The Wealth of Wetlands

An Economic Valuation of San Diego's Dynamic Edge

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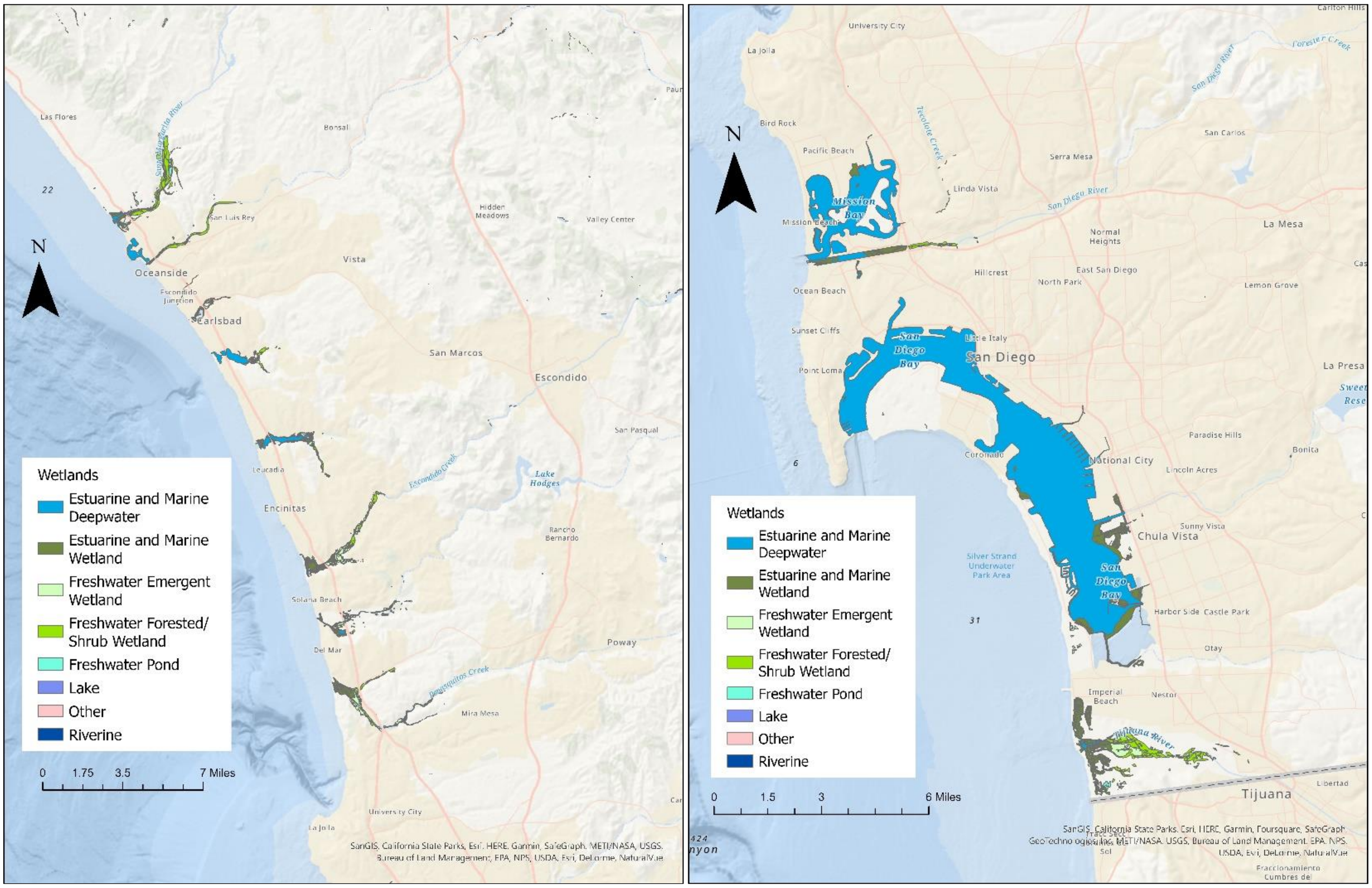
Table of Contents

Abstract
Coastal wetlands in San Diego County have experienced a significant decline in their extent over the past century due to erosion, sea-level rise, and development. Understanding the historical and current conditions of these wetlands is essential for effective management and restoration efforts. Furthermore, assessing the economic value of the ecosystem services provided by these wetlands is crucial for making informed decisions regarding their conservation and restoration. This paper presents a detailed valuation of two ecosystem services provided by San Diego County wetlands: nursery habitats for California halibut and carbon sequestration through blue carbon ecosystems. The valuation is based on existing scientific literature and government reports, and a Monte Carlo simulation is employed to account for the uncertainties associated with the complex and dynamic nature of coastal wetlands. The results indicate that these wetlands provide substantial economic benefits to the California halibut commercial fishery, valued at almost $998 thousand annually. The net present value analysis suggests that these wetlands could generate over $30.7 million in net benefits to the commercial fishery through the end of the century, assuming the habitats remain intact. Additionally, the wetlands contribute almost $5 million annually in natural capital through the production of juvenile California halibut. Utilizing a social cost of carbon value of $120/metric ton of CO_2, local eelgrass beds, salt marshes, and mudflats are valued at over $1.6 million annually, with over 50% coming from eelgrass beds. The net present value analysis suggests that these wetlands could generate over $50 million in net benefits via carbon sequestration through the end of the century, assuming the habitats remain intact. This detailed valuation approach provides valuable information for policymakers and the public, facilitating better decision-making and increased awareness of the importance of protecting and restoring coastal wetland ecosystems for their ecological and economic contributions.

Introduction
In the 1800s, there were approximately 11,000 hectares of estuarine ecosystems in San Diego County, including salt marsh, mudflats, and subtidal waters [1]. Since then, there has been an approximate 31% decline and loss of these ecosystems due to erosion, development, and sea-level rise [1]. The current list of major coastal wetlands in San Diego County includes:

San Diego County
- Santa Margarita Lagoon
- San Luis Rey Lagoon
- Loma Alta Slough
- Buena Vista Lagoon
- Agua Hedionda Lagoon
- Batiquitos Lagoon
- San Elijo Lagoon
- San Dieguito Lagoon
- Los Penasquitos Lagoon
- Mission Bay
  - Kendall-Frost Marsh Reserve
  - Northern Wildlife Preserve
- Famosa Slough
- South San Diego Bay
  - San Diego National Wildlife Refuge
- Tijuana River Estuary



Map of San Diego Wetlands – Left, North County | Right, South County [2]

Knowledge of historical and current coastal wetland conditions offers a baseline and can inform future management decisions for natural resources [1]. This understanding of wetland extent and historical threats, however, is only part of the story. To efficiently manage natural resources and determine restoration priorities, determining the value of the services these ecological systems provide is critical [3]. Coastal wetlands provide immense economic benefits through ecosystem services. These services include carbon sequestration via marsh plants, habitat for commercial and recreationally important fish species, increased property value, protection from sea-level rise, enhanced water quality through sediment removal, and a vast array of tourism opportunities. These essential services not only help sustain human life, but also provide habitat to countless marine species of birds, fish, invertebrates, and plants [4].

Ecosystem Services – Role in Conservation Management

"*Life on earth can't exist without ecosystem services, which makes their value infinite* [5]." This powerful quote from The Sustainable Economy by Robert S. Devine highlights a United Nations valuation report of the world's ecosystems and the human dependence on the services it provides. However, despite the pricelessness of our natural world, these resources are depleted or degraded for goods and services that can be bought and sold in a free market economy. Ecosystem services are commonly considered public goods or common pool resources, including examples like clean air and healthy fish stocks [6]. These services, however, are not included in conventional markets and therefore are not commonly associated with the costs and benefits associated with economic development.

An optimal balance of conservation and development is needed to sustain our way of life while ensuring enough resources for future generations. To aid in this system of trade-offs, many studies have provided non-market valuation methods for the services provided by distinctive biomes. For example, coastal estuaries and seagrass beds were globally estimated to provide $28,916 each in services per hectare per year [7]. Wetlands, which included tidal marsh, mangroves, swamps, and floodplains, were estimated to provide $140,174 per hectare per year in 2011. This was almost $120 thousand higher than the previous 1997 estimate [7].

For example, if a commercial real estate company were to fill a few hectares of wetland to build a new office complex or retail center, those ecosystem service benefits would be lost, along with the fish and wildlife that inhabited the area. This is not to say that no building should ever be constructed. We can afford the trade-off of some natural capital for the benefit of social capital, but an optimal balance between having the wetlands' ecosystem services and commercial spaces, in this example, is needed for all of us to live on this earth sustainably [5, 7].

Global to regional value aggregation methods for wetlands are beneficial for raising public awareness and assessing changes in natural capital [7]. However, to advocate for local policy development and restoration projects, a detailed valuation that includes specific, dynamic complexities for local areas must be implemented for known ecosystem services. This method can reduce variability associated with global estimates, account for additional services, and help conserve coastal wetland resources more efficiently. Assigning monetary values to ecosystem services is not meant to be perceived as commoditizing or as a way to privatize these habitats but instead to serve as a powerful communication tool for a broad, multidisciplinary audience [5].

San Diego Wetlands – A Detailed Valuation

Although the destruction of wetlands in San Diego County has slowed and restoration is becoming a widespread goal, they are continuously threatened by increased human population and development opportunities for residential and commercial infrastructure that provide economic profit to the coastal cities and stakeholder corporations [8]. These coastal wetlands also face habitat degradation due to pollution and sea-level rise. To promote awareness of wetland ecosystem services and encourage the public and policymakers to protect and restore these ecosystems, a spatially explicit valuation for two services was conducted. This approach could better quantify the benefits of restoration and support the costs associated with management. These services include nursery habitats for California halibut, a commercially important species for Southern California, and carbon sequestration from blue carbon ecosystems.

Data Analysis Methods and Limitations

These ecosystem service valuations are based on existing scientific, peer-reviewed literature and government reports. Habitat areas are an approximation, based on available data and publications. This is due to the lack of site-specific, updated, sub-habitat area sizes (mudflats, salt marshes, eelgrass beds, subtidal) of the coastal wetlands studied. Once the formula and corresponding values were determined for each study area, a Monte Carlo simulation was run through R Studio. This method deals with uncertainty by allowing big assumptions to fall within a reasonable and acceptable range of values [9].

Due to the highly complex and dynamic nature of coastal wetlands, there is a range of potential values these services can provide each year. To account for this ambiguity, the Monte Carlo analysis method selects a random value from each specified parameter range ten thousand times to generate a probability distribution where the average (mean) is selected [9]. These estimates are not the only way to value ecosystem services and is one approach to providing supporting data for wetland restoration.

```r
monte <- data.frame(NB_carbon = as.numeric(), Annual_carbon = as.numeric(),
                    NB_fish = as.numeric(), Annual_fish = as.numeric(),
                    total_fish = as.numeric())
#CA Halibut Habitat Area (hectares) by location, high tide and low tide
AH = 89.45
Bat = 108.5
Sel = 34
SDL = 32.3
Pen = 11.05
SDBay = 4345.5
MB = 882.2
TJ = 28.5

ST_hectares <- TJ #ST: Subtidal is suitable halibut habitat
discount_rate <- .03 #NOAA has adopted a 3.0 percent discount rate

    for(i in 1:10000){
      #Halibut Parameters
      juveniles_halibut <- rtri(1,
                                min = 198.7,
                                max = 1450.7,
                                mode = (198.7 + 1450.7)/2)
      survival_halibut <- .4416 #Calculated from life table tab in spreadsheet
      catch_rate_halibut <- runif(1,.1,.3) #Best estimate of fishing mortality
      price_halibut <- rtri(1, #average price from each port in San Diego County
                            min = 3.92,
                            max = 8.52,
                            mode = (5.89 + 5.35 + 4.09 + 8.52 + 5.66 + 6.02 +
                                    5.65 + 4.38 + 5.59 + 4.12 + 5.31 + 5.53 +
                                    4.38 + 3.92)/14)
      weight_halibut <- 3.5 #average weight at 22-inches

      #Creating data frame
      monte[i,] <- 0 #NPV of the project
      for(j in 0:76){ #0 to 76 represents 2023(today) to 2100
        discount_factor <- (1/(1+as.numeric(discount_rate))^j)
        PV_fish <- ((ST_hectares*juveniles_halibut*survival_halibut*
                       weight_halibut*catch_rate_halibut*price_halibut))*
                    discount_factor
        Annual_fish <- (ST_hectares*juveniles_halibut*survival_halibut*
                          weight_halibut*catch_rate_halibut*price_halibut)
        total_fish <- (ST_hectares*juveniles_halibut*survival_halibut*
                         weight_halibut*price_halibut)
        monte[i,3] <- monte[i,3] + PV_fish
        monte[i,4] <- Annual_fish
        monte[i,5] <- total_fish
      }
    }

#Get mean and standard deviation
mean(monte$Annual_fish)
sd(monte$Annual_fish)

mean(monte$NB_fish)
sd(monte$NB_fish)

mean(monte$total_fish)
sd(monte$total_fish)
```

```r
monte <- data.frame(NB_carbon = as.numeric(), Annual_carbon = as.numeric())

#change values as needed
U_acres <- 0 #U: Upland
T_acres <- 0 #T: Transitional
MHSM_acres <- 0 #MHSM: Global Salt Marsh
LSM_acres <- 5 #LSM: Local Salt Marsh
MF_acres <- 0 #MF: Mudflat
ST_hectares <- 0 #ST: Subtidal
EG_acres <- 0  #EG: Eel grass
B_acres <- 0 #B: Beach

discount_rate <- .03

for(i in 1:10000){
      #Total Carbon Sequestered
      U_storage <- 0 * U_acres
      T_storage <- 0 * T_acres
      MHSM_storage <- rtri(1, min = 1.58, max = 12.58, mode = 7.08) * MHSM_acres
      LSM_storage <- rtri(1, min = 1.755, max = 2.873, mode = 2.314) * LSM_acres
      MF_storage <- rtri(1, min = 4.756, max = 8.062, mode = 6.409) * MF_acres
      ST_storage <- 0 * ST_hectares
      EG_storage <- rtri(1, min = 3.041, max = 5.057, mode = 4.049) * EG_acres
      B_storage <- 0 * B_acres

      #SCC Values: 26, 51, 76, 120, 185, 417
      carbon_price <- 417

      #Creating data frame
      monte[i,] <- 0 #NPV of the project

      for(j in 0:76){ #0 to 76 represents 2023 to 2100
        discount_factor <- (1/(1+as.numeric(discount_rate))^j)
        PV_carbon <- (U_storage + T_storage + MHSM_storage + LSM_storage +
                        B_storage + MF_storage + ST_storage + EG_storage)*
          as.numeric(carbon_price)*discount_factor
        Annual_Carbon <- (U_storage + T_storage + MHSM_storage + LSM_storage +
                            B_storage + MF_storage + ST_storage + EG_storage)*
          as.numeric(carbon_price)
        monte[i,1] <- monte[i,1] + PV_carbon
        monte[i,2] <- Annual_Carbon
      }
    }

#Annual Value
min(monte$Annual_carbon)
mean(monte$Annual_carbon)
max(monte$Annual_carbon)
sd(monte$Annual_carbon)
#NPV
mean(monte$NB_carbon)
sd(monte$NB_carbon)
```

A code example (California Halibut analysis – left, Carbon sequestration analysis – right) of the Monte Carlo Method in R Studio [9].

