Bren School of Environmental Science and Management

Masters' Thesis Project

An Economic Valuation of Southern California Coastal Wetlands

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A Group Project submitted in partial satisfaction of the requirements for the degree of Master of Environmental Science and Management for the Bren School of Environmental Science & Management at the University of California, Santa Barbara.

Signature Page

An Economic Valuation of Southern California's Coastal Wetlands

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The Group Project is required of all students in the Master of Environmental Science and Management (MESM) Program. The project is a three-quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Group Project Final Report is authored by MESM students and has been reviewed and approved by:

Andrew Plantinga — Date

This thesis group project was developed in conjunction with Southern California Wetlands Recovery Project (SCWRP) with the goal of determining the value of Southern California Coastal Wetlands.

SOUTHERN CALIFORNIA WETLANDS RECOVERY PROJECT

BREN SCHOOL OF ENVIRONMENTAL SCIENCE & MANAGEMENT
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Abbreviations

CCC - California Coastal Commission
CV - Contingent Valuation
NGO - Non-governmental Organization
NOAA - National Oceanic and Atmospheric Administration
NWI - National Wetlands Inventory
SCC - Social Cost of Carbon
SCWRP- Southern California Wetlands Recovery Project
TIME - Temporal Investigations of Marsh Ecosystem
TRNERR - Tijuana River National Estuarine Research Reserve
WRP - Wetlands Recovery Project
WTP - Willingness to Pay

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Abstract

Southern California's coastal wetlands contain a variety of habitats that provide a range of services, which benefit human well-being, as well as the surrounding local and regional environment. These habitats provide ecosystem services such as flood protection, carbon sequestration, pollution buffering, and critical habitat for plant and animal species. While the physical extent of Southern California coastal wetlands is federally protected, the quality is being degraded by surrounding development, impacts from a growing population pressures, and impacts from climate change. Degraded habitats do not provide the same level of benefits and ecosystem services as healthy systems. The Southern California Wetlands Recovery Project (SCWRP) in conjunction with the Bren School, developed this project to increase the communication and transparency of land use decisions that are impacting wetland habitats along the Southern California coast. Increased understanding of the value of ecosystem services and their linkages to human well-being can help spur public demand and action to approve policies, projects and funding that benefit wetlands, so they can continue providing benefits to people. The goal of this project is to increase understanding by following an ecosystem service-based approach to determine a range of gross economic values for the ecosystem services provided by coastal wetlands. These values will serve as a communication tool and provide a baseline value of Southern California coastal wetlands, allowing decision-makers to increase their capacity of incorporating these ecosystems into the decision making process.

Executive Summary

The global stock of wetlands is currently being lost at a rate of about 1% per year and Southern California wetlands are no exception; Southern California has had an average cumulative loss of over 48% of coastal wetlands since the mid-19th Century, with some habitats incurring losses up to 75% (Stein et al. 2014a). While the physical extent of southern California coastal wetlands is federally protected, the quality is being degraded by surrounding development, impacts from other population pressures, and impacts from climate change.

At the same time that these coastal wetlands face this degradation, they also offer potential solutions to these problems. Wetlands do this by providing humans with ecosystem services – benefits humans gain from natural ecosystem functions – including flood protection, water filtration, and critical habitat provision for plant and animal species (Nicholls et al., 1999, Costanza et al., 1997). Degraded habitats do not provide the same level of ecosystem services as healthy systems and are less capable of providing benefits to human well-being as well as the surrounding local and regional natural environment.

With the potential impacts of sea level rise and population growth in coastal regions, there is a growing need to enhance wetland protection and facilitate migration. While measures have been taken to protect these wetlands from direct development, predicted sea level rise could eliminate or squeeze coastal wetlands, which are unable to migrate due to insufficient or non-existent buffer areas between human constructions and wetland areas (Nicholls et al., 1999). Additionally, upstream activities pollute and negatively impact the quality of the intact wetland systems.

The client, the Southern California Wetlands Recovery Project (SCWRP), focuses on a regional approach to restore, protect and expand the benefits that wetlands provide to the regional community, biodiversity and economy. To increase commitment to these wetlands, SCWRP sought to increase communication of the importance of these wetlands. One of the reasons that there is not widespread understanding of the value of these ecosystems is that there is not a common metric to communicate the value. This lack of a common metric is due to the non-market nature of many of the goods and services that these wetlands provide. To fill this gap, this project seeks to determine a monetary value for the wetland habitats by quantifying the ecosystem services provided by these wetlands.

This project focused on identifying the key ecosystem services that are provided by selected habitats of Southern California coastal wetlands and to value these services. Due to the non-market nature of many of these services, three different valuation methods were used in an attempt to capture both use and non-use values. The first is an ecosystem service rate valuation method, determining annual rates of ecosystem services that are provided by wetland habitats in Southern California and applying a monetary value to those rates. The second is the benefit transfer method, and the third is a contingent valuation survey developed for this project.

This valuation provides necessary context and a foundation to communicate the importance of Southern California coastal wetlands such that their worth will resonate with the general public

and promote future land-use and conservation policy decisions. Indicating the estimated worth will help coastal planners gauge the costs that will be incurred if these wetlands are lost. Therefore, knowing the benefits of these wetlands adds more information and transparency to the decision-making processes that involve coastal wetland areas. This will also foster better communication between coastal planners and politicians to create management plans that consider the quality of coastal wetlands. In addition, while immediately adjacent land areas surrounding coastal wetlands – often termed buffer zones – are of vital importance in contributing to the quality and resiliency of coastal wetlands, they are not always comparably considered or protected (Executive Order No. 11990, 1977). Considering both upstream and downstream impacts on wetlands could facilitate discussions on the expansion of the buffer zones to aid in the protection of the quality of these wetland systems. In general, the client intends to use these values primarily as a communication tool and to provide a baseline value of wetlands for decision-makers, thus increasing their capacity to incorporate these ecosystem services into decisions.

In summary, the goal of this project is to provide vital information to the general public and policy makers by following an ecosystem service-based approach to determine a range of total economic values for the ecosystem services provided by coastal wetlands. Increased understanding of the value of ecosystem services and their linkages to human well-being can help spur public demand and actions to approve policies and projects that benefit wetlands and to direct funding to these resources, so wetlands can continue providing services. In addition, our estimates help to inform policy decisions by monetizing the costs of wetlands degradation.

1.0 Significance of this Project

The rising concern for the protection and restoration of California's coastal wetlands provides compelling motivation for an economic valuation of these areas. Whenever a decision to protect, restore, or develop a wetland is made, that habitat is given an implicit value. Often times this implicit value is considered to be very low compared to the revenue that can be gained through development. This is largely because the environmental benefits provided by wetland habitats, called ecosystem services, are often non-market goods; their value is not explicit as they are not traded commodities. However, valuation studies of ecosystem services reveal that the benefits provided by wetland habitats can be large and are comprised of both use and non-use values. Ecosystem services with use values have an economic value associated with either their direct use, including fishing or nature-viewing, or their indirect use, such as water quality maintenance and flood protection (Raheem 2009). Ecosystem services with non-use values, by contrast, are the benefits individuals obtain from wetlands even if they are not directly using or interacting with those systems. These include existence value, the benefit people gain from simply knowing wetland areas exist, option value, the benefit individuals gain from knowing that preservation will allow them the opportunity to enjoy wetland resources in the future, and bequest value, the benefit individuals derive from knowing that wetland areas will exist for future generations to use and enjoy (Pascual et al. 2010; Ghosh & Mondal, 2013).

Therefore, explicitly stating the value of these wetland areas will provide decision-makers with the proper tools to compare and discuss the importance of protecting wetland habitats. Explicit valuation allows for better decisions to be made about our natural resources and allows for discussion of their importance in a way that is likely to resonate with the managers and general public—the tangible value of money.

Additionally, as political battles arise over wetland areas, organizations across the State are attempting to identify key conservation areas and develop data that can be used for more transparent policy making. For example, over the last three decades the Ormond Beach Wetlands in Oxnard, California have faced several development proposals, including the building of marinas, resorts, and even a theme park (California State Coastal Conservancy, 2016). However, the California Coastal Conservancy, along with the City of Oxnard, the community, and private landowners identified the area as an important conservation area and have since then blocked the development of lots, and prepared a restoration plan for the area.

The use of wetland ecosystems to protect coastal communities is becoming more popular throughout the State. Just recently the California Coastal Conservancy awarded the Orange County Coastkeeper $250,000 to restore oyster beds and eelgrass in Newport Bay in order to demonstrate how natural systems can protect against sea level rise and storm surge. Coastal Conservation and Research, Inc., in partnership with Central Coast Wetlands Group, were given

$15,000 to design a restoration plan for the sand dunes at Salinas River State Park, and the Marin County Open Space District was granted $165,000 to develop a restoration plan at the end of Bolinas Lagoon which will include the restoration of wetlands to reduce flooding affecting local roadways (California State Coastal Conservancy, 2015). With funding being granted to projects that focus on the restoration and protection of California wetlands, it is clear that wetlands are being recognized for the benefits they provide to society.

A range of monetary values for these coastal wetlands will allow for greater understanding of the importance of the resources, not only for decision-makers but also for environmental managers and the general public. These values will communicate the importance of wetland protection and restoration.

1.1 Policy Context

Policy Background

There has been a slow but growing awareness of the importance of these resources and their services in all levels of policy. At the federal level, wetlands are protected through Section 404 of the Clean Water Act and associated enforcement and mitigation regulations, regulating the discharge of dredge and fill materials into U.S. waters. They are also provided protection by Section 10 of the River and Harbors Act of 1899, which regulates the filling, diking, and placement of structures in navigable waterways (Clean Water Act, 1977; Environmental Protection Agency, 2013). The national Coastal Zone Management Act recognizes the importance of protecting coastal resources, which led the state of California to approve California Coastal Act (CCA) of 1976 (Coastal Zone Management Act, 1972; California Coastal Commission 1994). This resulted in the establishment of the California Coastal Commission (CCC), which recognizes the benefits provided by coastal wetland ecosystems and supports the economic valuation of ecosystem services to aid in the maximum protection of natural areas for public access, sensitive coastal resources, and water quality (CCA Section 30000, 1976).

The protection of the quality of these resources through ecosystem-based approaches has followed a slower path towards realization at the policy level, though there is abundant academic literature and research supporting these ecosystem-based management approaches (Arkema 2013; Herzog and Hecht 2013; NOAA 2010; Davis 2015). This is partly due to the different priorities of agencies; local policy makers are often concerned with critical infrastructure and the local economy, while state agencies such as the CCC prioritize public access and safety. Policymakers often are not aware of coastal and wetland habitats' contribution to each of the above interests. Current policy research is moving towards ecosystem-based approaches, as more reports and guidance documents are acknowledging what ecosystems can provide as solutions and their integral role in informing local and regional planning concerns.

Role of Wetlands in Policy Decisions

Wetland habitats provide an important defensive barrier for California's large coastally located urban areas. Degradation of these wetlands can potentially double the risk of coastal hazardous experienced by these communities (Arkema, 2013). Regarding climate change, these wetlands and their ecosystem services are critical. The two main foci in climate change policy are mitigation and adaptation, and these coastal wetlands can notably contribute to both efforts. Demonstrating that these wetlands can be beneficial for both interests will be useful, especially regarding adaptation strategies. As coastal impacts continue and increase in frequency, there will be tradeoffs between ecosystem preservation and protecting development (Herzog and Hecht, 2013). Ecosystem service-based approaches were identified as being particularly useful and relevant in preparing for the impacts of climate change, though lacking in current policy discussions.

California EPA's *Climate Change Research Plan for California* (CalEPA, 2015a) highlighted the need for non-traditional and non-economic factors in new economic analyses in order to consider and implement adaptation measures that the public will support. For example, the same plan notes that mitigation efforts such as reducing greenhouse gas emissions rely on carbon sequestered by these natural landscapes. In the recently adopted *California Coastal Commission Final Sea Level Rise Policy Guidance* (2015) adaptation strategies focused on "soft solutions", sediment management, and protecting ecosystem functions as approaches to preparing for impacts from sea level rise such as flooding and inundation. These approaches are contingent on healthy wetland ecosystems in order to provide successful coastal resiliency. The 2015 *Draft Safeguarding California Report* emphasized the importance of education and outreach on vulnerable habitats in order to support adaptation planning across the state (California Natural Resource Agency, 2015). Monetary values can be effective communication tools for assisting in these education efforts.

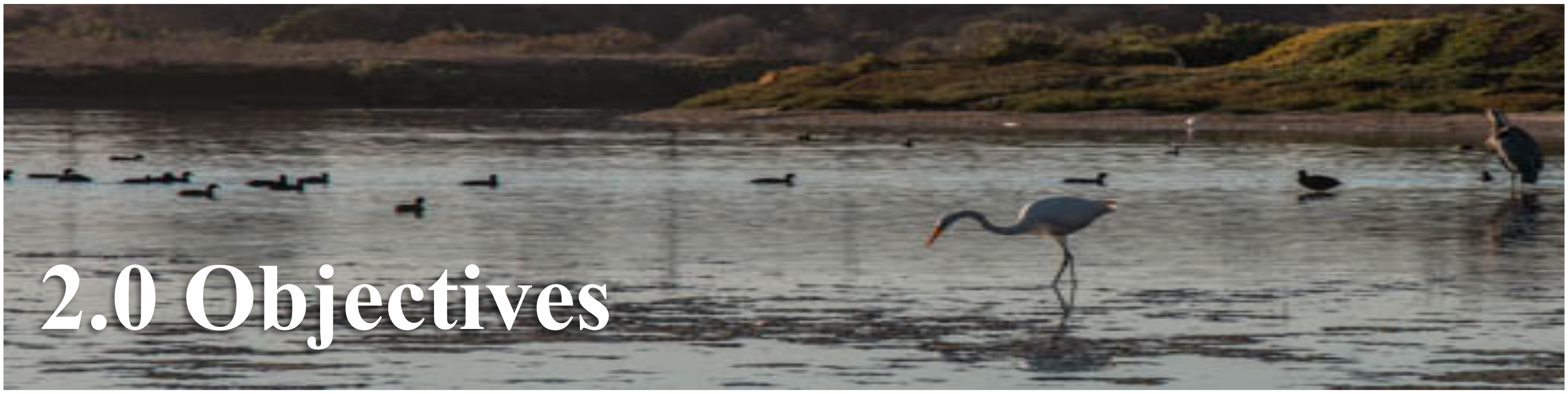
Wetlands currently provide these mitigation and adaptation solutions, among other services, at little or no cost to government budgets. Key actions identified in the CCC guidance document included a project funded by NOAA that will quantify and economically value beach ecological resources to address impacts from sea level rise and coastal armoring development (CCC, 2015). An economic valuation of these services can help place economic analyses alongside other factors that are necessary to create and implement successful adaptive solutions, such as public perception and consideration of impacts on the environment (CalEPA, 2015).

Demonstrating the increased focus on ecosystem based approaches, funding and grants have increasingly focused on wetlands and the services they provide. These funds are received not only for restoring wetlands but also for protecting the ecosystem services they provide. For instance, the California Department of Fish and Wildlife (CDFW) awarded 12 grants in the 2014-2015 period that enhanced wetlands in order to reduce greenhouse gas emissions (CDFW, 2015).

Policy Implications

In communities across the nation - from Chula Vista, CA to Boston, MA and Miami-Dade, FL - development near wetlands has been limited by state regulations, including stricter buffer requirements and increased focus on more types of wetland habitats (National Wildlife Federation, 2014). These communities acknowledged and sought to protect the variety of benefits, or ecosystem services, that the healthy wetland habitats can provide them.

Along the coast of California, development and projects are subject to the California Coastal Act (CCA). CCA Sections 30231, 30233 and 30240b require restoration and maintenance of the biological productivity and quality, limited filling, and adjacent development to prevent impacts that significantly degrade the resources of the wetlands, respectively (CCA Section 30000, 1976). While there is no specific language in the Coastal Act related to buffer requirements, recent CCC-certified plans demonstrate what is currently accepted. Many existing Local Coastal Plan documents currently have 100-foot buffers, while the recently certified UCSB 2010 Long Range Development Plan includes more detailed buffer requirements related to habitat types. It requires a minimum 100-foot buffer for freshwater wetlands, a 200-foot buffer for brackish marshes and a 300 foot buffer for coastal salt-marsh (UCSB, 2015). Other local jurisdictions currently only employ 25-35 foot buffers, demonstrating the possible ranges and uncertainty in what is "sufficient size" to ensure the biological integrity (CCC, 1995; City of Seaside, 2013). Increasing the knowledge and facilitating the discussion of the ecosystems services provided by wetland habitats will provide an increased opportunity to determine and protect the appropriate buffer sizes and other policy decisions affecting the health of these ecosystems.



2.0 Objectives

2.1 Key Objectives

- Identify the key ecosystem services provided by Southern California coastal wetlands that are feasibly quantifiable.

- Assess the value of those key ecosystem services to determine the gross benefit they provide to society.

2.2 Limitations

There were two major limitations faced throughout this project. The first was the issue of scaling and the second was a lack in available ecosystem service valuation data.

Scaling
The majority of values provided in this report are in dollars per hectare per year for each ecosystem service provided by each coastal wetland habitat type. This unit of measure makes adding up those values linearly based on the area of each habitat type the logical next step, however, there are two main reasons why doing so could lead to inaccurate values.

Problem 1: Uncertainty in Marginal Benefits
The first scaling problem is the uncertainty in where the determined values lie on the marginal benefit curve. Just like any market good or service, the demand curve for ecosystem services is presumed to be downward sloping, therefore the marginal value of benefits provided by wetland ecosystems decreases as the area of wetlands ecosystems increases. Therefore, adding up all the values of ecosystem services provided by each unique habitat and then scaling up those values to the entire Southern California coastal wetlands ecosystem is only appropriate if marginal benefits are constant (European Environmental Agency, 2010).

Some research shows that the area of the wetland has very little impact on the per acre value of the wetland, suggesting that values can be added up linearly in the form of dollars per acre without error (Woodward & Wui, 2001). With some global ecosystem services, such as carbon sequestration, aggregation can be considered, because marginal benefits are likely to be nearly constant (Luisetti et al., 2014). However, other services, such as habitat provision, may be considerably more valuable on large swaths of land or, alternatively, one additional hectare of a habitat may not be as marginally beneficial in areas where there is already a large portion of wetland habitat.

Additionally, there is uncertainty surrounding the lower bound or threshold amount of physical area necessary to provide a particular ecosystem service (European Environmental Agency, 2010). For example, salt marsh provides the ecosystem service of storm protection. However, if you had a wetland system that contained one hectare of salt marsh habitat, would that one hectare provide the ecosystem service of storm protection or is there a minimum amount of salt marsh area needed before the ecosystem service of storm protection is provided?

Problem 2: Lack in Available Habitat Extent Data
The second problem with scaling arises from the lack in available habitat extent data. Since the exact extent of Southern California coastal wetland habitats is unknown, it is nearly impossible to scale up the ecosystem services values on a per hectare basis by each habitat type.

To identify the distribution of specific wetland habitat types along the Southern California coast, California Aquatic Resource Inventory (CARI) data was used, in combination with a crosswalk to match the different habitat types (Stein, 2014b). The CARI data was originally from the National Wetlands Inventory (NWI) and the National Hydrography Dataset High from the U.S. Geological Survey (San Francisco Estuary Institute, 2014).

A report on the historical extent of Southern California wetlands stated that the total extent of current coastal wetlands in Southern California is approximately 10,274 hectares (Stein et al., 2014). However, using the crosswalk table and analyzing NWI codes and definitions provided by the U.S. Fish and Wildlife Service's classification systems, the Cowardin System, the resulting extent of Southern California coastal wetlands from the NWI shapefiles was 41,916 hectares (Cowardin, 1979; NWI, 2016).

Despite considerable effort, it was determined that there was too much uncertainty in the extent of individual habitat types based on the discrepancy between the Stien et al. 2014 paper and the maps created using NWI data. For example, 55% of the habitat, which was determined under the method using NWI data, fell into the category of "salt marsh." Because of the lack of detail on type of vegetation cover or soil composition and other distinguishing factors that are unique to particular coastal wetlands habitats, habitats which are unique subsets of salt marshes are indistinguishable from the whole. This is problematic when considering the unique and high value ecosystem services that some of these habitats provide, such as pickleweed.

This lack of available detailed habitat mapping data limited the scalability of the values presented in this report. Therefore, the values are not aggregated to give a total value to the entire Southern California coastal wetland region but rather they remain in 2015 USD/hectare/year.

Available Data
The second limitation faced in this project is the lack of available primary ecosystem service valuation data, especially on a small scale.

The majority of coastal wetland valuation data comes from global assessment studies. The validity of transferring these global assessments values to Southern California's coastal wetland systems is questionable because the data has a global context not necessarily consistent with Southern California's coastal Mediterranean climate.

There is also a limited amount of data available on the flow rates of ecosystem services. For example, there are very few studies that determine the rate at which nutrients cycle through salt marsh habitat. This lack of data describing the flow rates of particular ecosystem services significantly limits our ability to calculate values for ecosystem services provided by particular habitat types.

3.0 Approach

To complete the first objective, we developed an exhaustive list of ecosystem services provided by coastal wetland ecosystems (Appendix A). Key services were identified using ecosystem services lists from the scientific literature, including but not limited to: Millennium Ecosystem Assessment (2005), De Groot et al. (2002), Daily (1997), Chan et al. (2006), and the Tijuana River National Estuarine Research Reserve (TRNERR, 2015). Based on discussions with our client and wetland ecologists, we prioritized the services based on those, which could most feasibly valued (J. Lorda, personal communication, October 13, 2015).

To complete the second objective, assessing the value of those key ecosystem services to determine the gross benefit they provide to society, we used three different valuation methods.

The first method used annual flow rates for the identified key ecosystem services provided by Southern California coastal wetland habitats. For this method, the flow rates were closely aligned with Southern California habitats while the values placed on those rates came from various sources. These flow rates and values for the rates were then used to determine the monetary benefit provided by the ecosystem services.

The second method assigned market and non-market, use and non-use values to the ecosystem services using a Benefit Transfer Approach (Rosenberger & Loomis, 2003), in which we transferred ecosystem service values determined in the literature directly to our study.

Finally, to aid in measuring non-use values and to provide a region-specific assessment, our third method of valuation was the Contingent Valuation Method. This method was used to address gaps in the literature and to obtain the value of avoided degradation of Southern California coastal wetlands. The combined use of these valuation methods enabled the estimation of a range of monetary values for the collective entirety of Southern California’s coastal wetlands.

The values provided throughout this report are in units of 2015 USD/hectare/year. Values are assigned to each habitat type based on the determined values of the ecosystem services. However, due to the scaling issues mentioned above, these values are not aggregated to the entire study site and remain in $/hectare/year except where otherwise stated.

3.1 Study Area

The area of study for this economic valuation runs approximately 290 miles along the curved Southern California coast from Point Conception to Tijuana, just south of the California-Mexico border (measured using ESRI's ArcGIS online mapping tool). This area is often referred to as the "bight" (*Figure 1*). It has a semi-arid Mediterranean subtropical temperate climate, which is characterized by mild rainy winters and hot, dry summers (Regents of the University of California, 2016).

Figure 1. Extent of Study Area from Point Conception, just north of Santa Barbara to Tijuana, just south of the U.S.− Mexico Border.

3.2 Selected Habitats

Coastal Wetland Ecosystem Habitats

Wetlands are characterized by five major systems — palustrine (freshwater marsh), lacustrine (lakes), riverine, marine and estuarine systems (Cowardin, 1979).

The focus in this report are coastal wetlands, which are comprised of marine and estuarine systems (California Department of Fish and Game, 2001). Marine systems encompass nearshore ocean habitats, which are not readily diluted by freshwater. Salinity levels in marine systems rarely fall below 30 parts per thousand (ppt). Estuarine systems are systems found along the coast which are semi-enclosed from marine systems but have sporadic connection with the ocean. Estuarine systems extend inland from the coast. The salinity level of the systems waters is diluted by freshwater runoff or by inflow from freshwater systems, such as rivers. Estuarine systems include lagoons, river mouths and large bodies of saltwater that are significantly diluted by freshwater inputs (Dethier, 1990).

