

SALTON SEA MONITORING IMPLEMENTATION PLAN

Administrative Draft - February 2022

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SALTON SEA MONITORING IMPLEMENTATION PLAN

Prepared for

California Natural Resources Agency, California Department of Water Resources & California Department of Fish and Wildlife February 2022

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ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Definition
AQMIS	Air Quality Management Information System
BC3	Business Council on Climate Change
BEA	U.S. Bureau of Economic Analysis
BIOS	Biogeographic Information and Observation System
BLS	Bureau of Labor Statistics
CalEPA	California Environmental Protection Agency
CARB	California Air Resources Control Board
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CDPH	California Department of Public Health
CNDDB	California Natural Diversity Database
CNRA	California Natural Resources Agency
CPUC	California Public Utilities Commission
CPUE	catch-per-unit-effort
CVWD	Coachella Valley Water District
CWT	Clean Water Team
DO	dissolved oxygen
DWR	California Department of Water Resources
ESA	Environmental Science Associates
FGDC	Federal Geographic Data Committee
FRM	Federal Reference Method
GDP	gross domestic product
H ₂ S	Hydrogen sulfide
ICAPCD	Imperial County Air Pollution Control District
IID	Imperial Irrigation District
MAP	Monitoring and Assessment Plan
MIP	Monitoring Implementation Plan
NAAQS	National Ambient Air Quality Standards
NAVD 88	North American Vertical Datum of 1988
NDVI	Normalized Difference Vegetation Index
NGVD 29	National Geodetic Vertical Datum of 1929
NH ₃	ammonia
NLCD	National Land Cover Database

Acronym/Abbreviation	Definition
NO _x	Nitrogen oxides
NWIS	National Water Information System
OBIA	object-based image analysis
OEHHA	Office of Environmental Health Hazard Assessment
PCB	polychlorinated biphenyls
PM10	1987 24-hour Particulate Matter
PM10	particulate matter 10 micrometers and smaller in aerodynamic diameter
QA	Quality assurance
QAPP	Quality Assurance Project Plan
RWQCB	River Regional Water Quality Control Board
SCAG	Southern California Association of Governments
SCAQMD	South Coast Air Quality Management District
SCH	Species Conservation Habitat
Sea	Salton Sea
SLEV	St. Louis Encephalitis Virus
SOP	standard operating procedures
SSAQMN	Salton Sea Air Quality Monitoring Network
SSAQMP	Salton Sea Air Quality Mitigation Program
SSMP	Salton Sea Management Program
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TDS	Total Dissolved Solids
TEOM	Tapered Element Oscillating Microbalance
USBR	U.S. Bureau of Reclamation
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Service

CHAPTER 1 Introduction

1.1 Background

The Salton Sea is California's largest lake. The Salton Sea provides essential habitat for wildlife and migratory birds on the Pacific Flyway and serves as an important cultural and recreational resource (USGS 2013). It has no outlet, and dissolved salts contained in the inflows are concentrated through evaporation. The Salton Sea is currently twice as salty as the ocean. Reductions in inflows due to water transfers, reduced precipitation, water conservation and recycling have continued to lower the level of the Salton Sea, expose lakebed as the shoreline recedes, and accelerate the rate of salinity increases. This has reduced the suitability of fish and wildlife habitat and affected air quality by exposing lakebed ("playa") that generates dust (USGS 2013).

State and federal agencies, water districts, and local communities are planning and implementing projects to reduce the amount of exposed playa, suppress dust emissions from exposed playa, and create habitat (CNRA et al. 2021). One of these restoration efforts is the State's Salton Sea Management Program (SSMP), which is currently pursuing habitat restoration and dust control projects around the perimeter of the Salton Sea as part of its 10-Year Plan Phase I (CNRA et al. 2018a). The SSMP also seeks to establish a long-term pathway for the Salton Sea with consideration of further habitat restoration, dust suppression, and increased inflow. Broader efforts are underway to strengthen partnerships with local leaders and communities to deliver projects and institutionalize inclusive community engagement (CNRA et al. 2021).

Monitoring of the Salton Sea ecosystem is critical for informed decision-making and the success of mitigation and restoration actions (USGS 2013). Information derived from monitoring activities will be used to guide the initial designs and management. Monitoring will also help ensure success by identifying actions that are not having the desired effect so that they can be adjusted.

The Salton Sea Ecosystem Monitoring and Assessment Plan (MAP) proposed a broad framework for data collection, analysis, management, and reporting to inform management actions for the Salton Sea ecosystem (USGS 2013). Proposed monitoring activities were directed at the regional status and trends of natural resources, species, and habitats that could be affected by or drive future restoration efforts. All monitoring activities are intended to help answer key questions anticipated to be asked by managers responsible for restoration of the Salton Sea ecosystem (USGS 2013).

1.2 Purpose and Goals

The *Salton Sea Monitoring Implementation Plan* (MIP) is built from the 2013 MAP to identify, prioritize, and describe monitoring activities to track status and trends of resources at the Salton Sea, which can be used to inform the implementation of restoration programs. The MIP addresses monitoring for several resource areas including hydrology, water quality, geography, air quality, biological resources and socioeconomics.

The MIP has the following goals:

- 1. Identify and prioritize monitoring activities that will measure current and future conditions within the Salton Sea ecosystem.
- 2. Establish milestones against which data gathered during long-term monitoring can be compared.
- 3. Establish methods for measuring and reporting these metrics.
- 4. Identify and prioritize filling of existing data gaps.
- 5. Describe a framework to store, manage, and make monitoring data publicly available in a timely manner.

The data collected will form a basis to evaluate the overall, long-term effectiveness of projects through an adaptive management approach. It is envisioned that individual projects would develop effectiveness monitoring plans that tier off the MIP, tailored to that project's specific objectives. This would provide consistent methodology, facilitate comparison to regional trends, and allow roll-up of results across multiple projects. Where possible, monitoring activities would be coordinated among partners to increase data sharing and realize efficiencies of scale. The MIP does not serve to monitor implementation (building to design specifications) or compliance (meeting permit requirements) of individual projects.

The Salton Sea is a dynamic and changing ecosystem. Therefore, the MIP will be a living document and will remain flexible to respond to unanticipated events and evolving management needs (USGS 2013). The State plans to institute a new Salton Sea Science Program to manage data and coordinate monitoring and research. The MIP will be subject to periodic reviews and will be revised as needed. Types of metrics or sampling frequency and intensity may be adjusted as information gaps are filled, uncertainties resolved, or new questions emerge. Further, the initial protocols could change as new and improved techniques and assessment methods are identified.

1.3 Study Area

The study area spans the Salton Sea ecosystem, which is defined in Section 2931 of the Fish and Game Code as including, but not limited to, "the Salton Sea, the agricultural lands surrounding that sea, and the tributaries and drains within the Imperial and Coachella Valleys that deliver water to the Salton Sea" (**Figure 1-1, Regional Location**). The spatial extent and location of monitoring is further focused depending on the processes influencing each resource or factor of interest. For example, the watershed boundary defines the area of hydrologic monitoring, whereas air quality monitoring extends beyond the watershed boundary because the processes that govern wind erosion and deposition are not limited to the watershed boundary. The biological monitoring area will encompass habitats of the Salton Sea itself (open water and shoreline) (USGS 2013), as well as local habitats that may be affected by changes in sea elevation, such as adjacent wetlands, vegetation expanding on the playa and any ground-water dependent habitats. Biological monitoring will also include habitat for special status species that currently or historically occupied the Salton Sea and its shoreline and tributaries, such as desert pupfish and Yuma Ridgway's rail. Created habitats (freshwater, brackish, and saline impoundments) located adjacent to the Salton Sea will be included as they are constructed.

1.4 Plan Development Process

The MIP was developed by a team from the California Department of Water Resources (DWR), California Department of Fish and Wildlife (CDFW), California Natural Resources Agency (CNRA), and Environmental Science Associates. Development started with review of the MAP. Information from recent and ongoing monitoring and studies was also compiled and reviewed (**Appendix A**, *Inventory of Salton Sea Monitoring Efforts and Studies*). This inventory included planning documents, scientific studies, technical reports, and monitoring data pertaining to the Salton Sea collected by DWR, CDFW, CNRA, the Colorado River Regional Water Quality Control Board (RWQCB), California Air Resources Board (CARB), U.S. Bureau of Reclamation (USBR), U.S. Geological Service (USGS), Imperial Irrigation District (IID), Imperial County Air Pollution Control District (ICAPCD), Coachella Valley Water District (CVWD), South Coast Air Quality Management District (SCAQMD), Audubon California, and Southern California Association of Governments, and the 2019 Salton Sea Summit.

Early drafts received input from Working Groups consisting of key Salton Sea experts and stakeholders invited from DWR, CDFW, CNRA, the Colorado River Regional Water Quality Control Board (RWQCB), CARB, Desert Research Institute, ICAPCD, USBR, USFWS, IID, Coachella Valley Water District (CVWD), SCAQMD, Salton Sea Authority, Audubon California, Pacific Institute, Comite Civico del Valle, Alianza Coachella Valley, Environmental Science Associates and Tetra Tech. Working Group members provided feedback on identification and prioritization of key indicators; monitoring methods, frequency, duration, and locations; and information about existing monitoring efforts.

The next stage will involve independent scientific review by the Salton Sea Science Committee, as well as community outreach and public review of the draft MIP.



SOURCE: NAIP Imagery, 2020, CDFW, 2020; DWR, 2021.

ESA

Salton Sea Management Program Monitoring Implementation Plan

Figure 1-1 Regional Location



1.5 Document Organization

The MIP is organized into seven chapters:

- Chapter 1, *Introduction*, describes the MIP's goal, objectives, and organization, and the process of engaging stakeholders in its development.
- Chapter 2, *Salton Sea Setting and Monitoring Questions*, provides a conceptual model and review of affected resources of the Salton Sea ecosystem, and identifies key questions that drive the information needs and monitoring objectives.
- Chapter 3, *Indicator Selection and Sampling Design*, develops a set of priority indicators for monitoring.
- Chapter 4, *Monitoring Elements*, provides detailed monitoring methodologies.
- Chapter 5, Data Management, describes data management tools and reporting procedures.
- Chapter 6, *Data Assessment, Reporting and Adaptive Management*, summarizes the monitoring schema, discusses analysis and annual reports, refinement of the MIP and adaptive management.
- Chapter 7, *References*, provides references for information cited in this document.

The MIP has two supporting Appendices:

- Appendix A, Inventory of Salton Sea Monitoring Efforts and Studies
- Appendix B, Monitoring Indicators and Priority by Resource Category

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CHAPTER 2 Salton Sea Setting and Monitoring Questions

2.1 Conceptual Model and Indicators

This chapter reviews the current setting to provide the context for indicator identification and prioritization. A simplified conceptual model (Figure 2-1, Conceptual Model of Salton Sea Ecosystem – Hydrology, Water Quality, Biota, and Air Quality) of the Salton Sea ecosystem depicts linkages and functions among resources, which are discussed in more detail in Section 2.2, Salton Sea Setting. Monitoring should track three types of attributes: controlling factors or drivers (e.g., river inflows), structural factors (e.g., playa exposure), and functional factors or ecological response (e.g., bird community structure) (Roegner et al. 2008).

Table 2-1 summarizes an initial set of indicators and metrics considered. Indicators aremeasurable attributes that help assess the condition of the environment and how it changes overtime. Metrics are more specific measurements that quantify results about an indicator. Thesubsequent sections summarize current conditions and understanding for each resource.

2.2 Salton Sea Setting

2.2.1 Hydrology & Water Quality

The Salton Sea is a closed-basin saline lake with no outflows. It is located in the Sonoran Desert in the Salton Basin, approximately 278 feet below sea level (CH2M Hill 2018). Over millennia the Salton Basin has experienced alternating inundation by the Colorado River and drying into a desert basin. The modern Salton Sea formed in 1905, when Colorado River flood waters breached a nearby canal, sending flows into the dry lakebed (USBR 2016).

The level of the Salton Sea has declined from its 1906 elevation due to high evaporation rates that exceed inflows. The average annual elevation was 225.7 feet NAVD 88 in 2000, -235.6 feet NAVD 88 in 2020 (USGS 2021a).¹ In July 2021, water elevation measured -238.5 feet NAVD 88 (USGS 2021a). The existing Salton Sea is approximately 35 miles long and 9 to 15 miles wide with about 360 square miles of water surface area and 120 miles of shoreline (CH2M Hill 2018).

¹ Elevation data are from U.S. Geologic Survey Station 10254005 SALTON SEA NR WESTMORLAND CA (https://waterdata.usgs.gov/ca/nwis/uv?site_no=10254005). Note the unit conversion from the National Geodetic Vertical Datum of 1929 (NGVD 29) data to the North American Vertical Datum of 1988 (NAVD 88) data by adding 2.13 ft (SSMP 2018). The former is used by the U.S. Geological Survey in reporting Salton Sea elevations, and the latter is used in most design documents. USGS data in NGVD 29 can be converted to NAVD 88 by adding 2.13 ft (CNRA et al. 2018b).