Nursery Habitat for California Halibut

California halibut reside from Baja California, Mexico to Washington State. Most populations are found south of San Francisco, primarily from Bodega Bay, California to Magdalena Bay, Baja California [10]. This flatfish is a slow-growing, long-lived species that can reach maximum lengths of 60 inches (5 feet) and weigh up to 72 pounds [11]. Both sexes can live up to 30 years, but it is unlikely to find this species over 15 years old due to fishing and mortality [12]. Halibut have high fertility rates, especially in warmer waters, with an average offspring of 420,000 eggs [13]. The reproductive cycle begins when adult halibut come from deeper offshore water to inshore areas around 16-60 feet to spawn [11]. Fertilization is external (oviparous reproduction), where the females lay eggs on substrate, while the males release gametes into the water column [12]. When eggs hatch, larvae and post-larvae are pelagic and then settle in estuaries, lagoons, and bays for approximately one year until they reach 20 cm [12].

The California halibut then emigrates from its estuary and bay nursery habitats into deeper waters and grow to commercial size of 22 inches after about four years.

Newly hatched halibut use bays and estuaries as nurseries because these habitats provide protection and can decrease the risk of mortality [11]. Many wetlands and bays in Southern California are dredged and filled due to urban development, leading to poor environmental conditions for California halibut [10]. These conditions have contributed to the overall population decline of southern California halibut stocks.

According to a study conducted for San Diego County wetlands, California halibut density per hectare is highest in the San Elijo, Penasquitos, and Tijuana River estuaries [14]. The total halibut present in each wetland were highest in Agua Hedionda, Mission Bay, San Diego Bay, and the Tijuana River Estuary [14]. The findings from this study showed that 58% - 69% of all California halibut in San Diego County reside within protected wetlands, including bays, estuaries, and lagoons [14].

Area Type	**Agua Hedionda**	**Batiquitos**	**San Elijo**	**San Dieguito**	**Los Penasquitos**	**Mission Bay**	**San Diego Bay**	**Tijuana River**
High-tide bottom area (ha)	95	143.1	57.7	40.3	16.4	912.5	4517	40.8
Low-tide bottom area (ha)	83.9	73.9	10.3	24.3	5.7	851.9	4174	16.9
Average LT/HT (ha)	89.45	108.5	34	32.3	11.05	882.2	4345.5	28.85
2003 Halibut density (#/ha)	215.72	91.76	240.3	250.9	127.1	92.58	98.98	198.7
2004 Halibut density (#/ha)	294.85	101.84	524.4	379.4	763.2	100.83	73.17	1450.7

Halibut Density Chart in San Diego County [14].

California halibut has high commercial value, concrete data on recruitment and distribution, and information on mortality rate. Therefore, they are a great study species for wetland fish nursery habitats as an ecosystem service. To estimate the economic value of this service, several research papers and government reports were utilized. The 2006 study on juvenile California halibut density of each wetland in San Diego County provides detailed results of how many juvenile halibut reside in these habitats annually [14]. For California halibut to be commercially available for catch, they must reach 22 inches in length. Not all juveniles will survive to commercial size, so a mortality rate of 44% was applied by utilizing a life table analysis conducted in 2009 [15]. The average weight at commercial size is 3.5 pounds [12]. Fishing mortality would represent the annual fraction of California halibut commercially caught, however, there is limited data available on this subject. A probable range of 10% - 30% was used to capture the variability in the fraction caught [10, 16]. Finally, the average value of landings across the ports in San Diego County from 2017-2019 was calculated to get the average price per pound of $5.32 [9, 17]. In summary, the total annual economic value for the commercial fishery was calculated with the following formula:

*Annual Economic Benefit = Total Hectares of Specified Habitat * Juveniles per Hectare * Fraction Surviving to Adulthood * Average Weight * Fraction Caught * Ex-Vessel Value* [9]

Agua Hedionda, Batiquitos Lagoon, San Elijo Lagoon, San Dieguito Lagoon, Los Penasquitos, San Diego Bay, and the Tijuana River Estuary contain fish nursery habitats utilized in this calculation.

Location	Wetland Type	Mean Annual Commercial Fishery Landings Value (Today)	Mean NPV (Net Benefits) of Commercial Fishery Landings through 2100	Mean Annual Value of Juvenile Fish Produced by the Wetland (Today)
Agua Hedionda	Lagoon	$41,810	$1,288,062	$208,535
Batiquitos	Lagoon	$19,231	$592,468	$96,177
Mission Bay	Bay	$156,604	$4,824,580	$779,619
Penasquitos	Estuary	$8,942	$275,482	$44,900
San Diego Bay	Bay	$685,648	$21,123,176	$3,428,436
San Dieguito	Estuary	$18,646	$574,443	$93,249
San Elijo	Estuary	$23,786	$732,796	$118,969
Tijuana River	Estuary	$43,030	$1,325,646	$215,499
Total Value		$997,697	$30,736,653	$4,985,383

Summary of values for commercial fishery landings, cumulative net benefits through 2100, and natural capital value of fish produced by the studied wetlands.

The results (*Fig. 1*) showed that San Diego Bay, followed by Mission Bay, produces the most value to the California halibut fishery. The remaining locations provided an average annual commercial fishery landings value of $8,942 – $43,030 from the habitat provided. In total, these wetlands provide almost $1 million per year to the California halibut commercial fishery.

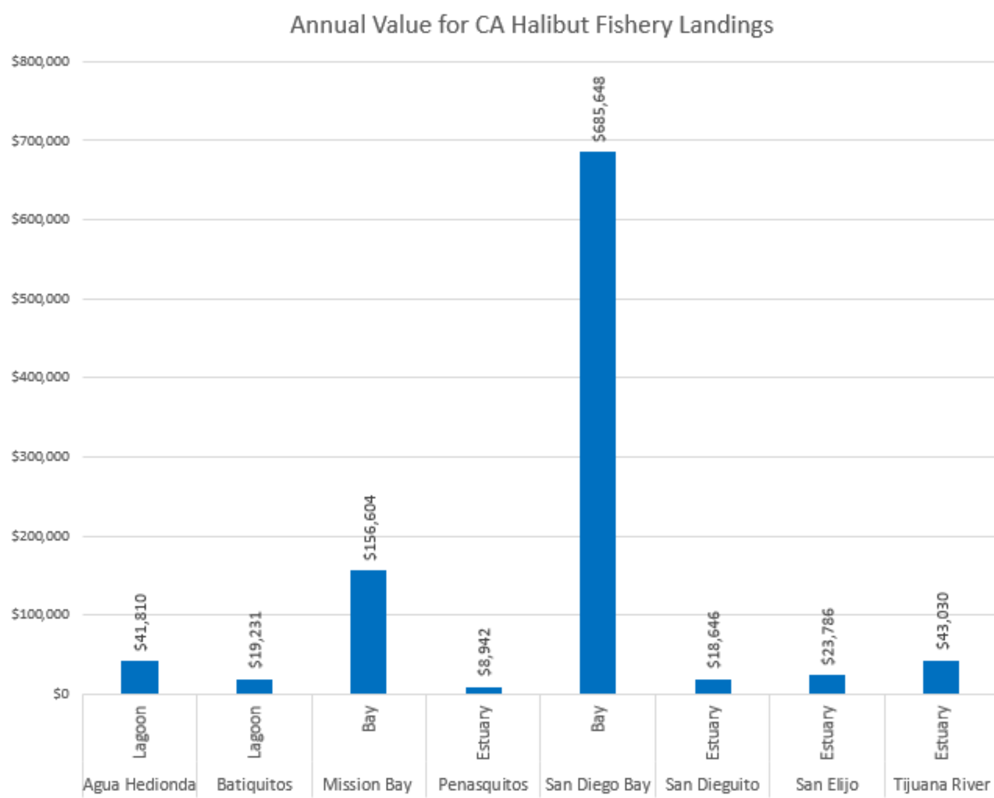


Figure 1 – Average annual benefit San Diego County wetlands provide for the California Halibut fishery.

In addition to calculating an annual value for commercial fishery landings, the net present value (NPV) from 2023 – 2100 was analyzed to determine how much value these wetlands would provide to the commercial fishery over the next 76 years at a 3% discount rate. A discount rate of 3% is a standard rate to account for the social rate of time preference when discounting restoration and assessment costs [18]. The economic value was calculated with the following formula:

Discount Factor Formula = 1 / (1 + 0.03) ^ 76

Net Economic Benefit *= ((Total Hectares of Specified Habitat * Juveniles per Hectare * Fraction Surviving to Adulthood * Average Weight * Fraction Caught * Ex-Vessel Value)) * Discount Factor* [9]

The results (*Fig. 2*) showed these wetlands could provide cumulative net benefits of over $30.7 million to the commercial California halibut fishery over the next 76 years (2023 – 2100) if the suitable wetland habitat remains of the same size and biological health.

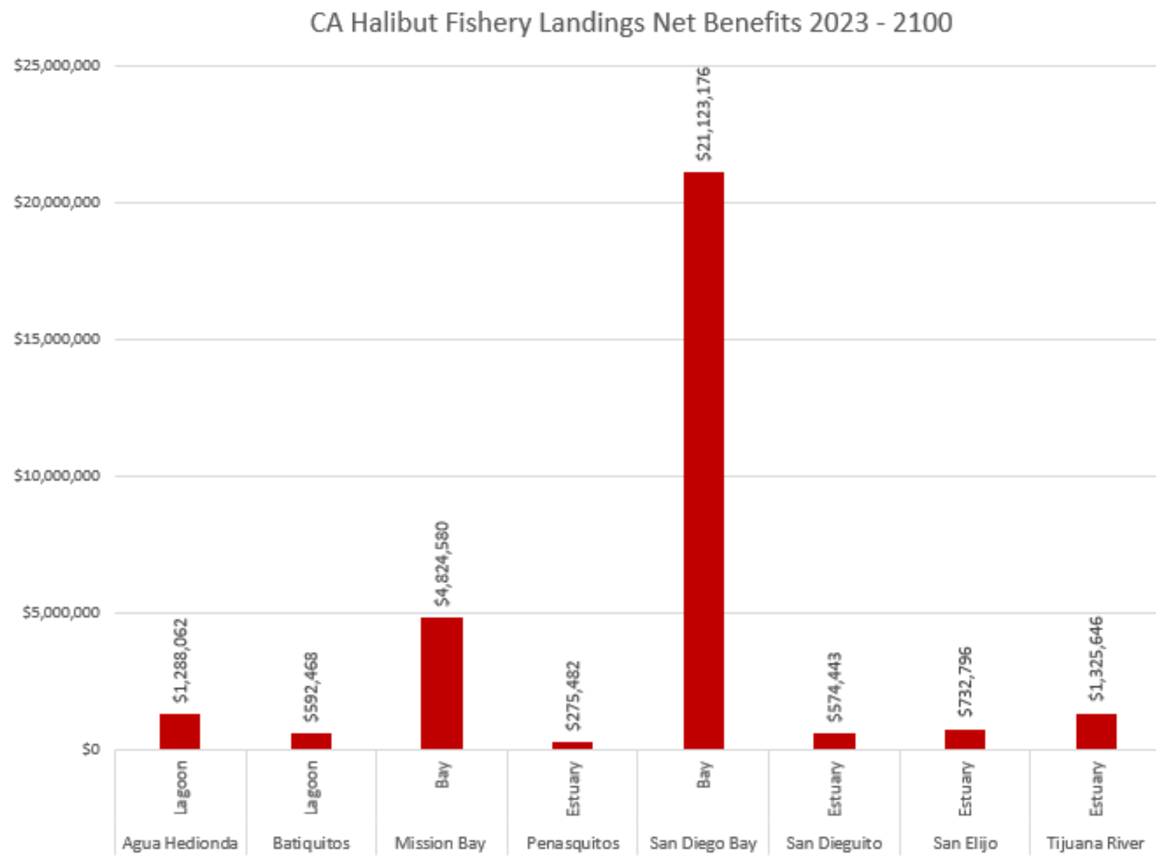


Figure 2 – Total average benefits from 2023 – 2100 San Diego County wetlands could provide for the California Halibut fishery using a 3% discount rate.

Lastly, the total commercial worth of California halibut produced by these wetlands, through the availability of critical nursery habitat, was analyzed. This is mainly an estimate of natural capital because human interaction (fishing) is needed for this resource to provide service benefits [7]. California halibut are reliant upon coastal wetland habitats for protection from predators and the availability of prey that also use these habitats for protection. These nursery habitats, including bays, estuaries, and lagoons contribute significantly to stock fitness [14]. If these habitats face degradation and loss, the corresponding halibut landings will also face a decline [10]. To calculate the natural capital of California halibut produced, *fraction caught* is removed from the original equation.

Annual Economic Benefit = *Total Hectares of Specified Habitat * Juveniles per Hectare * Fraction Surviving to Adulthood * Average Weight * Ex-Vessel Value* [9]

The results (*Fig. 3*) showed these wetlands provide almost $5 million annually of natural capital in juvenile California halibut fish production.

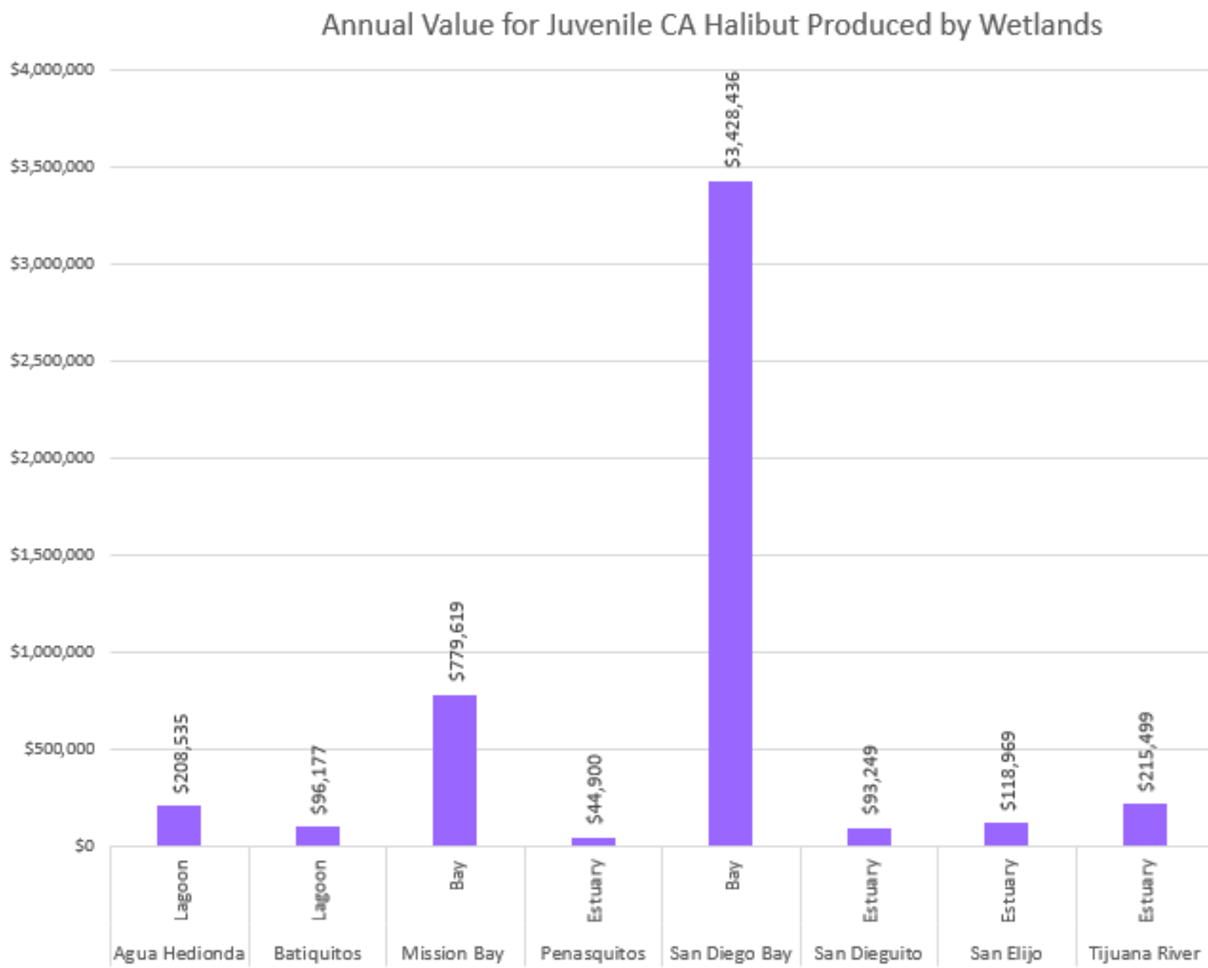


Figure 3 – Average annual natural capital San Diego County wetlands provide through the total production of juvenile California Halibut.