The Southern California coastal wetland habitats considered for valuation were identified with the help of an ecosystems services advisory group that is part of the Temporal Investigations of Marsh Ecosystems (TIME) project. Habitats were chosen based on local relevance, the typical focus of restoration projects and the detail of ecosystems that can be measured at these specific levels (J. Lorda, personal communication, October 13 2015). Habitats were identified based on the unique ecosystem services they provide to Southern California. Some habitats, such as pickleweed marsh and eelgrass were identified by SCWRP and the TIME project as separate due to their importance in ecosystem service provision and their abundance within Southern

California coastal wetland systems. While each of these habitats, identified as separate habitats by SCWRP and the TIME project, provide unique values, the regional scope of this project does not lend itself to detailed mapping of each of these habitats. Therefore, while we describe these "special" habitats, they are valued in conjunction with their parent habitat to avoid overvaluation or double-counting.

The following is a list of the selected habitats analyzed in this report. Those marked with an asterisk (*) are described but not valued.

- Salt Marsh
- Pickleweed Marsh
- Brackish Marsh
- Salt Flat
- Tidal Mudflat
- Shallow Subtidal
- Beaches and Dunes
- Eelgrass Beds*
- Oyster Beds*
- Ditch Grass Beds*
- Wetland/Upland Transition Zone*

For further information and descriptions of each habitat type examined in this report, see Appendix B.

3.3 Valuation

Valuing Southern California Coastal Wetlands

The range of ecosystem service values obtained through this economic valuation serve as preliminary economic values for Southern California coastal wetlands. While there are uncertainties for all of these values, even an initial estimate of the economic value of these important ecosystems can help prevent degradation and destruction, which often occurs when the economic value of nature is not stated and consequently considered to be zero.

To the extent possible, it was ensured that the rates and studies used in this project were satisfactorily applicable to the Southern California coast (i.e. comparable local ecology, population demographics, economic status, and property rights). Ensuring these similarities allowed the transfer of the rates and values determined for the habitats and ecosystem services in those studies to the coastal wetland valuation calculations completed in this project. Monetary values were provided in varying currencies (i.e. USD, Euros, Australian dollars) and units but were all converted to 2015 U.S. dollars per hectare per year using the appropriate exchange rates and the Consumer Price Index from the Bureau of Labor Statistics.

Background

The numerous benefits to human health and well-being provided by natural ecosystems were often entirely unaccounted for in decision making until the 1960s and 1970s, when case studies and other literature regarding ecosystem service valuation began to surface and the need to provide a monetized, economic value to these benefits became a major focus in environmental economics research (Hein et al., 2006). A large literature emerged, detailing everything from evaluations of different methodological approaches of ecosystem service valuation, to actual assessments of the value of particular ecosystems' services.

Some of these studies included scientific assessments and analyses of the specific rates at which particular ecosystem services are provided in wetland habitats, such as Yoskowitz et al. (2012) who quantified nitrogen regulation by oyster reefs and Craft (2007) who determined carbon sequestration rates in freshwater/brackish marsh. This rate-based approach was the primary method used for empirical calculation of ecosystem service values in this report.

Other studies have sought to conduct a meta-analysis of hundreds of different ecosystem service studies such as those described previously, the most cited of these including: Costanza et al. (1997), Turner et al. (2000), De Groot et al. (2002) and the Millennium Ecosystem Assessment (2005). These studies calculated ecosystem service valuation estimates based on global assessments of the world's wetlands, combining the data reported in hundreds of studies conducted across a diverse range of wetland types. The data provided in these studies has been used in other ecosystem service valuation studies through a benefit transfer approach, including Batker (2014), Brenner et al. (2010) and Feagin et al. (2010). While these studies have been very useful in identifying and articulating the characteristics of the various ecosystem services provided by wetland ecosystems, considerable caution was given in utilizing the economic values derived from these resources for benefits transfer in this report. See *Benefit Transfer* for additional explanation.

An additional method often used to conduct wetland valuation is the Contingent Valuation method. Unlike the rate-based valuation and benefits transfer approach, contingent valuation involves conducting a survey to determine individuals' stated preferences or "willingness to pay" as a means of estimating wetland value. In the context of this report, the empirical calculations of values for ecosystem service provision rates and the values garnered through benefit transfer provide *gross estimates* (see discussion of the counterfactual in the next subsection) of value while the survey provides an *avoided degradation estimate* for Southern California's coastal wetlands based on stated preferences (See Contingent Valuation Survey Method). The survey does not serve to provide specific estimates of individual ecosystem services, but rather an overall estimate of the perceived total value of protecting Southern California coastal wetlands. There are several advantages to using this method in combination with the others previously described. See *Contingent Valuation Survey Method* for explanation.

Valuation will contribute to raising awareness of these services and will also bring light to the importance of the wetlands that provide these services (Luisetti et al., 2014). While it would be ideal that increased knowledge of these values would incentivize coastal wetland protection by private entities, the ecosystem services wetlands provide are considered nonmarket, public goods. The benefits they provide do not solely accrue to private entities, but to the greater public. With this, the incentives aren't suitable for private protection. However, as the public is the primary benefactor of these benefits, it is possible that a public entity could be motivated and incentivized to provide protection and maintenance duties, given proper funding sources.
It is, of course, possible that private incentives for preservation can also result, through the reduction in operation costs and avoiding costs of compliance (Comello, 2011). For example, the ecosystem service of flood protection can be valued based on the costs of methods to replace

sediment or prevent flooding, such as dredge-and-fill and barriers, while the ecosystem service of water purification and quality management can be taken from the existing costs of water treatment plants.

3.4 Valuation Counterfactual

The functional role of counterfactual analysis is to provide a possible alternative that could, would, or might occur under different conditions from those in the study. This counterfactual can be "upward" or "downward" in nature, where the alternative state is "better" or "worse" respectively, than what actually happens. Additionally, it can either serve an *affective* (i.e. retrospective) function or *preventive* (preparing for the future) function (Roese, 1994).

This project assumes a state of nature where all existing Southern California's coastal wetlands are entirely conserved. Therefore, the counterfactual employed in this report for the rate valuation and benefit transfer valuation methods is an alternate state where all land area of Southern California's coastal wetlands is degraded to a point where there is no productive land providing ecosystem services. This kind of "downward" counterfactual is intended to help convey the potential loss to society of degrading these systems to the point where they are effectively removed. Realistically, if this scenario of complete degradation did occur, some other land use, which provides *some* level of benefit to humans would take the place of these wetlands. Therefore, total loss of benefits is an unrealistic scenario.

3.5 Valuation Methods

To the extent possible, the values of ecosystem services given in this report were determined using two empirical calculation methods to generate climate and habitat-specific measurements. Additional gaps and an understanding of the value of the whole wetland were addressed using a contingent valuation survey.

Ecosystem Service Rate Valuation Method

The first valuation method is a calculation based approach. It assesses annual flow rates of ecosystem services within habitats and applies a monetary value to these rates. Most ecosystem service flow-rates were gathered from studies and reports that were conducted in the Southern California coasts or in areas with comparable climates. These rates were based on biogeochemical processes within the soils and vegetation of a particular habitat. A monetary value was assigned based on previous, peer-reviewed approaches for valuing the rates. The resulting values determined an overall range of valued flow-rates for each quantifiable ecosystem service of all possible selected habitats. This method was used for valuing carbon and nitrogen sequestration as well as the value of seagrass as refugia to the commercial fishing industry. Other ecosystem service rates were derived from the observed public expenditures on particular ecosystem services, such as through grants. This observation-based approach assumed that the observed amount transferred would be *at least* what society is willing to pay for this service. This approach was used for the ecosystem service of education.

This ecosystem service rate valuation method allowed for valuation to be based on information specific to the coast of Southern California. Because of this, calculations were only feasible when original data were available. The approximated values can provide estimates of the benefits provided by ecosystem services, while the approaches can be refined as new research on the region's wetlands provides additional data.

Benefit Transfer Method

The second valuation method used in this report is the benefit transfer method. It involves transferring dollar estimates of non-market goods and services from past original research and applying them to a more current site for analysis (Boyle & Bergstrom, 1992). In employing this method, the assumption is made that the results from the original study can be applied to the new context. Benefit transfer applications fall into three categories: 1) estimates based on expert opinion, 2) estimates based on observation, and 3) estimates based on preference elicitation tools (Brookshire & Neill, 1992). There are several reasons why the benefit transfer methodology is widely used for policy analysis, legal proceedings and other evaluative projects.

Although primary data may be preferred in some research contexts, the ability to use existing data from comparable studies can be especially helpful in time-sensitive situations, such as when funding and/or adequate time is not available to gather original, case-specific data (Boyle & Bergstrom, 1992). For one, primary data collection can be very expensive, especially if done on a site-by-site basis, which can quickly exhaust research budgets. This situation is further complicated if the availability of funding necessary for this research cannot be guaranteed. In addition, empirical data collection is time intensive and, for many decisions, public agencies require inexpensive benefit estimates in a timely manner (Boyle & Bergstrom, 1992). With this, benefit transfer can sometimes serve as a convenient mechanism to mitigate these systematic obstacles and allow efficient, effective research to be conducted.

To ensure the valid use of benefit transfer, Boyle and Bergstrom (1992) propose a set of criteria for researchers that were used to evaluate and determine appropriate data to include in this report. These included

1. Ensuring that the ecosystem services we sought to value in our study were the same as those valued in the original research.
2. Making sure that the population demographics--including size, dynamics, distribution and all other influential characteristics--of coastal Southern California were as similar as possible to those in the original research.
3. Evaluating the quality of the data provided in the original research as any flaws, differences or points of contrast in the original research methodologies or techniques can lead to similar and potentially aggravated flaws when transferred (Brookshire & Neill, 1992)
4. Conducting additional research for other sources of supporting literature that help to support the findings and methodologies of the original research we sought to use.

In our application, particular kinds of research studies have inherent difficulties in meeting benefit transfer requirements. This is a characteristic concern for data provided in meta-analysis and global assessment studies, such as those by Costanza et al. (1997) and De Groot et al.

(2002). The data in such studies is derived from global averages, which are not necessarily relevant to a specific climate zone. As the focus of this project is solely on the coastal wetlands in the semi-arid, Mediterranean climate of Southern California, we expect the true value of the ecosystem services provided by these wetlands to diverge from those derived from global assessment data. However, as research for this project progressed it was found that even when existing research initially seemed to satisfy the requirements for benefit transfer, deeper analysis showed that a substantial portion of this literature derived their values for ecosystem services from the data provided by these global assessments. In the end, for the ecosystem services where no primary data was available, global assessment estimates were used for benefit transfer of ecosystem service values. However, their use was supported with other literature sources that provided validation for incorporating this data in benefit transfer.

The particular valuation methods employed in each of the transferable studies were dependent on the particular ecosystem service or habitat being valued. Some ecosystem services were valued using avoided cost methods while others were more suited for valuation with revealed preference methods. Detailed descriptions of the particular valuation methods used in this project are subsequently described. For a complete list of the valuation methods employed in the research literature used, see Appendix C.

Contingent Valuation Survey Method

The third valuation method used in this study was the contingent valuation method. Since the value of non-use goods and services provided by coastal wetland systems cannot be determined based on market prices or revealed through consumer actions, this method provided values to Southern California coastal wetland ecosystems as a whole, through the use of a carefully devised survey (Kotchen & Reiling, 2000). For this method, respondents are presented with a hypothetical, yet realistic program or referendum, which allows the respondent to indicate their willingness to pay (WTP) for that program. In turn the WTP is said to indicate the economic value individuals place on the particular natural system being studied. In this project, the contingent valuation survey was used to elicit California residents' willingness to pay to avoid the degradation of Southern California coastal wetlands.

Despite its merits, the use of contingent valuation as an appropriate method to measure non-use values of resources remains controversial. According to the Organization for Economic Co-operation and Development (OECD), the validity of Contingent Valuation (CV) surveys are the most contentious issues. How the questions are asked – whether they have been manipulated through sequencing or anchoring – can have significant effects on the outcomes of the survey (OECD, 2006)

In addition to the concern with validity and reliability of CV surveys, critics of this valuation method express concern over potential biases that can exist. Information bias occurs when individuals undervalue a wetland system because they are not fully aware of all benefits that are provided by that ecosystem or have a difficult time visualizing the benefits provided by the system (Ackerman, DeCanio, Howarth, & Sheeran, 2009; Carson, 2012). Hypothetical bias also brings a lot of controversy to CV studies. Hypothetical bias is the difference between what individuals say they would pay in a survey and what they would actually pay if money were collected (Murphy, Allen, Stevens, & Weatherhead, 2005). Therefore, people may be willing to pay more money in a hypothetical situation that in real life, which would result in an overvaluation. However, despite the controversy surrounding the CV method, it has been used to value environmental goods for over forty years (Portney, 1994).

The controversy surrounding the CV method lead to the creation of the Contingent Valuation Panel, appointed by the National Oceanic and Atmospheric Association (NOAA) in 1993. The panel was established to determine if the CV method provides reliable information about non-use values. After thorough examination of this method, the committee decided that the CV method can provide reliable information pertaining to non-use values. In addition to this conclusion, the panel developed suggested guidelines to increase the reliability of CV surveys. The guidelines can be viewed in Appendix D.

Overall, when designed thoroughly and appropriately, contingent valuation surveys have proven to be a reliable method for estimating individual WTP for non-use values (Carson, 2012). The more closely the NOAA Panel guidelines are followed, the better the obtained results, although the panel reports that it is not necessary for all recommendations to be strictly followed in order to gain useful information (Arrow et al., 1993).

4.0 Selected Ecosystem Services

This report defines ecosystem services as: the benefits that humans gain from natural ecosystem functions. Natural ecosystems provide market or non-market goods and services through non-use and direct or indirect use values. These include the "flows of materials, energy, and information" as well as processes that provide structure and organization for ecosystems, allowing passive and active utilization (Boyd & Banzhaf, 2007; Costanza et al., 1997). This report selected priority ecosystem services based on whether or not it was feasible to provide monetary quantifications, as well as the potential for improved management of these services and the perceived need for raising public awareness.

The overarching benefit that coastal wetland habitats provide to humans is derived from the particular level of ecosystem service provision. The type and amount of ecosystem services provided varies by habitat - with particular coastal wetland habitats providing different "bundles" of ecosystem services than others. The value of individual ecosystem service flows are used to partially assess the value provided by the habitats within the greater wetland system. As Gretchen Daily notes, services are likely to increase in number and importance as environmental impacts cause technological substitution of these services to become less feasible and more costly (Daily, 1997). Not all habitats provide all ecosystem services, and not all were valued in this report. *Table 1* shows which services are provided by the selected habitats and how each was valued. Discussion of the selected habitats is included in Appendix B.

Ecosystem Services by Habitats	Beaches and Dunes	Shallow Subtidal	Seagrasses	Oyster Bed	Tidal Mudflat	Salt Marsh	Saltflat	Brackish Marsh	Whole Wetland
Carbon Sequestration	ESRV	-	ESRV	ESRV	ESRV	ESRV		ESRV	CV
Shoreline Stability and Erosion Control	-	-	-	-	-	-	-	-	BT/CV
Biological Controls	-	BT	-		-	-	-	-	CV
Water Supply	-		-			-		-	BT/CV
Flood and Storm Protection	-	-	-	-	-	BT	BT	-	BT/CV
Education	-	-	-	-	-	-	-	-	ESRV/CV
Recreation	BT	-	-	-	-	BT	BT	-	BT/CV
Aesthetics	BT	-	-	-	-	-	-	-	BT/CV
Cultural Activities	BT	-	-	-	-	-	-	-	BT/CV
Refugia Habitat	-	ESRV	ESRV	-	-	-	-	-	ESRV/CV
Nutrient Cycling	-	-	BT	BT	-	-		-	BT/CV
Nitrogen Sequestration	-	-	ESRV	ESRV	ESRV	ESRV		ESRV	CV
Pollution Buffering and Wastewater	-	-	-	-	-	ESRV	-	ESRV	CV

Figure 2: Valuation methodology matrix of wetland habitats and provided ecosystem services.

The Millennium Ecosystem Assessment (MEA) organizes ecosystem services into four categories: Regulating, Provisioning, Cultural and Supporting (MEA, 2005). The ecosystem services analyzed in this report are similarly organized, with more focus given to the ecosystem services for which values were assigned. The ecosystem services in each category are interrelated, with many regulating services underlying the other categories (Raudsepp-Hearne, 2010). For example, the reduction of the ecosystem service of disturbance prevention could lead to increased sedimentation in turn leading to a reduction of light. If this happened seagrass would no longer be as capable of growth, which would reduce its ability to provide the ecosystem service of refugia habitat (McArthur & Boland, 2006). Each individual ecosystem service described below is valued using either the ecosystem service rate valuation method or the benefit transfer method. Where the rate-based approach was used, **ESRV** is used to signify this valuation method. Where values were not individually calculated, values were gathered from appropriate literature using the benefit transfer method, signified with a **BT** for ecosystem services that were valued using this approach. There are some ecosystem services, listed in boxes below, where unique values were not garnered from either existing literature or the contingent valuation survey. While their benefits to society are described, a monetary value was not assigned.

It is important to note that, because each ecosystem service is valued independently of others, trade-offs may not be appropriately captured due to this bottom up approach. In natural wetland ecosystems, the functioning of ecosystem services are integrally connected to each other—the provision of some ecosystem services help to facilitate the provision of others. For example, the ecosystem service of water supply regulation helps with the provision of water quality improvement and nutrient cycling. Because of the relationships and connections among ecosystem services, wetlands are often viewed as an entire system in land use and policy decisions rather than evaluated at the ecosystem-service level. From this holistic perspective, consideration of trade-offs between wetland areas and non-wetland areas is possible.

However, this consideration is not appropriate when valuation occurs from an ecosystem service-level perspective. As each ecosystem service was valued individually and independently from others in this report, their real-world relationships and connections are not included in their determined value. With this, it is not accurate to simply add up all the ecosystem services provided by a particular wetland. This would incorrectly assume *additive separability* among each ecosystem services—that they can be aggregated at any point in time without adjusting for any interaction between them. Rather, as ecosystem services *do* have frequent, if not dependent interactions, it is possible that such interaction allows the each ecosystem service to provide a greater degree of benefits than they would individually—following the logic that the value of a "whole" wetland being greater than the sum of its parts. With this, evaluating trade-offs of ecosystem service provisions are not possible.

4.1 Regulating Services

Regulating services is the largest category, containing many of the benefits from specific biogeochemical processes occurring in wetland habitats (MEA, 2005).

Carbon Sequestration (ESRV)

Wetlands play an increasingly recognized role as climate regulators and in sequestering and storing carbon. Due to the continuous accretion and burial that occurs in coastal wetlands, as well as the high rates of primary productivity, these habitats sequester more organic carbon than many other environments (Brevik, 2004). They have the highest carbon density among terrestrial ecosystems, containing up to 25% of the world's organic soil carbon (Mitra, 2005). Reducing atmospheric carbon concentrations helps maintain additional biologically-preferable ecosystem services, such as micro-climate regulation and regional air quality improvement.

Salt marshes store and accumulate a substantial amount of carbon per unit area due to consistent sediment deposition, while releasing minimal greenhouse gases (Chmura, 2003). The alkali bulrush (*Scirpus maritimus* L.) that is common in North America has a large amount of belowground biomass storage, contributing to high rates of carbon sequestration in salt and brackish marshes (Sousa et. al, 2010).

These carbon sequestration rates can be influenced by a variety of ecosystem functions and types. Climatic changes causing an increase in aridity could result in salt marsh habitat converting to salt flats, leading to a decrease in vegetation and therefore decreased amounts of carbon sequestration. In order for coastal wetlands to continue providing this ecosystem service, they must be able to maintain the same elevation and tidal frequencies as before. Sea level rise is a potential threat. As policymakers seek to mitigate greenhouse gas emissions, it will be useful to consider the carbon sequestration benefits that wetlands already provide, along with the additional ecosystem services discussed below.

Methods in Determining Values

Carbon sequestration rates were found for the following habitats: Salt Marsh, Seagrass, Fresh and Brackish Marsh, Mudflat, Oyster Beds and Dunes. Appendix E provides details about the literature used to determine the rates for each habitat. To determine a monetary value for carbon sequestration, the values were converted into metric tonnes of CO_2 sequestered per hectare per year by multiplying the tonnes of C by (44/12), which divides the molecular weights of CO_2 by the molecular weight of C. There are values on the price of carbon emissions both federally, through the EPA's Social Cost of Carbon (SCC) and within the state of California, through the cap-and-trade system established by AB-32. The SCC measures the damages contributed by one additional ton of carbon dioxide emitted into the atmosphere. It is calculated through Integrated Assessment Models but is often considered too low, not properly taking into account many externalities resulting from carbon emissions, such as respiratory illnesses or ocean acidification (Howard, 2014). Additionally, the impact of associated increased temperatures on economic growth is only recently being addressed. Fully accounting could potentially raise the price of carbon to upwards of $200 (Moore & Diaz, 2015). Despite these uncertainties, it is the most widely used pricing mechanism for carbon emissions, so this report used the SCC - equal to $36 in 2015 dollars using a 3% discount rate (EPA Interagency Working Group, 2015). A 3% discount rate is justified considering the long-term nature of natural resources. The EPA recommends a 3% rate when costs and benefits occur as changes in consumption flows rather than changes in capital stock, and since this report is addressing flows rather than stocks, this rate is assumed to be appropriate (EPA, 2010).

Another way to think about the values in *Table 1* is in terms of avoided cost. If these wetland habitats were not able to continue providing this service, some substitute mechanism for sequestering this carbon would need to be deployed in order to maintain the same carbon stock. Additionally, if these habitats are increasingly degraded, they will begin to emit the carbon that is already stored within the soils and sediments.

Table 1: Carbon Sequestration

Carbon Sequestration

Habitat Type	Original Study Location	Carbon Sequestered (tC ha-1 yr-1)		CO_2 Sequestered (tC ha-1 yr-1)		Value of Carbon Sequestered8 ($ ha-1 yr-1)		Carbon Stored (tC ha-1 yr-1)		CO_2 Stored (tC ha1 yr-1		Value of Carbon Storage ($ ha-1 yr-1)	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Seagrass	Global Assessment & Spain	-	0.83[1]	2.87[2]	3.04	$103	$109	0.56[3]	-	2.05	-	$73	-
Oyster Beds	Australia[4]	2.57	3.30	9.41	12.10	$338	$435	-	-	-	-	-	-
Dunes	United Kingdom[5]	0.32	0.84	1.17	3.09	$42	$111	-	-	-	-	-	-
Salt Marsh	Tijuana River Estuary[6] & Ballona Wetlands[7]	0.43	14.10	1.58	51.70	$56	$1,861	0.18	17.3	0.66	63.44	$23	$2,283
Tidal Mudflat and Channel	North America	2.20	-	8.07	-	$290		-	-	-	-	-	-
Brackish Marsh	New Jersey[8]	8.90	-	32.64	-	$1,174		-	-	-	-	-	-

1 Laffoley, D., & Grimsditch, G. D. (Eds). (2009)
2 Murray, B., Pendleton, L., Jenkins, W., & Stifleet, S. (2011)
3 Nellemann, D., Corcoran, E., Duarte, C.M., Valdes, L., De Young, C., Fonseca, L., Grimsditch, G. (Eds) (2009)
4 Hickey, J. P. (2008)
5 Jones, M. L. M., Sowerby, A., Williams, D. L., & Jones, R. E. (2008)
6 D. R. Cahoon, unpublished data, (1993)
7 Stifleet, S., Pendleton, L., & Murray, B. C. (2011)
8 Windham, L. (2008)

Shoreline Stabilization and Erosion Control (BT)

Shoreline stabilization and erosion control are increasingly gaining attention among researchers and policy-makers. In recent adaptation strategies for sea level rise, “opportunistic dredging” and increased sedimentation is seen as a viable management strategy for protecting against impacts of sea level rise and storm surges. Sediment accretion occurs naturally in wetlands and creates elevated land and stable shorelines that can help mitigate the impacts of rising sea levels and coastal- and upstream-erosion. Sediment deposition can also regulate water flow, preventing sediment migration downstream and promoting carbon sequestration. The more that sediment is retained and stabilized, the less stored carbon is washed away. Additionally, stabilization and erosion control can facilitate the ecosystem service of disturbance prevention, as less sediment would be in the water column.

