Managing Sandy Beach Ecosystems

Prepared for:

BEACON

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Executive Summary

The study of sandy beach ecology has been under-represented in coastal and marine science. However, recent advances in research provide new insight on the significance of sandy beaches as ecological systems that support extensive biodiversity and provide a wide range of ecosystem services and values, many critical in supporting human uses of these environments.

The first part of this report summarizes current knowledge of the ecological features and services of sandy beaches, the pressures currently facing these fragile ecosystems, and economic techniques for valuing these ecological services, functions and goods. Some key findings include:

- Beaches provide many important ecosystem functions and services as well as habitat to a number of unique species. Southern California beaches have a great deal of biodiversity.
- Population growth, coupled with demographic shifts, development and resource extraction, creates escalating pressures on the coast and, in particular, sandy beach environments... Global climate change, and the risk of sandy beaches being "squeezed" between landward development and rising seas, adds a new dimension to the pressures facing these environments.
- While sandy beaches are highly valued by society for their economic and cultural importance, their ecological features are often underappreciated. This is reflected in traditional management frameworks that promote maintaining and restoring physical features that support coastal defense and human recreation with little regard of ecological properties and processes.
- Given our current limited knowledge of beach ecosystems, it is not possible to place a specific dollar value on beach ecosystems. However, this does not mean that beach ecology is unimportant. Coastal managers need to be aware of the value of beach ecosystems in their decision-making.

To better link existing knowledge to management practices, we conducted structured interviews with decision-makers in the BEACON region to better understand their current ecological management practices of beaches. Some key findings include:

- Beaches within the BEACON area are under the jurisdiction of a number of different State, local and federal agencies. This regulatory structure is often cumbersome and inconsistent.
- Most of the focus on beach ecology has been on single "charismatic" species such as the snowy plover and grunion while much less attention has been paid to managing the entire beach ecosystem. Notably lacking is a master plan or management plan for stewarding beach ecosystem services, identifying what ecosystem services exists, and mitigating losses where necessary.
- Grooming/raking constitutes one of the most damaging activities to beach ecosystems since this practice reduces food for larger species. A few beaches in the BEACON area are groomed and subject to varying conditions.

- Dogs are a significant threat to shorebirds and enforcement of leash laws is inconsistent or non-existent at many beaches. A system of fines could possibly create a self-financing system for enforcing these laws.

Reconciling human demands on beach environments with the need to safeguard their unique biodiversity and status as functional ecological systems is not a simple task. However, there are some helpful perspectives and tools that could result in smarter management decisions.

- Beaches are part of regional littoral cells, and where possible should be managed at this scale rather than on a beach-by-beach basis. Inconsistent management approaches at contiguous beaches (e.g., Carpinteria City and State beaches) as well as those within the same littoral scale could result in adverse impacts to system connectivity and overall ecosystem function.
- In the BEACON region, baseline beach biodiversity assessments, including kelp and wrack, marine shorebirds, pinnipeds, sand crabs, clams, talitrid amphipods, and wrack–associated invertebrates are being conducted in support of MPA performance monitoring. Continued investments in measuring and monitoring ecosystems, their services, and their impacts to society can provide useful information for scientists and decision-makers.
- Environmental conditions at most urban beaches do not reflect their natural conditions, and reconstructing these historical conditions is generally not feasible. Consequently, a reasonable approach to management may come in the form of "sustainability" criteria... These criteria would vary by beach and region and would encompass differing stakeholder demands for ecosystem goods and services such as recreation, aesthetics, and biodiversity.

The final part of the report presents results of a survey of beach users' environmental perceptions. Key survey results include:

- Access, water cleanliness, sand cleanliness, crowding and beach size were the most important factors in the decision to visit a beach.
- Seawalls, revetments and groins have neither a negative or positive effect on the beachgoing experience of a majority of respondents.
- If ecological properties such as wrack were not cleaned from beaches, a majority of respondents would not change their frequency of visits.
- Nearly two-fifths of respondents perceived the ecological condition of the beach they were visiting to be healthy, one-quarter considered it to be unhealthy, and another quarter of respondents' were unsure.
- An overwhelming majority of respondents agreed of strongly agreed that they felt an obligation to protect the ecology of beaches.
- The vast majority of respondents were willing to pay more in annual taxes to preserve and restore the ecology of beaches. The average willingness to pay was approximately $30 per year in taxes.

Section 1: Review of the Literature

Purpose

The purpose of this section is to provide a broad overview of the ecological features and services of sandy beaches and evaluate the current state of knowledge of the economic techniques for valuing these ecological goods. This report is intended to inform those involved in the management of California's sandy beach ecosystems. We draw on a range of literature on the biological, physical and social processes that influence these environments. Where possible, we attempt to tailor the discussion to the BEACON region. This widely scattered literature was reviewed and synthesized to address questions such as:

- What are the ecological features and services of sandy beach environments?
- What are the pressures on sandy beach environments?
- How are beaches monitored to assess ecosystem health?
- What emergent management strategies and conservation tools are relevant to California's sandy beach environments?
- How are ecosystem services measured and valued?

Background

Coastal environments, often dominated by sandy shores, are a favored destination for tourism, recreation and leisure (Martinez et al. 2007; Culliton et al. 1990; Miller and Hadley 2005). Today, almost 70% of California residents live in counties that border on the coast (U.S. Census Bureau 2010). Sandy beaches are dynamic environments that exhibit an extensive variety of physical conditions, community structures and ecosystem functions (Brown and McLachlan 2002). The study of sandy beach ecosystems is largely under-represented in coastal and marine science. Prior to 1980, there was virtually no academic literature on beach ecosystems, but in the past 30 years our knowledge of these environments has grown significantly (Defeo and McLachlan 2005). This growing literature is often presented in academic journals and framed in terms that are not accessible to a non-technical audience. To more broadly communicate the emerging knowledge of this field, leading beach ecologists have produced a handful of summary documents on the key features of sandy beach ecosystems and their principal management challenges (e.g., Brown and McLachlan 2002; Schlacher et al. 2008; Defeo et al. 2009). The following discussion draws heavily from these resources.

Key Features

Physical Features

The physical features of a sandy beach reflect the interaction of waves and tides with the available sediment. Beach morphology is generally divided into two camps – reflective and dissipative. Reflective (accretional) beaches are generally narrow and steep, formed from a small tide range, a mild wave climate and coarse sediment. Conversely, dissipative (erosional) beaches are generally wide and flat, formed from a large tide range, sizeable waves and fine sediment (Short 1999). Most beaches, including those in the BEACON region, fall somewhere between these two extremes and can experience dramatic fluctuations following storms (Defeo et al. 2009; Finkl 2004).

Fauna

Sandy beaches support a range of biodiversity, including a number of organisms that do not inhabit any other environment. Most sandy beach species are uncharismatic and underappreciated, in part because they are small and live beneath the sand (Jones et al. 2004). A single beach can host several hundred species of invertebrates (Armonies and Reise 2000), and on one square meter of beach the abundance of macrobenthic invertebrates can reach 100,000 and biomass can exceed 1000 g (Defeo et al. 2009).

The intertidal beach zone provides habitat for a range of organisms. Bacteria, protozoa, microalgae and meiofauna form a unique food web between the sand. Macrobenthic invertebrates, including predators, scavengers, and filter-and-deposit feeders actively burrow in this area of beach. Dominant organisms include molluscs and polychaete worms (Defeo et al. 2009).

Beaches are dynamic environments often subject to harsh conditions. As a result, sandy beach species must be able to endure both pulse and chronic impacts. Invertebrates found on sandy beach shores demonstrate key adaptation traits, including: exoskeletons, mobility, burrowing ability, rhythmic behavior, orientation mechanisms and behavioral elasticity (Chelazzi and Vannini 1988; Brown 1996; Defeo et al. 2009).

Fauna of the lower beach may extend their distribution into the surf zone (e.g., zooplankton). The surf zone also provides foraging and nursery areas for fishes. The other side of the intertidal zone provides critical nesting habitat for shorebirds and turtles (Defeo et al. 2009). Figure 1 below illustrates the various biological components of sandy beach ecosystems.

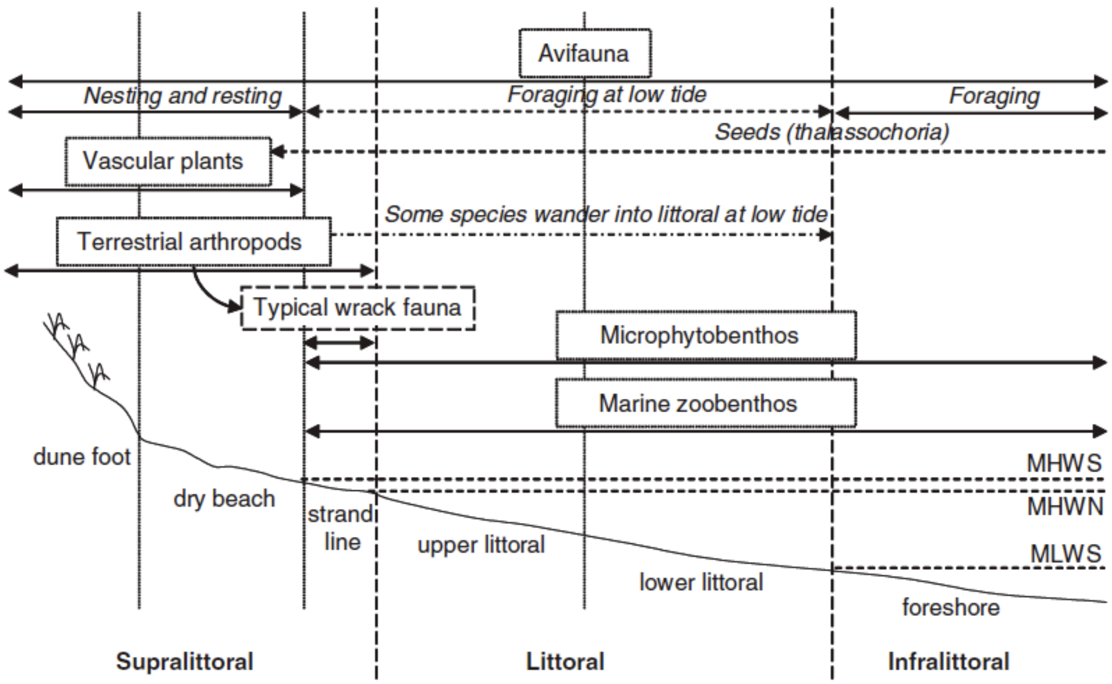

Figure 1: Scheme for considering the biological components of sandy beach ecosystems

Note: Supralittoral = strand line, dry beach and dune foot; littoral = intertidal zone; infralittoral = zone below MLWS; MHWS = mean high water level at spring tide; MHWN = mean high water level at neap tide; MLWS = mean low water level at spring tide.

Source: Speybroeck et al. 2006

Physical and Biological Relationships

Beach morphology is correlated with community structure, zonation and ecosystem functioning (Brown and McLachlan 2002). Beach slope, intertidal swash and sand conditions are the primary factors influencing species dynamics on sandy shores. Less harsh conditions on dissipative beaches allow for more species to inhabit and establish populations (McLachlan and Dorvlo 2005). While biological interactions (e.g., competition, predation) are trumped by physical factors at reflective beaches, they play of more significant role in community structuring at dissipative beaches (Defeo and McLachlan

2005). These relationships are evident at the latitudinal scale where tropical regions are dominated by reflective beaches and temperate regions by dissipative beaches (McLachlan et al. 1993; McLachlan and Dorvlo 2005). Figure 2 below illustrates species richness at sandy beaches in relation to wave action.

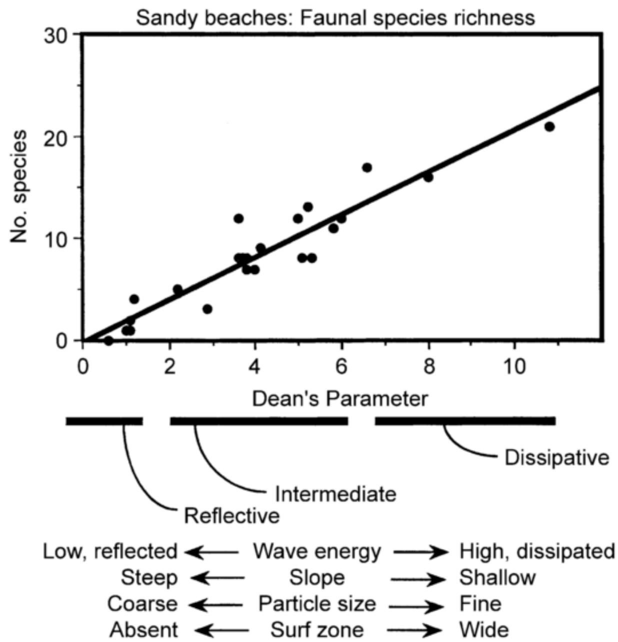

Figure 2: Species richness qualified as Dean's Parameter on sandy beaches in relation to wave action

Note: Dean's parameter integrates various aspects of the physical environment (i.e., beach slope, swash zone, sediment composition) to provide an overall correlative measure of the effects of wave action on species richness.

Source: Roberts et al. 2003

Ecological Linkages

Sandy beach ecosystems include a coupled surf zone, beach and dunes (Short and Hesp 1982), which collectively comprise an active-littoral zone of sand transport. Sandy beaches have functional ecological linkages with these adjacent ecosystems through the exchange of sediment, as well as organic matter and nutrients that affect the distribution and growth of sandy beach organisms.

The dynamic nature of sandy beaches prevents the colonization of stable substratum that can act as nutritional inputs of organisms (Jones et al. 2004). As a result, food webs on sandy beaches are mainly based on marine sources such as phytoplankton and stranded kelp (Koop et al. 1982). Phytoplankton is consumed by filter feeders, while kelp is decomposed and fragmented by bacteria and the grazing of small invertebrates (e.g., isopods, amphipods). The excrement from these invertebrates is nutrient rich and exploited by fauna that supports higher-level trophic species such as shorebirds (McLachlan et al. 1981).

There are a number of other ecological linkages supported by sandy beaches ecosystems, including, but not limited to, migratory and nesting habitats for birds and turtles and nursery and foraging areas for fish species (Jones et al. 2004). Thus, the interconnectedness of this system results in impacts to sandy beaches extending to contiguous environments. Figure 3 below demonstrates the functional relationships of sandy beach ecosystems.

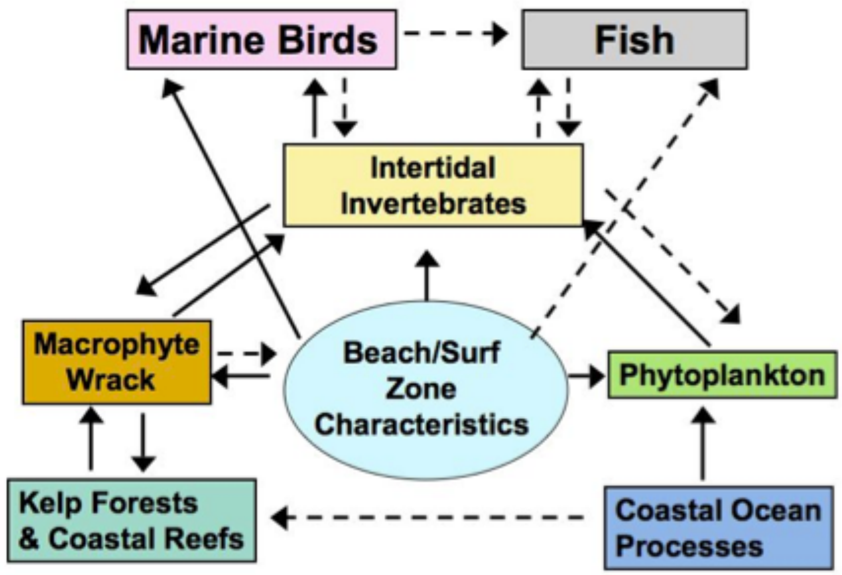

Figure 3: Hypothesized functional relationships among shorebirds, fish, macroinvertebrates, macrophyte wrack, beach characteristics and associated ecosystems for open coast sandy beach ecosystems

Note: Solid arrows indicate relationships supported by results to date in California and elsewhere. Dashed arrows refer to relationships still under investigation.

Source: Dugan et al. *In prep.*

Services and Functions

Sandy beach shorelines supply a number of ecosystem services. Many of these services are critical in supporting anthropogenic uses of these environments. As noted by Defeo et al. (2009) the most widely recognized ecosystem services provided by sandy beach globally include: (1) sediment storage and transport; (2) wave dissipation and associated buffering against extreme events (storms, tsunamis); (3) dynamic response to sea-level rise (within limits); (4) breakdown of organic materials and pollutants; (5) water filtration and purification; (6) nutrient mineralization and recycling; (7) water storage in dune aquifers and groundwater discharge through beaches; (8) maintenance of biodiversity and genetic resources; (9) nursery areas for juvenile fishes; (10) nesting sites for turtles and shorebirds, and rookeries for pinnipeds; (11) prey resources for birds and terrestrial wildlife; (12) scenic vistas and recreational opportunities; (13) bait and food organisms; and (14) functional links between terrestrial and marine environments in the coastal zone.

California's Beaches

The California coast includes approximately 1,100 miles of open coast, and sandy beaches play a critical role. California's beaches provide protection to private property and public infrastructure, and are an important destination for millions of Californian's searching for outdoor recreation opportunities (Neumann and Hudgens 2006). Nearly fifteen million people participated in beach activities in California in 2000, contributing billions of dollars to local, state and federal economies (King 1999; King and Symes 2004). Changes to beach profiles, primarily changes in beach width, following storms and permanent inundation from sea-level rise can substantially affect attendance rates, spending and recreational value (Pendleton et al. 2012). A majority of beach visitation and corresponding spending occurs in southern California. Because beaches underpin economies in southern California, various efforts are taken to maintain their physical profile, sometimes at the expense of their rich ecological profiles.

Sandy beaches cover approximately 80% of the southern California coastline (Smith et al. 1976). Table 1 below outlines the percent of coastline in southern California that hosts sandy profiles. Open coast sandy beaches in southern California are dynamic environments that undergo extensive modification year around. Morphology changes seasonally, including variations in beach slope, width and sediment composition (Inman and Jenkins 1998). The elevation and width of sandy beaches in southern California are generally at their maximum extent in the fall only to erode in the winter and spring, sometimes to the layer of exposed bedrock (Bascom 1980). Seasonally varying wind and wave climates play a significant role in the erosion and accretion dynamics along the southern California coast.

Table 1: Prevalence of sandy beach habitat on southern California mainland coast

County	Coastline (m)	% Sandy
Santa Barbara*	62	73%
Ventura	41	93%
Los Angeles	74	66%
Orange	42	86%
San Diego	76	81%
Total	**295**	**80%**

Note: * = South of Point Conception

Source: Dugan 2012, Personal Communication

Changes in beach width, elevation and sediment composition can impact intertidal habitat that serves as a critical food resource for a number of species. The winter and spring play host to narrower, coarser and steeper profiles that can be further exposed by large-scale physical processes such as ENSO events that elevate sea levels and storm waves. Beaches and dunes are at increasing risk of erosion from ENSO events, the impacts of which can affect macrophyte wrack and invertebrate communities that depend on them. Figure 4 below illustrates the decline in wrack coverage on BEACON coastline during the 1997-1998 ENSO events.

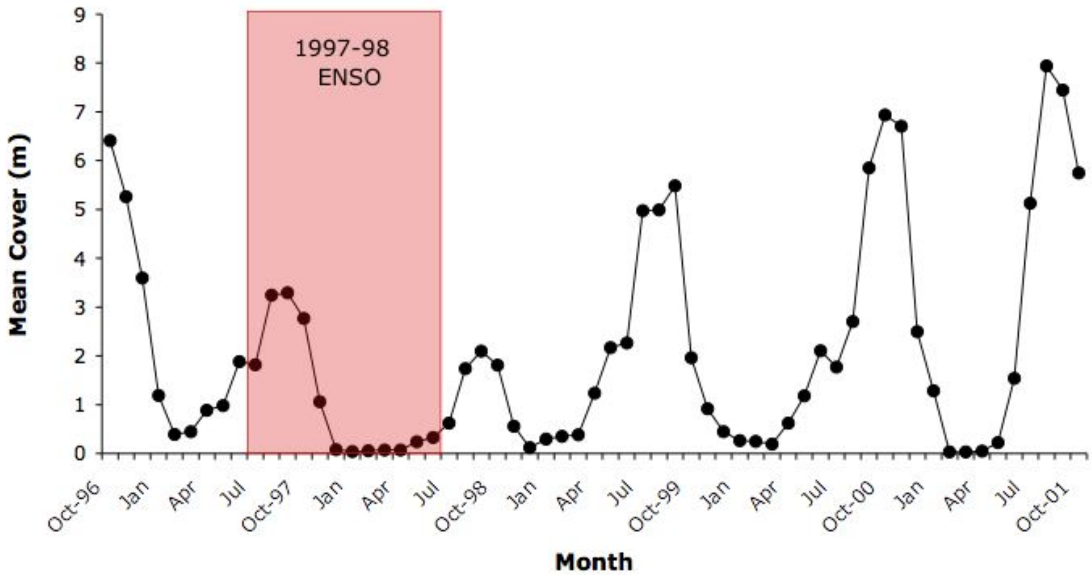

Figure 4: Effects of the 1197-98 ENSO (red shaded box) on marine macrophyte wrack abundance (3 month smoothed average cover) for 1996-2001 on a Santa Barbara County beach

Note: The data suggest a recovery of the kelp forest and beach from ENSO impacts required >2 years.