It is important to note that the high value San Diego Bay and Mission Bay provide as nursery habitat is mainly due to size. San Diego Bay and Mission Bay contain approximately 4,300 hectares and 880 hectares, respectively, while the estuaries and lagoons range between 6 – 108 hectares. The density of California halibut is higher within these estuaries and lagoons, therefore, the monetary value per hectare is higher than the bays. The results from this conclusion (*Fig. 4*) show that the Tijuana River Estuary, Los Penasquitos Lagoon, and San Elijo Lagoon have the highest monetary value per hectare for both commercial fishery landings and juvenile halibut produced by each wetland. This information could be critical in determining which wetlands would be considered a priority for restoration because enhancing or extending a higher value area would provide more ecosystem service benefits than a lower value area of the same size.

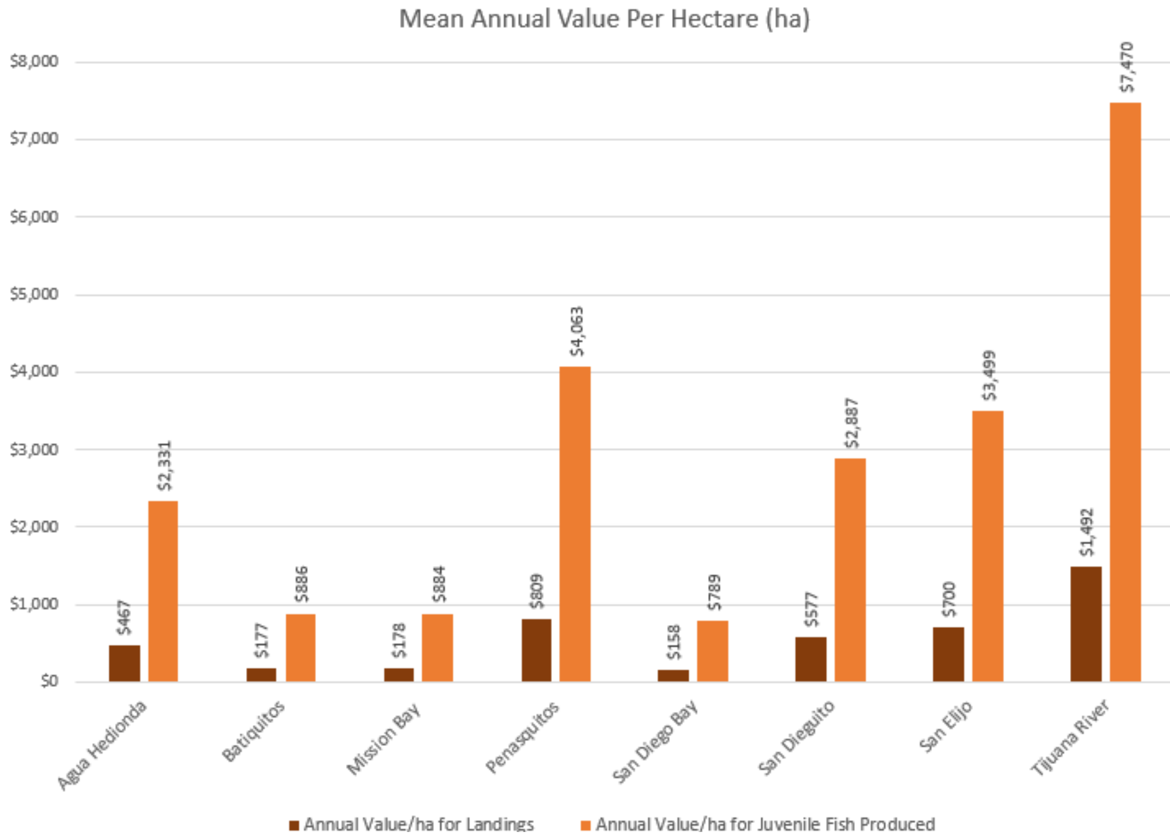


Figure 4 – Average annual benefit San Diego County wetlands provide by hectare for fishery landings and total production of juvenile California Halibut.

The results from these analyses reflect the current state of each coastal wetland. It is assumed that if these wetlands were further restored, enhanced, and protected, the annual values, and therefore benefits, would increase. To review the full economic valuation study for this ecosystem service, including standard deviation ranges, refer to Table 1 of the Appendix.

Carbon Sequestration

Seagrass beds, salt marshes, and mudflats can sequester and store copious quantities of CO2 from the atmosphere and are known as blue carbon ecosystems. Wetlands are known for this hallmark service because they are extremely efficient, sequestering carbon at a rate ten times higher than tropical forests [19]. The main drivers of this powerful ecosystem service are fast plant growth and anaerobic (without oxygen) soils, which allow for very slow plant decomposition [19]. These dead leaves, shoots, and roots, which contain carbon, can remain stored in anaerobic wetland soils for hundreds to thousands of years because microbes cannot break down and respire the plant matter [19]. As greenhouse gas (GHG) emissions accelerate global warming and climate change, these effective carbon sinks will become increasingly more valuable and therefore a critical ecosystem service to protect and restore.

To calculate the value a wetland provides through carbon sequestration, three principal factors were taken into consideration:

- Total hectares by wetland (salt marsh, mudflats, eelgrass beds)
- Wetland sequestration rate in metric tons of CO_2 per hectare per year
- The social cost of carbon (SCC)

Blue carbon habitat sizes in San Diego County, including mudflats, salt marshes, and eelgrass beds, were found through existing literature and government reports and converted from acres to hectares [20, 21, 22, 23, 24, 25, 26]. Wetlands sequester carbon at different rates depending on habitat type, health, and location, however, there is limited data available on each wetland habitat in San Diego County. Due to this, available sequestration rates from nearby wetlands in San Diego, including the Tijuana River Estuary, Mission Bay, and San Dieguito Lagoon were utilized for all salt marsh locations [20, 27, 28]. For eelgrass beds and mudflats, global and North American sequestration rates in reputable scientific literature were utilized [29, 30, 31]. To ensure proper sequestration rates and comparable monetary values, all sequestration rates were converted to metric tons of CO_2 per hectare per year. This is due to the varying ways to process and analyze carbon cores.

- Global and North America – Metric Tons of CO_2/Hectare/Year
    - North America - Tijuana River Estuary Salt Marsh: 7.08 (Min: 1.58, Max: 12.58) [27]
    - Global Mudflat: 6.409 (Min: 4.756, Max: 8.062) [30, 31]
    - Global Eelgrass Bed: 4.049 (Min: 3.041, Max: 5.057) [29]
- Local San Diego Wetlands - Metric Tons of CO_2/Hectare/Year
    - San Dieguito Lagoon Salt Marsh: 6.726 (Min: 4.254, Max: 9.198) [20, 28]
    - Mission Bay Salt Marsh: 2.314 (Min: 1.755, Max: 2.873) [20, 28]
    - Mission Bay Mudflat: 1.279 (Min: 0.568, Max: 1.990) [20, 28]

To review the full habitat sizes and sequestration rates by location, refer to Table 2 of the Appendix.

The SCC fluctuates based on state, federal, and environmental levels. The economic benefit is dependent on which dollar value is selected, which is determined based on current politics and government acceptance. The SCC dollar values per metric ton of CO_2 utilized for this valuation are $26 (California cap and trade program), $51 and $76 (White House, USA), $120 (EPA social cost of GHG), $185 (Nature paper by Kevin Rennert), and $417 (Scripps Institution of Oceanography, country-level) [9, 32, 33, 34, 35, 36]. This range of accepted values in politics and science shows how assigning different costs of damage to society caused by CO_2 emissions greatly affects the overall benefit of this service. Items included in the social cost incorporate human health effects, property damage from increased flood risk, the danger of social conflict, environmental migration, food security, disruption of energy services, and the productivity of ecosystem services [33]. It is also expected that future CO_2 emissions will produce higher cost damages due to the further stressed climate and increase willingness to pay (WTP) to avoid economic damages [34]. The differing dollar values in the literature are mainly due to the processes used for estimating the benefits of GHG emissions reductions and mitigation [35].

The total economic value was calculated with the following formula:

*Annual Sequestration Rate = Total Hectares of Wetland * Annual Carbon Removal Rate*
Total Economic Benefit *= Annual Sequestration Rate * Social Cost of Carbon* [9]

Agua Hedionda, Batiquitos Lagoon, Famosa Slough, Mission Bay, Santa Margarita Marsh, San Diego Bay, San Dieguito Lagoon, and the Tijuana River Estuary contain blue carbon ecosystems utilized in this calculation.

The results from this analysis (*Fig. 5*), based on North American and global estimates of carbon sequestration, show that eelgrass beds in San Diego County wetlands provide the most value, followed by salt marshes and mudflats. This is mainly due to the high area coverage of eelgrass beds in San Diego Bay and Mission Bay. As mentioned, the SCC used greatly affects the value of this service. Utilizing the SCC of $26, these three habitat types of the wetlands selected provide $352,007 in service benefits annually. Choosing a mid-range SCC of $76, these habitats provide $1,029,465 in service benefits annually. Selecting the highest SCC from this study of $417, these habitats provide a combined $5,649,505 in service benefits annually.

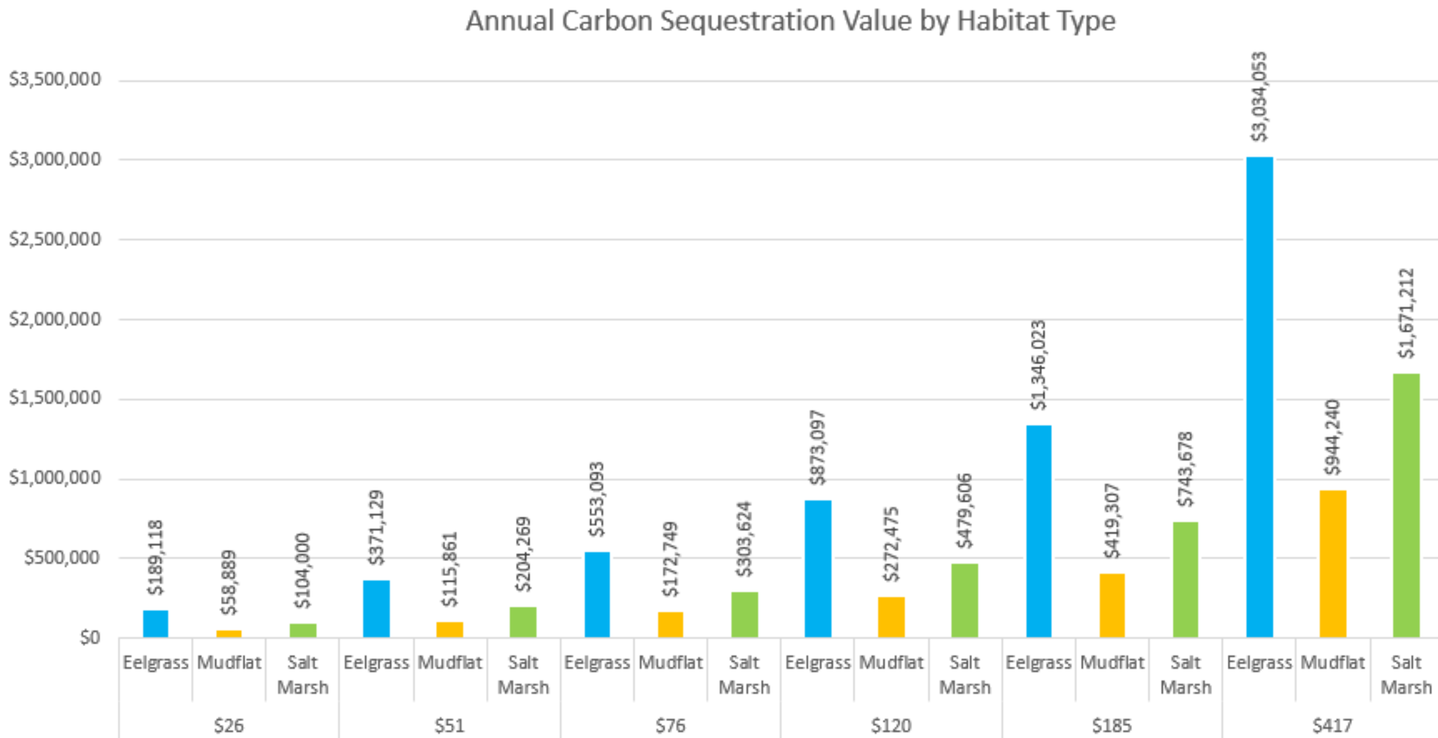


Figure 5 – Average annual benefit San Diego County wetlands provide through carbon sequestration by habitat type and differing dollar values for the social cost of carbon.

For Mission Bay and San Dieguito Lagoon, carbon cores collected in part of ongoing research by Dr. Matthew Costa at Scripps Institution of Oceanography were utilized [20, 28]. This analysis could be useful in seeing how this ecosystem service value changes with more site-specific data. Unique carbon cores from each wetland in San Diego County could provide a more accurate service value and help prioritize restoration projects. The results (*Fig. 6 & 7*) show that the differing carbon sequestration rates (North America – Tijuana River Estuary versus local) for the Mission Bay mudflats have the highest variance in value, followed by the salt marsh in Mission Bay. The sequestration rates for the salt marsh in San Dieguito Lagoon have a low variance, showing that the salt marsh in San Dieguito Lagoon has a similar rate to the overall North American – Tijuana River Estuary sequestration rate.

