

Chapter 4

Mitigating the adverse impacts of shoreline armoring on California beaches

Introduction

California's coastline is being armored in response to coastal erosion, and the California Coastal Commission is struggling to determine the value of beach loss to mitigate for adverse effects from the construction of shoreline protective devices. The California Coastal Commission requires in-lieu mitigation for loss of sand and beach recreation due to passive erosion from sea walls. At present the Coastal Commission approaches each mitigation effort using different values, methods and models. Consistent and more accurate methods to estimate the total economic value of lost beach ecosystem services from shoreline armoring impacts are needed to determine appropriate in-lieu mitigation fees and to ensure the public is being properly compensated for lost recreation and beach ecosystems services.

Approximately ten percent of the California coastline has been armored with seawalls, revetments and wood during the last 100 years (Griggs 2005). Armoring is more concentrated in Southern California's urban counties. Thirty percent of San Diego, Orange, Los Angeles and Ventura County beaches are armored (Griggs 2005). The extent of coastal armoring in California has increased by over four hundred percent during the period from 1971 to 1992 and

continues today (Griggs 2005). Shoreline armoring narrows and ultimately eliminates sandy beaches on eroding shorelines through a process called passive erosion (Griggs 2005). In California, approximately 86% of the coast is eroding (Griggs 1998). Accelerating sea level will increase the impacts of coastal erosion (Heberger, Cooley et al. 2009).

Sandy beaches are important natural resources that provide ecosystem services. Ecosystem services include both ecological functions and human services. Human services include coastal recreation, beach access and protection from storms (disturbance protection). Ecological services include habitat, nesting sites and food sources for numerous aquatic and terrestrial species (Defeo, McLachlan et al. 2009).

Despite requirements in the California Coastal Act (CCA) to avoid shoreline armoring for coastal development, existing property owners have a right to protect their property if threatened by erosion (Cardiff 2001, CCA §30253). In these cases, the Coastal Commission is required to “eliminate or mitigate adverse impacts on local shoreline sand supply” (CCA §30253). Adverse impacts include impacts to both ecological and human services provided by beaches.

The Coastal Commission has applied different methodologies for each project to determine the value of lost recreational use and has not considered ecosystem service-based approaches to value or restore impacted beaches. As a result, mitigation fees are often subject to litigation, values for lost recreation may

be improperly valued and other ecosystem services values have not been consistently considered.

The objective of this chapter is to provide conceptual models for supply-based service-for-service and demand-based approaches for mitigating for adverse impacts on local shoreline sand supply, discuss their strengths and limitations, review the use of non-market values to estimate lost coastal recreation, show through comparative analysis of past projects (case studies) the degree to which Coastal Commission approaches have accurately captured the value of lost beaches and provide recommendations for a consistent and more accurate approach based on accepted practices in the literature.

A conceptual model for an ecosystem-based approach to mitigation for loss of sand supply is provided. This model includes an explicit set of ecosystem services provided by sandy beaches. The federal Natural Resource Damage Assessment (NRDA) Habitat Equivalency Analysis (HEA) approach is discussed as an alternative. Limited research on beach ecosystem functions and their economic values prohibits valuation of these services but provides a conceptual model to show what values are not included. The models show that mitigation based on recreation and sand impoundment alone underestimates the adverse impacts of erosion. Two demand-based models are described and the amenity-based model shows potential as a practical approach for use by the Coastal Commission. A comparative analysis compares this approach to past practices

that have resulted both in overestimates and underestimates in valuing lost recreation from adverse impacts of shoreline protective devices.

The California Coastal Act

The California Coastal Act (CCA) was written to ensure balanced utilization of coastal zone resources taking into account the social and economic needs of the people of the state and to maximize public access and recreational opportunities (CCA, §30001.5). Numerous sections of the CCA specifically require protecting and maximizing coastal access and recreation along the coastal zone (See Sections 30210, 30211, 30212(a), 30213, 30221). The CCA further specifies that coastal areas suited for water-oriented activities that cannot be substituted inland shall be protected (CCA, §30220). When the CCA allows protection of coastal development that will impact beach access and recreation, the CCA requires that the impacts be mitigated.

Section 30235 of the CCA guides Coastal Commission decisions for permitting shoreline armoring to protect structures along the coast that are threatened by coastal erosion. Section 30235 of the California Coastal Act states:

Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alters natural shoreline processes **shall** be permitted when required to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion **and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply**. Existing marine structures causing water stagnation contributing to pollution problems and fishkills should be phased out or upgraded where feasible. (CCA, §30235, emphasis added)

Recent law journal articles have concluded that the California Coastal Act compels the Coastal Commission to make permitting decisions that are “in a manner which on balance is the most protective of significant coastal resources” and therefore should avoid shoreline armoring if at all possible (Cardiff 2001; Caldwell and Segall 2007). Caldwell and Segall (2007) find that in some cases it will be necessary for the Coastal Commission to permit shoreline armoring that will be destructive to public resources, public access and coastal recreation.

The Coastal Commission’s requirement for compensatory mitigation for the impacts of shoreline armoring has evolved over time. Since 1993, the Coastal Commission has required an in-lieu fee to mitigate for sand loss due to impoundment loss. Impoundment loss is sand trapped behind the structure. A procedural guidance document was created by the Coastal Commission in 1997 to provide a standard approach to calculating this fee (CCC 1997). Since 2004, the Coastal Commission has required an in-lieu fee to mitigate for lost recreational opportunity from beach loss due to passive erosion. The Coastal Commission has not used a consistent approach to calculate this fee. In some cases the Coastal Commission has acknowledged that their approach is conservative because the mitigation fee does not capture all values lost from a narrowing beach. For example, ecological services provided by beach habitats are not valued and included in the fee.

The impact of shoreline armoring on beaches and coastal recreation

Shoreline armoring structures protect coastal development by preventing naturally occurring beach and bluff erosion (Griggs 2005). Shoreline armoring structures are typically concrete walls or rock revetments designed to prevent wave action from eroding the shoreline (Figure 4.1). Shoreline armoring has several impacts that limit sand supply and reduce the width of the beach. First, beach area under the footprint of the actual armoring structure is lost. This is known as placement loss. For example, riprap revetments can occupy over 30 feet of beach width for their entire length. Second, beach sand that would have eroded from the beach or bluff is impounded behind the structure and is not available to the beach. This is known as impoundment loss. Third, beach is lost due to passive erosion (Figure 4.2). Passive erosion occurs because the back of the beach, that would otherwise naturally migrate landward, is fixed (Griggs 1985). As relative sea level rises the beach is submerged and the beach will gradually narrow until the public beach no longer exists.

Armoring the beach will ultimately result in the total loss of public beach seaward of the structure, limit beach access and deny other forms of coastal recreation in the area influenced by the shoreline armoring (Cardiff 2001; Caldwell and Segall 2007). For example, loss of the beach will reduce lateral access along the beach and can limit access to other beach areas or recreational sites. Loss of the beach can also cause wave reflection off the seawall or

revetment that can degrade the quality of a surfing area or make it unsafe for swimmers to enter the water.

Shoreline armoring and the resultant beach loss will reduce and eliminate intertidal and supratidal¹ sandy beach habitat. Sandy beaches are important habitats that provide food sources, nesting sites and rookeries for a broad range of species. (Dugan, Hubbard et al. 2000; Dugan, Hubbard et al. 2003; Hubbard and Dugan 2003). Dugan and Hubbard (2006) and Dugan, Hubbard et al. (2008) show that shoreline armoring has a negative effect on sandy beach habitat as the beach narrows by eliminating supratidal habitats and compressing intertidal habitats resulting in lower abundance, biomass and size of macroinvertebrate species. Loss of the macroinvertebrate species (e.g. beach hoppers) that are an important food source for birds, and reduces the species richness and abundance of shorebirds and Gulls (Dugan, Hubbard et al. 2008).

The adverse impacts of shoreline armoring on public recreation and beach ecosystems are a loss of public resources. Mitigation must accurately estimate the lost value of recreation and ecosystem functions to compensate the public for lost resources. Over 100 miles of the California coastline have been armored, and less than 0.2 miles have included mitigation for lost recreation and no mitigation has been required for loss of ecological functions.

¹ Supratidal is the zone of the beach immediately marginal to and above the high-tide level.

The Coastal Commission's definition of mitigation

The California Coastal Act does not contain a definition of mitigation. The Coastal Commission uses the California Environmental Quality Act (CEQA) definition of mitigation (CCC 1997). Mitigation as defined by the California Environmental Quality Act (CEQA) Section 15370 includes measures that will eliminate, avoid, rectify, compensate for or reduce environmental effects when an environmental impact or potential impact is identified (CEQA 2009). Mitigation is the proactive avoidance or compensation for anticipated impacts from a project. Compensation is used to replace or provide substitute resources or environments when a direct impact is avoidable and the resources cannot be mitigated on site. The CEQA definition of mitigation provides a hierarchical series of alternatives based on impact avoidance that should be considered in sequence (Figure 4.3). The sequencing approach to mitigation is based on a Memorandum of Agreement between the Environmental Protection Agency and the Department of the Army concerning the determination of mitigation under the Clean Water Act Section 404(b)(1) guidelines (MOA 1990).

The Coastal Commission applies this approach to mitigation through an alternatives analysis for each permit request for shoreline armoring. The Coastal Commission prefers to recommend mitigation that avoids, minimizes, rectifies or reduces impacts from shoreline armoring, but there are cases where it is impossible to avoid all impacts and therefore require compensatory mitigation for adverse impacts on local shoreline sand supply.

Prior to 1993, the Coastal Commission did not require compensatory mitigation for the adverse impacts to sand supply from the construction of shoreline protective devices. Between 1993 and the present, they began assessing an in-lieu fee for beach sand impounded behind the shoreline protective device. Starting in 2004 the Coastal Commission began assessing an in-lieu fee to mitigate for lost beach recreation due to passive erosion. The Coastal Commission (2005) and Caldwell and Segall (2007), acknowledge that this represents an incomplete model for assessment of the full adverse impacts to human and ecological services provided by the beach habitat.

Mitigating lost beach ecosystem services

Current decision making processes, including the Coastal Commission approach to mitigating the adverse impacts of shoreline armoring, often ignore or underestimate the value of ecosystem services (MA 2005).

Failure to quantify ecosystem values in commensurate terms with opportunity costs often results in an implicit value of zero being placed on ecosystem services. In most cases, ecosystem services have values larger than zero (Loomis, Paula et al. 2000).

Implementation of an ecosystem services approach could account for the full range of services provided by sandy beaches. These services include recreation and ecological services such as nutrient cycling (Table 4.1).

The Millennium Ecosystem Assessment (MA) report and the NRC report on Valuing Ecosystem Services provide an ecosystem service model to account

for the human and ecological services provided by beaches (NRC 2004; UNEP 2006). The Total Economic Value (TEV) approach, recommended by the MA, provides a model to account for the full range of economic values associated with ecosystem services. The Natural Resources Damage Assessment (NRDA) provides a service-for-service approach for restoration of lost ecosystem services. Use of these models can provide a more complete accounting for the services of beaches and how to value those impacts for compensatory mitigation.

The total economic value (TEV) model provides a framework for valuing ecosystem services, including sandy beaches. The TEV framework is based on the presumption that individuals have multiple values for ecosystems and provide a framework to ensure that components of that value are not missed or double counted (NRC 2004). The TEV framework separates ecosystem services into direct and indirect use values and considers non-use values (Figure 4.4). The sandy beach ecosystem services described by Defeo, McLachlan et al. (2009) are all either direct or indirect use values (Table 4.1). Direct use values can be measured using revealed and stated preference approaches (described in Chapter 1). Indirect uses are more challenging to measure and often require models that link direct use commodities with ecosystem services (NRC 2004). Production function approaches seek to determine how changes in ecosystem services affect an economic activity, then measure the impact of the change on economic activity (NRC 2004). For example, loss of sandy beach prey resources to lower biodiversity of shore birds could be linked to lost consumer surplus of bird watchers.

Option and bequest values describe the value of preserving the option for use of services in the future either by an individual (option value) or by future generations (bequest values). The primary non-use value is existence value. Existence value is unrelated to the use of the resource and represents the willingness to pay for the resource to exist (e.g., willingness to pay for the protection of a beach you will never visit). Non-use valuation requires contingent valuation methods.

Ecosystem services

Efforts to define and value ecosystem services go back several decades (Liu, Costanza et al. 2010). Ecosystem services are the benefits people obtain from ecosystems. The full definition of ecosystem services provided by the United Nations Millennium Ecosystem Assessment (MA) is:

Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits (MA 2005).

The ecosystem services model is anthropocentric by definition, but the MA makes clear that sound ecosystem management must include the intrinsic values of ecosystems. Intrinsic values cannot be given a monetary value and instead require a values-based decision making structure (MA 2005).

