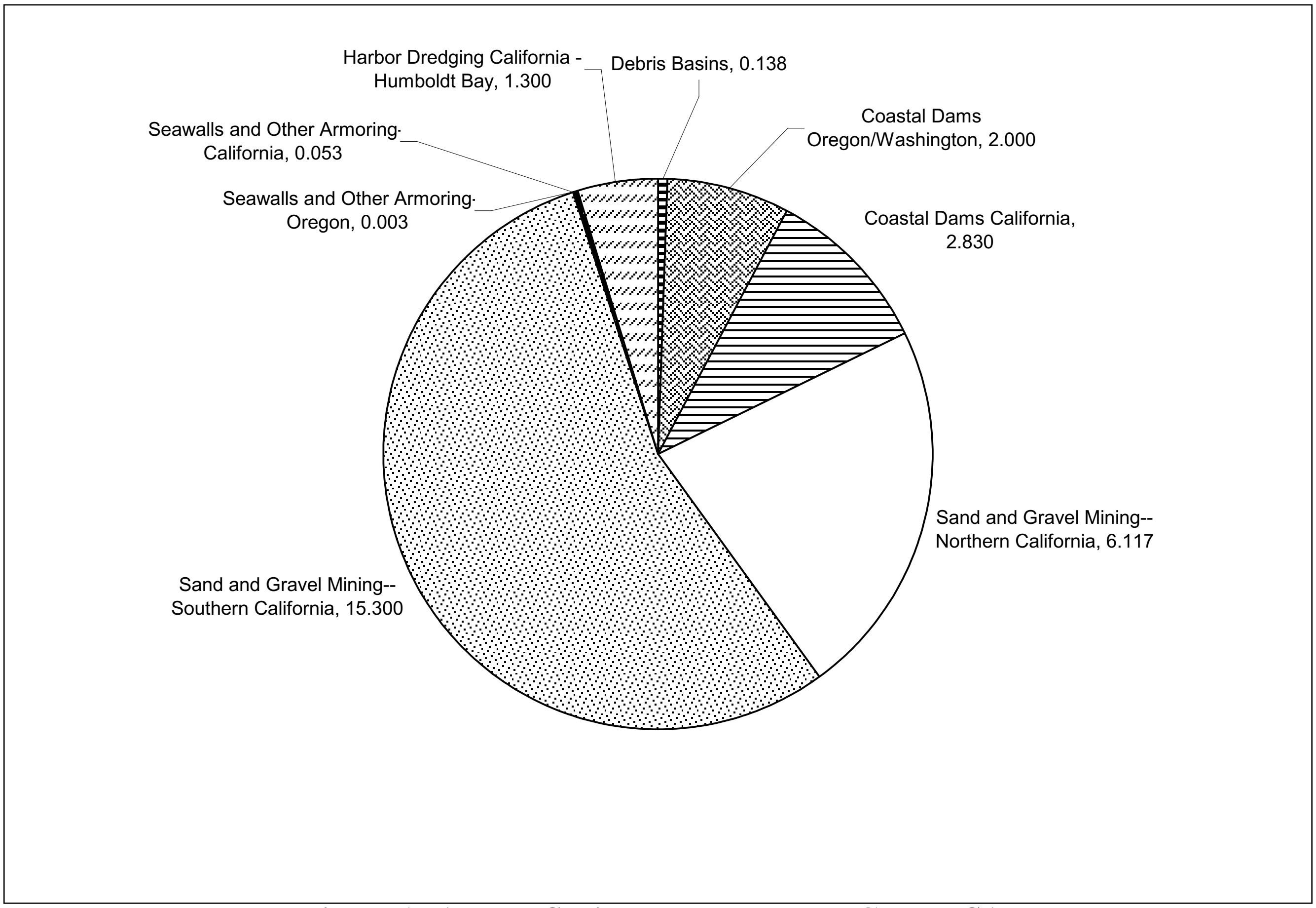

Figure 1. Annual Sediment Losses, West Coast USA
(millions of cubic meters)

As shown by percentage in Table 1, of the estimated volumes of sediment lost to the coast, sand and gravel mining and dams account for about 95% of the losses. Note that subsidence from fluid extraction has also resulted in large scale erosion losses in the Pacific coast region, but no estimates of the equivalent loss of sediment from subsidence were available. This paper examines how the losses associated with sand and gravel mining and dams could be reduced and/or included in the cost of products and services within the existing market structure.