Source: Revell et al. 2011, taken from Dugan et al. *In Prep*.

California's beaches support extensive biodiversity, including some of the most diverse invertebrate communities ever recorded (Dugan et al. 2000; Dugan et al. 2003). Primary suspension-feeding intertidal invertebrates found on sandy beaches in the southern California region (though in lesser abundance and biomass in the BEACON region) include sand crabs and clams, which also play a role in recreational fishing as consumption or bait. In California, 40 percent of beach invertebrate species can be associated with wrack (Dugan et al. 2003). These invertebrates mostly feed on phytoplankton and suspended wrack in the lower intertidal zone, converting it to invertebrate biomass. Beaches also process organic matter (e.g., wrack). Nutrient recycling and mineralization is a key ecosystem function of beaches that provides connectivity between marine and land environment. Results from studies at beaches in Santa Barbara County indicate that wrack processing and mineralization may provide nutrients to the surf zone that could affect nearshore primary producers such as surf grass (Dugan et al. 2011).

High levels of abundance and biomass of sand crabs and clams have been recorded in southern California, providing the majority of biomass consumed by higher trophic level species such as shorebirds and fishes (Dugan et al. 2000). These invertebrate communities serve as a critical source of prey for shorebirds that migrate, winter or breed along the coast.

California's coastal wetlands now represent approximately 10 percent of their historic coverage. As a result, beaches now serve as a critical foraging habitat substitute (Hubbard and Dugan 2003). Shorebird response to changes in beach condition makes them a possible indicator of ecosystem condition in the southern California region. Over 25 species of shorebirds use open coast sandy beaches in California, and at a number of beaches in southern California, shorebird density can average greater than 100 birds km^{-1} year around (Hubbard and Dugan 2003). Table 2 below shows relative density of shorebirds at beaches in the BEACON region compared to other sandy beaches in the world.

Table 2: Shorebird surveys on exposed sandy beaches in Santa Barbara County and elsewhere in the world

Abundance (individuals km^{-1})		Species richness (number)		Number	Length of	Total		
Mean	Maximum	Mean	Total	of sites	transects (km)	length (km)	Study region	Reference
8.9	14.7	–	7	3	3–40	>60	S. Africa east coast	McLachlan et al. (1980)
98.1[a]	–	–	>6	1	1	1	S. Africa west coast	Griffiths et al. (1983)
50–68[b]	117[b]	–	21	5	3–34	123	USA, North Carolina Outer Banks	Dinsmore et al. (1998)
23.9	–	–	19	2	0.6–1.4	2	Mexico, Baja California	Lopez-Uriarte et al. (1997)
44.0[c]	124[c]	2.6	12	40	0.5	20	USA, N. California Humboldt Co. Del Norte Co.	Colwell and Sundeen (1998)
44.0	603	3.1	23	14	1	14	USA, S. California Ventura Co.	McCrary and Pierson (1999)
77.9	1200	4.0	28	20	1	20	USA, California Santa Barbara Co. San Luis Obispo Co.	Dugan et al. (2001)
98.6	886	5.5	26	1	1	1	USA, S. California Santa Barbara Co.	Present study

Note: Abundance values are adjusted to 1km if needed, but species values are not adjusted.
(a) = value is seasonally adjusted; (b) = spring/fall migration; (c) = winter/spring

Source: Dugan and Hubbard 2003.

Studies have recorded a positive correlation between shorebird use of beaches and invertebrate prey and wrack and beach morphological profile (Dugan et al. 2003; Revell et al. 2011). However, Dugan et al. (2003) identify a lack of evidence to suggest that morphodynamics, swash climate and other related variables strongly influenced macrofaunal communities at beaches in the Santa Barbara region. While not definitive to other regions, their results indicate that macrophyte wrack subsidies, additional recruitment dynamics and disturbance from activities like grooming can greatly affect macrofauna communities. A number of nearshore fish species depend on beach invertebrates (e.g., crabs). Vulnerable birds such as the Western Snowy Plover and the California Least Tern nest on exposed sandy beaches in the Santa Barbara region (Lehman 1994; Page et al. 1995) and the California grunion spawn in upper intertidal zones.

Threats to Sandy Beach Ecosystems

Sandy beach systems face many threats from a number of sources that act at varying temporal and spatial scales. Major stressors globally include: recreation; grooming; nourishment; pollution; exploitation; biological invasions coastal development and engineering; mining; and climate change (Defeo et al. 2009). Critical features and processes of sandy beach ecosystems vulnerable to these stressors include: modification of sand budgets under high-energy conditions; limited water circulation that can slow the dispersal of materials under low-energy conditions; disturbance of dune vegetation and the resulting destabilization of dunes; removal of organic subsidies that are critical to food webs; webs; and the disturbance of higher trophic level species that nest on the backshore (Defeo et al. 2009). Some of these stressors, such as off road reccreational vehicles, mining and forms of exploitation are less of an issue to the BEACON region and as a result are not discussed below. Figure 5 below illustrates the conceptual relationship of spatial-temporal scales of key stressors on sandy beaches.

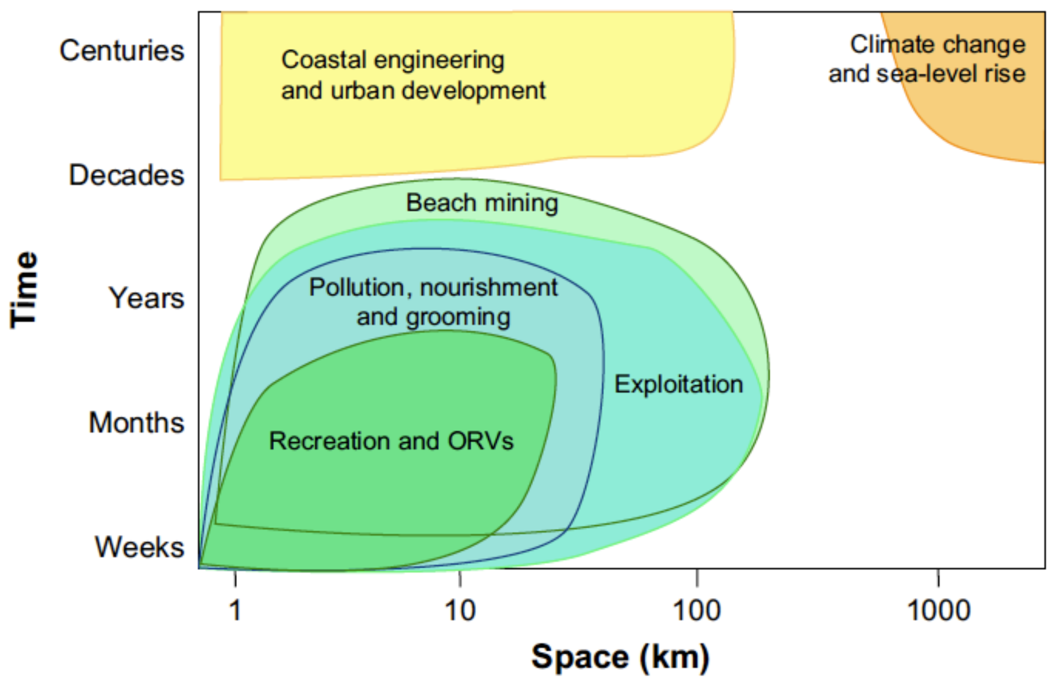

Figure 5: Conceptual model of the relative spatial-temporal scales of the key stressors on sandy beaches

Note: "Boxes/envelopes indicate the potential extent of individual impacts in space and time with the lower curve reflecting the lower limit of impacts in time and space, whereas the upper curve reflects the corresponding maximum…However, the temporal extent of impacts from the anthropogenic pressures depicted here could be drastically altered if the intensity of the disturbance is increased and/or its timing is more protracted."

Source: Defeo et al. 2009

Recreation

Sandy beaches are best known for their recreational services, which generate various forms of spending to the benefit of coastal economies (Klein et al. 2004). To maximize the recreational experience for beach users, nourishment, beach grooming and the development of tourism infrastructure has become commonplace, often with little regard to their ecological impacts (Speybroeck et al. 2006; Dugan et al. 2003; Dugan and Hubbard 2006; Dugan et al. 2008). The effects of recreation are evident on scales ranging from weeks to months and landscapes of less than one km to an upwards of ten km (Defeo et al. 2009), and are typified by trampling and general disturbance.

Our understanding of human impacts such as trampling on sandy beach organisms is limited. While some research indicates that increased human activity can result in negative impacts (Moffett et al. 1998; Weslawski et al. 2000; Veloso et al. 2006), these findings are not definitive (Jaramillo et al. 1996). Because high-use recreation areas often coincide with other habitat modifications such as armoring and grooming, there are challenges to isolating the impacts of human trampling (Barros 2001).

Sandy beaches serve as important habitat for shorebirds (Hubbard and Dugan 2003) that are sensitive to human disturbance. For example, human activities along the shoreline alter the behavior of shorebirds in ways that influence survival and reproduction, resulting in decreases to food in-take, paternal care and nesting densities (Burger 1994; Lord et al. 2001; Verhulst et al. 2001).

Grooming

Grooming is commonly used at beaches with high recreational use (Davenport and Davenport 2006). The typical practice involves deploying heavy equipment to clear the beach of wrack, litter and additional debris (Fanini et al. 2005). In the process, resident organisms are disturbed, injured or collected (Llewellyn and Shackley 1996). The removal of wrack deprives the ecosystem of critical nutritional inputs, (Brown and McLachlan 2002) microhabitat refuge for macroinvertebrates (Colombini and Chelazzi 2003), and primary fauna (e.g., talitrid amphipods, insects) that support higher trophic levels (Dugan et al. 2003). As a result, grooming has significant impacts to community structure (Colombini and Chelazzi 2003; Dugan et al. 2003; de la Huz et al. 2005). Figure 6 below illustrates species richness relative to the standing crop of wrack at groomed and non-groomed beaches.

For example, grooming affects the total number of shorebirds on a beach; there is a positive correlation between shorebird population with wrack coverage and the biomass of the invertebrate prey feeding on it (Hubbard and Dugan 2003; Dugan et al. 2003). Further, grooming devices can affect the breeding populations of beach-nesting vertebrates such as shorebirds and fish, including the mortality of eggs and juveniles (Martin et al. 2006). Grooming practices vary by beach in the BEACON region, but as a general rule, grooming is not practiced in the intertidal.

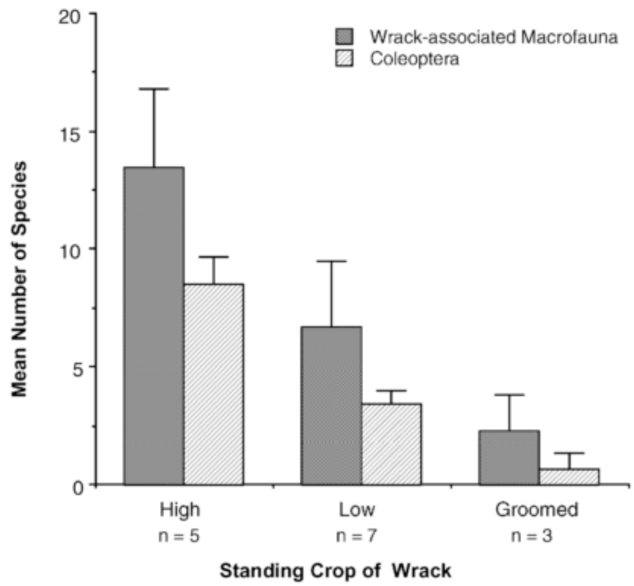

Figure 6: Mean species richness of wrack associated macrofauna and Coleoptera for beaches with high and low standing crop of wrack, and for groomed beaches

Note: Error bars represent standard errors.

Source: Dugan et al. 2003

Nourishment

Approximately 65% of California's coastline is eroding in the short term and 40% over the long term (Hapke et al. 2009). Structural engineering techniques, such as seawalls, jetties and breakwaters, used to combat this problem do not always prove effective, and may even play a role in the loss of intertidal beach (Hsu et al., 2007). For species that rely on sandy beaches for habitat, such as shorebirds and turtles, and in particular at reaches of the shoreline that have been completely eroded because of hard structures, nourishing the beach can provide environmental benefits (National Research Council 1995). As a result, beach nourishment is often viewed as a preferred alternative to erosion or coastal armoring for both economic and conservation reasons (Finkl and Walker 2004). However, nourishment can result in adverse impacts for species that rely on the beach for feeding, nesting or spawning (Peterson and Bishop 2005; Speybroeck et al. 2006).

Nourishment projects generally cover beach lengths from one to ten km (Peterson and Bishop 2005) and the process can take weeks to years (Defeo et al. 2009). Key determinants in the character and degree of ecological impacts include the mechanical process (e.g., are bulldozers used), timing (in relationship to spawning and nesting cycles), and the quantity and quality of sediment used (Speybroeck et al. 2006). Nourishment results in a short-term ecological disturbances generally followed by recovery over a period of months (Peterson and Bishop 2005); the degree of impact and corresponding rate and extent of recovery is highly affected by the quality of sediment used (Nelson 1988 and 1993 A and B; Peterson et al. 2000 and 2006).

Nourishment impacts can range from direct (e.g., mortality of submerged organisms, disturbance to nesting and foraging) to indirect (e.g., reduced prey) (Nelson 1993 A and B; Bishop et al. 2006; Peterson et al. 2006). These impacts can be magnified when physical changes to the beach profile occur, in particular increases to the slope of a beach can reduce the area of critical habitat (Peterson et al. 2006; Fanini et al. 2007; Fanini et al. 2007 and 2009). Further, nourishment to artificially extend or flatten a beach can result in the takeover of macrofauna leading to reduced biodiversity (Peterson and Bishop 2005).

Water Pollution

Pollution threats to sandy beaches are subject to significant public attention given the high recreational value of these environments. Pollution can affect the aesthetic experience of recreational users and pose risks to their health. These factors, among others, affect public perception of beach quality, which in turn affects visitation (Tudor and Williams 2003). At the ecological level, pollution ranging from molecules to large debris, can affect the physiology, survival, reproduction and behavior of species found in habitats across the beachscape (e.g., interstitial, surf zone) (Noble et al. 2006).

Waves and currents transport the majority of the solid debris ashore. Plastic, which typifies the debris found on beaches globally (Derraik 2002), poses the risk of ingestion and entanglement for vertebrates like seals and seabirds (Mascarenhas et al. 2004).

Sewage and wastewater represent other primary pollution threats. When discharged directly in coastal waters or estuaries (Stretch and Mardon 2004), intertidal sediment (Salvo and Fabiano 2007) and water in the surf zone (Bonilla et al. 2007; Noble et al. 2006) can become contaminated. This can result in impacts to human health, and when bacteria thresholds are met, beaches can be subject to closure. Reductions to biodiversity and population density of economically valuable species are also at risk from wastewater (e.g. accumulation of metal pollution) (Haynes et al. 1997). Further, freshwater effluents can play a role in deteriorating beach habitat (Lecrari et al. 2002), and can affect the ecological organization of sandy beach organisms (e.g., Lercari and Defeo 2003).

Beach environments are also subject to oils spills that can have drastic affects across all trophic levels (Bodin, 1988; Suderman and Thistle 2003). These impacts range from acute (i.e., days, weeks) to more chronic (i.e., months, years) (Irvince et al. 2006), depending on beach morphology and exposure (Benabeu et al. 2006), and can extend to cleanup activities.

Coastal Development and Engineering

Shoreline management characteristically focuses on the sediment budget, which has been starved by the construction of dams and further disrupted by mining, deforestation, agriculture and development (Sherman et al. 2000). To manage shorelines that are experiencing accelerated rates of erosion, society often relies on engineering techniques, including the placement of hard structures (e.g., seawalls and revetments) on beaches (Griggs 2005ab).

While capable of providing coastal defense, these structures can affect sand transport rates that regulate beach erosion and accretion dynamics (Hsu et al. 2007). When armoring structures arrest the landward migration of the shoreline, passive drowning of beach can occur (Griggs 2005b). Further, shoreline structures can deprive beaches of sand from eroding coastlines.

Reductions in habitat area can lower the diversity and abundance of biota in the upper intertidal zone (Dugan et al. 2008), which, collectively, can affect higher trophic levels. For example, lower numbers and fewer species of birds have been documented on armored compared to unarmored beaches in California (Dugan and Hubbard 2006).

The loss of dry beach also reduces the available nesting habitats for some species of fishes like the California grunion. Further, armoring can lower rates of deposition and retention of wrack and other natural debris that are vital food and habitat resources for beach biota (Dugan and Hubbard 2006).

Climate Change

Climate change is likely to affect sandy beach ecosystems through changes to species distribution, composition and interaction (Brown and McLachlan 2002, Jones et al. 2007). Given the dearth of literature on the direct impacts of climate change on beach ecosystems, the effects of potential stressors are often derived from other systems (Defeo et al. 2009).

Changes in temperature are likely to affect the distribution and composition of organisms on sandy shores. The degree of change will vary by latitude and the dispersive capacity and ranges of taxa. Endemic species with narrow-ranges or limited migratory ability are likely to face significant declines and possibly even extinction (O'Hara 2002). Temperature change can also affect marine productivity (Richardson and Schoeman 2004), which can result in indirect impacts to beach biota. For example, ENSO events resulted in significant reductions to a number of species on Peruvian beaches, followed by rapid recovery when normal conditions returned (Tarazona and Parendes 1992).

Increases to sea and air temperature are resulting in accelerating rates of sea-level rise (IPCC 2007). As sea level continues to rise, the high-water mark will extend landward, resulting in the migration of the shore inland. Where development has arrested the shoreline, sea-level rise will narrow the beach face, resulting in reduced habitat area (Feagin et al. 2005). Further, changes in storminess and wave climates from warming sea and air temperature may escalate beach erosion. Highly susceptible to erosion are low gradient dissipative beaches, which host the greatest biodiversity (Defeo et al. 2009). The ensuing dynamic is likely for eroding beaches to recede further, stable beaches to begin retreat, and accreting beaches to slow or even reverse this trend (Slott et al. 2006). It is likely that some narrow beaches, including beaches in the BEACON region, will disappear completely if mitigating actions are not taken.

The world's oceans act as a carbon sink. Increasing atmospheric carbon dioxide levels is altering seawater chemistry by lowering ocean pH. Over the past two centuries, ocean pH has decreased by 0.1 units. By the end of the century, ocean pH could drop another 0.3 to 0.4 units (Meehl et al. 2007). This phenomenon, known as ocean acidification, lowers the saturation states for primary calcium carbonate biominerals (e.g., aragonite and calcite) that marine species use to build their shells (Feely et al. 2004). As a result, ocean acidification may alter the physiological function of sandy beach organisms with shells and exoskeletons (e.g., molluscs, crustaceans), and increase their vulnerability to abrasion and predation (Hall-Spencer et al. 2008).

Managing Sandy Beach Ecosystems

Ideally, the management of sandy beach environments should be guided by the best science and best practices. Unfortunately, our knowledge of the natural dynamics of beach systems and their capacity to respond to human and natural impacts is limited. To preserve the ecological integrity of sandy beaches, including their biodiversity and ecosystem functions, the ecological components of these environments must also be considered. While the knowledge of beach ecosystems and their stressors is growing rapidly, this knowledge base is still in infancy. To address critical information gaps that impede the management of beach ecosystems, the following non-exclusive research agendas have been suggested by Schalcher et al. (2007):

1. The identification, quantification, and economic valuation of vital ecosystem services provided by beaches.
2. The responses of beach ecosystems to the intensification of erosion and disturbance regimes and to human interventions that seek to counteract shoreline change and beach erosion.
3. The ecological consequences, including impacts on ecosystem services, of human activities, such as recreation, extractive use, and pollution, that directly impact beaches.
4. The functional relationships between drivers of the physical environment (e.g. wave regimes, sediment properties), organism transport, and the structure and function of beach ecosystems.
5. The implications of habitat loss and fragmentation as well as weakened linkages across critical ecotones and habitats for the conservation of sandy beach biodiversity, including endangered vertebrates such as turtles.
6. The effects of cumulative impacts from multiple stressors and disturbances operating at increasingly larger spatial scales and greater frequencies on the structure, function, and recovery dynamics of sandy beach ecosystems.

Monitoring Ecosystem Health

Measuring and monitoring ecosystems, their services, and their impacts to society can provide useful information for decision-makers. It is impossible to measure all relevant environmental variables in an ecosystem. Even if this wasn't the case, there are difficulties integrating vast amounts of data into a decision-making processes (Barros 2001). To feasibly evaluate the status and trend of ecosystems (e.g., degradation, maintenance, sustainability) at varying scales, environmental indicators can be used (UNEP 2011; Cairns et al. 1993). Environmental indicators can also serve the important role of relaying complex message in a simplified and useful manner for decision-makers and end users (Linton and Warner 2003).

Ecological indicators, which include physical chemical, and biological measures, are one subset of environmental indicators used to evaluate human impacts (Niemi and McDonald 2004). Ecological indicators are generally defined as measurable characteristics of the structure, composition or function of ecosystems. The most universally accepted criteria for an ecological indicator include (Lucrezi et al. 2009; Dale and Beyeler 2001; Niemeijer and de Groot 2008):

- Ease of measurement at low cost;
- Sensitivity to stresses and predictable response to specific pressures;
- Largely insensitive to expected sources of interference;
- Documented reaction to natural and anthropogenic disturbances in the system;
- Delivery of information at spatial and temporal scales that match management responses; and
- Ability to predict changes that can, theoretically, be prevented through management.

