potential for future beach loss due to climate change stressors. Thus, physical and topographic change were also important to capture.

Indicators

Utilizing indicators helps track changes in the environment, and consistently collecting data on these indicators over time allows for long-term trends in habitat condition to be evaluated. The sandy shore habitat includes 15 indicators across four categories which will be used to detect changes in this environment (Table 6.1). Indicators will be monitored using a variety of programs and studies identified in the subsection below. Where possible, indicators are reflective of quantitative measurements at specific geospatial scales. Note that the indicator list is not intended to be comprehensive or exhaustive, rather it is intended to be representative to capture extent, condition, and trends over time for this habitat.

Table 6.1. Indicators for sandy shore habitats in the Santa Monica Bay region.

Indicator Category	Sandy Shore Indicators
Habitat Extent	Area of Sandy Shore Habitats
Ecological Condition	Nursery and Habitat Provisioning for Fish
	Foraging Function for Birds
	Nursery and Roosting Function for Rare Birds
	Invertebrate Food Web Support
	Native / Invasive Flora
Stressors	Anthropogenic Infrastructure / Beach Hardening
	Habitat Protection
	Human Activities
	Beach Management Practices
	Beach Water Quality
Climate Change Vulnerability	Shoreline Erosion / Topography Change
	Nearshore Surface Water Temperature
	Coastal Flooding
	Hazard / Disturbance Response

Monitoring Program and Current Studies

This section of the report contains details on specific monitoring program implementation components that will be used to evaluate trends in the indicators for sandy beach ecosystems over time. Information is provided on monitoring programs, responsible parties, and frequency of data collection.

For habitat extent, this indicator will be evaluated by tracking area of beach habitats providing ecosystem functions by type (e.g., coastal strand, dunes, intertidal sand etc.); mapping and proportions of human use or specific recreational areas; biologically relevant or sensitive habitat areas; and location and mapping of back dune systems. Various geospatial layers can be used to inform this indicator, including grooming data from LACDBH, mapping data from CRI's beach characterization study, and other mapping data such as opportunistic research programs conducted by USC Sea Grant or other entities. Aerial photographs, such as from the California Coastal Records Project (www.californiacoastline.org), may also serve to inform this indicator or others below. In general, except for seasonal variations in beach width and sediment movement, data layers for habitat extent are unlikely to frequently exhibit substantial changes, but may be updated annually, biennially, or as new policies are put into effect.

For the other three categories of indicators, i.e., ecological condition, stressors, and climate change vulnerability, details on implementation strategies and monitoring program elements can be found in Tables 6.2, 6.3, and 6.4, respectively.

With the exception of the beach monitoring program led by CRI, data collected to inform trends associated with various indicators are often informed by monitoring or research programs that are conducted opportunistically or not comprehensive throughout the Santa Monica Bay. For example, regular UCSB surf zone fish surveys are only conducted on Leo Carrillo State Beach and Point Dume Beach, Malibu, and rare bird surveys for California least terns and western snowy plovers are only conducted on beaches they are known to use for roosting or nesting. Additionally, note that monitoring programs that do not have a formal plan associated with them or are largely associated with opportunistic filling of data gaps state "opportunistic surveys / research" or "no current programs" in the tables below as they may not currently be funded programs.