Table 1: Annual Sediment Losses, Millions of Cubic Meters

Activity	Loss	% of Total
Coastal Dams Oregon/Washington	2.000	7.25%
Coastal Dams California	2.830	10.25%
Sand and Gravel Mining--Northern California	6.117	22.16%
Sand and Gravel Mining--Southern California	15.300	55.43%
Seawalls and Other Armoring-California	0.053	0.19%
Seawalls and Other Armoring-Oregon	0.003	0.01%
Harbor Dredging California - Humboldt Bay	1.300	4.71%

The following sections indicate the annual quantity of material lost to the coterminous Pacific coastline, by activity. Further we suggest options for mitigating or avoiding the shoreline losses by changes in market behavior and/or modifying the market price of the offending goods and services to include the cost to mitigate coastal sediment losses.

Sand and Gravel Mining

In 2002, 1.13 billion metric tons of sand and gravel were produced and consumed in the U.S. In California, the production of sand and gravel was an estimated 151 million metric tons (USGS 2002), or the equivalent of about 89 million cubic meters. In that same year, an estimated 28 million cubic meters of sand and gravel were lost to the California coastline from sand and gravel mining.

A Statistical Compendium (Tepordei, 1990) indicates "The demand for construction sand and gravel is determined mostly by the level of construction activity and therefore the demand for construction materials.… Construction sand and gravel is a high-volume, low-value commodity. The industry is highly competitive and is characterized by thousands of operations serving local or regional markets…. Transportation is a major factor in the delivered price of construction sand and gravel. The cost of moving construction sand and gravel from the plant to the market often exceeds the sales price of the product at the plant. Because of the high cost of transportation, construction sand and gravel continues to be marketed locally…. Truck haulage is the main form of transportation used in the construction sand and gravel industry. Rail and water transportation combined account for about 10% to 20% of total construction sand and gravel shipments…. The industry also faces increasing competition from crushed stone that can substitute for sand and gravel in most applications."

Note that are numerous problems in understanding the impact of sand and gravel mining on the coastline. "Based on county level information available on the Internet, sand and gravel mining in Northern California from the Russian River to the Oregon border is approximately 6.1 million cubic meters per year. No site specific statistics for sand and gravel mining in Southern California are available…. For the purposes of this paper, it is estimated that 50 percent of this material may be from or associated with coastal watercourses in the first flood plain and we roughly estimate that annual sand and gravel extraction in coastal watersheds in Southern California is 15.4 million cubic meters

…." (Magoon et al., 2004). Note the authors made no attempt to estimate additional losses to the coast that may result from the sometimes very similar activities related to the crushed stone industry. From sand and gravel alone, using a conversion factor of 1.69 metric tons per cubic meter, the 27.6 million cubic meters lost to the shoreline equates to 47 million metric tons, or 31% of California's total 151 million metric ton production in 2002. Moreover, the demand for sand and gravel is increasing. "By using very conservative assumptions, we have projected trends in the production of crushed stone and sand and gravel at average annual growth rates of one percent and 0.5 percent respectively" (USGS 1999). In order to mitigate or eliminate the loss of sediment to the shoreline, four options are considered.

Substitution and Conservation. First, using less sand and gravel from sensitive sources would reduce the loss of sediment. Alternatives to domestic sand and gravel from mining are available as inputs to construction. Steel buildings offer options to concrete construction, as do wood and fabricated replacement components. These options are limited based on the size, location and type of construction as well as local structural requirements. Building less new structures, or reducing the size of new structures could also be used to reduce the amount of sediment lost to the coastal regions.

Recycling. A second option, already widely used in the U.S. and elsewhere, is to replace 'virgin' sand and gravel with recycled concrete products. A recent report (FHWA, 2004) outlined existing uses of recycled material and the pros and cons associated therewith. Benefits in performance including strength, durability, control over gradation and the potential to minimize cracking are cited. Resource conservation advantages include reduction in land disposal and dumping, conservation of virgin aggregate, reduced impacts to landscape from unsightly piles of concrete rubble and reuse of existing concrete, metal recovery for recycling and its definition as an inert material in solid waste regulations. Economic benefits included limiting haul distance by onsite or near site use of a heretofore waste material, reduction of disposal costs as dumping or burial of recycled aggregate can be more expensive, reduction in material acquisition costs for reusing agencies and general cost savings through the use of less virgin aggregate. "The savings is increased by the reduction of transportation and disposal costs. Another economic benefit is the recovery of steel from the recycling process. This material usually becomes property of the contractor, who can sell as scrap metal. There is also potential for cost savings in many areas where aggregates are not locally available, and have to be hauled long distances, often 50 miles or more. Environmental impacts reduction and extending available life of landfills is also a long term benefit that can be experienced by local governments due to increased recycling of recycled concrete aggregate." (FHWA, 2004). In 2002 California recycled 1.8 million metric tons of concrete at an average price of $6.43 per metric ton and 681,000 tons of asphalt at an average unit price of $4.52 per metric ton. (FHWA, 2004) No estimates were found to indicate how much potential there is for increasing recycling to replace use of virgin sand and gravel.