Resource Category	Potential Indicators	Potential Metrics
Hydrology and Water Quality	 Surface water hydrology Hydrodynamics Groundwater Water quality: Physicochemical Water quality: Contaminants Nutrients Land cover and use 	 Discharge/flow rates, lake elevation Sea currents, stratification, and mixing Groundwater levels, water quality Salinity, temperature, dissolved oxygen, pH Selenium, arsenic, boron, legacy and current use pesticides in water and sediments Nitrogen, phosphorus, potassium Area of each land cover and use type (especially playa
Coography	Sediment	and wetland habitat occurring at drain mouths)Soil type, crust, and moisture, source of particulates
Air Quality Biological Resources	 Meteorology Particulate matter Pollutants Birds Fish Plankton and invertebrates Special-status species 	 Air temperature, precipitation, wind speed and direction Dust sources, emissions (total emissions, per area emissions, annual emissions), PM10 & PM2.5, dust composition Contaminants from playa sediment, cyanotoxins Species composition, distribution and abundance, nesting colonies, roost sites, foraging Species composition, distribution and abundance, size classes Primary production (chlorophyll a), phytoplankton and algae, cyanobacteria, zooplankton, macroinvertebrates. Microbial (bacteria, archaea, micro-algae, micro-plankton) Threatened and endangered species (Desert pupfish, Yuma Ridgway's Rail, Southwestern Willow Flycatcher) and other special status wildlife species
Socio-economics	 Demographics Economy Public health Public perception 	 Census info (Population, ethnicity), Population centers Economic sectors, employment due to SSMP activities, agriculture, number of individuals trained in a specialized skill(s) for the implementation of SSMP projects, property value Air quality alerts, childhood asthma Participation in the SSMP Engagement Plan activities

TABLE 2-1 POTENTIAL INDICATORS AND METRICS CONSIDERED

The Salton Sea receives most of its inflow from the Alamo River (52 percent), New River (34 percent), and Whitewater River (5 percent) (CNRA et al. 2021). These flows are sustained mainly by seepage and return flow from irrigated agriculture (Amrhein et al. 2001) in the Imperial Valley, Coachella Valley and Mexico. The remaining inflows (9 percent) come from agricultural drains that flow directly to the Salton Sea, ephemeral flows from Salt Creek on the eastern shore and San Felipe Creek on the southwest shore, as well as direct precipitation and groundwater (LLNL 2008; CH2M Hill 2018). Groundwater historically accounts for only about 0.01 percent of annual inflow (CNRA 2006). Most seepage probably occurs along the east and west sides and north end of the Salton Sea adjacent to the Coachella Valley, where soils are more permeable (Amrhein et al. 2001).



SOURCE: ESA, 2022

Salton Sea Monitoring Implementation Plan

Figure 2-1

Conceptual Model of Salton Sea Ecosystem - Hydrology, Water Quality, Biota, and Air Quality

The Colorado River is the main water supply for irrigation, with some areas in Coachella Valley partially supported by groundwater. Inflows have decreased due to the Quantification Settlement Agreement, which transferred a large portion of IID's Colorado River allocation to the San Diego County Water Authority. To reduce the impact of the water transfer, IID temporarily provided 53,000 acre-feet of "mitigation water" annually from 2003 to 2017.

The Salton Sea's high salinity is due to historic salt accumulation, high evaporation rates and minimal inflows. Salinity² levels were 44,000 mg/L in 1999, 46,000 mg/L in 2004, and 50,000 mg/L in 2009. Recent reductions in inflows have accelerated the increase to 61,000 mg/L in 2017 and 74,000 mg/l in 2020 (USBR 2020). By comparison, river salinity was 1,230 mg/L in Whitewater, 1,860 mg/L in Alamo and 3,220 mg/L in New River in 2020.

Inflows also contribute nutrients (e.g., nitrogen from fertilizer) and contaminants associated with agricultural runoff. High nutrient levels contribute to high primary productivity by algae (e.g., eutrophication), which can lead to low dissolved oxygen conditions. The Salton Sea is stratified in spring and summer, but high wind events in late summer can cause upwelling and mixing of deeper anoxic high-sulfide water (Hurlbert et al. 2007).

Contaminants have been found in the water and sediment of the Salton Sea, rivers and drains including minerals and metals (e.g., selenium, arsenic, boron) as well as legacy pesticides (e.g., DDT) and recent-use pesticides (e.g., pyrethroids, organophosphate, and chlorpyrifos) (LLNL 2008; USGS 2010a; Schlenk et al. 2014). Selenium in Colorado River water is transported into the Salton Sea in irrigation tailwater (USGS 2010a). Contaminants, especially selenium, have to potential to build up and bioaccumulate through the food web (Schlenk et al. 2014).

Groundwater quality varies widely in the shallow system and commonly has high salinities (LLNL 2008). Groundwater at near the south shore of the Salton Sea measured approximately 14,000 mg/L dissolved solids in the late 1990s.

2.2.2 Geography

Geographic conditions refer to the landscape or surface characteristics of the study area that will be important in assessing opportunities for and outcomes of restoration. These characteristics include bathymetry, land-surface elevation (topography), and land use (USGS 2013). As the Salton Sea declines and shrinks, the playa is exposed, especially in the flatter alluvial areas of the south shore and north shore. Mapping of satellite imagery from the end of 2002 (prior to the start of the conserved water transfer) through 2020 estimated an increase of 25,589 acres of exposed playa, comprised of open playa (17,293 acres), small pools, drain water and sheet flow (660 acres), and playa vegetation (7,006 acres) (IID 2021). In 2020, 2,400 acres of lakebed were

² Salinity is a measure of the amount of salts in the water. Because dissolved ions increase salinity as well as conductivity, the two measures are related (CWT 2004). Salinity is often measured gravimetrically as total dissolved solids (TDS, mg/L) or parts per thousand (ppt) (Pacific Ocean approximately 35,000 mg/L). Electrical conductivity (EC, micromho or micro-Siemen per centimeter [μ S/cm]) is measured by a probe applying voltage between two electrodes to measure the resistance of water. Because electrical conductivity greatly depends on temperature, scientists use the term "specific conductivity" if the value has been corrected to reflect the measurement temperature (CWT 2004). Specific conductivity (μ S/cm at 25°C) has been recommended for Salton Sea is a more precise surrogate measure than TDS (Amrhein et al. 2001).

estimated to have been exposed (CNRA et al. 2021). Recession of the Salton Sea has also stranded harbors and docks and cut off most boat access to the open water.

Several biogeographic zones or strata were identified based on their influence on bird distribution (Patten et al. 2003) to facilitate stratification of sampling (USGS 2013). These areas are defined as follows.

Salton Sea Open Water

The open water stratum represents most of the Salton Sea's surface area. For purposes of monitoring, the MAP defined this stratum as the area more than 1 kilometer from the shoreline (USGS 2013).

Salton Sea Shoreline

The shoreline stratum includes an approximately 1-kilometer band around the outer margin of the Salton Sea. The Salton Sea shoreline is measured from the waterline to 25 meters landward of the waterline and 1 kilometer toward the center of the lake. The physical location and area of the shoreline stratum is expected to change as the elevation of the Salton Sea fluctuates seasonally and annually. This stratum includes beaches and nearshore habitat such as mudflats and shallow water (habitats generally up to 30 cm) (USGS 2013; Jones et al. 2016).

Wetlands and Riparian

Emergent wetland vegetation such as cattails and bulrush is found at the edges of ponds, lakes, and along rivers and ditches (Patten et al. 2003). Nonnative species (e.g., tamarisk and common reed) have become dominant along rivers and ditches. New wetland and riparian vegetation is emerging where irrigation drains, ephemeral washes and streams, and perennial streams discharge onto the recently exposed playa, such as near Bombay Beach (Audubon 2020). More extensive wetlands are present on lands managed for wildlife, described below as created freshwater impoundments.

Halophytic Scrub

Halophytic scrub includes areas supporting vegetation tolerant of alkaline soils such as iodine bush, tamarisk and arrowweed (Patten et al. 2003). This vegetation community is generally restricted to areas with sufficient soil moisture, typically from irrigation seepage, and occurs in a thin band around the Salton Sea shoreline, known as the shoreline strand. Existing halophytic plant communities are expanding onto the playa, most often on historic "beach ridges," and particularly along the southern shoreline and areas north of Alamo River (IID 2021).

Created Freshwater Impoundments

The created freshwater impoundment stratum includes created water bodies that are managed at salinity levels less than 20,000 mg/L. The created freshwater impoundment stratum encompasses both seasonal and permanent water bodies, including shallow open water habitat and vegetated

wetlands with both brackish and freshwater hydrology. Several created freshwater impoundments occur around the Salton Sea or are planned.

- Imperial Wildlife Area, located in the southeast and managed by CDFW, includes seasonally flooded ponds to support waterfowl and permanently flooded impoundments managed for rails. The Imperial Wildlife Area includes Finney and Ramer Lakes, freshwater ponds, and a treatment wetland system along the Alamo River, and the Wister Unit along the southeast shoreline near Niland.
- Sonny Bono Salton Sea National Wildlife Refuge (Refuge) includes freshwater marsh and brackish water ponds and is managed by USFWS for rails and other waterfowl. There is also a pond at the Refuge that will be managed for desert pupfish.
- **IID Managed Marsh complex**, located about 2 miles south of Niland, was constructed in phases between 2009 and 2019 to provide freshwater marsh, ponds, and riparian habitat (IID 2017). This project will be transferred to CDFW once completed.
- **Torres Martinez Wetlands Project** is planned on the Torres Martinez Desert Cahuilla Indian Tribe reservation land on the northwest shoreline in Mecca (IID 2017).
- Additional created freshwater impoundments will be incorporated into the SSMP monitoring program as they are constructed (e.g., 25 acres of pupfish habitat will be created at the north end of the Salton Sea as mitigation for drain maintenance in CVWD drains).

Created Saline Impoundments

The created saline-impoundment stratum will include created water bodies that are managed at salinity levels greater than 20,000 mg/L. DWR recently broke ground on the Salton Sea Species Conservation Habitat Project, which will cover exposed playa near the mouth of the New River and create saline impoundments to provide habitat and prey for piscivorous bird species (Cardno and ESA 2015). In addition, some areas within the ponds are expected to support desert pupfish and connectivity of drain habitat. Newly constructed saline impoundments will be incorporated into the SSMP monitoring program as they are constructed.

Direct Drains

The direct drain stratum includes drains and ponds in the study area with a direct connection to the Salton Sea, from the point of discharge upstream to the first pump or check structure. This portion of the drains are either currently directly connected to the Salton Sea or were until recently, and support aquatic species that move between these two water bodies, such as desert pupfish. CVWD manages approximately 25 drains on the north shore, and IID manages approximately 30 drains and a couple ponds on the south shore. Vegetation along agricultural drains mainly consists of common reed and tamarisk, with some small areas of cattails and bulrushes.

Agricultural Land

Agricultural lands include actively managed agricultural areas within the study area that support irrigated crops, as well as areas that are temporarily or permanently fallowed. Agricultural lands typically provide one or more habitat functions for wildlife species, including foraging and roosting habitat for birds. Extent of use by wildlife is generally influenced by crop type,

agricultural practices, and proximity to other features such as the Salton Sea (USGS 2013). There are also a few fish farms in the lower East Coachella Valley.

2.2.3 Air Quality

The exposed playa contains areas with highly emissive surfaces that are a potential source of dust emissions during wind events. Suspended dust from the playa has the potential to increase airborne particulate matter, thereby reducing air quality in the Imperial and Coachella Valleys.

The major source of Imperial County's airborne particulate matter is fugitive windblown dust, with other contributions resulting from entrained road dust, farming, construction activities, off-road vehicles, and managed burning. Between 2017 and 2018, estimates of the median particulate matter 10 micrometers and smaller in aerodynamic diameter (PM10) emissions were 1.23 tons per day for exposed playa and 124 tons per day for the adjacent, more expansive desert (IID 2020).³ Elevated PM10 events have been directly attributed to high-wind-driven dust storms in which precursor emissions played an insignificant role (ICAPCD 2018; CARB 2018; SCAQMD 2002, 2016). Periods of high winds occur most frequently during April and May (CNRA 2020). Windspeeds are typically higher on central and southern shores compared to northern shore.

Exposure to elevated outdoor levels of PM10 and particulate matter 2.5 micrometers and smaller (PM2.5) is associated with lung- and heart-related respiratory illness, including asthma (Johnston et al. 2019; Farzan et al. 2019). Metals and pesticides in the Salton Sea sediments may be suspended in dust and could increase particulate matter toxicity (Parajuli and Zender 2018). Populations most likely to experience adverse health effects with exposure to PM10 and PM2.5 include older adults with chronic heart or lung disease, children, and asthmatics (CARB 2021a).

Sites for dust suppression projects were identified by IID's Salton Sea Air Quality Mitigation Program (SSAQMP) (IID 2016) and SSMP's Dust Suppression Action Plan (CNRA et al. 2020) based on information about air and water quality, soil properties, wind, and sand-related dust emissions. Areas along the western shoreline have the highest emissions potential, primarily attributed to the presence of surface sand caused by the migration of sand from the western desert (IID 2021). Additional sites close to residential populations (North Shore, Bombay Beach) were identified to benefit communities. Other factors related to implementation feasibility were also considered (i.e., permitting, access authorization, water supply for certain suppression methods) (CNRA et al. 2020).

2.2.4 Biological Resources

Special-Status Fish and Wildlife Species

Special-status fish and wildlife species are compiled in **Table 2-2**. The Salton Sea area is home to three species protected under the federal and California Endangered Species Acts. The desert pupfish occupies small tributaries, drains, and pools that form along the Salton Sea shoreline. The

³ These emissions estimates are not approved by Imperial County Air Pollution Control District (ICAPCD), California Air Resources Board (CARB), or the U.S. Environmental Protection Agency (USEPA) as emission inventories for the Salton Sea playa or Salton Sea Air Basin. Rather, the estimates are intended to prioritize dust source areas for mitigation and are not intended to be the actual inventory numbers for regulatory purposes.

Yuma Ridgway's rail occupies herbaceous freshwater wetlands and managed marshes, such as the Imperial Wildlife Area and Wister Unit. The southwestern willow flycatcher is found in riparian areas, not necessarily close to the shoreline but could eventually occupy riparian scrub and forest that becomes established on the playa over time.