Figure 6-1. Groomed beaches in Santa Monica Bay with various recreational activities and driving occurring (top) and a marathon event (bottom, credit both: TBF).
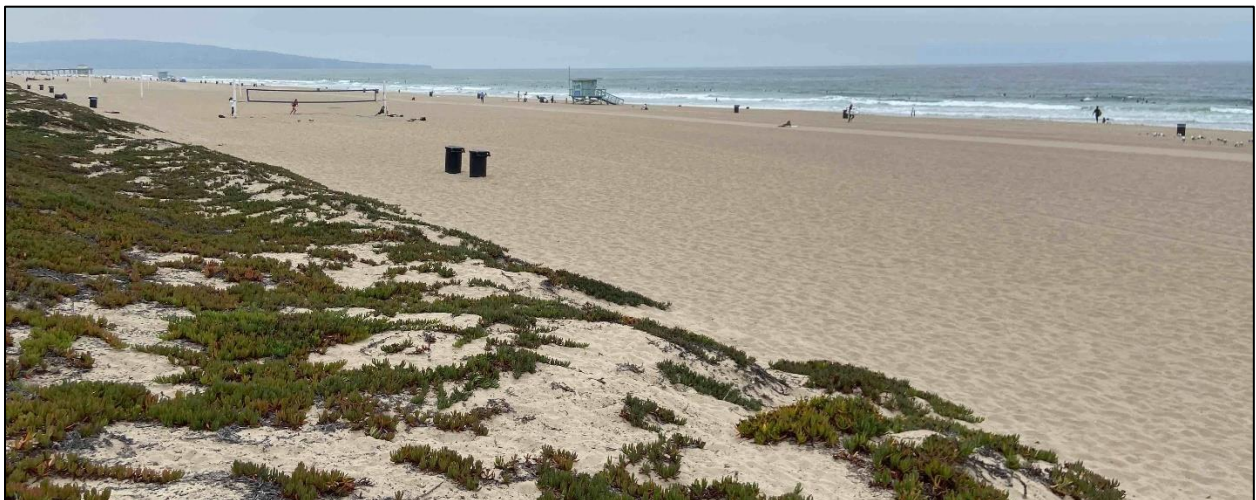

Figure 6-2. Back dune in Manhattan Beach with invasive iceplant and groomed beach to the west (right) (credit: TBF).

Figure 6-3. Santa Monica Beach Restoration Pilot Project with native vegetation approximately four years after restoration (credit: TBF).

Table 6.2. Ecological Condition Metrics and Monitoring Program Details.

Indicator	Monitoring Metric / Parameter	Monitoring Data Program / Responsible Party	Frequency
Nursery and Habitat Provisioning for Fish	Median grunion run size over time; grunion run distributions and geographic range	Pepperdine University (Grunion Greeters program) led by Dr. Karen Martin	Runs monitored by citizen scientists opportunistically annually between March and August
	Abundance, composition, and size structure of surf zone fish	Quantitative surf zone surveys (nearshore seines and motion cameras) collected in MPAs and reference sites (Point Dume SMR, Leo Carrillo State Beach) led by Dr. Jenny Dugan, UCSB	Three times annually at Point Dume SMR and Leo Carrillo State Beach
		Vantuna Research Group surf zone data (Occidental College) collected at several locations in the Bay; some research by Dr. Chris Lowe's Lab at CSULB	Annually; opportunistic Lowe research
Foraging Function for Birds	Presence and abundances of resident and migratory bird species	Data collected by TBF / CRI associated with living shoreline projects and beach characterization studies	Semi-annually at Santa Monica, Zuma, Point Dume, Manhattan, and Dockweiler Beaches; opportunistic surveys at other beaches
		Quantitative bird, wrack and beach characteristics surveys collected in MPAs and reference sites (Point Dume SMR, Leo Carrillo State Beach) led by Dr. Jenny Dugan UCSB	August – January monthly surveys (Point Dume SMR, Leo Carrillo State Beach)
		e-bird data (quality control checked citizen science)	Opportunistic data collection
	Bird activity observations	Audubon Christmas Counts (long-term data); some data collected by TBF / CRI associated with living shoreline projects; research projects (not comprehensive)	Annually in winter; Opportunistic surveys / research