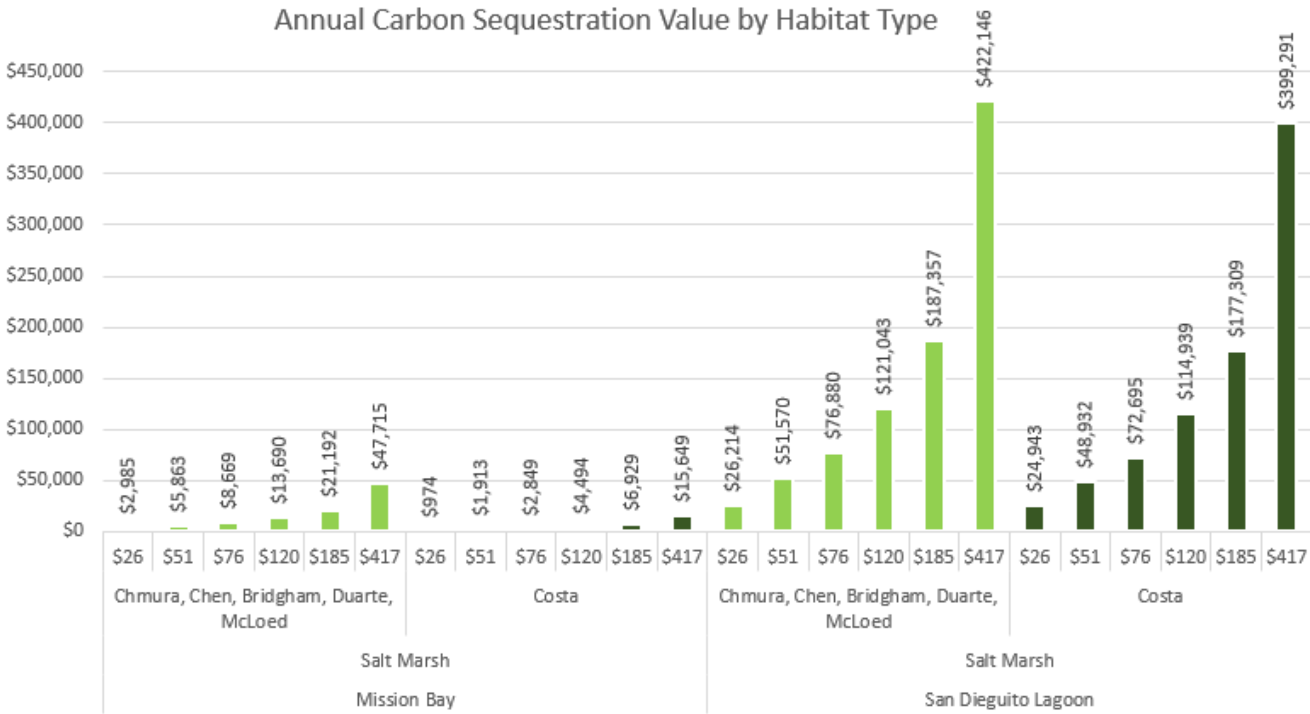


Figure 6 – Average annual benefit San Diego County wetlands provide by salt marsh carbon sequestration through differing dollar values for the social cost of carbon. The chart is broken up by which carbon sequestration rates were utilized. North America – Chmura | Mission Bay and San Dieguito - Costa

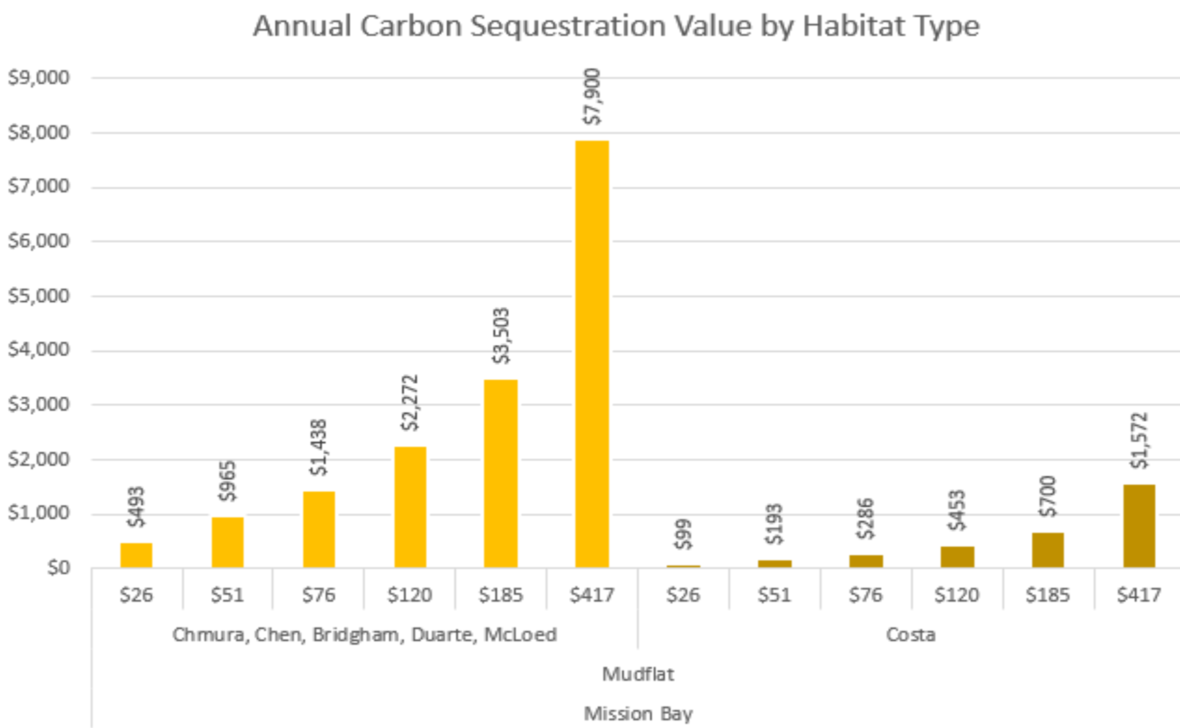


Figure 7 – Average annual benefit San Diego County wetlands provide by mudflat carbon sequestration through differing dollar values for the social cost of carbon. The chart is broken up by which carbon sequestration rates were utilized. North America and Global – Bridgham and Chen | Mission Bay - Costa

In addition to calculating an annual benefit value for carbon sequestration, the NPV from 2023 – 2100 was analyzed to determine how much value these wetlands would provide for climate regulation over the next 76 years at a 3% discount rate. Utilizing the standard discount factor, the economic value was calculated with the following formula:

*Annual Sequestration Rate = Total Hectares of Wetland * Annual Carbon Removal Rate*
***Total Economic Benefit** = Annual Sequestration Rate * Social Cost of Carbon * Discount Factor* [9]

The results from this analysis (*Fig. 8*), based on North American and global estimates of carbon sequestration, show that these blue carbon ecosystems can provide significant value through 2100 if maintained. Utilizing the SCC of $26, these three habitat types of the wetlands selected could provide $10,844,477 in service benefits. Choosing a mid-range SCC of $76, these habitats could provide $31,715,349 in service benefits. Selecting the highest SCC from this study of $417, these habitats could provide a combined $174,047,680 in service benefits. This potential value, however, will be significantly influenced by the threat of sea-level rise, habitat degradation, and increased urban development.

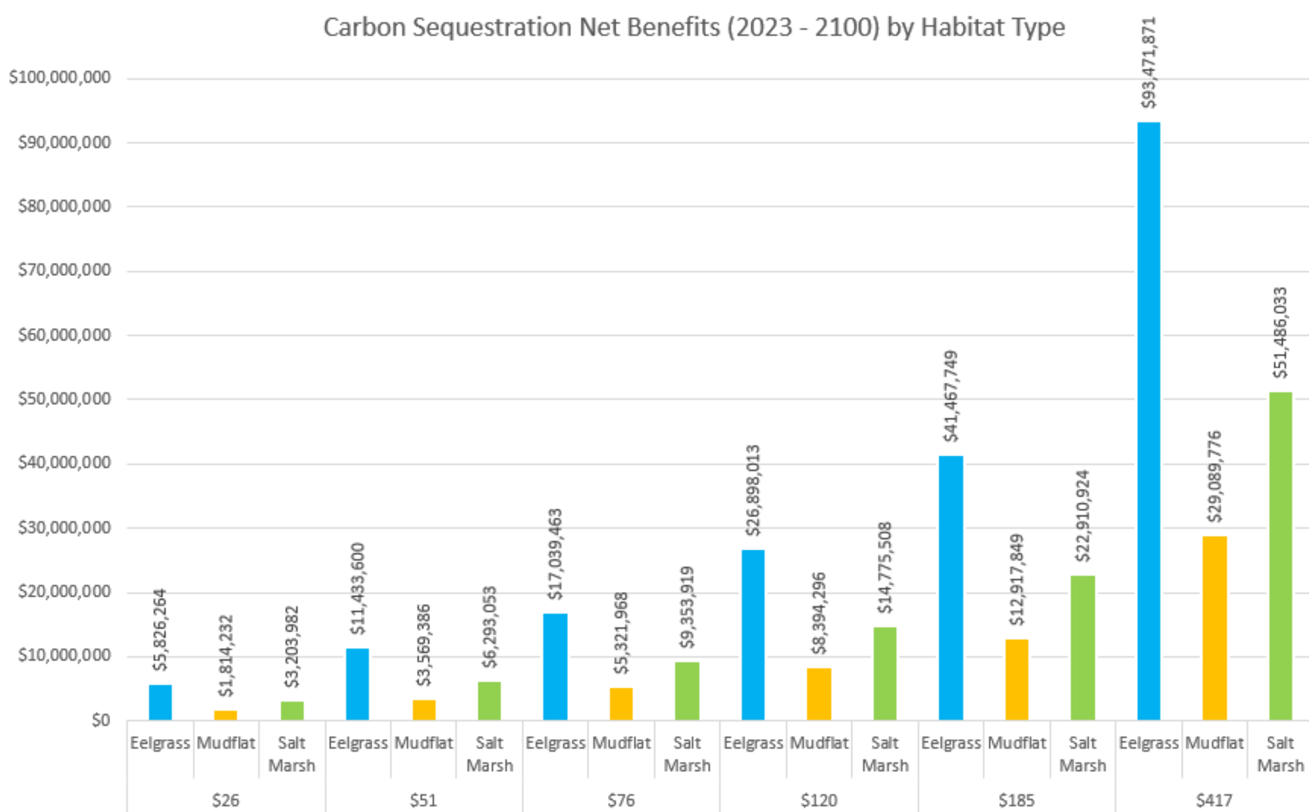


Figure 8 – Total average benefits from 2023 – 2100 San Diego County wetlands could provide towards climate mitigation using a 3% discount rate.

To review the full economic valuation study for this ecosystem service by location, including standard deviation ranges, refer to Tables 3 and 4 in the Appendix.

Key Takeaways and Advantages of Valuing Ecosystem Services

There are many advantages of an ecosystem service valuation, including improved site selection and restoration design, increased community and stakeholder support, better communication among interdisciplinary teams, effective adaptive management strategies, and the ability to influence new funding/grant requests [37]. While it is more effective to complete an economic valuation study for a new restoration project before it has begun, showcasing the already existing benefits these coastal wetlands passively provide can play a key role in maintaining biological health and physical integrity [37].

For the 8 out of approximately 14 coastal wetlands in San Diego County, these two ecosystem services provide a combined **$2,622,875** in socioeconomic benefits every year when selecting the annual halibut fishery landings ($997,697) and $120 SCC value for carbon sequestration ($1,625,178). The total net benefits from 2023 – 2100 at a 3% discount rate for these same benefits could provide a combined **$80,804,470** in socioeconomic benefits. These total values would increase if an additional analysis were conducted on the remaining wetlands. Furthermore, coastal wetlands provide many additional ecosystem service benefits. An incomplete list includes climate regulation, increased biodiversity, erosion control, improved water quality, recreational opportunities, cultural resources, storm buffering, increased property value, and habitat for additional commercial and recreationally important fisheries [7].

Case Study – ReWild Mission Bay

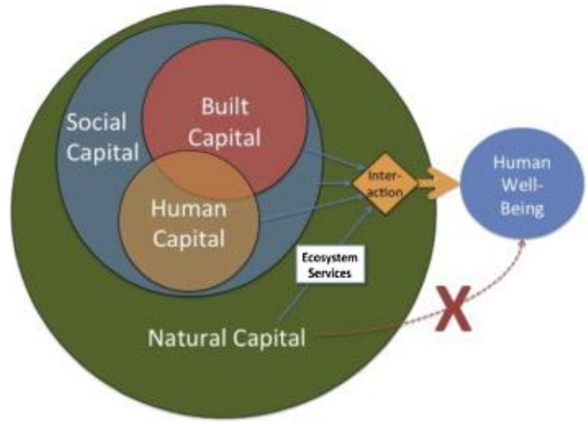
This same economic valuation method was originally created and applied to a potential restoration project in Mission Bay. This project, ReWild Mission Bay, involves 75 community partners that are pursuing the restoration of natural wetlands in the northeast corner of the bay [38]. The coalition's 'wildest' plan proposes the restoration of 277 acres. In addition to halibut nursery habitat and carbon sequestration, this economic study valued the additional services the restored acres could provide, including water purification, sea level rise mitigation, housing value increases, and tourism potential [39]. The total estimated annual benefits for the restored section of Mission Bay is $2,847,100 [39].

- Commercial Fishery Landings: $31,100
- Juvenile Fish Production (natural capital): $440,140
    - *Not included in annual value*
- Carbon Sequestration: $43,900
- Water Purification: $200
- Housing Value Increases: $2,756,300
- Increased Tourism: $15,600

Combining the potential ecosystem service benefits from this restoration plan with the current benefits calculated in this study for Mission Bay (California halibut landings and carbon sequestration – SCC $120), Mission Bay's marshes could provide a combined $3,340,740 in service benefits every year.

Communicating to Policymakers and the Public

A common misconception of supporting habitat conservation and restoration is to advocate against economic development. However, this is not an environment versus the economy, zero-sum approach where one person's gain is another's loss. Since natural capital is a key contributor to human well-being, it is a main contributor to the economy [7]. Therefore, the choices made about economic development and environmental protection instead become how to balance these assets effectively and sustainably to strengthen economic opportunity while improving natural capital and increasing ecosystem service values [7].



Relationship between human, social, and natural capital required for ecosystem services to support human well-being [7].

In addition to this economic valuation, an ArcGIS Story Map and fact sheets were created to promote public engagement. Interested parties, including San Diego tourists, hikers, bird watchers, wetland enthusiasts, restoration managers, and environmentalists can engage with this visual story to learn more about the coastal wetlands in San Diego County, including ways they can help support restoration and visit local discovery centers. The fact sheets were created to increase awareness of the wetland ecosystem service values and advocate policymakers for their continual conservation. Organizations like WILDCOAST, The San Dieguito River Valley Conservancy, and the Agua Hedionda Lagoon Foundation can use these fact sheets to advocate for wetland, blue carbon, and habitat restoration bills and grant funding opportunities if needed.

The Wealth of Wetlands: Links and materials to promote wetland conservation, recreation, and political action.

- Link to Story Map
- Link to San Diego County Wetlands Fact Sheet
- Link to Mission Bay Restoration Fact Sheet
- Link to Mission Bay Restoration Post Card

Future Development

San Diego County has numerous restoration projects that are currently in the planning, development, and execution phase. This ecosystem service valuation method could be applied to these projects to support restoration costs and further advocate for their completion. From the Southern California Wetlands Recovery Project Board database, there are currently 11 active restoration projects [40]. If the annual socioeconomic value of $2,622,875 for just the two ecosystem services was applied to the costs of these projects, it provides the same benefit value as the cost of 6 projects.