Class	Scientific Name	Common Name	Federal	State
Fish	Cyprinodon macularis	Desert pupfish	FE	SE
Birds	Pelecanus erythrorhynchos	American white pelican	None	SSC
	Pelecanus occidentalis	California brown pelican	Delisted	Delisted, SFP
	Phalacrocorax auritus	Double-crested cormorant	None	WL
	Chlidonias niger	Black tern	None	SSC
	Gelochelidon nilotica	Gull-billed tern	None	SSC
	Rynchops niger	Black skimmer	None	SSC
	Charadrius alexandrinus nivosus	Western snowy plover (Inland)	BCC	SSC
	Charadrius montanus	Mountain plover	None	SSC
	Plegadis chihi	White-faced ibis	None	WL
	Rallus obsoletus yumanensis	Yuma Ridgway's rail	FE	ST, SFP
	Laterallus jamaicensis coturniculus	California black rail	None	ST, SFP
	Ixobrychus exilis	Least bittern	None	SSC
	Aythya Americana	Redhead	None	SSC
	Mycteria americana	Wood stork	None	SSC
	Branta bernicla	Brant	None	SSC
	Dendrocygna bicolor	Fulvous whistling duck	None	SSC
	Elanus leucurus	White-tailed kite	None	FP
	Pandion haliaetus	Osprey	None	WL
	Grus canadensis canadensis	Lesser sandhill crane	None	SSC
	Grus canadensis tabida	Greater sandhill crane	None	FP
	Leucophaeus atricilla	Laughing gull	None	WL
	Larus californicus	California gull	None	WL
	Athene cunicularia	Western burrowing owl	None	SSC
	Empidonax traillii extimus	Southwestern willow flycatcher	FE	SE
	Numerius americanus	Long-billed curlew	None	WL
	Aechmophorus occidentalis	Western grebe	BCC	None
	Aechmophorus clarkii	Clark's grebe	BCC	None
	Calypte costae	Costa's hummingbird	BCC	None
	Recurvirostra americana	American avocet	BCC	None
	Limosa fedoa	Marbled godwit	BCC	None
	Tringa semipalmata	Willet	BCC	None
	Larus livens	Yellow-footed gull	BCC	None

 TABLE 2-2

 SPECIAL-STATUS SPECIES AT THE SALTON SEA

Class	Scientific Name	Common Name	Federal	State
	Asio otus	Long-eared owl	BCC	SSC
	Melanerpes uropygialis	Gila woodpecker	BCC	SE
	Gymnorhinus cyanocephalus	Pinyon jay	BCC	None
	Auriparus flaviceps acaciarum	Verdin (southwest)	BCC	None
	Toxostoma curvirostre palmeri	Curve-billed thrasher (Palmer's)	BCC	None
	Toxostoma bendirei	Bendire's thrasher	BCC	SSC
	Toxostoma lecontei	LeConte's thrasher	BCC	SSC
	Spinus lawrencei	Lawrence's goldfinch	BCC	None
	Agelaius tricolor	Tricolored blackbird	BCC	ST, SSC
	Cardinalis sinuatus	Pyrrhuloxia	BCC	None
Reptiles	Phrynosoma mcallii	Flat-tailed horned lizard	None	SSC
	Uma notata	Colorado Desert fringe-toed lizard	None	SSC

NOTES

FE: Federally Endangered
FT: Federally Threatened
BCC: Bird of Conservation Concern
SE: State Endangered
ST: State Threatened
SFP: State Fully Protected
SSC: State Species of Special Concern
WL: State Watch List
SOURCE: Shuford et al. 2000; CDFW 2020a

Many other special-status bird species have been documented in the Salton Sea area. Of particular note are those birds that utilize the Salton Sea open water (e.g., pelicans, cormorant, terns, grebes), shoreline (e.g., shorebirds), and impoundments (e.g., rails, ducks).

Special-status reptiles include the flat-tailed horned lizard and the Colorado Desert fringe-toed lizard, which require fine windblown sand and are found in dune areas near San Felipe Creek and on the test base.

Birds

The Salton Sea is an important stopover and wintering area on the Pacific Flyway (Shuford et al. 2000; Audubon 2019). The Salton Sea and surrounding area historically provided significant breeding and wintering habitat for numerous special-status bird species, such as the Yuma Ridgway's rail, western snowy plover, black skimmer, gull-billed tern, American white pelican, and California brown pelican (Shuford et al. 2000). However, many of these species' populations are declining due to changes in habitat quality, resource availability and degradation of breeding habitats (Audubon 2019). In recent years, a double-crested cormorant breeding colony on Mullet Island was abandoned after a land bridge developed due to surface water decline, allowing terrestrial predators access to the island (Audubon 2019).

Populations of American white pelican, double-crested cormorant, and eared grebe have experienced marked declines at the Salton Sea, which are attributed in large part to increased salinity (Audubon 2019). Declining fish populations have resulted in declines in the piscivorous bird population at the Salton Sea, such as the double-crested cormorant, American white pelican, and California brown pelican. In 2017, annual monitoring conducted by CDFW and the USFWS showed low numbers of both tilapia and piscivorous birds, though still within the low range of historic estimates of both species documented by CDFW from 2003 to 2008 (CDFW and USFWS 2017). However, present-day salinity levels in the Salton Sea are now above optimum levels for fish and are thus anticipated to further reduce the viability of fish populations and their ability to support piscivorous birds into the future (Audubon 2019).

Eared grebe numbers subsequently declined following the loss of their main prey pileworms (Jehl and McKernan 2002; Anderson et al. 2007). This has possibly caused a decline in the Sea's capacity to support eared grebes (Hurlbert et al. 2007). Eared grebes have been observed recently foraging on water boatmen (R. McKernan pers. comm., 2021).

Disease outbreaks (e.g., avian cholera, avian botulism, salmonellosis, and Newcastle disease) once caused massive avian mortality events at the Salton Sea two decades ago (Barnum et al. 2002). The frequency and magnitude of outbreaks have generally decreased (Anderson 2019; Audubon 2019). Outbreaks could potentially increase should birds concentrate in specific areas such as around freshwater inflows (Audubon 2019).

Aquatic Biota

Planktonic and macroinvertebrate organisms form the foundation of the aquatic biological community. The aquatic food web is productive but not diverse. Key components include phytoplankton, zooplankton, water column macroinvertebrates (e.g., larvae of pileworms and barnacles, water boatmen [corixids]), and benthic macroinvertebrates (e.g., pileworm adults, barnacles, and larvae of brine fly).

Introduced species dominate the fish community in the Salton Sea and drainages. At one time, the Salton Sea supported marine fishes such as orangemouth corvina, Gulf croaker, and sargo (Hurlbert et al. 2007; USBR 2016). Tilapia, an omnivorous fish introduced in the late 1960s then became dominant. Populations fluctuated widely from the 1980s to early 2000s (Hurlbert et al. 2007; Caskey et al. 2007) and have declined greatly in recent years as salinity levels exceed 60,000 mg/L (CDFW and USFWS 2017). The endangered desert pupfish inhabits small tributaries and irrigation drains, as well as shoreline pools at the end of the tributaries and agricultural drains (Saiki et al. 2010).

Physiological stressors to aquatic life include high salinity, anoxia, high sulfide levels, and water temperature fluctuations (Hurlbert et al. 2007; Caskey et al. 2007). Seasonal upwelling has periodically caused tremendous mortality to plankton, benthic invertebrates, and fish (Hurlbert et al. 2007; Swan et al. 2010). The pileworm population has crashed presumably due to increased salinity, sulfide, and anoxia. In addition, omnivorous tilapia feeding on phytoplankton (Anderson et al. 2007) and pileworm larvae (Tiffany et al. 2007) may have contributed to the

decline. Recent macroinvertebrate surveys have failed to detect pileworms (A. Jones, Audubon, pers. comm. 2021).

Changes in the aquatic community have greatly affected the birds that use the Salton Sea. Declining fish populations impacted fish-eating birds such as pelicans and cormorants. The shorebird community will likely shift diet and/or bird species composition as the invertebrate community shifts toward more saline-tolerant species such as corixids and brine flies, and eventually brine shrimp (Wurtsbaugh et al. 2017).

2.2.5 Socioeconomic Context

Overview

This socioeconomic context is provided as background for a broad understanding of the social, economic, and demographic setting of the Salton Sea and its surrounding communities. It covers topics that are not intended to be monitored over time under this plan because any changes in these metrics cannot positively be attributed to the SSMP projects: many unrelated variables contribute to the social, economic, and demographic makeup of the region. However, this context is relevant to the overall understanding of indicators and metrics that are proposed for monitoring relative to the SSMP projects. As explained where they are presented in Chapter 4, that narrower suite of indicators focuses on things that are most directly tied to actions that managers can take in response to the information gathered. Socioeconomic activity in the region includes agriculture, geothermal energy production, recreation, tourism, and real estate. A variety of communities rely on or are affected by the Sea. There are also a variety of stakeholders who live outside the immediate basin who derive benefits from the Sea, such as groups associated with bird watching in the Pacific Flyway. In addition, given the high price of housing in Southern California, residential communities around the Salton Sea have become an important option for affordable housing.

Social, demographic, and economic conditions have changed as the Sea's elevation and water quality have declined. The Salton Sea was once a popular destination for boating and fishing. But recreational use of the lake plummeted due to the drop in water levels, which has cut off boat access from docks and marinas, and the rising salinity. Today, fishery resources are severely depressed and health advisories discourage consumption due to selenium (OEHHA 2009). Recreation is largely limited to shoreline activities, such as bird watching and off-highway vehicle activity around the exposed shoreline of the Sea, especially near towns of Salton City and Bombay Beach. Poor air quality due to airborne particulate matter and periodic dust storms contributes to public health risk.

Population Demographics

The Salton Sea basin spans both Riverside and Imperial Counties and includes the cities of Brawley, Calipatria, and Westmorland, as well as the unincorporated communities of Niland, North Shore, Valerie, Oasis, Mecca, Desert Shores, and Salton City, as shown on Figure 1-1. **Table 2-3** shows the population demographics of cities within the Salton Sea basin with populations greater than 5,000 individuals, as well as at the County and State level. A majority of the populations within Calipatria and Brawley are of Hispanic or Latinx descent and speak a language other than English at home, which is reflective of the demographics within Imperial County as a whole. Income and educational levels within these communities are also lower than the state average, with a poverty level between 31.8 and 32.3 percent, which is more than double the state average (13.7 percent). Furthermore, within Calipatria and Brawley only 62.6 to 73.6 percent of households, respectively, have access to internet (U.S. Census Bureau 2020). Census tracts within Calipatria, Brawley, Niland, North Shore, and Mecca have been further identified by the California Environmental Protection Agency as disadvantaged communities, which refers to areas that suffer a combination of economic, health, and environmental burdens, including poverty, high unemployment, air and water pollution, presence of hazardous wastes, and high incidence of asthma and heart disease (CPUC 2020).

Census Data	Calipatria	Brawley	Imperial County	Riverside County	State of California
Population					
Estimated Population, 2010	7,705	24,953	174,528	2,189,641	37,253,956
Race					
American Indian and Alaska Native ¹	1.0%	0.6%	2.5%	1.9%	1.6%
Asian ¹	0.9%	0.9%	2.1%	7.1%	15.3%
Black or African American ¹	15.9%	1.8%	3.4%	7.2%	6.5%
Native Hawaiian and other Pacific Islander ¹	0.7%	0.5%	0.2%	0.4%	0.5%
White	34.6%	79.1%	90.1%	79.7%	72.1%
Persons reporting two or more races	3.8%	6.4%	1.7%	3.6%	3.9%
Ethnic Origin					
Hispanic or Latinx ²	75.6%	82.8%	84.6%	49.6%	39.3%
Education					
High school graduate or higher (persons age 25+ years), 2014–2018	58.5%	70.3%	69.0%	81.7%	82.9%
Bachelor's degree or higher (persons age 25+ years), 2014–2018	2.2%	13.5%	14.5%	21.8%	33.3%
Income and Poverty					
Median household income, 2014-2018	\$35,842	\$42,687	\$45,834	\$63,948	\$71,228
Percentage of people with family incomes below poverty	32.3%	31.8%	21.4%	12.7%	13.7%

TABLE 2-3 POPULATION DEMOGRAPHICS WITHIN THE SALTON SEA BASIN RELATIVE TO COUNTY AND STATE DEMOGRAPHICS

NOTES:

¹ Includes persons reporting only one race.

² Per the U.S. Census Bureau (2020), Hispanic or Latinx is an ethnicity rather than a race. Individuals responding to this question are also included in the race categories above.

SOURCE: U.S. Census Bureau 2020

In addition, the Torres Martinez Reservation consists of a patchwork of land areas on the northwest side of the Salton Sea that cover parts of the communities of Salton Sea Beach, Desert Shores, Oasis, Valerie, and Martinez. The Torres Martinez Desert Cahuilla Indians tribal headquarters is located in Thermal. As of the 2020 Decennial Census, the total population in the geographic areas of the Reservation is 3,454 people; however, among these, fewer than 400 identified as American Indian and Alaska Native, and nearly 1,900 identified as "Some Other Race Alone" (U.S. Census Bureau 2020). The population associated with the Torres Martinez Desert Cahuilla Indians lives within and outside of the Reservation lands, throughout the communities around the Salton Sea that are described in this section.

Economy

Gross domestic product (GDP) in Imperial County was \$8.0 billion in 2018, ranking 30th in the state's economy out of 58 counties (BEA 2019). Agriculture and its related industries drive the economy within the Imperial Valley. In 2018, a total of 537,192 acres of land were actively harvested, with total farm commodities valuing approximately \$2.3 billion (County of Imperial 2019). Agricultural production in Imperial County includes production of livestock, field crops, vegetables and melons, fruit and nut crops, seed and nursery crops, and apiary products. Vegetables and melons had the highest production value in 2018 accounting for \$984.5 million, with field crops also accounting for an additional \$507.8 million (County of Imperial 2019). The other crops with the highest production value for 2018 included alfalfa (\$218.5 million), leaf lettuce (\$122.6 million), head lettuce (\$115.2 million), broccoli (\$101 million), onions (\$98.6 million), and bermuda grass (\$95.5 million) (County of Imperial 2019). The production of livestock in the Imperial Valley also accounted for \$532.1 million in 2018, primarily consisting of cattle (County of Imperial 2019).

In Imperial County, the agricultural industry provides the greatest number of jobs, contributing 17.9 percent of all employment (SCAG 2019a). The agricultural industry is also known to contribute to other economic sectors that provide employment in Imperial County, including retail/sales (13.8 percent) and transportation (6 percent) (SCAG 2019a). Government agencies also contribute high levels of employment in Imperial County, with a combined 33.2 percent of jobs in the public and education sectors (SCAG 2019a). Jobs in these sectors are associated with school and utility districts, prisons and detention facilities, and border security agencies operating in Imperial County. Unemployment rates totaled 18.1 percent in Imperial County, higher than the statewide average of 4.4 percent (BLS 2020).