Coastal ecosystems are among the most productive and heavily used ecosystems in the world and provide many services to human society (UNEP 2006). Sandy beaches are one of the largest marine biomes on the planet (Etnoyer, Wood et al. 2010). Sandy beach ecosystems are one of the most heavily used but poorly understood coastal ecosystems, and our understanding of their ecological functions is limited (Defeo, McLachlan et al. 2009). Defeo, McLachlan et al. (2009) describe the ecosystem services provided by beaches (Table 4.1).

Together, the ecosystem services model and the TEV model provide a framework to account for a more complete set of ecosystem services provided for by sandy beaches. Option values and non-use values pose a difficult challenge to determine quantitative dollar values, but their values are greater than zero (MA 2005).

Coastal Commission's mitigation approach

In cases where the Coastal Commission has no choice but to permit shoreline armoring (Step 5 in the mitigation hierarchy in Figure 4.3), impoundment loss, placement loss and passive erosion will narrow the beach and cause a loss of the flow of recreational and ecological services provided by the sandy beach. The Coastal Commission is faced with a choice of how best to compensate for the impact by either replacing or providing substitute resources or environments. At present, the Coastal Commission uses a demand-based approach to compensate for lost beach services. This approach uses non-market valuation to determine the lost value of beach recreation resulting from the loss

of beach but has yet to account for loss of ecological services. An alternative is a supply-based approach, using the Natural Resource Damage Assessment's Habitat Equivalency Analysis (HEA), which could provide a more robust model that accounts for lost beach recreation and also lost ecological services. This approach inherently accounts for the total economic value of the beach by seeking to restore all the use and nonuse values provided by the sandy beach.

Demand-based approach: non-market valuation

Non-market valuation is a demand-based approach that can be used to determine compensation for loss of beach services. The value of use and non-use values for beach services are expressed in terms of consumer surplus. Consumer surplus is a measure of the economic benefit to the individual – the difference between the maximum willingness to pay and the price actually paid for the good (See Chapter 1). This approach is well studied for beach recreation but is limited when applied to non-use values (Figure 4.4) and ecological services. This is the approach currently used by the Coastal Commission to value lost beach recreation. To capture the full set of ecological services provided by sandy beaches, the non-market valuation approach requires determining consumer surplus values for lost recreation and ecological services.

Estimating the baseline recreational value of a beach

The annual recreational value (or total consumer surplus) of a beach is determined by summing all of the individual consumer surplus values of beach

visitors. This can be calculated by multiplying the average individual consumer surplus (per person per visit) by the annual attendance at the beach area.

$$CS_{beach} = CS_{ave} * attendance$$

Equation 4.1: Consumer surplus value of a beach.

where CS_{beach} is the total annual consumer surplus. CS_{ave} is the average individual consumer surplus per visit and *attendance* is the annual attendance of the beach area. The average individual consumer surplus (per visit) can be determined by site-specific original non-market valuation approaches such as Random Utility Models (discussed below), travel cost methods, and contingent methods or approximations derived from original research conducted elsewhere (i.e. benefit transfer method) (See Chapter 1). Annual attendance is based on counts of beach visitors. See King and McGregor (2010) for a discussion on attendance counts at California beaches.

Using benefits transfer to determine the consumer surplus of a beach visit

It is recognized that site-specific studies are more accurate to determine non-market values, however site specific studies are expensive and time consuming (Pendleton, Atiyah et al. 2007). For example, if the cost of the site specific study by City of Solana Beach study (\$100,000) for 1.4 miles of sandy beach was applied to the 668 miles of sandy beach in California, it would cost over \$47 million to develop site specific studies for all beaches in the state. One alternative is to “transfer” the benefit estimates from existing studies (study site)

to the site being considered (policy site). The transfer of value estimates from the study site to the policy site range from complex analysis that adjusts the consumer surplus based on a comparison of the individual attributes of each site called a function transfer (e.g. meta-analysis transfer) to simply applying a single value from a related study site to the policy site (point transfer). See Atiyah (2009) for a review of benefit transfer applications in coastal management. If relevant studies exist, a range of values can be considered or averaged. The weighted amenity approach (discussed below) provides a middle ground that adjusts the consumer surplus based on a weighted set of beach amenities, including weather, water quality, beach width and quality, overcrowding, additional amenities and substitution. All benefit transfer methods are limited by the quality of the original study and the transferability of the conditions from the study site to the policy site (Desvouges, Johnson et al. 1998).

Valuing lost recreation on an eroding beach

Determining the value of lost beach recreation that occurs because of shoreline armoring is more complicated. It requires determining lost recreational value of the beach area seaward of the shoreline armoring structure as the beach narrows over time. It should also include adjacent beach impacts, down coast impacts and loss of access to adjacent beaches. The primary characteristic of beach change over time is beach width. Beach width is an amenity that limits the area of the beach available to users and can affect the consumer surplus of a beach visit directly by changing the area of beach available to recreate.

Reduction in width can also affect the level of crowding at a beach, which also may affect consumer surplus (although this last affect is complicated by the fact that lower per person per visit consumer surplus also lowers attendance at the affected beach). A portion of the beach width is lost immediately from placement loss when the shoreline protective device is constructed. Over time, the change in beach width is controlled by the erosion rate at the beach. Lost beach width can reduce the individual consumer surplus or can result in substitution, if the visitor chooses to visit a different beach. (King 2001; Lew and Larson 2005; Pendleton, Mohn et al. 2011). The time over which the lost value is estimated is determined by the lifetime of the project, which is set by the Coastal Commission upon permitting the shoreline protective device.

Changes in the recreational value of a beach are determined by summing the lost individual consumer surplus per visit due to lost beach width for each visit over the lifetime of the project adjusted to the net present value.

$$CS_l = \sum_{t=0}^n \frac{(\Delta CS_i (bw_t) * attendance_t)}{(1 + r)^t}$$

Equation 4.2 Consumer surplus lost on an eroding beach.

Where CS_l is the net present value of lost consumer surplus over the lifetime of the project. n is the project lifetime in years. ΔCS_i is the loss of consumer surplus as a function of beach width (bw_t) on year t . bw_t is a function of placement loss at $t=0$ and

the erosion rate from $t=1$ to $t=n$. *attendance* is the annual number of beach visits for year t . r is the discount rate.

Random utility model

The most sophisticated methods to account for lost recreational value over time use a Random Utility Model (See Chapter 1). These methods model site choice based on beach characteristics and the cost of visiting the beach. A RUM models beach choice by including all beaches that the beach goer might consider as reasonable choices (and sometimes includes non-beach options too). Using a RUM the value of beach visits is revealed through the choice of which beach to visit, based on beach characteristics and the cost of visiting the beach. The RUM requires survey data for multiple beaches and complex economic modeling. RUM studies are time consuming, costly and impractical for coastal planners.

Area-based model

A simpler method, previously used by the Coastal Commission, is the area-based model. The area-based model estimates the annual value of each unit area of beach based on the consumer surplus per visit, the total number of visitors and the total area of this beach. In this method, the individual consumer surplus (per visit) is determined using a benefits transfer approach.

$$CS_{area} = \frac{CS_{bt} * attendance}{area}$$

Equation 4.3 Area-based Consumer surplus.

Where CS_{area} is the annual consumer surplus per unit area. CS_{bt} is the individual consumer surplus (per visit) based on the benefits transfer. *attendance* is the annual attendance at the beach and *area* is the area of the beach that is between the shoreline protective device and the ocean. Lost consumer surplus is then estimated by summing the annual value of lost beach due to erosion over the lifetime of the project and adjusted to the net present value.

$$CS_{total} = \sum_{t=0}^n \frac{(CS_{area} * er * t)}{(1 + r)^t}$$

Equation 4.4 Area-based method to determine consumer surplus lost on an eroding beach.

Where CS_{total} is the total consumer surplus lost during the lifetime of the project. n is the project lifetime in years. er is the annual erosion rate, t is time (the number of years since project started) and r is the discount rate. In the area-based model individual consumer surplus value does not change as the beach narrows. The limitations of this method are described below.

Amenity-based model

Developed by King (2005; 2006), the amenity-based model is used both as a benefit transfer method and to adjust the individual consumer surplus (per visit) as the beach narrows. As a benefit transfer method, the amenity-base

approach adjusts the consumer surplus of a study site by weighting and rating the amenities at the policy site compared to a base case study site.

The beach amenities considered are: weather, water quality, beach width and quality, overcrowding, other recreational amenities and availability of substitutes. Based on the Cobb-Douglass functional form, each amenity is given a weight and amenity point value from 0 to 1, as described in Equation 4.5

$$IV = W^a * WQ^b * BWQ^c * C^d * A^e * S^f \quad \text{where: } a + b + c + d + e + f = 1$$

Equation 4.5 Index Value (IV) based on weighted amenities.

Where IV is the total index value, W , WQ , BWQ , C , A and S are amenity index point values. a through f are the relative weightings. See example in Table 4.2.

The weighted amenity value is then used to adjust the consumer surplus from the study to the policy site. The amenity values and weights were assigned using general criteria described in King (2006) and builds on US Corps of Engineers' point values used to estimate the value of a recreational day. In practice, the values and weights have been based on personal judgment and have not been empirically based. The index value (IV) is then used to adjust the consumer surplus value at the policy site (CS_p) from the consumer surplus value at the study site (CS_s).

$$CS_p = CS_s * IV$$

Equation 4.6: Using the Index Value (IV) to adjust the consumer surplus at the policy site (CS_p).

Where CS_p is the consumer surplus at the policy site and CS_s is the consumer surplus at the study site and IV is the index value from the weighted amenities (Equation 4.5).

Weighted beach amenities are also used to determine the decrease in consumer surplus value from $t=0$ and over time project lifetime ($t=n$) as the beach width decreases. As beach width decreases, the amenity point values for beach width (BWQ) and overcrowding (C) decrease proportional to percentage of total beach width (B_n). The total lost consumer surplus is from lost amenity value to each visitor due to the narrowing beach over the lifetime of the project.

$$CS_{SL} = \sum_{t=0}^n \frac{CS_p - (CS_p * IV_t) * att}{(1 + r)^t}$$

where

$$IV_t = W^a * WQ^b * (B_t * BWQ^c) * (B_t * C^d) * A^e * S^f \text{ where: } a + b + c + d + e + f = 1$$

$$\text{and } B_t = \frac{bw_t}{bw_{t=0}}$$

Equation 4.7 Consumer surplus lost over project lifetime due to lost amenity value from beach erosion (King 2006).

Where CS_{SL} is the net present value of the total lost consumer surplus over the project lifetime ($t=n$), CS_p is the consumer surplus at the policy site, IV_n is the amenity value adjusted for a narrowing beach and B_t is the percentage of beach remaining. r is the discount rate. When $B_t = 0$, the lost consumer surplus of the beach in front of the sea wall (CS_{SL}) is at its maximum for the remaining project lifetime.

Review of the demand-based models

Use of a demand-based approach by the Coastal Commission, as described above, requires an individual consumer surplus value per visit using a benefit transfer approach, annual attendance counts, and a model to account for lost attend loss of consumer surplus from recreation and ecological services as the beach narrows (Table 4.3). The benefit transfer requires an empirically based per-person per-visit consumer surplus value for beach recreation at the study site that is transferred to the policy site and adjusted for time and based on objective, repeatable criteria. It requires an erosion-value loss model that represents a reasonable approximation of the loss of consumer surplus as the beach narrows. Pendleton, Mohn et al. (2011) recently published a RUM based empirical model that describes changes in beach visitation and consumer surplus due to beach narrowing.

Beach recreation consumer surplus values

Estimates of the consumer surplus value for California beach visits appear throughout the literature. Table 4.4 shows a sampling of values for existing site-specific studies for California beaches that can be used as the study site for benefits transfer. The consumer surplus of a beach visit from site-specific studies varies from \$12 to \$90 vary with a range of over \$78. The average value across these studies is \$39. Pendleton and Kildow (2006) used a range of \$15 to \$50 for their overview of the non-market value of beach recreation in California. The consumer surplus of a beach visit is a critical parameter in the valuation of the

total value provided by the beach and is the basis benefit transfer from a study site to the policy site. It is also the basis for determining the lost recreational value as the beach narrows.

Attendance

The recreational value of a beach is proportional to the attendance. Attendance is the largest multiplier in determining the consumer surplus of a beach. Dwight, Brinks et al. (2007) show that there are attendance counts for most Southern California beaches. Literature on beach attendance for other California beaches is limited. Most attendance records come from beach management agency and lifeguard attendance estimates and often overcount visits (King and McGregor 2010). Wallmo (2003) and King and McGregor (2010) provide methods for site specific studies using periodic counts and sub-sampling to determine the multiplier. The Coastal Commission does not have the time or funding for site specific studies for each project and must rely on available data. Unlike consumer surplus values, it is not possible to transfer attendance counts due to the extremely high variability of beach attendance, which is dependent on the location, season, access and beach width. A complicating factor is that beach attendance is dependent on beach width and shoreline armoring, but our understanding of this relationship is limited and requires complex RUM modeling (Pendleton, Mohn et al. 2011).