Location	Project Name	Project Type	Project Cost
Batiquitos Lagoon	Batiquitos Lagoon Wetland Restoration Project	Interpretive/Education, Restoration,	N/A
Batiquitos Lagoon	San Diego County Marine Protected Area (MPA) Wetland Restoration Project	Restoration	$550,000
Buena Vista Lagoon	Buena Vista Audubon Society Wetlands Reserve Restoration Project: 60% Design and Engineering	Restoration	$287,575
Buena Vista Lagoon	Buena Vista Lagoon Enhancement Project: 65% Design and Engineering Plans	Restoration	$3,800,000
Loma Alta Slough	Loma Alta Slough Wetlands Enhancement Project – Phase 2 Implementation	Restoration	$2,688,400
Los Penasquitos Lagoon	Los Penasquitos Lagoon Restoration Design and Feasibility Study	Restoration Planning	$633,320
San Diego Bay	Sweetwater Marsh Community Wetlands Restoration Project	Restoration	$30,000
San Dieguito Lagoon	San Dieguito Watershed Invasive Species Control and Revegetation	Restoration	$4,766,000
San Elijo Lagoon	San Elijo Lagoon and Dune Habitat Restoration Project	Restoration	$96,000
Santa Margarita	Santa Margarita River Fish Passage and Bridge Replacement: Final Design	Restoration Planning	$714,000
Tijuana River Estuary	Tijuana Estuary Tidal Restoration Program II: Phase I restoration design	Restoration Planning	$1,095,000

List of active restoration projects in San Diego County in 2023 [40]

Valuing Additional Ecosystem Services

As mentioned, numerous additional services could be economically valued to further support the importance of coastal wetlands in San Diego County. If this project were to be carried forward, water quality improvements, sea-level rise mitigation, mariculture growth, energy services, tourism opportunities, and additional commercial and recreational fisheries could be evaluated.

For example, San Diego Bay supports a substantially diverse range of commercial and recreationally important fish species that use the bay as a nursery habitat. Shortfin corvina, spotted sand bass, and queenfish are all notable examples of valuable commercial fish found as juveniles in the bay that could provide additional monetary benefits as a service [41]. For recreational fisheries, economic inputs such as expenditures on fishing equipment, trip-related expenses, bait and tackle shops, employment, permit fees, and indirect inputs from supporting industries could all be incorporated as an annual ecosystem service value. As an example, the Conservation Strategy Fund (CSF) and the California Department of Fish and Wildlife (CDFW) compiled and analyzed data from 28 ports in California for boat anglers who targeted California halibut [42]. The study focused on costs associated with travel, including the type of boat used, time spent fishing, and water areas visited. This method estimated the benefits by utilizing the surplus benefit beyond their costs and found that a surplus value of $2.6 million per year is generated by California halibut anglers [42]. Bays, estuaries, and lagoons make up a portion of this value and could be incorporated into this study as an additional ecosystem service to the California halibut fishery.

Promoting Policy Development

New materials that promote the incorporation of ecosystem service benefits in policy development, such as the 30 x 30 initiative (at a global scale) and the San Diego Climate Action Plan (at a local scale), could be created, in addition to the fact sheets. The goal of 30 x 30 is to protect 30% of land and 30% of oceans by 2030. A World Bank report argues that the ecosystem services accrued by achieving 30 x 30 would almost entirely offset the costs created by safeguarding additional land and water to meet the target [43]. The report states "*Preserving nature and maintaining its services are critical for economic growth,… It is a combination of* (nature smart) *policies that shows the greatest win-wins for both biodiversity and for economies"*[43]. Not only can evaluating ecosystem services support the 30 x 30 target, but it can also create co-benefits. For example, when carbon sequestration services such as carbon market payments are factored in, additional 'green' policies become more effective while enhancing economic gains [43].

On a local scale, further development of this study could help support San Diego's commitment to restore 700 acres of tidal wetlands by 2035. Enhancing communication tools and valuing additional services can provide data evidence and support the continued restoration and preservation of wetland coverage. This will benefit not only the city of San Diego and its people, but all wildlife that thrives in our coastal wetlands.

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Photos:
San Elijo Lagoon – Beverly Scharnhorst
Snowy Plover – Nicole Rosenberg
California Halibut - Mike Carr – iNaturalist
Pickleweed (Salicornia) – Beverly Scharnhorst

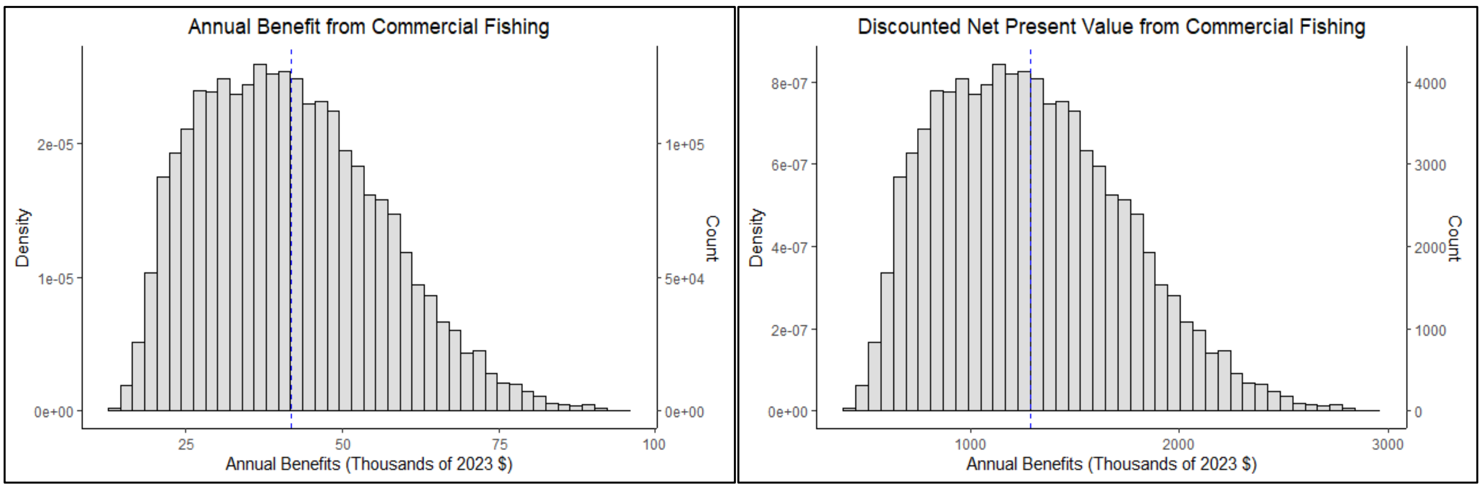
Appendix

Table 1 - Economic Values for California Halibut Commercial Fishery and Production by Location

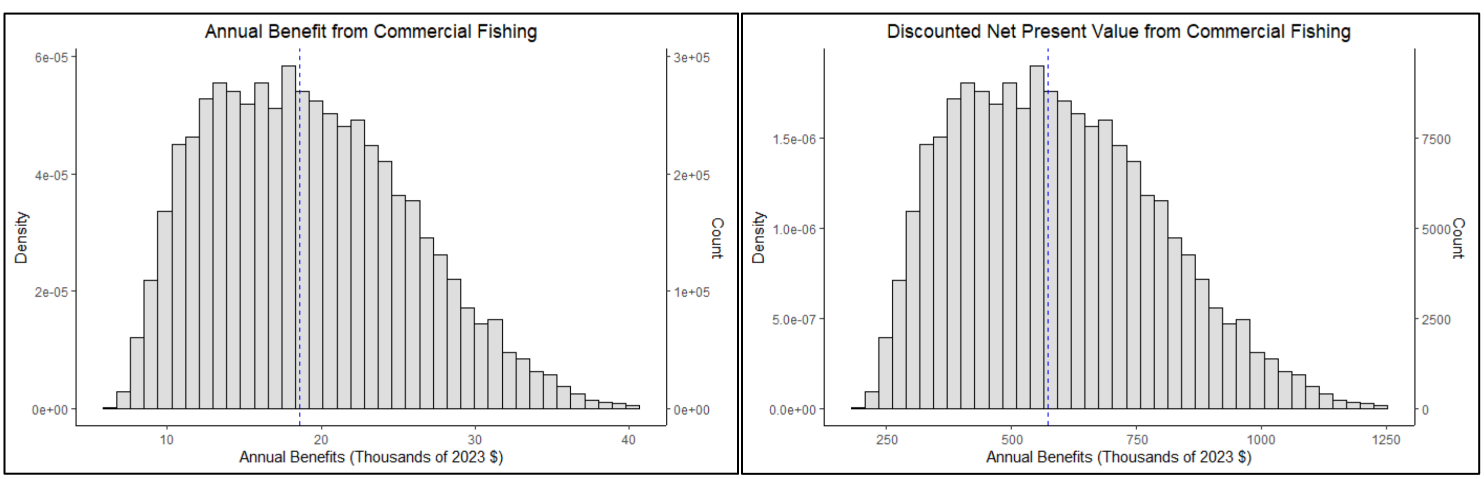
Location	Wetland Type	Suitable Habitat Size (ha)	Average Halibut Density #/ha	Mean Annual Commercial Fishery Landings Value (Today)	Standard Deviation	Mean Annual Value per hectare	Mean NPV (Net Benefits) of Commercial Fishery Landings through 2100	Standard Deviation	Mean Annual Value of Juvenile Fish Produced by the Wetland (Today)	Standard Deviation	Mean Annual Value per hectare
Agua Hedionda	Lagoon	89.45	255.3	**$41,810**	$14,238	$467	**$1,288,062**	$438,624	**$208,535**	$36,613	$2,331
Batiquitos	Lagoon	108.5	96.8	**$19,231**	$6,382	$177	**$592,468**	$196,606	**$96,177**	$15,531	$886
Mission Bay	Bay	882.2	96.7	**$156,604**	$52,192	$178	**$4,824,580**	$1,607,921	**$779,619**	$126,820	$884
Penasquitos	Estuary	11.05	445.2	**$8,942**	$4,052	$809	**$275,482**	$124,828	**$44,900**	$15,110	$4,063
San Diego Bay	Bay	4345.5	86.1	**$685,648**	$233,866	$158	**$21,123,176**	$7,204,851	**$3,428,436**	$597,103	$789
San Dieguito	Estuary	32.3	315.2	**$18,646**	$6,385	$577	**$574,443**	$196,706	**$93,249**	$16,839	$2,887
San Elijo	Estuary	34	382.4	**$23,786**	$8,769	$700	**$732,796**	$270,165	**$118,969**	$26,800	$3,499
Tijuana River	Estuary	28.85	824.7	**$43,030**	$20,139	$1,492	**$1,325,646**	$620,425	**$215,499**	$76,060	$7,470
Total Value				**$997,697**			**$30,736,653**		**$4,985,383**		

Table 1.a – Standard Deviation Graphs of CA Halibut Commercial Values by Location