Methods in Determining Values
A primary valuation method is to assess the costs that can be avoided by maintaining this service, such as costs associated with seawalls and dredging. For example, a study performed in the state of Washington determined the value associated with sediment deposition, erosion control, and related flood protection based on the reduction effects and cost of potential enhancement measures as well as the percent reduction effects of existing wetlands (Leschine, 1997). This served as the proxy value that existing wetlands offer for this combination of ecosystem services. For similar context, specific to Southern California and hard armoring, the price of a sea wall is about $880/linear foot in 2015 dollars, while larger walls that include upper bluff retaining walls are upwards of $11,750/linear foot (Hanak & Moreno, 2008).

This report used the financial costs associated with creating living shorelines along coastal areas to determine a value provision rate for shorelines stabilization. Rather than hard armoring, living shorelines are becoming a commonly used approach by coastal communities as a means to strengthen shorelines against erosion. Rather than absorbing the entirety of wave energy, as hard barriers do, living shorelines can attenuate and diffuse this energy, and in some cases offer better protection (Lutz, 2005).

The technique involves planting native wetland plants and grasses, shrubs, and trees at various points along the tidal water line (Chesapeake Bay Foundation, 2007). One important caveat in using living shoreline prices is that there are additional ecosystem services inherently provided with living shorelines – beyond erosion control and wave attenuation – which is often the attraction to these options in the first place. These ecosystem services include microclimate regulation, water quality improvement and habitat provision. However, for the purposes of this report, it was assumed that the foremost purpose for using living shorelines was to directly enhance shoreline stability, thereby mitigating erosion, whereas all other potential ecosystem service benefits follow as side effects.

The costs associated with living shorelines projects (*Table 2*) listed in the studies provided below were interpreted as an indirect WTP metric for the valuation of this service. The financial costs of installing a living shoreline were assumed to indicate that the communities undertaking these projects believe the value of the shoreline stabilization to be *at least* equivalent to, if not greater than, the incurred costs. As a means to avoid overvaluing the benefit of shoreline stabilization and justify the decision to value it as a single ecosystem service – and not a combined value for a bundle of ecosystem services – only the lowest-cost estimates for living shoreline installation projects were used in this report (Chesapeake Bay Foundation, 2007). It was found that some communities pay larger costs for living shoreline projects that had particular features such as breakwaters, beach replenishment and stone reinforcement. It would be harder to justify the decision to ignore the full bundle of ecosystem services if these larger costs were used in the valuation. In only using the lowest-cost living shorelines project estimates, which only include use of soil stabilizing plants, this deficiency is at least partially mitigated.

Table 2: Shoreline Stabilization

Shoreline Stabilization				
Habitat Type	**Original Study Location**	**Valuation Method**	**Total Value (US $2015 per linear foot)**	
			Low	**High**
Whole Wetland	Maryland, USA[1]	Replacement Cost	$100	$200
	Delaware Estuary, USA[1]	Replacement Cost	$103	$232
	Northern Gulf of Mexico[1]	Replacement Cost	$50	-
	Maryland, USA[1]	Replacement Cost	$57	$114
	Florida, USA[1]	Replacement Cost	$50	-
	Virginia, USA[2]	Replacement Cost	$57	$114

1 Rust, M. (2014)   2 Chesapeake Bay Foundation (2007)

Water Quality - Pollution Buffering and Wastewater (ESRV)

In this report, water quality is valued through pollution buffering, wastewater treatment and nitrogen sequestration, which is discussed in depth under Supporting Services. Coastal wetlands act as a natural treatment facility for polluted water. As waters polluted with organic materials, nitrates and phosphate move through a wetland system, the pollutants are removed and assimilated by the vegetation. Removal of pollutants is most effective during the growing season (Jing et al., 2001). The water filtering abilities of coastal wetlands depends on the biochemical properties as well as the hydrology and land cover (Turner, 2000).

In Southern California particularly, this ecosystem service is becoming increasingly important. As water reuse and reclamation programs increase for use in irrigation and beyond, treated wastewater continues to be discharged into coastal streams and rivers (San Diego Regional, Water Quality Control Board, 1988; Sanitation Districts of Los Angeles County, 2016; Cooley, 2014). Additionally, these discharges do not continuously flow through coastal systems and wetlands, but instead primarily flow intermittently during wet periods (Zedler, 1994). This intermittency affects the amount of pollution buffering that can occur at one time.

Methods in Determining Values

Values for pollution buffering were assessed on an entire-wetland basis as sparse data were found for rates specific to habitat types and even less data were available on rate-values for specific pollutants. The values used for the flow rate of pollution buffering for coastal wetlands were taken from studies employing benefit transfer and avoided cost methodologies (USD/ha/yr), all of which satisfied the criteria for benefit transfer discussed above.

Table 3: Pollution Buffering

Pollution Buffering				
Habitat Type	**Original Study Location**	**Valuation Method**	**Total Value (US \$2015 ha^{-1} yr^{-1})**	
			Low	**High**
Whole Wetland	Global Assessment[1]	Benefit Transfer	\$86	\$9,888
	Colorado River Basin[2]	Benefit Transfer	\$27	\$31
	Thibodaux, LA[3]	Avoided cost	\$3,102	\$3,497
	Catalan, Spain[4]	Benefit Transfer	\$16,783	-
	British Columbia[5]	Replacement Cost	\$1,395	-

1 De Groot, R. S., Wilson, M. A., & Boumans, R. M., (2002)
2 Batker et al., (2014)
3 Braux, A., Farber, S., & Day, J., (1995)
4 Brenner, J., Jimenez, J. A., Sardia, R., & Garola, As., (2010)
5 Wilson, S. J., (2010)

Biological and Pest Control (BT)

Biological and pest control is the use of a naturally occurring organism against another organism that might be considered a pest in higher concentrations (van Lenteren, 2005). The potential for wetlands to be effective at biological control depends in part on the biodiversity of the system. If there is a diverse amount of biota, then resource and niche competition reduces the amount of any individual population (Lehman & Tilman, 2000).

This ecosystem service is important for nearby agricultural activities and other plant species, as it stabilizes existing natural systems. This ecosystem service is closely tied with biodiversity and species richness (MEA, 2005). Natural pest control can come from a variety of sources, such as parasites, pathogens and predators. Value can be attained through marginal agricultural productivity and stability, as well as the reduced need for chemical control mechanisms in agricultural systems (Daily, 1997).

This biological control contributes to the other ecosystem services often mentioned, such as the suppression of noxious weeds. If healthy wetland habitat is maintained, invasive and noxious weeds are less likely to dominate. Weeds, like pests, can cause reduction in agricultural yield, but can also lead to buildup in waterways and reduce the aesthetic and cultural value of a wetland habitat (MEA, 2005; Naeem et al., 2000). Maintaining healthy wetlands can reduce the presence of noxious weeds and prevent the spread to nearby communities as well.

Methods in Determining Values

The only appropriate value for this ecosystem service was from a global assessment, supported by the inclusion of a study that applied it to the Catalan coast, which is a similar Mediterranean climate to Southern California and adhered to the BT method requirements (Costanza, 1997; Brenner-Guillermo, 2007).

Table 4: Biological Control

Biological Control				
Habitat Type	**Original Study Location**	**Valuation Method**	**Total Value (US \$2015 ha^{-1} yr^{-1})**	
			Low	**High**
Whole Wetland	Global Assessment[1]	Benefit Transfer	\$61	-
1 Brenner-Guillermo, J. (2007)				

Water Supply Regulation (BT)

This ecosystem service encompasses groundwater recharge and water flow regulation. The vegetation and soil biota in coastal wetland ecosystems play a key role in maintaining regular water flows, filtering flowing and retained water, and storing inflowing water from both the ocean and terrestrial rivers and streams for deposition into underground aquifers. Since they have significant storage capacity, wetlands help mitigate overflow from flooding events as well as maintain surface water flow during dry periods, although this varies with unique characteristics, such as differences in the topography and subsurface attributes (EPA, n.d.; De Groot, Wilson & Boumans, 2002).

In regulating the water supply, there is reduced risk of costly property damages to human developments adjacent to the wetland. Plants and soils slow the movement of the retained water flows, allowing sediment to settle out and microorganisms to metabolize waste and excess nutrients, effectively filtering and cleansing the water. Lastly, purified retained water slowly percolates through porous wetland soils, contributing to groundwater recharge by allowing the groundwater supply to be recharged in underlying aquifers (EPA, n.d.).

Methods in Determining Values

Many studies include the benefits of water supply in combination with the flow rates of other ecosystem services including water quality regulation and nutrient regulation. Appropriate literature available for the value of water supply specific to coastal wetland habitats was limited. The values used in this report were taken from a benefit transfer study conducted in northwest Mexico and from a meta-analysis global assessment.

Table 5: Water Supply Regulation

Water Supply Regulation				
Habitat Type	**Original Study Location**	**Valuation Method**	**Total Value (US $2015 ha^{-1} yr^{-1})**	
			Low	**High**
Whole Wetland	Northwest Mexico[1]	Benefit Transfer	$1,906	-
	Global Assessment[2]	Benefit Transfer	$24	-

1 Camacho-Valdez, F., Ruiz-Luna, A., Ghermandi, A., & Nunex, P. A. (2013)
2 Costanza, R., et al., (1997)

Flood and Storm Protection (BT)

The vegetative structure and soil composition in coastal wetland ecosystems helps to mitigate the potential severity of effects from “natural” hazards and other catastrophic occurrences, particularly flood damage. Similar to the service of water regulation, both the plant and soil components in these areas promote water storage capacity and surface resistance, which can help drainage and flood mitigation in the event of large storms (De Groot, Wilson & Boumans, 2002). For example, natural organic soils, in large supply in wetlands, have a specific soil texture and structure requisite for holding large amounts of water, which can help buffer the potential flooding of areas downstream. Further, vegetation such as shrubs and small trees rooted in the floodplains attenuate water flow, which helps to further prevent downstream flooding (Lead, de Guenni, Dardoso & Ebi, 2005).

Methods in Determining Value

Data for specific coastal habitat types was limited, although a few studies were identified with values of flood and storm protection on an entire-wetland basis: one study focused on benefits provided by wetlands of the Colorado River Basin and one examined replacement costs in the Charles River Basin in Massachusetts (Batker et al., 2014). The Colorado River study is applicable for benefit transfer in this report as the study area is most similar to that of the California coastal wetlands. The Massachusetts study stipulates the data provided is not suitable for benefit transfer, and hence has been included only as an upper estimate in this report to offer insights into what the values are elsewhere. Other studies and global assessments include values for flood and storm protection, however, some studies combine these with other ecosystem services collectively under the service of disturbance regulation, including De Groot et al. (2002) Costanza et al. (1997) and Brenner et al. (2010). As these other ecosystem services were not included elsewhere in this report, values from these authors were not used for this ecosystem service. Global assessment estimates for flood and storm protection were only used from Woodward and Wui (2001).

Table 6: Flood/Storm Protection

Flood/Storm Protection				
Habitat Type	**Original Study Location**	**Valuation Method**	**Total Value (US \$2015 ha^{-1} yr^{-1})**	
			Low	**High**
Salt Marsh	Galveston Island, TX[1]	Avoided Cost	\$15,194	\$15,194
Salt Flat	Galveston Island, TX[1]	Avoided cost	\$476	\$476
Whole Wetland	Charles River Basin, MA[2]	Replacement Cost	-	\$215,000
	Colorado River Basin, USA[3]	Benefit Transfer	\$40	\$20,830
	Global Assessment[4]	Benefit Transfer	\$400	\$7,830
	Global Assessment[4]	Benefit Transfer	\$49	\$23,040

1 Feagin, R. A., Martinez, M. L., Mendoza-Gonzalez, G., & Costanza, R. (2010)
2 Thibodeau, F. R., & Ostro, B. D. (1981)
3 Batker et al., (2014)
4 Woodward, R. T., & Wui, Y. S. (2001)

Another approach to determining the benefit of storm protection is to use the costs of traditional hard-armoring solutions. For instance, the prices for seawalls discussed in the ecosystem service of shorelines stabilization and erosion control could likewise be considered here, depending on specific priorities.

Table 7: Seawall

County	Miles of Seawall	# Levees or Breakwaters	Linear Foot Measurement	Total Value (low estimate)
Santa Barbara	14.3	1	75,504	\$56,628,000.00
Ventura	25.7	2	135,696	\$101,772,000.00
Los Angeles	17.5	4	92,400	\$69,300,000.00
Orange	16.7	2	88,176	\$66,132,000.00
San Diego	24.7	3	130,416	\$97,812,000.00
Total				\$391,644,000.00

Source: Hanak, E., & Moreno, G. (2012)

Box 1. Regulating Ecosystem Services (Not Valued)

Limiting Pathogens and Vectors of Human Disease

This ecosystem service is related to several others that were valued, including water quality and biological and pest control. Intact coastal wetland ecosystems have a vital role in controlling the spread and transmission of many infectious diseases to the human population. Water quality maintenance via continual water filtering further helps prevent disease spread by contaminated water. When unperturbed, the equilibrium of the diversity of inhabitant species is maintained - some of these species can serve to mitigate and regulate the entrance of particular diseases by playing a specific ecological role that excludes invasive species that can transmit or maintain disease (MEA, 2005). In consequence, the quality of human health adjacent to these wetlands is protected. However, these conditions are highly sensitive to outside disturbances that can lessen the provision of this ecosystem service. Anthropogenic influences – such as population growth and development – can cause ecological mechanisms to be triggered, that may alter the risk of disease spread or make nearby human populations more vulnerable to other ailments (MEA, 2005). This can contribute to the perception that wetlands harbor disease-carrying insects and promote disease. Often, this is a result of alterations to the natural environment that diminish water flow.

There are very few studies valuing wetland provision of this ecosystem service. Some studies categorize the benefits of this ecosystem service under the benefits of other services, such as water quality regulation and pollution buffering, as can be reasoned from the above description of the ecosystem service. The only studies identified as providing flow rates (but not values) for the benefits of pathogen removal were based on an analysis of surface flow through constructed wetlands, thus not suitable for benefit transfer in this report. However, studies were conducted in areas with climates similar to that of Southern California (Spain and Italy), providing support for the provision of this ecosystem service by Southern California's wetlands.

Noise Reduction

Noise pollution from human activities — such as construction and traffic — can cause various degrees of damages both physically and psychologically (Gómez-Baggethun & Barton, 2013). The vegetation and soil biota present in coastal wetland ecosystems helps to abate such damage through absorbing and refracting sound waves, sufficiently dissipating noise pollution (Gómez-Baggethun & Barton, 2013).

No literature was found providing the value or rate of provision for noise reduction in coastal wetlands that met the requirements for benefit transfer for use in this report. While this ecosystem service is recognized in several global assessments, it is categorized as a partial contributor to the ecosystem service of waste treatment. One study determined a value for the provision of noise reduction but could not be merited for benefit transfer for this report. The study was conducted to determine the value of ecosystem services in urban areas of Stockholm using habitats other than wetlands. The relative contributions of particular habitat types were not distinguished (Bolund and Hunhammar, 1999).*—Continued on next page.*

Box 1. Regulating Ecosystem Services (Not Valued) - continued

Microclimate Regulation
Temperatures are expected to increase throughout the Southern California region, with heat waves, measured in number of extreme heat days per year, predicted to increase in frequency in downscaled projections (Cal-Adapt 2016). Added to this are the growing concerns surrounding urban heat islands, demonstrated with the California Environmental Protection Agency's Urban Heat Index (CalEPA, 2015b). It will be increasingly relevant to know the contribution coastal wetlands in urban areas have on reducing air pollution and heat.

Local climate and weather conditions in areas surrounding coastal wetlands are influenced by the biological interactions and patterns of coastal wetland topography, vegetation, albedo, and the physical configuration. Each element provides consistent, favorable conditions for human health, recreation, and cultural activities (De Groot, Wilson & Boumans et al., 2002). For example, the interaction of vegetation and the atmosphere helps to sequester greenhouse gases, including carbon dioxide, methane, nitrous oxide, chlorofluorocarbons and tropospheric ozone (Gómez-Baggethun & Barton, 2013). Shrubs and small trees help provide shade and prevent excessive water evaporation. Combined, these factors help maintain favorable temperatures and climate in the surrounding local region.

The research studies available that seem to provide a valuation of microclimate regulation do not meet the requirements for benefit transfer for use in this report. Many of the studies combine their values for microclimate regulation, climate regulation, and gas regulation--as seen in De Groot et al. (2002), Batker et al. (2014), and Brenner et al. (2010). Although some studies appeared to specifically provide values for climate regulation, these values resulted from benefit transfer from sources that had originally combined this ecosystem service with gas regulation. Gas regulation inherently includes ecosystem services such as nitrogen and carbon sequestration as well as nutrient cycling. Since gas regulation represents a bundle of ecosystem services that are separately valued in this report, these studies were unsuitable for benefit transfer. Although one study was found to value microclimate regulation specifically, it did not meet benefit transfer requirements as its area of study did not solely include wetlands and the area of focus was Stockholm, Sweden, with dissimilar climate and environment to Southern California (Bolund & Hunhammar, 1999).

4.2 Provisioning Services

Provisioning ecosystem services result in material products that people use (MEA 2005). These ecosystem services are valued differently depending on regions, with areas outside of Southern California using wetlands more for direct sources of fuel and food. As a result, the studies that quantified most of these ecosystem services did not fulfill the benefit transfer method requirements, necessitating more downscaled studies that look at regional-specific aspects.

Science and Education (ESRV)

Wetland ecosystems provide opportunities for both formal and informal research and education, where the public and school groups can learn about nature and its processes (De Groot et al., 2006; Millennium Ecosystem Assessment, 2005). As complex, dynamic ecosystems, wetlands provide extensive opportunity for researchers to explore subjects such as species relationships, chemical cycling, and bird behavior.

Methods in Determining Values

In the literature on the valuation of ecosystem services, science and education are valued together. However, values for these services were calculated using data specific to Southern California coastal wetlands, and only the calculation of education values could be justified. Therefore, the estimates provided below are considered to be a lower bound on the benefits that coastal wetland provided in terms of education only. Additionally, education was valued for the entire wetland system, rather than for each individual habitat found in wetland systems. While certain habitat types may be explored through education, entire wetlands and the connections between their differing habitats provide important educational opportunities.

A form of revealed preference was used to calculate the benefit Southern California coastal wetlands provide in terms of education. This method of calculating the benefits is much like the travel cost method but, rather than using the cost of travel, the dollar value of grants was used to obtain the value of educational programs. This assumes that society was willing to pay *at least* the observed amounts of money spent on education.

To determine the benefits provided by educational programs, dollar values of grants supporting educational programs in specific Southern California coastal wetlands were identified. It was assumed that 1) money would be granted for educational purposes as long as the wetland area exists and 2) the one time grant represented the continued benefit per year provided by the wetland area. These grant values were divided over the area of the wetland that received the grant to obtain dollars per hectare. It was assumed that when calculating the present value of benefits over time, the annual benefit over time was constant. This assumption allowed the annual benefit to be calculated using the following formula where PVB=(Present value benefits), AB=(Annualized benefit), r=(present value discounted to perpetuity, 0.05) :

$$PVB = \frac{AB}{r} \rightarrow AB = rPVB$$

Annual benefits were calculated using the standard discount rate value of 5% and aggregated to obtain the dollar value for educational benefit that a hectare of coastal wetlands provides annually. The values obtained through these calculations are considered a lower bound on the educational benefits provided by coastal wetland habitats. Full calculations and grant information can be found in Appendix F.

It was decided that this method of eliciting benefits could not be applied to scientific research because once a research project has been carried out, the wetland may no longer provide the same level of scientific research benefits because there is no longer a lack in scientific knowledge of the area. The possibility that scientific research benefits could decrease with research efforts makes it difficult to argue that the value provided, in the form of grant money, is a continuous benefit provided by the wetland each year.

Table 8: Education

Education				
Habitat Type	**Original Study Location**	**Valuation Method**	**Total Value (US $2015 ha^{-1} yr^{-1}) (r=5%)**	
			Low	**High**
Whole Wetland	Ballona Wetland, CA[1]	ESRV	$0.98	$7.44
	Upper Newport Bay Nature Preserve, CA[1]	ESRV	$10	
	Devereux Slough, CA[2]	ESRV	$1	$7
	Bolsa Chica Wetlands[3]	ESRV	$1	

1 EPA. (2015)
2 Coil Oil Point Reserve (n.d.)
3 Bolsa Chica Land Trust (2015)

Recreation (BT)

Recreation takes many forms. The three that are primarily recognized for wetland habitats are outdoor recreation, nature observation, and ecotourism. Each form relies on a healthy and functioning wetland habitat necessary for enjoyment.

Outdoor- Wetland habitat encompasses everything from marshes and saltpans to beach and dune areas (Zedler & Leach, 1998). Such diverse landscapes provide abundant opportunities for outdoor recreation. Most recreational activities classified under "outdoor" recreation include direct interaction with the coastal wetland environment. For example, visitors enjoy both fresh and saltwater fishing, hunting of waterfowl, hiking, kayaking, swimming, surfing, and beach-going (Bell & Leeworthy, 1990; Bergstrom, Stoll, Titre & Wright, 1990).

Nature Observation- Nature observation is a passive form of recreation, in which individuals simply observe the wetland habitat and its inhabitants from a distance, with activities including birdwatching, painting, and photography (Zedler & Leach, 1998). The passive nature of observational recreation promotes preservation of wetland habitats and wildlife, which may be damaged by active recreational activities such as hunting or hiking (Westerberg, 2010).

Ecotourism- Ecotourism is nature- or culture-based travel. Ecotourists learn about the local environment and conservation of local environmental resources, and minimize their environmental impact through environmentally conscious activities. Wetlands provide opportunity for ecotourism due to the natural and cultural benefits they provide to local communities (Zang & Lai Lei, 2012).

Methods in Determining Values
While the initial intent was to calculate the value of recreational activities that take place in Southern California coastal wetlands, visitation rates and visitation costs were difficult to determine for wetland areas. Recreational birding values for the state of California were calculated using data from the U.S. Fish & Wildlife Service's 2011 *Birding in the United States: A Demographic and Economic Analysis* report, which provided the total amount of money spent on birding in the United States per year along with information on the number of birders in California. The dollar amount spent on birding in California was determined per person per year. However, there was no way to distinguish where birding was taking place, which made it difficult to distinguish expenditures on birding trips to coastal wetlands and all other birding locations. Additionally, there was no way to determine if the birders were located in Northern or Southern California. Therefore valuing recreation based on birding values was not performed, based on the judgment that the available data contained too many uncertainties and would lead to overvaluation.

Therefore, recreational values were obtained through existing literature. We made certain that the values transferred for recreation were taken from areas with recreational activities similar to that of Southern California.

Table 9: Recreation

Recreation				
Habitat Type	**Original Study Location**	**Valuation Method**	**Total Value (US \$2015 ha^{-1} yr^{-1})**	
			Low	**High**
Beaches and Dunes	New Jersey, USA[1]	Benefit Transfer	\$7,550	\$7,550
Salt Marsh	Galveston, TX[2]	Benefit Transfer	\$5,337	\$5,337
Salt Flat	Galveston, TX[2]	Benefit Transfer	\$5,337	\$5,337

1 N. Raheem et al. (2012) original data from Costanza et al., (1997)
2 Feagin, R. A., Martinez, M. L., Mendoza-Gonzales, G., & Costanza, R., (2010)

Aesthetic Values and Cultural Activities (BT)

Ecosystems can provide sites for cultural activities, which provide non-material services in the form of aesthetic values, inspiration for culture and art, spiritual experience, and cognitive development (De Groot et al., 2012; MEA, 2005). Wetlands hold value simply because of their beauty and the pleasure they bring from the view they provide (De Groot et al., 2006). Aesthetic value is often judged by the improvements or degradations of a natural area and how individuals feel about those changes (Faber et al., 2006).

Methods in Determining Values
Aesthetic and cultural values are difficult to determine due to their subjectivity and the reliance on individual perceptions of beauty and cultural heritage. These values can to some extent be captured in market goods. For example, housing prices tend to increase with better views and close proximity to natural spaces, however, aesthetic values would need to be identified separately from other sources of price variation (De Groot, Wilson & Boumans, 2002). Aesthetic and cultural values for this report were drawn from existing literature using the benefit transfer method. Aesthetic and cultural activities values were separated and valued individually.