Erosion model for loss of recreational value

As described above, the value of lost recreation on an eroding beach is estimated by determining the lost beach area and then determining the lost consumer surplus value from the narrower beach on an annual basis over the lifetime of the project. At present, the only empirical model describing changes in consumer surplus and beach attendance on an eroding beach in California is Pendleton, Mohn et al. (2011). Pendleton, Mohn et al. (2011) describe changes in beach attendance and consumers surplus to Orange and San Diego County beaches in response to sea level rise using a RUM model. They show that beach erosion reduces both consumer surplus and beach visits and that those losses can be significant. For example, at 50% decrease in width of San Clemente beaches results in an annual loss of over \$8 million in consumer surplus and over 100,000 fewer beach visits. The direct application of Pendleton, Mohn et al. (2011) to individual shoreline armoring permits is limited but could be used as a study site for benefits transfer and to set the bounds for estimates of consumer surplus loss at armored beaches.

As a practical matter, the Coastal Commission is limited to applying simple models such as the area-based or the amenity-based models. The area-based method applies a constant consumer surplus value as the beach narrows. This model assumes that beach attendance decreases linearly with lost beach area. This model does not account for visitor adjustment to beach narrowing, such as moving closer together (beach crowding) or accepting a lower consumer

surplus from a visit on a narrower beach. In contrast, the weighted amenity-based model assumes that the consumer surplus of each visitor decreases slightly each year from the loss of amenities associated with beach width and overcrowding as the beach narrows. In the amenity-based model, the first year of erosion has little effect on the total value of the beach, but as the beach narrows, the loss increases exponentially until it reaches a maximum when the beach width equals zero (Figure 4.5).

The total lost recreational value over the project lifetime is adjusted to the net present value because the in-lieu mitigation fee is charged at the outset of the project, not on an annual basis. The Coastal Commission has consistently used a 3% discount rate, which is standard practice in the literature and recommended by NOAA (NOAA 2000; Dunford, Ginn et al. 2004).

The amenity-based model has advantages over the area-based model but is also limited in theory and application. The amenity-based model can be used to estimate the policy site consumer surplus value and then adjust that value as the beach narrows due to the loss of amenities. The amenity-based model estimates the loss of consumer surplus for each visitor due to loss of beach width and overcrowding through a decline in the amenity values that correspond to percentage of beach lost. In the amenity-based model, visitation does not decline linearly with area of beach lost. The amenity-based model accounts for variation in site characteristics of individual beaches and provides a rudimentary means to account for substitution. The amenity-based model accounts for variation in site

characteristics of individual beaches and also provides a rudimentary means to account for substitution.

The primary shortcoming of King's application of the amenity-based method is not a methodological but the subjective assignment of amenity values and weights at the beach. Although King (2006) provides some basis for the relative weights and amenity point values, the values are not based on empirical data nor is there a standard method for determining the weights or the point values. The amenity point values and weights are subjective and vary for each permit application. The RUM used for the Southern California Beach Valuation project could provide an empirical method to determine amenity values but is beyond the scope of this paper.

Another theoretical shortcoming of King's amenity-based model is that it does not account for lost beach attendance as the beach narrows. Instead, it assumes that beach attendance stays constant or grows up to the point where the beach ceases to exist. The method could be improved by accounting for loss in beach attendance based on a minimum area of beach required for each beach visitor. Pendleton, Mohn et al. (2011) show that the amenity-based model may be conservative because it does not account for lost attendance from substitution, which they observed. Inclusion of lost visits would increase the total lost consumer surplus at an eroding beach because one hundred percent of that visitor's consumer surplus would be included the mitigation model.

A loss of beach area may simply cause beach goers to choose (substitute) another beach. Theoretically, a single site approach like that in the Amenities model should over estimate the impact of beach loss because it does not account for the substitution possibilities available to the beach goer. In contrast, use of multi-site RUM models that account for substitution show that consumer surplus values for reduced beach attributes (e.g. beach width) or complete loss of a site will be less than single site approaches such as the amenity-based model (Lew and Larson 2005). In practice, the number of beach substitution possibilities are limited in southern California, even though the total number of beaches is large. Cutter, Pendleton, et al. (2007) show that restrictions in the types of activities and the effect of site attributes on activities limits the substitutability of sites. Further, while travel cost to a large set of beaches may be similar for people coming from inland areas, people who live near the beach face significant increases in travel cost if they cannot go to their local beach. Small beaches with highly local visitors may also limit the actual substitution set. For example, Pendleton, Mohn et al. (2011) show that even in a model that includes 50 potential substitute sites changes in beach width can result in large loss of consumer surplus and visitors (e.g. a 50% loss in beach width at San Clemente Beach would result in an annual consumer surplus loss of \$8 million). The current amenity-based model accounts for substitution possibilities through the inclusion of a linear explanatory factor – a coarse and subjective way of accounting for the potential bias caused by substitution possibilities. With additional research to develop empirically based point values and weights, the amenity-based model could provide a practical,

objective and transparent model for the Coastal Commission to estimate the loss of consumer surplus of each beach visitor to a narrowing beach. Furthermore, the chapter demonstrates that methodological biases that may cause amenity-based models to overestimate the impact of beach loss on recreation values are likely to be offset by the omission of numerous other beach values (e.g. habitat protection) that are not included in more sophisticated models that include only recreational values.

Ecosystem services in the demand model

At present, there is no research in the literature that quantifies the entire set of ecosystem service values for sandy beaches described in Table 4.1 (Liu, Costanza et al. 2010). Liu, Costanza et al. (2010) provide an ecosystem services value for New Jersey beaches at \$42,147 (\$2004) per acre. Their ecosystem services value includes an aesthetic and recreational value (\$14,847/acre) and a shoreline protection (disturbance control) value (\$27,276/acre) but does not include values for other ecosystem services. Aesthetic and recreational consumer surplus values for California beaches are well researched and can be applied more appropriately than the generic model provided by Liu, Costanza et al. (2010). Disturbance control is not relevant for beaches where shoreline protective devices are being constructed because these structures are designed to eliminate any future shoreline disturbance.

At present, the limited understanding of beach ecosystems and the lack of models linking beach ecosystem services to direct use activities precludes

assigning a value to ecosystem services outside of recreational opportunities and disturbance avoidance (Liu, Costanza et al. 2010). The total economic value (TEV) of ecosystem services outside of recreational opportunities and disturbance avoidance is greater than zero and shows that valuation efforts that do not include ecosystem services are an underestimate of the total economic value of beach ecosystems. The TEV model reveals the practical need for future research that explains the linkages between impacts to beach ecosystem services and economic values of beaches.

Supply-based approach: Natural Resource Damage Assessment

An alternative approach to the demand-based model for determining the compensatory mitigation for lost ecosystem services is the federal Natural Resource Damage Assessment (NRDA) approach. The federal NRDA process provides a rigorous and well-tested method for assessing and restoring natural resources and services impacted by oil and chemical spills with a rich peer reviewed body of literature (Roach and Wade 2006). While the NRDA process is reactive (responding to the injury of natural resources) and the Coastal Commission's mitigation process is proactive (requiring mitigation for future impacts), the concepts in the NRDA process can provide a model for implementing an ecosystem services approach to mitigating adverse impacts to beaches from shoreline armoring.

Habitat equivalency analysis

In recent NRDA cases, NOAA has recommended that compensation should be based on restoration projects using habitat equivalency analysis (HEA). HEA is a method for quantifying ecological service losses and calculating the scale of compensatory restoration required to offset those losses (Dunford, Ginn et al. 2004). Compensation is based on the cost to replace the natural resource services that the public has lost (Hampton and Zafonte 2002). Scaling is used to account for restoration that does not meet the baseline functionality of the lost resource and to discount for the time between the loss and full restoration, known as interim losses (Figure 4.6).

The four basic requirements needed for an HEA are: 1) the primary services lost are biological, as opposed to human use services, 2) there exists a means of quantifying the level of lost services due to the injury and the level of services gained by the compensatory mitigation, 3) an estimate of the recovery rates is available, and 4) a suitable restoration site exists. Further, HEA requires that a single measure of ecological services be used for each type of habitat assessed in the model (NOAA 2000). This metric is the single most important parameter in the HEA model because it is the basis for all assessment of injury and restoration (Dunford, Ginn et al. 2004). The input parameters required for the HEA model are listed in Table 4.5

Use of HEA requires a number of assumptions. They include a preference for compensation with the same services, use of a single service metric, a fixed

proportion of habitat services to habitat value, a constant real value of injured services and an equal unit value for the injured and compensatory habitat values (Dunford, Ginn et al. 2004).

NOAA's (2000) guidance document provides an overview and examples of HEA application. Dunford, Ginn et al. (2004) discuss the conceptual foundation, key assumptions and sensitivity analysis using a hypothetical example. Milon and Dodge (2001) show the application of HEA to coral reef damage assessment and restoration. Roach and Wade (2006) provide an example of HEA applied proactively for policy analysis.

Use of HEA for beach ecosystems services

The use of HEA by the Coastal Commission for compensatory mitigation to adverse impacts to beaches from shoreline armoring would shift their approach from a demand-based model aimed at compensating lost beach recreation to a supply-based model that is focused on restoration of ecological services of beaches. This approach would require that beach dredge and fill (beach nourishment) projects are focused on returning ecological services of beaches to an established baseline as opposed to the current focus on sediment quality and beach width.

At present, use of HEA for compensatory mitigation of lost beach services is limited by a lack of understanding of the ecological services of beaches. Table 4.6 shows that sandy beach ecosystem services do not meet the four basic

requirements to conduct HEA. The primary service considered by the Coastal Commission is recreation, a human use, not a biological use. The current lack of basic science on ecological services of beaches precludes selecting or quantifying a single measure of ecological services lost or providing recovery rates from impacts (Martin 2009). Impacts include loss of habitat from the gradual narrowing of beaches or burial from the dredging and dumping of sand on the eroded beach (Peterson and Bishop 2005; Dugan, Hubbard et al. 2008). Suitable sites for restoration of beach services could be the beach being adversely affected or nearby beaches.

The HEA approach is further limited because shoreline protective devices are issued on different temporal and spatial scales than coastal erosion, and beach dredge and fill projects. Shoreline armoring permits are issued at the spatial scale of a single development and episodically, based on threats from erosion. Coastal erosion and beach dredge and fill projects occur on the littoral cell scale and are also episodic. Beach erosion occurs episodically based on decadal weather system, such as ENSO (Griggs 1998). Beach dredge and fill projects are episodic and based on federal, state and local funding cycles and permit requirements. HEA does provide a mechanism to address spatial and temporal mismatches but would be challenged by having numerous small compensatory mitigation actions cumulatively support one larger restoration effort. There are also governance challenges. The Coastal Commission is the agency responsible for permitting and seeking mitigation for adverse impacts of shoreline armoring but other state and federal agencies are responsible for beach

dredge and fill projects. Coordination between these agencies would be required for the HEA model to function successfully.

Model choice conclusions

The Coastal Commission is faced with two primary limitations when determining the compensatory mitigation for lost beach services from shoreline armoring. First, the lack of scientific understanding of baseline sandy beach ecological services and the inability to quantify services lost or recovery rates of those services precludes the use of service-for-service (HEA) models for mitigation or the inclusion of ecological services in demand-based models. Second, limitations in permit time lines, budget and expertise on the Coastal Commission staff preclude the application of site specific beach valuation studies or the use of Random Utility Models for demand-based modeling of the loss of beach services values on armored beaches except for large projects. Given these limitations, a demand-based approach using the amenity-based model could provide the best alternative for the Coastal Commission because it provides a transparent and repeatable approach to adjust of consumer surplus values to the study site and model loss on consumer surplus as the beach narrows. To use this model, the Coastal Commission should support some RUM studies of representative beaches, which supplement the Southern California Beach Valuation Study, to develop a set of study sites that can be used to develop amenity weights and values for use in benefit transfers.

The methods currently used by the Coastal Commission can be improved to provide more accurate and consistent compensatory mitigation values. To show this a comparative approach is taken reviewing five case studies where the Coastal Commission has applied demand-based models. The case studies are described and compared against recommended consumer surplus value choices for benefit transfer of beach recreation values, attendance and beach erosion value loss models.

Case studies: mitigation for loss of beach recreation

Since 2004, the Coastal Commission has required compensatory mitigation for the value of lost recreational beach use for five projects. All projects have used a benefits transfer approach. The Coastal Commission has applied both the area-based and the amenity-weighted method. The Coastal Commission is also reviewing a site-specific approach for the City of Solana Beach. Each case study includes a description of the project, the recreational use at the beach (attendance), the method of estimating consumer surplus and lost consumer surplus over time and a total in-lieu fee assessed. Table 4.7 provides a summary of the projects. The Las Brisas and Ocean Harbor House projects are the best representations of the area-based and amenity-based methods and are reviewed in more detail.