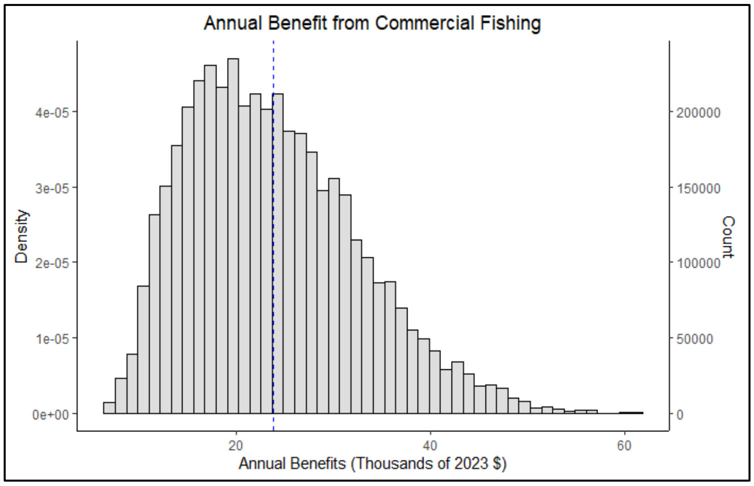
Agua Hedionda

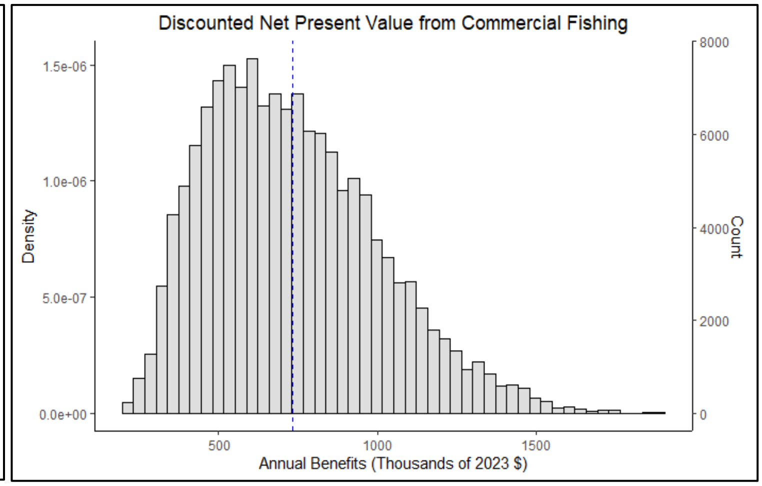


Batiquitos Lagoon

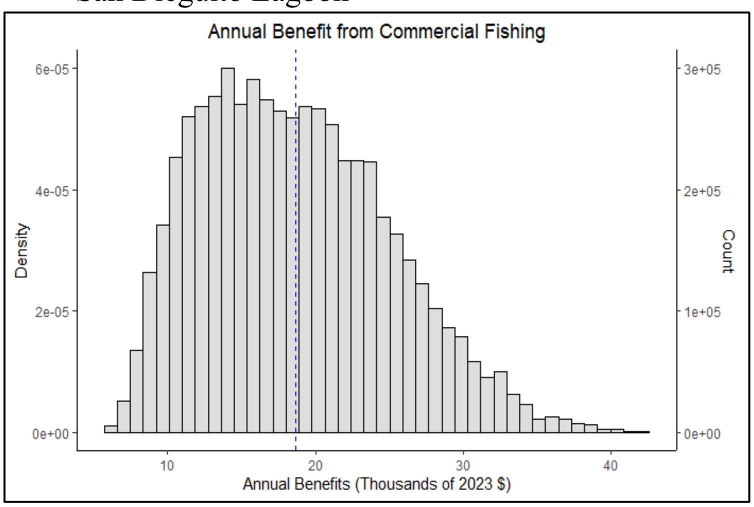


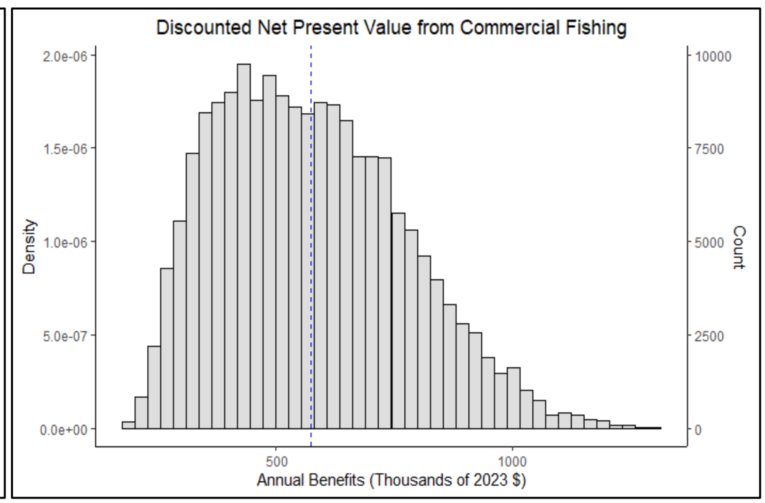
San Elijo Lagoon



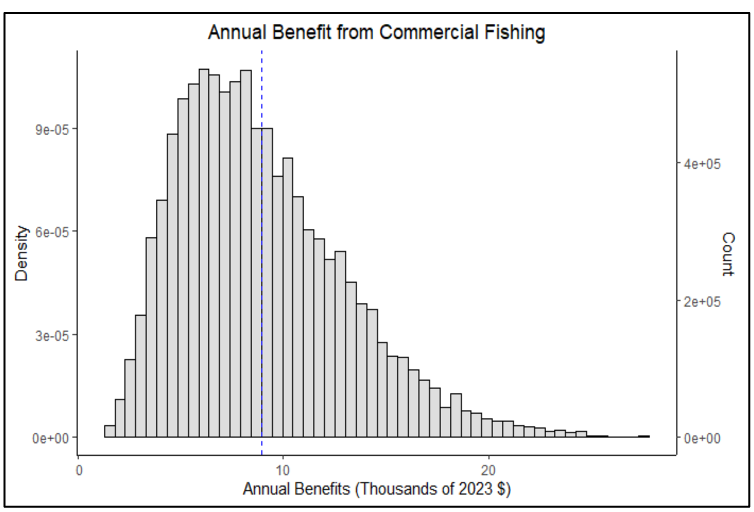


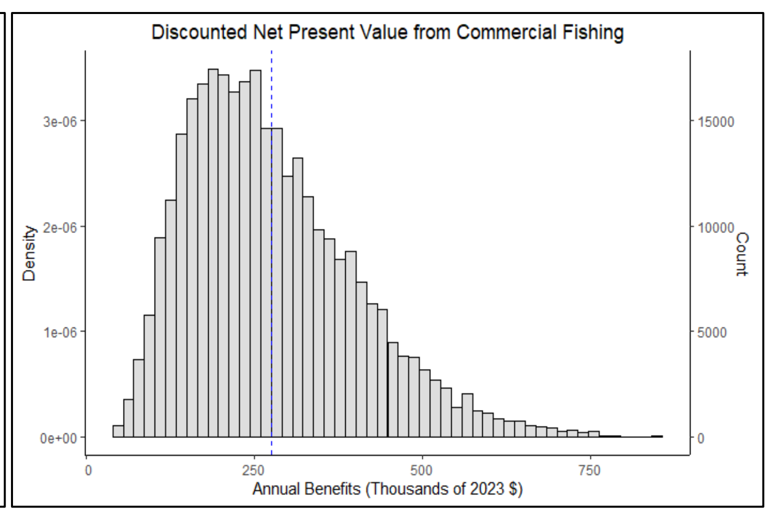
San Dieguito Lagoon



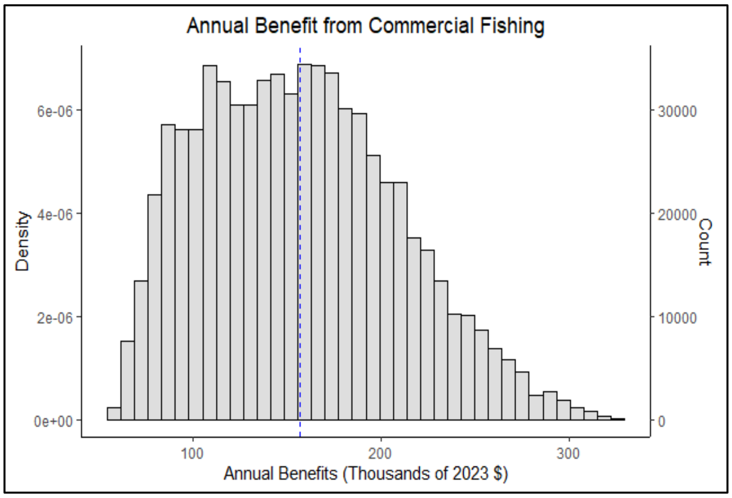


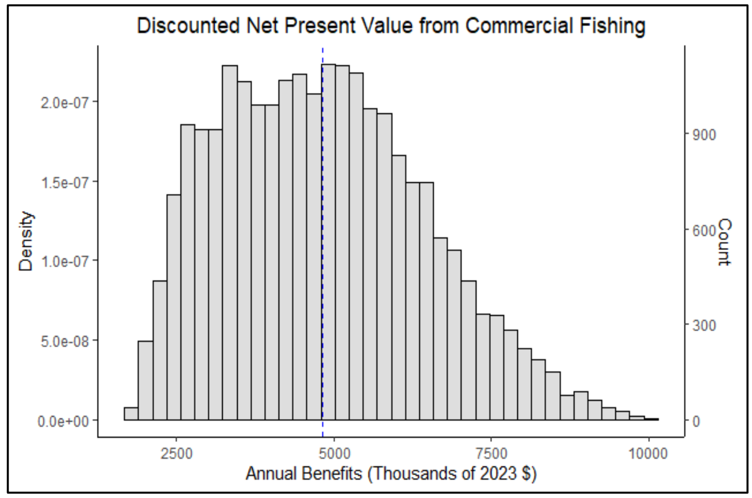
Los Penasquitos Lagoon



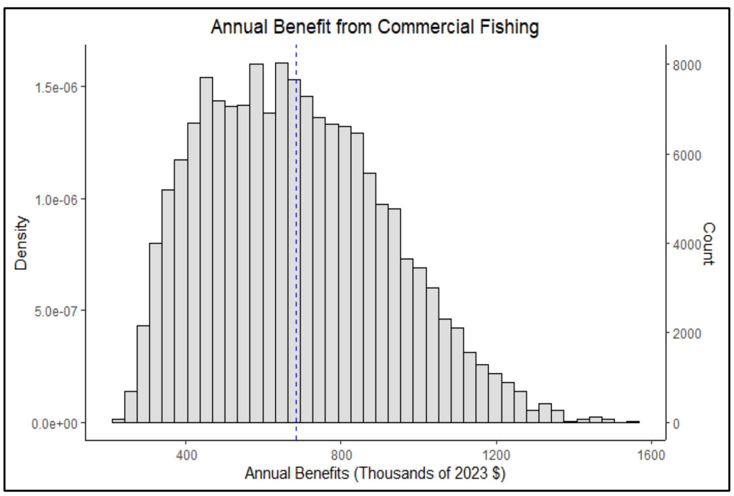


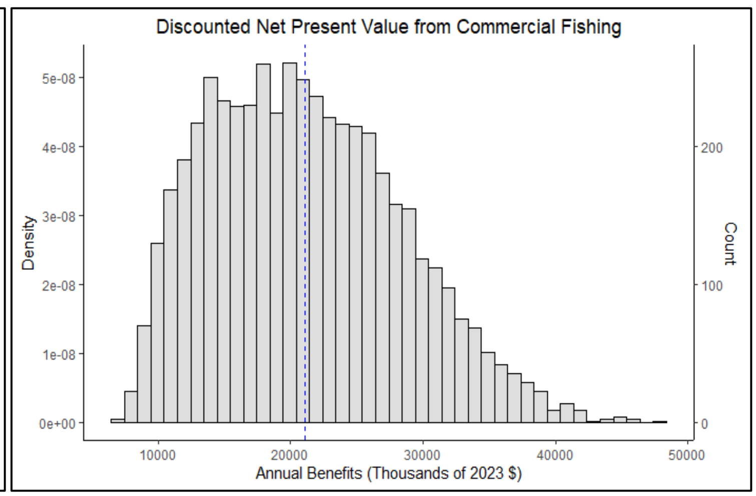
Mission Bay



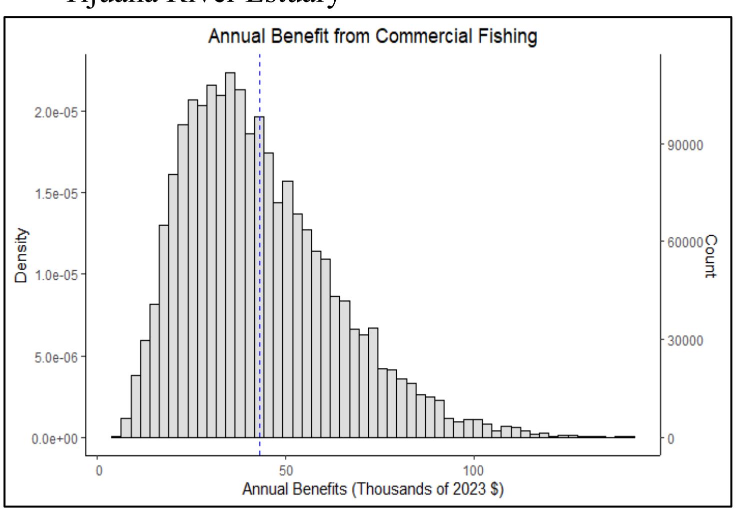


San Diego Bay





Tijuana River Estuary



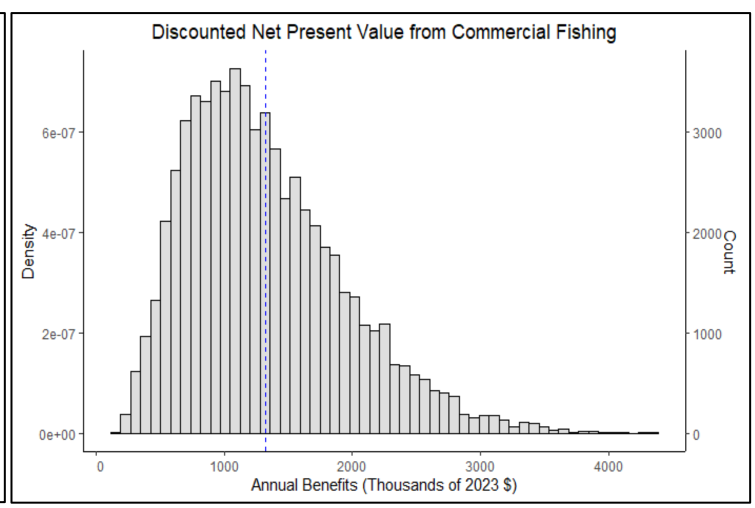


Table 2 – Habitat Size and Sequestration Rates for Blue Carbon Ecosystems (Eelgrass, Mudflats, Salt Marsh) by Location

Location	Wetland Type	Habitat Area (ha)	Seq Rate (MT CO2/ha*yr) Chmura, Chen, Bridgham, Duarte, McLoed	Seq Rate (MT CO2/ha*yr) Costa
Tijuana River	Estuary - Salt Marsh	257.38	7.08 (Min - 1.58, Max - 12.58)	N/A
Tijuana River	Estuary - Mudflat	38.04	6.409, (Min - 4.756, Max - 8.062)	N/A
San Dieguito Lagoon	Estuary - Salt Marsh	142.449	7.08 (Min - 1.58, Max - 12.58)	6.726 (Min - 4.254, Max - 9.198)
San Dieguito Lagoon	Lagoon - Eelgrass	2.792	4.049 (Min - 3.041, Max - 5.057)	N/A
San Diego Bay	Bay - Eelgrass	1052.183	4.049 (Min - 3.041, Max - 5.057)	N/A
San Diego Bay	South Bay - Mudflats	309.989	6.409, (Min - 4.756, Max - 8.062)	N/A
San Diego Bay	South Bay - Salt Marsh	103.195	7.08 (Min - 1.58, Max - 12.58)	N/A
Santa Margarita	Estuary - Salt Marsh	38.4451	7.08 (Min - 1.58, Max - 12.58)	N/A
Santa Margarita	Estuary - Mudflat	2.8328	6.409, (Min - 4.756, Max - 8.062)	N/A
Mission Bay	Marsh - Salt Marsh	16.19	7.08 (Min - 1.58, Max - 12.58)	2.314 (Min - 1.755, Max - 2.873)
Mission Bay	Mudflat	2.954	6.409, (Min - 4.756, Max - 8.062)	1.279 (Min - 0.568, Max - 1.990)
Mission Bay	Bay - Eelgrass	661.054	4.049 (Min - 3.041, Max - 5.057)	N/A
Famosa Slough	Estuary - Salt Marsh	7.284	7.08 (Min - 1.58, Max - 12.58)	N/A
Batiquitos Lagoon	Lagoon - Eelgrass	57.870	4.049 (Min - 3.041, Max - 5.057)	N/A
Agua Hedionda	Lagoon - Eelgrass	23.634	4.049 (Min - 3.041, Max - 5.057)	N/A

Table 3 – Economic Values for Blue Carbon Ecosystems (Eelgrass, Mudflats, Salt Marsh) by Location Global and North America Carbon Sequestration Rates

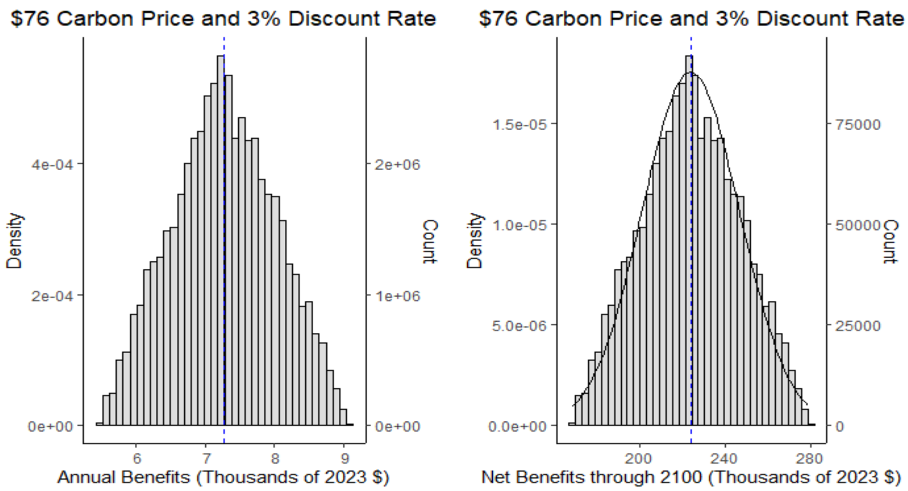
SCC Price	Habitat Type	Location	Sum of Mean Annual Value	Sum of Net Benefits 2023 through 2100
$26	**Eelgrass**	Agua Hedionda Lagoon	$2,488	$76,658
		Batiquitos Lagoon	$6,094	$187,756
		Mission Bay	$69,503	$2,141,214
		San Diego Bay	$110,738	$3,411,583
		San Dieguito Lagoon	$294	$9,053
	Eelgrass Total		**$189,118**	**$5,826,264**
	Mudflat	Mission Bay	$493	$15,184
		San Diego Bay	$51,586	$1,589,242
		Santa Margarita Marsh	$473	$14,573
		Tijuana River Estuary	$6,337	$195,233
	Mudflat Total		**$58,889**	**$1,814,232**
	Salt Marsh	Famosa Slough	$1,339	$41,253
		Mission Bay	$2,985	$91,947
		San Diego Bay	$18,891	$581,972
		San Dieguito Lagoon	$26,214	$807,583
		Santa Margarita Marsh	$7,076	$218,001
		Tijuana River Estuary	$47,496	$1,463,227
	Salt Marsh Total		**$104,000**	**$3,203,982**
$26 Total			**$352,007**	**$10,844,477**
$51	**Eelgrass**	Agua Hedionda Lagoon	$4,880	$150,354
		Batiquitos Lagoon	$11,946	$368,022
		Mission Bay	$136,822	$4,215,160
		San Diego Bay	$216,904	$6,682,281