Indicator	Monitoring Metric / Parameter	Monitoring Data Program / Responsible Party	Frequency
Nursery and Roosting Function for Rare Birds	Western snowy plover and California least tern abundances (roosting) over time	Plover and tern abundances and locations conducted by LA Audubon Society and Ryan Consulting	Monthly surveys
		Data collected by TBF / CRI associated with living shoreline projects and beach characterization studies	Opportunistic surveys / research
	Western snowy plover and California least tern number of nests and successfully fledged chicks	Breeding bird surveys conducted by LA Audubon Society and Ryan Consulting	Monthly surveys during breeding season
	Sand crab and beach hopper zone fauna in intertidal areas	Schooler, Dugan, and Hubbard unpublished data (UCSB); MPA monitoring data (UCSB)	Opportunistic research; three times annually at Point Dume SMR and Leo Carrillo State Beach
	Food web support index	Schooler, Dugan, and Hubbard unpublished data (UCSB); MPA monitoring data (UCSB)	Opportunistic research; three times annually at Point Dume SMR and Leo Carrillo State Beach
	Indicator species (e.g., bean clams as an indicator of warmer waters)	Schooler, Dugan, and Hubbard unpublished data (UCSB); MPA monitoring data (UCSB)	Opportunistic research; three times annually at Point Dume SMR and Leo Carrillo State Beach
Native / Invasive Flora	Presence / cover of native vegetation; presence / cover of invasive vegetation	Data collected by TBF / CRI associated with living shoreline projects and beach characterization studies	Semi-annually at Santa Monica, Zuma, Point Dume, Manhattan, and Dockweiler Beaches; opportunistic surveys at other beaches
	Wrack cover / presence by species; presence of invasive *Sargassum horneri*	Data collected by TBF / CRI associated with living shoreline projects and beach characterization studies	Semi-annually at Santa Monica, Zuma, Point Dume, Manhattan, and Dockweiler Beaches; opportunistic surveys at other beaches
		Wrack data collected by UCSB at Leo Carrillo State Beach and Point Dume	August – January monthly surveys and with all fish surveys (Point Dume SMR, Leo Carrillo State Beach) UCSB

Table 6.3. Stressor Metrics and Monitoring Program Details.

Indicator	Monitoring Metric / Parameter	Monitoring Data Program / Responsible Party	Frequency
Anthropogenic Infrastructure / Beach Hardening	Percentage of shoreline that has been armored; number, location, and type of infrastructure (e.g., pier, jetty, groin)	Dorsey beach characterization study results and mapping data; NOAA Office of Oil Spill Response and Restoration (Environmental Sensitivity Mapping)	Once and then tracking as infrastructure is changed over time
	Percentage of beach shoreline with beachfront infrastructure; number and location of structures and beach facilities	Dorsey beach characterization study results and mapping data; NOAA Office of Oil Spill Response and Restoration (Environmental Sensitivity Mapping)	Once and then tracking as infrastructure is changed over time
	Sand transport via wind direction and speed	National Weather Service – many stations throughout SM Bay	Hourly; downloaded as needed
Habitat Protection	Percentage of habitats under various levels of protection (e.g., grooming practices, MPA areas)	MPA area data from CDFW; maps of fenced areas (e.g., Santa Monica Beach pilot, Venice Least Tern Colony)	Once and then tracking as practices are changed over time
		Beach grooming data from LACDBH	Once and then tracking as practices are changed over time
Human Activities	Numbers, locations, and types of events on beaches (e.g., camps, cultural events, sports, trainings)	County Beach Commission – groups of over eight people or classes must register	As occurring
	Beach driving and other vehicle disturbance factors	County lifeguard data or LACDBH	Unknown
	Off-leash dogs on the beach	County lifeguard data and Audubon records	Opportunistic surveys / research
	Recreational fishing activities	Heal the Bay outreach surveys; MPA Watch; CDFW	Opportunistic surveys / research

Indicator	Monitoring Metric / Parameter	Monitoring Data Program / Responsible Party	Frequency
Beach Management Practices	Volume of dredge and fill for beach replenishment / nourishment	Army Corps data for locations of dredging and nourishment areas	Every few years or as needed
	Beach grooming activities	LACDBH activity logs and efforts (equipment used, weight and disposal of materials collected), varies by beach	Data collected daily; provided as requested from LACDBH
	Seasonal winter berm construction	See LACDBH winter berm report for details on locations	Annually between October and March
	Grunion protection zones / high tide line wrack protection	Pepperdine and LACDBH data	Annually between March and August
	Vegetation protection areas	Dorsey CRI beach characterization study results and mapping data	Opportunistic surveys / research
	Snowy plover protection zones (fencing, enclosures, signage)	Audubon Society (several chapters)	As occurring
	Fire safety, rings, and illegal bonfires	State Parks and LACDBH	Unknown
Beach Water Quality	Long-term FIB trends	Heal the Bay Beach Report Card data; outfall monitoring data by County and City	Daily
	Nutrient inputs and limitations	SCCOOS Santa Monica Pier Shore Station	Daily, calibrated monthly
	Temperature	SCCOOS Santa Monica Pier Shore Station	Daily, calibrated monthly

Table 6.4. Climate Vulnerability Metrics and Monitoring Program Details.