Case study 1: Las Brisas, Solana Beach, California

In 2005, the Coastal Commission required mitigation for the adverse impacts of a seawall on beach recreation using the amenity-based model to estimate the consumer surplus value of an individual beach visit and for the erosion value loss model.

Project description

Las Brisas is a 36 condominium complex immediately adjacent to a coastal bluff near Fletcher Cove in Solana Beach, CA. The bluff is eroding due to wave action and threatening the structure. To protect the structure, the homeowners requested a permit from the Coastal Commission to construct a 120-foot long 35-foot high seawall at the base of the bluff on the public beach (Figure 4.7). The long-term average annual erosion rate was determined to be 0.27 feet/year. In addition, the seawall resulted in an additional 652 square feet of placement loss from the footprint of the structure on the public beach. During the 22-year lifespan of the project 1,372.8 square feet of beach will be lost. For the economic analysis the beach in front of the Las Brisas project is considered a subset of the larger Fletcher cove beach.

Beach sand mitigation

A fee of \$22,977.36 based on the in-lieu fee beach sand mitigation PGD was required to mitigate for the loss of sand impounded by the seawall. In the Las Brisas staff report, the Coastal Commission states:

The Commission also expressed concern because the In-Lieu Beach Sand Mitigation Fee formula that has previously been used to calculate the amount of fee to charge to mitigate the adverse effects of shoreline protective devices does not fully mitigate those impacts, and does not mitigate the impacts to public recreation and access from the physical beach loss at all (CCC 2005).

Consumer surplus value of a beach visit

To determine the value for the lost recreation, the Coastal Commission contracted independent economist Dr. Phillip King to provide an analysis of the lost recreational value that would result from the construction of the seawall. King applied the amenity-based benefit transfer method. King assigned a value of \$14.00 for an individual's visit at a "perfect" beach. King (2005) adjusted the consumer surplus from Chapman and Hanneman (2001) from \$13 to \$14 (\$2005) by subjectively balancing inflation with approximate consumer surplus values from the Southern California Beach project. King used the amenity-based model based on weighted amenity values (weather, water quality / surf, facilities and services, availability of substitutes), growth in numbers of beach visitors and discount factors to estimate a beach value of \$6.81 (\$2005) per visit per visit (48.7% of the study site) (King 2005). Table 4.9 shows the amenity point values and weights to transfer the value of the "perfect" study site to the policy site.

King (2006) later used the amenity-based benefit transfer method to find a consumer surplus value of \$11.18 (per person per visit) for Huntington Beach using the same amenity point values and weights in Table 4.8. This is inconsistent with his benefit transfer approach for Las Brisas. If King uses Huntington Beach as a "perfect beach," then the amenity point values should all be one hundred percent. Based on King's amenity point values for Huntington

Beach and using Chapman and Hanemann's (2001) consumer surplus value for Huntington Beach as the study site, the consumer surplus for a "perfect beach" can be estimated and used as the reference beach (study site) for all future amenity-weighting. Applying King's \$14 (\$2005) consumer surplus value yields a reference beach value of \$17.54 (\$2005). Adjusting Chapman and Hanemann's value to \$19.71 (\$2005) solely for inflation yields a reference beach value of \$24.69 (\$2005). Using the reference beach consumer surplus value and applying King's amenity value approach yields a consumer surplus value at Las Brisas of \$8.54 (\$2005) without adjusting for inflation or \$12.02 (\$2005), if properly adjusted for inflation.

Recreational use (attendance)

The project site is located on a public beach utilized by local residents and visitors for a variety of recreational activities including swimming, surfing, jogging, walking, surf fishing, beachcombing and sunbathing. King estimated the attendance at the beach to be 40,460 visitors over 100 days during the high season (approximately June, July and August). The City of Solana Beach does not track attendance at Fletcher Cove. King derived attendance from estimations by City lifeguards and use of a recent parking study for a park on the bluff above the beach (King 2005).

Erosion value loss model: amenity-based

The amenity-based model was used to estimate lost consumer surplus. Two amenities (beach width and overcrowding) were adjusted proportionately to the reduction of beach width, and these changes were used to calculate the

consumer surplus lost by all beach visitors from the narrower beach. In the first year, this results in a \$0.25 loss in consumer surplus per visitor and increases to a \$0.31 loss per visitor after the fifth year of the project when the entire beach in front of Las Brisas is lost.

King avoids the issue of loss in attendance from beach narrowing in this amenity-based model by considering a total beach area that is larger than the project site. In King's approach, all visitors of Fletcher Cove and the beach in front of Las Brisas (Figure 4.7) suffer loss of consumer surplus as the beach area in front of the project narrows. It is implicit that when the entire beach is lost in front of Las Brisas that beach visitors move to Fletcher Cove, where crowding is increased. In other cases where only the project area is considered, the amenity-based model should account for loss of beach attendance if the beach narrows to a point where the visitors cannot physically fit on the beach.

Total in-lieu mitigation fee

Based on the high season attendance, a yearly attendance growth (0.5%) over the 22-year project lifetime and incremental loss of consumer surplus per visitor, the total loss of consumer surplus during the high season was estimated at \$207,233.94 (\$2005). The low season estimate is approximated at 20% of the high season or \$41,447. The total lost consumer surplus resulting from the seawall was valued at \$248,680.72 during the 22-year lifespan of the project (King 2005).

The Coastal Commission approved the shoreline armoring and included a special condition that required the applicant to pay an in-lieu mitigation fee of \$331,977.36, which is the total that includes the sand mitigation fee of \$22,977.36.

The benefit transfer for the consumer surplus of an individual beach visit should be based on a reference beach with 100% amenities adjusted for inflation, described above. This would yield a consumer surplus value of a beach visit of \$12.02 (\$2005). Using this CS value in the amenity-based erosion value loss model would increase the total lost value at Las Brisas from \$284,000 to \$501,000, a 43% increase (See Table 4.15).

Cost of estimation

The CCC contracted with Dr. Phil King to conduct this analysis for \$5000.

Las Brisas case study conclusions

The Las Brisas case provides two important insights and shows one error regarding mitigation for adverse impacts on local shoreline sand supply. For the first time, the in-lieu beach sand mitigation fee accounts for both impoundment loss and lost recreational use of the beach. Second, the amenity-based model is used for the first time to determine the base consumer surplus for a beach visit and also to adjust the consumer surplus value of a beach visit as the beach narrows from erosion. The amenity-based method for value transfer fails to accurately apply a “perfect” reference beach or account for inflation in the amenity-based benefit transfer. As a result, a consumer surplus value of an individual beach visit is underestimated and resulted in an underestimate of the

total in-lieu fee by 43%. The value of sandy beach ecological services was not considered.

Case study 2: Ocean Harbor House, Monterey, California

In 2004, the Ocean Harbor House project was the first case where the Coastal Commission applied a fee for the value of lost recreation to mitigate the impacts of beach loss from a seawall.

Project description

Ocean Harbor House is a condominium complex on Del Monte Beach in the City of Monterey. It was built in the late 1960s and mid-1970s and has been threatened by coastal erosion for almost 30 years. To secure permanent protection of the structure, the homeowners association applied to the city and the Coastal Commission for permits to build a revetment with a lateral length of 435 feet (CCC 2005) (Figure 4.8). Using the mitigation approach defined in CEQA, the Environmental Impact Review and Coastal Commission staff report determined that the only feasible alternative to protect the structure was through the construction of a seawall.

Using the footprint of the sea wall and an erosion rate of 2 feet/year, it was determined that the seawall would result in the loss of 1 acre (43,560 square feet) of public beach over the 50 year life span of the seawall and that no onsite mitigation was available (CCC 2005).

Beach sand mitigation

The Coastal Commission staff used the PGD for In-Lieu Fee Beach Sand Mitigation to calculate the fee required to replace the sand. The staff report states:

... the volume of sand that approximates the area of beach land lost to the project can be calculated (38,200 to 44,700 cy); if this sand volume and current market prices for sand were to be used as a basis for an in lieu fee to mitigate the loss of recreational beach area, the fee would range from approximately \$1,031,400 to \$1,206,900 (CCC 2005).

The Coastal Commission decided they could not assess this fee because the Monterey region lacks a regional beach nourishment program (CCC 2005). They also acknowledge that this fee would only mitigate the sand supply and would not address the lost recreational value from the beach loss.

However, as discussed, no formal beach nourishment and mitigation program is in place in the southern Monterey Bay area. Moreover, although this fee estimate is based on a quantifiable, site-specific volume of sand and market condition, this estimation of the beach loss through a sand volume calculation does not really address the recreational value of the anticipated one-acre of beach loss (CCC 2005).

In the absence of a beach mitigation program, the Coastal Commission decided to require an in-lieu fee paid to the Monterey Peninsula Regional Parks District for acquisition of beach front dune property for public recreational use in the southern Monterey Bay to mitigate for the lost coastal recreation resulting from the seawall and because Monterey County lacks of a beach nourishment program.

Consumer surplus value of a beach visit

The Coastal Commission used a point transfer benefit transfer approach to determine the consumer surplus per individual beach visit. After considering consumer surplus values per person per visit ranging from \$10.98 (\$2001) to \$70 (\$2001), the consumer surplus for Huntington Beach (study site) of \$13 per beach visit from Chapman and Hanemann (2001) was used to estimate the consumer surplus of a beach visit in Monterey (policy site) at the \$13 (\$2005) per person per visit. The Coastal Commission justified using the study site consumer surplus value at the policy site based on a qualitative assessment of tradeoffs between inflation and the differences in use and amenities between Huntington Beach and Monterey.

Given even the low rate of inflation, this amount would be \$1 to \$2 higher today. Although the beaches in the City of Monterey are not as highly developed as Huntington Beach, there are kayak and other rentals available, a large beachside hotel exists, as well as a number of other visitor amenities (restaurants, shops, etc.) nearby. In addition, the beaches in Monterey have a high non-market consumer surplus value because of the generally wide, sandy quality of the beaches, and their location in an urbanized area that is an extremely popular visitor destination along the Central California coast. The \$13.00 figure is probably a reasonable estimate for the consumer surplus of the beaches in the Monterey area (CCC 2005,p. 37).

Beyond the subjective adjustments used to justify the point transfer, the CCC made the same error as King (2005) when applying a point transfer from the study site to the policy site. Adjustment of the CS value for inflation using the consumer price index from \$13.00 (\$1990) is \$19.71 (\$2005), not a \$1 to \$2 difference as suggested by the Coastal Commission. The Coastal Commission

may have underestimated the consumer price index difference adjustment by adjusting the value based on the publication date of Chapman and Hanneman (2001), which would yield the \$1 to \$2 difference they cited, instead of on the date of the valuation (1990).

Using the recommended amenity-based benefit transfer approach for Monterey beaches by applying reasonable amenity values and weights (Figure 4.9) based on the corrected reference beach consumer surplus value of \$24.69 (\$2005), a more accurate consumer surplus value of an individual beach visit is \$13.50 (\$2005).

Recreational use (attendance)

Recreational use at the beach was determined using Monterey State Beach attendance estimates. Monterey State Beach has three separate beaches approximately two miles apart. Activities at these beaches that are included in the attendance counts are beachcombing, kite flying, volleyball, surfing and kayaking. The annual average beach attendance between 2001 and 2004 was 968,287 visits over the 60.6 acres of state beach. A per acre average attendance was calculated as 15,978 visits/acre. The area affected by the revetment was one acre of beach midway between two primary areas of state beach so the per acre average of 15,978 visits/year was used.

Erosion value-loss model: area-based

The Coastal Commission used the area-based model to estimate the value of lost consumer surplus. Using a consumer surplus value of \$13 per person per

visit and the average annual attendance of 15,978 visits/acre, the annual value of one acre of beach was estimated at \$207,714/acre/year or \$4.77/square foot/year. Based on an estimated loss of 870 square feet of beach per year, the lost consumer surplus was estimated at \$4,148/year. This loss was applied linearly over 50 years for a lost consumer surplus of \$5.3 million over the project lifetime. Using a point transfer BT that accounts for inflation at the study site increases the CS value for an individual beach visit to \$19.71 and would have increased the lost recreational value at OHH from \$5.3 million to \$8 million over the project lifetime (Table 4.10).

The amenity-based method applied to OHH produces a substantially lower total in-lieu mitigation fee. The consumer surplus value for an individual beach visit using the amenity-based benefit transfer is \$13.50 (\$2005). Using this CS value and the amenity-based erosion value loss model, the total lost recreational value is \$2,680,000.