Table 10: Aesthetics

Aesthetics				
Habitat Type	**Original Study Location**	**Valuation Method**	**Total Value (US \$2015 ha^{-1} yr^{-1})**	
			Low	**High**
Whole Wetland	Global Assessment[1]	Benefit Transfer	\$10	\$2,600

1 De Groot, R., Wilson, M., Boumans R. (2002)

Table 11: Cultural Activities

Cultural Activities				
Habitat Type	**Original Study Location**	**Valuation Method**	**Total Value (US \$2015 ha^{-1} yr^{-1})**	
			Low	**High**
Beaches and Dunes	Global Assessment[1]	Benefit Transfer	\$12	\$12
Whole Wetland	Global Assessment[1]	Benefit Transfer	\$7	\$7

1 N. Raheem et al. (2012) original data from Costanza et al., (1997)

Ornamental Resources (BT)

Ornamental resources are the flora and fauna within a natural ecosystem that has the potential to provide ornamental use (De Groot et al., 2012). Ornamental resources can be products such as animal skins, shells, driftwood or flowers which can serve a variety of purposes such as being sold as souvenirs, made into jewelry, crafted into clothing or used for religious, cultural, or spiritual ceremonies (SEQ Ecosystem Services Framework, 2015).

Methods in Determining Values
Ornamental resources were valued based on existing literature using the benefit transfer method. Values were based on global estimates for ornamental resources from De Groot et al. (2002).

Table 12: Ornamental Resources

Ornamental Resources				
Habitat Type	**Original Study Location**	**Valuation Method**	**Total Value (US $2015 ha^{-1} yr^{-1})**	
			Low	**High**
Whole Wetland	Global Assessment[1]	Benefit Transfer	$4	$214

1 De Groot, R., Wilson, M., Boumans R. (2002)

Box 2. Provisioning Ecosystem Services (Not Valued)

Direct Provision of Food
A variety of food products come directly from wetland habitats. Wetlands are home to a variety of fish and birds, which are taken both commercially and recreationally for human consumption. The value of wetland habitats, primarily seagrass, to commercial fishing is calculated for the ecosystem service of refugia and is therefore not accounted for under the direct provision of food service. Wetlands also produce fruits and grains, which are harvested and consumed by humans, however this is not a substantial service provided by Southern California coastal wetlands (De Groot et al., 2006; Millennium Ecosystem Assessment, 2005).

Raw Materials and Fuel
Renewable biomass produced by wetlands has the potential to be harvested and used as a fuel source. These same materials can increase resistance to various pests, however this would be accounted for in the ecosystem service of Biological Control (De Groot et al. 2006).

Genetic Resources for Biotechnology and Natural Medicines for Pharmaceuticals
The potential for biodiversity of wetlands to contribute to genetic resources is a primary example of ecosystem services that could be captured in the future, as need arises or technology develops (Beaumont, 2007). Preservation of a diverse gene pool is important not only for the species within and adjacent to the wetland habitats to continue providing current services, but also for potential future uses in biotechnology. Similarly, the pharmaceutical industry can benefit from using genetic resources that have arisen from natural biodiversity for medicinal purposes.
Value for genetic resources in general can be captured through the values associated with maintaining the abundance of genetic diversity. Valuation studies have been carried out for temperate forest ecosystems, but because this particular ecosystem service relates to potential value of particular biota, it is difficult to quantify for the Southern California coastal region (Wilson, 2005).

4.3 Supporting Services

Supporting services are the foundation for many ecosystem services in the other. These services are those necessary for the production of the ecosystem services in both the provisioning and regulating categories. Supporting services are different than provisioning and regulating categories because they do not always have direct impact on humans (MEA, 2005). Those supporting services which have the most direct impact on human well-being are valued below.

Refugia (ESRV)

Refugia habitat provides protection and nurseries for many juvenile fish species and invertebrates. Fishermen depend on these habitats to produce and maintain the supply of commercially viable species. At the same time, many upstream activities are affecting how well the current habitats can provide refugia. Based on feedback at the Wetlands Recovery Project Board of Governors meeting in December 2015, special attention is given to refugia habitats for commercially viable species.

Seagrasses play an important role in providing refugia to a large and diverse number of fish and are increasingly recognized for their contribution to commercial fishing. In an effort to demonstrate the significance, particular attention was given to the potential value of seagrass habitat to commercial fisheries (Box 3). Additional values for refugia were found from existing literature for other habitats.

-- Box 3 on next page --

Box 3. Seagrass and Commercial Fishing in Southern California

This habitat was valued following research that assessed the economic contribution of seagrass to the commercial fishing industry in Southern Australia (McArthur & Boland, 2006). The study used primary productivity rates to determine secondary production, which was considered to be the total relevant annual commercial catch. The Encyclopedia of Coastal Science estimates that secondary production is less than primary production, but that the values are likely to be similar where there are sources of organic matter (Schwartz, 2006). Other approaches that similarly valued seagrass habitat for this service valued the benefit of enhancement or restoration, or required detailed information on biomass (Peterson et al., 2003; Watson et al., 1993; Powers et al., 2003). Secondary productivity is considered an appropriate proxy for total relevant annual catch because it takes into account density and biomass and measures and deals with ecosystem flows and functions (Benke, 2010).

The total relevant annual catch was captured through combined totals of value of landings of 22 commercial fish into California for the areas of Santa Barbara, Los Angeles and San Diego (CDFW, 2015). The species considered were based on juvenile reliance on Southern California habitat containing seagrasses (Appendix H). The study performed by McArthur and Boland developed a model for a local Seagrass Residency Index based on the time that species spent in seagrass at different life stages. In lieu of this, literature was gathered that supported the inclusion of 22 species that depend on seagrass as critical refugia habitat in Southern California (Appendix G). The total monetary average of these species for 2010-2014 is $16,649,368.72 in 2015 dollars (Appendix H). The primary production of seagrass is estimated to be between 700 g C m-2 yr-1 for the global average and 812 g C m-2 yr-1 for *Zostera marina*, the species of seagrass widely distributed in the region (McArthur & Boland, 2006; McRoy, 1974). For the counterfactual, global primary productivity rates for non-tropical shelves were used with a rate of 310 g C m-2 yr-1 (Pauly & Christensen, 1995).

To determine habitat extent, initially the NWI data was used for both the open ocean and the seagrass extent. However, comparing the results of the NWI estimation for Aquatic Bed habitat (approximately 500 acres) with a regional technical report resulted in a discrepancy, with the report estimating the acreage to be approximately 55,615 acres (Bernstein et al. 2011). Noting the discrepancy, the numbers from the technical report were used due to the downscaled level of focus. For the open ocean extent, NWI was still used as it was the best option available.

The percentage that seagrass contributes to refugia for commercial fishing is gathered from dividing the primary production contribution solely from seagrass by the sum of the total primary production for both seagrass and non-seagrass habitat. This percentage was multiplied by the average value from the commercial catch and then divided by the total area of seagrass in order to determine a value per hectare per year (TABLE REFUGIASG). The resulting range is between $80.11 and $91.35 that a hectare of seagrass contributes as refugia for the commercial fishing industry annually. – *Continued on next page.*

Box 3. Seagrass and Commercial Fishing in Southern California

Table 13: Refugia for Commercial Fishing

Refugia for Commercial Fishing							
Seagrass					Non-Seagrass		
Primary Productivity (g Cm^{-2} yr^{-1})		Area of Seagrass[3] (m^2)	Primary Productivity Seagrass (g C yr^{-1})		Primary Productivity[4] (g Cm^{-2} yr^{-1})	Area of Open Ocean/Shelf[5] (m^2)	Primary Productivity Seagrass (g C yr^{-1})
Low[1]	High[2]		Low	High			
700	812	225066118.9	1.58E+11	1.83E+11	310	4.18E+09	1.30E+12

1 McArthur, L. C., & Boland, J. W., (2006)
2 McRoy, C. P., (1974)
3 Bernstein, B. et al., (2011)
4 Pauly, D., & Christensen, V., (1995)
5 NWI (2010)

Some notable caveats include the uncertainty in seagrass and non-seagrass habitat acreage. The overall formula and calculations can be applied to acreage values as knowledge and studies continue to advance. The recognized necessity of protected estuaries and bays for productive and valuable nursery habitat, rather than just the presence of seagrass along an exposed coast for instance, is another factor to consider. However, since seagrasses primarily grow in shallow and protected habitats, it is reasoned that using the seagrass habitat as the habitat of choice for this valuation successfully isolates this type of habitat (NOAA Fisheries, 2015). The nature of the ocean, and migration patterns of fish, may result in species that are caught in Southern California to use the seagrasses up or down the coast. Additionally, potentially significant, recreational catch and discarded by-catch were not accounted for, possibly leading to an undervaluation.

If primary productivity rates and acreage were known for all of the habitats that provide similar services, as well as the degree of contribution from each of the habitats, it would be possible to analyze each. However since all were not known, the original study method was followed and only the values for seagrass were calculated. While seagrass habitat and catch cannot be completely linked with this method, studies acknowledge this approach is effective when detailed quantitative measurements, such as biomass weights and success of juveniles, cannot be directly measured (Blandon & Zu Ermgassen, 2014).

From existing literature, additional values have been determined for entire coastal wetlands.

Table 14: Refugia

Refugia			
Habitat Type	Original Study Location	Total Value (US $2015 ha^{-1} yr^{-1}) Low	High
Whole Wetland	Catalan Zone, Spain[1]	$623	-
	Santa Cruz County, CA[2]	$293	$700

1 Brenner, J., Jimenez, .A., Sardia, R., & Carola, A., (2010) with original values from Costanza, R., (1997)
2 Schmidt, R., Lozano, S., Robins, J., Schwartz, A., Batker, D., (2014)
Original values from: Kazmierczak Jr., R. F., (2001)

Nutrient Cycling (BT)

Nutrient Cycling involves acquiring and processing nutrients, resulting in high amounts of primary production. This in turn contributes to other ecosystem services that rely on primary production, such as refugia (MEA, 2005). The natural ecosystems in coastal wetlands help facilitate the breakdown and cycling of macronutrients important to sustain healthy regulating functions as well as the productivity of flora, fauna and abiotic factors throughout the ecosystem (De Groot, Wilson & Boumans, 2002). The availability of many required natural elements - carbon, hydrogen, sulfur, iron, etc. - is often a limiting factor for biological processes that facilitate the necessary processes of respiration and decomposition (De Groot, Wilson & Boumans, 2002). Their continuous cycling is vital to maintaining the health of the ecosystem. Organisms in wetland soils help to decompose organic matter, breaking down the element nutrients and releasing them to the surrounding plants as well as to the atmosphere. Nutrient cycling is also maintained by animals such as birds, fish, and other mammals supported by these ecosystems. Through activities and processes such as consumption, defecation, and migration, wetland fauna help to disperse and cycle vital nutrients through the ecosystem.

Methods in Determining Values

Values for nutrient cycling rates were specifically found for only two habitats while the other estimates are given for an entire-wetland basis. The value for nutrient cycling provided by seagrass beds was taken from an ecosystem services assessment conducted for the coastal Catalan zone in Spain, and meets the requirements of benefit transfer for this project (Brenner, 2010). The nutrient regulation value provided for oyster reefs was taken from a study conducted in the Mission-Arkansas Estuary in Texas, USA that approximated the engineering cost equivalent to the annual amount of nutrient regulated and cycled by oyster reefs, specifically looking at the cost of denitrification. This study does not account for other nutrient cycling within the oyster reef habitat and thus is used as a low estimate for nutrient regulation. The other values were taken from global assessments that do not meet the strict criteria for benefit transfer. Because those values are used in nearly all ecosystem service studies, we include them in this report as additional information.

Table 15: Nutrient Cycling

Nutrient Cycling				
Habitat Type	**Original Study Location**	**Valuation Method**	**Total Value (US \$2015 ha^{-1} yr^{-1})**	
			Low	**High**
Seagrass Bed	Catalan Zone, Spain[1]	Benefit Transfer	\$30399	-
Oyster Bed	Texas, USA[2]	Avoided Cost	\$8.36	-
Whole Wetland	Global Assessment[3]	Benefit Transfer	\$5,864	\$30,399
	Global Assessment[4]	Benefit Transfer	\$139	\$33,745

1 Brenner, J., Jimenez, .A., Sardia, R., & Carola, A., (2010) with original values from Costanza, R., (1997)
2 Yoskowitz, D., Kim, H. C., & Montagna, P. A. (2012)
3 Costanza et al., (1997)
4 De Groot, R.S., Wilson, M. A., & Boumans, R. M. (2002)

Nitrogen Sequestration (ESRV)

Nitrogen sequestration is another service provided by wetlands. Wetlands have significant capacity to sequester nitrogen, nearly twice the amount retained in other semi-aquatic systems such as lakes and rivers (Saunders & Kalff, 2001). Soil bacteria and other biota, such as plants, contribute to nitrogen sequestration and cycling through the combined processes of denitrification, nitrogen sedimentation, and absorption by plants. For example, coastal dunes have high nitrogen accumulation rates, primarily through biological fixation rather than atmospheric deposition (Jones, 2008). As a result, the nitrogen concentrations in downstream ecosystems and other areas are reduced. The provision of nitrogen sequestration, and the larger ecosystem service of nutrient cycling, by coastal wetlands is particularly important given the detrimental impacts of human activities that continually increase the loading of nutrients to the environment (e.g., through nitrogen fertilization in agriculture). High nitrogen concentrations in aquatic ecosystems downstream substantially contribute to eutrophication. For this reason, wetlands are increasingly being recognized for their role in regulating nitrogen dynamics, as well as being actively used to protect against wastewaters (Saunders & Kalff, 2001).

Methods in Determining Values

Rate values for nitrogen sequestration were determined using data from European and U.S. reports detailing the relative costs of health impacts associated with different forms of nitrogen pollution (Brink, van Grinsven, Jacbosen &Velthof, 2011; Sobota, Compton, McCrackin & Singh., 2015). Cost estimatess of the impacts of nitrogen to air quality and water quality were included in this study, including the health costs associated with nitrogen as an atmospheric respiratory irritant and those associated with nitrate contamination to water quality (USD/kgN/yr). The rates of nitrogen sequestration relative to habitat type were taken from the sources noted in *Table 16*. For these sources, measured rates of nitrogen fixation were used as representative of nitrogen sequestration. Rates of denitrification - i.e. nitrogen release and degassing - were also measured in some of these studies. While it is possible under certain conditions for denitrification rates to exceed rates of nitrogen fixation, thereby eliminating nitrogen sequestration, it was reasoned that the rates of nitrogen fixation represented an upper end estimate of nitrogen sequestration at the study sites and are considered as such in calculations. Where suitable, rates of nitrogen fixation were averaged across seasonal data to produce an average annual rate. The rates, in kgN/ha/yr, were multiplied by the determined dollar values to calculate the annual flow value rate of nitrogen sequestered by a hectare of wetland habitat.

Table 16: Nitrogen Sequestration – Air Quality

Nitrogen Sequestration – Air Quality					
Habitat Type	**Original Study Location**	**Nitrogen Sequestered ($kg\ ha^{-1}\ yr^{-1}$)**		**Value of Nitrogen Sequestered ($\$\ ha^{-1}\ yr^{-1}$)**	
		Low	**High**	**Low ($5.67 kg^{-1})**	**High ($42.53 kg^{-1})**
Eelgrass	South Bay Estuary, NY[1]	-	8.40	$47	$357
Seagrass Bed	Bassin d'Arcahon, France[2]	3.07	-	$17	$130
Salt Marsh (Tidal Marsh	Chesapeake Bay, VA[3]	2.40	-	$13	$102
Tidal Mudflat and Channel	Australia[4]	3,036	33,737	$17,215	$1,434,850
1 Capone, D.G. (1982) 2 Welsh, D. T., et al., (2000) 3 Marsho, T. V., Burchard, T. P., & Fleming, R. (1975) 4 Cook, et al., (2004)					

Table 17: Nitrogen Sequestration – Water Quality

Nitrogen Sequestration – Water Quality					
Habitat Type	**Original Study Location**	**Nitrogen Sequestered ($kg\ ha^{-1}\ yr^{-1}$)**		**Value of Nitrogen Sequestered ($\$\ ha^{-1}\ ya^{-1}$)**	
		Low	**High**	**Low ($5.67 kg^{-1})**	**High ($42.53 kg^{-1})**
Salt Marsh	San Diego Bay[1]	2.40		$0.04	$0.30
Brackish Marsh	Mississippi River Delta[1]	67	-	$39	$306
1 DeLaune, R.D., Smith, C. J., & Sarafyan, M. N., (1986)					

Box 5. Supporting Ecosystem Services (Not Valued)

Air Quality Regulation (ESRV)

Coastal wetland ecosystems affect local and regional air quality through atmospheric cleansing processes and nutrient cycling, due to the combined effect of chemical reactions and processes in sediments, water flow and plants (Reid et al., 2005). These benefits are most prominent in urban areas where human populations are highly concentrated (Bolund & Hunhammar, 1999). The specific composition of biotic and abiotic components in coastal wetlands helps to maintain a balance in biogeochemical cycles, which in turn help maintain a balance in the chemical composition and interaction between the ocean and the atmosphere (De Groot, Wilson & Boumans, 2002). These plants and soils serve as sinks for air pollutants such as carbon dioxide and nitrous oxides and aid with redistribution and cycling of other airborne particulates, such as sulfur oxides. Such processes are becoming increasingly vital given the growing impacts of human activities to natural elemental cycles. They help to mitigate the environmental impacts of increased carbon dioxide emissions, reduce damage risks from acid rain, and prevent the formation of ground level ozone. Although nitrous oxides are a precursor to ground level ozone, nitrogen sequestration was valued in a previous section.

There is very little available research on the flow rates of this ecosystem service specific to coastal wetland habitats. Most of the global assessments that determine ecosystem service values for an entire wetland classify air quality regulation under a general category of "gas and climate regulation" which include several other ecosystem services, notably carbon and nitrogen sequestration. One study evaluates the benefits of air filtration from wetlands and other habitats in urban areas (Bolund & Hunhammar, 1999). However, this study did not pass the standards for benefit transfer because it focused on ecosystem services locally important to Stockholm, Sweden, and included several other non-wetland areas.

Habitat Provision

Habitat provision is critical for many species of plants and animals in and adjacent to wetlands. Due to the diversity of the habitats types, the species that rely on these habitats are diverse as well. They include many endangered and threatened species, such as the Light Footed Clapper Rail (*Rallus longirostris levipes*), the Western Snowy Plover (*Charadrius nivosus ssp. nivosus*), the California red-legged frog (*Aurora draytonii*) and the Tidewater Goby (*Eucyclogobius newberryi)* (United States Fish and Wildlife Service (USFWS) 2004 and 2006; Zedler, 1996).

While there are no unique values for habitat support for endangered or culturally significant species, there is growing interest in markets for endangered species. Prices for credits in California range from $4,500 to $90,000 for habitat that supports endangered species of coastal California. Grants from the US Fish and Wildlife Service range between approximately $15,000 and $35,000 per acre for acquiring land for the federally threatened Gnatcatcher (*Polioptila californica californica*) in Los Angeles and San Diego coastal habitats (USFWS 2014). These values do not transfer to direct valuation of ecosystem provision, but can offer context for the potential values contributed by these habitats. – *Continued on next page.*

Box 5. Supporting Ecosystem Services (Not Valued)-Continued

Habitat Provision –Continued

Other than endangered and sensitive species, these wetlands also provide habitat for species that are culturally and recreationally significant. Many shorebirds use these habitats, demonstrated by the listings of Important Bird Areas by the National Audubon Society (Cooper, 2004). The variety of habitats also act as refugia and foraging grounds for aquatic and terrestrial species (Sheaves et al., 2014).

Dispersal of Seeds and Translocation of Nutrients

Seed dispersal and nutrient transport is critical for natural vegetation growth to continuously occur and for biodiversity to continue. Seed dispersal is often attributed to waterfowl and shorebirds, which rely on healthy ecosystems for their habitat (Green, 2014). Healthy coastal wetlands thus facilitate seed dispersal and nutrient translocation by providing a habitat and a regulating mechanism for the plants and birds as well as the nutrients necessary in this process.

Crop Pollination Support

Healthy wetlands provide habitat for insects, which in turn pollinate nearby agricultural crops and wild plant species. Crop pollination supports the regulatory service of biological control. As with the majority of these services, pollination depends on the quality of the wetland, with lesser quality habitats leading to less pollination (Klein et al., 2007). This ecosystem service can lead to avoid costs in agriculture because many crops depend on insect or animal facilitated pollination to reproduce (De Groot, Wilson & Boumans, 2002). The value can also be derived from the marginal production increase of crops that require pollination to reproduce (Kremen et al., 2007).

5.0 Contingent Valuation

The previous two methods valued the gross benefit to society with the counterfactual being that the land would provide no ecosystem services. In contrast, our third method assesses the benefit of avoided degradation.

Although different in valuation type, the contingent valuation survey provides a means to avoid three measurement problems commonly encountered in the valuation of individual ecosystem services. First, it circumvents the assumption of "additive separability" that is needed to add up the individually-estimated service values to determine a total value for the wetland. This assumption will not hold if the value for a given service is dependent on the levels of other services provided. Second, it avoids the assumption of constant marginal benefits that is needed to sum per-hectare values. Finally, it avoids extrapolation of per-hectare valuation estimates to a much larger region, a procedure that requires an accurate measure of the average provision rates for each wetland habitat.

5.1 Methods

In conducting contingent valuation, a survey instrument was developed following the NOAA panel contingent valuation survey guidelines to the greatest extent possible. Because our contingent valuation survey is only a portion of our economic valuation of Southern California coastal wetlands and because this valuation is being conducted for a Master's thesis project, our ability to adhere to the guidelines was restricted by our limited available funding and time. We were able to adhere to 14 of the 18 suggested elements suggested to develop a reliable survey (See Appendix D for Guidelines and Appendix J for the survey instrument).

Survey Platform:
The survey instrument was developed based on the NOAA Panel guidelines and created using the Qualtrics survey platform. The survey was administered on January 29, 2016 to California residents over the age of 18 by the Amazon Mechanical Turk (MTurk). This crowdsourcing Internet marketplace enables individuals and companies (Requesters) to coordinate the use of human intelligence to perform tasks (HITS).

Research has found that Amazon MTurk is a reliable way to obtain data in a quick and affordable manner. Studies show that MTurk provides a demographic makeup that is representative of the target population. Additionally it is believed that the data gained from surveys conducted on MTurk is of good quality and not influenced by the level of payment provided to survey takers (Paolacci, Chandler, Ipeirotis, 2010; Buhrmester, Kwang & Gosling, 2011).

When used to conduct surveys, those taking the survey (workers), are given the opportunity to browse available tasks and are then paid upon completion of each task. Workers can be rated based on the quality of their work on previous tasks completed and can be filtered based on satisfaction ratings from previous Requesters. When distributing this survey MTurk Workers with a satisfaction rating below 70% could not participate in the survey.

Survey Development Steps:

1. Identified question to be answered by the CV Survey.
    a. What are California residence willing to pay to avoid degradation of Southern California coastal wetlands?
2. Identified which NOAA Panel guidelines were possible to follow given the limited time frame and available funding. (See Appendix D for the full list of guidelines). The following is a list of guidelines which were not strictly adhered to, along with the alternative used.
    a. **Personal Interview**- Surveys were conducted online rather than in person due to a lack of time and funding.
    b. **Pretesting for Interviewer Effects**- Adhering to this guidelines was unnecessary since in person interviews were not conducted.
    c. **Adequate Time Lapse from the Accident-** This survey was not assessing damages due to an accident, therefore this guideline was not relevant to the situation.
    d. **Temporal Averaging-** Due to limited time frame of this project, samples could not be taken at different points in time.
3. Developed the survey instrument following the NOAA Panel guidelines using the online survey development software, Qualtrics.
4. Pretested the survey instrument using a focus group.
5. Distributed the survey to California residence using Amazon Mechanical Turk as the respondent pool.
6. Collected and analyzed responses after the survey was open for 2 weeks.

Sample Size:

Based on a 95% confidence interval (Z=1.96) with a margin of error of +/-5% (C), a standard deviation of 0.5 (P) and the estimated population size of California at 38.8 million in 2015,the desired sample size of 384 individual respondents was calculated using the formula below (US Census Bureau, 2015).

$$Sample\ Size = \frac{z^2 * (p) * (1 - p)}{C^2}$$

The benefit of Amazon MTurk is that responses are practically guaranteed, which significantly reduced the number of non-responses received. With available funding a total of 400 surveys were distributed and 400 responses were received, yielding a response rate of 100%.