		San Dieguito Lagoon	$577	$17,783
	Eelgrass Total		**$371,129**	**$11,433,600**
	Mudflat	Mission Bay	$965	$29,717
		San Diego Bay	$101,551	$3,128,528
		Santa Margarita Marsh	$928	$28,597
		Tijuana River Estuary	$12,417	$382,544
	Mudflat Total		**$115,861**	**$3,569,386**
	Salt Marsh	Famosa Slough	$2,631	$81,045
		Mission Bay	$5,863	$180,623
		San Diego Bay	$37,387	$1,151,802
		San Dieguito Lagoon	$51,570	$1,588,734
		Santa Margarita Marsh	$13,938	$429,392
		Tijuana River Estuary	$92,882	$2,861,457
	Salt Marsh Total		**$204,269**	**$6,293,053**
$51 Total			**$691,259**	**$21,296,039**
$76	**Eelgrass**	Agua Hedionda Lagoon	$7,270	$223,958
		Batiquitos Lagoon	$17,833	$549,390
		Mission Bay	$203,539	$6,270,551
		San Diego Bay	$323,593	$9,969,130
		San Dieguito Lagoon	$858	$26,434
	Eelgrass Total		**$553,093**	**$17,039,463**
	Mudflat	Mission Bay	$1,438	$44,315
		San Diego Bay	$151,371	$4,663,369
		Santa Margarita Marsh	$1,380	$42,507
		Tijuana River Estuary	$18,560	$571,777
	Mudflat Total		**$172,749**	**$5,321,968**
	Salt Marsh	Famosa Slough	$3,919	$120,745
		Mission Bay	$8,669	$267,082
		San Diego Bay	$55,572	$1,712,047
		San Dieguito Lagoon	$76,880	$2,368,499
		Santa Margarita Marsh	$20,652	$636,235
		Tijuana River Estuary	$137,931	$4,249,311
	Salt Marsh Total		**$303,624**	**$9,353,919**
$76 Total			**$1,029,465**	**$31,715,349**
$120	**Eelgrass**	Agua Hedionda Lagoon	$11,490	$353,988
		Batiquitos Lagoon	$28,125	$866,475
		Mission Bay	$321,074	$9,891,518
		San Diego Bay	$511,053	$15,744,307
		San Dieguito Lagoon	$1,354	$41,724
	Eelgrass Total		**$873,097**	**$26,898,013**
	Mudflat	Mission Bay	$2,272	$69,984
		San Diego Bay	$238,736	$7,354,878
		Santa Margarita Marsh	$2,182	$67,214
		Tijuana River Estuary	$29,286	$902,220
	Mudflat Total		**$272,475**	**$8,394,296**
	Salt Marsh	Famosa Slough	$6,212	$191,377
		Mission Bay	$13,690	$421,769
		San Diego Bay	$87,777	$2,704,195
		San Dieguito Lagoon	$121,043	$3,729,034
		Santa Margarita Marsh	$32,485	$1,000,795
		Tijuana River Estuary	$218,399	$6,728,338
	Salt Marsh Total		**$479,606**	**$14,775,508**

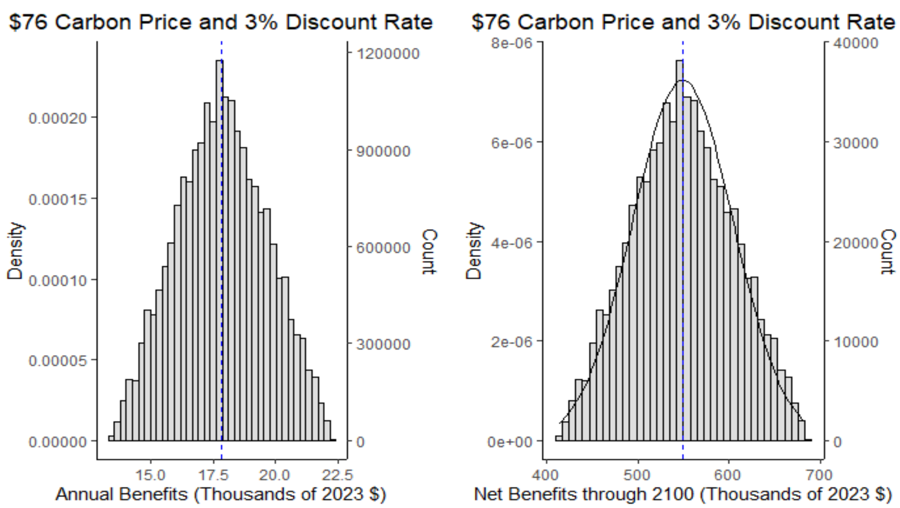
$120 Total			**$1,625,178**	**$50,067,816**
$185	**Eelgrass**	Agua Hedionda Lagoon	$17,728	$546,158
		Batiquitos Lagoon	$43,380	$1,336,422
		Mission Bay	$494,455	$15,232,984
		San Diego Bay	$788,369	$24,287,744
		San Dieguito Lagoon	$2,092	$64,441
	Eelgrass Total		**$1,346,023**	**$41,467,749**
	Mudflat	Mission Bay	$3,503	$107,928
		San Diego Bay	$367,387	$11,318,296
		Santa Margarita Marsh	$3,359	$103,481
		Tijuana River Estuary	$45,059	$1,388,145
	Mudflat Total		**$419,307**	**$12,917,849**
	Salt Marsh	Famosa Slough	$9,562	$294,592
		Mission Bay	$21,192	$652,870
		San Diego Bay	$135,245	$4,166,567
		San Dieguito Lagoon	$187,357	$5,772,003
		Santa Margarita Marsh	$50,631	$1,559,816
		Tijuana River Estuary	$339,691	$10,465,075
	Salt Marsh Total		**$743,678**	**$22,910,924**
$185 Total			**$2,509,008**	**$77,296,522**
$417	**Eelgrass**	Agua Hedionda Lagoon	$39,897	$1,229,117
		Batiquitos Lagoon	$97,682	$3,009,355
		Mission Bay	$1,115,395	$34,362,638
		San Diego Bay	$1,776,361	$54,725,407
		San Dieguito Lagoon	$4,718	$145,354
	Eelgrass Total		**$3,034,053**	**$93,471,871**
	Mudflat	Mission Bay	$7,900	$243,384
		San Diego Bay	$827,088	$25,480,590
		Santa Margarita Marsh	$7,564	$233,017
		Tijuana River Estuary	$101,689	$3,132,785
	Mudflat Total		**$944,240**	**$29,089,776**
	Salt Marsh	Famosa Slough	$21,400	$659,282
		Mission Bay	$47,715	$1,469,988
		San Diego Bay	$304,896	$9,393,108
		San Dieguito Lagoon	$422,146	$13,005,312
		Santa Margarita Marsh	$113,301	$3,490,534
		Tijuana River Estuary	$761,754	$23,467,809
	Salt Marsh Total		**$1,671,212**	**$51,486,033**
$417 Total			**$5,649,505**	**$174,047,680**

Table 3.a – SCC $76 Standard Deviation Graphs of Blue Carbon Ecosystems by Location