Loss of beach visits due to lack of physical space on the beach at OHH is irrelevant because the daily attendance is so low. The daily attendance of beach visitors at OHH is just over 43 visitors per day. Making a conservative assumption that a beach visitor needs at least 18 square feet (the size of an average beach towel), 43 visitors would only require 780 square feet. At OHH, there would be at least 870 square feet of beach until the last year of the project lifetime. This does not account for beach visitors changing their site choice due to the narrow beach. At other beaches with higher daily attendance, loss of beach visitors due to lack of physical space should be accounted for. The

amenity-based model does not account for site choice so it cannot account for loss of visitors who prefer wider beaches.

Total in-lieu mitigation fee

Applying this consumer surplus value and the number of visits over a 50 year period resulted in a total mitigation fee of \$5.3 million for the value of lost recreation over the lifetime of the project. The homeowners challenged the Coastal Commission authority to assess the fee and the validity of their methodology, but the California State Appellate Court upheld the Coastal Commission's decision and methodology (OHH 2008).

The area-based method overestimates the beach value because it assumes every square foot of the beach is valued equally and fails to account for adjustments made by beach visitors as a beach narrows. Given the low average daily visitation of 43 beach visits, it is unlikely that the relatively small loss of beach in the early years of the project will even be noticed. The amenity-based model more accurately reflects the relatively small loss of consumer surplus when the armoring is first installed.

Valuing ecological services

The consumer surplus for the ecological services of sandy beaches was not directly accounted for. The Coastal Commission noted that the consumer surplus value used for beach recreation was conservative because habitat and aesthetic values were not included.

Cost of estimation

The in-lieu mitigation fee approach was used in the estimation completed by the Coastal Commission staff as part of the staff report for the Coastal Development Permit. An outside consultant was not used. The cost of estimation was the opportunity cost of Coastal Commissions staff time.

Ocean Harbor House case study conclusions

The Coastal Commission approach at OHH has several shortcomings. The point transfer used to estimate the consumer surplus of an individual beach visit underestimated the value at the policy site because inflation was not considered. The area-based erosion value-loss model likely overestimates the total consumer surplus of the beach as it erodes. Using the amenity-based benefit transfer approach, the consumer surplus value for an individual beach visit is \$13.50 and the total in-lieu beach mitigation fee using the amenity-based erosion value method is \$2,680,000, which is 51% lower than the fee assessed by the Coastal Commission.

The OHH case also provides additional insights about how the Coastal Commission approaches mitigation for adverse impacts on local shoreline sand supply. First, the in-lieu fee beach sand mitigation was not applied because there was no regional beach nourishment program. Second, it shows that fees to mitigate for the value for lost beach recreation from shoreline armoring impacts can be determined, assessed and upheld in court if reasonable methods are used. Last, the value of sandy beach habitats is acknowledged to show that the consumer surplus of a beach visit is conservative.

Case Study 3: 629-633 Circle Drive, Solana Beach, California

In 2006, the Coastal Commission required mitigation for the adverse impacts from a seawall for a project one half mile from the Las Brisas project. This project straddles the border of the Solana Beach and Encinitas. The homes are located in Solana Beach, but the beaches at the base of the bluff are in Encinitas.

Project description

The Coastal Commission determined that bluff erosion due to wave action threatened the structure and conditionally permitted a 145 -foot long, 22-foot high seawall at the base of the bluff on the public beach (Figure 4.10). At this site the long-term average annual retreat rate was determined to be 0.4 ft/yr. The seawall footprint would result in the placement loss of 362.5 square feet, and 1,276 square feet of beach will be inundated and will not be replaced by new inland beach area during the 22-year lifespan of the project. During the 22 -year lifespan a total of 1,638.5 square feet of beach will be lost.

Beach sand mitigation

A fee of \$21,420.00 based on the in-lieu fee beach sand mitigation PGD was required to mitigation for the loss of sand that would have been added to the littoral cell were it not for the proposed seawall.

Consumer surplus value of a beach visit

To mitigate for lost recreation, the consumer surplus for a beach visit was determined using the amenity-based method. The same weighted amenity values used by King (2005) at the Las Brisas project were used for this project. The consumer surplus value for a beach visit was adjusted to reflect the day-use-value developed by King for Encinitas beaches and set at \$8 per person per visit. The adjustment from the Las Brisas value of \$6.81 (\$2005) to \$8 (\$2006) is based on verbal communication with City of Encinitas staff but is not explicitly described (CCC 2005). Adjustment for inflation alone, based on the Consumer Price Index, would increase the consumer surplus from \$6.81 (\$2005) to \$7.03 (\$2006).

The amenity-weighted consumer surplus value corrected using the 100% amenity reference beach, as described in the Las Brisas case, and inflation is \$12.41 (\$2006) per individual beach visit.

Recreational use (attendance)

Beach attendance was based on vehicle and attendance counts from the City of Encinitas website and used to generate a high season (June through September) average of 53,602 visits per month (CCC 2005).

Erosion value loss method: amenity-weighted

Lost consumer surplus was estimated using the amenity-based model and used the identical approach King applied at Las Brisas with two exceptions. The initial consumer surplus value of a beach day was subjectively adjusted to \$8.00

(\$2006) per visit, and an attendance count of 53,602 visits per month during the high season was used. As in Las Brisas, the low season was estimated at 20% of the high season.

Total in-lieu mitigation fee

Based on this modification from the Las Brisas analysis and the calculation of beach loss for this site, the loss of recreational value over the 22-year lifespan of the project was determined to be \$198,133.74 (Table 4.11).

Adding this to the \$21,420.00 for the beach sand mitigation, the total in-lieu mitigation fee was \$219,553.74.

Correcting for inflation and the appropriate reference beach increases the consumer surplus to \$12.41 (\$2006) per individual beach visit and the total lost consumer surplus over the project lifetime to \$307,351.86, which is 36% higher than the value calculated by the Coastal Commission. Inclusion of the beach sand mitigation fee increases the total in-lieu mitigation fee to \$328,771.86.

Cost of estimation

This estimate was also conducted by the CCC staff and incurred no outside consultation fees.

Circle Drive case study conclusions

The 629-633 Circle Drive case continues the use of the amenity-based method for the benefit transfer to determine the consumer surplus of a beach day and for the lost consumer surplus. The consumer surplus was adjusted from Las

Brisas value of \$6.81 to \$8 subjectively. Lost recreational opportunity is undervalued by 36% because the methodological errors found in the Las Brisas case were also applied to this project. The staff report also notes that the total in-lieu mitigation fee is underestimate because it fails to account for aesthetic impacts and lost lateral (along the beach) access (CCC 2005). This project does not mention or consider the loss of ecological services of the beach.

Case Study 4: 417 & 423 Pacific Avenue, Solana Beach, California

In 2008, the Coastal Commission received another permit request for a seawall to protect ocean front bluff top homes in Solana Beach.

Project description

The applicants requested a permit to construct a 170-foot long, 35-foot high seawall at the base of the bluff. The Coastal Commission determined that the proposed seawall would result in 340 sq. ft. of placement loss due to the footprint of the seawall (Figure 4.11).

Beach sand mitigation

Using the PGD, the impoundment loss was determined to be 3,073.60 cubic yards of sand. This figure was reduced by 466 cubic yards to account for sand contributed to the beach by recent bluff failures (CCC 2008). The in-lieu beach sand mitigation fee was determined to be \$61,164.64 to be paid to SANDAG for their beach nourishment program.

Erosion value loss method: interim linear value model

In this case, the Coastal Commission found that they could not apply Dr. King's study for Fletcher cove to this project site because the Coastal Commission decided that the character of the beach, the number of users, the width of the beach and several other variables were too different (CCC 2008).

To more precisely determine the economic costs to beach recreation from shoreline armoring, the City of Solana Beach began a site-specific beach recreational values study in 2007. While the beach recreation study is underway, the City of Solana Beach established an interim in-lieu fee program to mitigate adverse impacts associated with shoreline armoring (City of Solana Beach Resolution 2007-042). The interim program requires \$1000 per linear foot of armoring to be assessed and that the applicant agrees to modifications to the fee once the economic study is completed and a more site-specific fee can be assessed. The mitigation fee is to be directed to the City of Solana beach for use in public access and recreational projects (CCC 2008). The fee used in the interim linear value method is independent of consumer surplus value per beach visit and the amount of recreational use (attendance).

Total in-Lieu mitigation fee

In this case the interim mitigation fee for the 170-foot seawall is \$170,0000 for the 22-year lifetime of the project. The beach sand mitigation fee of \$61,164.64 was paid separately for use for beach projects in San Diego County. The interim fee is lower than all other cases when lost consumer surplus is converted to a linear value (Table 4.12).

Pacific Drive case study conclusions

The Pacific Drive case shows the Coastal Commission abandoning the amenity-based approach because the beach was too different from Las Brisas. Instead the Coastal Commission used a method based on a flat fee per linear foot of beach impacted by the shoreline protective device to establish an interim mitigation fee. The fee is designed as interim mitigation while the City of Solana Beach conducts a site-specific study for Solana Beach City beaches.

Case Study 5: City of Solana Beach site specific study

The City of Solana Beach is the first city in California to try to develop a site specific study of city beaches to empirically determine the consumer surplus values of a beach visit, measure annual attendance and develop a method to estimate lost consumer surplus from beach loss due to the construction of shoreline protective devices.

Project description

The City of Solana Beach has 1.7 linear miles of beach, which is 0.15% of California's entire coastline and 0.25% of California's sandy beaches. The City of Solana Beach is the last city in San Diego County without a Local Coastal Plan (LCP). Approval of an LCP by the Coastal Commission transfers permitting authority to the city. As part of the LCP, the City of Solana Beach is attempting to establish a local in-lieu sand mitigation fee program to mitigate for lost sand supply and coastal recreation from shoreline armoring. Studies to determine average erosion rates have been completed as part of the LCP process. The City

of Solana Beach hired an independent consultant and formed a citizen committee to determine the economic values associated with coastal recreation in Solana Beach. The request for proposals (RFP) for the project was \$100,000. The goal of the study is to empirically derive site-specific consumer surplus values for beach use and annual attendance figures. They plan to derive a consumer surplus value (per person per visit) for coastal recreation using the travel cost method. Attendance will be determined by counting beach goers using a randomized schedule over a one-year period.

The study to determine consumer surplus values and beach attendance began in 2007. The study remains in draft form as of June 29, 2011 when the City of Solana Beach held a public comment hearing on their Local Coastal Plan. According to the City of Solana Beach staff report, the beach mitigation fee was not included in the LCP because they were “unable to agree to a set fee” (City of Solana Beach 2011). On March 7, 2012 the CCC approved the Solana Beach LCP and required them to complete the site specific consumer surplus study in 18 months. After spending \$100,000 and four years, the City has not yet been able to complete a site-specific single site travel cost study to estimate consumer surplus values for the beaches in Solana Beach, and an erosion value-loss model has yet to be addressed.

Case study conclusions

The case studies show that the Coastal Commission is taking an inconsistent approach to determine the sand loss from impoundment and placement loss by using the 2005 procedural guidance document. Comparison of

the values and methods used on the project described above shows that the Coastal Commission is not using a consistent methodology to determine the lost recreational values from shoreline armoring.

Coastal Commission mitigation methods: a review

As shown in the case studies above and summarized in Table 4.13 the Coastal Commission has subjectively transferred benefits to determine the consumer surplus of a beach visit and to determine the loss in consumer surplus as a beach erodes. All consumer surplus values originated from Chapman and Hanneman (2001) but were either subjectively altered or adjusted using the amenity-based method with a low reference value. Four approaches have been applied to determine the value of lost beach recreation: 1) the Ocean Harbor House (OHH) project used the area-based method, 2) Las Brisas and Circle Drive projects used the amenity-based method, 3) the Pacific Drive project used a flat fee based on the length of the seawall as an interim fee, and 4) the City of Solana Beach attempted but has yet to complete a site-specific study using single site travel cost method to estimate consumer surplus for their 1.7 miles of beach. To date, the mitigation projects include only in-lieu mitigation for lost recreational value. The lack of research on the value of sandy beach ecosystems limits the assessment of fees for beach ecosystem services, but only two of the projects acknowledge that this results in a conservative estimate for the value of lost beach.

Review of consumer surplus values

In all cases that used benefit transfer, the consumer surplus from Chapman and Hanemann (2001) was used as the study site then adjusted for the policy site consumer surplus value using subjective and qualitative approaches. At OHH, the Coastal Commission may have underestimated the consumer price index difference adjustment by adjusting the value based on the publication date of Chapman and Hanneman (2001), which would yield the \$1 to \$2 difference they cited, instead of on the date of the valuation (CCC 2005). At Las Brisas, King used the imperfect beach at Huntington Beach to represent a “perfect beach”, instead of using Chapman and Hanneman and Huntington Beach’s weighted amenities to establish a “perfect beach” to be used as the study site. The Las Brisas value was then adjusted for the Circle Drive case study. At Pacific Drive, the interim linear value of \$1000 per linear foot of shoreline armoring is less than all other cases when converted to value per linear foot (Table 4.12). All cases resulted in an underestimate of the consumer surplus and represent values below the consumer surplus values found in the literature (Figure 4.12). The impact of these underestimates on the total in-lieu mitigation fee is discussed below.