The GDP in Riverside County greatly exceeds that of Imperial County, with a total of \$79.775 billion in 2018, ranking of 10th overall in the state (BEA 2019). As a whole, Riverside County provides more diversified employment types in both the private and public sectors, and lower unemployment levels than Imperial County. In 2017, education was the largest job sector, contributing 23.4 percent of all jobs in Riverside County (SCAG 2019b). Other major job sectors included retail (13.9 percent), hospitality/leisure (12.9 percent), professional (9.8 percent), construction (8.0 percent), manufacturing (6.5 percent), and transportation (6.0 percent) (SCAG 2019b). In 2018, unemployment rates in Riverside County were 4.4 percent, which is generally reflective of the state average (BLS 2020). However, these metrics relate to Riverside County as a whole, and may not be reflective of the communities in the lower Coachella Valley near the

Salton Sea. Similar to the Imperial Valley, agriculture represents a large portion of the economy in the Coachella Valley. In 2018, crop production in the Coachella Valley occurred on 61,933 acres, with gross domestic crop production valued at \$585.7 million (CVWD 2018). The crops with the highest production value for 2018 included grapes (\$109.4 million), dates (\$77.9 million), bell peppers (\$67.9 million), lemons and limes (\$50.9 million), turf (\$49.1 million), carrots (\$25.7 million) and lettuce (\$23.9 million) (CVWD 2018).

Public Health

Chronic Disease and Respiratory Illness

Poor air quality is related to adverse public health outcomes such as chronic disease and respiratory illness. Asthma is an indicator of public health related to air quality, with the caveat that many factors (such as other sources of particulate matter, general health) in addition to dust emissions from the Salton Sea playa are likely contributors. Imperial and Riverside Counties have an overall asthma prevalence of approximately 15 percent (CDPH 2020a). Hospitalizations and emergency room visits due to asthma are higher in Imperial County than Riverside County, and higher than statewide averages. In Imperial County, hospitalizations due to asthma were 5.4 per 10,000 individuals and emergency room visits were 65.7 per 10,000 individuals in 2017. In Riverside County, hospitalizations due to asthma were 3.7 per 10,000 individuals and emergency room visits were 43.2 per 10,000 individuals in 2017 (CDPH 2020a). However, Riverside County had higher death rates related to asthma (8.5 per 10,000 individuals) compared to Imperial County (less than 5 per 10,000 individuals) between 2014 and 2016 (CDPH 2020a). Studies have also shown a high incidence of childhood asthma in the Imperial Valley. Based on parentreported survey information, an overall asthma prevalence of 22.4 percent was observed in school-aged children in Imperial County, which is significantly higher than the state average of 14.5 percent in children ages 0 to 17 (Farzan et al. 2019). Additional respiratory symptoms such as wheezing, allergies, bronchitic symptoms, and persistent dry cough were prevalent in both asthmatic and non-asthmatic children, further suggesting childhood asthma rates in Imperial County may be under-diagnosed (Farzan et al. 2019).

To date, the factors contributing to the high rates of adverse adult and childhood respiratory health conditions in Imperial Valley have not been studied (Farzan et al. 2019). Recent studies suggest that windborne dust in the Imperial Valley can be attributed to environmental sources associated with the exposed playa at the Salton Sea, sea spray, and the Whitewater River alluvial fan, as well as anthropogenic sources related to agricultural dust, agricultural burning, vehicle emissions, and industrial production (Frie et al. 2019). Concerns have been raised by the scientific community and public that exposure of the Salton Sea playa will increase the amount of fugitive wind-borne dust containing environmental contaminants, which could have long-term health consequences (Johnston et al. 2019; Farzan et al. 2019).

Mosquito-Borne Illness

Mosquitoes are carriers (vectors) of human and animal diseases, particularly West Nile virus and Saint Louis encephalitis virus. These viruses have been reported in many regions in California, including the Coachella and Imperial Valleys, though Saint Louis encephalitis has been detected more rarely since the introduction of West Nile virus in 2003 (CDPH 2020b). In 2019, a total of three human infections with West Nile virus and two infections with Saint Louis encephalitis virus were reported in Imperial County (State of California 2019a). In Riverside County, infections of West Nile virus were reported in 2019 (State of California 2019a, 2019b). No human infections of Saint Louis encephalitis virus were reported in 2019 (State of California 2019b).

Fish Advisories

Safe eating guidelines have been issued for the Salton Sea and its tributaries due to high levels of contaminants found in fish, which can have long-term health consequences such as impaired brain development in unborn babies and children and cancer (OEHHA 2016). The California Office of Environmental Health Hazard Assessment recommends the consumption of no more than two servings of fish from the Salton Sea per week due to selenium levels (OEHHA 2009). The Alamo and New Rivers also have advisories for carp, tilapia, and channel catfish due to contaminants such as mercury, selenium, DDT, and polychlorinated biphenyls (PCBs) (OEHHA 2016).

2.3 Monitoring Questions Objectives

The MIP monitoring activities are intended to help answer key questions regarding resources, restoration, and dust suppression (USGS 2013). These questions are addressed through a tiered sequence of monitoring goals and objectives, which are in turn addressed by a suite of environmental and socioeconomic indicators. **Table 2-4** outlines key questions and information needs posed in the MAP (USGS 2013) and the 2014 State of the Salton Sea Workshop (USGS 2017) for each resource category, then links them to objectives and a potential set of indicators.

Resource Category	Monitoring Questions (source)	Monitoring Goals	Monitoring Objectives	Potential Indicators Suggested
Hydrology – Surface Water	 What are the trends in inflow/outflow quantity? (MAP) What factors affect inflow/outflow quantity? (MAP) What are the effects of climate change on inflow/outflow? (MAP) How does the changing hydrology affect water supply and management? (SSS) For example, irrigation practices and crop selection) among farmers will have a profound influence on water levels. (SSS) 	Understand the relative contribution of different inflows to the Salton Sea.	 Measure surface water flows to the Sea. Monitor changes in surface water flows to the Sea over time. Measure water-surface elevation in the Salton Sea. 	 Inflows Surface water elevation Evaporation rates (temporal) Salinity (affects evaporation) Precipitation amount
Hydrology – Hydro-dynamics	 How do physical and biological factors influence the hydrodynamics in the Sea? (MAP) 	Improve the ability to predict through modeling future conditions related to the size and character of the future Salton Sea and guide decisions related to the placement and prioritization of potential created habitats.	 Measure water temperature, salinity, and dissolved oxygen profiles of the Salton Sea over time. 	 Water temperature (profile) Salinity (profile) Dissolved oxygen (profile)
Hydrology – Shallow Groundwater	 How does groundwater interact with the Salton Sea and exposed playa? (MAP) 	 Assess the potential for groundwater to interact with surface water in created habitats. Evaluate the potential effects of the receding sea. 	 Measure shallow groundwater levels in the Salton Sea area, and changes over time. Measure quality of shallow groundwater near the Salton Sea, and changes over time. 	Groundwater elevation
Water Quality	 What are the trends in water quality of surface inflows and sediment (rivers, drains, creeks)? (MAP) What are the trends in Salton Sea water and sediment quality? (MAP) Water is limited, and there is concern about water quality (including selenium). (SSS) How does hydrology affect hydrogen sulfide, selenium, and anoxic lake conditions? (SSS) What is the salinity of groundwater? Can it be used to sustain vegetation for dust suppression? 	Understand loading of key constituents and the processes that influence the health of the ecosystem to assess the potential effects of future management actions and evaluate the potential for created habitats to support the desired biological function.	 Measure water and sediment quality in the Salton Sea area over time. Measure water quality in the groundwater near project sites. 	 Salinity Temperature Dissolved oxygen Turbidity pH Chlorophyll a Nutrient concentrations Contaminants (metals, pesticides)

 TABLE 2-4

 MONITORING QUESTIONS, GOALS, OBJECTIVES, AND INDICATORS

Resource Category	Monitoring Questions (source)	Monitoring Goals	Monitoring Objectives	Potential Indicators Suggested
Water Quality – Selenium	 What is the risk associated with selenium in the Salton Sea? (MAP) Does selenium in soil and water bioaccumulate and have biological effects? (SSS) 	 Evaluate the ecological and human health risks related to selenium in the Salton Sea. 	 Measure selenium concentrations in water, sediment, invertebrates, fish 	 Selenium concentrations in water, sediment, biota Bird deformities
Geography – Topography	 How much area will be exposed as the shoreline recedes? (MAP) How does erosion and deposition affect shoreline and delta areas? What is the rate of erosion and sedimentation? (MAP) What is the distribution of soils? (MAP) What are geographical changes that may occur as a result of climate change? (MAP) What are sources of potential airborne dusts and where do they originate? (air quality) (MAP) 	 Understand the extent, type, and location of exposed playa. Characterize geographic conditions, such as landscape and surface characteristics, at the Salton Sea to project the amount of lakebed playa that would be exposed. Understand how humans and climate are modifying the land resources in the area to help predict some of the fundamental effects of these changes on the environment and humans. Assess changes to the landscape as a result of restoration. 	 Collect high-resolution LIDAR data to track changes in the Salton Sea related to topography and surface water elevation, area, and volume over time. Document status and trends (location, area) of exposed playa, with consideration of emissive surfaces. 	 Bathymetric elevations & contours (LiDAR) Land-surface elevation modeling Exposed playa (orthoimagery or other remote sensing) Model-Orthoimagery comparisons for ground truthing.
Geography – Land Cover and Land Use	 What is the distribution of vegetation? (MAP) What are sources of potential airborne dusts? Where do the potential airborne dusts originate? (MAP) How are drainage patterns being changed in the watershed? (MAP) What type of land uses around the Sea could affect or benefit restoration activities? (MAP) How much development will occur around the Sea? (MAP) Where is the distribution of housing and infrastructure? (MAP) Where are changes in agricultural uses? (MAP) Where are snags and islands? (MAP) How will geothermal development affect the landscape? (MAP) Evaluate availability, quality, and quantity of habitat. (SSS) 	 Characterize geographic conditions, such as landscape and surface characteristics, at the Salton Sea to project the amount of lakebed playa that would be exposed as a result of declines in water-surface elevations. Understand how humans and climate are modifying the land resources in the Salton Sea area to help predict some of the fundamental effects of these changes on the environment and humans. Assess changes to the landscape as a result of restoration. 	 Document status and trends (location, area) in land cover and land use in the areas surrounding the Salton Sea. 	 Land use & cover (orthoimagery or other remote sensing) Model-Orthoimagery comparisons for ground truthing. Geothermal activity and locations of hotspots

Resource Category	Monitoring Questions (source)	Monitoring Goals	Monitoring Objectives	Potential Indicators Suggested
Air Quality – Pollutants	 What are the existing conditions and trends for air quality at the Salton Sea? (MAP) What are sources of potential airborne dusts? (land cover) (MAP) Where do the potential airborne dusts originate? (land cover) (MAP) Are the dust suppression projects working to reduce emissions? What is the predicted consequence of a smaller lake for air quality, dust, public health, plants, and agriculture? (SSS) How emissive is the soil and how variable is the playa? Can we predict site emissivity; can we control emissivity? (SSS) What can we do about hydrogen sulfide emissions? (SSS) 	 Characterize existing air-quality conditions and emission sources at the Salton Sea to support estimation of potential future emissive conditions and planning of air quality management actions. Understand the relationships among emission sources, pollutants, meteorological factors, and other causes of variability in air quality. 	 Measure ambient concentrations of the pollutants of concern at and near the Salton Sea. Monitor changes in ambient concentrations of pollutants of concern at the Salton Sea over time. 	 Particulate Matter (PM2.5, PM10) Ozone and Nitrogen oxides (NOx) Sulfur dioxide, hydrogen sulfide, ammonia Particulate matter deposition rates Analysis/speciation of collected PM filter samples
Air Quality – Meteorology	What are the surface meteorological conditions at the Salton Sea? (MAP)	 Characterize meteorological conditions to support estimation of potential emissive conditions and planning of air quality management Understand the relationships among emission sources, pollutants, meteorological factors, and other causes of variability in air quality. 	 Monitor surface meteorological indicators near potential priority sites. 	 Wind speed and wind direction Temperature, Solar radiation Precipitation Evaporation Relative humidity, barometric pressure
Biological Resources – Birds	 What are the trends in bird use in the Salton Sea area? (MAP) What are the environmental attributes and conditions that affect bird use at the Salton Sea? (MAP) What factors contribute to the productivity of breeding birds at the Salton Sea? (MAP) What happens to bird populations as fish decline? (SSS) Disease vectors (SSS) 	Characterize the status of bird species at the Salton Sea.	 Document species composition, spatial and temporal distribution, relative abundance, and habitat associations of bird species/ guilds that use the Sea and created freshwater and saline impoundments. Track population trends in bird species/guilds at the Sea. Document relative abundance and distribution of special-status bird species dependent on Sea or created impoundments (Western snowy plover, gull-billed tern, Yuma Ridgway's rail) Document incidence, magnitude, and vectors of bird disease outbreaks. 	 Species composition & relative abundance Distributional patterns Colony phenology & success Foraging behavior Species composition & numbers of bird affected by disease Disease causative agents & mode of transmission

Resource Category	Monitoring Questions (source)	Monitoring Goals	Monitoring Objectives	Potential Indicators Suggested
Biological Resources – Plankton and Invertebrates	 What are the trends of plankton populations? (MAP) What environmental attributes and conditions affect plankton populations? (MAP) What are the trends in benthic and water column macroinvertebrate populations? (MAP) What environmental attributes and conditions affect benthic and water column macroinvertebrate populations? (MAP) What environmental attributes and conditions affect benthic and water column macroinvertebrate populations? (MAP) Can we model the resilience and mutability of the lake ecosystem? (SSS) Changes in water chemistry and impact on invertebrate populations (SSS) Do we expect a "tipping point" or nonlinear responses of biological systems to changing environmental features? (SSS) Mechanism of ecosystem transition from fish-driven food chain to something else? (SSS) 	 Characterize the existing conditions of "foodweb species" (phytoplankton, zooplankton, and macroinvertebrates) in the Salton Sea and created impoundments. Characterize the microbial community 	 Characterize the density and species composition of phytoplankton, zooplankton and macroinvertebrates in the Salton Sea and created freshwater and saline impoundments Document trends in abundance and composition Identify ecological variables that affect abundance and diversity 	 Density (number of organisms per unit volume) Species composition & relative abundance Distributional patterns Water quality & physical attributes
Biological Resources – Fish	 What are the trends in fish populations in the Salton Sea area? (MAP) What are the environmental attributes and conditions that affect fish populations in the Salton Sea? (MAP) Changes in water chemistry and impact on vertebrate populations (SSS) Tilapia physiology and salinity tolerance thresholds (SSS) 	Characterize the status of fish populations in the Salton Sea and its tributaries.	 Document species composition, distribution, relative abundance, and broad-scale habitat associations of fish populations in the Salton Sea, tributaries and drains, and created freshwater and saline impoundments. Track population trends in fish populations at the Sea and the environmental attributes and conditions that influence them. 	 Annual & seasonal catch per unit effort Species composition & relative abundance Distributional patterns Size/age distribution (breeding success) Breeding condition Die-off events
Biological Resources – Desert Pupfish	 What are the trends in desert pupfish populations in the Salton Sea area? (MAP) What environmental attributes and conditions affect desert pupfish populations in the Salton Sea area? (MAP) 	Understand the distribution of desert pupfish in the Salton Sea and its tributaries.	 Document the distribution and relative abundance of desert pupfish at the Sea (shoreline), tributaries and drains, and created freshwater and saline impoundments. Identify the environmental attributes and conditions that influence pupfish use of various habitats. 	 Pupfish annual & seasonal catch per unit effort Pupfish abundance & distribution in various habitats Pupfish size/age distribution Pupfish breeding condition