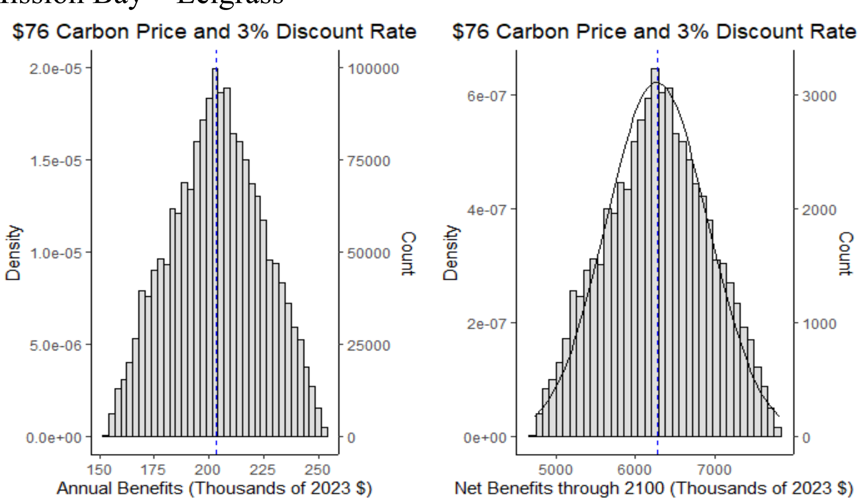
Agua Hedionda – Eelgrass



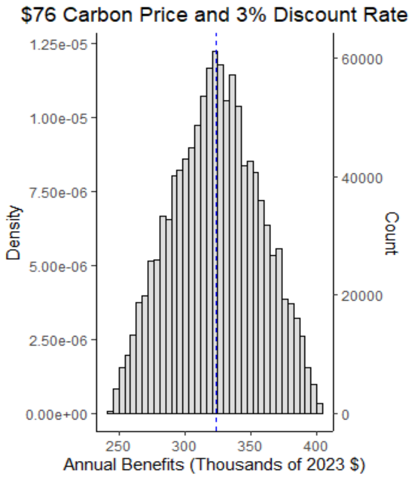
Batiquitos Lagoon – Eelgrass

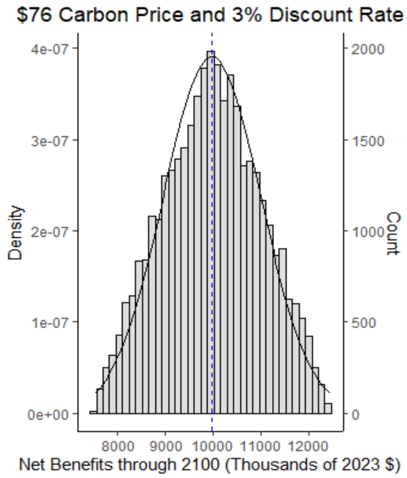


Mission Bay – Eelgrass

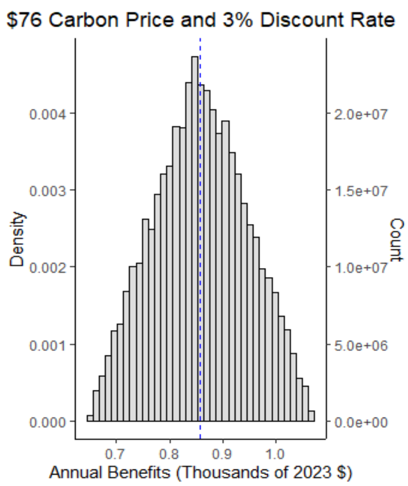


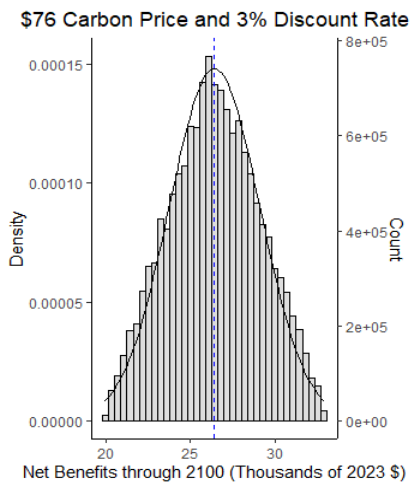
San Diego Bay – Eelgrass



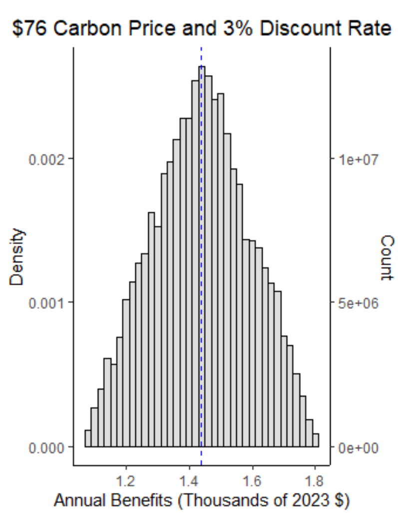


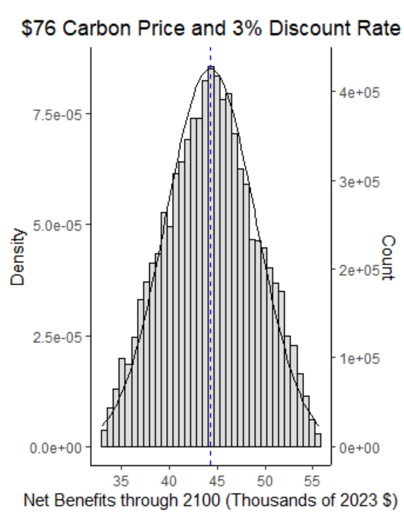
San Dieguito Lagoon – Eelgrass



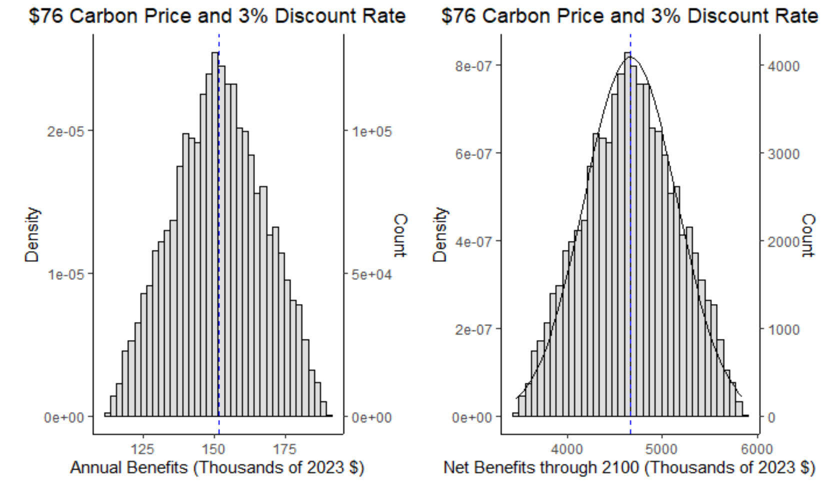


Mission Bay - Mudflat

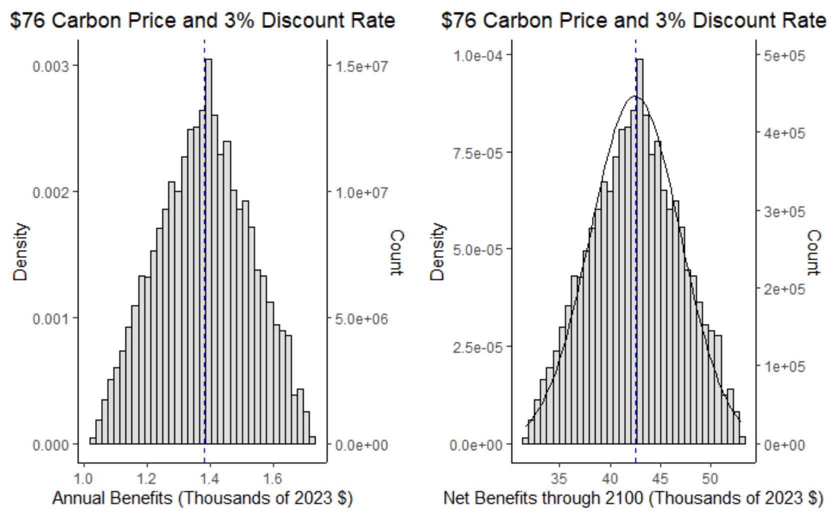




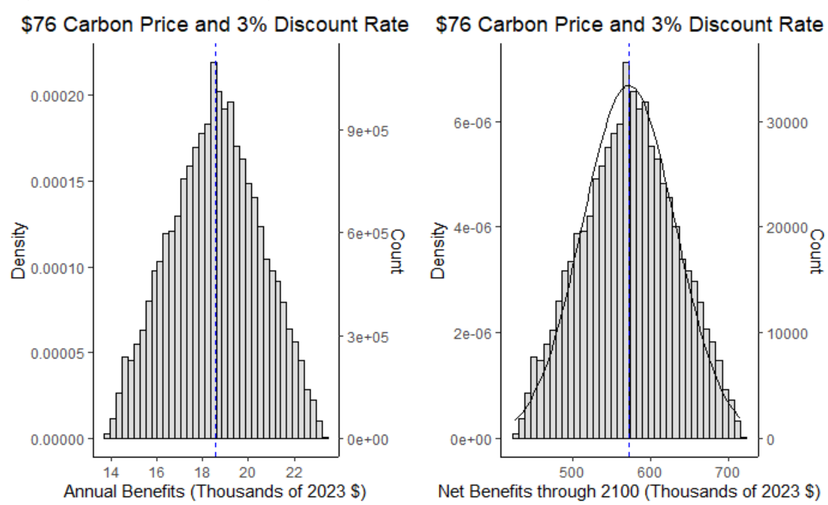
San Diego Bay – Mudflat



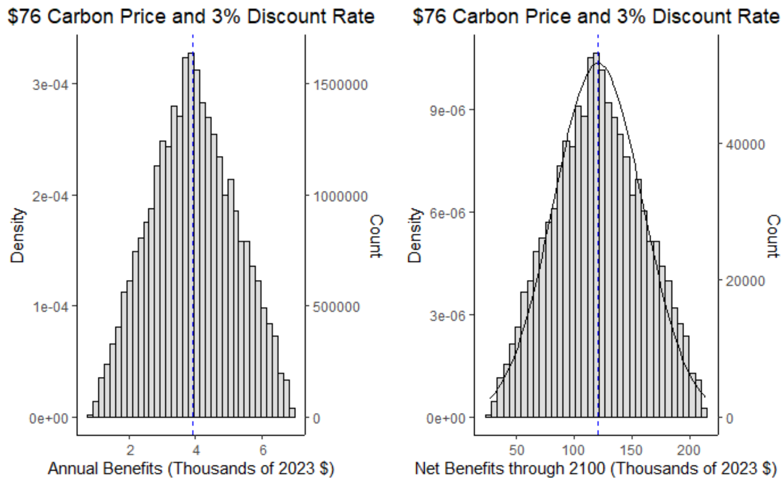
Santa Margarita Marsh – Mudflat



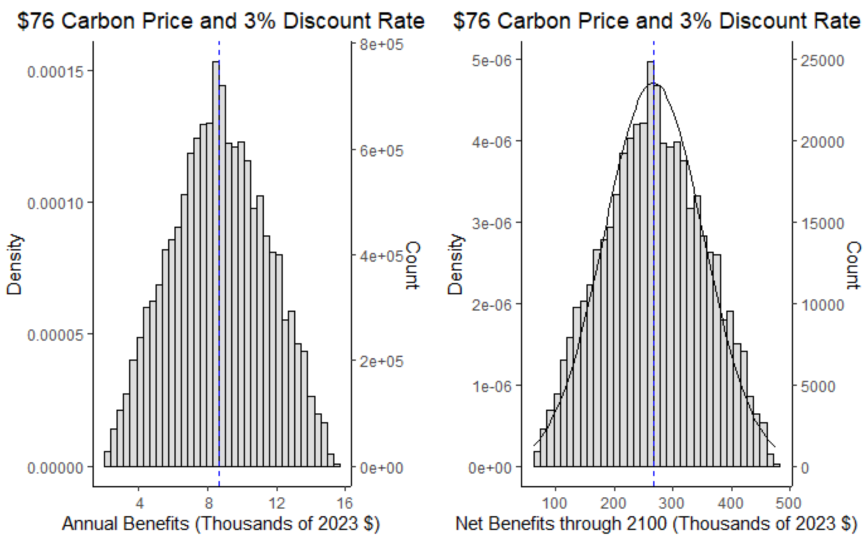
Tijuana River Estuary- Mudflat



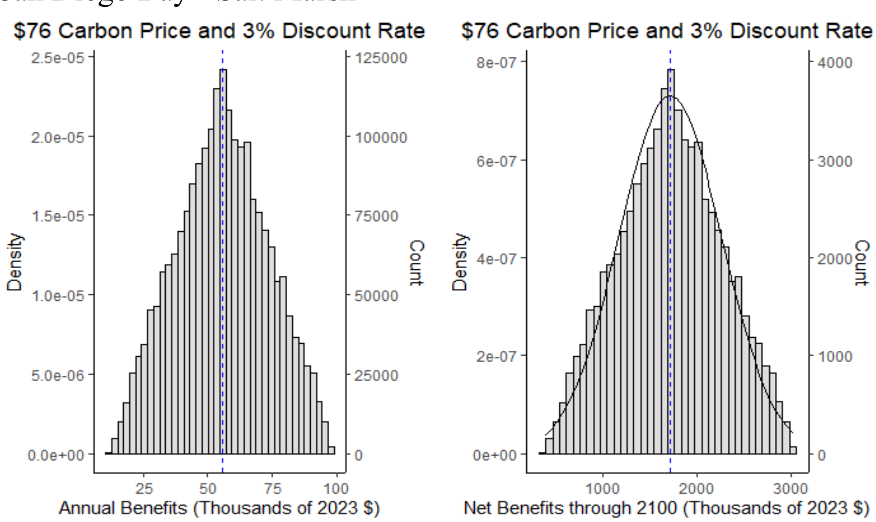
Famosa Slough - Salt Marsh



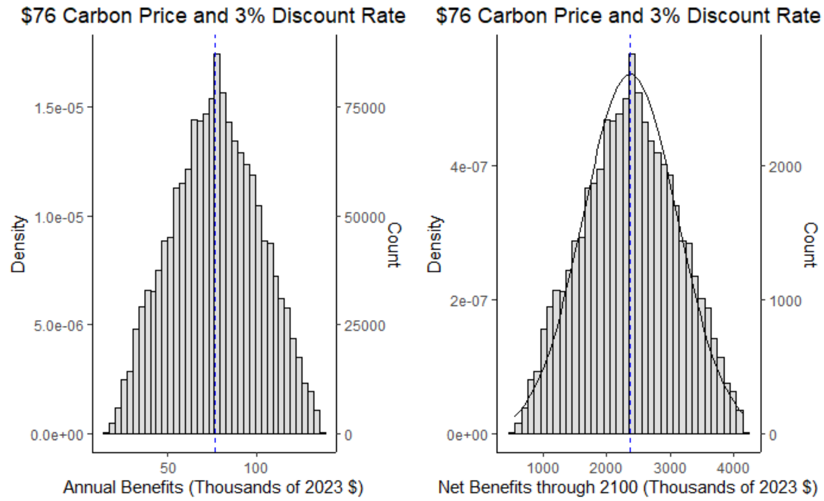
Mission Bay - Salt Marsh



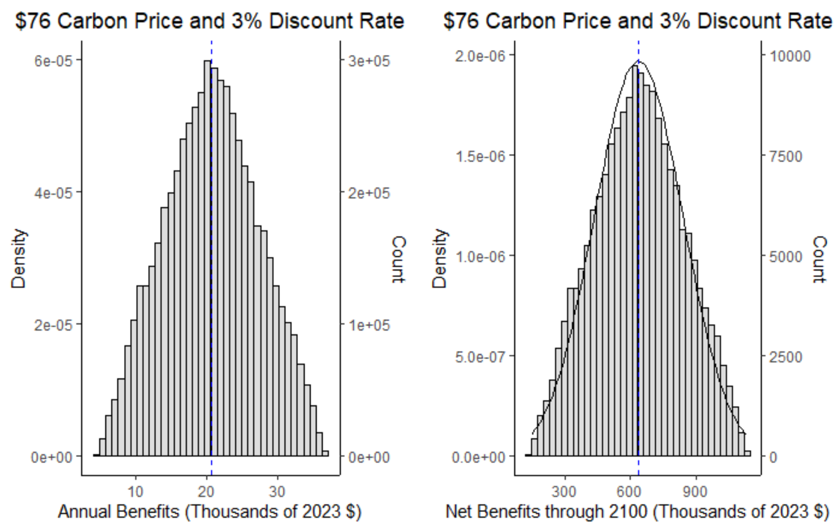
San Diego Bay - Salt Marsh



San Dieguito Lagoon - Salt Marsh



Santa Margarita Marsh - Salt Marsh



Tijuana River Estuary - Salt Marsh

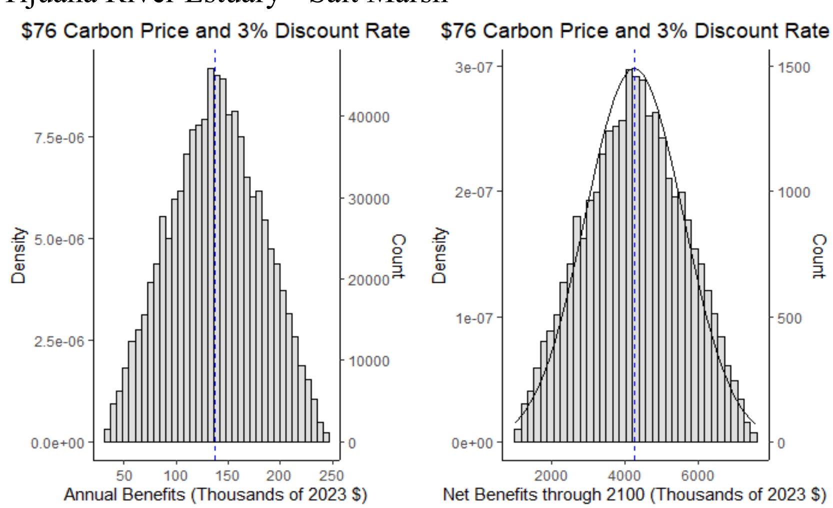
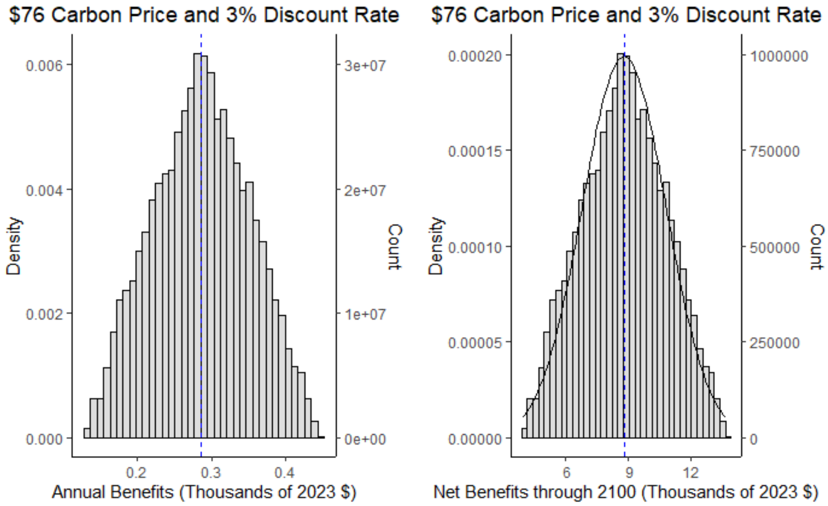


Table 4 – Economic Values for Blue Carbon Ecosystems (Eelgrass, Mudflats, Salt Marsh) by Location Local San Diego County Carbon Sequestration Rates

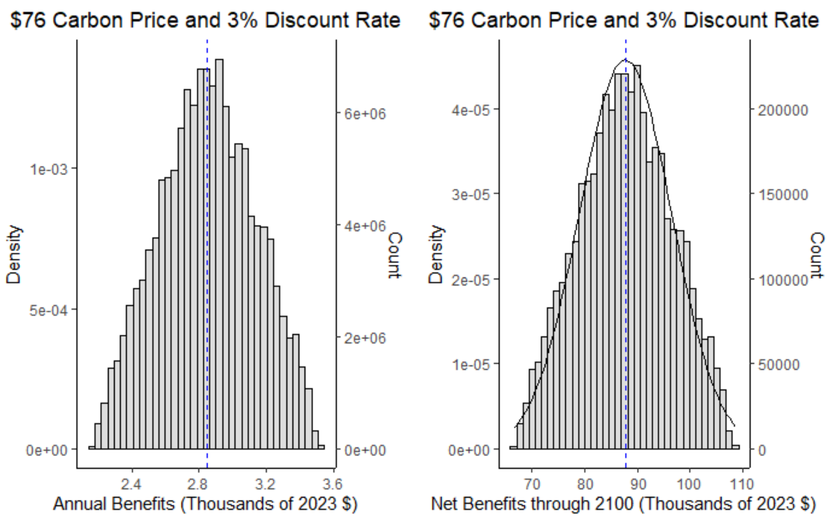
SCC Price	Habitat Type	Location	Sum of Mean Annual Value	Sum of Net Benefits 2023 through 2100
$26	**Mudflat**	Mission Bay	$99	$3,037
	Mudflat Total		**$99**	**$3,037**
	Salt Marsh	Mission Bay	$974	$30,004
		San Dieguito Lagoon	$24,943	$768,446
	Salt Marsh Total		**$25,917**	**$798,450**
$26 Total			**$26,016**	**$801,487**
$51	**Mudflat**	Mission Bay	$193	$5,933
	Mudflat Total		**$193**	**$5,933**
	Salt Marsh	Mission Bay	$1,913	$58,936
		San Dieguito Lagoon	$48,932	$1,507,491
	Salt Marsh Total		**$50,845**	**$1,566,427**
$51 Total			**$51,038**	**$1,572,360**
$76	**Mudflat**	Mission Bay	$286	$8,822
	Mudflat Total		**$286**	**$8,822**
	Salt Marsh	Mission Bay	$2,849	$87,764
		San Dieguito Lagoon	$72,695	$2,239,549
	Salt Marsh Total		**$75,543**	**$2,327,313**
$76 Total			**$75,830**	**$2,336,135**
$120	**Mudflat**	Mission Bay	$453	$13,969
	Mudflat Total		**$453**	**$13,969**
	Salt Marsh	Mission Bay	$4,494	$138,459
		San Dieguito Lagoon	$114,939	$3,540,983
	Salt Marsh Total		**$119,433**	**$3,679,442**
$120 Total			**$119,886**	**$3,693,411**
$185	**Mudflat**	Mission Bay	$700	$21,571
	Mudflat Total		**$700**	**$21,571**
	Salt Marsh	Mission Bay	$6,929	$213,467
		San Dieguito Lagoon	$177,309	$5,462,460
	Salt Marsh Total		**$184,238**	**$5,675,927**
$185 Total			**$184,938**	**$5,697,498**
$417	**Mudflat**	Mission Bay	$1,572	$48,425
	Mudflat Total		**$1,572**	**$48,425**
	Salt Marsh	Mission Bay	$15,649	$482,120
		San Dieguito Lagoon	$399,291	$12,301,186
	Salt Marsh Total		**$414,940**	**$12,783,306**
$417 Total			**$416,512**	**$12,831,731**

Table 4.a – SCC $76 Standard Deviation Graphs of Blue Carbon Ecosystems by Location

Mission Bay – Mudflat



Mission Bay – Salt Marsh



San Dieguito Lagoon – Salt Marsh