Surveys, which were completed in less than three minutes, less than half the average time it took the pretest focus group to take the survey, were considered unreliable and were thrown out. It is hard to believe that respondents who completed the survey in less than three minutes fully grasped and considered the information presented in the survey. Additionally, surveys that were incomplete were removed from analysis. Of the 400 returned survey responses 63 responses were thrown out based on survey duration and 5 were thrown because they were incomplete, resulting in 335 survey responses that were useable for analysis.

Using Amazon MTurk allowed for surveys to be conducted online rather than in person. According to the NOAA panel guidelines, conducting in person interviews is believed to be the best method for eliciting individual's willingness to pay in contingent valuation studies. However, upon discussing the best methods of conducting surveys for the thesis project, it was concluded that with our limited time and funding the only feasible way to successfully administer the survey and receive responses was to use Amazon MTurk. Using a virtual platform to conduct this survey leads to the risk that the results are not as accurate as they would have been had in person interviews been conducted. Using this method of survey did, however, remove the need to pretest for interviewer effects since there were no interviewers present who could potentially sway the opinions of respondents.

Description of Payment Vehicle:
According to the NOAA Panel, in order to determine the appropriate payment vehicle to elicit a respondent's willingness to pay, the resource being valued, socio-economic characteristics, and political structure must be considered (Arrow et al., 1993). Since the natural resources being valued in this survey are full coastal wetland ecosystems, a hypothetical income tax increase was applied that would fund a land trust to perform wetland monitoring and maintenance.

This form of payment vehicle could have led to some individuals to not respond or not be willing to pay to monitor and maintain the quality of wetlands because increase in taxes is not often a favorable action. To reduce this negative view on increasing taxes, respondents were assured that the money was going to a neutral entity who would be in full control of the funding. This was done in hopes that people would be more willing to accept increased taxes to protect wetland systems because they knew exactly where the money would be going and how it would be used.

Alternately, to reduce the effects of individual dislike of increased taxes, the use of a voluntary, donation based payment vehicle was considered. However, hypothetical donation based payment vehicles introduce hypothetical bias. This bias can lead to overvaluation of a resource because individuals tend to state a much higher willingness to pay in the hypothetical situation than they would actually donate in a real situation. It was decided that using a tax payment vehicle would encourage respondents to provide a more conservative and realistic willingness to pay than a donation based payment vehicle (Loomis, 2014).

Willingness to Pay Elicitation Format:
The use of double-bounded dichotomous choice format to estimate the economic value of environmental goods and services has become standard practice in the contingent valuation literature. This approach to contingent valuation was first proposed by Hanemann in 1985. The

double-bounded dichotomous choice (DB-DC) format takes the form of a bidding mechanism in which respondents are asked if they are willing to pay the stated initial dollar amount. Then based on whether the respondent answered “yes” or “no” to the initial bid they are asked a follow-up question in which the bid is higher or lower than the initial bid (McLeod & Berglund, 1999; Hanemann, Loomis & Kanninen, 1991). By asking a follow-up question, dependent on the respondent's initial answer, both an upper and lower bound on their willingness to pay can be obtained (Hanemann, 1985). For example, if an individual is asked to pay $50 and they answer “yes,” but then the individual is asked if they are willing to pay the higher amount of $65 and they answer “no,” it can be deduced that $50 and $65 are the lower and upper bounds on the individual's willingness to pay for the proposed good or service.

The DB-DC format is preferred over the single-bounded format (SB-DC), which was pioneered by Bishop and Herberlein in 1979. In the SB-DC format individuals are asked if they are willing to pay a single value, which is seen as a threshold value in which individuals will answer “yes” if they value goods or services more, and “no” if they think it is worth less than the proposed amount. While this elicitation format is simpler for the respondent than the DB-DC format, in which respondents are faced with two of three possible bid amounts, the DB-DC format is statistically more efficient. Additionally this format provides a tighter confidence interval and requires fewer responses to derive a relatively precise value (Hanemann, Loomis & Kanninen, 1991; Kanninen, 1993).

In the survey conducted for this report, respondents were initially asked if they were willing to pay $35 dollars per year to support a statewide tax, which would fund coastal wetland monitoring and protection. This initial value was determined based on previous contingent valuation survey instruments and an assessment of the appropriate value conducted during the focus group pretesting (Andrews, 2000). If the respondent answered “yes” to the initial value of $35, they were provided with a multiple choice question asking them why they would pay the stated amount. They were then asked if they would be willing to pay $45 per year. If respondents answered no to the initial value of $35, they were provided with a multiple choice question asking them why they were not willing to pay the stated amount. Then they were then given a follow-up question asking if they would be willing to pay $25 per year to support the wetland restoration and protection program. By using this double-bounded dichotomous format the lower and upper bounds of respondents’ willingness to pay for the program were determined.

In the case that respondents answered “yes” to both values or “no” to both values, it was assumed that the individual's willingness to pay for the program in order to avoid degradation was more than $45 per year or less than $25 per year. In cases where individuals said yes they were willing to pay $45 for this program, the respondent’s stated willingness to pay for the program provided an upper bound while the $45 was considered a lower bound. In cases where individuals said “no” they were not willing to pay $25 for the program, $25 was considered their upper bound and their lower bound was determined from their response to the open-ended willingness to pay question.

One concern with using this double-bounded dichotomous choice model is that providing respondents with a starting dollar amount may influence their final value; it may provide an anchoring point that may influence a respondent’s stated willingness to pay (Herriges &

Shogren, 1996; Boyle, Bishop & Welsh, 1985). Methods for controlling for this bias were discussed, and it was determined that by varying starting values throughout the distributed surveys, starting point bias could be addressed. However, in this study, due to a lack in resources, distributing surveys with varying starting values was not possible and it is acknowledged that the results could be subject to starting point bias.

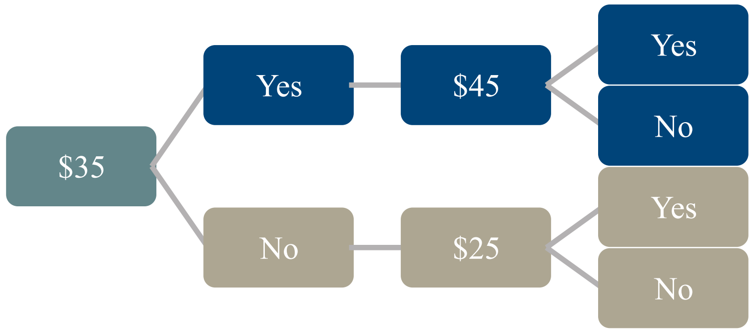


Figure 3. Double-Bounded Dichotomous Choice Flow Chart. Depicts how respondents were questioned based on their willingness to pay the initial tax increase of $35.

Pretesting:
Pretesting of the survey instrument was conducted. A focus group of ten participants was assembled in order to thoroughly analyze the clarity and effectiveness of the survey. These ten individuals were selected based on a collection of unique skills including attention to detail, past experience with the development of survey instruments, experience communicating science to general audiences, and little to no knowledge of coastal wetland environments.

We opted to create a focus group rather than sending the survey out to the entire Bren School student body because we wanted to be sure we received well thought out and critical observations of our survey instrument. After consulting with other thesis groups who had conducted survey pretesting, it was decided that using a focus group for pretesting was much more effective than sending out a call for pretest participants to the entire school. Focus group participants were more likely to respond to the survey because they were part of a limited number of handpicked individuals asked to do so.

Once chosen, the ten participants were contacted and informed that they had been chosen as one of ten participants in our survey instrument pretest focus group. Each individual was asked to complete the survey and write down their first reactions to each question (i.e. emotional reactions, confusion, editing suggestions, etc.). Each individual was also asked to time themselves while taking the survey, to ensure we could pay our desired number of MTurk respondents accordingly. After taking the survey each pretest focus group participant was asked to participate in a 15 minute interview to discuss the survey instrument.

Five out of the ten (50%) pretest focus group participants responded to our requests and provided 15 minute face to face or phone interviews. Each participant was asked the following questions at some point during the interview:

- How did you feel about the description of coastal wetlands? Did the description influence how you answered the questions throughout the survey?
- How engaging was the text provided about Southern California Coastal Wetlands? Did you learn anything from the information that you did not already know? Did this influence how you responded to questions in the survey?
- Did the photos provided elicit emotional reactions which swayed your opinions when taking the survey or did they provide necessary information in visual format?
- What did you think about the starting value provided when asked your willingness to pay for the program described in the referendum?
- What were your reactions to the tax money that would be collected if the referendum passed going to a land trust?
- Do you have any comments or recommendations on parts of the survey that were confusing, could be worded differently, or questions that could be put in a different order to make the survey flow better?

The pretesting of our survey instrument provided us with insights into how individuals were reacting to the survey and ensured that we had done a good job of carefully crafting the descriptions of coastal wetlands, the general questions, and the referendum.

5.2 Contingent Valuation Results

Conservative Design: When aspects of the survey design and the analysis of the responses are ambiguous, the option that tends to underestimate willingness to pay is preferred. A conservative design increases the reliability of the estimate by eliminating extreme responses that can implausibly inflate estimated values.

Average Willingness to Pay

Average WTP across all valid responses was determined to be approximately $66 (n = 335). A key observation is that this value is considerably larger than our initial tax increase amount of $35. However, our judgment is that this WTP is not unreasonable, as the dichotomous choice model results showed that a majority of the respondents (approximately 60%) were willing to pay $45 or more to prevent wetland degradation (Figure 5). This average WTP value is consistent with the results of CV surveys conducted in other ecosystem service valuation studies measuring individual's WTP of Broadland wetlands to mitigate increased risk of flooding (not to prevent degradation) (Gren et al., 1994). The distribution of respondents' WTP is given in *Figure 4*.

The majority of respondents' stated WTP values fell between $0-$100. Four data points were excluded from this graph due to their status as outliers (two $1000 responses and two $500 responses).

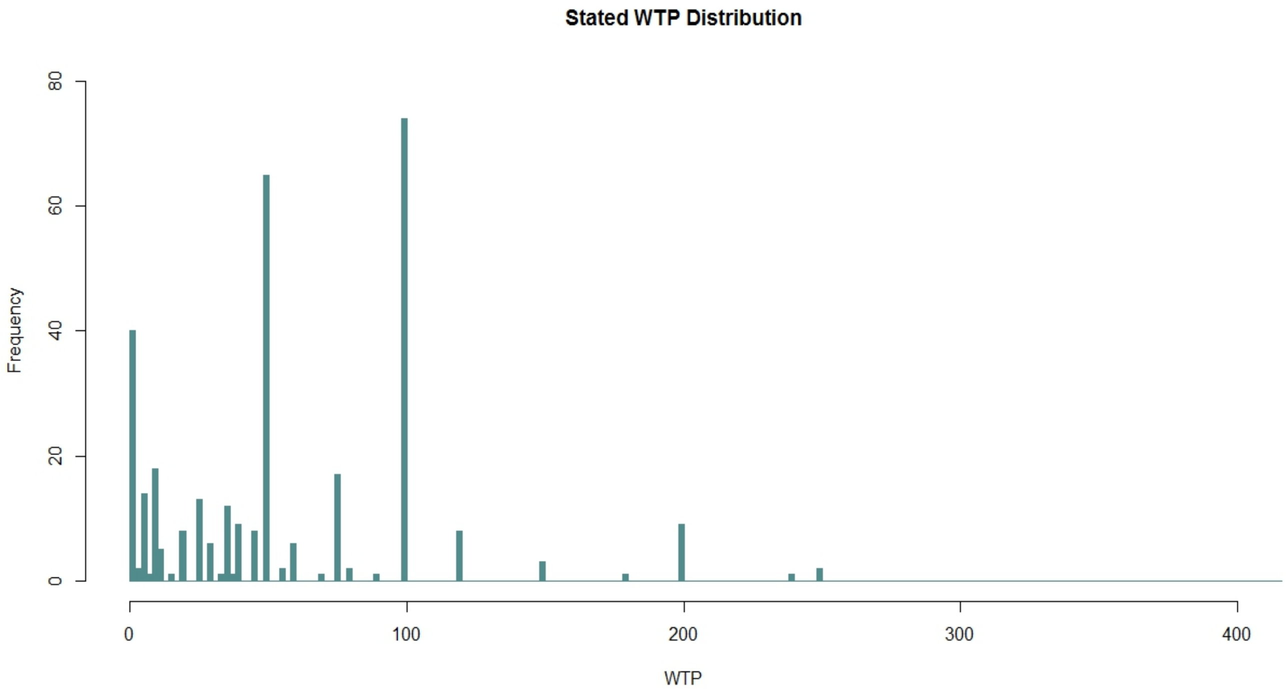


Figure 4. Stated WTP Distribution. Histogram of respondents' stated WTP values (blue bars, x-axis) by relative frequency (y-axis) determined from the CV survey (n=335).

Dichotomous Choice WTP Analysis

To better understand the distribution of individual's willingness to pay to avoid degradation to Southern California's coastal wetlands, respondent's decisions in the double-bounded dichotomous choice elicitation mechanism were analyzed to determine the divergence among those willing to pay larger taxes versus smaller taxes, or no taxes at all, and the primary reasoning behind these decisions. From the initial question asking if respondents were willing to pay a $35 increase in taxes, 70% of respondents chose that they would willingly pay this amount (Figure 5; blue bar chart). Of this 70% respondent subgroup, 85% chose that they would also willingly pay a $45 increase in taxes for the Land Trust program (Figure 5; teal bar chart). Collectively, these results indicate that 60% of respondents indicated that the lower bound of their WTP to prevent degradation of these wetlands was $45. For the 30% of respondents whom were not willing to pay the initial $35 tax increase, the majority of this subgroup was also opposed to paying $25 (Figure 5; gray bar chart). When prompted to state the primary reason for their disposition, these respondents stated that their limited budget restricted them from accepting a tax increase for the proposed program.

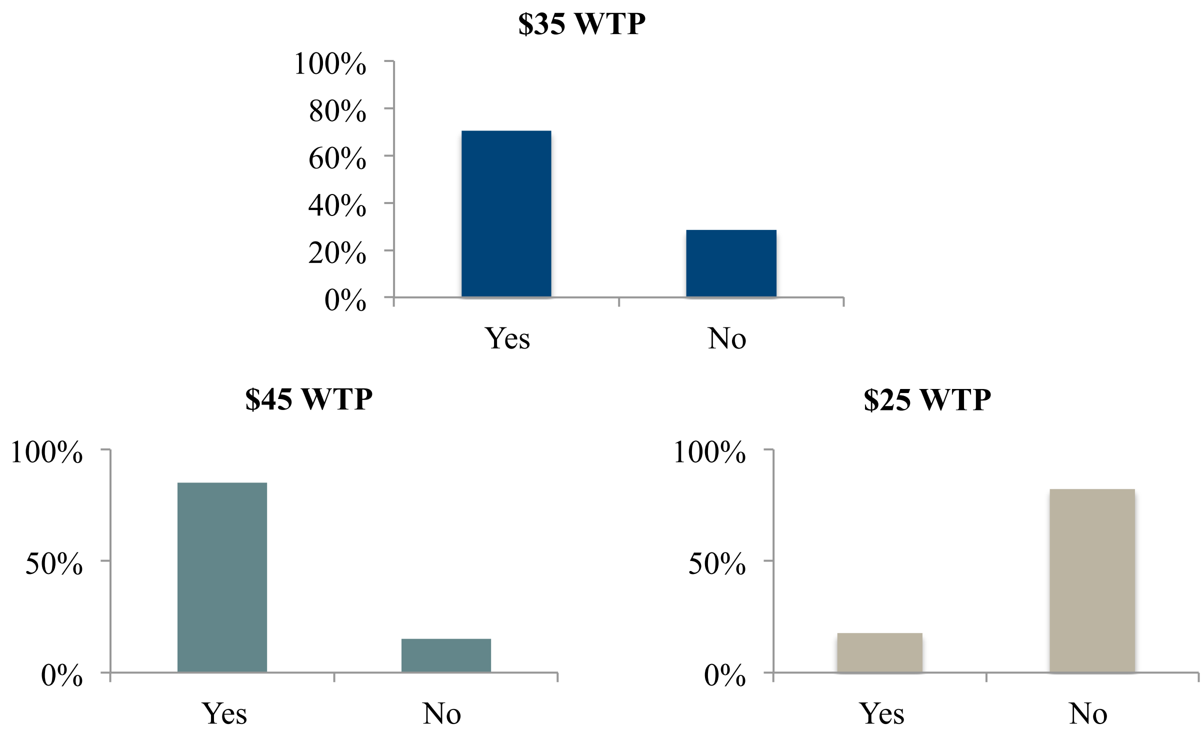


Figure 5. Percent Distribution of WTP Responses to Double-Bounded Dichotomous Choice Referendum Question. The left axis represents percent of respondents (n=335). The bottom axis represents whether the respondent answered yes they were willing to pay the tax increase or no they were not willing to pay the tax increase.

Multiple Linear Regression Results
A multiple linear regression was conducted for respondents' survey data to determine the influence of stated demographic characteristics on the stated willingness to pay of each respondent to avoid degradation to Southern California's Coastal wetlands (n=332). Regression results showed demographics' of Age and Income to be the most influential factors affecting individual's WTP. The other listed demographic factors: Education (highest attained education), Gender, Distance (residence distance from the Southern California coast), and Visitation (frequency of visitation to Southern California coastal wetlands) were not found to be statistically significant in affecting respondents' stated WTP (*Table 18).*

Table 18: Multiple Linear Regression Results. Coefficients, Standard Error, t-Statistic and P-values for demographics variables Gender, Age, Distance, Visitation, Education and Income of 332 individual responses from the CV survey.

Multiple Linear Regression Results				
	Coefficients	**Std. Error**	**t. Stat**	**P-value**
Intercept	77.57345	30.49622	2.544	0.0114
Gender	-5.73534	10.53045	-0.545	0.5864
Age	-6.87381	3.72941	-1.843	**0.0662***
Distance	0.02072	0.01804	1.149	0.2515
Visitation	9.68012	7.32797	1.321	0.1874
Education	-6.05231	5.31292	-1.139	0.2555
Income	5.08223	2.4855	2.045	**0.0417****

Tables 18 and 19 summarize the descriptive statistics and analysis results. Gender (male being the model default), Age, and Education were found to be negatively correlated with stated WTP while Distance, Visitation and Income were found to be positively correlated with stated WTP. However, only coefficients for variables Age and Income were found to be statistically significant (p-value = 0.0662, p-value = 0.0417, respectively, =0.05). Further, based on the model, the predictor variables do not explain a considerable portion of the variance in stated WTP values ($R^2 = 0.015$, $F(6,324)=1.819$, $p=0.095$).

Regression Statistics	
Multiple R	0.03258
Adjusted R Square	0.01466
Standard Error	93.24
Observations	332

Table 19: Regression Statistics. Multiple R, Adjusted R Square, Standard Error and Observations data for collected respondents' WTP values as a function of demographic variables from the CV survey. n=332

6.0 Analysis: Comparing Methods

Some of the ecosystem service values determined through the rate valuation method in this report can also be valued through other methods, such as benefit transfer from relevant existing literature (Costanza 1997, Wilson 2010, Chmura 2003, Turner et al. 2003). Below the ecosystem services valued by the rate valuation method were compared to their respective values provided in existing literature to compare similarities and/or differences in the estimates. The comparison of the ecosystem service values provided by the two valuation methods are given in *Table 20. Valuation Method Comparison.*

Carbon Sequestration

The ESRV method resulted in an annual range of $42 to $1,174 per hectare for carbon sequestration, depending on the habitat type. This was similar to the ranges found in existing literature, which had a range of $12 - $1,737 per hectare (Wilson, 2010; Costanza, 1997; Schmidt et al., 2014). For a hectare of salt marsh, the low value determined through the ESRV method was $56 annually, while the global estimate was $42 annually (Barbier, 2011; Chmura, 2003).

Refugia for Commercial Fishing

In comparing the ESRV values with Benefit Transfer (BT) methods for refugia for commercial fishing, a larger range was found in the existing literature, though information on particular habitats was scarce. For example, the ESRV method resulted in a range of $80-$91 for a hectare of seagrass annually, while the range found in the literature was $5 - $6,365 annually for a hectare of estuarine wetland. The study that was considered for the valuation of seagrass in Southern Australia resulted in an estimate of $117 in 2015 USD (McArthur & Boland, 2006). While this estimate is similar, the comparison is complicated by factors such as the values of landings, bycatch, and recreational fishing, which were included in the McArthur and Boland study but not in our calculations.

Nitrogen Sequestration/Air Quality/Water Quality

The value of nitrogen sequestration as an ecosystem service is not commonly valued on its own but rather incorporated into the ecosystem service of nutrient cycling, which also accounts for other nutrient processes in its value. Few sources of existing literature provide estimates for nitrogen sequestration, much less as it specifically pertains to air quality and/or water quality. In comparing the values of nitrogen sequestration determined by the ESRV method with those taken from existing literature through BT, a larger range of possible values was found with the ESRV method. The range of values determined with BT was within the ESRV range of estimates. Using ESRV, the value of nitrogen sequestration, as it pertains to the improvement of air quality, was determined to be $13 (the low estimate of nitrogen fixation for seagrass habitats) to approximately $17,000 (the low estimate of nitrogen fixation for tidal mudflat habitats). The high value for nitrogen fixation for tidal mudflats was not included in our estimates as we judge it to be an overestimate for the Southern California region. Further, the value for nitrogen sequestration regarding the improvement of water quality determined by ESRV ranged from $0.04 for salt marsh habitat to $306 for fresh/brackish marsh habitat. Comparatively, BT values ranged from approximately $41 to $323 (Turner et al., 2003).

Table 20: Valuation Method Comparison

Valuation Method Comparison				
Ecosystem Service	Valuation Method			
	ESRV		Benefit Transfer	
	Total Value (US $2015 ha^{-1} yr^{-1})		Total Value (US $2015 ha^{-1} yr^{-1})	
	Low	**High**	**Low**	**High**
Carbon Sequestration	$42	$1,174	$17[1]	$1,737[1]
Carbon Sequestration Specific to Seagrass	$56[2]	-	$42[2]	-
Refugia for Commercial Fishing	$81	$91	$5	$6,365
Nitrogen Sequestration – Whole Value	-	-	$41[3]	$323[3]
Nitrogen Sequestration – Air Quality	$13	$17,000	-	-
Nitrogen Sequestration – Water Quality	$0.04	$306	-	

1 Wilson (2010); Costanza (1997); Schmidt et al. (2014)
2 Barbier (2011); Chmura (2003)
3 Turner et al. (2003)

7.0 Moving Forward

From the results of this project, three recommendations are provided. These are focused on how this information can be used and what actions should be taken in the future to attain more precise and accurate coastal wetland values. First, the results of this project can be leveraged in conversations between environmental groups, community planning organizations, and policy makers regarding conservation and land use decisions. Second, it was determined that future efforts seeking to more accurately quantify the economic value of Southern California's coastal wetlands would benefit from studying a single wetland ecosystem and calculating the individual ecosystem flow rates for that particular area. This would more easily allow measured flow rates to be validly scaled up and extrapolated across all of Southern California's coastal wetlands. Lastly, it was determined that additional methods for more accurately valuing these wetlands would be hedonics valuation and restoration/rehabilitation valuation. Although these methods would not generate values for individual ecosystem services, they could more accurately capture the total use value of Southern California's coastal wetlands.

7.1 Starting the Conversation

The values determined in this report can help the client, SCWRP, simply start a conversation with a wider audience on the importance of healthy wetland habitats and their contribution to valuable services. This is a first step in raising public awareness that can better encourage community engagement in monitoring and restoring the quality of wetlands. Currently, public concern is demonstrably low for most provisioning and regulating services, with little discussion observed in the media (Wall, 2004). When concern is low, people are less likely to notice changes to these wetlands.

Public deliberation and discussion can be more successful if people have a common metric. Putting wetlands values in dollars make them more transparent and can encourage people to be part of discussions. Beyond this, these values can increase awareness of these ecosystem services in general and can facilitate conversations about the importance of these services and the habitats providing these services. If people are more aware and understand that *healthy* wetlands are important, and the effect that upstream or downstream impacts have, they are more likely to be aware of current and potential threats to these habitats.