Resource Category	Monitoring Questions (source)	Monitoring Goals	Monitoring Objectives	Potential Indicators Suggested
Biological Resources – Special Status Wildlife	 What are the distribution and status of special-status wildlife species in the Salton Sea area? (MAP) Biological impacts that we have not been considering, and threatened populations (for example, desert tortoise, pile worms, desert plants, Clapper Rail, pupfish)? (SSS) 	 Understand the distribution of desert pupfish in the Salton Sea and its tributaries. 	 Document the distribution and relative abundance of special-status wildlife dependent on the Salton Sea (shoreline), tributaries and drains, and created freshwater and saline impoundments. 	 Abundance & distribution in various habitats near the Sea
Social – Demographics, Economics, Public Health	 Who is affected socially and economically by the Sea? (MAP) What is the nature of different groups' socioeconomic relationship (agriculture, tourism, geothermal energy) to the sea? (MAP) What are the socioeconomic drivers influencing where (geographically) these groups live and their interactions with the sea? (MAP) How have these individuals and their communities experienced the effect of changes in the Salton Sea over time, and how do these differ on the basis of group, social, and economic position and status? (MAP) What are the trends in key economic indicators? (MAP) How will management activities affect land uses? What will the economic effect of SSMP activities be on surrounding communities? (MAP) What factors are driving large disparities in childhood asthma and other health conditions in Salton Sea basin? (MAP) How can these disparities be addressed and reduced through collaboration with the local community? (MAP) 	 Understand how people are tied in an economic and social capacity to the Salton Sea. Understand the effects of management and resulting changes to the Salton Sea have on communities that are within its catchment. Understand how the public perceives the changes taking place at the Salton Sea related to where they live, work, and recreate. 	 Document and track changes to socioeconomic conditions related to the health and function of the Salton Sea ecosystem. Identify communities and socioeconomic clusters affected by the physical, biological, and cultural condition of the Salton Sea, and individuals and communities who could be affected by changes to the Salton Sea environment due to management activities (such as built/created habitat ponds). Document and track perceptions of the lake from both the proximate and non-proximate public relative to the Salton Sea. 	 Population demographics & socioeconomic indicators (e.g., housing, property values, employment, income) from census data Economic sectors (e.g., agriculture, tourism, recreation) Air quality-related health indicators Public perception of Salton Sea and SSMP projects Jobs created from SSMP activities and projects

SOURCES: Salton Sea Monitoring and Assessment Plan (MAP) (USGS 2013), State of the Salton Sea (SSS) (USGS 2017)
CHAPTER 3 Indicator Selection and Monitoring Design

3.1 Indicator Selection

The MAP outlined a comprehensive set of data needed to support long-term management of the Salton Sea, which, however, presents challenges with respect to cost, duration, and long-term data management. It may not be feasible to sample all metrics with the required replication to make meaningful comparisons at all sites. In some cases, this may mean not measuring highly variable metrics, and instead using resources for monitoring less-variable metrics (IEP 2017a). To focus MIP monitoring activities, indicators were defined and prioritized using a progression of criteria (USEPA 2015):

- 1. *Conceptual Relevance or Soundness*—Is the indicator relevant to the question and the resource at risk (Table 2-4)? Is the indicator correlated to environmental conditions and/or responses?
- 2. *Feasibility of Implementation*—Are the methods practical, technically feasible, cost-effective and efficient for use in in terms of funding, manpower, sample processing, and the complexity of analysis and data interpretation?
- 3. *Response Variability*—Are human errors of measurement and natural variability over time and space sufficiently understood and documented? Is the indicator quantifiable and repeatable? Is the indicator ecologically responsive, with high signal-to-noise ratio and high discriminatory ability?
- 4. *Interpretation and Utility*—Will the indicator convey information on resource conditions that is meaningful to Salton Sea managers and decision-makers? Is the indicator understandable and relevant to stakeholders? Is the indicator currently monitored or likely to be easily monitored in the future? Can monitoring efforts be coordinated among federal, state, and local entities and communities?

Proposed indicators were reviewed by Working Group experts and assigned to one of the following priority categories:

- *Primary priority*—core indicators for understanding changing conditions and their relationship to SSMP actions. These indicators have well-understood and strong linkages or correlation with status and function of Salton Sea resources. In addition, the methods of measurement are feasible and the analysis and interpretation is meaningful and actionable.
- Secondary priority—indicators that could improve understanding, but may have indirect linkage or weak correlation to ecosystem function, are less relevant to management decisions, and/or less feasible to measure (e.g., more expensive or logistically difficult).
- *Focused Study*—indicators that may be considered for a distinct stand-alone study that may provide deeper understanding of causal mechanisms, but is not essential to track important long-term status and trends. These indicators are lower priority compared to primary and

secondary indicators. This could include indicators that may be conceptually relevant but lack clear methods and means of interpretation at the present time, metrics that are not strongly linked or responsive to changes in conditions at the Sea, or information that is not actionable by managers.

Indicators with their priority are listed in **Table 3-1**. The full prioritization table provides notes on the four prioritization criteria and identifies agencies currently monitoring indicators (**Appendix B**, *Monitoring Indicators and Priority by Resource Category*).

Category	Indicator	Priority	Responsible Entity for Ongoing Monitoring
Hydrology	Lake elevation	Primary	USGS
	Inflow – rivers	Primary	USGS
	Inflow – direct drains	Primary	IID and CVWD
	Inflow –tributaries (San Felipe Creek, Salt Creek)	Primary	USGS (San Felipe Creek- historic, Salt Creek-active)
	Groundwater levels	Primary	IID
	Hydrodynamics	Focused Study	
Water Quality	Salinity (EC), Temperature, Dissolved oxygen, pH, Turbidity	Primary	USBR, IID
	Total Suspended Solids, Total Dissolved Solids	Secondary	USBR
	Nutrients (N, P)	Primary	USBR
	Selenium	Primary	USBR, IID
	Other contaminants (not Se)	Secondary (ambient), Primary (project ponds)	
	Groundwater quality	Primary	
	Pathogens (viruses)	Focused Study	
Geography	Land cover	Primary	IID
	Playa area extent	Primary	IID
	Surface characteristics	Secondary	IID
	Playa emissivity potential	Focused Study	IID
Air Quality	Meteorology/ Climate	Primary	IID
	Playa emissions	Primary	IID
	Ambient air quality (particulate matter)	Primary	IID, Torres Martinez Cahuilla Tribe
	Particulate matter chemistry	Focused Study	
	Gaseous Pollutants	Secondary	
Biological – Birds	General bird survey (shoreline area survey)	Primary	CDFW; Audubon, Oasis Bird Observatory, Point Blue
	Piscivorous bird surveys (aerial survey)	Primary	CDFW
	Colonial breeding bird surveys	Primary	CDFW

TABLE 3-1 PRIORITY INDICATORS AND METRICS

Category	Indicator	Priority	Responsible Entity for Ongoing Monitoring				
	Colonial roosting bird surveys	Secondary					
	Marsh bird surveys	Primary	CDFW				
	Dead and sick bird counts	Secondary					
Biological – Fish	General fish surveys	Primary	CDFW				
Biological –	Primary productivity (chlorophyll a)	Primary					
Plankton and Macro-	Phytoplankton surveys	Secondary					
invertebrates	Zooplankton surveys	Secondary					
	Macroinvertebrates (water column, benthic) surveys	Primary	Audubon (during bird shoreline survey)				
Biological –	Cyanobacteria	Focused Study					
Microbial	Microbial loop	Focused Study					
Biological – Special-status	Desert pupfish surveys	Primary	CDFW (ongoing), IID (past periodically)				
Species	Southwestern willow flycatcher surveys	Primary	IID (ongoing)				
	Western snowy plover surveys	Secondary					
Socioeconomics	Public Participation at SSMP events	Primary	SSMP				
	Community benefits	Primary					
	Economic indicators	Secondary					

3.2 Monitoring Design

3.2.1 Stratified Sampling Design

A stratified design that focuses on accessible but representative sampling sites is necessary. It may not be feasible to sample all metrics with the required replication to make meaningful comparisons at all sites. True random distribution may be problematic due to a limited number of boat launch sites and distance to aquatic sampling sites. Access to shoreline waters from the land is also hindered by physical accessibility. Therefore, to avoid these problems, programs may use both intensive and extensive sampling, sampling some areas at high spatial and/or temporal intensity, and other areas at lower frequency or replication (IEP et al. 2017a).

Intensive monitoring at a small spatial scale can be complemented through mapping using an aerial photo and ground truthing methods or other remotely sensed information such as LiDAR data to characterize aspects of the Salton Sea ecosystem in its entirety. The use of georeferenced surveys wherever possible will permit the integration of hydrology, vegetation, fish, elevation, and other data at multiple scales (Roegner et al. 2008).

3.2.2 Concurrent Sampling

Many of these metrics are related and should be measured together in a single sampling event to maximize ecological relevance, as well as sampling efficiency (IEP 2017a). Concurrent water

quality sampling should be performed with aquatic organism sampling to allow correlation between habitat conditions, species abundance and community composition. Wherever possible, the location of surveys should be spatially linked so that changes in multiple metrics can be evaluated for a single site (Roegner et al. 2008).

3.2.3 Triggered Metrics

Some metrics are only measured when triggered by other metrics, situations, or observations (IEP 2017a). For example, contaminant analysis may be focused on locations with highly emissive playa or areas targeted for creating impoundments, or triggered if abnormalities are observed in fish or birds. Testing for microcystin toxins would only be triggered if clumps of cyanobacterium *Microcystis* are detected visually. Dead bird surveys would be triggered if a disease outbreak is detected.

3.2.4 Types of Sampling

The MIP uses several approaches for obtaining samples and observations.

- *Fixed instrumentation for continuous data collection* water quality, flow, meteorological conditions, air quality.
- *Periodic ground-based field surveys* grab samples of water or sediment, spot measurements with handheld sondes, nets or traps for fish and invertebrate sampling, bird counts, habitat assessment.
- *Periodic aerial surveys* bird counts from plane.
- *Remote imagery mapping* interpretation of imagery collected by aerial flights or satellite.
- *Questionnaires and public surveys* socioeconomic indicators and opinions from residents and stakeholders.

3.2.5 Environmental Observations

Basic water quality and environmental variables should be recorded at any sampling location where aquatic organisms or water quality grab samples are collected (IEP 2017b). This includes but is not limited to sampling metadata (time, date, location, crew, station identifier, water depth), environmental conditions (wind, air temperature, cloud cover), water quality probe measurements, turbidity, substrate, vegetation, and algal blooms.

3.2.6 Standard Operating Procedures and Quality Assurance

The MIP provides a general summary of sampling methods in Chapter 4 Monitoring Elements, but does not include detailed standard operating procedures (SOPs). There are several resources that can be consulted for SOPs from other large-scale field monitoring programs (e.g., Roegner et al. 2008; UDWQ 2014; IEP 2017a, 2017b) as well as general EPA and SWRCB guidance for collection and lab analysis of water, sediment, and biota (e.g., Ode et al. 2016).

Quality assurance (QA) is a critical element of all monitoring programs (USGS 2013). Inclusion of a QA element helps ensure that the type, amount, and quality of data collected are adequate to meet study objectives. As stated in the MAP (USGS 2013), data collected in the monitoring program must be quality assured and quality controlled at all points in the process. Sampling, sample labeling, preservation, storage, transport, analysis, and data entry and compilation must all follow established and accepted guidelines. Any automated analysis must follow guidelines of calibration and standardization. State of California requirements for data management also include specific quality-control requirements. State and federal agencies could have specific quality-control and quality-assurance guidelines that will need to be met.

QA plans will be developed for each monitoring element and modified and updated as necessary and as consistent with the "living document" philosophy of the MAP and MIP (USGS 2013).

3.2.7 Other Considerations

Other considerations for implementing a field monitoring program include obtaining permission to access sites, securing sampling gear that must be left unattended, scientific collecting permits (especially for protected species), and safety planning (IEP 2017a, 2017b).

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CHAPTER 4 Monitoring Elements

This chapter includes a description of protocols for each resource category and indicator: rationale, existing data and monitoring, timing, location, methods, analysis, and other considerations. Protocols are provided for primary and secondary priority indicators, but not for all lower-priority focused study indicators (Table 3-1).

Detailed procedures (standard operating procedures, SOPs) are not provided in the MIP, but should be developed prior to monitoring implementation.

4.1 Hydrology and Water Quality

Hydrology and water quality indicators include the surface water hydrology (e.g., elevation and inflow rates), groundwater elevations, hydrodynamics (e.g., currents, vertical stratification), and water quality. **Table 4-1** summarizes the hydrological and water quality indicators and protocols.

4.1.1 Surface Water Hydrology

Inflow is a key determinant of the volume of the Salton Sea and its surface elevation, which in turn affects water quality, hydrodynamics, aquatic habitat quality, and playa exposure.

Rationale

Inflow data are used by the hydrological model developed by the IID, SALSA2 (Salton Sea Elevation Model version 2) to predict salinity, shoreline elevation, and water depth, and to validate the predicted water surface elevations (CH2M Hill 2018). Inflow data and the modeling based on it characterize the water available for potential restoration actions, which informs their design and management.

Small creek and direct drain inflows, while only a small contributor to the total water inflow, have a major influence on local conditions. Therefore, monitoring these inflows would inform potential habitat creation and air-quality management. San Felipe Creek is no longer monitored by the USGS, but it is located near proposed dust suppression projects and supports populations of desert pupfish (**Figure 4-1, Hydrology and Water Quality Monitoring Locations**). Similarly, flow monitoring of direct drains can support habitat evaluation for pupfish populations.