Consumer surplus of a beach visit

Table 4.14 shows the range of values for the consumer surplus per person per visit for California beaches used by the Coastal Commission and in the published literature. The lowest value (\$6.81) is thirteen times less than the highest value (\$90.58). Table 4.14 also shows the inflation-adjusted values for Las

Brisas and OHH. Accounting for inflation increases the consumer surplus by up to 34%.

Table 4.15 shows how the choice of consumer surplus value can affect the total value for lost recreation at OHH and Las Brisas. Selecting the appropriate consumer surplus value for the beach under consideration can have a dramatic impact on the total mitigation fee. For example, based on the range of consumer surplus values shown in Table 4.14, the lost recreational value at OHH could range from \$2.8 million to \$37 million. At Las Brisas, the lost consumer surplus could range from \$284,000 to \$3.78 million. If King (2005) used the reference beach adjusted for inflation shown in Table 4.14 the lost recreational value at Las Brisas would increase from \$284,000 to \$501,000. Using a consumer surplus value that accounts for inflation alone would increase the lost recreational value at OHH from \$5.3 million to \$8 million.

A review of the Coastal Commission projects shows that the consumer surplus values applied in permits are lower than the range of values in the literature (Figure 4.12). It could be argued that the consumer surplus values for narrow eroding beaches should be lower than wide sandy beaches that are usually the subject of the studies. However, the lower values used by the Coastal Commission are a result of benefit transfer error, not necessarily adjustment to a lower value policy site. As shown in the OHH and Las Brisas case studies, those errors include failure to adjust consumer surplus values for inflation, subjective adjustment of values, and use of an imperfect lower value reference beach.

Sensitivity to project lifetime, erosion rate and beach width

Beyond the economic methods and models used to determine the lost value of beach ecosystem services from shoreline armoring, three additional parameters can affect the total in-lieu mitigation fee. Project lifetime is a policy parameter that does not change the mitigation fee per annum but affects the net present value of the fee applied at the time of the permit. Beach width and erosion rate used in the erosion value-loss model will affect the number years before the point when the maximum annual fee is reached, which will affect the total mitigation fee. A series of counterfactuals are shown for OHH and Las Brisas to show how these parameters can change the total in-lieu mitigation fee.

Project lifetime

The CCC establishes project lifetime during the permitting process. Project lifetime can vary from 22 years to 100 years. For in-lieu mitigation projects, the project lifetime can be established for a number of reasons, including the estimated time before the beach is completely lost or the remaining economic life of the structure. Project lifetime has a linear relationship with loss of consumer surplus.

As shown in Table 4.16 the project lifetime controls the upfront fee that an applicant is required to pay for mitigation at the time a permit is issued. Increased project lifetime increases the upfront cost, even when a discount rate is applied because additional years of lost consumer surplus are not reflected in the NPV. No projects have reached their full project lifetime, so it is unclear what the CCC will require when a project lifetime expires. Variation in project lifetime

makes comparison of in-lieu mitigation fees for similar projects challenging for the Coastal Commission and the public.

Beach width

California beaches subject to approval of shoreline protective devices are inherently narrow enough that coastal development is threatened. The loss of beach width due to passive erosion reduces the recreational value (loss of area or amenities) over time (King 2001). The beach width is determined at the time of permitting. Beach width is highly dynamic on daily, seasonal and decadal time scales. Beach width is also affected by prior shoreline modifications at adjacent areas or within the littoral cell (Griggs 1998).

In either method (area-based or amenity-based), the total lost consumer surplus is dependent on total amount of beach lost. At the point where the beach width equals zero, the lost consumer surplus reaches its annual maximum and is constant for the duration of the project lifetime. If the preexisting beach is wide and the entire beach is lost during the project lifetime, there is more beach to lose and therefore more consumer surplus to be lost. Table 4.17 shows how beach width effects lost recreational value. If the preexisting beach at Las Brisas was 30.8 feet wide and beach was lost each year during the 22-year project lifetime, the mitigation value would have increased by 22%. At OHH, if the beach width was 8.5 feet, resulting in total beach loss by year 5, the lost consumer surplus would hold constant for the remaining 45 years of the project lifetime, and the mitigation value would decrease more than four times. The determination of beach width and the preexisting state of beach width will influence the

mitigation value. If the beach is already narrow due to pre-existing shoreline alterations or seasonal variation, the lost recreational value will be reduced.

Erosion rate

The beach erosion rate describes that average annual rate of beach narrowing (feet per year) and controls the total beach area lost per year. Erosion rate is determined through the permitting analysis to justify the shoreline protective device. In both methods (area-based or amenity-based), the total lost consumer surplus is dependent on amount of beach lost. Erosion rate controls the amount of time before the beach width equals zero and annual recreational loss is maximized. Table 4.18 shows the effect of erosion rate on lost recreational value. Because the beach at Las Brisas is relatively narrow and the percentage of beach lost compared to the adjacent beach is small, lost recreation value is not sensitive to erosion rate. Doubling the erosion rate at Las Brisas decreases the lost recreational value by 5%. Reducing the erosion rate by 90% increases the lost recreational value by 14%.

At OHH, where the beach is wide compared to Las Brisas, the lost recreational value is more sensitive to erosion rate. For the area-based method at OHH, lost recreational value is linearly related to erosion rate. A 90% reduction in erosion rate leads to a 90% reduced lost recreational value. If the erosion rate is higher, the entire beach will be lost before the project lifetime is completed and the recreational loss will be at its maximum for the remaining years. For example, if the erosion rate at OHH doubled, the beach would be lost at year 25 and lost recreational value is at the maximum for the final 25 years of the project

lifetime, leading to a lost recreational value of over \$7.9 million, an increase of 33% over the value assessed by the Coastal Commission. Using the amenity-based method at OHH with the erosion rate doubled increases the lost recreational value from \$2,600,000 to \$4,200,000, an increase of 39%. Erosion rate is more important on wide beaches than narrow beaches, because wide beaches are more sensitive to the year when the maximum lost recreational value is reached. This shows that the determination of beach width at the outset of the permitting process is important.

Conclusions and Recommendations

The California Coastal Commission is required to eliminate or mitigate adverse impacts on local shoreline sand supply when approving the construction of shoreline protective devices (CCA §30253). In-lieu mitigation should compensate for the flow of all ecological and recreational services provided by sandy beaches. Two possible approaches to determine the mitigation fee are a supply-based approach based on the NRDA HEA model or demand-based approach based on the consumer surplus of lost services.

The HEA model provides a supply-based service for service model. The HEA model would require that mitigation for lost ecosystem services be equal to the cost of restoring those ecosystem services by a beach dredge and fill project. This approach is limited by the lack of research on beach ecosystem functions and is challenged by the mismatch of spatial and temporal scales of permitting for coastal erosion and beach dredge and fill projects. The demand-based approach using consumer surplus values is also limited by the lack of research

on the ecological functions of beaches, but can be used to determine lost value recreational values on narrowing beaches. In recent cases, the Coastal Commission has included compensatory mitigation for lost recreation resources but has not used consistent methods to determine the value of a beach visit or model to determine the loss of that value over time. This has resulted in cases where mitigation was both over and underestimated and beach ecosystem services were not given full consideration (Table 4.13).

The consumer surplus of an individual beach visit is well studied in California and the literature provides a large number of studies and a wide range of values that could be used as study sites for benefits transfer. To date, the Coastal Commission has used Chapman and Hanemann's (2001) study of Huntington Beach as the study site for every project with a consumer surplus value of \$13 (\$1990) per person per visit, and then adjusted that value subjectively and without adjusting for inflation. As a result, the consumer surplus values used by the Coastal Commission are lower than the range of beach values found in the literature (Figure 4.12).

The Coastal Commission's choices for estimating lost consumer surplus value on narrowing beaches are limited. Random utility models (RUM) are too costly and time consuming for all but very large projects. Site-specific studies often prove to be also impractical – being both costly and time consuming. The City of Solana Beach spent \$100,000 to conduct a study to estimate the value of 1.4 miles of beach and after 5 years has yet to produce any conclusive results. On the other hand, the California Coastal Commission used an area-based method that built upon values of the literature to estimate lost beach value at the Ocean

Harbor House. In a subsequent ruling, the California State Appellate Court that deemed the method as a reasonable method to approximate lost consumer surplus (OHH 2008) and provides a simple means to account for lost consumer surplus on an eroding beach but overestimates the loss (Figure 4.5).

More recently, the Coastal Commission has applied an amenity-based benefits transfer model (King 2005) that improves upon earlier attempts to adapt values from the literature to beaches in question. Given the Coastal Commission's limitations on time, expertise, and funding for economic consultants, King's amenity-based model could provide a reasonable and practical approach to estimate consumer surplus values at the project scale but to do so requires further refinements in the way model weights and values are derived. The amenity-based model provides a mechanism to account for variation in beach attributes, water quality and substitution and those values can be adjusted to reflect reduced consumer surplus to beach visitors as the beach narrows but the values must be empirically grounded. Like any benefits transfer model, the results are only as reliable as the values used for the study site. Values and weights for reference beaches could be assigned more empirically through review of the literature, including Pendleton, Mohn et al. (2011), combined with selected contingent valuation model studies on user preferences. In practice, even the application of sophisticated economic analysis to natural resource damage assessment is subject to judicial review, political debate, and even public negotiation. While multi-site models like the RUM may provide more accurate estimates of consumer surplus change, these models are likely to be too complicated to serve as points of departure for public review and

discussion. Despite shortcomings when compared to more sophisticated models, the amenity-based model has the advantage of being simple enough to be understandable by policy analysts, decision makers and the public. This allows the method, benefit transfer, baseline values and weights to be discussed publicly and even negotiated in the decision making process.

As shown at OHH (2005), Chapman and Hanneman (2001) and Pendleton, Mohn et al. (2011) the potential economic cost of beach loss can be millions of dollars. In these cases, the Coastal Commission should either fund or require the project proponent to fund more sophisticated analysis conducted by trained economists.

To date, the Coastal Commission has failed to include estimates of the economic values for lost of ecological services that may occur when beaches are lost. The failure stems largely due to the lack of established scientific description of the ecological functions of the beach or an explicit model for the valuation of those services. Mitigation that is limited to beach recreation is an underestimate of the total economic value of beach ecosystem services because these values are greater than zero (MA 2005). In some cases Coastal Commission has acknowledged the value of beach ecosystems but has not explicitly articulated where valuation is missing. This chapter provides a conceptual model of the total economic value of beach ecosystem services to show what values are not considered in the final valuation. There is a clear and practical need for more research on the ecosystem functions and services provided by sandy beaches and the non-market values associated with those services.

Beyond the economic methods and models used to value the loss of beach services on an eroding beach, three additional parameters deserve consideration in an in-lieu mitigation valuation. Project lifetime is a policy parameter that is dependent on permit specific issues, ranging from the lifetime of the beach to the lifetime of the structure the shoreline protective device is protecting. Variation in project lifetime inhibits the ability for the Coastal Commission to compare projects. Short project lifetime reduces the upfront mitigation cost required from the permit applicant and may require future permitting for mitigation beyond the project lifetime. Project lifetime should be extended to the maximum lifetime that the shoreline protective device will be allowed.

Sensitivity to pre-existing beach width and average erosion rate should be considered for every project. Beach width is highly variable on multiple temporal scales. Erosion rate relative to pre-existing beach width and the project timeline control when the annual mitigation fee is maximized and can influence the total in-lieu mitigation fee.

The Coastal Commission has been inconsistent in its method of determining mitigation fees for loss of beach recreation. They have used different and subjective consumer surplus values for a beach visit and different methods for determining the loss of value on a narrowing beach. Development of an academically based empirical values for beach attributes and a procedural guidance document based on the recommendations above will standardize the methods and models applied to in-lieu mitigation fees and will make the permit process more consistent and legally defensible.

Sandy Beach Ecosystem Services	Direct Use Value	Indirect Use Value
Sediment storage and transport;		x
Wave dissipation and associated buffering against extreme events (storms, tsunamis);		x
Dynamic response to sea-level rise (within limits);		x
Breakdown of organic materials and pollutants;		x
Water filtration and purification;		x
Nutrient mineralization and recycling;		x
Water storage in dune aquifers and groundwater discharge through beaches;		x
Maintenance of biodiversity and genetic resources;		x
Nursery areas for juvenile fishes;	x	x
Nesting sites for turtles and shorebirds, and rookeries for pinnipeds;	x	x
Prey resources for birds and terrestrial wildlife;		x
Scenic vistas and recreational opportunities;	x	
Bait and food organisms;	x	x
Functional links between terrestrial and marine environments in the coastal zone.		x

Table 4.1 Sandy beach ecosystems services by use value type.