These values can be used to analyze trade-offs between habitats or options if combined with costs, such as those for conservation activities, and estimated values for benefit that are currently lacking. Additionally, these values are useful in raising awareness and conveying the advantages of conserving these wetlands, both socially and ecologically (Beaumont, 2007; Blandon & Zu,

2014). These value ranges provide a middle-ground between theoretical, less-tangible analyses and participatory approaches that lack analysis (Niemeyer & Spash, 2001).
By increasing awareness of threats to wetlands, these values may encourage people to avoid actions that lead to degradation, thus increasing the protection of the services that these habitats provide. In addition to changing the perception of wetlands, these values can help shift opinions towards considering these habitats as an asset worthy of investment. Our estimates provide a starting point for determining appropriate payments for ecosystem services (Comello, 2011; UNEP, 2008).

7.2 Having a Downscaled Focus Area

To better provide values specific to Southern California coastal wetlands, future research focused on determining the value of particular ecosystem services provided by coastal wetland habitats needs to start on a small scale before attempting to value the entire area of Southern California coastal wetlands.

Research should begin by selecting a representative Southern California coastal wetland for study, such as Ormond Beach Wetlands in Oxnard, California. Then researchers should determine the ecosystem services flow rates provided by each individual habitat in the representative study site. Once the rates of each ecosystem service are determined for each habitat, valuation can then be attempted. Once both the ecosystem service flow rate and the value provided by each individual ecosystem service is known, those values can be scaled to the larger Southern California coastal wetlands area. When scaling up their values, researchers must keep in mind the scaling issues which were mentioned in section 2.2 of this report. While scaling does present many problems the economics literature provides guidance on how to mitigate the concerns. However, researchers must be cognizant of the issues with scaling and be clear in stating their assumptions.

Finally, since scaling up of ecosystem service values depends on existing habitat extents, it is imperative that future wetland habitat extent mapping is completed prior to this research in order to most accurately quantify the overall value of these coastal wetland systems. While the extent of these wetlands is currently uncertain, as discussed previously, California State University, Northridge's Center for Geographical Studies in conjunction with the Southern California Coastal Water Research Project are currently working to update the wetland habitat maps of the Southern California Coast (Center for Geographical Studies, n.d.). Once completed this project will provide researchers with the habitat extent necessary for more accurate valuation.

7.3 Using Additional Valuation Methods

Future research efforts attempting to quantify the economic value of Southern California's coastal wetlands could also use hedonics, restoration or rehabilitation valuation as study methods. Although these methods do not quantify the values of individual ecosystem services, they can be used to provide a more accurate estimate of these wetlands on a comprehensive basis and these values can be more accurately scaled up across a greater portion of Southern California's coastal wetlands.

Hedonics Study
A hedonics study would use data on the sales prices of housing properties along with other neighborhood and amenity characteristics to gauge how a change in one characteristic--such as proximity to a coastal wetland--would impact the property value (Boyer & Polasky, 2004). Property values in close proximity to these coastal wetlands are likely to be considerably higher than those of communities farther away from these wetland areas. This difference in property value would be inferred to represent the added use values of the ecosystem services provided by the coastal wetlands. Further, this method assumes that higher property values near to coastal wetlands are solely due to factors attributed to the wetlands. While there may be other confounding factors influencing the property values such as their distance away from a particular unfavorable structure or object, such as a landfill or airport, thorough data collection allows for the use of controls for these factors, isolating the influence of wetland. An advantage of using hedonics analysis is that it allows the total use values of wetlands to be estimated. Specifically, difference in property value captures the use values of the wetland that accrue to nearby residents (i.e. benefits that residents incur from direct use of wetlands, such as recreation, aesthetics and education, can be directly assigned a value).

That said, there are some aspects of hedonics valuation to consider that can affect the benefit estimate of wetland proximity. First, it is possible that properties located too close to wetlands may incur a negative benefit from their proximity. Such properties may have greater exposure to foul odors, mosquitoes and other wildlife pests, and therefore may be valued less than other properties. These features are considered *disamenities* that wetlands also provide and that would also be captured in a property value differential. The hedonic study would need to consider properties at varying distances from the wetland in order to measure both positive and negative effects. Additionally, not all of the ecosystem services provided by the coastal wetlands may be captured in the value determined from the difference in property values. Specifically, hedonics analysis would not capture the non-use values of the wetlands. For example, it is possible that the housing values of properties near the wetland are higher solely for the aesthetic benefit of the view, leaving out the value of other ecosystem services such as nutrient cycling and wildlife habitat. This would lead to an underestimate of the true value of these wetlands.

Restored or Rehabilitation Valuation
Using a restoration or a rehabilitation valuation method would use the cost estimates of restoration or rehabilitation projects that have been conducted for coastal wetlands to analogously represent the perceived value of the wetland by local communities. That is, the amount of funds spent by communities and residents for these projects would indicate that they believe the benefits provided by Southern California's coastal wetlands to be worth at least this amount. This valuation method would be similar to the approach used to determine the value of education as an ecosystem service in this report.

Again, there are several possible drawbacks to these methods. First, it is not possible to determine which ecosystem services provided by Southern California's coastal wetlands would be captured in the cost estimate value. The decision to restore or rehabilitate these areas could be solely based on the desire for their aesthetic value and natural beauty. In this way, residents would completely disregard the other services provided from restoring these areas, such as improved water and air quality. The cost estimate of the restoration project, therefore, would be an underestimate of the true value of the wetland. A further drawback is that this method assumes the decisions made by public agencies to restore or rehabilitate coastal wetlands accurately reflect society's values and desires. However, public agencies also make bad decisions; they do not necessarily base their reasoning on the potential benefits that would be incurred by the public from undertaking a particular project. There are many examples of such instances, such as decisions to bulldoze mountain areas to allow for construction of new homes and river-diversion projects that redirect water flows for industrial use and away from dependent natural ecosystems. That said, this method could still be a viable option for valuing Southern California's coastal wetlands, but thorough research regarding the nature of the project decision should be conducted to ensure valid use.

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Appendix A:
Exhaustive List of Ecosystem Services

1. *Aesthetic values*[1 2]
2. *Air quality improvement*[1 3 4]
    a. *Air Filtering*[5]
    b. *Air Purification*[2]
3. *Biodiversity*[6]
    a. *maintenance of biodiversity, from which humanity has derived key elements of its agricultural, medicinal, and industrial enterprise*
4. *Biological Control*[1 7 8]
    a. *Suppression of noxious weeds*[3]
5. *Carbon Sequestration and/or Storage*[1 4 6 8 9 10]
6. *Climate Regulation*[1 2 7 11 12]
7. *Conservation*[9]
8. *Cultural* [2 5 7 12 13]
    a. *Artistic Information*[1]
9. *Dispersal of seeds and translocation of nutrients*[2]
10. *Flood Control*[2 3 6 11]
    a. *Flood Prevention*[13]
    b. *Flood and Storm Protection* [9 4]
    c. *Floodwater Attenuation* [14]
    d. *Disturbance Regulation* [1]
11. *Food* [1 7 13]
    a. *Forage Production*[6]
12. *Gas Regulation* [1 5 7]
13. *Genetic Resources* [1 7]
14. *Habitat Provision* [1 12 13]
    a. *Support for special status species endangered or culturally significant*[3]
15. *micro-climate regulation (heat islands)*[2 5]
    a. *Local effects on temperature, wind, rainfall, etc.*[3]
    b. *moderation of temperature extremes and the force of winds and waves*[2]
16. *Natural medicines and pharmaceuticals*[1]
17. *Nitrogen sequestration*[15]
18. *Noise reduction*[5]
19. *Nutrient Cycling*[16 17]
20. *Nutrient Supply Regulation* [1]
21. *Ornamental resources: shells, driftwood, flowers, etc.*[1]
22. *Pest control*[1 2 11]
    a. *Limit pathogens or vectors of human disease*[3]

23. *Pollination*[1 8]
24. *Pollution buffering*[10]
25. *Raw materials such as fuel including biofuels, wood and fibers*[1]
26. *Recreation* [1 5 6 7 13]
    a. *Outdoor*[4]
    b. *Nature Observation*[4]
    c. *Eco-tourism*[12]
27. *Refugia – habitat for resident of transitory populations*[1 7]
    a. *Fish Nurseries* [9 10]
    b. *Commercial fishing habitat*[4]
28. *Science and education*[1]
29. *Sediment and soil retention*[1 7 8]
    a. *Erosion Control and Sediment Retention* [3 7]
30. *Sediment deposition and elevation building*[14]
31. *Shoreline stabilization*[14]
    a. *Shoreline tidal creek or river bank stabilization*[3]
    b. *Coastline Protection*[10]
32. *Soil Formation*[1 2 7 11 17]
33. *Spiritual and Historic Information*[1]
34. *Waste assimilation*[4 9]
35. *Waste Treatment*[1 2 5 7]
36. *Water quality*[4]
    a. *purification or contaminant dilution*[8]
37. *Water Supply*[1 7]
    a. *Provision*[6]
    b. *Regulation* [1 13]
    c. *Groundwater recharge* [3]
38. *Wave attenuation*[14]

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Appendix B: Selected Habitats

Some habitats listed here were identified as extremely important to Southern California coastal wetlands. However they were no valued or are included for valuation in parent habitats. These "Special" habitats are indicated with an asterisk (*).

Salt Marsh

Salt marshes, also referred to as tidal marshes, are wetland habitats along the coast, which are considered one of the most ecologically productive and diverse ecosystems. Salt marshes are normally found in low-lying areas of the coast, allowing them to be intermittently inundated by the tides. Characterized by their plant communities, which are adapted to wet, saline to hypersaline soils, salt marsh habitats are divided into two distinct zones, low and high marsh. The low marsh is located on the seaward edge of the salt marsh. In general low marsh is inundated with saltwater at every high tide and exists from mean sea level to the level of mean high tide. Low marsh is most easily identified by the predominant plant species cordgrass (*Spartina foliosa*), which leads tidal habitats to occasionally be referred to as cordgrass marshes (New Hampshire Department of Environmental Services, 2004).

The transition between low and high marsh occurs near the mean high tide mark. High marsh is found between the low marsh and the upland marsh border. High salt marsh can be inundated up to two times daily. However, more often these areas are flooded only during unusually high tides. The infrequency of inundation leads some high marsh areas to experience flooding only a few times a year, usually during spring tides or storm events (Zedler, 1982; New Hampshire Division of Forests and Lands, 2015). High marsh is dominated by saltgrass (*Distichlis spicata)* however it has the greatest diversity of vegetation between the two zones. In high marsh zones of Southern California species such as fat hen (*Atriplex patula*), Sea-blite (*Suaeda californica*), Australian saltbush (*Atriplex semibaccata*) and salt marsh bird's beak (*Cordylantus sp.*) can be found (New Hampshire Department of Environmental Services, 2004).

Often times Southern California salt marshes are divided into three zones, low, middle and high marsh, while some characterizations of salt marshes only include low and high marsh. California marshes are described including a middle marsh, which is dominated by pickleweed (*Salicornia virginica*) and it is described as its own salt marsh zone. When marsh areas are distinguished by tidal level however, middle marsh exists between the mean high tide mark and the mean higher high tide mark, leading it to be labeled as high marsh in most characterizations (New Hampshire Department of Environmental Services, 2004). Due to the importance and abundance of pickleweed in Southern California salt marshes, it is described as its own distinct habitat type in this report.

The soils of tidal marshes are composed mostly of marine peat created by decomposing plant materials. The organic material layer of the salt marsh can range from 16” to over 50” thick, overlaying sand, silt or bedrock throughout the marsh area. Due to the variation in inundation level, temperature, and oxygen levels found in salt marshes, both plant and animal species living in these areas are very well adapted to their specific locations (NOAA, 2014).

Salt marshes provide a wide range of ecosystem services, which enhance the quality of both human life and the environment. The peat soils and extensive cover of grasses, characteristic of salt marsh habitats, filter pollutants such as herbicides, and heavy metals from runoff. These habitats also collect excess sediments and nutrients coming from agricultural operations as well as stormwater runoff (EPA, 1993). Salt marshes help combat climate change by sequestering organic carbon as they accumulate and bury organic material such as dead marsh plants (Brevik & Homburg, 2004). Additionally, salt marshes provide critical habitat to wildlife, provide shoreline stabilization by reducing wave action, and they reduce the speed of overland flow from upstream locations, which lead to a reduction in erosion and flooding (Brevik & Homburg, 2004; Wigand, 2001).

Pickleweed Marsh*

Pickleweed marshes are areas of salt marsh dominated by Pickleweed (*Salicornia virginica*). Pickleweed marshes are typically found at lower marsh elevations where flooding and soil waterlogging is frequent. In coastal Southern California wetland systems this region of salt marsh is often referred to as the middle marsh zone (Pennings & Callaway, 1992).

Pickleweed marshes provide habitat to many species, such as the endangered Beldings Savannah sparrow (*Passerculus sandwichensis beldingi*), which feeds on the pickleweed seeds during the winter months and uses the vegetation as protection for their nests (Cairns, 1994). Just like the salt marsh, pickleweed marshes provide nutrient cycling, reduced water runoff, and erosion control. Pickleweed marshes sequester carbon and in some areas the pickleweed plant provides a direct provisioning of food. The tender green tips of the pickleweed plant are harvested and used in salads, pickled, or eaten like green beans (NOAA, 2008).

Brackish Marsh

Brackish marsh habitat often develops in the transition zone between salt and freshwater marshes. Brackish marshes are infrequently inundated by saltwater which is then significantly diluted by rainfall or groundwater. Brackish marshes therefore contain waters with salinities lower than the normal 30-35 ppt found in oceans. Due to the variation in salinity of brackish marshes, these areas consist of a notable amount of diversity in both plant and animal species, compared to the salt marsh (Williams & Faber, 2004). In brackish marsh habitats, it is common to find both salt and freshwater organisms with the dominant species depending on variation in salinity levels. The vegetation often consists of saltwater intolerant cattails and bulrush as well as vegetation such as pickleweed, which is most commonly found in very saline soils. (Zedler 2000; TRNERR, 2000).

Salt flat

Salt flats are un-vegetated, upper intertidal areas of coastal wetland systems. Upon first look at salt flats it seem as if there is little life, however salt flats are vibrant with organisms. Salt flats are found interspersed with high salt marsh. Salt flats are occasionally inundated by high tides and become saturated by a high water table. Salt flats are conducive to high rates of evaporation which leads to salt deposits on the surface as well as high soil salinity levels, which are typically too high to foster much vegetated growth (U.S. Fish and Wildlife Service, 2014a). Even after evaporation some water remains on the surface of these flats, resulting in small pools, which have salinity levels of 40 - 60 ppt (New Hampshire Division of Forests and Lands, 2014). Despite the extreme conditions these flats, they provide habitat for an extensive array of invertebrates and sensitive species such as the tiger beetle (*Cicindela species*). These pools serve as foraging grounds for birds, amphibians and other small animals. Compared to mudflats, salt flats are typically less exposed to frequent tidal occurrences, resulting in higher accumulation of salt and mineral deposits (Zedler, 1996).

Tidal Mudflats

Tidal mudflats are areas that are protected from wave action yet inundated daily by high tides. Tidal mudflats are made up of fine sand and sediments, which are deposited on the flat from river flow as well as tidal action (U.S. Fish and Wildlife Service, 2014). Tidal mudflats and channels lack vegetation the majority of the year, with some non-vascular plants establishing during opportune times (Federal Geographic Data Committee [FGDC], 2013).

Mudflats are most well known for their provision of habitat for shorebirds, both as a food source and as a resting area. Healthy mudflats contribute not only to an increase in the number, but also an increase in the diversity, of shorebirds compared to other habitats (Zedler, 2000). Birds commonly found in this habitat include willets (*Catoptrophorus semipalmatus*), godwits (*Limosa fedoa*), dowitchers (*Limnodromus spp.*) and sandpipers (*Calidris spp*.) (Armitage, 2007).

Mudflats and their associated channels are very sensitive to both upstream and downstream impacts (Dyer, 2000). Upstream impacts arise from development while sea level rise puts additional pressure on the systems. The primary impact from both development and sea level rise is a change in the elevation of mudflat habitat, due to either accretion or erosion, which could lead to transformation of mudflats into a different habitat type (TRNERR, 2000).

Beaches and Dunes

Beach and coastal dune habitats are found between marine and terrestrial ecosystems. (Prisco, Carboni, & Acosta et al., 2013). Physically dynamic habitats, beaches and dunes take part in the storage, transport, and exchange of sand. Beaches act as an exchange point for sand as it makes a transition from the ocean to land. Waves carry sand to and from the marine environment and wind transports the sand over beaches. The sand is then collected and stored by dunes (Defeo et al., 2009).

Beaches and dunes provide many ecosystem services. They act as habitat to many plants and animals, including the federally-listed Western Snowy Plover *(Charadrius nivosus nivosus),* which nests on these Southern California coastal habitats (Lafferty, 2001). Beaches and dunes are the most visited coastal wetland habitats, with hundreds of millions of people traveling to these sandy Southern California shorelines each year (Dwight et al., 2007). These wetland areas support a myriad of recreational activities, from beach-going, surfing and camping to birdwatching and fishing.

Shallow Subtidal

The shallow subtidal habitat consists of areas that are continuously submerged and fringe coastal wetlands, in between the open water and intertidal zones (Dahl, 2011; FGDC, 2013). For the purpose of this report, this category includes all estuarine, subtidal systems. It includes seagrasses, (Zedler, 2000) oyster beds, and ditch grass beds, which are described in further detail below. In general, shallow subtidal habitats provide food and habitat for fish and invertebrates (CRAM, 2013). The habitat, often in the form of refugia or nurseries, contributes to all or part of the life cycle of certain fish and invertebrates (Jackson, 2001). While protecting these species from some predators, these habitats can also serve as a food source for waterfowl. Because much of this habitat does consist of seagrass, more specifically eelgrass (*Zostera marina*) and because there is abundant information on the ecosystem services of seagrass, the values for seagrass are applied to the entire Shallow Subtidal habitat.

Eelgrass Beds*

Eelgrass (*Zostera marina and Z. pacifica*), a species of seagrass dominant in Southern California, is often considered its own habitat, since it provides many unique ecosystem services at different rates than other seagrass species. Eelgrass beds are a type of underwater flowering grasses that live in shallow waters. Eelgrass can exist both in freshwater and marine systems, and is typically found growing in coves, tidal creeks, and estuaries (NOAA, 2012). It can be found growing at water depths ranging from a few inches to several feet, depending on water clarity and the availability of light for photosynthesis. Its growth is impacted by temperature, salinity and anthropogenic influences, such as sediment loading (MIT Sea Grant, 2006). Eelgrass in Southern California coastal areas has broad, long leaves in deep water areas, but are short and have dense root masses in shallower waters.

Eelgrass beds provide many ecosystem services - acting as vital areas for refuge, foraging and spawning of many marine species (Plummer et al., 2013). Along the Southern California coast, eelgrass beds provide direct benefits to human welfare in the form of direct food provisioning by way of commercial fishing, and local economic stimulation. Additionally, these dynamic aquatic systems, provide vital regulating services including the filtration of polluted stormwater runoff, absorption and cycling of nutrients such as phosphorus and nitrogen, and they also help protect and buffer coastal shorelines from erosion through wave attenuation (NOAA, 2012a).

Oyster Beds*

Oyster Beds are included in the shallow subtidal habitat for the purpose of this report, however, they are differentiated both in the NWI database and in many ecosystem service measurements. As indicated by their name, oyster beds, or “oyster reefs,” are structurally complex clusters of oyster populations and have been long acknowledged for the habitat they create for other marine organisms (Stunz et al., 2010). Oyster populations typically establish themselves along the rocky or muddy bottoms of coastal wetlands, continuing to build and establish on top of older oysters as they die. This recruitment process creates a "living layer" from the structure of nonliving shells. While the most obvious ecosystem service provided by these habitats is food provisioning to other marine life as well as humans, oysters also aid in water filtration and reduced turbidity by cycling nutrients in the water. The ecosystem service of water filtration improves the clarity of the water, which supports the growth of other estuarine and marine organisms, including seagrasses, fish, and crabs (NOAA, 2015). Lastly, oyster beds consolidate and stabilize sediments, as well as reduce coastal erosion by attenuating wave action in low-lying wetlands (Meyer et al, Townsend & Thayer, 1997).

Ditch Grass Beds*

Ditch Grass (*Ruppia cirrhosa*) are also a sub-habitat of shallow subtidal areas. Similarly to oyster beds and eelgrass, ditch grass habitat has been separated out because of the unique ecosystem services that it provides. Ditch grass beds are a habitat under the class of aquatic beds. These aquatic beds include wetland and deepwater habitats dominated, in this case, by the rooted vascular ditch grass plant. Ditch grass grows below the surface of the water and best in areas of permanent inundation or repeated flooding (California Native Plant Society, 1997). Ditch grass beds formed in coastal wetlands are most commonly found in well-protected shallow brackish locations, thriving in waters with salinities less than 30 ppt. These vegetated aquatic beds provide habitat to many invertebrate and vertebrate species. Additionally, they have high rates of primary productivity, which removes carbon dioxide from the atmosphere (Adams & Bate, 1994).

Wetland-Upland Transition Zone*

The wetland-upland transition zone, often referred to more simply as an ecotone, marks the end of the coastal wetland community as it transitions into terrestrial upland habitat. The wetland-upland transition zone, which lies between marsh and upland habitats, like most wetland habitats, is distinguished by its vegetative composition. Thirty-three percent of the vegetation found in Southern California transition zones is unique to the transition habitat type. The most common vegetation, which is unique to these transition zones, include salt grass (*Distichlis spicata*) and alkali heath (*Frankenia salina*). Mixed in with these unique transition zone plants are the salt marsh-dominating pickleweed plant, as well as common upland plants such as coyote brush (*Baccharis pilularis)*, stinging nettle (*Urtica dioica*), creeping wild rye (*Leymus triticoides*), and rushes (*Juncus spp*) (Wasson & Woolfolk, 2011). The transition zone provides habitat to a variety of reptiles, mammals and birds. Additionally, these are important in concentrating and processing the flow of materials such as nutrients (Kennish, 2003).

Despite these unique attributes, this report does not value the wetland-upland transition zone as its own habitat, due to lacking existing literature on the particular habitat area. The interconnectivity and the difficulty of distinguishing this small yet important habitat from surrounding wetland habitat could potentially lead to double counting and therefore an overvaluation of Southern California's coastal wetland systems.

However, it is important to note that upland transition zones between wetland habitat and development are particularly vulnerable to detrimental human impacts. These zones face greater threats due to their proximity to a developed area and as a result, their capacity to continue providing such services is at substantial risk of severe degradation from the human activities (Semlitsch & Jensen, 2001).

Appendix C: Benefit Transfer Valuation Methods from Existing Literature

Non-Market Goods Valuation Techniques		
Valuation Method	**Description**	**Applicable Studies**
Avoided Cost	"Uses the cost of replacing ecosystem services with a human-engineered system as an estimate of the value of providing ecosystem services via protection of an ecosystem."[1]	Rust, M. (2014) Breaux, A., Farber, S., & Day, J. (1995). Yoskowitz, D., Kim, H. C., & Montagna, P. A. (2012). Chesapeake Bay Foundation. (2007)
Replacement Cost	Refers to "the value of having one particular means of providing an ecosystem service which allows for not having to pay to replace services via some other means." However, it does not directly represent the value of the ecosystem service, itself.[1]	Wilson, S.J. 2010.
Hedonics Pricing	Uses the value of an associated good or service to measure the implicit price of a non-market good or service. (e.g. using housing prices to provide a value for ecosystem services of the surrounding environment)[2]	Parsons, G. R., & Powell, M. (2001) Pompe, J. J., & Rinehart, J. R. (1995)
Global Assessments	Global Assessment studies reconcile data from hundreds of existing ecosystem service research conducted globally and average them into global value ranges.	Batker, D., Christin, Z., Graf, W., Jones, K. B., Loomis, J., Cooley, C., & Pittman, J. (2014) Camacho-Valdez, V., Ruiz-Luna, A., Ghermandi, A., & Nunes, P. A. (2013) N. Raheem et al. (2012) Feagin, R. A., M. Luisa Martinez, G. Mendoza-Gonzalez, and R. Costanza. (2010) Costanza, R., d'Arge, R., de Groot, R., Farberk, S., Grasso, M., Hannon, B., & Raskin, R. G. (1997) De Groot, R. S., Wilson, M. A., & Boumans, R. M. (2002) Costanza, R., Wilson, M. A., Troy, A., Voinov, A., Liu, S., & D'Agostino, J. (2006)

Appendix D: NOAA Panel Guidelines

Survey Guidelines

In this section we try to lay down a fairly complete set of guidelines compliance with which would define an ideal CV survey. A CV survey does not have to meet each of these guidelines fully in order to qualify as a source of reliable information to a damage assessment process. Many departures from the guidelines or even a single serious deviation would, however, suggest unreliability prima facie. To preserve continuity, we give only a bald list of guidelines here. They are repeated together with further explanatory comments in the Appendix to this Report.