Biological indicators, or bioindicators, are a subset of ecological indicators that use biota to signal the impact of human activities. Monitoring bioindicators for presence or absence, condition, behavior and numbers can provide information on the state of an ecosystem (Linton and Warner 2003). Biological responses are cumulative and observable after the event that caused them. Thus, bioindicators can be used to evaluate the effects of both episodic and chronic events on biota (Linton and Warner 2003). Also, biological indicators can help to evaluate synergistic or additive relationships among impacts, a critical issue when considering the number and type of impacts on coastal systems (Ginsburg 1994).

Indicators can be chosen from varying levels of biological and ecological organization, yet species are the most common (Noss 1990). There is a broad conceptual range for indicator species, including (Lambeck 1997; Lucrezi et al. 2009):

- Keystone species: demonstrate strong interactions with other species;
- Umbrella species: extensive habitat range;
- Dispersal-limited species: demonstrated site fidelity;
- Resource-limited and process limited species: sensitive to changes in an ecological resource or process; and
- Flagship species: elevated public profile.

Invertebrates are effective indicators of human activities across a number of environments (Chessman 1995; Fulton et al. 2005; Resh 2008). This can be attributed to their response at finer spatial scales, and their distribution and population characteristics being well linked to environmental conditions that are subject to human modification (Schoener 1986; Lucrezi et al. 2009). Rapid assessments of biota have been successfully used in freshwater environments (e.g., mangroves) to determine environmental quality and identify human impacts (Chessam 1995; Wright 1995). Yet, such assessments have not been widely developed for exposed sandy beaches, regardless of the fact that these ecosystems are heavily used in urban areas (Ranwell and Boar 1986).

Field studies of sandy beach invertebrates, a majority of which are not observable to the human eye, is a timely and challenging exercise; waves, tides and currents result in physical parameters that are difficult to replicate in space and time. (Barros 2001). Ghost crabs, due to their size and activity, are one of the most noticeable invertebrates found on sandy beaches. This species has been identified as meeting several criteria for an indicator taxon because they occur at relatively high densities (Lucrezi et al. 2009), can be found in a wide-range of geographic areas (Jones 1972) can be counted rapidly by focusing on burrow openings (Lucrezi et al. 2009) and respond in predicable ways to human disturbance (Barros 2001; Schlacher et al. 2010).

Ecological Indicators in Practice

Olympia National Park, in Washington state, has developed a long-term monitoring program to assess the health of is its sandy beach ecosystems. This program is designed to measure ecosystem response to stressors such as trampling, pollution, climate change and aquaculture, among others (Jenkins et al. 2003). Chosen indicator types include water temperature, species composition and abundance of intertidal invertebrates, sediment composition and morphological profile. The Park plans to use the monitoring results to refine their management plan.

California's Marine Protected Areas

Marine protected areas (MPAs) are discrete geographic areas regulated for conservation and sustainable provision of human uses. Recognizing the need to safeguard the long-term health of California's marine environment, the state legislature passed the Marine Life Protections Act (MLPA) in 1999. This legislation directs the state to reevaluate and redesign California's marine protected areas (MPAs). The creation, monitoring and management of California's MPA network are premised on both credible science and stakeholder engagement. The MLPA calls for California's MPAs to be designed and management with the following goals in mind (DFG Code 2853):

- To protect the natural diversity and abundance of marine life, and the structure, function and integrity of marine ecosystems.
- To help sustain, conserve and protect marine life populations, including those of economic value, and rebuild those that are depleted.
- To improve recreational, educational and study opportunities provided by marine ecosystems that are subject to minimal human disturbance, and to manage these uses in a manner consistent with protecting biodiversity.
- To protect marine natural heritage, including protection of representative and unique marine life habitats in CA waters for their intrinsic values.
- To ensure California's MPAs have clearly defined objectives, effective mgmt. measures and adequate enforcement and are based on sound scientific guidelines.
- To ensure the State's MPAs are designed and managed, to the extent possible, as a network.

To evaluate MPA performance, the MPA Monitoring Enterprise, a program of the California Ocean Science Trust, was established to lead the development and implementation of MPA monitoring. Impartial and cost-effective scientific assessments are being conducted inside and outside of sanctioned MPAs, including an assessment of beach and adjacent surf zones, to identify baseline conditions for consideration in future MPA management decisions (MPA Monitoring Enterprise 2011). In the South

Coast, which includes Santa Barbara and Ventura counties, baseline biodiversity assessments are being conducted. Focusing on linkages between beaches and other coastal and nearshore ecosystems, the following indicators, among others, are being monitored: kelp and wrack, marine shorebirds, pinnipeds, sand crabs, clams, talitrid amphipods, and wrack–associated invertebrates (Johnson 2011). Figure 7 below illustrates California's MPA monitoring framework.

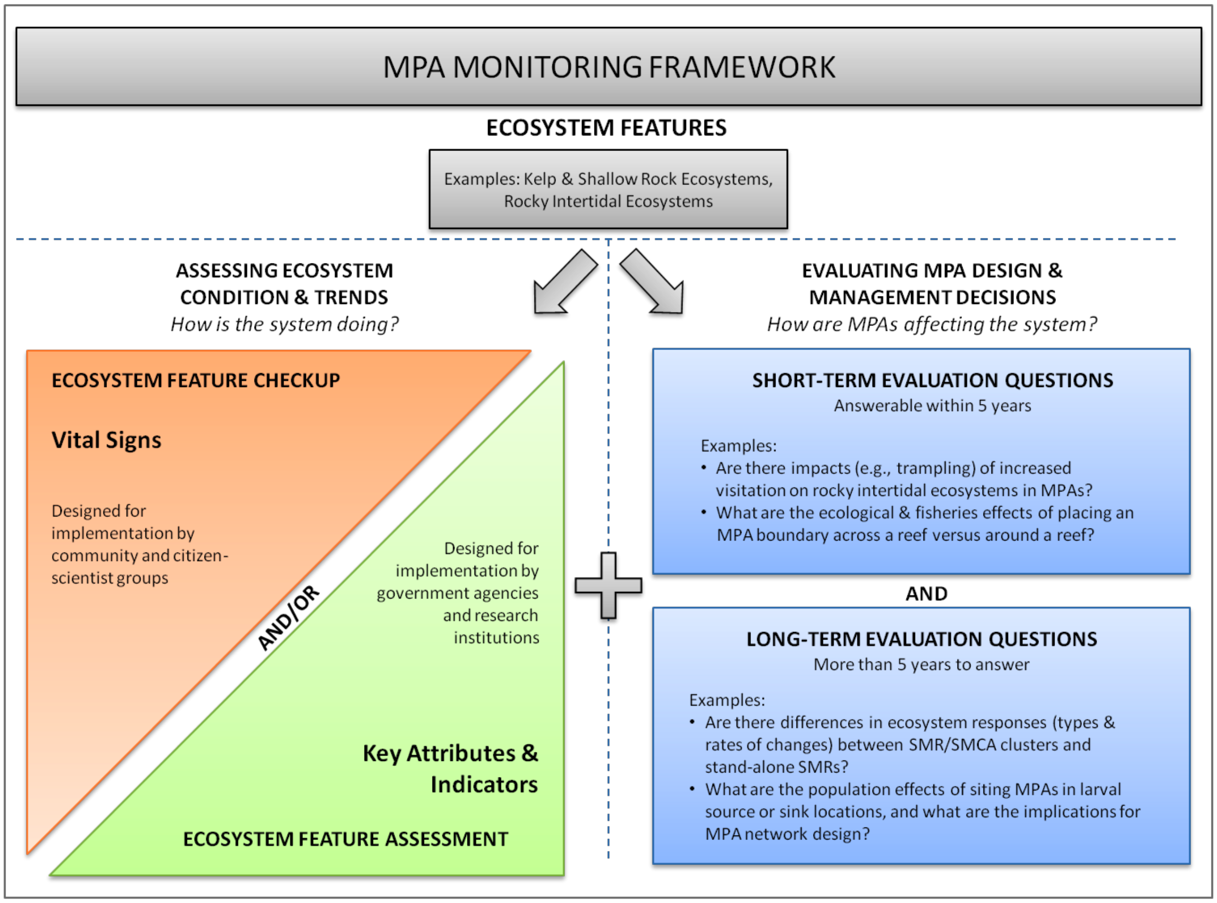

Figure 7: California's marine protected area monitoring framework

Source: MPA Monitoring Enterprise 2011

Valuing the Economic and Ecological Services of Beaches

Recreational Benefits

Most beaches in California are public property. Beaches and other “free” goods are referred to by economists as “non-market” goods. Assessing the value of these good involves estimating how much visitors are actually willing to pay for the experience of going to the beach. Economists have developed a number of techniques for assessing recreational value but all involve estimating a visitor’s willingness to pay (WTP) for the beach experience. It’s often expressed in terms of a “day-use” value—how much is a day at the beach worth to a visitor.

A large literature has developed for both academics and practitioners (e.g., Phaneuf and Smith 2004; Bockstael 1995) on how to measure WTP. This paper will not attempt to recreate this literature but will only touch on the key issues. WTP can be elicited either by surveying visitors about their preferences (generally referred to as contingent valuation method or CVM) or by estimating the effort they take to travel to a specific site (the travel cost method, TCM, and also more sophisticated versions referred to as random utility models, (RUMs) (Phaneuf and Smith 2004). CVM was popular in the 1990s but has fallen out of favor with most economists since the answers that survey respondents provide may be biased (e.g., Diamond and Hausman 1994) though academic studies have revealed that in practice the two main methods (CVM and TCM) yield very similar results (Carson et. al. 1996).

Most studies of beach recreational value in California have used TCM or RUM, though King (1995) used CVM in an early study. The value of a beach day at a California beach varies on the beach and type of study from a few dollars a day to $30-$40 a day (Leeworthy and Wiley, 2007). One common criticism of studies which have higher values per day is that they do not properly account for close substitute beaches, though given the congestion and parking constraints at many beaches in high season it’s unclear whether this criticism is completely valid.

More recently, a few studies have looked at the benefits derived from greater beach amenities. The southern California Beach project applied a RUM to Orange County and LA County beaches (Hanemann et. al. 2004). This model was later extended to incorporate the value of wider beaches (Pendleton et al. 2012) as well as the costs of sea level rise (Pendleton et al. 2011).

One problem with all of these valuation studies is that they can be quite expensive and the methodology is likely to vary from beach to beach, making direct comparison more difficult. Coastal managers need a relatively simple tool that can be applied to all beaches in California. This technique is referred to as “benefits transfer” (BT)—it relies on applying existing studies to other beaches and recreational sites. Probably the most widely used BT method is the Army Corps of Engineers technique (USACE 2012), which the Corps uses for many of its projects, including beach nourishment projects, where a specific study is too expensive. The Corps’ valuation technique was created for general recreational value at parks and other public facilities and is not specific to beaches. One problem with the technique is that there is no explicit way to value increases in beach width, which makes it hard to use for nourishment projects, even though that is by far the most common beach application.

To address some of the limitations of the Corps model, the State of California developed the Coastal Sediments Benefits Analysis Tool (CSBAT). CSBAT is a BT tool specifically designed to analyze California beaches and changes in the recreational value as amenities change, in particular beach width. CSBAT has been calibrated using a number of studies in California as well as a few on the east coast. Both the USACE technique and CSBAT provide values for a day at the beach ranging from a few dollars to about $18 a day (2012 dollars—the value is indexed to inflation). These estimates are consistent with the Southern California Beach model as well as the American Trader case. However, if the possibility for substituting between beaches (due to congestion) is lower than assumed in these models, the true value may be higher (King et. al. 2011).

Economic Impacts

Non-economists often confuse economic impacts and economic benefits. As discussed above, benefits measure a visitor's willingness to pay to go to the beach. In contrast, economic impact analysis estimates how much people spend at the beach or on their way to the beach. King and Symes (2004) conducted surveys at a number of beaches in southern California to determine how much visitors spend. The average amount varies in a range of about $10 to $30 and depends crucially on the percentage of visitors who stay overnight, who spend far more. King and Symes' estimates are consistent with other similar studies such as the Southern California beach project (Hanemann et al. 2004).

Economic impacts can be estimated at the local (city or county) level if one knows the percentage of spending occurring locally. Similarly tax impacts can be estimated as well. Sales taxes are easiest to estimate if one knows the breakdown of goods between taxable (e.g., restaurants) and non-taxable (most groceries) items. Transient Occupancy taxes (TOTs) and other taxes can also be estimated.

Difficulties in Measuring Economic Benefits and Impacts

Over the past ten years our knowledge of both economic benefits and economic impacts at California's beaches has increased markedly. Ironically, the variable which is often least understood is attendance. Most of the techniques discussed above involve multiplying a benefit or impact per visitor per day by the number of visitors. However, attendance data is spotty and where it exists there is strong evidence that values may be misestimated (King and McGregor 2012).

Ecological Functions, Goods and Services

Although there is a large literature on the theoretical underpinnings of the economics of ecological functions, goods, and services (hereafter referred to as EFGS), the field is still in its infancy. Ecological goods and services generate a wide variety of benefits to society both direct (e.g., recreation, mining) and indirect (e.g., biodiversity). As depicted in Figure 8 below, valuing EFGS properly requires a sound understanding of ecosystem functions as well as the production of the ecosystem goods and services derived from these functions.

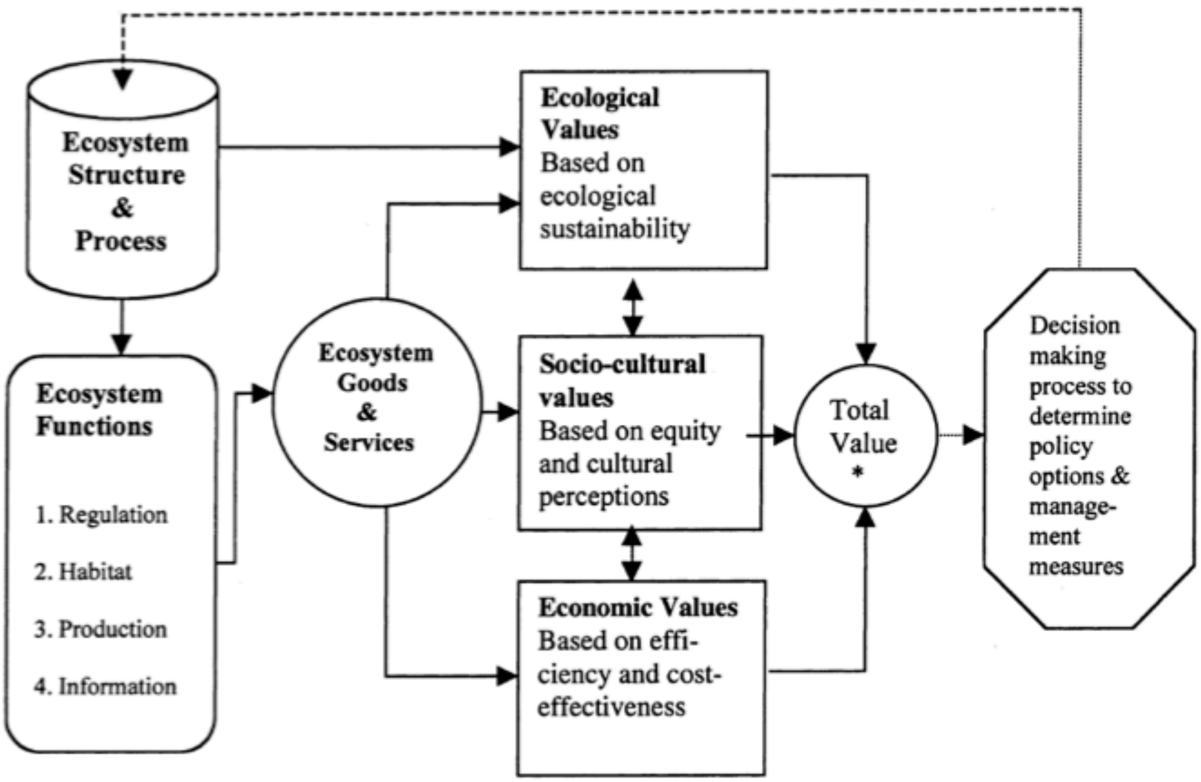

Figure 8: Framework for integrated assessment and valuation of ecosystem functions, goods and services

Source: DeGroot et al. 2002

Table 3 below, from Costanza et al. (1997) provides a general taxonomy of these ecological functions, goods and services potentially provided by an ecosystem. In the case of beaches, almost all of the attention has been directed at #16 below (recreation) as well as some analysis of # 3, disturbance regulation, in the form of USACE storm damage prevention analyses of some beach projects as well as some work on the economics of sea level rise (e.g., King et al. 2011). CVM studies may also capture some of #17, the cultural value of beaches. Given the importance of California's beaches to many residents and the historical significance of some beaches, especially in southern California, this factor could also be quite significant.

Food production (#13), primarily seafood, has been the subject of numerous studies, though the specific role that beaches play has received little discussion. There is little direct raw material (#14) extraction from beaches with the notable exception of sand mining.

Beaches provide a unique habitat for a number of flora and fauna who live on the beach, in dune systems behind the beach, in the intertidal zone, or who rely on the beach for key functions (e.g., grunion spawning).

A number of studies (e.g., Dugan 2004; Greene 2002) have examined some of the key ecological functions and services provided by beaches and a greater number of scientific studies have examined specific species and/or ecological services. Critical habitat (e.g., kelp, grunion spawning) has also been identified in the CSBAT and other models. However, there is no comprehensive framework for identifying or valuing ecological services at California's beaches

Table 3: Functions, goods and services of natural and semi-natural systems

#	ECOSYSTEM SERVICE*	ECOSYSTEM FUNCTIONS	EXAMPLES
1	**Gas regulation**	Regulation of atmospheric chemical composition.	CO_2/O_2 balance, O_3 for UVB protection, and SO_x levels.
2	**Climate regulation**	Regulation of global temperature, precipitation, and other biologically mediated climatic processes at global or local levels.	Green-house gas regulation, DMS production affecting cloud formation.
3	**Disturbance regulation**	Capacitance, damping, and integrity of ecosystem response to environmental fluctuations.	Storm protection, flood control, drought recovery, and other aspects of habitat response to environmental variability mainly controlled by vegetation structure.
4	**Water regulation**	Regulation of hydrological flows.	Provisioning of water for agricultural (e.g., irrigation) or industrial (e.g., milling) processes or transportation.
5	**Water supply**	Storage and retention of water.	Provisioning of water by watersheds, reservoirs, and aquifers.
6	**Erosion control and sediment retention**	Retention of soil within an ecosystem.	Prevention of loss of soil by wind, runoff, or other removal processes, storage of silt in lakes and wetlands.
7	**Soil formation**	Soil formation processes.	Weathering of rock and the accumulation of organic material.
8	**Nutrient cycling**	Storage, internal cycling, processing, and acquisition of nutrients.	Nitrogen fixation, N, P, and other elemental or nutrient cycles.
9	**Waste treatment**	Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds.	Waste treatment, pollution control, detoxification.
10	**Pollination**	Movement of floral gametes.	Provisioning of pollinators for the reproduction of plant populations.
11	**Biological control**	Trophic-dynamic regulations of populations.	Keystone predator control of prey species, reduction of herbivory by top predators.
12	**Refugia**	Habitat for resident and transient populations.	Nurseries, habitat for migratory species, regional habitats for locally harvested species, or over wintering grounds.
13	**Food production**	That portion of gross primary production extractable as food.	Production of fish, game, crops, nuts, fruits by hunting, gathering, subsistence farming, or fishing.
14	**Raw materials**	That portion of gross primary production extractable as raw materials.	The production of lumber, fuel, or fodder.
15	**Genetic resources**	Sources of unique biological materials and products.	Medicine, products for materials science, genes for resistance to plant pathogens and crop pests, ornamental species (pets and horticultural varieties of plants).
16	**Recreation**	Providing opportunities for recreational activities.	Eco-tourism, sport fishing, and other outdoor recreational activities.
17	**Cultural**	Providing opportunities for non-commercial uses.	Aesthetic, artistic, educational, spiritual, and/or scientific values of ecosystems.

*We include ecosystem "goods" along with ecosystem services.

Source: Costanza et al. 1997

Techniques for Valuing Ecological Functions, Goods, and Services: Assigning a Dollar Value to Ecological Services

It is now common to assign a dollar value to recreational value (see discussion above) to beaches. Further, given accurate geophysical and geomorphological data, assigning a dollar value to the storm damage prevention benefits of a beach is also possible and common in USACE studies. However assigning a dollar value to ecological functions, goods, and services is fraught with difficulties. First, it requires a comprehensive analysis of existing ecological functions. In practice, this requirement is rarely, if ever satisfied. Indeed, it is likely that we still do not fully comprehend the importance of many ecological functions. Even where such knowledge exists, such a study requires a large budget with a team of experts from many disciplines (e.g., Bockstael, 1995). Translating ecological functions into goods into a specific, quantifiable inventory of goods and services is also difficult.

Perhaps the most difficult and controversial requirement is that one must put a dollar value on the ecological goods and services. While some goods (e.g., timber from a forest) have a market value and some non-market values (e.g., recreation) can be estimated using established techniques, assigning a dollar value to other ecological services if difficult. For example, there is a literature assigning a dollar value to some endangered species (cite example) but values vary enormously.

Costanza et al. (1997) estimated the value of the world's ecological services at $16 to $54 trillion a year. Later, an analysis by Costanza et al. (2006) of 94 peer-reviewed papers and 6 other studies to estimate the economic values of seven types of biomes (including beaches) and the cumulative ecosystem services in New Jersey. The authors estimated that New Jersey's beaches deliver $42,147 per acre per year in economic/ecological services. They further break these benefits down into recreational and aesthetic value ($14,847 per acre per year) and other services ($27,300 per acre per year).