Metrics

Flow (i.e., daily discharge) of rivers and creeks, and pump rate of direct drains in cubic feet per second (cfs); water surface elevation.

Indicator—Metric	Priority	Method	Timing, Frequency	Location(s)	Entity
Salton Sea Water Surface Elevation	Primary	Gaging	Daily/continuous	USGS existing gage, Salton Sea Near Westmorland	USGS IID
				IID existing gage at Fig Tree John (only if the USGS gage becomes non-operational)	To-be-determined for potential new gages
				Potential new gage may be required depending on the extent of decline in water surface elevation. Location TBD.	
Inflows – Riverine	Primary	Gaging	Daily/continuous	USGS existing gages (3): Whitewater River	USGS
				Near Mecca, New River Near Westmorland, Alamo River Near Niland	To-be-determined for potential new gages
Inflows – Small Creeks	Primary	Gaging	USGS daily/ continuous	USGS existing gage: Salt Creek, if needed	USGS
			Potential New	Potential new tributary flow monitoring at San Feline Creek at or near discontinued	To-be-determined for
			Gage (frequency TBD)	USGS gage, if needed	potential new gages
Inflows – Direct Drains	Primary	Gaging,	TBD	IID existing direct-drain monitoring locations	IID
		Pump rates for pumped flows		CVWD direct drains Potential new direct- drain monitoring locations may be established as needed (e.g., pupfish locations, restoration sites)	CVWD
Hydrodynamics	Focused Study	Field instrument to establish depth profiles	Quarterly	Co-located with temperature measuring field devices	USBR (Salton Sea) CDFW (freshwater & saline impoundments)
Groundwater elevation	Primary	Groundwater well	Quarterly	At potential and planned restoration management planning areas as needed	To-be-determined for potential new gage
Surface Water	Primary	In situ measurement with	Quarterly, and	Salton Sea – 3 sites	Sea, Rivers – USBR
Physical – Temperature,		handheld sonde. Vertical	during aquatic	Rivers – Alamo, New, Whitewater	Smaller tributaries – TBD
DO, pH, EC (salinity), turbidity		water column prome by boat	biological sampling	Smaller tributaries – San Felipe	Drains – IID, CVWD
				Agricultural drains – IID (up to 15), CVWD (up to 26)	Impoundments – CDFW
				Impoundments – saline & freshwater TBD	

 TABLE 4-1

 Hydrological and Water Quality Monitoring

Indicator—Metric	Priority	Method	Timing, Frequency	Location(s)	Entity
Surface Water Total Dissolved Solids, Total Suspended Solids, Nutrients, Chlorophyll a, Contaminants (Selenium, Arsenic, Boron, Pesticides)	Primary	Grab samples in open water, lab analysis	Quarterly	(Same as surface water sites above)	(Same as surface water sites above)
Surface Water Pathogens – viruses	Focused Study	Grab samples in open water, lab analysis	Quarterly	(Same as surface water sites above)	(Same as surface water sites above)
<u>Groundwater</u> Temperature, DO, pH, EC (salinity), turbidity	Primary	In situ measurement with handheld sonde, or grab samples from existing wells.	Quarterly	Groundwater wells – 3 wells (TBD)	TBD
Groundwater Total Dissolved Solids, Total Suspended Solids, Nutrients, contaminants (Se, Ar, Bo, etc.)	Primary	Grab samples from existing wells. Lab analysis	Quarterly, then semiannual	(Same as groundwater sites above)	(Same as groundwater sites above)
<u>Groundwater</u> Pesticides – current use	Secondary	Grab samples from existing wells.	Annual	(Same as groundwater sites above)	(Same as groundwater sites above)
Sediment Quality – Selenium	Secondary	Sediment samples	Annual (spring)	At potential and planned restoration management planning areas as needed	CDFW



SOURCE: NAIP Imagery, 2020; CDFW, 2020; DWR, 2021.

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Available Data Sources/Responsible Entity

The USGS monitors stream flow of the Whitewater River, New River, Alamo River, and Salt Creek, but has discontinued monitoring of San Felipe Creek.⁴ The USGS also monitors the Sea's water surface elevation near Westmorland⁵ (Figure 4-1). The IID has an existing water surface elevation monitor at Fig Tree John; however, it is recommended for use for the MIP only if the USGS gage becomes non-operational.

The IID and CVWD each monitor drains in their respective jurisdictions (Figure 4-1). CVWD collects flow data monthly at 27 drains of which 25 flow directly to the Salton Sea area. Monitoring uses a Sontek flow meter or dedicated pump meter, depending on site conditions. Annual flows based on the water year (Oct-Sep) are published in the Indio Subbasin SGMA Annual Report (Z. Rodriquez del Rey, CVWD pers. comm. 2021).

Locations

The monitoring locations will be the existing monitoring locations for the USGS flow and water surface monitoring, as well as the IID and CVWD direct drain monitoring (Figure 4-1).

Timing/Frequency

The USGS gages measure daily discharge (cfs). The timing for the potential new gage at San Felipe Creek will be determined upon its establishment. The IID and CVWD direct drain monitoring is to be determined based on the districts. The CVWD collects flow data at direct drains monthly.

Method

Surface water inflows will be monitored using stream flow gaging. Water surface elevation will be monitored using a pressure sensor and intermittent water level surveys.

None of the drains have gages. The majority of drains are gravity fed and flows are measured by manual flow meter (e.g., Sontek flow meter). Some subsurface drains are pumped into the open drains due to elevation differential; these pump meters provide the best estimates of monthly flows to the drains. Pumped flows (of direct drains) will be monitored by pump rate.

Analysis

Inflow and water surface elevation data will be used to describe inflows on a seasonal and annual basis. This data will continue to be used to compare against and refine the SALSA2 water and salt balance model.

⁴ Flow gaging at USGS stations: 10259540 WHITEWATER R NR MECCA, 10255550 NEW R NR WESTMORLAND CA, 10254730 ALAMO R NR NILAND CA, 10254050 SALT C NR MECCA. Accessed 12/23/2021 at https://waterdata.usgs.gov/ca/nwis/current/?type=flow

⁵ Water surface elevation at USGS gage 10254005 SALTON SEA NR WESTMORLAND CA. Data reported as NGVD 1929, add 2.13 ft to convert to NAVD 88. Accessed 12/23/2021 at https://waterdata.usgs.gov/ca/nwis/uv?site_no=10254005

Other Considerations

As the elevation declines the existing USGS water surface elevation gage may become inoperable. A potential new gage may be needed if this occurs. Various projects such as the SCH Project may divert water from the rivers and pump water from the Salton Sea. Water pumped from the Salton Sea is not yet captured in the SALSA2 model. Monitoring the pumping directly from the Salton Sea (outflows), such as for specific projects, may be valuable for understanding the Salton Sea's water balance and refining the SALSA2 model. Also, the San Felipe Creek flow monitoring gage could be reinstalled at its previous location to reestablish monitoring.

4.1.2 Groundwater Hydrology

Groundwater contributes minimally (about 0.01 percent) to annual inflows to the Salton Sea (CNRA 2006). Precipitation-based recharge is very low throughout the basin (LLNL 2008). Groundwater could provide irrigation for vegetation enhancement actions to suppress dust on the playa. However, the volume is likely insufficient to serve as the sole water supply for created impoundments.

Shallow groundwater occurs in areas dominated by agricultural return flows, leakage from the remaining unlined sections of canals, and from the Colorado River along the southern basin boundary in Mexico.

Rationale

Understanding the depth and quality of shallow groundwater and how it changes over time at existing and potential SSMP project sites (where surface water availability is limited) will inform habitat creation and air quality management at the Salton Sea. Shallow groundwater could influence the emissivity of particles from sediments on exposed playa, and it could affect the feasibility and operations and maintenance of dust suppression projects. Shallow groundwater also could serve as a water source and salt-management tool for air quality management.

Metrics

Groundwater elevation (NAVD88)

Available Data Sources/Responsible Entity

There is no existing comprehensive groundwater monitoring effort that covers the entire Salton Sea perimeter. Several public and private agencies or entities have collected groundwater data in the vicinity of the Salton Sea. Some of these data are "point" data that represent a single time or event. Other data are collected as part of monitoring programs. Many of these data are not available in the public domain but could be available by request. The MAP lists several studies performed that describe geologic and hydrogeologic conditions and notes that a variety of older studies or data compilations were developed by the USGS and others. CVWD has not typically collected shallow GW levels, because of its agency focus on the deep aquifer, but as part of new CV-SNMP monitoring, partnering agencies will be constructing some shallow wells in the East CV with some being relatively near the Salton Sea north shore (Z Rodriguez del Rey, CVWD pers. comm. 2021).

The entities that will conduct the groundwater elevation monitoring will be determined based on restoration management planning areas.

Locations

The sampling locations will be at potential and planned restoration management planning areas as needed.

Timing/Frequency

The frequency of sampling will be quarterly.

Methods

Groundwater elevation will be measured using an installed groundwater well and manually taken. The elevation of the wells will be surveyed (feet in NAVD88). The groundwater depth in the well will be monitored using a well depth sounder or other typical sensor. If levels are highly variable and a more continuous record is desired, a pressure transducer and datalogger may be installed, which would need to be checked and calibrated every few months.

Analysis

Groundwater-elevation data would be tabulated and used to describe shallow-groundwater elevations around the Salton Sea on a seasonal and annual basis. This information will provide a preliminary indication of the potential for shallow groundwater to interact with surface sediments, which could influence dust suppression activities on the exposed playa. Data collected on the quality of the groundwater, combined with elevation data, can be used to assess the potential for groundwater to interact with surface water in created habitats and to evaluate the potential effects. The water-quality data also could be used to assess the suitability of shallow groundwater as a water source for establishing vegetation to control dust. The groundwater-elevation data will be analyzed to better understand sustainability of pumping rates in relation to the aquifer. The shallow-groundwater monitoring activities are expected to be modified in the future on the basis of results of the initial monitoring.

Other Considerations

Groundwater is managed differently in different parts of the basins, so groundwater monitoring may need to be divided up by region. Eastern and western sides are where new wells are currently being proposed. More investigation is needed to identify locations that have sufficient water quality and pump rates that will be sustainable without causing negative impact to the aquifer. Security considerations may affect where permanent monitoring equipment is installed at groundwater wells.

4.1.3 Hydrodynamics

Hydrodynamic processes in the Salton Sea influence water quality via circulation, stratification, and vertical mixing.

Rationale

Monitoring changes in circulation and vertical mixing of the Salton Sea could increase understanding of the causes of changes in water quality, which in turn affect fish and bird populations.

Current (i.e., water velocity) measurements have been previously considered to calibrate hydrodynamic models of the Salton Sea for stratification, mixing, and circulation (USGS 2013). These hydrodynamic models formerly served the purpose of earlier restoration concepts aimed at reducing the size of the lake, however, there is not currently a direct effort to change the lake. Therefore, velocity monitoring is unnecessary for calibrating hydrodynamic models.

Metrics

Direct metric is Surface Water Current/Velocity (feet per second). Indirect metrics include salinity, temperature, and DO profiles.

Current (i.e., water velocity) measurements may be used to provide vertical water-velocity profile information to quantify stratification, however, we assume that direct measurements of physical water quality (i.e., salinity, temperature, DO) using a handheld sonde at multiple depths would be an easier method to quantify stratification, if desired.

Available Data Sources/Responsible Entity

Available data sources are listed in Table 4-2 (Section 4.1.4, Water Quality).

Locations

Three locations in the center of the Salton Sea (Figure 4-1).

Timing/Frequency

Quarterly concurrent with water quality measurements (Section 4.1.4).

Methods

Temperature and dissolved oxygen (DO) will be measured in the field using handheld multiparameter sondes or other field probes and meters calibrated in accordance with manufacturer instructions and QAPP procedures. Measurements will be taken throughout the water column (1meter intervals) using a weighted sonde with a long cable to obtain vertical profiles.

Analysis

The data will be tabulated and posted to the CEDEN database. An annual report will be prepared that documents the sampling events, tabulates the data, provides a trend analysis for each metric analyzed, and provides recommendations (Section 4.1.4).

4-8

Other Considerations

While the MAP (USGS 2013) recommends monitoring of current/velocity to better understand hydrodynamics of the Salton Sea, current/velocity monitoring is costly and can be impractical, due to the significant size and the high variability of currents and velocity over time and location.

4.1.4 Water and Sediment Quality

Rationale

Water and sediment are key drivers of ecosystem function and condition at the Salton Sea (USGS 2013). Salinity, nutrients (i.e., nitrogen and phosphorus), sulfate, and selenium (Se) are among the constituents that threaten the health of the Salton Sea ecosystem (Schroeder et al. 2002). These same factors could influence the success of proposed created habitats and the ability of the area to support fish and wildlife over the long term.

Monitoring water quality will support the siting, design, and management of projects by:

- Documenting current conditions and trends in constituents of water and sediment quality that directly or indirectly are stressors of fish and bird populations.
- Supporting identification and evaluation of potential human risks associated with water or sediment-borne compounds.
- Predicting the productivity of restored habitats and the potential for algal blooms that are harmful to wildlife and humans.

Note that groundwater is being considered for use to establish vegetation for dust control but is unlikely to have sufficient yield to serve as a water supply for the constructed impoundments.

Metrics

Standard analytes are salinity, temperature, DO, turbidity, pH nutrients, ammonia, ReDox, H2S, total organic carbon, grain size, chlorophyll a, dynamics (stratification/ destratification), selenium (speciation), sulfur (speciation), pesticides, arsenic and boron (USGS 2013). Pathogenic bacteria and viruses are a lower priority metric for focused study of surface water samples only.

Table 4-1 identifies the sampling metrics, methods, locations, sampling frequency, and priorities of this monitoring. In general, water-quality samples are a combination of field measurements and grab samples collected at specified intervals and sent to a laboratory for analysis (USGS 2013).

Available Data Sources/Responsible Entity

Available data sources are listed in **Table 4-2**. USBR has conducted quarterly monitoring from 1999 to 2019 in the Salton Sea and influent rivers.