Imports and Exports. A third option for reducing sand and gravel mining is to import needed sand and gravel from other regions and/or reduce U.S. exports. Currently, the U.S. imports 3.8 million metric tons of sand and gravel at an average cost of $12.51 per metric ton. The vast majority of the imports come from Canada, 2.8 million metric tons (Bolen, 2002 Table 17). "Aggregate imports by barge and ship from Canada and Mexico continued to increase in the San Francisco and San Diego bay areas. California imported about 2.2 million metric tons of sand and gravel during 2002, compared with 816,000 metric tons in 2001, a 160% increase. Imports to the San Francisco Bay area are expected to increase significantly during the next few years. This is largely becaue of the closure of

Anson Aggregates iMid Pacific Inc.'s Radum plan in 2001. The Radum plant produced more than 3.6 million tons per year of aggregate " (USGS, 2002). The U.S. exports of and and gravel in 2002 totaled 2.6 million metric tons of sand and 600 thousand metric tons of gravel primarily to other countries in North America (Bolen, 2002 Table 16). Reductions in exports may be infeasible in light of the high quality of U.S. sand and advanced technology in processing the sand. "The United States is the world's leading exporter of silica sand. … Because of the extensive, high quality deposits of sand, combined with the technology to process sand and gravel into nearly any quality for any application, sand and gravel companies in the U.S. are able to provide a product for any application. The U.S. exports sand and gravel to nearly every region in the world." (Minerals Information Institute, 2002).

Offshore Mining. When alternatives to conserve, recycle or import sand become cost prohibitive, a fourth option is to replace the sediment lost to the shoreline from sand and gravel mining from other sources. To the extent that sand is dredged from waterways, ports and harbors, the dredged material can be placed in the nearshore system. California follows this practice in most regions, Humboldt Bay being the exception. To further augment the supply, sand can be moved from offshore into the nearshore system, as is sometimes done in beach nourishment. As noted, prior research (Magoon et al., 2004) indicate a generic price for beach nourishment of $12 per cubic meter.

Economic Impacts. The overall ongoing impact of sand and gravel mining is a loss of 27.6 million cubic meters of sediment annually, which may increase with increased demands for construction. Using the generic value of $12 per cubic meter to replace this sediment along the coastline, the dollar impacts total $331 million per year.

Uses of sand and gravel in California are shown in Table 2. Identified uses all relate to construction, as either construction materials or inputs to construction. Using 2001 prices and production levels, to mitigate the $331 million per year, the cost of construction sand and gravel per metric ton in California would increase $2.22, on average 31%. Concrete products, already the highest unit value cost, increase 15% while fill, the use with the lowest unit value increases 39%. The percentage price increase, by use, is shown in Table 3. Note that this does not represent a corresponding increase in the final construction project, for which sand and gravel inputs are only one of many components.

Table 2. California Sand and Gravel Sold or Used in 2001. by Major Use Category*

Use Category	Quantity (000's metric tons)	% of Total	Value (000)	Unit Value
Concrete aggregates (incl. concrete sand)	39,600	26.6%	$367,000	$9.27
Plaster and gunite sands	2,920	2.0%	$23,200	$7.95
Concrete products (blocks, bricks, pipes, etc.)	233	0.2%	$3,350	$14.38
Asphalt concrete aggregates & other bitiminiuous mixtures	18,700	12.6%	$144,000	$7.70
Road base and coverings	14,900	10.0%	$98,900	$6.64
Fill	7,770	5.2%	$44,700	$5.75
Other milscellaneous uses	1,450	1.0%	$12,300	$8.48
Unspecified (reported and estimated)	63,000	42.3%	$387,000	$6.14
Total or average	149,000		$1,080,000	$7.25

*USGS (2002), Table 5

Table 3. Adjusted California Sand and Gravel Cost by Major Use Category

Use Category	% of Total	Unit Value	Increased cost with Mitigation	% Increase
Concrete aggregates (incl. concrete sand)	26.6%	$9.27	$11.49	24%
Plaster and gunite sands	2.0%	$7.95	$10.17	28%
Concrete products (blocks, bricks, pipes, etc.)	0.2%	$14.38	$16.60	15%
Asphalt concrete aggregates & other bitiminiuous mixtures	12.6%	$7.70	$9.92	29%
Road base and coverings	10.0%	$6.64	$8.86	33%
Fill	5.2%	$5.75	$7.97	39%
Other milscellaneous uses	1.0%	$8.48	$10.70	26%
Unspecified (reported and estimated)	42.3%	$6.14	$8.36	36%
Total or average		$7.25	$9.47	31%