While these types of studies are useful in pointing out that beaches and other public areas and preserves do have substantial economic value which should not be overlooked, they do not necessarily provide managers with a framework for preserving key habitat or ecological functions. Further, it is dangerous to apply a "one size fits all" approach to beaches or other habitat since the ecological functions, good and services vary enormously even at beaches near each other.

Natural Capital

An alternative approach to assigning a dollar value to ecological functions, goods and services is to focus on ecological sustainability. Daly (2005), Costanza and Daly (1992) and others have developed the concept of "natural capital" to recognize the important role that EFGS play in economic functions. Their main argument is that economists often fail to account for environmental degradation when measuring economic growth and development. Their sustainability criteria incorporate the concept of natural capital and also incorporate manufactured capital (e.g., factories and other human-made material used to produce goods and services) and human capital (e.g., educated labor). Thus the total capital stock, K can be subdivided into the three components, manufactured capital, K_M, human capital, K_H, and natural capital, K_N,:

$$K = K_M + K_H + K_N.$$

Turner (1993) defines two different types of sustainability. In "weak sustainability" losses in natural capital can be substituted for by increases in some types of human or physical capital. For example, building more swimming pools might compensate for loss of beach recreation. In contrast, Turner suggests, one could also adopt a "strong sustainability" approach which posits that natural capital must be preserved—thus no substitution is possible. Given the stress on many ecosystems the strong sustainability hypothesis may be unworkable. Further, some natural capital may be more important than others. To address this problem, Ekins et al. (2003) and others distinguish between critical natural capital (CNC), which must be preserved and other types of natural capital, which can be substituted for with manufactured or human capital. Ekins goes on to develop some general criteria for defining CNC which include:

- Life Support: EFGS, which is critical to maintaining human society (e.g., ozone, reduction of greenhouse gases).
- Human Health: EFGS necessary to maintain human health (e.g., clean air and water)
- Other welfare: EFGS with unique aesthetic and cultural importance (e.g., Grand Canyon).

As one can see, the above criteria, while useful, still leaves a great deal of ambiguity in terms of practical application. In policy settings, defining EFGS CNC and thus will likely involve stakeholders as well as policy analysis.

Mitigation

For most coastal managers and policy makers the key decisions involve dealing with changes in the coastal environment due to either development or erosion (likely exacerbated by sea level rise). The challenge is to identify when losses occur (e.g., due to building a seawall) and when and how to mitigate these losses. Mitigation may take the form either of monetary compensation (e.g., a sand mitigation fee for building a seawall) or providing alternate habitat (e.g., creating a new wetland to replace an old one).

Habitat Equivalency Analysis (HEA)

Habitat Equivalency Analysis (HEA) is a technique that has been developed for NOAA, USACE, MMS and other federal agencies, generally as a compensation scheme for significant ecological damages created by oil spills or other disasters. Ray (2008) outlines the necessary steps for HEA:

1. Determine the area of the impacted habitat
2. Select an appropriate service to replace and a metric to represent the service
3. Estimate the loss in service of the impacted habitat
4. Determine the shape of the recovery curve
5. Estimate losses occurring while recovery proceeds
6. Estimate total losses
7. Calculate the amount of restored habitat necessary to offset total losses.

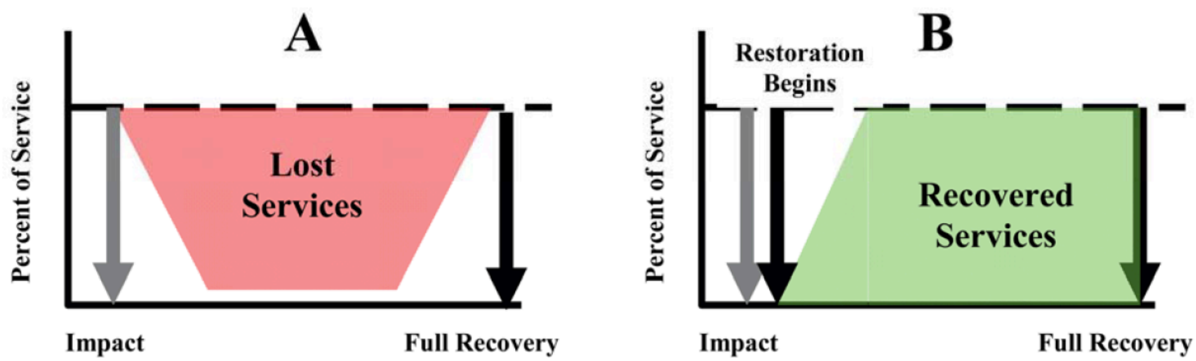

Figure 9: Estimation of lost and recovered service

Source: Dunford 2003

As indicated by the steps above and shown in Figure 9 above, the key to HEA is defining a habitat area (often quite large) and EFGS impacted by the damage. It is generally assumed that the EFGS will eventually recover, or will be mitigated by a restoration program. Further, as Dunford (2003) points out, HEA assumes that "the injured habitat, untransformed compensatory habitat, and transformed compensatory habitat all have a common service metric, either a single service or a composite index of services."

Consequently, while HEA may be an enormously useful tool for some applications, its application to beach ecosystems may be limited. Further, HEA generally requires a large interdisciplinary team of experts and a large budget, often in short supply when analyzing beaches.

Discussion

As detailed in this section, beach ecosystems, especially those in California, face unprecedented stress from both human and natural factors. Management interventions such as grooming, armoring and nourishment can have adverse impacts to beach environments when they are pursued haphazardly.

Critical to the health of sandy beach ecosystems is the continuation of natural ecological, physical and biochemical processes. Beaches can be broken down into zones, each of which plays a critical role in maintaining the functional relationships of these ecosystems. The upper intertidal zone of exposed sandy beaches play a critical role in supporting these relationships, and are under critical stress from both large-scale (e.g., ENSO) and local-scale alterations (e.g., grooming, armoring).

Environmental conditions at most beaches in urban areas do not reflect natural conditions, and reconstructing these historical conditions is generally not feasible. Therefore, a reasonable approach to management may be to apply a "sustainability" criterion where scientific knowledge and expert opinion indicate that a beach will maintain itself indefinitely if existing conditions are preserved (Andreasen et al. 2010); potential sea-level rise impacts must be accounted for. The criteria for sustainability will vary by beach and encompass differing societal demands for ecosystem goods and services such as recreation, aesthetics, and biodiversity.

One possible mechanism for preserving beach environments would be to prioritize beaches with high biodiversity and ecological function, and restore and/or enhance biodiversity at beaches capable of retreat (Dugan 2012). Ecological restoration is widespread for wetlands and endangered species habitats and generally involves an effort to return a damaged ecosystem to a more natural condition (National Research Council 1992). In the event that development results in adverse impacts to beach ecosystem functioning, mitigation fees could be explored. Where functional replacement is unlikely at the damaged site, mitigation ratios could be adjusted to the maximum relative value (Zedler and Callaway 1999) and/or redirected to another identified site. While restoration is guided by scientific knowledge, the success or failure of technical, public and regulatory parties will likely interpret a project differently.

California is well equipped to strengthen its sandy beach management practices. The ongoing collection of baseline data throughout the state in support of MPAs as well as participatory citizen-science efforts are helping to characterize sandy beach ecosystems and provide critical information on biological and human indicators that will allow us to monitor the health of our beach ecosystems and alter our management regimes overtime. Further, management concepts such as integrated coastal management and ecosystem-based management provide a framework for balancing, environmental, economic and social objectives, within the natural limits of sandy beach environments. Improvements in managing and conserving the environmental quality of sandy beaches require that one consider all dimensions of beach ecosystems and their interactions. To this end, conservation tools applied in other marine systems such as marine protected areas and marine spatial planning are of increasing relevance to the collection of information, decision-making, planning, management and monitoring of sandy beach environments. In all of these management paradigms, stakeholders play a significant role throughout the life stages of the decision-making process and have a strong hand in shaping outcomes.

Moving forward there is critical need to evaluate current beach management practices to maintain the morphological profiles (e.g., nourishment), protect property and infrastructure (e.g., seawalls) and promote aesthetic quality (e.g., grooming) in a way that explicitly captures ecological, economic and cultural tradeoffs. While development and high recreational use of California's beaches is inevitable, a science-based and collaborative approach can help to ensure a portfolio of management interventions promote the continued existence of California's sandy beach ecosystems services and functions for the benefit of the citizens and species in the natural environment.

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Section 2: Drivers for Beach Resource Management

Background

Our literature review of the ecological services, functions, and goods of sandy beaches made it evident that sandy beaches are diverse and productive ecological systems facing unprecedented stress from both human and natural factors. The need for management interventions to mitigate for ecological impacts is receiving growing attention. Yet, the responsibility for managing beach ecosystems occurs at different geographical and political scales that often conflict. This complexity poses challenges in reconciling human demands on beach environments with the need to safeguard their unique biodiversity and status as functioning ecological systems.

To identify current management practices that impact beach ecological features and services, and understand their drivers, we reached out to key resource managers in the BEACON region. Specifically, we focused on individuals with various management responsibilities at four beaches in the region – Hendry's beach, Santa Claus beach, Carpinteria City beach and Carpinteria State beach. We targeted our efforts towards these individuals because long-term ecological data exists at each of these sites, which can be analyze in conjunction with the knowledge gained in these interviews, and the findings from of a survey (detailed in Section 3 below) we conducted on beach environmental perceptions and its management.

We conducted interviews with staff from the County of Santa Barbara, City of Santa Barbara, City of Carpinteria, California Coastal Commission, and the California Department of Parks and Recreation. Each interview was loosely structured and followed a series of questions, provided at the end of this report. *Participants were informed that information obtained from the interviews would remain anonymous. Further, it is important to note that the views expressed by those interviewed may not express the opinions of the wider departments and institutions that these individuals work for.*

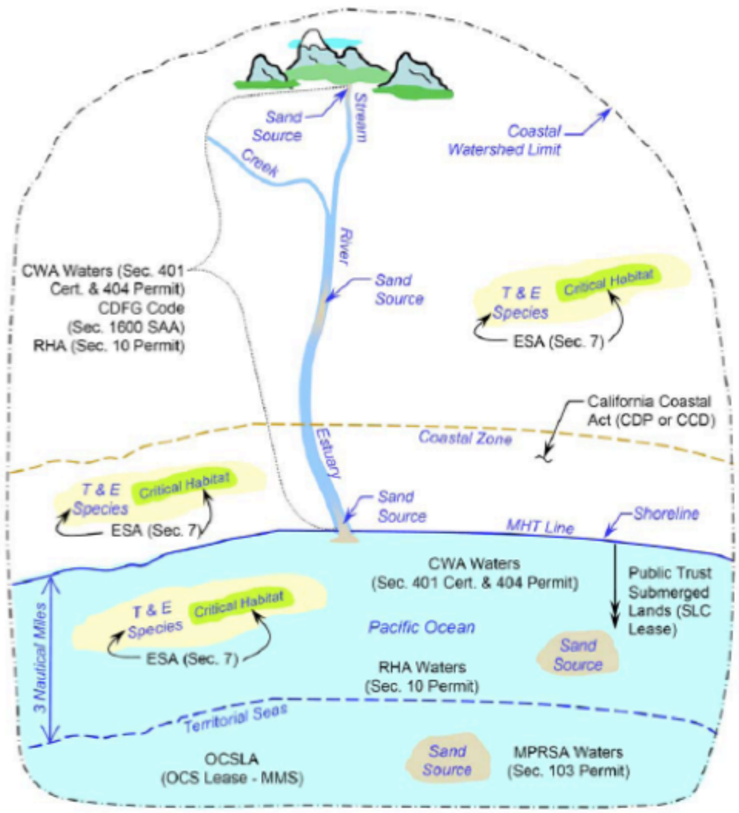
Interview Findings

Regulatory Framework

Most coastal management activities are subject to various regulations and agencies at the Federal, State and local levels. Figure 10 below summarizes which regulatory authorities have jurisdiction over which aspects of beach ecology. As the schematic indicates, the health (and regulation) of the system depends upon critical interactions with both the offshore and inland environment.

The cornerstone coastal resource statute, the Federal Coastal Zone Management Act (CZMA) of 1972, was enacted to "preserve, protect, develop, and, where possible, to restore or enhance the resources of the nation's coastal zone." The CZMA, administered by NOAA's office of Ocean and Coastal Resource Management, is a national policy designed to assist states in developing management practices that balance economic development, environmental conservation and cultural values, among others.

California's coastal zone management program was approved by the federal government in 1977 and is primarily administered by the California Coastal Commission and the Bay Conservation and Development Commission. For the purpose of this report, our discussion will focus on the Coastal Commission, as they are the primary regulatory authority responsible for overseeing planning and permitting decisions in the BEACON region.



Legend

CDP = California Coastal Act
CWA = Clean Water Act
ESA = Endangered Species Act
RHA = Rivers and Harbors Act
CDFG = California Department of Fish and Game
MHT = Mean High Tide
SAA = Streambed Alteration Agreement
OCSLA = Outer Continental Shelf
MMS = Minerals Management Service
MPRSA = Marine Protection, Research and Sanctuaries
SLC = State Lands Commission
CCD = Coastal Consistency Determination
CDP = Coastal Development Permit
T&E = Threatened and Endangered

Source: Everest International 2006

Figure 10: Schematic of Regulatory Statutes and Entities Involved in Permitting Beach Nourishment Projects

The Coastal Commission's primary workflow is rooted in the California Coastal Act of 1976 and involves planning and permitting, including the issuance of coastal development permits (CDPs), the certification of Local Coastal Programs (LCPs), appeals review of locally approved CDPs, and federal consistency review. Chapter 3 of the Coastal Act details the Coastal Commission's enforceable policies, and serves as the legal standard of review.

The Coastal Commission has regional offices throughout the state that work with local governments to develop their LCPs, ensuring that they meet the minimum standards of the Coastal Act. Upon LCP certification, the local government secures the primary permitting authority. Yet, the Coastal Commission maintains permitting jurisdiction on public trust lands and other specified lands such as wetlands and tidelands. Every 5 years, LCPs are to be reviewed, and if necessary, updated to account for evolving science and policy. Yet, in most cases, this does not happen because of resource limitations.

Reviewing permits is at the core of the Coastal Commission's responsibilities. The general procedure is for Coastal Commission staff to prepare a report and recommendations. Specifically, these reports incorporate a statement of facts, analysis, and legal conclusions that determine if a proposed permitting activity conforms to the Coastal Act, and where applicable, the California Environmental Quality Act (CEQA). Appointed commissioners approve outright, approve with condition, or deny a CDP after agency review and the public comment period are completed.

Environmental Considerations Guiding Planning and Permitting

The Coastal Commission is guided by broad environmental principles in their planning and permitting decisions. For instance, the Coastal Act (1976) states that:

> *…the California coastal zone is a distinct and valuable natural resource of vital and enduring interest to all the people and exists as a delicately balanced ecosystem;*
>
> *…the permanent protection of the state's natural and scenic resources is a paramount concern to present and future residents of the state and nation; and*
>
> *…it is necessary to protect the ecological balance of the coastal zone and prevent its deterioration and destruction.*

CEQA also requires project applicants "to afford the fullest possible protection to the environment within the reasonable scope of the statutory language." These broad environmental principles are bolstered by additional considerations for managing environmentally sensitive areas where species or habitats are critical to ecosystem functioning and sensitive to human impacts. California's beaches host a range of species and habitats that are protected through federal and state regulation. The most notable statute, the Federal Endangered Species Act, details that any project or activity that jeopardizes the continued existence of these species, including adverse impacts to critical habitat, is subject to regulations by the US Fish and Wildlife Service (USFWS). The state equivalent, the California Endangered Species Act, is administered by the California Department of Fish and Wildlife. These statutes, among others, are indicative of the strong ecological framework guiding coastal management activities in California.

Local Government Management Activities and Considerations

The local governments we interviewed -- the City of Santa Barbara, the County of Santa Barbara and the City of Carpinteria -- all have certified LCPs that guide the management of their shoreline resources. These local governments have a number of departments that share in the management of shoreline resources (e.g., Parks and Recreation, Flood Control), with each department having a different mission. Among these diverse departments, a range of cultural, economic, environmental and legal considerations influence coastal resource management decisions. Though, all departments take concerted steps to design policies that provide a safe and enjoyable coastal user experience.

Grooming and Raking

The Cities of Santa Barbara and Carpinteria groom or rake their beaches to collect trash and debris in order to promote recreation, which is an important driver for the local economies. The City of Santa Barbara rakes their beaches twice a month in the summer and once a month in the winter. The City of Carpinteria operates a summer time grooming program a few mornings each week from June to September. Beach grooming is considered a development activity and requires a CDP. Currently, the Coastal Commission does not have a formal policy on grooming, and when it approves this type of activity on a case-by-case basis, there are often conditions attached. Some examples follow:

- The Coastal Commission has authorized a 5-year permit for the City of Santa Barbara to rake East beach and West beach. The City is only allowed to groom above the wrack line and was required to place educational signs along the path to the beach that discuss why it is important to maintain the wrack line.
- The City of Carpinteria also has a 5-year permit to rake the City beach. The City's raking practice includes removing dry kelp from the upper swash zone, and pushing this material back into the ocean, an activity that has been grandfathered in over time.
- The City of Ventura was denied permission by the Coastal Commission to groom their beaches. This decision has garnered some unfavorable pushback from homeowners who would like sand buildup on the back of the beach to be redistributed back to the shoreline.

Berm Building

The City of Santa Barbara and the City of Carpinteria both maintain annual winter berm programs to mitigate winter storm damage. The City of Carpinteria builds a berm at the back of the northwest portion of the City beach to protect residential property. The City of Santa Barbara builds two winter berms, one on the west side of the harbor to protect the yacht club and another in front of Mission Creek to prevent debris flows from entering the harbor. These projects are considered development activities and require a permit by the Coastal Commission and the U.S. Army Corps of Engineers. The common berm building practice of taking sand from the upper intertidal zone is often accompanied by varying conditions such as pre and post project ecological monitoring.

Nourishment

The City of Santa Barbara uses dredge spoils from the harbor to nourish their beaches. Annually, the USACE dredges 300,000 cubic yards of sand from the harbor, which is spread across different areas of the shoreline and groomed into "ideal contours." This activity is permitted under the Regional Sediment Management Plan adopted by the local jurisdictions in consultation with the Corps and with State Agencies. Surveying of sensitive species is conducted both before and after distribution of the dredged spoils, and these projects are scheduled in a way that attempts to minimize ecological impacts. The City also maintains other periodic dredging activates outside of the Federal channel. These projects are much smaller in magnitude, usually around 10,000 cubic yards, and occur every three to five years. It is important to note that if it weren't for the dredging of the harbor dating back to the 1960s, the City's popular waterfront beaches would not exist as they do today.

Stewardship Experiences

The coastal managers we interviewed also implement management activities to promote the stewardship of natural coastal features. For example, the City of Carpinteria manages the Carpinteria Costa Vista Trail that connects the Carpinteria Salt Marsh Nature Park to the beach, a freshwater wetland bio swell, and the Carpinteria creek, which has undergone multi-million dollar steel head restoration projects. The trail also connects to the Carpinteria bluffs, which is a nature preserve, Tar Pits Park and the Harbor Seal Sanctuary that is managed by volunteers and draws tens of thousands of annual visitors. The City is very passionate about stewarding the trail and its surrounding coastal and marine resources. Formal education programs and interpretive signs are placed throughout the shoreline to help engender an appreciation for these resources. However, there are no interpretive panels on the beach.

Managing for Ecological features of special interest

Individuals interviewed from the Coastal Commission, State Parks, and local governments all stated that their agencies give special consideration to species and habitats contained in authorized federal and state endangered/sensitive lists. Yet, interviewees also noted that solely focusing on individual species and habitats has its limitations, and can conflict with broader ecosystem based management frameworks that consider the composite whole of the environment. Further, from a practical standpoint, several interviewees noted that the high rate of recreational use on beaches in the BEACON region makes it nearly impossible to manage (at most areas of the shoreline) for a single species without significantly reducing recreational and economic benefits.

Snowy Plover

The Snowy Plover is one of a few species in the BEACON region where special management considerations are made. For instance, the Fish and Wildlife requires the County of Santa Barbara close Surf Beach in Lompoc every year for 7 months. Another recent example is Fish and Wildlife's designation of a 2-mile stretch of waterfront in the City of Santa Barbara as critical habitat for the Snowy Plover, the implications of which are not known at this time. The City wrote to Fish and Wildlife, objecting to this designation as the area of shoreline in question is heavily used for recreation in the summer and fall, while Snowy Plovers are present in the winter, when crowds on the beach are small. Only one Snowy Plover nest has been spotted along this area in the last 70 years. The nest was found at the sand spit in the harbor and resulted in the closure of this small patch of sand for several months. While posing a temporary hardship to the City of Santa Barbara's management activities, the isolated location made the closure manageable. However, closing beaches with hundreds of thousands of annual visitors could pose significant challenges to management and be costly to cities that rely on tourist spending.

California Grunion

The California Grunion is another species of special concern in the BEACON region, generally requiring pre and post monitoring for special projects. For example, the City of Carpinteria is required to monitor for grunion if they do not remove their winter berm prior to the first scheduled grunion run in March.

The Role of Science

Our knowledge of sandy beach ecosystems is limited and relatively under-represented in coastal and marine science. This reality poses challenges to regulating these ecosystems. Prior to 1980, there was virtually no academic literature on beach ecosystems. In the past 30 years, this body of knowledge has grown steadily. Yet, integrating the evolving science of beach ecology into decision-making is challenging.