Database	Contributor	Notes
_	USBR	Since 1999, USBR has been conducting quarterly water quality monitoring of the Salton Sea (three locations in the center) and influent rivers (Alamo, New, and Whitewater Rivers). Data collected since 2004 is available at: (https://www.usbr.gov/lc/region/programs/ saltonsea.html)
CEDEN	Multiple	The CEDEN database includes data for the Salton Sea, and the Whitewater, New and Alamo River. The CEDEN database may also include some of USGS river data from the NWIS. The CEDEN database does not include IID and CVWD data. ¹ Note that the CEDEN database has numerous filters (e.g., programs, parent projects, projects, station names, sample agencies, lab agencies, submitting agencies, and date ranges. Consequently, searching the database requires knowing the filter names. CEDEN is available at: http://ceden.org/
NWIS	USGS	The NWIS database is limited to USGS data for samples collected from the Whitewater, New and Alamo Rivers, and the Salton Sea. Some of the USGS data in the NWIS database is also in the CEDEN database. The NWIS database is available at: https://waterdata.usgs.gov/nwis.
NOTES: Groundwater wells a	are not yet installed.	

TABLE 4-2
WATER QUALITY DATABASES

¹ IID and CVWD conduct sampling under programs separate from the SSMP.

IID and CVWD conduct sampling under programs separate from the SSMP. Given that the data generated by IID and CVWD is required by and provided to the RWQCB, it is assumed the IID and CVWD data will be available to the SSMP.⁶ Note that groundwater wells that could be used to establish vegetation for dust control have not yet been installed.

Locations

Water quality will be measured in Salton Sea, rivers, smaller tributaries, IID drains, and CVWD drains (Figure 4-1). To the extent possible, samples will be collected near the existing flow-measurement gage locations. Contaminants such as selenium and pesticides will also be measured in water and sediment samples from the Sea, rivers and drains because those water bodies receive agricultural drain water. Groundwater wells would be installed at dust suppression areas where revegetation may be used for dust control. Locations would be determined based on priority areas for dust control and accessibility.

Timing/Frequency

Field measurements and water grab samples will occur quarterly for all metrics. Sediment grab samples will occur annually, assuming temporal variability is lower for these materials than for water.

⁶ Note that for CVWD, a subset of drains is monitored for compliance, (e.g., Irrigated Lands Regulatory Program compliance on behalf of the Coachella Valley farming coalition CVILC). Since this is a regulatory program, data is submitted to the Regional Water Quality Control Board. All other monitoring of direct drains is voluntary and not reported to the Regional Water Quality Control Board regularly.

Field measurements will also occur during every field survey for aquatic biota (plankton, invertebrates and fish). Pairing water quality measurements with sampling organisms allows inference on correlation between fish abundance and water quality factors.

Methods

Field Measurements

Electrical conductivity,⁷ temperature, DO, pH, and turbidity will be measured in the field using handheld multi-parameter sondes or other probes and meters calibrated in accordance with manufacturer instructions and QAPP procedures. Measurements will be taken throughout the water column (1-meter intervals) to obtain vertical profiles. At sites greater than two meters in depth, a second water quality measurement should be taken from the bottom of the water column using a weighted sonde with a long cable.

Groundwater monitoring will focus on parameters (i.e., salinity, nutrients) that could determine whether groundwater could be suitable for establishing vegetation for dust control. Unless nearby groundwater wells are available, groundwater wells may need to be installed at priority dust suppression sites where revegetation may be used for dust control. The locations of any new groundwater wells will depend on access considerations.

Water Grab Samples

Water grab samples from rivers, tributaries, drains, and canals will be collected directly from surface water (top 10 cm) by extending samplers or sample bottles into the water bodies. Grab samples for Salton Sea samples will be collected from boats, concurrently with sonde measurements. At sites greater than two meters in depth, a second water quality measurement should be taken from the bottom of the water column using a Van Dorn sampler. Sediment grab samples will be collected by using a small dredge (e.g., Eckman or Ponar), three samples for each sampling location. These will be analyzed principally for contaminants (selenium, arsenic, boron, pesticides). Groundwater samples will be collected using an appropriate sampling devise lowered into the monitoring well.

Samples will be collected into sample bottles provided by the analytical laboratory, stored in a cooler with ice, and transported an accredited and pre-approved laboratory within 8 hours of collection under a standard chain of custody procedure. Samples will be processed by the laboratory using standard analytical methods.

Analytes will include nutrients (phosphorus (total-P), ortho-phosphate (o-PO₄), ammonia (NH₃-N), nitrate and nitrite (NO₃/NO₂-N), and organic nitrogen, which together provide information about productivity), total organic carbon (an indicator of organic enrichment), TSS (an indicator of the load of suspended sediment being discharged to the Salton Sea, but not bed load), TDS (an

⁷ Electrical conductivity is a surrogate measure for salinity and is usually represented as "specific conductivity," which is conductivity normalized to 25° Celsius (μ S/cm at 25°C). Monitoring electrical conductivity provides information on salt content, which can be correlated to laboratory-derived measurements of total dissolved solids (TDS). Precise values for water temperature should be recorded at the time of EC measurement to allow accurate conversion of specific conductance to salinity (Amrhein et al. 2001).

indicator of dissolved salts), chlorophyll a (indicator of primary productivity by phytoplankton), and sulfate (toxic to aquatic life).

In addition, samples of water and sediment will be analyzed for contaminants and trace elements known to have toxic effects in the environment. For the Salton Sea ecosystem, constituents of concern are selenium, arsenic, boron, and pesticides (legacy and current use). Tracking the concentrations and trends of these contaminants is important to monitor current conditions and track the overall trends of key stressors on the ecosystem. The data will inform siting, design and operations (e.g., water supply) of created impoundments.

Analysis

The data from the laboratory analysis will be tabulated and posted to the CEDEN database. An annual report will be prepared that documents the sampling events, tabulates the data, provides a trend analysis for each metric analyzed, identifies any toxic elements that exceed levels of effect, and provides recommendations.

Other Considerations

Access to the Salton Sea sampling sites requires a boat launch. The boat launch on the southern shoreline is no longer functional, but a boat launch ramp is planned at the Species Conservation Habitat (SCH) project site on the southern Salton Sea shoreline, and another boat launch is currently under construction on the north shore. Continuous water quality sondes would not be installed in the Salton Sea because the high salinity is damaging to equipment, although these could be considered for constructed impoundments. Depending on security considerations, permanent sampling equipment may be installed in groundwater wells.

4.2 Geography

4.2.1 Land Cover

Rationale

The purpose is to measure changes in the distribution and area of land cover types as the Sea recedes and projects are implemented. In addition, vegetation is naturally establishing where irrigation drains and tributaries discharge onto the exposed playa (Audubon 2020). Tracking the rate and amount of playa exposure is an important metric for compliance with the State Water Resources Control Board's stipulated order (SWRCB 2017).

Metrics

The metrics are area and type of land cover (e.g., open sea, exposed playa, vegetation communities, waterways, agricultural areas, communities).

Available Data Sources/Responsible Entity

Existing NLCD datasets from 1992 and 2001 are available, NLCD 2019 now offers land cover for years 2001, 2004, 2006, 2008, 2011, 2013, 2016, and 2019. The USGS released a new generation of National Land Cover Database (NLCD) products named NLCD 2019 for the

conterminous U.S., which provides land cover data for years 2001, 2004, 2006, 2008, 2011, 2013, 2016, and 2019 (USGS 2021b).

Locations

Entire Salton Sea and adjoining area extending at least 2 km from the landward edge of the exposed playa, inclusive of managed wetlands and wildlife areas.

Timing/Frequency

Updating vegetation mapping via remote sensing is recommended annually given the rapid changes observed on the playa with shoreline recession and emergence of vegetation, and no less frequently than every 3 years.

Methods

Ortho-rectified multispectral imagery (i.e., RGB, near infrared, and color infrared [NIR/CIR]) 10meter resolution satellite imagery will be collected. For mapping of new emerging vegetation, it is recommended to use imagery that is obtained during a period that is cooler and wetter and with low cloud cover, which increases the change for assessing healthy vegetation on the playa (Audubon 2020).

This imagery will be used to create a Normalized Difference Vegetation Index (NDVI) map for shoreline and nearshore areas of the Salton Sea and calculate vegetation percent coverage through an object-based image analysis (OBIA). NDVI is a vegetation index that uses near-infrared imagery to determine vegetation characteristics. Vegetation data from ground surveys will be used to ground truth OBIA to ensure object accuracy and limit false positive classifications.

Analysis

Quantify the acreage for each land cover type of interest. Examine trends in distribution and rate of change over time, especially in areas known to have high emissive potential for particulate matter (CNRA et al. 2020). Compare patterns of emerging vegetation with mapped locations of irrigation drains, ephemeral washes and streams, and perennial streams and rivers. This information can inform siting and methods for dust suppression projects and habitat restoration (Audubon 2020).

4.3 Air Quality

Indicators identified as priorities for air quality monitoring include particulate matter, surface meteorological conditions, and gaseous pollutants (hydrogen sulfide, ammonia) (**Table 4-3**).

Indicator—Metric	Priority	Method	Timing, Frequency	Location(s)	Entity
PM10 Concentrations	Primary	Non-Regulatory Monitors	Continuous	Salton Sea-Adjacent Monitoring Locations and temporary remote site monitoring at specific locations where ecosystem restoration projects are implemented.	IID Torres Martinez Cahuilla Tribe
PM2.5 Concentrations	Focused Study	Non-Regulatory Monitors	Continuous	Salton Sea-Adjacent Monitoring Locations and temporary remote site monitoring at specific locations where ecosystem restoration projects are implemented.	IID Torres Martinez Cahuilla Tribe
PM10 Deposition and Chemical Profiles	Focused Study	Non-Regulatory Monitors	Continuous	Salton Sea-Adjacent Monitoring Locations impacted by high winds off-sea and most likely to capture dust from exposed lakebed and specific locations where there is newly exposed playa.	IID Torres Martinez Cahuilla Tribe
PM10 Health Studies	Focused Study	Non-Regulatory Monitors	Continuous	Health studies should be based on data obtained from locations described above for PM10 and PM2.5 and extrapolated for potential exposure at population centers.	IID Torres Martinez Cahuilla Tribe
H ₂ S and NH ₃ Concentrations	Secondary	Non-Regulatory Monitors	Continuous	Salton Sea-Adjacent Monitoring Locations and areas with substantial geothermal activities, large-scale algae blooms, fish kills, or other biological decomposition events.	IID Torres Martinez Cahuilla Tribe
Surface Meteorological Data	Primary	Meteorological instruments	Continuous	Meteorological data should be collected at all permanent and temporary monitoring locations.	IID Torres Martinez Cahuilla Tribe

TABLE 4-3 METRICS FOR AIR QUALITY MONITORING

4.3.1 Particulate Matter

PM10 and PM2.5 Concentrations

Rationale

The objectives of the air quality monitoring activities are to characterize existing air quality conditions and emission sources to provide a baseline from which to evaluate the effects of ecosystem restoration projects on regional air quality. Emissions of PM10 in the Salton Sea Air Basin are highly correlated to fugitive dust; therefore, PM10 is a primary priority metric. Emissions of PM2.5 are highly correlated to combustion exhaust and are not expected to increase substantially from ecosystem restoration projects; therefore, PM2.5 is a focused study.

Metrics

Ambient air concentrations of PM10 and PM2.5 (micrograms per cubic meter); and mass rate emissions (tons of emissions per year), which can be used to estimate ambient air concentrations through dispersion modeling.

Available Data Sources/Responsible Entity

The Salton Sea Air Quality Monitoring Network (SSAQMN) was developed collaboratively by IID, CARB, and the USEPA to monitor air quality. IID has funded, constructed and maintained the existing shoreline PM10 and meteorological network since its operation commenced in 2010 (IID 2016). The network includes multiple air quality, meteorological, and camera stations for the purpose of monitoring and characterizing windblown dust emissions at the Salton Sea.

Monitoring data are available at the publicly accessible CARB Air Quality Management Information System (AQMIS) for the six permanent monitoring stations.⁸ Some datasets for monitors deployed during high wind events at select field-scale pilot studies adjacent to the Salton Sea are available with IID permission at the Salton Sea Air Quality Mitigation Program (SSAQMP) Data Portal.⁹ The high wind events monitoring are considered a living dataset and additional monitoring locations are expected to be added over time.

Annual reports by IID summarize the activities associated with implementation of the SSAQMP and estimate the annual and maximum PM10 emissions from the playa and adjacent western desert areas. Various technical memoranda provide an overview of data collected by the SSAQMN, provide an annual analysis of playa exposure at the end of each year when the Salton Sea is at the lowest point of its hydrological cycle, and review meteorological and air quality data for quality assurance and quality control.

⁸ CARB AQMIS: https://www.arb.ca.gov/aqmis2/aqmis2.php.

⁹ SSAQMP Data Portal: https://saltonseaprogram.com/aqm/data-portal/data-portal.php

Locations

There are six permanent monitoring stations in the SSAQMN located around the Salton Sea near existing communities, known emission sources, or sensitive receptor areas (USGS 2013)

(Figure 4-2, Air Quality Monitoring Locations):

- Salton Sea Naval Test Site Located on the west shore approximately 16.5 miles northwest of Westmorland.
- Salton City Located at a Salton Community Services District wastewater-treatment plant.
- Whitewater River Outlet, North Shore Located on the Torres Martinez Tribe lands is adjacent to a wetlands project being developed by the Tribe.
- Salton Sea Recreation Area Located at the State Parks' Salton Sea Recreation Area headquarters facility and visitor's center. Bombay Beach Located on land owned by the Federal Government and managed by California State Parks.
- Salton Sea South Shore Located on the Sonny Bono National Wildlife Refuge.

Since 2011, IID has managed five of the six stations. Since 2010, the Torres Martinez Tribe has managed one of the six stations. The network also includes five portable stations around the Salton Sea, and three portable stations in the desert (Figure 4-2).

Temporary remote site monitoring is currently being conducted at specific locations where ecosystem restoration projects are implemented to monitor the effectiveness of dust suppression at a local scale. Temporary remote site monitoring should continue to occur at locations where ecosystem restoration projects are implemented, and should include monitoring at upwind and downwind sites relative to the project location and the dominant wind vector to measure the pollutant gradients.

Timing/Frequency

Continuous

Methods

These permanent stations monitor hourly average mass concentrations of particulate matter and associated meteorological parameters on a continuous basis. At each permanent station, a TEOM instrument continuously measures particulate matter concentrations. Partisol instruments may be used to collect filter samples to provide elemental information on the chemical composition of the particles.