Coastal Dams and Flow Regulation

Coastal dams and flow regulation are the second largest contributor to sediment loss along the Pacific coast (Magoon et al., 2004). As shown in Table 1, 4.8 million cubic meters of material are lost annually. Dams and flow regulation are constructed or undertaken for a number of reasons, most notably flood control, hydroelectric power and water supply. Many projects incorporate more than one of these functions which are project specific. The overall impact in terms of the replacement cost for the loss of sediment at $12 per cubic meter is $57.6 million, annually. The allocation of cost to use would require project specific data on the loss of sediment by dam or flow regulation and identification of the beneficiaries of the project, an extensive effort well beyond the scope of this paper. For projects involving flood control, the standard procedure used to justify public monies is the measure of avoided damages by the project. Those for whom damages are avoided could be allocated the cost of the sediment lost to the shoreline from the project, proportional to the damages avoided. In the case of power generation, the unit cost of the power sold could be increased to reflect the lost sediment, the same could be applied to water users and any other identified beneficiaries from a project-specific analysis.

Conclusion

Engineered interferences are a significant factor in the deterioration of the Pacific coastline. At the present time, the products of these interferences, for the most part, are not costed to include the cost to remediate detrimental effects on the shoreline. Thus, the benefits that result from a healthy shoreline are reduced at the expense of those who benefit from the engineered interferences. The losers in this process are the owners of shoreline properties and neighboring properties, whose value is directly affected by the shoreline condition. Also in the loser category are all those who use and value the coastal region, wherein the use and/or value received has been depleted by the sediment loss. The winners in this process are the recipients of the goods or services that result from the engineered interferences, herein identified as those who purchase the goods and/or services of the construction industry, flood control projects, power from hydroelectric plants and water from reservoirs. The economic impact of this process is to subsidize the winners at the expense of the losers, resulting in overconsumption of the underpriced products of engineered interferences and lost consumption from reductions in coastal amenities, assuming competitive market forces for both winners and losers.

While routinely a paper relating to economics focuses on the numbers, the authors boast little confidence in the accuracy of the numbers. As with the research preceding this effort (Magoon et al., 2004) the numbers were estimated by the authors from secondary sources supplemented by the judgement of the authors and other researchers. The values are not accurate, nor do we wish to have this research judged by the accuracy of the numbers. Much more research is needed to begin to accurately define these values. What is important in this paper is the concept. If we as a society choose to underprice certain endeavors for any reason, and that underpricing results in losses to others, there is a strong argument that we as a society should bear the cost. Yet at the same time sediment is being lost to the system by a variety of economic activities undertaken for public or private gain, public monies to remedy the results are becoming more scarce. In the case of oil spills, the courts have affirmed the concept of 'the polluter pays' (Chapman et al., 2001) and held the oil industry responsible for damages to the coastline from oil spills. Following similar reasoning, the remover of sediment from the coastal environment, resulting in economic harm to the owners and users of this environment, should reimburse the losses and/or mitigate the damages.

References

Bolen, W.B (2002). "Sand and Gravel, Construction," USGS Minerals Yearbook, Tables 1-17, http://minerals.er.usgs.gov/minerals/pubs/commodity/sand_&_gravel_construction/sandgmyb02r.pdf

Chapman, D. J. and Hanemann, M., (2001). "Environmental Damages in Court: The *American Trader Case.*" In: The Law and Economics of the Environment, ed. Anthony Heyes, pp. 319-367.

Federal Highway Administration [FHWA] (2004). "Transportation Applications of Recycled Concrete Aggregate: FHWA State of the Practice National Review," U.S. Department of Transportation, September 2004

Magoon, O. T., et al. (2004). "Economic Impacts of Anthropogenic Activities on Coastlines of the United States," Proceedings, 29th International Conference on Coastal Engineering, ASCE, Lisbon, Portugal.

Mineral Information Institute (2002). "Sand & Gravel," http://www.mii.org/Minerals/photosandgr.html

Tepordei, V. V. (1990). Construction Sand and Gravel Statistical Compendium." USGS: Minerals Information, http://minerals.usgs.gov/minerals/pubs/commodity/sand_&_gravel_ construction.stat/. Tables 1-14.

U.S. Geological Survey [USGS] (1999). Natural Aggregates—Foundation of America's Future," USGS Fact Sheet FS 144-97 Reprinted February 1999, htp://minerals.er.usgs.gov/minerals/pubs/commodity/ aggregates/fs14497.pdf

USGS, California Geological Survey (2002). "The Mineral Industry of California," http://minerals.usgs.gov/minerals/pubs/state/2002/castmyb02.pdf