Amenity	Amenity Point Value	Weight	Weighted Amenity Value
Weather (<i>W</i>)	.85	.20	.968
Water Quality (<i>WQ</i>)	.75	.20	.944
Beach Width and Quality (<i>BWQ</i>)	.20	.15	.786
Overcrowding (<i>C</i>)	.50	.15	.901
Other Amenities (<i>A</i>)	.50	.15	.901
Substitutes (<i>S</i>)	.30	.15	.835
Total Index Value	--	1	.487

Table 4.2 Example of weighted amenity values for the policy site beach.

CCC Demand model requirements
Beach recreation CS value (per person per visit)
Benefit transfer method
Beach attendance count (annual)
Beach erosion-value loss model
Ecological Services CS value

Table 4.3 Requirements of a demand model to value lost beach value.

Beach	Consumer Surplus for a Beach Visit (per person, \$2005)	Author
Cabrillo-Long Beach	\$12.16	Leeworthy and Wiley (1993)
Solana Beach	\$17.57 ¹	King (2001)
Huntington Beach	\$19.71 ²	Chapman and Hanemann (2001)
Encinitas	\$22.56 ¹	King (2001)
Carpenteria	\$24.70 ¹	King (2001)
Santa Monica	\$27.36	Leeworthy and Wiley (1993)
San Diego – 3	\$28.27	Lew and Larson (2005)
San Clemente	\$30.96 ¹	King (2001)
San Diego – 2	\$36.73 ³	Lew (2002)
Pismo State Beach	\$39.04	Leeworthy (1995)
Leo Carillo State Beach	\$77.39	Leeworthy and Wiley (1993)
San Onofre State Beach	\$85.39	Leeworthy (1995)
San Diego	\$90.58	Leeworthy (1995)

- 1) midpoint between two methods
2) corrected for inflation using CPI
3) cited by authors and preferred value

Table 4.4 Summary of existing site-specific study estimates of consumer surplus for a beach visit in California.

Input parameters	Units
Size of injury	Area
Year of injury	Year
Level of services in injury year	Percentage <i>(relative to baseline services)</i>
Year recovery starts	Year
Services at maximum recovery	Percentage <i>(relative to baseline services)</i>
Year recovery starts	Year
Year net service gains start	Year
Shape of recovery function	Function <i>(usually assumed to be linear)</i>

Table 4.5 Input parameters required in a HEA model (NOAA 2000).

Requirement	Beach ecosystem services
Primary services are biological	Not at present
Quantification of services lost	No
Estimate of recovery rate is available	No
Suitable site exists	Yes

Table 4.6 Assessment of HEA requirements for sandy beach ecosystem services.

Project/ year	Project Lifetime (years)	In-Lieu Beach Sand Mitigation Fee	Attendance Total / Source (Annual visits)	Consumer Surplus Value /Source (per visit per person)	Consumer Surplus Loss Model	Cost of estimation / Agency	Total Recreation Fee
Ocean Harbor House (OHH) (2004)	50	0 ¹	15,978 (CA State Parks)	\$13.00 (American Trader)	Area-based	Staff time ² (CCC staff)	\$5,300,000
Las Brisas (2005)	22	\$22,977.36	92,460 (King)	\$6.81 (King, based on OHH)	Amenity-based	\$5000 (CCC consultant)	\$309,000
Circle Drive (2006)	22	\$21,420.00	53,602/mnth ³ (City of Encinitas)	\$8.00 (City of Encinitas, adjusted from Las Brisas)	Amenity-based	Staff time ² (CCC staff)	\$198,132
Pacific Avenue (2008)	22 ⁴	\$61,164.64	Not applicable	\$1000/linear foot ⁵	Linear	\$100,000 (City of Solana Beach consultant)	\$170,000 ⁶

1) No fee established because Monterey lacks an appropriate beach program

2) Determined by Coastal Commission staff. No consulting fees.

3) Average monthly attendance during high season (June – September)

4) The in-lieu beach recreation fee is provisionally established for a 73-year period

5) Interim in-lieu fee program adopted by the City of Solana Beach

6) Proposed interim mitigation fee

Table 4.7 California Coastal Commission in-lieu beach sand and beach recreation mitigation fee.

Monterey Beach

Amenity	Amenity Point Value	Weight	Weighted Amenity Value
Weather	50%	20.00%	87.1%
Water Quality	80%	20.00%	95.6%
Beach Width and Quality	90%	15.00%	98.4%
Overcrowding	90%	15.00%	98.4%
Other Recreational Amenities	25%	15.00%	81.2%
Availability of Substitutes	30%	15.00%	83.5%
Total Index Value		100%	54.7%
Monterey	\$ 13.50		
Maximum "Perfect Beach"	\$ 24.69		

Figure 4.9 Amenity values and weights of Monterey beaches.

Huntington Beach / Perfect Beach

Amenity	Amenity Point Value	Weight	Weighted Amenity Value
Weather	85%	20.00%	96.8%
Water Quality	75%	20.00%	94.4%
Beach Width and Quality	95%	15.00%	99.2%
Overcrowding	75%	15.00%	95.8%
Other Recreational Amenities	95%	15.00%	99.2%
Availability of Substitutes	60%	15.00%	92.6%
Total Index Value		100%	79.8%
American Trader	\$ 14.00		
Maximum "Perfect Beach"	\$ 17.54		

Table 4.9 Weighted amenity values for Huntington Beach used to find a "perfect" reference beach. Based on King (2006).

Method	Consumer Surplus (\$/person/ visit)	Lost Recreation Value (\$2005)	Net Present Value¹ (\$2005)
Area-based	13.00 ²	5,300,000	2,150,000
	19.71 ³	8,000,000	3,250,000
Amenity-based	13.00	2,570,000	960,000
	13.50 ⁴	2,680,000	1,000,000

1) Based on a 3% discount rate and project lifetime of 50 years

2) CS value used in the CCC permit process for OHH

3) CS value adjusted for inflation using BLS Consumer Price Index

4) Adjusted consumer surplus values corrected for "perfect" reference beach and inflation.

Table 4.10 The amenity-based method applied to Ocean Harbor House.

Season	NPV Lost consumer surplus (\$2006)
High Season Loss	\$165,109.78
Loss Season Loss	\$33,021.96
Total Loss	\$198,131.74

Table 4.11 Lost consumer surplus for Circle Drive project using amenity-based method.

Project	Value (\$ per linear foot)¹	Difference²
Pacific Avenue	1000	--
Las Brisas	2072	+52%
Ocean Harbor House ²	1612	+38%
Circle Drive	1366	+27%

1) Not corrected for inflation

2) Adjusted for a 22-year project lifetime

Table 4.12 Comparison of consumer surplus value per linear foot of shoreline armoring.

Valuation Parameters	OHH	Las Brisas	Circle Drive	Pacific Avenue	City of Solana Beach
Valuation method	BT: Point	BT: Amenity	BT: Amenity	Linear value	Single-site TCM
Study Site	Huntington Beach ¹	Huntington Beach ¹	Las Brisas		Site specific
CS value used ²	\$13.00	\$6.81	\$8.00	\$1000	n/a
Recommended CS value ²	\$13.50	\$12.02	\$12.41	--	--
Difference²	+\$0.50	-\$5.21	-\$4.41	--	--
Erosion value loss model	Area	Amenity	Amenity	Linear	n/a
CS Lost	\$5,300,000	\$284,000	\$219,554	--	--
Recommended CS Lost	\$2,680,000	\$501,275	\$307,352	--	--
Difference³	+\$2,620,000	-\$217,000	-\$87,798	--	--
Attendance Source	State Park	City	City	n/a	Site specific study
Beach ecosystem values	Acknowledged	Acknowledged	No	No	No

1) Chapman and Hanneman (2001)

2) Consumer surplus per individual visit

3) Project lifetime for OHH is 50 years. Project lifetime for other projects is 22 years.

Table 4.13 Comparison of methods and values used to estimate the in-lieu mitigation fees.

Amenity	Amenity Point Value	Weight	Weighted Amenity Value
Weather	85%	20.00%	96.8%
Water Quality	75%	20.00%	94.4%
Beach Width and Quality	20%	15.00%	78.6%
Overcrowding	50%	15.00%	90.1%
Other Recreational Amenities	50%	15.00%	90.1%
Availability of Substitutes	30%	15.00%	83.5%
Total Index Value		100%	48.7%
Maximum Value per Day	\$ 14.00		
Fletcher/Las Brisas Value	\$ 6.81		

Table 4.8 Weighted amenity value for the Las Brisas project (King 2005).

Consumer Surplus (\$ / person / visit)	Source of Value (\$ year of value)	Percent Change
6.81 ¹	Las Brisas Amenity Weighted - Las Brisas (\$1990)	--
10.18	Las Brisas Amenity Weights (\$2005)	33%
8.54 ²	Las Brisas Amenity Weighted - Reference Beach (\$1990)	--
12.02 ³	Las Brisas Amenity Weighted -Reference Beach (\$2005)	29%
13.00	OHH - based on Chapman & Hanemann (\$1990)	--
19.71 ⁴	Chapman & Hanemann (\$2005)	34%
39.00 ⁵	Average consumer surplus for CA Beaches	--
50.00	High value from Pendleton and Kildow (2006) (\$2006)	--
90.58	Leeworthy (1995)	--

1) Reference beach is modification of Chapman and Hanemann (\$1990)

2) Based on a perfect beach consumer surplus maximum beach value of \$17.54 (\$1990)

3) Based on a perfect beach consumer surplus maximum beach value of \$24.69 (\$2005)

4) Corrected for inflation based on CPI

5) Average consumer surplus value based on literature review summarized in Table 4.4

Table 4.14 Description of the range of consumer surplus values, the source and the year on which that value was based and percent change resulting from inflation correction.

Consumer Surplus (\$ /person/visit)	OHH Lost Recreational Value (\$)	Las Brisas Lost Recreational Value (\$)
6.81 ¹	2,776,385	284,000 ¹
8.54	3,481,692	356,147
12.02	4,900,462	501,275
13.00 ²	5,300,000 ²	542,144
19.71	8,035,615	821,974
39.00	15,900,000	1,626,432
50.00	20,384,615	2,085,169
90.58	36,928,769	3,777,492

1) Value used by CCC for Las Brisas

2) Value used by CCC for OHH

Table 4.15 Effect of changes in consumer surplus value on total lost recreational value from passive erosion at OHH and Las Brisas.

Project	Project Lifetime (years)	Consumer Surplus (\$/person/ visit)	Beach Lifetime (years)	Lost Recreation Value (\$)	Net Present Value¹ (\$)
Las	22 ²	6.81	5	284,000	207,000
Brisas	50	6.81	5	706,000	356,000
OHH	50 ³	13.00	50	5,300,000	2,150,000
	22	13.00	50	1,050,00	703,000

1) Based on a 3% discount rate and project lifetime

2) Values used in the CCC permit process for Las Brisas

3) Values used in the CCC permit process for OHH

Table 4.16 The impact of project lifetime on the in-lieu mitigation fee.

Project	Consumer Surplus (\$/person/visit)	Project Lifetime (years)	Beach Width (feet)	Beach Lifetime (years)	Lost Recreation Value (\$)	Net Present Value¹ (\$)
Las Brisas	6.81	22	7.0	5	284,000	207,000
			14	10	325,000	236,000
			30.8	22	365,000	260,000
OHH	13.00	50	85	50	5,300,000	2,150,000
			8.5	5	1,200,000	600,000

1) Based on a 3% discount rate and project lifetime

Table 4.17 The impact of beach width on in-lieu mitigation fee.

Project	Erosion Rate (ft/yr)	Annual Beach Loss (ft²/yr)	Beach Lifetime (years)	Lost Recreation Value (\$)	Net Present Value¹ (\$)
Las Brisas	1.4	32.5 ²	5	284,000	207,000
	0.14	3.25	57	244,000	180,000
	0.70	16.3	11	281,000	205,000
	2.8	65	3	298,000	220,000
OHH	1.7	870 ³	50	5,300,000	2,650,000
	0.17	87	500	530,000	26,500
	0.85	435	100	2,650,000	1,080,000
	3.4	1740	25	7,880,000	2,700,000

1) Based on a 3% discount rate and project lifetime

2) Values used in the CCC permit process for Las Brisas

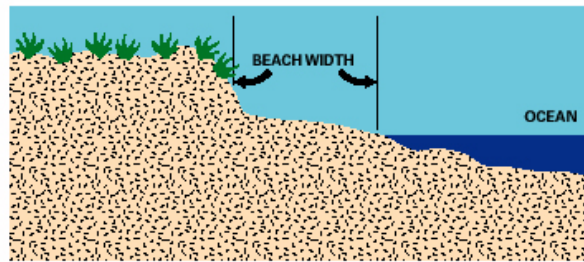
3) Values used in the CCC permit process for OHH

Table 4.18 The impact of erosion rate on the in-lieu mitigation fee.