Barriers to Linking Science to Decision-Making

The Coastal Commission strives to use the best available science in guiding their decisions on beach ecological resources, including reports, peer-reviewed articles and consultation with subject matter experts. The Coastal Commission staff that we interviewed was aware of a growing body of beach ecology research, but felt that the results are mostly published in academic journals and framed in terms that are not accessible to a non-technical audience. While the Coastal Commission makes efforts to bring the best available science to bear on their decisions, there are gaps in knowledge, especially in terms of the life histories of species and habitat. An established baseline of knowledge on beach ecology is absent, which impedes the assessment project impacts, especially cumulative impacts.

While there are challenges to incorporating the most recent knowledge of beach ecology into the production and review of CDPs, the Coastal Commission noted that they are pursuing ecological projects to link science to policy. Currently the Coastal Commission is collaborating with a group of academic ecologists and economists, natural resource managers and environmental advocates to develop a metric for measuring the health of the beach. Additionally the Coastal Commission has secured federal funding to value the loss of beach ecological services arising from coastal development decisions such as armoring.

Capacity Restraints

Even if no information gaps existed relating to beach ecology, the Coastal Commission has just 2 staff biologists statewide, and only 180 days to determine if the science put forth in a permit application is adequate. Individuals we interviewed from city and county agencies also indicated they often lack the in-house expertise to address ecological matters relating to beaches. When such issues do arise, and funding is available, these agencies often make use of outside consultants. This type of workflow makes it challenging to build internal capacity for managing and monitoring beach ecosystems.

Scientific Accountability

Interviewees noted that the Coastal Act and CEQA require them to make use of the best available science when evaluating permit applications, and the science they (or consultants) produce is subject to public review. This review process allows special interest groups to comment and enlist subject matter experts to provide further input, potentially increasing scientific accountability to decision-making.

Ongoing Management Challenges

Across the board, interviewees recognized the need to promote management activities that can help sustain a portfolio of environmental, economic and social services from their beach landscapes. The local government staff we interviewed noted that they are taking actions to do just this, and that they do not believe that major changes are needed in their on-going management regime. However, they identified a few issues beyond their control that pose challenges to sustainably managing coastal resources in their jurisdiction.

End-User Compliance

Interviewees noted that stakeholders are critical to protecting shoreline resources. Certain beaches, such as west end of the City of Carpinteria allow visitors to bring their dogs provided they are on leash. However, many visitors break this rule at the expense of the shorebirds that use this as habitat for resting and foraging. Interviewees noted that there is limited staff to enforce regulations on dogs and other restricted activities like poaching.

Cross Jurisdictional Issues

Interviewees also noted that the challenges they face are often a result of political processes that operate at levels beyond their local jurisdiction. For example, the City of Carpinteria faces the challenge of dealing with beach erosion, as one big winter storm can result in a large amount of fine grain-size sediment being lost offshore. Staff noted that debris basins have cut off coarse grain-size sediment, which tends to stay onshore during high-energy storm events. Without watershed scale changes, the City will continue to face challenges with shoreline erosion, challenges that will be further exacerbated by sea-level rise. All of the interviewees are grappling with the question of how best to deal with sea-level rise without adversely impacting the natural environment. Shoreline management techniques such as armoring and nourishment will continue to remain options for combating sea-level rise, but our knowledge of how these projects will impact public access, recreation, beach ecology and sediment transport processes is limited.

Short-Term Decision-Making Frameworks

One interviewee acknowledged that matters are further complicated when considering the political environment in which decisions are made. Politicians often focus on short-term decisions, while certain management issues, such as climate change, require long-term points of view. One mechanism in place to address long-term change is Climate Action Plans that are required by State law in Master Plan updates. While these Plans will help to internalize concepts such as adaptive management, interviewees noted that very little policy direction has been provided on this end.

Discussion

While coastal ecosystems in these jurisdictions often face the most impact from their own projects, interviewees noted that protecting coastal species and habitats has been a longstanding priority, and serious efforts have been made to ensure that beach management activities comply with the law and minimize environmental impacts. Our interviewees were earnest in their desire to steward their beach ecological resources. Yet, they indicated they are ill equipped to address a number of issues because of knowledge gaps and/or impractical regulatory burdens. The following policy issues surfaced in our interviews:

- **Grooming or Raking:** Local governments maintain raking or grooming programs to promote recreation and public safety at their beaches. These activities are implemented in a way that complies with the law and are designed to minimize ecological impacts in the swash zone. Additionally, these programs are only carried out at specific areas of their shoreline. For instance, the City of Carpinteria manages a coastline approximately 3 miles long, yet they practice raking/grooming along a single 1,500-foot stretch of beach (about 10% of the total length) that is heavily used by visitors. Outside this urbanized area of beach, the coastline is primarily managed for natural uses. Further information on the ecological significance of the impacts to habitat loss and fragmentation from raking or grooming could help to improve management practices.
- **Dogs:** The presence of dogs on the beach can be a disturbance to shorebirds. Scientists and managers alike recognize this, and there are policies at most beaches in the BEACON region restricting dog use. However, these laws are often disregarded by users, and in many cases not enforced. Further challenges arise when considering the potential for spillover disturbance at contiguous stretches of beaches where jurisdictional boundaries change and respective policies are not clearly identified. It may be possible for managers to address these failures without adding undue regulatory burdens through a system of fines that should make the policy self-financing, though there could be political opposition from some dog-owners.
- **Single species management:** Local governments in the BEACON region are highly dependent on the economic activity and taxes generated by beach recreation and leisure. Drastically altering management regimes in ways that impact human uses of the shoreline could result in significant consequences to local economies that are dependent on beach tourism (e.g., the City of Carpinteria). Managing for endangered or threatened species is challenging given the high recreational use rates at many beaches in the region, and also potentially conflicting to the principles of broader ecosystem management. It may make sense to designate particular stretches of shoreline in the BEACON region as reserves to accommodate these species rather than imposing strict regulations on a heavily used beach in an urban area such as Santa Barbara. In addition, providing such designated spaces may increase the probability for ecological benefits to identified species like the Snowy Plover.

- **Cumulative Impacts:** Cumulative impacts from multiple stressors that operate across varying spatial and temporal scales have the ability to impact the structure, function, and recovery of sandy beach ecosystems. Cumulative impact analysis is an imperfect science that faces the challenge of evaluating impacts that do not act in a purely linear or additive way, but also in a synergistic or antagonistic fashion. Evaluating cumulative impact analysis, while required by CEQA, continues to be a challenge for regulators due to the very small body of available empirical reference work.

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Everest International Consultants. (2006). *California Coastal Sediment Master Plan Policies, Procedures, and Regulations Analysis: Beach Restoration Regulatory Guide*. Prepared for the California Coastal Conservancy and the California Sediment Management Workgroup. 45pp.

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Interview Questions

1. What are your organization's primary responsibilities/mandates?
    a. What role do you play in your organization?
2. What are the key considerations you make in guiding beach management techniques/policies?
    a. Economic (e.g., tourism)
    b. Legal (e.g., regulations, permits, mitigation)
    c. Environmental
    d. Other
3. What geographic scale do you work at and what management techniques are applied (e.g., municipal, county, State)?
    a. Are management techniques/policies applied consistently across the board, or are site-specific considerations made?
4. What would you describe as the most important ecosystem features and functions at the beaches you manage or interact with?
    a. Are their particular species or taxa that your agency monitors to ensure a beach's ecological health? If so, do you think the use of these key indicator species/taxa is efficient and appropriate?
    b. What specific data/analysis do you use to monitor beach ecological health?
    c. What role does science play (e.g., in-house research, reports, journal articles, expert judgment)?
    d. Do you have any documents (e.g., policies, internal guidance, reports) regarding these policies (e.g., EIRs, regulatory documents, etc.) that you can provide us with?
5. What are the key challenges in managing the ecological services of beaches under your jurisdiction?
    a. Are there important gaps in knowledge or information, including data and monitoring, which would lead to better decision-making with respect to this issue?
    b. Could science (or the scientific community) play a more effective role?
6. In the short-and-long term, is sustaining a balanced portfolio of environmental, economic, social services from beaches a priority? If so, what do you consider the critical management activities necessary to achieve this (e.g., nourishment, grooming, other types of restoration, amenities)?
7. Do you work with any regulators, managers or other non-governmental groups on issues related to beach ecology?
8. Is there anything we have not touched on that you want to tell us about?

9. Are there additional people that you recommend we talk to?
10. May we contact you in the future if follow-up would be beneficial?

Section 3: Beach Visitor Perceptions of Environmental Quality and its Management

Background[1]

The study of sandy beach ecology has been under-represented in coastal and marine science. However, recent research provides new insight on the significance of sandy beaches as ecological systems that support extensive biodiversity and provide a wide range of unique ecosystem services and values, many of which are critical in supporting anthropogenic uses of these environments.

Detailed information on sandy beach users can assist in crafting management policies that can help to sustain the benefits of these ecosystems. There is a growing body of knowledge of coastal user activity and expenditure patterns. Yet there is little information linking the behavior (e.g., beach choice, recreational activities, spending) of coastal users to their perceptions and attitudes of beach environmental quality and its management. This gap in knowledge hinders the development of management policies that consider the suite of physical, biological and cultural dimensions of the beach environment.

Because environmental conditions and *perceptions* of these same conditions are not always in agreement, testing relationships between perception and reality is a crucial step in managing these resources. For example, Santa Claus beach shares a number of characteristics with Carpinteria City beach, but it lacks dedicated services and has no formal management structure. Both beaches are heavily visited, which on the surface indicates that different users may prefer different beach landscapes (e.g., natural vs. urban). To this end, we designed a survey instrument to test environmental perceptions in a place-based and context-specific setting – Santa Barbara County and Ventura County beach users. We believe this survey, while constrained by resources for its development and implementation, is a step forward in evaluating the relationships between a user's beach choice, activities, and perceptions of environmental quality and its management.

Findings

The following summarizes key descriptive findings from our survey results – the survey design and sampling methodology are described in detail below. Results are aggregated for all surveys conducted across both Santa Barbara County and Ventura County.

- Access to the beach, water cleanliness, sand cleanliness, crowding and beach size were considered the most important factors to respondents' beachgoing experience (on average). Abundance of shorebirds, other wildlife and vegetation were also considered important (on average).

[1] The authors would like to acknowledge Justin Whittet, Isaac Pearlman and Michael Conrardy for helping to proctor the survey that underpins this section.

- The most popular activities for respondents were walking and swimming/wading. Additionally, approximately one-third of respondents indicated they participated in viewing shorebirds and other marine life.
- Seawalls, revetments and groins have neither a negative or positive effect on the beachgoing experience of a majority of respondents.
- If charged with designing a program for cleaning beaches in Santa Barbara County or Ventura County, a majority of respondents would not remove ecological properties such as crustaceans, wrack, shells or dried starfish.
- If ecological properties such as wrack were not cleaned from beaches in Santa Barbara County or Ventura County, a majority of respondents would not change their frequency of visits.
- A majority of respondents were either very unfamiliar, unfamiliar or neither familiar nor unfamiliar with the ecology of beach (e.g., kelp, shells, shorebirds, invertebrates).
- Nearly two-fifths of respondents perceived the ecological condition of the beach they were visiting to be healthy, one-quarter considered it to be unhealthy, and another quarter of respondents' were unsure.
- Over two-fifths of respondents indicated that more measures should be taken to manage the ecology of the beach they were visiting, while another two-fifths of respondents were unsure.
- An overwhelming majority of respondents agreed of strongly agreed that they felt an obligation to protect the ecology of beaches.
- The vast majority of respondents were willing to pay more in annual taxes, ranging from $1 to more than $100, to preserve and restore the ecology of beaches in Santa Barbara County or Ventura County. The average (range mid-point) willingness to pay was approximately $30 per year in taxes.
- A slight majority respondents preferred more access to ecological information at the beach they were visiting. Of these respondents, the highest preference was for information on websites, followed by displays/exhibits, maps and lastly, brochures.
- Nearly one-half of respondents were out of town visitors that stayed overnight. Approximately three-quarters of these respondents lodged in fee-based facilities (i.e., hotels, beach rentals, camping sites).

Survey Process and Methodology

Developing the Survey

This survey instrument was informed by three discrete tasks. First, we reviewed the literature on sandy beach ecosystems. In particular we evaluated key features; threats and pressures; approaches for monitoring condition and health; methods for valuing economic and ecological services; and relevant regulatory mechanisms. Second, we conducted interviews with coastal planners, resource managers and non-profit stakeholders in Santa Barbara County and Ventura County. We structured these interviews to gather perspectives on the key considerations made in developing and implementing beach management policies that affect ecological services; the key challenges in managing beach ecosystems; and the short-term and long-term management activities critical for sustaining a balanced portfolio of environmental, economic and social services from these environments. Third, we reviewed the literature that addresses environmental behavior and quality in coastal environments. We focused our review on studies that use surveys to solicit information of beach users. Collectively, this information was used to structure the survey.

Survey Design and Methodology

We created an intercept survey, whereby a surveyor approaches beachgoers with a questionnaire. We chose this method over a phone or mail in survey because it was more feasible both from a financial and time management perspective. Our past experience with these types of surveys also indicates that these intercept surveys have much higher response rates (typically 80-90%) and efficiently target beach visitors. The intercepted beachgoer (i.e., respondent) had a choice of (1) taking the survey by themselves or (2) being interviewed by the surveyor (i.e., the proctor reads the questions and respective responses to the respondent). Administering the survey as a handout also minimizes interview biases such as respondents tailoring of answers to what they believe an interviewer wants to hear. Respondents that chose to take the survey by themselves had access to a surveyor if they had any questions.

We took efforts to maximize the number of responses by limiting the survey to two and one-half pages, and framing most of the questions in closed-end format. The survey questions addressed visitation characteristics (i.e., day trip, overnight trip, number of days visited), the activities they would participate in, the importance of varying factors (e.g., size of beach, wildlife abundance) to their beachgoing experience, environmental perceptions (e.g., health of beach ecological features), management perceptions (e.g. should more measures be taken to manage the beach); access to educational resources and basic demographics (e.g., age, gender, income).

The survey instrument was tested in multiple stages. First we, we tested the survey on approximately one dozen coastal and marine resource professionals. After further revision we pre-tested the survey on approximately 20 beachgoers in the study area. After these individuals took the survey, we asked them for any comments they had to improve the survey.

Sampling Strategy and Protocol

Geographically Representative Sampling Strategy

It was our intention to develop a survey that could be given at multiple beach locations to evaluate the relationships between beachgoer motivations, activity modes, perceptions of environmental quality and management. This approach allows for developing baseline knowledge of beach users in Santa Barbara County and Ventura County rather than an exhaustive characterization of all the users of these environments. With this objective in mind, we attempted to conduct surveys at a representative sample of beaches in Santa Barbara County and Ventura County. Our beach selections were informed by local managers, beach ecologists, and key stakeholders to best represents beach types (e.g., urban, natural), activities (e.g., surfing, bird watching, camping) available to users, and varying management techniques (e.g., raking beaches, dog policies) in practice. Our rationale for using a geographically representative sample is that people visit a beach to interact with certain habitats and pursue specific activities. By limiting a survey to only a few beaches, it is likely that the characteristics of the diversity of users would not be captured.

For this survey, we selected 13 beaches. In Santa Barbara County, we surveyed beachgoers at El Capitan State Beach, Arroyo Burro County Beach, West Beach, East Beach, Santa Claus Beach, Carpinteria City Beach and Carpinteria State Beach. In Ventura County, we surveyed beachgoers at Solimar Beach, Emma Wood State Beach, San Buena Ventura State Beach, Pierpont Beach, Marina City Beach, and Silver Strand Beach. Collectively, these beaches are managed by different governmental entities, including State Parks, Santa Barbara County, Ventura County, City of Santa Barbara, City of Carpinteria, City of Ventura and the City of Oxnard. Each of these groups has different protocols for managing their beaches, allowing for us to evaluate the role of varying management techniques on beachgoer activities and environmental perceptions.

Schedule Protocol

We conducted this survey over Labor Day weekend in September 2012. The dense crowds made it possible to obtain a large number of responses over a short period of time, and to survey at a large number of beaches and get a more representative sample. Surveys were conducted from 11am to 6:00 pm with a majority falling between the hours of 11am-3pm. This is generally the busiest time on the beach.

Survey Administration

Four trained research assistants conducted the survey. The research assistants broke into teams of two, each team with a fluent or proficient Spanish speaker. Each team was assigned different beaches to cover. Surveyors were instructed to zig-zag across the beach, and approach every nth group, where n depended on the number of surveys they expected to collect at that site, and the density of the crowd. Only people on the sand were intercepted.

When approaching a beachgoer, the proctor would introduce the survey by asking if they were 18 years old, and if this was the case, saying something along the lines of: "Hello, my name is _____. I'm sorry to bother you, but I was wondering if you would be willing to take a few minutes to complete this survey that is being conducted on behalf of a local resource management organization (i.e., the Beach Erosion Authority for Clean Oceans and Nourishment). Our goal is to learn about your motivations for visiting the beach and your perceptions of environmental quality. All responses are anonymous and confidential and you will not be identified in any way with the information collected." If the beachgoer wanted to know more about the survey, the proctor was instructed to say something similar to: "This survey would provide local resource managers with additional information on their users (e.g., what activities you do, how far you travel to the beach) and that such information could inform decision-making." Proctors were instructed not to bias the survey by saying things like: "This information will help the beach."

If an individual agreed to participate in the survey, they were asked if they would be willing and able to take the survey as a handout. If they said no for any reason, which only happened in a handful of cases, the surveyor offered to interview the respondent. Respondents who were taking the handout were provided with a survey that was attached to a clipboard, and a ballpoint pen. The proctor noted that the survey was 3 single-sided pages, and that they would be close-by if they had any questions. For respondents that selected the interview route, proctors dictated the questions and answers as they appeared on the survey. Overall, respondents had very few questions about the survey, yet in reviewing the results, there are a handful of surveys where respondents wrote-in clarifying statements or questions.

Data Entry Methodology

We created a coding tree to streamline the recording of survey data for quantitative analysis. Each survey was recorded in an excel spreadsheet and entries were double checked for quality control. A final check of the data was made by randomly selecting 10% of the total responses. A majority of the errors we found were connected to handwriting that was difficult to interpret.

Summary Statistics

On September 1st and 2nd of 2012 – Labor Day weekend – a total of 251 surveys were collected. Of the 251 surveys, 12 were removed because they had not been completed to a level sufficient for analysis (i.e., <50% of questions were completed). This left 239 surveys for quantitative analysis. Almost all of the respondents (234) completed the survey on their own (i.e., handout); 5 respondents asked for the surveyor to ask the questions (i.e., interview). Summary statistics on survey responses accompanied by a short discussion are found below.

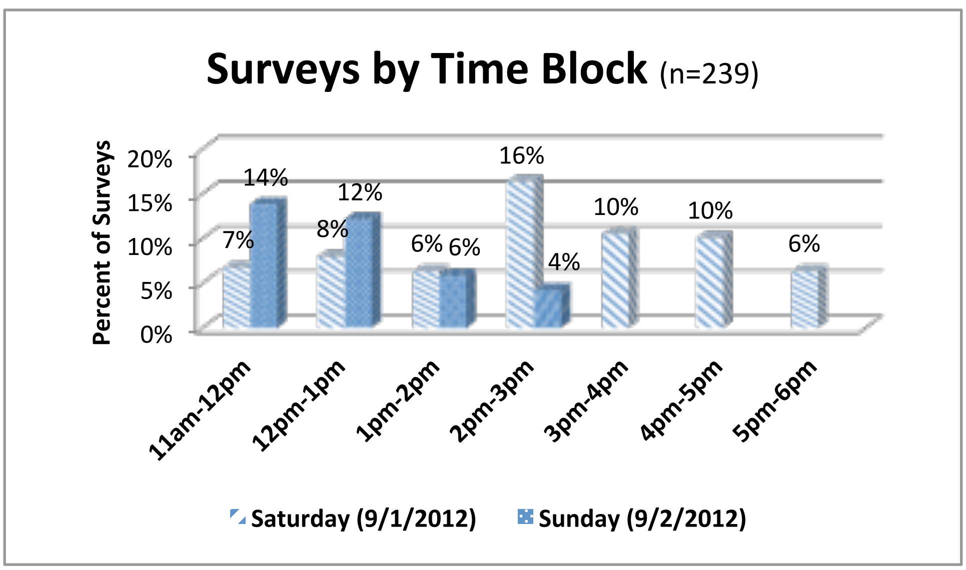

Figure 11: Number of surveys collected during each time block

Surveys were conducted between the hours of 11am and 6pm. Approximately 64% of the surveys were collected on Saturday and 36% on Sunday. Our target goal was to collect 250 surveys. Once this number was met, surveying was stopped on Sunday. The largest number of surveys were collected between the 11am-12pm (21%) and the 2pm-3pm (21%) time blocks, followed by 12pm-1pm (20%), 1pm-2pm (12%), 3pm-4pm (10%), 4pm-5pm (10%) and 5pm-6pm (6%).