Indicator	Monitoring Metric / Parameter	Monitoring Data Program / Responsible Party	Frequency
Shoreline Erosion / Topography Change	Beach width change; volume accretion / erosion	USGS models; Holland study - SLR/erosion	Opportunistic surveys / research
		aerial imagery; remote sensing data / NASA public data sets; LiDAR data over time	Opportunistic surveys / research
		Data on beach zone distribution, slopes, and widths collected by UCSB at Leo Carrillo State Beach and Point Dume for MPA monitoring	Three times per summer
		Data collected by TBF / CRI associated with living shoreline projects and beach characterization studies	Semi-annually at Santa Monica, Zuma, Point Dume, Manhattan, and Dockweiler Beaches; opportunistic surveys at other beaches
	New dune formations	Data collected by TBF / CRI associated with living shoreline projects and beach characterization studies	Semi-annually at Santa Monica, Zuma, Point Dume, Manhattan, and Dockweiler Beaches; opportunistic surveys at other beaches
	Outflow or runoff change / storminess	Possible LACDPW data	Unknown
	Slope and berm morphology (nearshore processes and beach face)	No current programs	No current programs
	Wave height and period	NOAA buoy data	Hourly

Indicator	Monitoring Metric / Parameter	Monitoring Data Program / Responsible Party	Frequency
Nearshore Surface Water Temperature	Surface water temperature	SCCOOS SM Pier data; National Weather Service offshore station data	Daily; calibrated monthly
	Larval abundance	No current programs	No current programs
Coastal Flooding	Sea level rise vulnerability	Apply CoSMoS/OCOF tool to model ecosystem responses (see Myers et al. 2017); apply CRI Site Suitability Model analyses	Opportunistic surveys / research
	Frequency and location of flooding events	CoSMoS/OCOF tool for southern California, CRI Site Suitability Model study; king tide citizen science surveys by USC Sea Grant	Opportunistic surveys / research
	Infrastructure vulnerability	Apply CRI Site Suitability Model analyses; king tide citizen science surveys by USC Sea Grant; Vulnerability studies conducted by LACDBH (2016), City of LA, City of Manhattan Beach, USC Sea Grant (2017) and other coastal municipalities	Opportunistic surveys / research
Hazard / Disturbance Response	Intensity of disturbances, e.g., aftermath of major storm events; modeling El Niño events and responses	Before / after LiDAR data and scans; side-scan sonar	Infrequent – every few years
		Opportunistic modeling research	Opportunistic surveys / research

Data Sharing and Reporting

Sandy shore monitoring data will be compiled and analyzed approximately every five years associated with production of the SMBNEP SotB Report and led by the NEP's Technical Advisory Committee. The SotB Report will be made publicly available via website. Data will be consolidated and used to develop the SotB condition and trend graphics and will be represented visually as appropriate. Detailed information on data quality control, quality assurance, database management, and analysis will be available in the next update of SMBNEP's Quality Assurance Program Plan, scheduled for review in 2021. Data will be stored on TBF's servers with summaries available to the public upon request. When possible, data will be incorporated into public databases like the grunion monitoring portal (www.grunion.org) or other similar public data sharing portals. The non-profit Beach Ecology Coalition shares information with beach managers, resource agencies, lifeguards, and others at its semi-annual meetings.

Data Gaps and Future Studies

Former data gaps identified for sandy shore habitats by the 2015 SotB Report were extensive for sandy shores, including the indicator and metrics associated with the habitat extent category. However, significant progress has been made in recent years on the characterization of sandy shore habitats in the Santa Monica Bay led by Dr. John Dorsey, LMU and CRI, and by TBF. These new data will be reflected in SMBNEP's next SotB Report. Additional data gaps identified in the 2015 SotB Report include all or portions of the following indicators: beachfront protection, areas of development, armoring trends, sediment supply, beach management practices, nutrient inputs, invasive species, and trend data for native flora and fauna. Though some of these indicators have been evaluated and updated for this revised CMP, many of them continue to be reflected in Tables 6.2-6.4 as important condition metrics with data gaps.