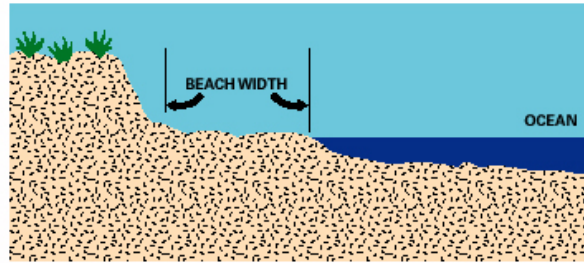


Figure 4.1 Shoreline armoring structures: a rock revetment in San Clemente, CA and a seawall in Monterey, CA. Source: Surfrider Foundation.

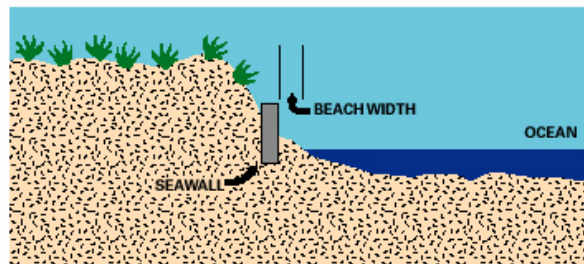
Passive Erosion



A. Initial shoreline showing beach width



B. Shoreline after sea level rise & associated dune or bluff erosion, although the shoreline has moved landward, the beach width remains the same



C. Shoreline after sea level rise where seawall has fixed shoreline position, note reduced beach width

Figure 4.2 Passive erosion resulting from shoreline armoring. Source: Surfrider Foundation, based on Pilkey and Dixon (1996).

CEQA Mitigation Steps

- 1) Avoid the impact altogether by not taking a certain action or parts of an action.
- 2) Minimize impact by limiting the degree or magnitude of the action and its implementation.
- 3) Rectify the impact by repairing, rehabilitating, or restoring the impacted environment.
- 4) Reduce or eliminating the impact over time by preservation and maintenance operations during the life of the action.
- 5) Compensate for the impact by replacing or providing substitute resources or environments.

Figure 4.3 Hierarchical steps for mitigation based on Section 15370 of the CEQA guidelines.

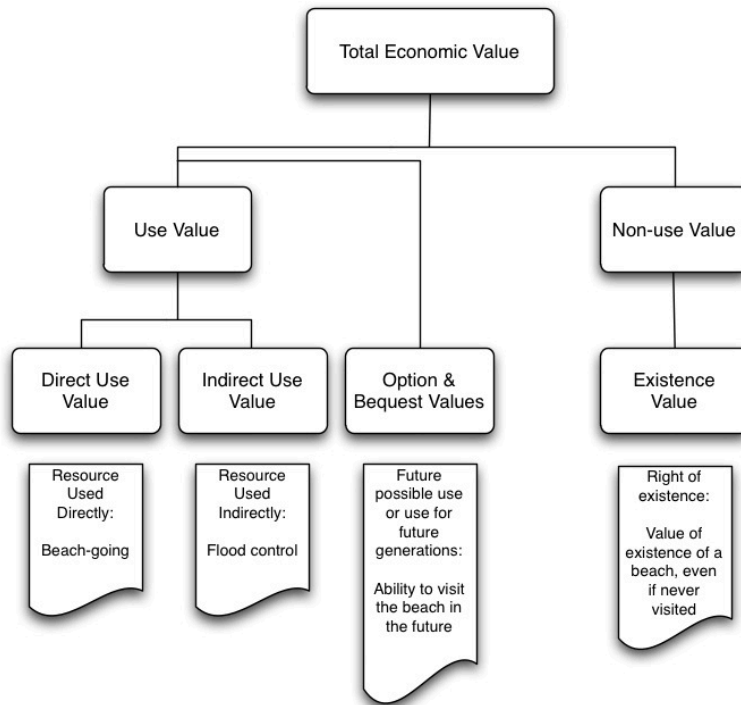


Figure 4.4 The total economic value of ecosystem services provided by sandy beaches.

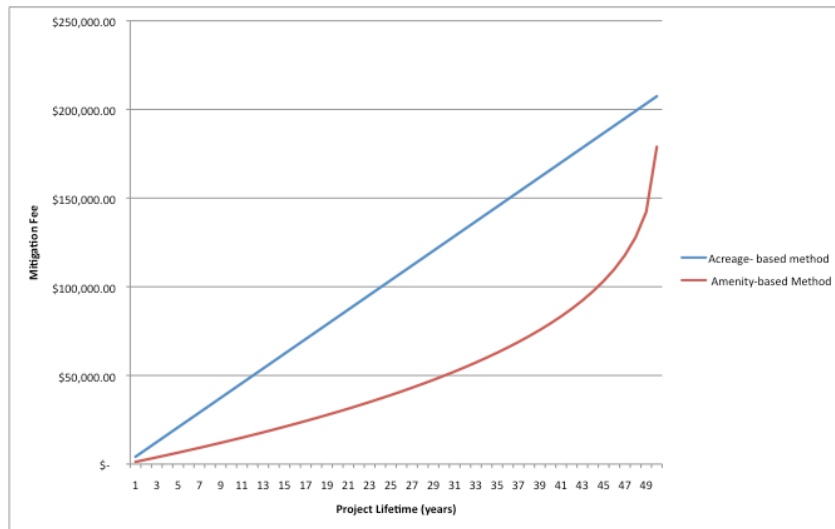


Figure 4.5 The area-based method and amenity-based methods for annual recreational value of the beach at Ocean Harbor House.

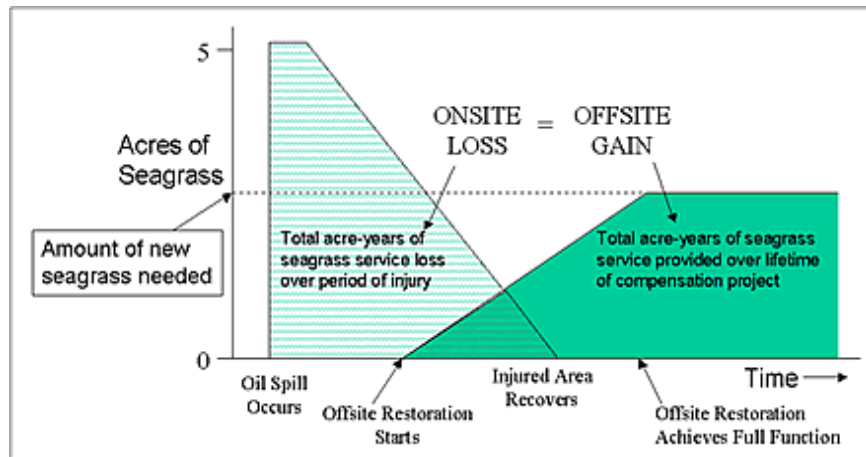


Figure 4.6 Example of HEA approach to scale offsite mitigation (CSC 2001).

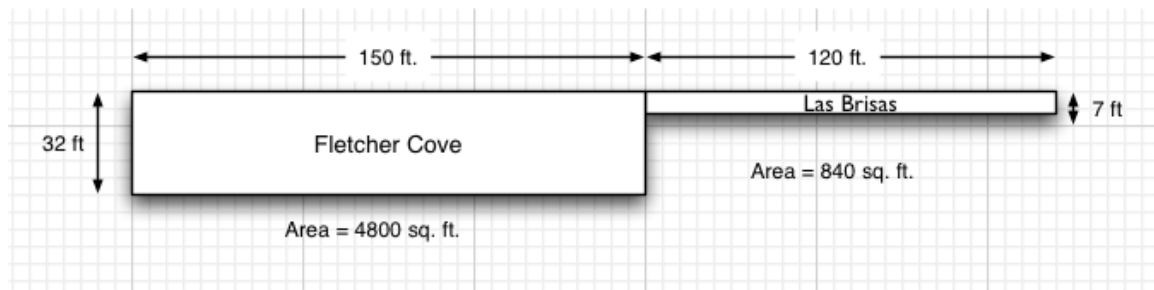


Figure 4.7 Configuration of beaches at Las Brisas and Fletcher Cove.

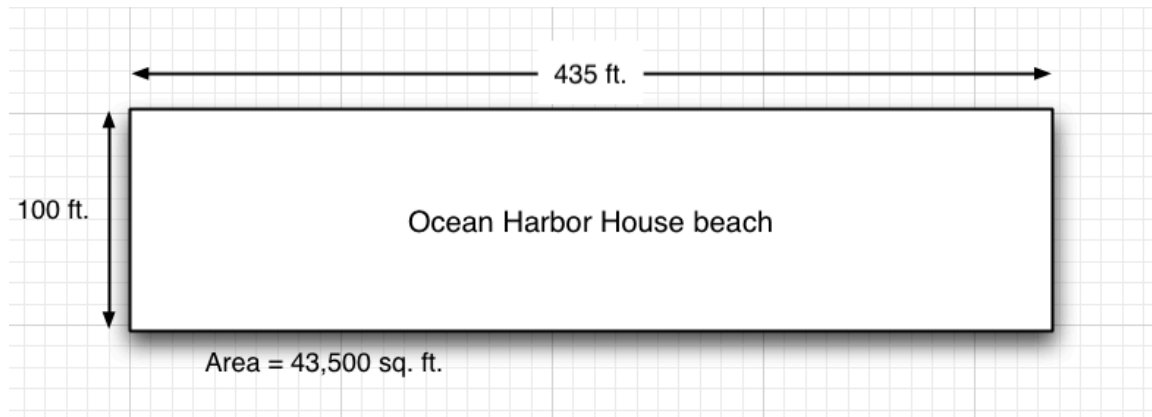


Figure 4.8 Configuration of beach at Ocean Harbor House.

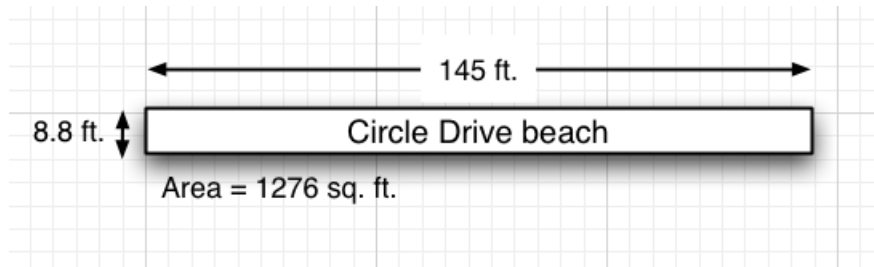


Figure 4.10 Configuration of beach at 629-633 Circle Drive.

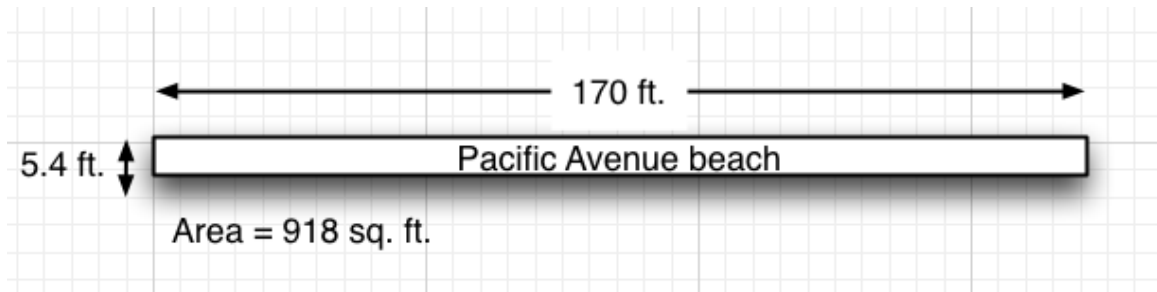


Figure 4.11 Configuration of beach at 417-423 Pacific Avenue.

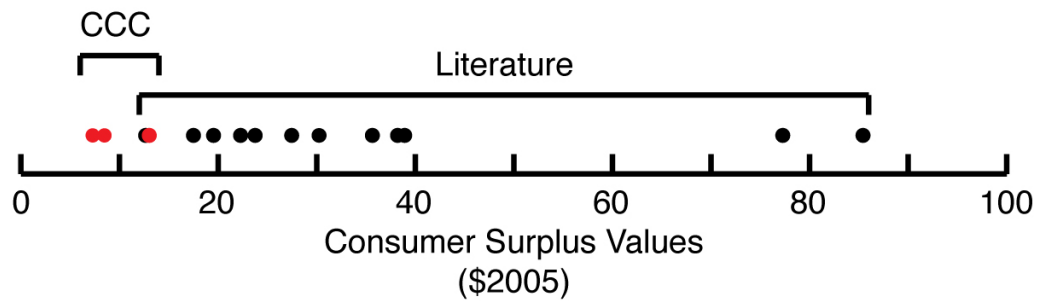


Figure 4.12 A comparison of consumer surplus values in the literature with those used by the Coastal Commission.

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