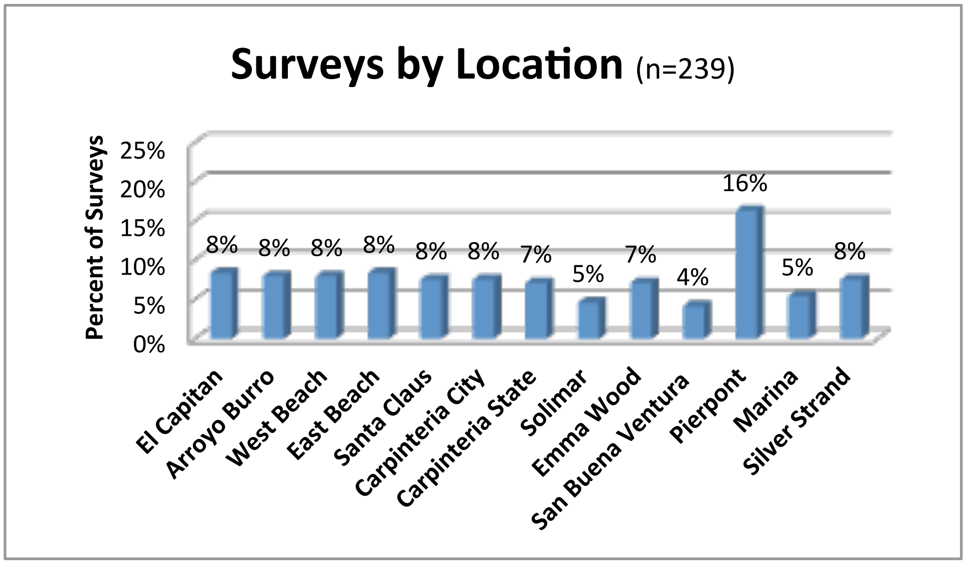

Figure 12: Number of surveys collected by location

A total of 13 beaches were surveyed, 7 in Santa Barbara County and 6 in Ventura County. Approximately 55% of the surveys were conducted in Santa Barbara County and 45% in Ventura County. The distribution of survey responses was relatively even at beaches in Santa Barbara County. In Ventura County, the distribution was less even because of our focus on Pierpont beach, which our management interviews identified as a place of special interest, and the relatively smaller number of patrons to survey at small pocket beaches such as Emma Wood and Marina.

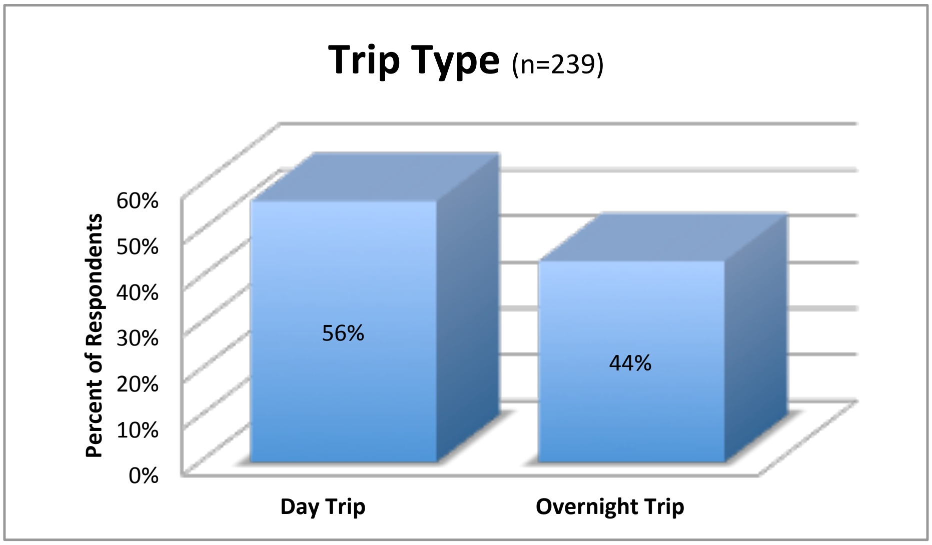

Figure 13: Distribution of trip type of respondents

Day-trippers accounted for a majority of respondents (56%), with the remaining respondents (44%) staying overnight at a location that was not their primary residence. Because this survey was conducted on Labor Day weekend, it is possible that the ratio of day trip to overnight trip visitors is not representative of other times in the year.

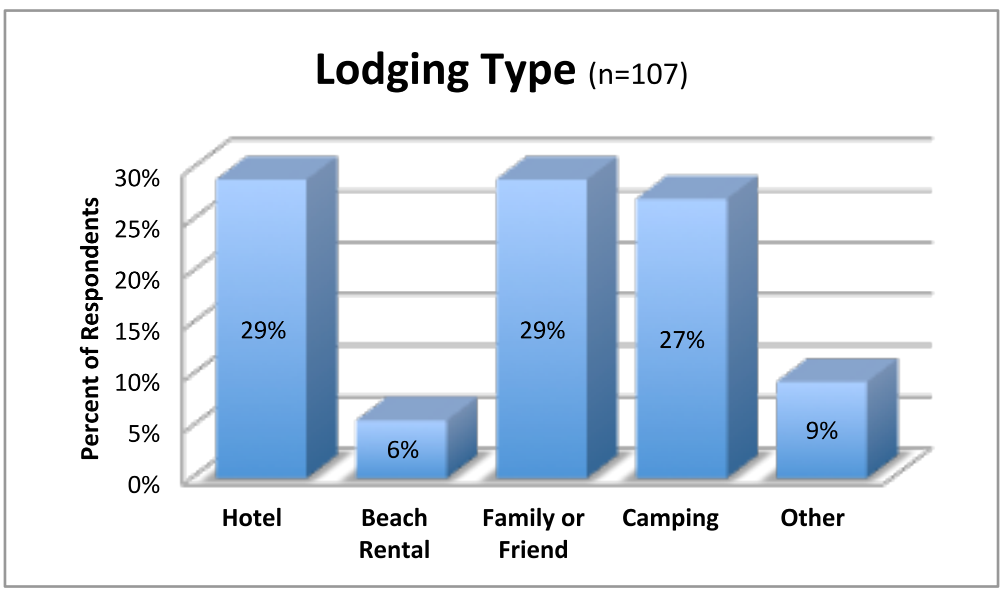

Figure 14: Distribution of type of overnight lodging of respondents

Lodging for survey respondents that were on an overnight trip was greatest at hotels (29%) and a family or friend's residence (29%), followed by camping (27%), other (9%) and beach home rentals (6%). The camping responses are traced to Emma Wood State Beach, El Capitan State Beach and Carpinteria State Beach, all of which have dedicated camping facilities.

Table 4: Distribution of household size of respondents visiting the beach

N	Mean	Median	Std. Dev.	Min	Max
232	3.3	3.0	2.5	1	20

Respondents were asked how many people from their household, including themselves, were in their beach party. The average respondent reported slightly over 3. Based on the maximum reported value of 20, it is likely that some respondents misinterpreted this question, and reported the total number of people in their party.

Table 5: Frequency of visits in the past 12 months to the beach respondents were visiting

N	Mean	Median	Std. Dev.	Min	Max
235	24	4	60	0	365

Respondents were asked how many times in the past 12 months, not including this trip, they had visited the beach they were currently at. The average response was 24, though there was a significant standard deviation (60) resulting from 16 respondents recoding values of 100 or more. The median response was 4.

Table 6: Frequency of visits of respondents in the past 12 months to other beaches in Santa Barbara County or Ventura County

N	Mean	Median	Std. Dev.	Min	Max
230	16	3	39	0	300

Respondents were asked how many times in the past 12 months, not including this trip, they had visited other beaches in Santa Barbara County or Ventura County. The average response was 24, though there was a significant standard deviation (39) resulting from 8 respondents recoding values of 100 or more. The median response was 3.

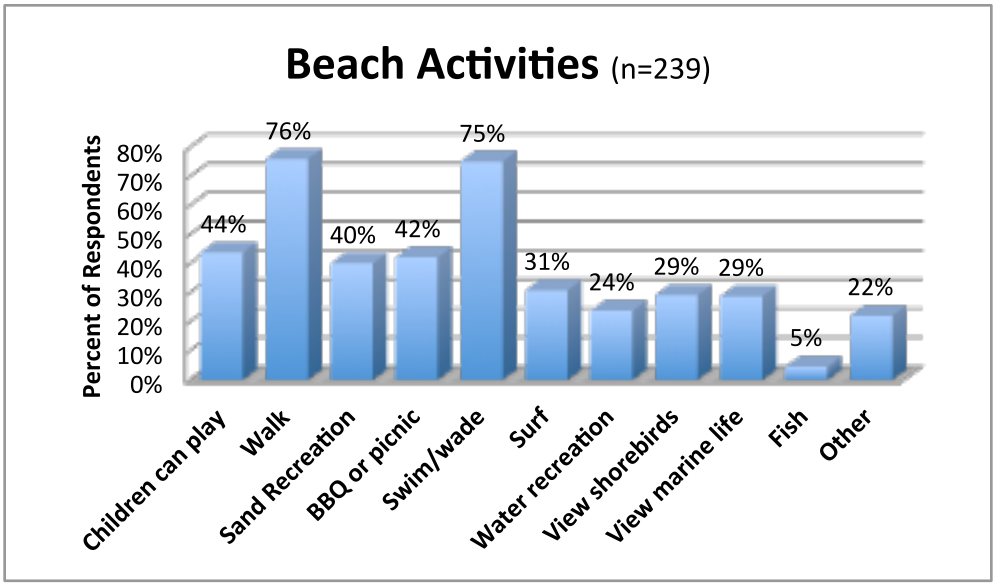

Figure 15: Distribution of beach activities that respondents were participating in at the beach

Respondents were asked to indicate which of the above activities they or anyone else in their party would participate in on their visit to the beach. Respondents were asked to mark all activities that applied. The highest reported activity was walking (76%) followed closely by swimming or wading (75%). The next most popular activities included children can play (44%), BBQ or picnicking (42%), and sand recreation (40). Following these activities was surfing (31%), viewing shorebirds (29%), viewing marine life (29%), water recreation (24%), and other (22%). The least reported activity was fishing (5%). On average, survey respondents indicated they would participate in 4 of the above activities on their visit.

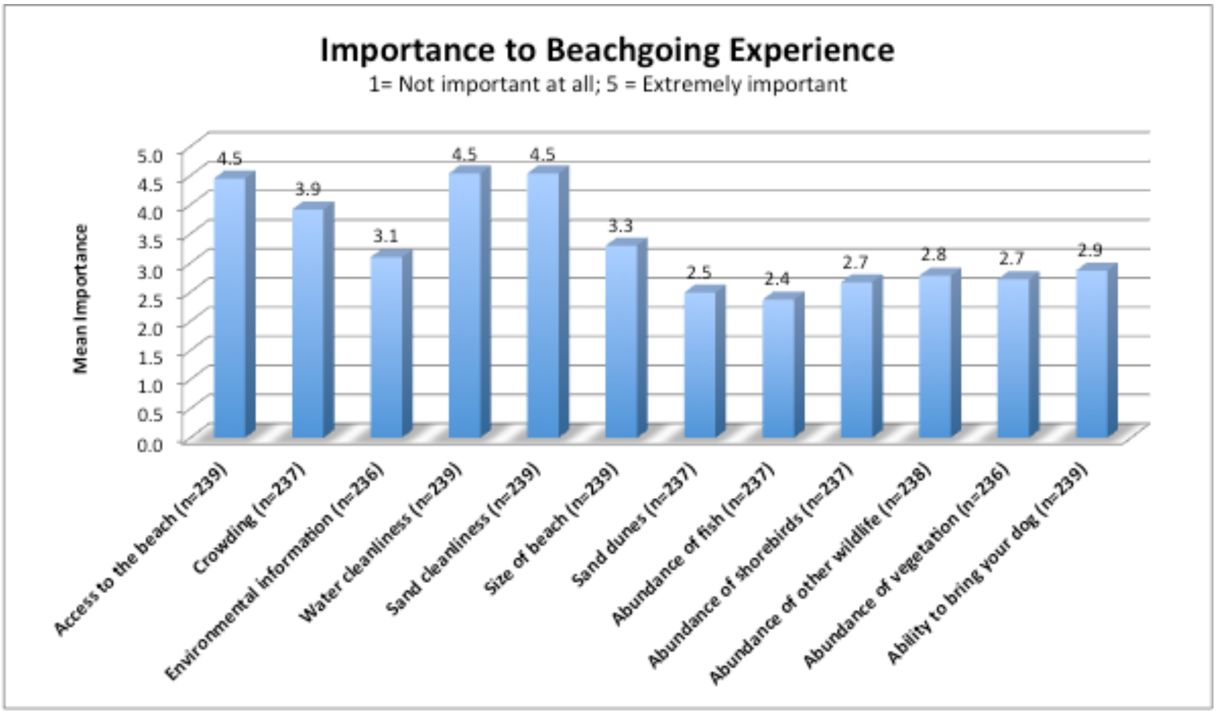

Figure 16: Mean level of importance to the beachgoing experience of respondents

Respondents were asked rate the importance of the above factors to their beachgoing experience. A 5-point scale was used, with 1 equaling not important at all and 5 equaling extremely important. The most highly rated factors were access to the beach, water cleanliness and sand cleanliness, followed by crowding, beach size and environmental information. Next were the ability to bring your dog, abundance of other wildlife, abundance of shorebirds and abundance of vegetation. The lowest recorded factors were sand dunes and abundance of fish. On average, all of the factors excluding sand dunes and abundance of fish were considered important to the beach going experience. It is important to note that sand dunes are not present at a majority of the sites we surveyed at, and that only 5% of respondents indicated that they would be fishing on their trip to the beach.

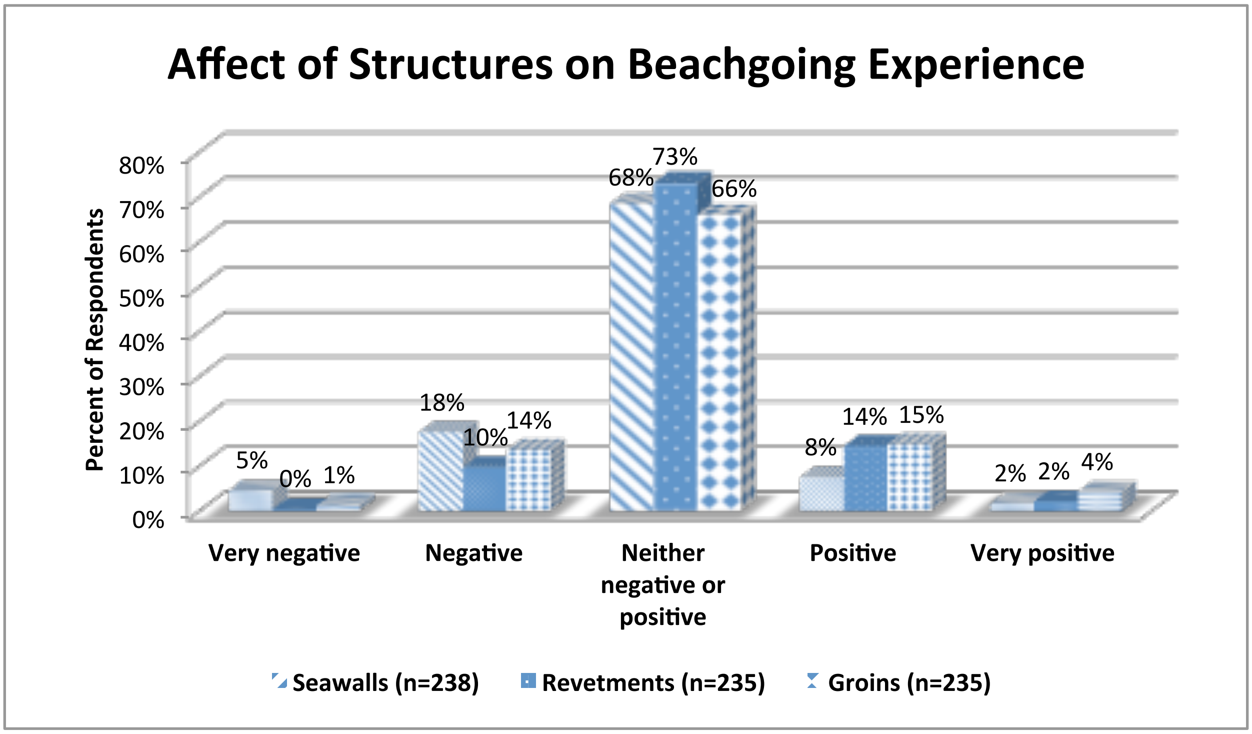

Figure 17: Distribution of structures affects to the beach going experience of respondents

Respondents were asked how seawalls, revetments and groins affect their beachgoing experience. A majority of respondents indicated that these structures had neither a negative or positive affect on their experience (seawalls 68%; revetments 73%; groins 66%). Seawalls have the most negative affect (18%) and groins have the most positive affect (15%) on beachgoing experience.

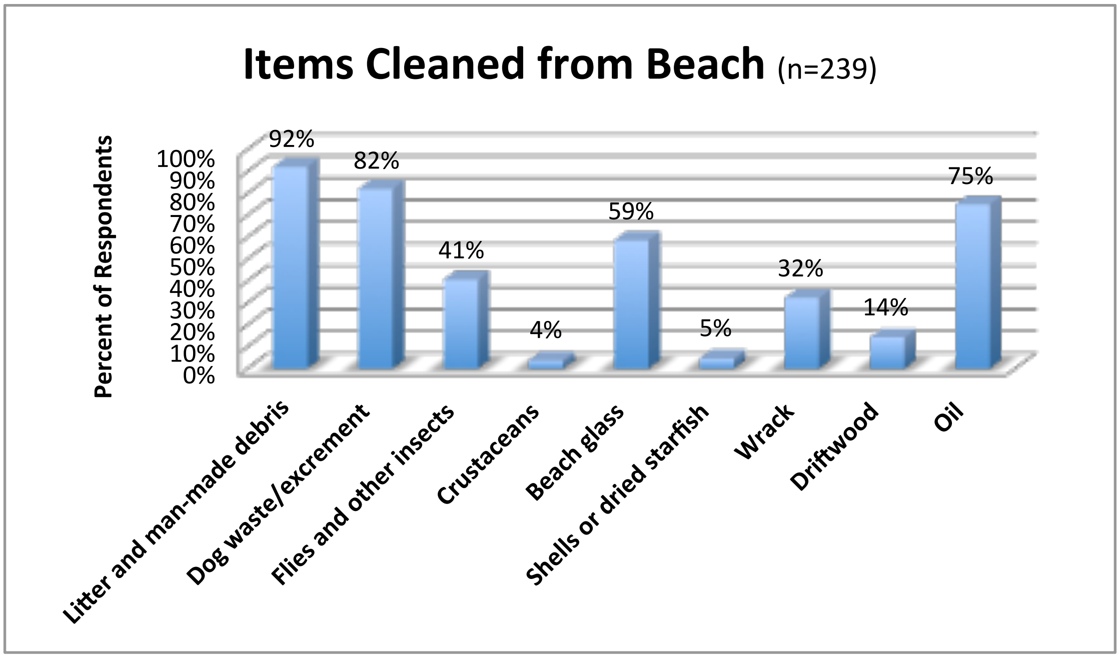

Figure 18: Distribution of respondents of items that would be cleaned from the beaches in Santa Barbara County or Ventura County

Respondents were asked-- if they were responsible for designing a program cleaning beaches in Santa Barbara County or Ventura County, which of the above items they would remove. The highest recorded items included litter and man-made debris (92%), dog waste/excrement (82%), oil (75%) and beach glass (59%). Following these items were flies and other insects (41%), wrack (32%), driftwood (14%), shells or dried starfish (5%) and crustaceans (4%).

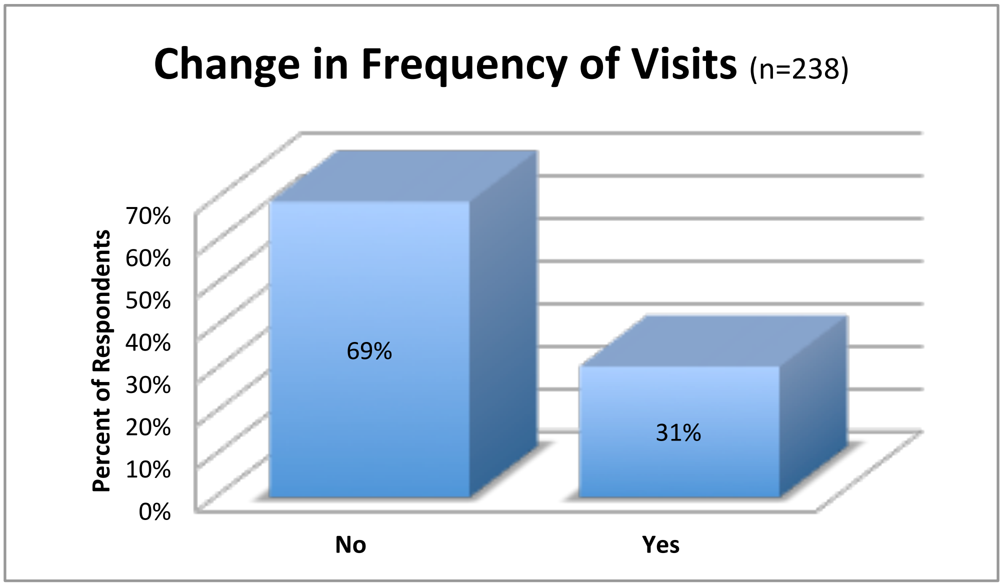

Figure 19: Distribution of changes in visitation of respondents to beaches in Santa Barbara County or Ventura County if beaches are not cleaned of kelp and surf grass, shells, beach glass, driftwood and dried starfish

Respondents were also asked if they would change the number of visits they would take to beaches in Santa Barbara County or Ventura County if kelp and surf grass, shells, beach glass, driftwood and dried starfish were not cleaned from the beach. A majority of respondents recorded replied that the number of visits they would take would not change (69%) if these items were not cleaned from the beach.