Additionally, several indicators have some data (e.g., invertebrates, temperature) in specific locations, but not enough for broad scale trends throughout the Bay. There are other indicators such as "coastal flooding" that have partial data for a particular element such as tidal flooding, but a full data gap in the form of storm flooding on back beach areas or around infrastructure. "Best management practices" has similar gaps. There are also several indicators that need development and are without current monitoring programs, e.g., slope and berm morphology and larval abundance.

Several new metrics associated with the new "climate change vulnerability" category are also identified in the tables above as data gaps (e.g., marine larval studies associated with surface water temperature, comprehensive assessments of sediment change or movement, and many others such as nearshore bathymetry studies or detailed information on human impacts). Table 6.5 summarizes priority data gaps identified for the sandy shores habitat; types of data gaps; potential sources of funding at the federal, state,

and local levels for filling these data gaps; and cross-references to relevant actions and potential funding sources identified in the 2019 CCMP Finance Plan (also provided in Table 9.5 of Chapter 9).

Next steps for this habitat type include continuing to prioritize and fill data gaps listed above and in Tables 6.2-6.5, especially the categories that are "no current programs" or "unknowns" and require more information, as well as additional new studies that could further support the evaluation of the key indices for this habitat. Note that Tables 6.2-6.4 may look complete in areas, but still may have spatial or metric data gaps. New studies that are recommended include building on observational data for extreme tide events, adding monitoring stations or targeted research for many of the indicators above (e.g., surfzone fishes), higher resolution / better geospatial coverage for invertebrate taxa data, more detailed spatial / frequency information on beach best management practices, and incorporation of new modeling efforts. Innovative ideas such as 3D mapping to detect shoreline change or dune formation, or single-beam or side-scan sonar in the nearshore environment to track seasonal shifts in sediment movement or sediment loss should also be explored. Lastly, developing indices and a rapid assessment framework for sandy shore surveys that could be applicable across the Southern California Bight or even standardized at the state level would allow for additional cross-comparisons of data and consistent analyses.

Additional future studies could contribute to a potential future revision of the indicator list, including indicators that were identified by the expert workgroup, but not included in this document. Examples of these new indicators could include marine mammal pupping or strandings, wrack cover and diversity, sediment grain size, microplastics, and other constituents of concern.

Table 6.5. Sandy Shores Habitat – Summary of Data Gaps and Potential Funding Sources.

Indicator Category	Sandy Shores Habitat Data Gaps	Data Gap Type	Potential Funding Source(s)
Habitat Extent	Additional information on beach width, extent, and seasonal variation	Special study (supplement existing data)	USEPA, CRI, Sea Grant, Universities, NASA/JPL
Ecological Condition	Additional monitoring locations for surfzone fishes, and other native fauna	Index component; Single metric	OPC-MPA, UCSB, others
	Higher resolution / better geospatial coverage for invertebrate taxa data	Index component	OPC-MPA, UCSB, others
	Long-term trend data for Invasive flora	Single metric	OPC-MPA, UCSB, others
	Indices and rapid assessment framework for sandy shore surveys	Index development	Prop. 50, others
Stressor	Long-term tracking of percentage change of anthropogenic Infrastructure / Beach Hardening (beachfront protection, development, and armoring, etc.)	Index component	LACDBH, USGS, NOAA, others
	Detailed and expanded information on human impacts	Single metric; Special study (existing data, new data acquisition)	Unknown
	More detailed spatial / frequency information on beach management practices	Index component	LACDBH, others
	Data on nutrient inputs and limitations	Single metric	Unknown

Indicator Category	Sandy Shores Habitat Data Gaps	Data Gap Type	Potential Funding Source(s)
Climate Vulnerability	New modeling efforts and innovative mapping to detect and assess shoreline change or dune formation, track seasonal shifts in sediment movement or sediment loss	Special study (new data acquisition, new methods/tools development)	Sea Grant, OPC, SCC, others (2019 CCMP Finance Plan Action #36)
	Slope and berm morphology	Special study (new data acquisition)	Unknown
	Larval abundance studies associated with surface water temperature	Special study (new data acquisition)	Unknown

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