General Guidelines

Sample Type and Size: Probability sampling is essential for a survey used for damage assessment. The choice of sample specific design and size is a difficult, technical question that requires the guidance of a professional sampling statistician.

Minimize Nonresponses: High nonresponse rates would make the survey results unreliable.

Personal Interview: The Panel believes it unlikely that reliable estimates of values could be elicited with mail surveys. Face-to-face interviews are usually preferable, although telephone interviews have some advantages in terms of cost and centralized supervision.

Pretesting for Interviewer Effects: An important respect in which CV surveys differ from actual referenda is the presence of an interviewer (except in the case of mail surveys). It is possible that interviewers contribute to "social desirability" bias, since preserving the environment is widely viewed as something positive. In order to test this possibility, major CV studies should incorporate experiments that assess interviewer effects.

Reporting: Every report of a CV study should make clear the definition of the population sampled, the sampling frame used, the sample size, the overall sample non-response rate and its components (e.g., refusals), and item non-response on all important questions. The report should also reproduce the exact wording and sequence of the questionnaire and of other communications to respondents (e.g., advance letters). All data from the study should be archived and made available to interested parties (see Carson et al. (1992), for an example of good practice in inclusion of questionnaire and related details; as of this date, however, the report has not been available publicly and the data have not been archived for open use by other scholars).

Careful Pretesting of a CV Questionnaire**:** Respondents in a CV survey are ordinarily presented with a good deal of new and often technical information, well beyond what is typical in most surveys. This requires very careful pilot work and pretesting, plus evidence from the final survey that respondents understood and accepted the main description and questioning reasonably well.

Guidelines for Value Elicitation Surveys

The following guidelines are met by the best CV surveys and need to be present in order to assure reliability and usefulness of the information that is obtained.

Conservative Design: Generally, when aspects of the survey design and the analysis of the responses are ambiguous, the option that tends to underestimate willingness to pay is preferred. A conservative design increases the reliability of the estimate by eliminating extreme responses that can enlarge estimated values wildly and implausibly.

Elicitation Format: The willingness to pay format should be used instead of compensation required because the former is the conservative choice.

Referendum Format: The valuation question should be posed as a vote on a referendum.

Accurate Description of the Program or Policy: Adequate information must be provided to respondents about the environmental program that is offered. It must be defined in a way that is relevant to damage assessment.

Pretesting of Photographs: The effects of photographs on subjects must be carefully explored.

Reminder of Undamaged Substitute Commodities: Respondents must be reminded of substitute commodities, such as other comparable natural resources or the future state of the same natural resource. This reminder should be introduced forcefully and directly prior to the main valuation question to assure that respondents have the alternatives clearly in mind.

Adequate Time Lapse from the Accident: The survey must be conducted at a time sufficiently distant from the date of the environmental insult that respondents regard the scenario of complete restoration as plausible. Questions should be included to determine the state of subjects' beliefs regarding restoration probabilities.

Temporal Averaging: Time dependent measurement noise should be reduced by averaging across independently drawn samples taken at different points in time. A clear and substantial time trend in the responses would cast doubt on the "reliability" of the finding.

"No-answer" Option: A "no-answer" option should be explicitly allowed in addition to the "yes" and "no" vote options on the main valuation (referendum) question. Respondents who choose the "no-answer" option should be asked nondirectively to explain their choice. Answers should be carefully coded to show the types of responses, for example: (i) rough indifference between a yes and a no vote; (ii) inability to make a decision without more time or more information; (iii) preference for some other mechanism for making this decision; and (iv) bored by this survey and anxious to end it as quickly as possible.

Yes/no Follow-ups: Yes and no responses should be followed up by the open-ended question: "Why did you vote yes/no?" Answers should be carefully coded to show the types of responses, for example: (i) It is (or isn't) worth it; (ii) Don't know; or (iii) The oil companies should pay.

Cross-tabulations: The survey should include a variety of other questions that help to interpret the responses to the primary valuation question. The final report should include summaries of willingness to pay broken down by these categories. Among the items that would be helpful in interpreting the responses are:

- Income
- Prior Knowledge of the Site
- Prior Interest in the Site (Visitation Rates)
- Attitudes Toward the Environment
- Attitudes Toward Big Business
- Distance to the Site
- Understanding of the Task
- Belief in the Scenarios
- Ability/Willingness to Perform the Task

Checks on Understanding and Acceptance: The above guidelines must be satisfied without making the instrument so complex that it poses tasks that are beyond the ability or interest level of many participants

Goals for Value Elicitation Surveys

The following items are not adequately addressed by even the best CV surveys. In the opinion of the Panel, these issues will need to be convincingly dealt with in order to assure the reliability of the estimates.

Alternative Expenditure Possibilities: Respondents must be reminded that their willingness to pay for the environmental program in question would reduce their expenditures for private goods or other public goods. This reminder should be more than perfunctory, but less than overwhelming. The goal is to induce respondents to keep in mind other likely expenditures, including those on other environmental goods, when evaluating the main scenario.

Deflection of Transaction Value: The survey should be designed to deflect the general "warm-glow" of giving or the dislike of "big business" away from the specific environmental program that is being evaluated. It is possible that the referendum format limits the "warm glow" effect, but until this is clear the survey design should explicitly address this problem.

Steady State or Interim Losses: It should be made apparent that respondents can distinguish interim from steady-state losses.

Present Value Calculations of Interim Losses: It should be demonstrated that, in revealing values, respondents are adequately sensitive to the timing of the restoration process.

Advance Approval: Since the design of the CV survey can have a substantial effect on the responses, it is desirable that -- if possible -- critical features be preapproved by both sides in a legal action, with arbitration and/or experiments used when disagreements cannot be resolved by the parties themselves.

Burden of Proof: Until such time as there is a set of reliable reference surveys, the burden of proof of reliability must rest on the survey designers. They must show through pretesting or other experiments that their survey does not suffer from the problems that these guidelines are intended to avoid. Specifically, if a CV survey suffered from any of the following maladies, we would judge its findings "unreliable":

- A high nonresponse rate to the entire survey instrument or to the valuation question.
- Inadequate responsiveness to the scope of the environmental insult.
- Lack of understanding of the task by the respondents.
- Lack of belief in the full restoration scenario.
- "Yes" or "no" votes on the hypothetical referendum that are not followed up or explained by making reference to the cost and/or the value of the program.

Reliable Reference Surveys: In order to alleviate this heavy burden of proof, we strongly urge the government to undertake the task of creating a set of reliable reference surveys that can be used to interpret the guidelines and also to calibrate surveys that do not fully meet the conditions.

Reference

Arrow, K., Solow, R., Portney, P. R., Leamer, E. E., Radner, R., & Schuman, H. (1993). Report of the NOAA Panel on Contingent Valuation.

Appendix E: Sources for Carbon Sequestration and Storage Rates

Carbon Sequestration						
Habitat Type	Study Area	Rate (tC/ha/yr)		Rate (tCO_2/ha/yr)		Source
		Low	High	Low	High	
Beach and Dunes	United Kingdom	0.32	0.84	1.17	3.09	Jones, M. L. M., Sowerby, A., Williams, D. L., & Jones, R. E. (2008). Factors controlling soil development in sand dunes: evidence from a coastal dune soil chronosequence. Plant and Soil, 307(1-2), 219-234.
Shallow Subtidal	-	-	-	-	-	-
Seagrass Bed	Spain	-	-	2.87	-	Sifleet, S., Pendleton, L., & Murray, B. C. (2011). State of the Science on Coastal Blue Carbon. A Summary for Policy Makers. Nicholas Institute Report, 11-06.
	Global	-	0.83	-	3.04	Laffoley, D., & Grimsditch, G. D. (Eds.). (2009). The management of natural coastal carbon sinks. Iucn.
Oyster Bed	Southern Australia	0.7	0.9	2.57	3.03	Carbon Sequestration Potential of Shellfish. (2009) The Fish Site. http://www.thefishsite.com/articles/615/carbon-sequestration-potential-of-shellfish/
Tidal Mudflat and Channel	North America	2.2	-	8.07	-	Bridgham, S. D., Megonigal, J. P., Keller, J. K., Bliss, N. B., & Trettin, C. (2006). The carbon balance of North American wetlands. Wetlands, 26(4), 889-916.
Salt Marsh (Tidal Marsh)	Tijuana River Estuary	0.43	3.43	1.58	12.58	D. R. Cahoon, unpublished data, 1993 taken from Chmura, G. L., Anisfeld, S. C., Cahoon, D. R., & Lynch, J. C. (2003).

						Global carbon sequestration in tidal, saline wetland soils. Global biogeochemical cycles, 17(4). Cahoon, D. R., J. C. Lynch, and A. Powell, Marsh vertical accretion in a southern California estuary, U.S.A. Estuarine Coastal Shelf Sci., 43, 19–32, 1996
	Ballona Wetlands	1.4	14.1	5.13	51.70	Sifleet, S., Pendleton, L., & Murray, B. C. (2011). State of the Science on Coastal Blue Carbon. A Summary for Policy Makers. Nicholas Institute Report, 11-06.
	Global Average	2.1	2.18	7.70	7.99	Laffoley, D., & Grimsditch, G. D. (Eds.). (2009). The management of natural coastal carbon sinks. Iucn.
Saltflat	-	-	-	-	-	-
Brackish Marsh	New Jersey	8.9	-	32.64	-	Craft, C. (2007). Freshwater input structures soil properties, vertical accretion, and nutrient accumulation of Georgia and US tidal marshes. Limnology and oceanography, 52(3), 1220-1230.
Whole Wetland	-	-	-	-	-	-

Appendix F: Education Details

Education									
Whole Wetland	Area(Ha)	Number of Grants Awarded	Value ($2015)		Total Value ($/ha)		Discounted Total Value ($/ha/yr)		Source
			Low	High	Low	High	Low	High	
Ballona Wetland	242.8	2	$4,740.00	$36,131.00	$19.52	$148.81	**$0.98**	**$7.44**	EPA, 2015
Upper Newport Bay Nature Preserve	54.6	1	$11,391.00		$208.63		**$10.43**		EPA, 2015
Devereux Slough	63	7	$1,227.00	$8,873.00	$19.48	$140.84	**$0.97**	**$7.04**	Coal Oil Point Reserve, n.d.
Bolsa Chica	485.62	1	$10,000.00		$20.59		**$1.03**		Bolsa Chica Land Trust, 2015

Appendix G: Supporting Literature for Species with Juvenile Reliance on Seagrass

Supporting Literature for Species with Juvenile Reliance on Seagrass		
	Species	Supporting Literature
1	Dungeness Crab	Emmett, R. L., S. L. Stone, S. A. Hinton, and M. E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in West Coast estuaries, Volume II: species life history summaries. ELMR Rep. No. 8. NOAA/NOS Strategic Environmental Assessments Division, Rockville, MD, 329pp Rooper, C. N., D. A. Armstrong, and D. R. Gunderson. 2002. In Crabs in Cold Water Regions: Biology, Management, and Economics, 608–629. Alaska Sea Grant, University of Alaska Fairbanks Hughes, B. B., Levey, M. D., Brown, J. A., Fountain, M. C., Carlisle, A. B., Litvin, S. Y., ... & Gleason, M. G. (2014). Nursery functions of US West Coast estuaries: The state of knowledge for juveniles of focal invertebrate and fish species. The Nature Conservancy, Arlington, VA. 168pp.
2	Leopard Shark	Ebert, D. A., and T. B. Ebert. 2005. Reproduction, diet and habitat use of leopard sharks, Triakis semifasciata (Girard), in Humboldt Bay, California, USA. Marine and Freshwater Research 56:1089–1098 Hughes, B. B., Levey, M. D., Brown, J. A., Fountain, M. C., Carlisle, A. B., Litvin, S. Y., ... & Gleason, M. G. (2014). Nursery functions of US West Coast estuaries: The state of knowledge for juveniles of focal invertebrate and fish species. The Nature Conservancy, Arlington, VA. 168pp.
3	Bat Ray	Love, M. S. 2011. Certainly more than you want to know about the fishes of the Pacific Coast, a postmodern experience. Really Big Press, Santa Barbara, CA. 672p Hughes, B. B., Levey, M. D., Brown, J. A., Fountain, M. C., Carlisle, A. B., Litvin, S. Y., ... & Gleason, M. G. (2014). Nursery functions of US West Coast estuaries: The state of knowledge for juveniles of focal invertebrate and fish species. The Nature Conservancy, Arlington, VA. 168pp.
4	California Halibut	Rooper, C. N., D. A. Armstrong, and D. R. Gunderson. 2002. In Crabs in Cold Water Regions: Biology, Management, and Economics, 608–629. Alaska Sea Grant, University of Alaska Fairbanks Reeve, L. D. 2013. Can eelgrass (Zostera marina) serve as a nursery habitat for

		California halibut (Paralichthys californicus)? M.S. Thesis. San Diego State University Hughes, B. B., Levey, M. D., Brown, J. A., Fountain, M. C., Carlisle, A. B., Litvin, S. Y., ... & Gleason, M. G. (2014). Nursery functions of US West Coast estuaries: The state of knowledge for juveniles of focal invertebrate and fish species. The Nature Conservancy, Arlington, VA. 168pp.
5	English Sole	Hosack, G. R., B. R. Dumbauldt, J. L. Ruesink, and D. A. Armstrong. 2006. Habitat associations of estuarine species: Comparisons of intertidal mudflat, seagrass (Zostera marina), and oyster (Crassostrea gigas) habitats. Estuaries and Coasts 29:1150 Hughes, B. B., Levey, M. D., Brown, J. A., Fountain, M. C., Carlisle, A. B., Litvin, S. Y., ... & Gleason, M. G. (2014). Nursery functions of US West Coast estuaries: The state of knowledge for juveniles of focal invertebrate and fish species. The Nature Conservancy, Arlington, VA. 168pp.
6	Brown Rockfish	Stein, D., & Hassler, T. J. (1989). Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Southwest). Brown Rockfish, Copper Rockfish, and Black Rockfish. OREGON STATE UNIV CORVALLIS COLL OF OCEANOGRAPHY. Hughes, B. B., Levey, M. D., Brown, J. A., Fountain, M. C., Carlisle, A. B., Litvin, S. Y., ... & Gleason, M. G. (2014). Nursery functions of US West Coast estuaries: The state of knowledge for juveniles of focal invertebrate and fish species. The Nature Conservancy, Arlington, VA. 168pp.
7	Splitnose Rockfish	Boehlert, G. W. 1977. Timing of the surfaceto-benthic migration in juvenile rockfish, Sebastes diploproa, off southern California. Fish. BuU., U.S. 75:887-890
8	Spiny Lobster	Green, E. P., & Short, F. T. (2003). World atlas of seagrasses. Univ of California Press.
9	Worms	Green, E. P., & Short, F. T. (2003). World atlas of seagrasses. Univ of California Press.
10	Barracuda	Schmidt, T. W. (1989). Food habits, length-weight relationship and condition factor of young great barracuda, Syphraena barracuda (Walbaum), from Florida Bay, Everglades National Park, Florida. Bulletin of Marine Science,44(1), 163-170.
11	Copper Rockfish	Froese, R. and Luna, S. S. Sebases caurinus Richardson, 1844 Copper rockfish. FishBase. Accessed 1/27/2015
12	Moray Eel	Essential Fish Habitat Assessment Revised Final Report. 2013. U.S. Department of the Nav. Hawaii Southern California Training and Testing

		Essential Fish Habitat Assessment.
13	Black Rockfish	Pacific Fishery Management Council (2005). Pacific Coast Groundfish Fishery Management Plan. Appendix B: Pacific Coast Groundfish Essential Fish Habitat.
14	Blac-and-Yellow Rockfish	Pacific Fishery Management Council (2005). Pacific Coast Groundfish Fishery Management Plan. Appendix B: Pacific Coast Groundfish Essential Fish Habitat.
15	Blue Rockfish	Pacific Fishery Management Council (2005). Pacific Coast Groundfish Fishery Management Plan. Appendix B: Pacific Coast Groundfish Essential Fish Habitat.
16	Blue Rockfish	Pacific Fishery Management Council (2005). Pacific Coast Groundfish Fishery Management Plan. Appendix B: Pacific Coast Groundfish Essential Fish Habitat.
17	Lingcod	Pacific Fishery Management Council (2005). Pacific Coast Groundfish Fishery Management Plan. Appendix B: Pacific Coast Groundfish Essential Fish Habitat.
18	Gopher Rockfish	Pacific Fishery Management Council (2005). Pacific Coast Groundfish Fishery Management Plan. Appendix B: Pacific Coast Groundfish Essential Fish Habitat.
19	Grass Rockfish	Pacific Fishery Management Council (2005). Pacific Coast Groundfish Fishery Management Plan. Appendix B: Pacific Coast Groundfish Essential Fish Habitat.
20	Kelp Greenling	Pacific Fishery Management Council (2005). Pacific Coast Groundfish Fishery Management Plan. Appendix B: Pacific Coast Groundfish Essential Fish Habitat.
21	California Scorpion fish	Pacific Fishery Management Council (2005). Pacific Coast Groundfish Fishery Management Plan. Appendix B: Pacific Coast Groundfish Essential Fish Habitat. Nightingale, B., & Simenstad, C. A. (2001). Overwater structures: Marine issues (No. WA-RD 508.1,). Washington State Transportation Commission, Planning and Capital Program Management.
22	Red rock crab	Hovel, K.A., 2003. Habitat fragmentation in marine landscapes: relative effects of habitat cover and configuration on juvenile crab survival in California and North Carolina seagrass beds. Biological Conservation. 110, 401-412.

Appendix H: Commercially Viable Species

General Value and Poundage of 22 Commercially Viable Species						
	2010	2011	2012	2013	2014	Average
Total pounds	1,278,588	1,376,084	1,571,498	1,557,096	2,188,771	1,594,407.40
Total Value	$13,073,409.00	$14,615,667.00	$15,595,906.00	$15,949,575.00	$20,677,797.00	$15,982,470.80
Total Value US$2015	$14,215,362.49	$15,658,133.30	$16,227,559.82	$16,311,564.87	$20,834,223.14	**$16,649,368.72**
Source: Final California Commercial Landings. California Department of Fish and Wildlife. Poundage And Value Of Landings Of Commercial Fish Into California By Area. 2012-2015						

Detailed Value and Poundage of 22 Commercially Viable Species						
2014	SB		LA		SD	
	lbs	US$	lbs	US$	lbs	US$
Dungeness crab	2,578	$11,539.00	0	$0.00	0	$0.00
Bat Ray	1,759	$868.00	5,460	$86.00	78	$624.00
Black Rockfish	1	$2.00	0	$0.00	41	$177.00
Black-and-Yellow Rockfish	437	$2,882.00	0	$0.00	5	$11.00
Blue Rockfish	1,003	$4,137.00	97	$291.00	0	$0.00
Brown Rockfish	547	$3,075.00	178	$534.00	122	$510.00
Cabezon	10,826	$78,779.00	204	$1,332.00	369	$2,030.00
California Barracuda	1,380	$1,045.00	5,915	$5,078.00	9	$9.00

California Halibut	77,620	$423,633.00	9,886	$53,139.00	16,013	$76,043.00	
Copper Rockfish	7,552	$42,502.00	1,092	$3,276.00	189	$556.00	
English Sole	2,852	$2,895.00	27	$0.00	0	$0.00	
Gopher Rockfish	554	$3,669.00	0	$0.00	123	$443.00	
Grass Rockfish	9,682	$98,039.00	27	$192.00	36	$211.00	
Kelp Greenling	8	$73.00	0	$0.00	0	$0.00	
Leopard Shark	830	$925.00	620	$668.00	115	$173.00	
Lingcod	9,686	$35,981.00	710	$1,975.00	390	$717.00	
Moray Eel	85	$553.00	1,778	$2,078.00	4,234	$8,850.00	
Red Rock Crab	952,867	$1,486,684.00	97,869	$119,056.00	7,851	$7,279.00	
Scorpionfish	119	$262.00	2,390	$12,375.00	118	$333.00	
Spiny Lobster	399,259	$7,832,868.00	279,451	$5,405,900.00	272,683	$4,941,518.00	
Splitnose Rockfish	534	$1,222.00	282	$284.00	0	$0.00	
Worms (invertebrate unspecified)	0	$0.00	0	$0.00	230	$416.00	
							TOTALS
Total lbs	1,480,179		405,986		302,606		**2,188,771**
Total$		$10,031,633.00		$5,606,264.00		$5,039,900.00	**$20,677,797.00**
2013	SB		LA		SD		
	lbs	US$	lbs	US$	lbs	US$	
Dungeness crab	5982	$27,779.00	0	$0.00	0	$0.00	
Bat Ray	120	$120.00	6099	$935.00	15	$30.00	

Black Rockfish	0	$0.00	0	$0.00	0	$0.00
Black-and-Yellow Rockfish	471	$3,324.00	0	$0.00	0	$0.00
Blue Rockfish	387	$1,823.00	16	$48.00	18	$52.00
Brown Rockfish	736	$4,499.00	54	$162.00	182	$781.00
Cabezon	12,989	$90,676.00	293	$1,627.00	530	$3,012.00
California Barracuda	2108	$1,757.00	14888	$11,215.00	221	$205.00
California Halibut	94414	$491,319.00	12640	$70,526.00	15257	$70,635.00
Copper Rockfish	7683	$45,183.00	541	$1,707.00	241	$724.00
English Sole	2427	$2,540.00	48	$0.00	0	$0.00
Gopher Rockfish	816	$5,701.00	0	$0.00	82	$268.00
Grass Rockfish	12,731	$127,405.00	50	$462.00	38	$220.00
Kelp Greenling	24	$158.00	0	$0.00	0	$0.00
Leopard Shark	479	$497.00	79	$75.00	102	$174.00
Lingcod	4,739	$16,466.00	476	$1,051.00	229	$490.00
Moray Eel	564	$9,708.00	644	$11,106.00	2457	$6,000.00
Red Rock Crab	563237	$896,356.00	9559	$12,653.00	4133	$12,478.00
Scorpionfish	639	$1,068.00	5,195	$26,202.00	63	$182.00
Spiny Lobster	277889	$5,202,628.00	230624	$4,175,744.00	263792	$4,611,682.00
Splitnose Rockfish	62	$74.00	26	$26.00		
Worms (invertebrate unspecified)	0	$0.00	0	$0.00	7	$22.00

							TOTALS
Total lbs	988497		28123 2		28736 7		**1,557,096**
Total$		$6,929,081.0 0		$4,313,539.0 0		$4,706,955.0 0	**$15,949,575. 00**
2012	SB		LA		SD		
	lbs	US$	lbs	US$	lbs	US$	
Dungeness crab	1550	$9,378.00	0	$0.00	0	$0.00	
Bat Ray	157	$91.00	14225	$1,238.00	896	$669.00	
Black Rockfish	44	$150.00	0	$0.00	48	$30.00	
Black-and-Yellow Rockfish	85	$591.00	0	$0.00	1	$5.00	
Blue Rockfish	127	$522.00	0	$0.00	1	$4.00	
Brown Rockfish	131	$826.00	234	$702.00	284	$1,331.00	
Cabezon	11,818	$75,458.00	996	$6,176.00	979	$5,120.00	
California Barracuda	3612	$2,130.00	30404	$22,825.00	41	$31.00	
California Halibut	111497	$562,405.00	32464	$182,569.00	20367	$92,228.00	
Copper Rockfish	5290	$27,223.00	513	$1,791.00	55	$166.00	
English Sole	1215	$1,215.00	0	$0.00	0	$0.00	
Gopher Rockfish	589	$3,770.00	0	$0.00	1,090	$2,117.00	
Grass Rockfish	12,800	$120,856.00	61	$533.00	134	$753.00	
Kelp Greenling	4	$28.00	72	$360.00	0	$0.00	
Leopard Shark	1533	$1,407.00	2430	$2,387.00	571	$622.00	
Lingcod	3,460	$10,702.00	547	$1,111.00	109	$216.00	
Moray Eel	103	$1,955.00	9	$23.00	1310	$2,839.00	