Table 7: Percentage change of respondents in frequency of trips to the beach in Santa Barbara County or Ventura County over the next 12 months if beaches are not cleaned of kelp and surf grass, shells, beach glass, driftwood and dried starfish

N	Mean	Std. Dev.	Min	Max
66	-35%	44	-100%	100%

For those who responded that a beach-cleaning program of the above items would affect their visitation frequency, a large majority indicated that they would take fewer trips (85%), on average 35% fewer trips.

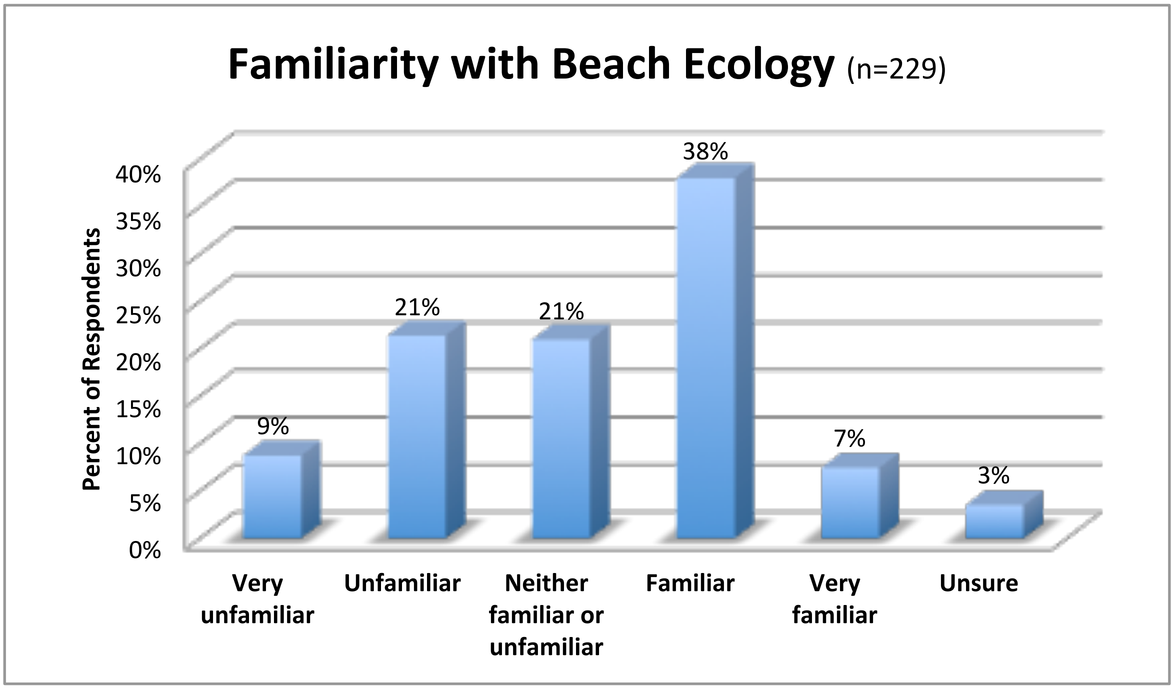

Figure 20: Distribution of respondents in their familiarity with beach ecology

Respondents were asked to indicate their level of familiarity with beach ecology. The highest recorded category was familiar (39%), followed by unfamiliar (21%), neither familiar or unfamiliar (21%), very unfamiliar (9%), very familiar (7%) and unsure (3%).

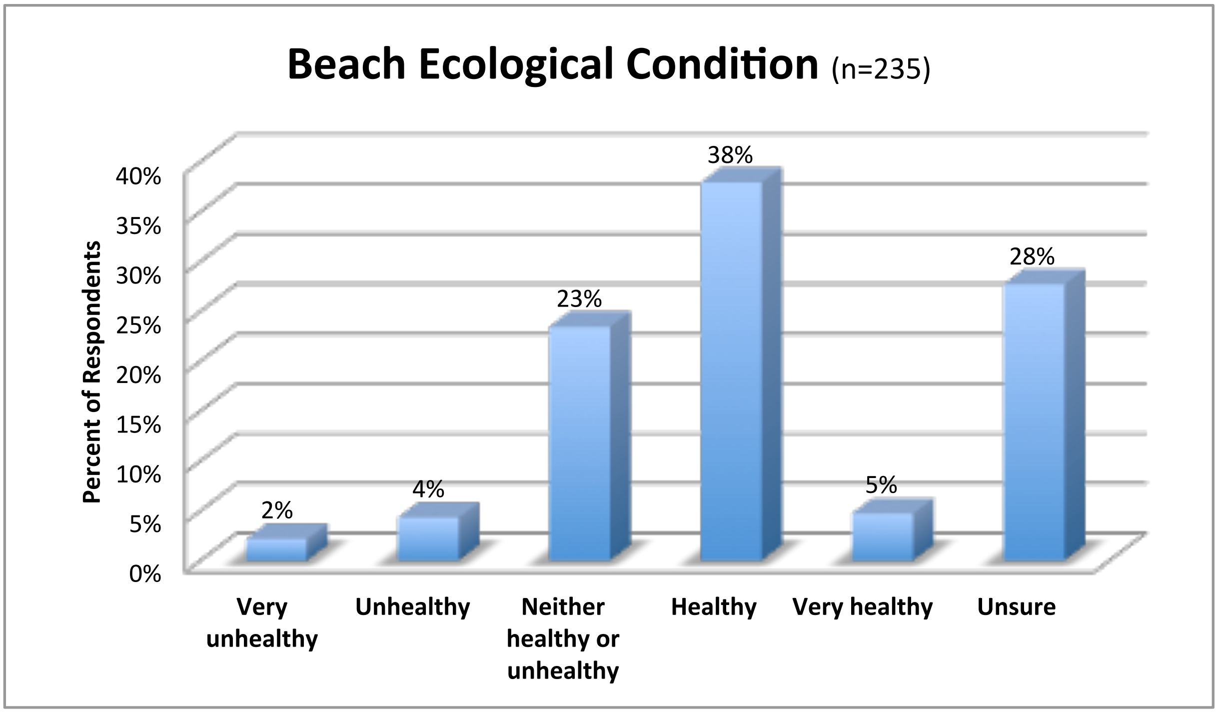

Figure 21: Distribution of perception of the ecological condition of the beaches respondents were visiting

Respondents were asked to rate the ecological condition of the beach they were visiting. The highest recorded category was healthy (38%), followed by unsure (28%), neither healthy or unhealthy (23%), very healthy (5%), unhealthy (4%) and very unhealthy (2%).

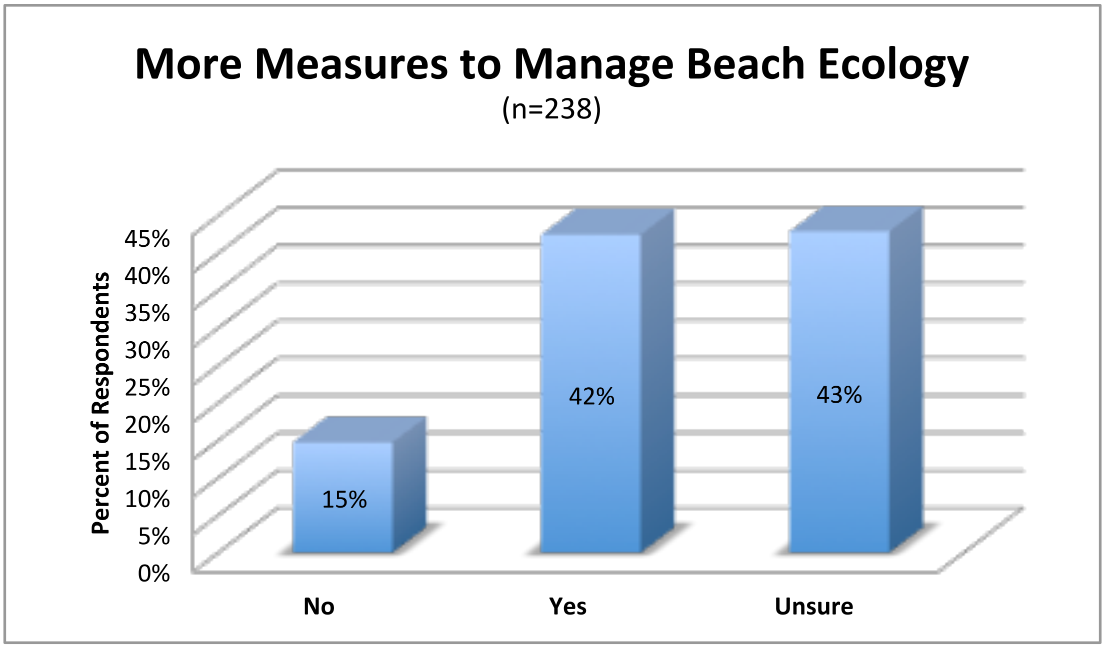

Figure 22: Distribution of the perception for additional measures to manage the ecology of the beaches respondents were visiting

Respondents were asked if more measures should be taken to manage the ecology of the beach they were visiting. The highest reported response was unsure (43%), followed by yes (42%) and no (15%).

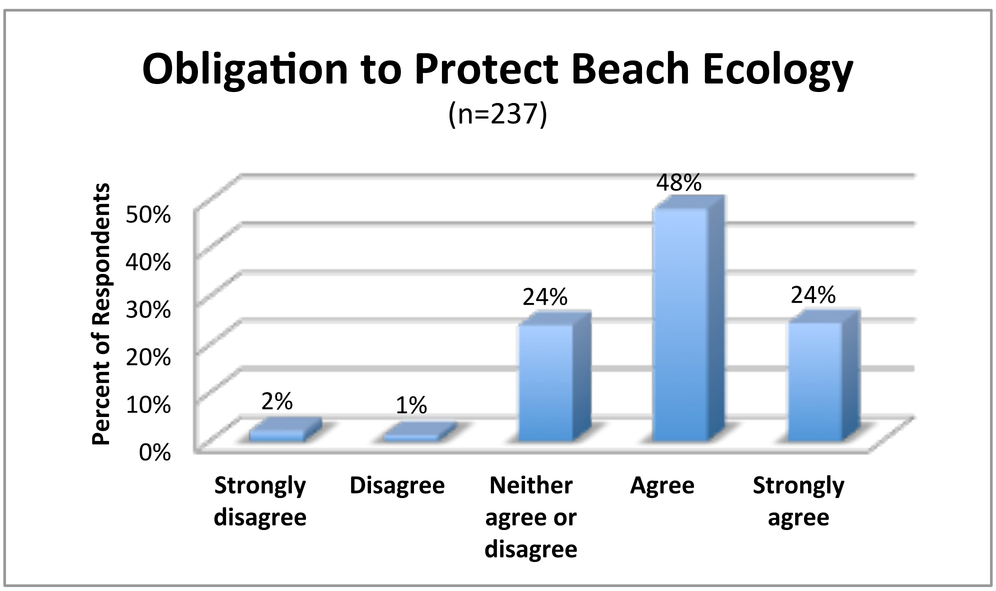

Figure 23: Distribution of obligation of respondents to protect the ecology of beaches

Respondents were asked if they felt an obligation to protect the ecology of beaches. Nearly one-half of respondents agreed (48%), while approximately one-quarter either strongly agreed (24%) or neither agreed or disagreed (24%). Collectively, only 4% of respondents disagreed or strongly disagreed.

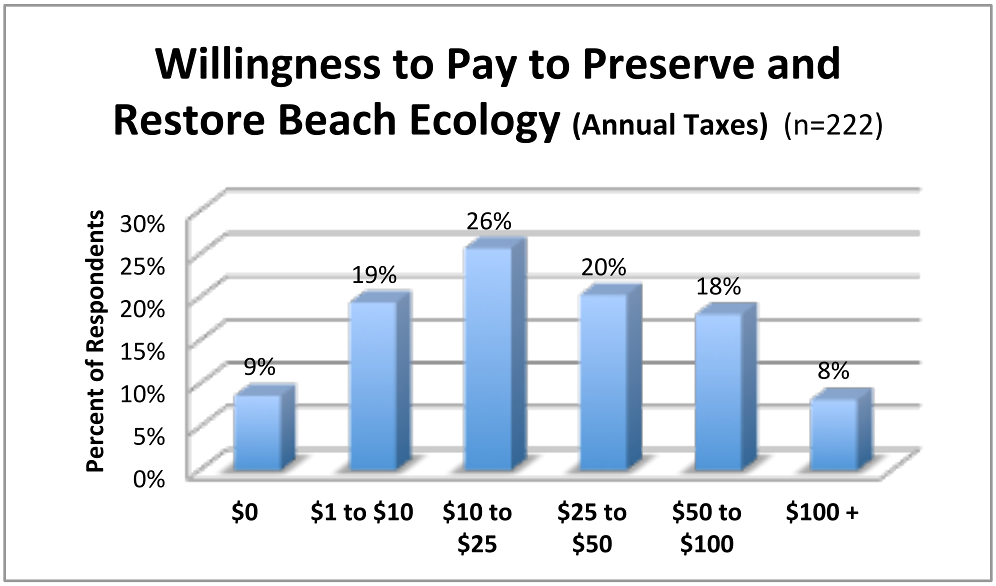

Figure 24: Distribution of willingness to pay in annual taxes of respondents to preserve and restore the ecology of beaches in Santa Barbara County or Ventura County

Respondents were asked the amount they would be willing to pay in annual taxes to preserve and restore the ecology of beaches in Santa Barbara County or Ventura County. Less than 10% of respondents were not willing to pay any annual taxes. For those willing to pay, the highest rated response was for $10 to $25 (26%), followed by $25 to $50 (20%), $1 to $10 (19%), $50 to $100 (18%) and greater than $100 (8%). The average willingness to pay was approximately $30 per year in taxes, assuming the mid-point of the ranges and a high of $100. We randomized the order of the response options to avoid anchoring—a phenomenon observed by cognitive psychologists where people are more likely to reveal higher willingness to pay if the first choice is a higher number (e.g., $100) and a lower willingness if the first choice is lower (e.g., 0). Future surveys would benefit from randomizing the ranges of tax options.

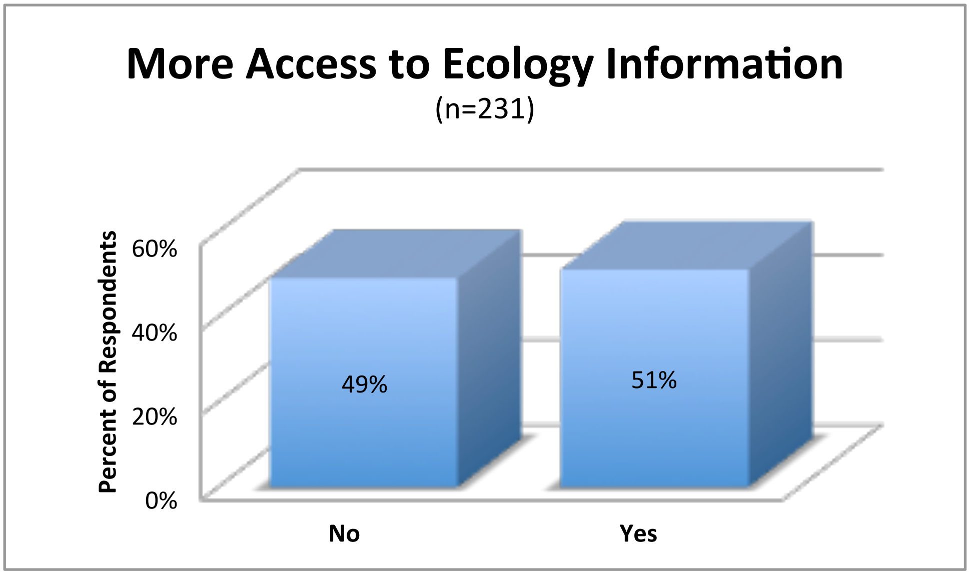

Figure 25: Distribution of preference for more access to more beach ecological information at the beaches respondents were visiting

Respondents were asked if they preferred more access to ecological information on the beach they were visiting. A slight majority responded yes (51%).

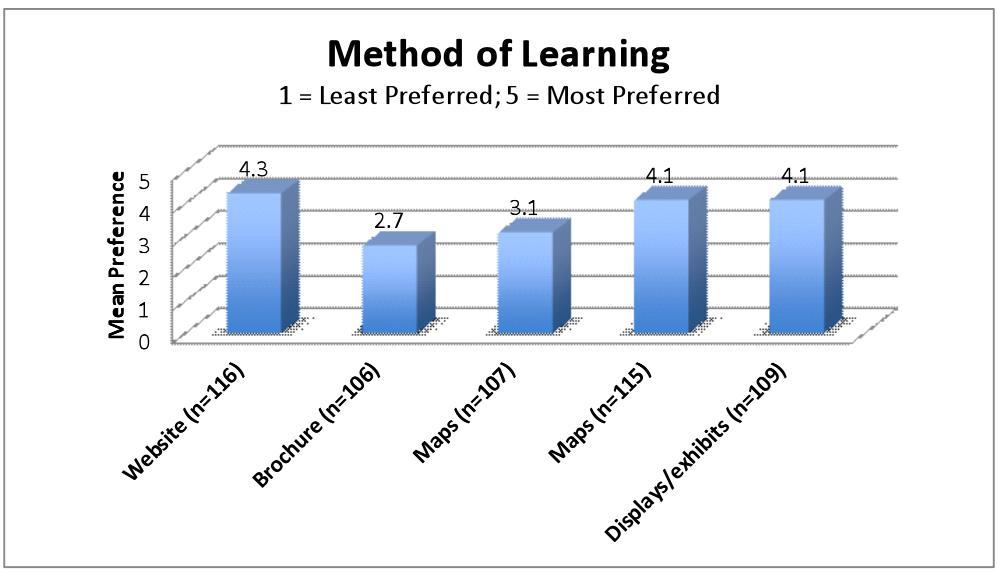

Figure 26: Mean preferred method of learning of beach ecology of respondents

Individuals that indicated they would prefer more access to beach ecological information were asked to rate their preference level for varying modes of learning. A 5-point scale was used, with 1 equaling least preferred and 5 equaling most preferred. The highest preference (on average) was for information on websites, followed by maps, displays/exhibits, maps and lastly, brochures.

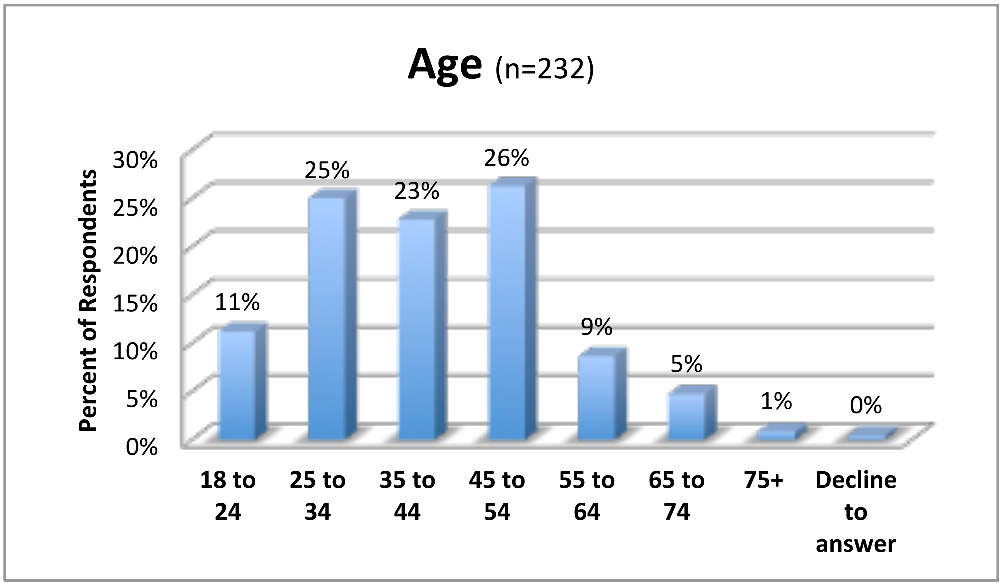

Figure 27: Distribution of age of respondents

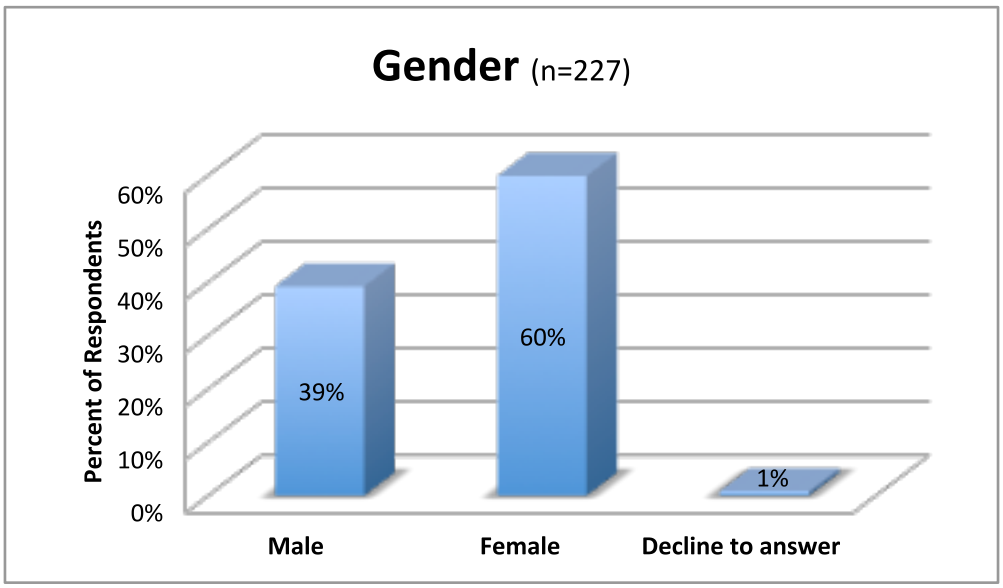

Figure 28: Distribution of gender of respondents

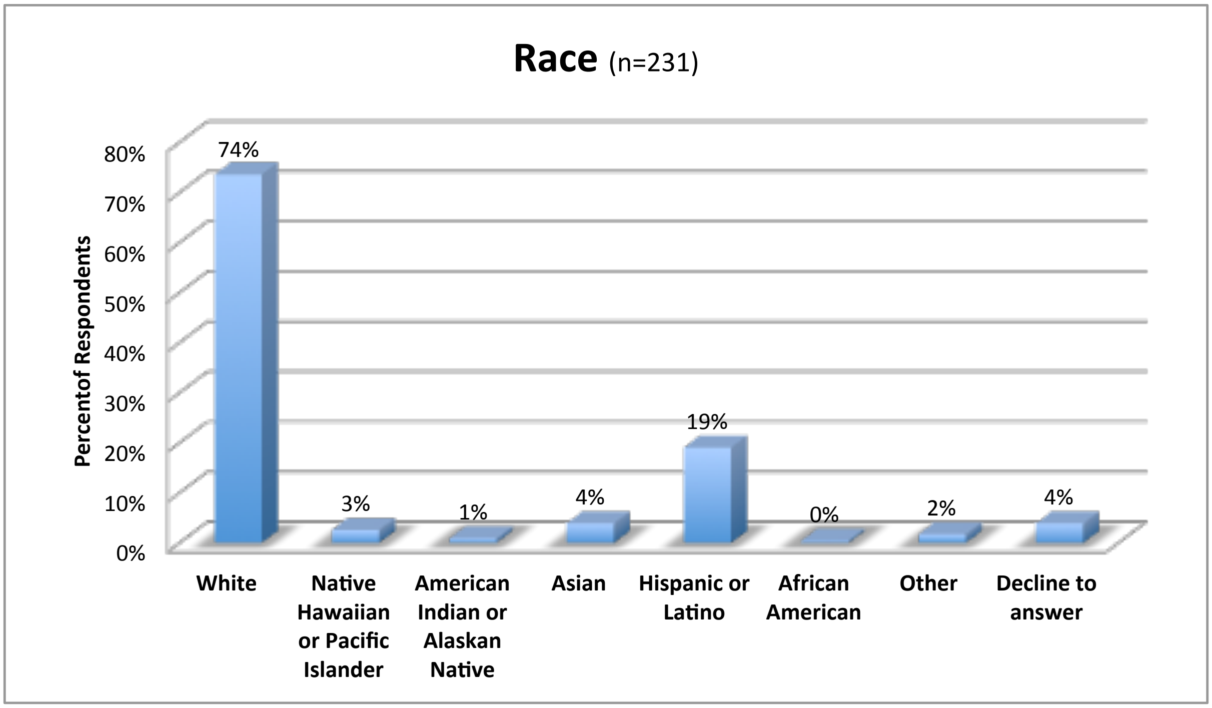

Figure 29: Distribution of race of respondents

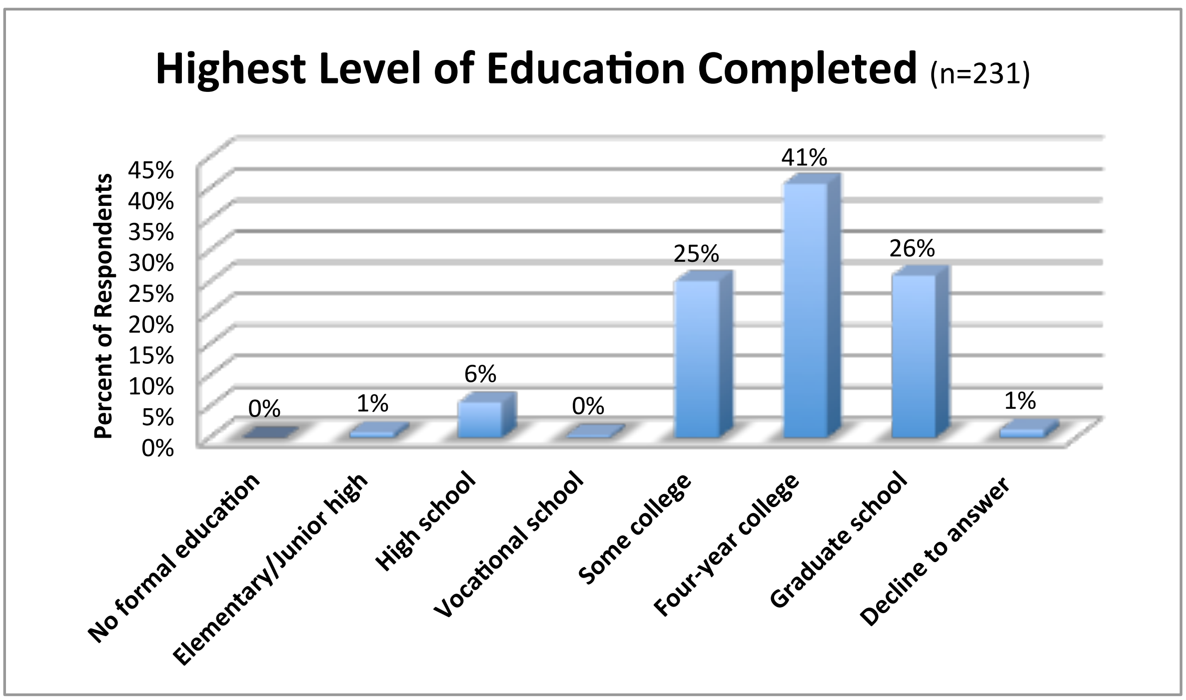

Figure 30: Distribution of education of respondents

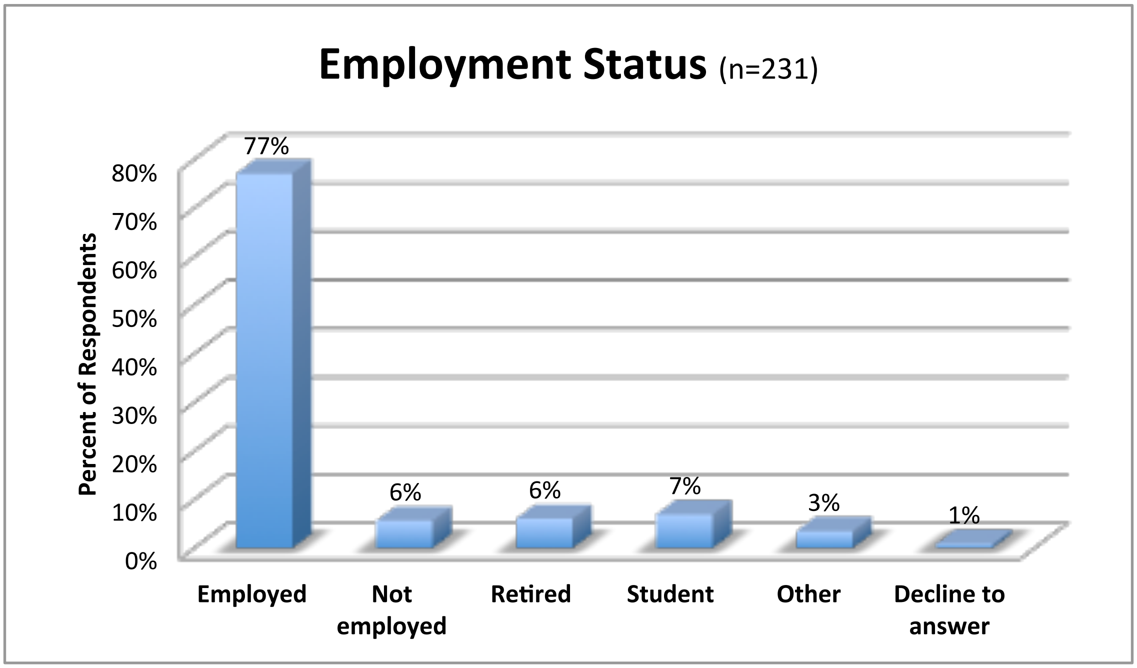

Figure 31: Distribution of employment status of respondents

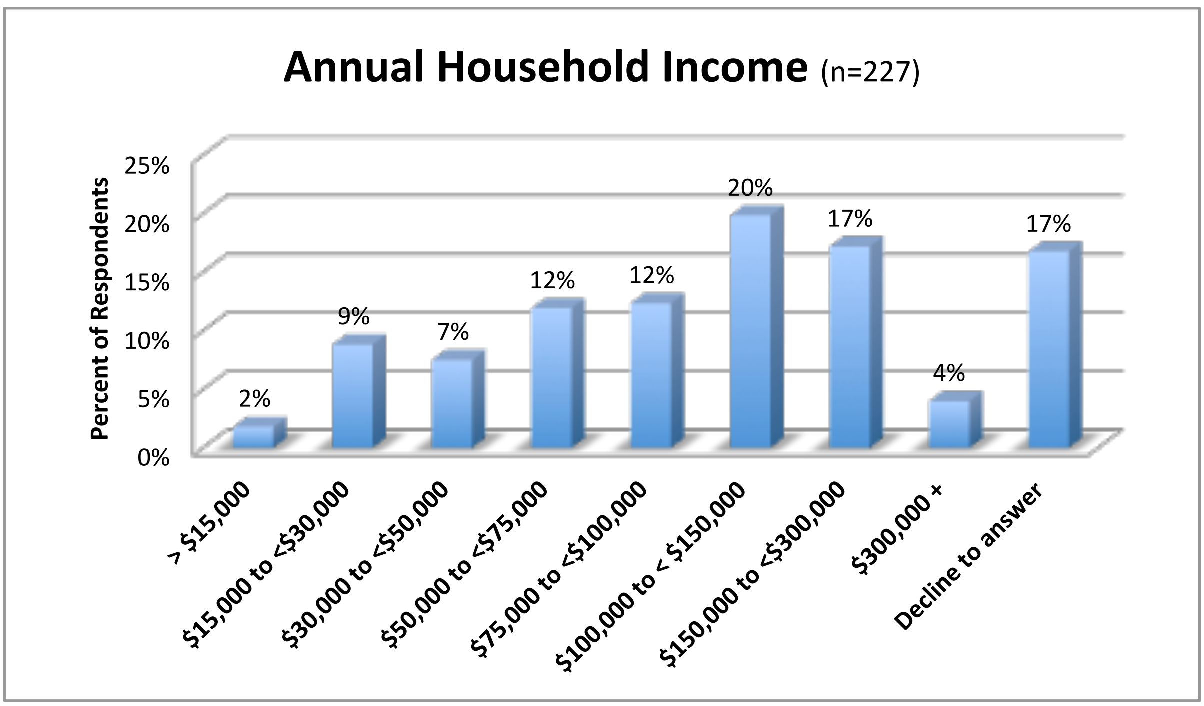

Figure 32: Distribution of annual household income of respondents

Limitations

Sampling Strategy

Data was only collected over one-weekend, a holiday weekend at that. As a result, our data may not be representative of the year-round population of users. Time blocks for corresponding beach sites were not chosen randomly because of limited time and resources. We surveyed beaches in their geographic order (e.g., north to south, east to west) starting in the late morning and worked our way down the coast. While we made efforts to not solely focus on beaches that were clustered together – in Santa Barbara County and Ventura County the surveyed sites were both spread over approximately 30 mile. Some activities, such as walking and surfing, are most popular in the morning or late in the day. Further, it is much more difficult to intercept these types of beach users. Our sampling time blocks (11am-6pm) occurred when these activity levels are lower.

Homogenous Interviewer Characteristics

While the surveyors were instructed to take efforts to interview a representative sample of users, doing so is challenging. For example, approximately 60% of respondents were female. However, it was noted by the surveyors that when they would approach a party at the beach, females were often the ones in the group who volunteered to take the survey. Whether response rates would have changed if the race, age or gender of the surveyor was different we are not sure.

Robust Testing of Statistical Relationships

Our choice not to include certain questions out of concerns of survey length and potential biasing limits the testing of relationships of respondent behavior and perception. For example, we asked respondents to indicate what activities they would participate in on their visit to the beach. If we had asked respondents to indicate their priority activity, instead of and/or in addition to all the activities they would participate in, more robust statistical analysis could be conducted between respondent behavior and perception. We also asked respondents if more measures should be taken to manage the beaches they were visiting. Yet, we did not ask respondents their awareness of environmental management policies and practices at play. Awareness of such initiatives could influence perceptions of environmental quality. Wording questions about environmental awareness in unbiased ways is challenging, but could allow for further relationships to be tested between a respondent's management knowledge and their perceptions about environmental quality.

Unclear Wording of Questions

While an overwhelming majority of respondents appeared to understand the wording of questions, we came across a few places where respondents either did not fully read the question, or failed to understand the intent of the question. For example, we asked respondents to indicate how many people in their household, *including themselves*, were in their party at the beach. A few respondents wrote zero for this answer, when the lowest possible response would be one. There were two other no or yes questions where respondents were instructed to skip the next question if they marked no. In a handful of cases, respondents marked no, and then filled out the following questions. For the above examples, where there were only a few inconsistencies, we corrected the answer to align with the survey logic rather than excluding these responses from analysis.

Lack of Structured Feedback

To our knowledge, this is the first survey conducted in California (or anywhere) to collect data on user behavior and perceptions of beach ecology and its management. While efforts were taken to test the survey and incorporate comments, there were limited mechanisms for respondents to provide feedback. Some respondents made various comments in the survey, and interviewers recoded some feedback on particular questions. We hope that this survey can be improved for use in Santa Barbara County and Ventura County and in other coastal environments in the future. Adding questions to get specific feedback could help us achieve this goal, though this would come at the cost of a more lengthy survey that could result in a lower response rate.

Discussion

Finding ways to support both recreational and ecological opportunities requires careful consideration of the pressures facing beach environments, the behaviors and perceptions of their users, and the availability of management techniques to sustain a balanced portfolio of benefits from these landscapes. The type of information produced from this survey is critical to evaluating management practices in a way that explicitly captures ecological and economic tradeoffs. Future work could focus on a more robust analysis using statistical tests to evaluate the relationships between the behaviors (e.g., beach choice, recreational activities, spending) of coastal users and their perceptions and attitudes of beach environmental quality and its management. For example, respondents who participated in viewing shorebirds had the same environmental perceptions as respondents who did not participate in this activity. In addition, respondents who visited beaches that were not groomed had the same environmental perceptions as people who visiting beaches that were groomed. In addition to testing these relationships, collaborating with beach ecologists to compare the environmental quality perceptions of respondents with the actual conditions at select beaches would provide further insight on the role education could play in aligning beach users' environmental perception with reality.

Beach Visitor Survey

We are conducting this survey for the Beach Erosion Authority for Clean Oceans and Nourishment (BEACON). Our goal is to learn about your motivations for visiting the beach and your perceptions of environmental quality. We would appreciate your help by taking a few minutes to complete this survey.

All responses are confidential. *Thank you very much for your participation.*

1. **Is this an overnight trip away from your primary residence?** ☐ Yes ☐ No → If 'NO', **skip** to Question 2

   a. If this is an overnight trip, what type of lodging will you be using?

   ☐ Hotel ☐ Beach rental ☐ Family or friend ☐ Camping ☐ Other________________

2. **Including yourself, how many people from your household are in your party today?** ____ people

3. **Not including this trip, how many days have you visited this beach in the past 12 months?** _____ days

4. **Not including this trip, how many days have you visited other beaches in Santa Barbara County or Ventura County over the past 12 months?** _____ days

5. **What activities will you or anyone in your party do on this trip to the beach (choose all that apply)?**

   ☐ Children can play ☐ Walk ☐ Sand recreation (e.g., volleyball) ☐ BBQ or picnic

   ☐ Swim/wade ☐ Surf ☐ Water recreation (e.g., kayak) ☐ View shorebirds

   ☐ View marine life ☐ Fish ☐ Other________________

6. **In general, how important are the following factors to your beach going experience?**

Factors for your consideration	**Level of Importance** 1 = Not at all important 5 = Extremely important				
Access to the beach	1	2	3	4	5
Crowding	1	2	3	4	5
Availability of environmental information	1	2	3	4	5
Water cleanliness	1	2	3	4	5
Sand cleanliness	1	2	3	4	5
Size of beach	1	2	3	4	5
Sand dunes	1	2	3	4	5
Abundance of fish	1	2	3	4	5
Abundance of shorebirds	1	2	3	4	5
Abundance of other wildlife	1	2	3	4	5
Abundance of vegetation	1	2	3	4	5
Ability to bring your dog	1	2	3	4	5

7. **What affect do the following features have on your beach going experience?**

   a. Seawalls (vertical concrete walls generally at the back of the beach):

   ☐ Very Negative ☐ Negative ☐ Neither negative or positive ☐ Positive ☐ Very Positive

   b. Revetments/Riprap (rock boulders or stones generally at the back of the beach):

   ☐ Very Negative ☐ Negative ☐ Neither negative or positive ☐ Positive ☐ Very Positive

   c. Jetties/groins (wood, stone, or rock structures that extend from the beach into the water):

   ☐ Very Negative ☐ Negative ☐ Neither negative or positive ☐ Positive ☐ Very Positive

Figure 33: Page 1 of the survey instrument

8. If you were responsible for designing a program for cleaning beaches in Santa Barbara County or Ventura County, what items would you remove (choose all that apply)?

☐ Litter and man-made debris ☐ Dog waste/excrement ☐ Flies and other insects

☐ Crustaceans (e.g., crabs, clams) ☐ Beach glass ☐ Shells or dried star fish

☐ Wrack (e.g., seaweed, kelp) ☐ Driftwood ☐ Oil

9. If kelp and surfgrass, shells, beach glass, driftwood and dried starfish were not cleaned from beaches in Santa Barbara County or Ventura County, would this affect the number of visits you take?

☐ Yes ☐ No → If 'NO', **skip** to Question 10

a. If yes, how would the frequency of your trips to the beach change over the next 12 months?

Less trips No change More trips

-100% -75% -50% -25% 0% +25% +50% +75% +100%

10. How familiar are you with the ecology (e.g., kelp, shells, invertebrates, shorebirds) of beaches?

☐ Very unfamiliar ☐ Unfamiliar ☐ Neither familiar or unfamiliar

☐ Familiar ☐ Very familiar ☐ Unsure

11. The ecological condition (e.g., kelp, shells, invertebrates, shorebirds) of this beach is:

☐ Very unhealthy ☐ Unhealthy ☐ Neither unhealthy or healthy ☐ Healthy ☐ Very healthy ☐ Unsure

12. Should more measures be taken to manage the ecology (e.g., kelp, shells, invertebrates, shorebirds) of this beach?

☐ Yes ☐ No ☐ Unsure

13. I feel an obligation to protect the ecology (e.g., kelp, shells, invertebrates, shorebirds) of beaches:

☐ Strongly disagree ☐ Disagree ☐ Neither disagree or agree ☐ Agree ☐ Strongly agree

14. How much in annual taxes would you be willing to pay to preserve and restore the ecology (e.g., kelp, shells, invertebrates, shorebirds) of beaches in Santa Barbara County or Ventura County?

☐ $0 ☐ $1 to $10 ☐ $10 to $25 ☐ $25 to $50 ☐ $50 to $100 ☐ $100+

15. Would you prefer more access to ecological information at this beach?

☐ Yes ☐ No → If 'NO', **skip** to Question 16 below

a. If yes, circle your preferred level of preference for the methods of learning below:

Method of Learning	Level of Preference 1 = Least preferred 5 = Most preferred				
Website	1	2	3	4	5
Brochure	1	2	3	4	5
Maps	1	2	3	4	5
Informational signs	1	2	3	4	5
Displays/Exhibits	1	2	3	4	5

Figure 34: Page 2 of the survey instrument

The following questions are designed to give us a better idea of the characteristics of visitors. *Please note that your responses are anonymous and you are not identified in any way with this information.*

16. What is your age:

☐ 18 to 24 years ☐ 25 to 34 years ☐ 35 to 44 years ☐ 45 to 54 years

☐ 55 to 64 years ☐ 65 to 74 years ☐ 75 years and over ☐ Decline to answer

17. Are you: ☐ Male ☐ Female ☐ Decline to answer

18. Home zip code: ___________ **If not living in the United States, where do you live:** ______________

19. Race (choose all that apply):

☐ White ☐ Native Hawaiian or Pacific Islander ☐ American Indian or Alaskan Native

☐ Asian ☐ Hispanic or Latino ☐ African American

☐ Other ☐ Decline to answer

20. Highest level of education completed (choose only one):

☐ No formal education ☐ Elementary/Junior High ☐ High School

☐ Vocational School ☐ Some College ☐ Four-year College

☐ Graduate School ☐ Decline to answer

21. Employment status (choose only one):

☐ Employed ☐ Not employed ☐ Retired ☐ Student ☐ Other ☐ Decline to answer

22. Total annual household income before taxes (from all sources):

☐ Less than $15,000 ☐ $15,000 to under $30,000 ☐ $30,000 to under $50,000

☐ $50,000 to under $75,000 ☐ $75,000 to under $100,000 ☐ $100,000 to under $150,000

☐ $150,000 to under $300,000 ☐ More than $300,000 ☐ Decline to answer

Official Use Only: Respondent ID#_________ Location Completed___________ Surveyor_____________ Date___________ Time____________

Figure 35: Page 3 of the survey instrument