Red Rock Crab	420166	$655,072.00	2688	$4,441.00	1785	$2,767.00	
Scorpionfish	483	$1,039.00	7,894	$40,451.00	68	$220.00	
Spiny Lobster	298081	$4,711,014.00	277069	$4,381,651.00	300786	$4,653,546.00	
Splitnose Rockfish	10	$0.00	203	$731.00	409	$421.00	
Worms (invertebrate unspecified)	0	$0.00	0	$0.00	0	$0.00	
							TOTALS
Total lbs	872755		369809		328934		**1,571,498**
Total$		$6,185,832.00		$4,646,989.00		$4,763,085.00	**$15,595,906.00**
2011	SB		LA		SD		
	lbs	US$	lbs	US$	lbs	US$	
Dungeness crab	1562	$4,668.00	0	$0.00	0	$0.00	
Bat Ray	0	$0.00	5605	$56.00	2878	$1,506.00	
Black Rockfish	0	$0.00	2	$10.00	0	$0.00	
Black-and-Yellow Rockfish	142	$1,017.00	0	$0.00	0	$0.00	
Blue Rockfish	53	$87.00	0	$0.00	0	$0.00	
Brown Rockfish	471	$2,861.00	2	$11.00	772	$3,781.00	
Cabezon	10,487	$69,453.00	450	$2,761.00	849	$4,770.00	
California Barracuda	9842	$5,952.00	65996	$46,067.00	1157	$762.00	
California Halibut	142894	$702,529.00	39646	$202,260.00	12923	$52,471.00	
Copper Rockfish	2702	$17,521.00	122	$369.00	59	$172.00	

English Sole	728	$728.00	0	$0.00	0	$0.00	
Gopher Rockfish	856	$5,651.00	4	$22.00	106	$419.00	
Grass Rockfish	10,205	$99,475.00	6	$49.00	41	$225.00	
Kelp Greenling	1	$11.00	0	$0.00	0	$0.00	
Leopard Shark	1508	$1,607.00	2239	$2,093.00	192	$222.00	
Lingcod	2,000	$6,705.00	445	$1,007.00	142	$336.00	
Moray Eel	779	$449.00	5	$0.00	524	$1,999.00	
Red Rock Crab	286289	$413,683.00	1654	$1,973.00	8484	$11,238.00	
Scorpionfish	129	$175.00	9,761	$37,773.00	123	$359.00	
Spiny Lobster	247583	$4,273,660.00	238983	$4,146,418.00	264509	$4,490,127.00	
Splitnose Rockfish	71	$76.00	0	$0.00	103	$103.00	
Worms (invertebrate unspecified)	0	$0.00	0	$0.00	0	$0.00	
							TOTALS
Total lbs	718302		364920		292862		**1,376,084**
Total$		$5,606,308.00		$4,440,869.00		$4,568,490.00	**$14,615,667.00**
2010	SB		LA		SD		
	lbs	US$	lbs	US$	lbs	US$	
Dungeness crab	1707	$5,100.00	0	$0.00	0	$0.00	
Bat Ray	131	$0.00	8989	$124.00	4791	$4,662.00	
Black Rockfish	0	$0.00	0	$0.00	0	$0.00	
Black-and-Yellow	706	$4,916.00	0	$0.00	0	$0.00	

Rockfish							
Blue Rockfish	83	$212.00	0	$0.00	0	$0.00	
Brown Rockfish	167	$1,151.00	0	$0.00	422	$1,834.00	
Cabezon	9,355	$57,392.00	178	$1,064.00	930	$5,058.00	
California Barracuda	3460	$1,559.00	36663	$24,400.00	1324	$1,103.00	
California Halibut	180360	$847,890.00	38380	$184,111.00	14316	$59,712.00	
Copper Rockfish	2839	$19,176.00	0	$0.00	97	$278.00	
English Sole	0	$0.00	0	$0.00	0	$0.00	
Gopher Rockfish	1,358	$8,268.00	4	$8.00	94	$374.00	
Grass Rockfish	13,829	$129,952.00	45	$361.00	73	$398.00	
Kelp Greenling	14	$48.00	0	$0.00	0	$0.00	
Leopard Shark	1205	$1,567.00	1730	$1,520.00	561	$329.00	
Lingcod	2,522	$7,534.00	294	$776.00	185	$692.00	
Moray Eel	3	$18.00	10	$60.00	3943	$15,366.00	
Red Rock Crab	222260	$317,000.00	1742	$4,653.00	778	$557.00	
Scorpionfish	135	$305.00	6,867	$25,304.00	282	$925.00	
Spiny Lobster	270643	$4,301,241.00	220681	$3,466,564.00	224382	$3,569,793.00	
Splitnose Rockfish	16	$20.00	0	$0.00	12	$12.00	
Worms (invertebrate unspecified)	0	$0.00	0	$0.00	22	$22.00	
							TOTALS
Total lbs	710793		315583		252212		**1,278,588**

Total$		$5,703,349.00	$3,708,945.00		$3,661,115.00	**$13,073,409.00**

Appendix I: Additional Literature for Valuation of Ecosystem Services

Shoreline Stabilization and Erosion Control	
#	Full Citation
1	Rust, M. (2014). Living Shoreline Implementation: Challenges and Solutions. Rivers & Coast, 9(2).
2	Chesapeake Bay Foundation. (2007). Living Shorelines: For the Chesapeake Bay Watershed. National Fish and Wildlife Foundation, 1–12.
Water Quality - Pollution Buffering and Wastewater	
#	Full Citation
1	De Groot, R. S., Wilson, M. A., & Boumans, R. M. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological economics, 41(3), 393-408
2	Batker, D., Christin, Z., Graf, W., Jones, K. B., Loomis, J., Cooley, C., & Pittman, J. (2014). Nature's value in the Colorado River Basin.
3	Breaux, A., Farber, S., & Day, J. (1995). Using natural coastal wetlands systems for wastewater treatment: an economic benefit analysis. Journal of environmental management, 44(3), 285-291
4	Brenner, J., Jiménez, J. A., Sardá, R., & Garola, A. (2010). An assessment of the non-market value of the ecosystem services provided by the Catalan coastal zone, Spain. Ocean & Coastal Management, 53(1), 27–38. Retrieved from http://www.sciencedirect.com/science/article/pii/S0964569109001422
5	Wilson, S. J. (2010). Natural capital in BC's Lower Mainland: valuing the benefits from nature. David Suzuki Foundation.
Biological and Pest Control	
#	Full Citation
1	Brenner-Guillermo, J. (2007). Valuation of ecosystem services in the Catalan coastal zone. Marine Sciences, Polytechnic University of Catalonia.
Water Supply	
#	Full Citation
1	Camacho-Valdez, V., Ruiz-Luna, A., Ghermandi, A., & Nunes, P. A. (2013). Valuation of ecosystem services provided by coastal wetlands in northwest Mexico. Ocean & Coastal Management, 78, 1-11.
2	Costanza, R., d'Arge, R., de Groot, R., Farberk, S., Grasso, M., Hannon, B., ... & Raskin, R. G. (1997). The value of the world's ecosystem services and natural capital. NATURE, 387, 253.
Flood and Storm Protection	
#	Full Citation
1	Feagin, R. A., M. Luisa Martinez, G. Mendoza-Gonzalez, and R. Costanza. 2010.
2	Thibodeau, F.R., Ostro, B.D. 1981
3	Batker, D., Christin, Z., Graf, W., Jones, K. B., Loomis, J., Cooley, C., & Pittman, J.

	(2014). Nature's value in the Colorado River Basin.
4	Woodward, R. T., & Wui, Y. S. (2001). The economic value of wetland services: a meta-analysis. Ecological economics, 37(2), 257-270.
Education	
#	Full Citation
1	EPA. (2015). Ballona Wetlands Foundation. Profiles of Environmental Education Grants Awarded to Organizations in California. Retrieved from http://www.epa.gov/education/profiles-environmental-education-grants-awarded-organizations-california
2	Coal Oil Point Reserve. (n.d.). Coal Oil Point Reserve- Grant Runding. Retrieved from http://coaloilpoint.ucnrs.org/Funding.html
3	Bolsa Chica Land Trust. (2015). Bolsa Chica Land Trust Newsletter 119, 7. Retrieved from http://bclandtrust.org/wp-content/uploads/2015/12/BCLT_Fall-Final.pdf
Noise Reduction (Not Valued)	
#	Full Citation
1	Bolund, P., & Hunhammar, S. (1999). Ecosystem services in urban areas. Ecological Economics, 29(2), 293–301. Retrieved from http://www.sciencedirect.com/science/article/pii/S0921800999000130
Microclimate Regulation (Not Valued)	
#	Full Citation
1	Batker, D., Christin, Z., Cooley, C., Graf, W., Jones, K. B., Loomis, J., & Pittman, J. (2014, July 1). Nature's value in the Colorado River basin. Tacoma. Retrieved from http://bibliotecavirtual.minam.gob.pe:8080/biam/handle/minam/1833
2	Bolund, P., & Hunhammar, S. (1999). Ecosystem services in urban areas.Ecological economics, 29(2), 293-301.
3	Brenner, J., Jiménez, J. A., Sardá, R., & Garola, A. (2010). An assessment of the non-market value of the ecosystem services provided by the Catalan coastal zone, Spain. Ocean & Coastal Management, 53(1), 27–38. Retrieved from http://www.sciencedirect.com/science/article/pii/S0964569109001422
4	de Groot, R. S., Wilson, M. A., & Boumans, R. M. . (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological Economics, 41(3), 393–408. Retrieved from http://www.sciencedirect.com/science/article/pii/S0921800902000897
5	Seidl, A. F., & Moraes, A. S. (2000). Global valuation of ecosystem services: application to the Pantanal da Nhecolandia, Brazil. Ecological economics, 33(1), 1-6.
Nutrient Cycling	
#	Full Citation
1	Brenner, J., Jiménez, J. A., Sardá, R., & Garola, A. (2010). An assessment of the non-market value of the ecosystem services provided by the Catalan coastal zone, Spain. Ocean & Coastal Management, 53(1), 27-38
2	Yoskowitz, D., Kim, H. C., & Montagna, P. A. (2012). Role and value of nitrogen regulation provided by oysters (Crassostrea virginica) in the Mission-Aransas Estuary, Texas, USA. PloS one, 8(6), e65314-e65314.
3	Costanza, R., d'Arge, R., de Groot, R., Farberk, S., Grasso, M., Hannon, B., ... & Raskin, R. G. (1997). The value of the world's ecosystem services and natural capital. NATURE, 387, 253.

4	De Groot, R. S., Wilson, M. A., & Boumans, R. M. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological economics, 41(3), 393-408
Nitrogen Sequestration	
#	Full Citation
1	Capone, D. G. (1982). Nitrogen fixation (acetylene reduction) by rhizosphere sediments of the eelgrass Zostera marina. Marine ecology progress series.
2	Welsh, D. T., Bartoli, M., Nizzoli, D., Castaldelli, G., Riou, S. A., & Viaroli, P. (2000). Denitrification, nitrogen fixation, community primary productivity and inorganic-N and oxygen fluxes in an intertidal Zostera noltii meadow. Marine Ecology Progress Series, 208(5).
3	Marsho, T. V., Burchard, R. P., & Fleming, R. (1975). Nitrogen fixation in the Rhode River estuary of Chesapeake Bay. Canadian journal of microbiology, 21(9), 1348-1356.
4	Cook, PLM, Revill, AT, Butler, ECV & Eyre, BD 2004, 'Carbon and nitrogen cycling on intertidal mudflats of a temperate Australian estuary: II. Nitrogen cycling', Marine Ecology Progress Series, vol. 280, pp. 39-54
1	DeLaune, R. D., Smith, C. J., & Sarafyan, M. N.. (1986). Nitrogen Cycling in a Freshwater Marsh of Panicum Hemitomon on the Deltaic Plain of the Mississippi River. Journal of Ecology, 74(1), 249–256
2	Sobota, D. J., Compton, J. E., McCrackin, M. L., & Singh, S. (2015). Cost of reactive nitrogen release from human activities to the environment in the United States. Environmental Research Letters, 10(2), 025006.
Cultural Activities	
#	Full Citation
1	Raheem, N., Lopez, R. D., & Talberth, J. (2009). The economic value of coastal ecosystems in California. US Environmental Protection Agency, Office of Research and Development.
Aesthetic	
#	Full Citation
1	De Groot, R. S., Wilson, M. A., & Boumans, R. M. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological economics, 41(3), 393-408
Ornamental Resources	
#	Full Citation
1	De Groot, R. S., Wilson, M. A., & Boumans, R. M. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological economics, 41(3), 393-408

Additional Literature for Habitats for Carbon Sequestration
Salt Marsh
A Nicholas Institute Report on State of the Science on Coastal Blue Carbon looked at a total of six observation for sequestration and storage rates of Salt Marsh for California (Sifleet 2011). One of the observations was of the Southern California Ballona wetland. The related paper noted that sequestration rates were much higher at this site than in salt marshes of more northern study sites along the Pacific coast (Brevik 2004). Luisetti assumed linear relation

between saltmarsh area and carbon sequestration (Luisetti 2014).The range of values was taken from the following:

Chmura, G.L., et al. 2003. Global carbon sequestration in tidal, saline wetland soils. Global Biogeochemical Cycles 17(4):1–12

Brevik, E.C. and J.A. Homburg. 2004. A 5000-year record of carbon sequestration from a coastal lagoon and wetland complex, Southern California, USA. Catena 57: 221–232

Patrick, W.H.J. and R.D. DeLuane. 1990. Subsidence, accretion, and sea-level rise in south San Fransisco Bay marshes. Limnology and Oceanography 35:1389–1395

Seagrass

The Nicholas Institute Report on State of the Science on Coastal Blue Carbon did not have specific studies for California for seagrass, so instead the rates for Spain, a similar temperate Mediterranean climate, were used:

Cebrian, J. 2002. Variability and control of carbon consumption, export, and accumulation in marine communities. Limnology and Oceanography 47(1):11–22.

Duarte, C.M., et al. 2101. Seagrass community metabolism: Assessing the carbon sink capacity of seagrass meadows. Global Biogeochemical Cycles 24(GB4032):1–8. Mateo, M.A., et al., Dynamics of millenary organic deposits resulting from the growth of the mediterranean seagrass Posidonia oceanica. Estuarine Coastal and Shelf Science 44:103–110.

Romero, J., et al. 1994. The belowground organs of the Mediterranean seagrass Posidonia oceanica as a biogeochemical sink. Aquatic Botany 47:13–19.

Lo Iacono, C., et al. 2008. Very high-resolution seismo-acoustic imaging of seagrass meadows (Mediterranean Sea): Implications for carbon sink estimates. Geophysical Research Letters 35:L18601.

Gazeau, F., et al. 2005. Whole-system metabolism and CO2 fluxes in a Mediterranean Bay dominated by seagrass beds (Palma Bay, NW Mediterranean). Biogeosciences 2:43–60

Holmer, M., et al. 2004. Carbon cycling and bacterial carbon sources in pristine and impacted Mediterranean seagrass sediments. Aquatic Microbial Ecology 36(3):227–237.

Cebrian, J., et al. 2000. Fate and production of the seagrass Cymodocea nodosa in different stages of meadow formation. Marine Ecology Progress Series 204:119–130.

Odum, H.T. 1963. Productivity measurements in Texas turtle grass and the effects of dredging an intracoastal channel. Institute of Marine Science of the University of Texas 6:48–58

Dunes

Based on data from temperate dune system in the UK over a 140 year period, Though the climate between Southern California and the UK differs, the processes of dry dune habitat for carbon sequestration are considered to be appropriately transferable due to the similar soil composition, patchy vegetation and the mobility expressed by both dune systems. To avoid over-counting and considering the differences in temperature and productivity between the two regions, wet dune sequestration rates were not included.

Jones, M. L. M., Sowerby, A., Williams, D. L., & Jones, R. E. (2008). Factors controlling soil development in sand dunes: evidence from a coastal dune soil chronosequence. Plant and Soil, 307(1-2), 219-234.

Appendix J: Contingent Valuation Survey Instrument

Southern California Wetlands Survey

The information gathered by this survey is for a Master's thesis project and will provide insight on how California residents value natural areas. The data will be collected anonymously. We greatly appreciate your participation.

Question 1

- How often do you think about the environment?
- Never
- Rarely (Only when environmental issues are major news stories)
- Sometimes (when it's brought to my attention)
- Often (I seek out information on environmental issues)

Upon thinking about the Southern California landscape the first thing that comes to mind is usually a dry arid landscape, which has been intensified by the drought. However, what many people are unaware of is along the coast, southern California has a large collection of wetland ecosystems. These wetland ecosystems include popular locations such as Malibu Lagoon, the Ballona Wetlands just south of Marina del Rey in Los Angeles, and Batiquitos Lagoon in Carlsbad, just to name a few. In total there are 331 coastal wetland systems, along the Southern California coast, from Point Conception (between Santa Barbara and San Luis Obispo) to the US-Mexico border. Map shaded area does not represent acreage of Southern California coastal wetlands. It is merely intended to represent the general study area.

These wetlands include landscapes such as beaches and sandy dunes, marshes, lagoons, rivers, streams and mud and salt flats. They provide a wide range of benefits and services to humans, including flood protection, water filtration, food, aesthetic open space, and recreational opportunities. These wetlands also provide unique and critical habitat to plants and animals, many of which are threatened or endangered species, such as the Southern California Steelhead Trout, the Western Snowy Plover and the Light-Footed Clapper Rail.

Question 2

When answering the following questions please keep in mind California's coastal wetlands. People have differing opinions about coastal wetland habitats. Some people see coastal wetlands in terms of marshes or bogs that should be developed for more useful purposes. Others believe coastal wetlands are beneficial to the community because they provide opportunities for recreation (i.e. fishing, bird watching), are beautiful to look at, enhance water quality and reduce storm surge. Below are some common reasons people have stated that wetlands are important to them. Please state how each is important to you from Not Important to Very Important.

How often do you participate in the following activities in wetland areas?

	Never	Less than once a month	Once a month	Once a week	Multiple times a week	Daily	N/A
Walking/Hiking	❍	❍	❍	❍	❍	❍	❍
Beach-going	❍	❍	❍	❍	❍	❍	❍
Picnicking	❍	❍	❍	❍	❍	❍	❍
Science/Research	❍	❍	❍	❍	❍	❍	❍
Educational Trips	❍	❍	❍	❍	❍	❍	❍
Photography	❍	❍	❍	❍	❍	❍	❍
Bird Watching	❍	❍	❍	❍	❍	❍	❍

Question 3

People have differing opinions about coastal wetland habitats. Some people see coastal wetlands in terms of marshes or bogs that should be developed for more useful purposes. Others believe coastal wetlands are beneficial to the community because they provide opportunities for recreation (i.e. fishing, bird watching), are beautiful to look at, they enhance water quality and reduce storm surge.

Below are some common reasons people have stated that wetlands are important to them. Please state how each is important to you from Not Important to Very Important.

	Not Important	Slightly Important	Moderately Important	Important	Very Important
They provide recreational opportunities (i.e. bird watching, beach-going)	❍	❍	❍	❍	❍
They provide protection to plants and animals	❍	❍	❍	❍	❍
They have intrinsic value even if I do not directly benefit	❍	❍	❍	❍	❍
They have value because of their beauty	❍	❍	❍	❍	❍
They have value because of the open space they provide	❍	❍	❍	❍	❍
They enhance air quality	❍	❍	❍	❍	❍
They reduce flooding during storms	❍	❍	❍	❍	❍
They enhance water quality	❍	❍	❍	❍	❍

While the physical area of wetlands is currently protected under both federal and state law, the quality of the wetlands is not protected. Wetlands all along the Southern California coast are being degraded from human activities such as urban drainage, agricultural runoff, and storm water runoff. As wetlands become degraded they lose their ability to provide benefits such as water filtration, carbon sequestration and habitat for terrestrial and aquatic species. Additionally, pollution can increase the chances of invasive species taking over wetlands, decreasing their ability to provide the same benefits. Consider the following hypothetical scenario: To protect Southern California's coastal wetlands, a tax applied to all California citizens will be added to your annual income taxes. The money collected from the tax will go directly to a local land trust, which has developed an active monitoring program that will observe and maintain the quality of all Southern California coastal wetlands. This increase on your annual income taxes is to help enhance and sustain the health of these wetlands for the benefit of present and future generations. If this tax is not enforced, the physical area of these wetlands will still be preserved, though the quality is not guaranteed. For the following questions please provide your preferred responses even if you are unsure.

Question 4

If the increase in taxes will be $35 per year would you support this program?

- o Yes
- o No

Question 5a (If answer to question 4 was "Yes")

What is the primary reason you support this new program?

- o The program is worth at least this much
- o I think it is our duty to protect natural wetland environments against degradation
- o I want to contribute to a good cause
- o To pay fair share to protect services provided

Question 5b (If answer to question 4 was "No")

What is the primary reason you DO NOT support this program?

- o The policy is not worth anything/not important to me
- o I do not think this policy would be effective
- o I think current level of maintenance is sufficient
- o I do not think that I should be responsible for funding this program
- o Degradation due to human activity is inevitable
- o I am on a limited budget

Question 6 (If answer to question 4 was "Yes")
If the increase in taxes will be $45 per year would you support this program?

- Yes
- No

Question 7a (If answer to question 6 was "Yes")
What is the primary reason you support this new program?

- The program is worth at least this much
- I think it is our duty to protect natural wetland environments against degradation
- I want to contribute to a good cause
- To pay fair share to protect services provided

Question 7b (If answer to question 6 was "No")
What is the primary reason you DO NOT support this program?

- The policy is not worth anything/not important to me
- I do not think this policy would be effective
- I think current level of maintenance is sufficient
- I do not think that I should be responsible for funding this program
- Degradation due to human activity is inevitable
- I am on a limited budget

Question 8 (If answer to question 4 was "No")
If the increase in taxes will be $25 per year would you support this program?

- Yes
- No

Question 9a (If answer to question 8 was "Yes")
What is the primary reason you support this new program?

- The program is worth at least this much
- I think it is our duty to protect natural wetland environments against degradation
- I want to contribute to a good cause
- To pay fair share to protect services provided

Question 9b (If answer to question 8 was "No")
What is the primary reason you DO NOT support this program?

- The policy is not worth anything/not important to me
- I do not think this policy would be effective
- I think current level of maintenance is sufficient
- I do not think that I should be responsible for this funding this program
- Degradation due to human activity is inevitable
- I am on a limited budget

Question 10
What is the maximum you would be willing to pay per year to protect Southern California's Wetlands? (Please use whole dollar values: for example 1, 20, 100, 7,000)

(OPEN ENDED QUESTION)

Demographic Information Questions
This information is for statistical purpose only and is completely anonymous

Please specify your gender

- Male
- Female
- Prefer not to answer

How old are you?

- 18-24
- 25-30
- 31-40
- 41-50
- 51-60
- 61-70
- Older than 70

How far away from the coast of Southern California do you live? (Please indicate your distance in number of miles using a whole number)

(OPEN ENDED QUESTION)

What is your zip code?

(OPEN ENDED QUESTION)

Are you a registered voter?
- o Yes
- o No

How many times have visited southern California coastal wetlands? (e.g. Tijuana Estuary, Goleta Slough, Ballona Wetlands, Ormond Beach, etc.)
- o 0 Visits
- o 1-10 Visits
- o Over 10 Visits

Please check the level of education you have successfully completed.
- o Elementary School
- o High School
- o Some College
- o College Degree
- o Masters/Professional Degree
- o Law/Doctorate Degree

About how much was your household income in 2014
- o Less than $20,000
- o $20,000 to $40,000
- o $40,000 to $60,000
- o $60,000 to $80,000
- o $80,000 to $100,000
- o $100,000 to $120,000
- o $120,000 to $150,000
- o Greater than $150,000
- o Prefer not to answer

Thank you for participating in our survey! If you would like more information about our thesis work please visit our website http://bren-ucsb.wix.com/socalwetlands or email us @ socalwetlands@lists.bren.ucsb