Meteorological towers are also installed near each permanent station. The meteorological towers at the permanent monitoring stations are about 30 feet tall and measure wind direction, wind speed, relative humidity, solar radiation, and temperature. The portable and field scale pilot study meteorological towers are 6-meter stainless steel tripods with anchored guy wires. The portable monitoring stations monitor wind speed and direction at various locations and heights.



SOURCE: NAIP Imagery, 2020; MapBox, 2020; DWR, 2021.

Salton Sea Management Program Monitoring Implementation Plan



Non-Regulatory Monitors shall be used in the vicinity of the Salton Sea and surrounding areas. Non-Regulatory Monitors are not used to determine compliance with the National or California Ambient Air Quality Standards and are not required to meet the Federal Reference Method, Federal Equivalent Method, or Approved Regional Method (40 CFR Part 58 App C), siting criteria (40 CFR Part 58 App E), and quality assurance requirements (40 CFR Part 58 Appendix A). Non-Regulatory Monitors shall be capable of providing data suitable for laboratory analysis and shall be calibrated and maintained in accordance with manufacturer specifications. Calibration and maintenance documentation shall be maintained for at least 3 years. Instruments should be operated in conformance with a Quality Assurance Project Plan (QAPP) developed and implemented by the ICAPCD.

Analysis

Hourly PM10 data will continue to be loaded onto the publicly accessible CARB AQMIS system within 20 minutes following the end of each hour. After validation, these data will be used by airquality agency staff, researchers, and the general public to assess information on existing PM10 levels around the Salton Sea.

Continuously monitored PM10 concentrations should be averaged over 5-minute and 1-hour periods and provided to IID or their approved contractor for initial quality-assurance review and then to CARB. Five-minute average PM10 data should be uploaded within 20 minutes after each hour, or as quickly as feasible, from the monitoring station data loggers and provided to IID or their approved contractor for initial quality-control review. These files should then be provided to CARB for placement on an FTP site for access by Salton Sea researchers.

PM10 samples should also be collected on filters over 24-hour averaging periods to aid in quality-assurance checks of the continuous particulate matter monitoring data.

If a focused study on PM2.5 is conducted, data would be continuously monitored and analyzed similarly to PM10 data. Additionally, filter samples would be sent to laboratories for chemical (i.e., speciation) analyses, if undertaken as a Priority 3 focused study.

Annual reporting of the data should be incorporated into existing annual reports or as stand-alone reports using graphs, tables, and other data analytics easily understood by the general public.

Other Considerations

The information collected as part of the monitoring plan will be used in an adaptive management framework to inform and guide management actions that could be implemented with or without a restoration program.

However, environmental constraints and assumptions should be considered when evaluating the success of the monitoring plan and restoration program. For instance, median PM10 emissions estimated for exposed Salton Sea playa and the desert for the 2017/2018 monitoring year (IID 2020b) are intended to prioritize dust source areas for mitigation but are not approved by ICAPCD, CARB, or the USEPA as emission inventories for regulatory purposes. Ecosystem restoration projects at the Salton Sea are not expected to reduce region wide PM10 emissions in the Salton Sea Air Basin to below the CAAQS or NAAQS.

Placement and maintenance of monitoring equipment must also consider engineering and physical constraints, such as accessibility by vehicles, power availability within 100 feet of the site pad, site security in these remote areas, lack of nearby significant land-surface disturbance (and resultant dust emissions) from human activity unrelated to ecosystem restoration projects, and cell-phone reception to upload data.

Further, any management actions and efforts related to the implementation of air quality monitoring and ecosystem restoration projects will need to comply with applicable laws.

PM10 Deposition and Chemical Profiles

PM10 is not a single pollutant but consists of mixtures of many chemical species and are often complex mixtures of solids and aerosols composed of small droplets of liquid, dry solid fragments, and solid cores with liquid coatings and vary widely in size, shape and chemical composition (CARB 2021a). Emissions of PM10 are derived from different emissions sources, which leads to different chemical compositions.

Rationale

Studying PM10 deposition and its chemical profile would characterize existing PM10 compositions from Salton Sea playa emissions, which would support evaluation and management of longer-term conditions and sources, and could inform PM10-related health studies and the development of additional long-term monitoring.

Metrics

Ambient air concentration of PM10 and its chemical constituents (micrograms per cubic meter), mass rate emissions (tons of emissions per year), which can be used to estimate ambient air concentrations through dispersion modeling, and flux (mass of emissions per unit area per second), which can be used to identify areas with relatively higher emissivity.

Available Data Sources/Responsible Entity

IID is using multiple monitoring techniques to identify when a project site requires dust control maintenance activities (augmentation or replacement). Monitoring includes aerial LiDAR, high wind event upwind/downwind PM10 monitoring, targeted sand motion monitoring, and visual (video camera) evidence (CNRA et al. 2020).

Objectives for IID's Emissions Monitoring Program include map playa exposure, evaluate playa surface characteristics, and measure emissions potential of different surface types (IID 2016 and 2021). IID has continued operation and maintenance of the air quality monitoring network. Annual reports summarize estimated annual and maximum PM10 emissions from the playa and adjacent western desert areas, analysis of playa exposure at the end of each year when the Sea is at the lowest point of its hydrological cycle, and meteorological and air quality data for quality assurance and quality control (IID 2021).

Funding provided by the USEPA between 2017 and 2018 was used to purchase two stationary and eight portable monitors. The objective was to collect dust samples for constituent analysis.

However, the dust samples did not capture very high wind events (samples were collected on days that did not exceed 150 micrograms per cubic meter concentration). Funding was not available to analyze all of the samples.

A research team at the University of California, Riverside conducted an analysis of playa soils, desert soils, and aerosolized PM10 collected at the Salton Sea (Frie et al. 2017). Aerosolized PM10 was collected at Bombay Beach (August 2015), and at Salton City (August 2015 and February 2016) and compared to 25 playa and 88 desert samples collected during August 2015 and February 2016 from a wide area around the Salton Sea. Note that monitoring for aerosolized PM10 did not occur during the high dust season, which typically occurs in April and May. Playa soils were significantly enriched in calcium, sodium, and selenium relative to desert soils. Playa-like and desert-like sources contributed to a daily average of 8.9 percent and 45 percent of PM10 mass, respectively. Playa sources contributed to 38 to 68 percent of PM10 sodium. Furthermore, PM10 selenium concentrations showed strong seasonal variations, suggesting a seasonal cycle of selenium volatilization and recondensation (Frie et al. 2017). Selenium is a State of California identified toxic air contaminant with chronic (annual) inhalation and oral risk assessment health values. Calcium and sodium in their elemental forms are not identified toxic air contaminants.

Another study conducted in 2017 and 2018 analyzed deposited dust collected approximately monthly at five sites in the Salton Sea Basin for total elemental and soluble anion (a negatively charged molecule) content (Frie et al. 2019). The approximately monthly samples were collected from April 2017 to May 2018, yielding 11 sample sets from four of the sites and 9 samples from one site due to access constraints. The analysis found that playa emissions in the Salton Sea region were most intense during the late spring to early summer and contain high concentrations of evaporite mineral tracers, particularly magnesium, calcium, and sulfates (Frie et al. 2019). Sulfates are a State of California identified toxic air contaminant with acute (1-hour) inhalation risk assessment health value. Sulfates can also be a significant portion of particulate matter emissions. Magnesium and calcium in their elemental forms are not identified toxic air contaminants.

Locations

For PM10, locations of deposition and chemical profile monitoring would be determined during design of these special studies. However, the Bombay Beach (Site 5, along the eastern shoreline) and Sonny Bono (Site 6, along the southeastern shoreline) locations tend to be impacted by high winds off-sea, and therefore are most likely to capture dust from exposed lakebed. Specific locations where there is newly exposed playa may also be selected for monitoring by remote site monitors located downwind of the exposed playa.

Timing/Frequency

PM10 deposition samples will be collected on filters over 24-hour averaging periods. Sampling may be conducted weekly or less frequently based on available funding. The monitoring period will capture the high dust season (April–May).

Methods

Deposition monitors should be used at the monitoring stations and at downwind sites remote from monitoring stations to quantify particulate matter deposition rates near the Salton Sea shoreline.

Analysis

The deposited particulate matter should be collected from the monitors at the end of each month and sent to an appropriate laboratory to be analyzed for mass and chemical composition.

Other Considerations

Constraints and other considerations include those discussed previously. In addition, special studies are subject to funding and staffing availability, among other constraints. Partnerships with other research organizations, such as University of California, Riverside, may be beneficial.

With respect to environmental constraints and assumptions, PM10 deposition will likely include a mix of playa, desert (i.e., non-playa), and potentially other particulate matter such as particulate transport from other areas of the Salton Sea Air Basin and the South Coast Air Basin. Laboratory analysis is constrained by detection limits for various chemicals.

PM10 Health Studies

Rationale

PM10 health studies would characterize existing and future potential health risks from exposure to Salton Sea playa emissions, to support evaluation and management of longer-term conditions and sources. The results of the health studies may be used to identify areas of the Salton Sea that may require control and to establish a control effectiveness target for dust control projects.

This indicator is prioritized as a focused study.

Metrics

Health risk studies evaluate carcinogenic risk in terms of risk in one million. OEHHA is responsible for developing and revising guidelines for health risk assessments under California's Air Toxics Hot Spots Program Risk Assessment (AB 2588) regulation. In March 2015, OEHHA adopted revised guidelines that update the previous 2003 guidance by incorporating advances in risk assessment with consideration of infants and children using age sensitivity factors, modifying the breathing rates for different ages, modifying exposure durations. Non-cancer effects based on the Reference Exposure Level at toxicological endpoints and the Hazard Index.

Available Data Sources/Responsible Entity

Various health assessments have been conducted or are in the process of being conducted. Notable studies include, but are not limited to, the following:

- National Institute of Environmental Health Sciences in partnership with University of Southern California, University of Washington, Public Health Institute, California Department of Public Health, and Comité Cívico Del Valle, Inc. "The Salton Sea and Children's Health: Assessing Imperial Valley Respiratory Health and the Environment."
- University of California, Riverside, School of Medicine Center for Health Disparities Research. "Childhood Asthma and the Salton Sea."

Locations

Health studies should be based on data obtained from locations described above for PM10 and extrapolated for potential exposure at population centers.

Timing/Frequency

Not applicable.

Methods

Health risk assessments should be conducted in accordance with the California Environmental Protection Agency, OEHHA Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments (OEHHA 2015).

Analysis

CALPUFF is an advanced, integrated Lagrangian puff modeling system that may be used to model particulate concentrations at population centers where exposure may occur based on collected PM10 monitoring and deposition data.

Other Considerations

Constraints and other considerations include those discussed previously. In addition, the process of assessing health risks and impacts includes a degree of uncertainty. The level of uncertainty depends on the availability of data and the extent to which assumptions are relied upon in cases where the data are incomplete or unknown. All health risk assessments rely upon scientific studies to reduce the level of uncertainty; however, it is not possible to completely eliminate uncertainty from the analysis. Where assumptions are used to substitute for incomplete or unknown data, it is standard practice in performing health risk assessments to err on the side of health protection to avoid underestimating or underreporting the risk to the public. In general, sources of uncertainty that may lead to an overestimation or an underestimation of the risk include extrapolation of toxicity data in animals to humans and uncertainty in the exposure estimates.

Evaluating health risks from exposure to Salton Sea playa emissions through these special studies may require several years and may require extrapolated emissions data into future years, as well as development of a regional plume dispersion model to quantify transport of these emissions.

In addition to uncertainty, there exists "a natural range or variability in measured parameters defining the exposure scenario" and that the "the greatest quantitative impact is variation among the human population in such properties as height, weight, food consumption, breathing rates, and susceptibility to chemical toxicants." It is typical to err on the side of health protection by assessing risk on the most sensitive populations, such as children and the elderly, by modeling potential impacts based on high-end breathing rates, by incorporating age sensitivity factors, and by not taking into account exposure reduction measures, such as mechanical air filtration building systems.

4.3.2 Hydrogen Sulfide

Hydrogen sulfide (H_2S), as well as SO₂, are generated in the Salton Sea by geothermal activity and anaerobic decomposition of organic matter. H_2S is also released from some tectonic faults that cross under the Salton Sea (USGS 2013).

 H_2S is a colorless gas with a strong odor of rotten eggs. Exposure to H_2S can induce tearing of the eyes and symptoms related to overstimulation of the sense of smell, including headache, nausea, or vomiting; additional health effects of eye irritation have only been reported with exposures greater than 50 parts per million, which is considerably higher than the odor threshold (CARB 2021b). H_2S is regulated as a nuisance based on its odor detection level; if the ambient air quality standards were based on adverse health effects, it would be set at a much higher level (CARB 2021b).

Rationale

Monitoring of H_2S may inform the siting, design, or management of SSMP projects in areas with substantial geothermal activities, large-scale algae blooms, fish kills, or other biological decomposition events.

Metrics

Atmospheric concentration of H2_s (parts per million, parts per billion).

Available Data Sources/Responsible Entity

There are no pre-existing available data sources in the Salton Sea area. H_2S are not currently monitored at any of the six monitoring locations around the Salton Sea. However, H_2S is monitored at Mecca, which is located to the north of the Salton Sea and to the north of the Torres Martinez monitoring location.

Locations

Monitors for H_2S would be located at one or more of the six monitoring locations around the Salton Sea (refer to *Locations* in Section 4.3.1 for a description of the locations).

Timing/Frequency

H₂S would be monitored continuously to monitor emissions from geothermal activities, largescale algae blooms, fish kills, or other biological decomposition events.

Methods

Non-Regulatory Monitors would be used. Non-Regulatory Monitors are not used to determine compliance with the National or California Ambient Air Quality Standards and are not required to meet the Federal Reference Method (FRM), Federal Equivalent Method, or Approved Regional Method (40 CFR Part 58 App C), siting criteria (40 CFR Part 58 App E), and quality assurance requirements (40 CFR Part 58 Appendix A). Non-Regulatory Monitors shall be capable of providing data suitable for laboratory analysis and shall be calibrated and maintained in accordance with manufacturer specifications. Calibration and maintenance documentation shall be maintained for at least 3 years. Instruments should be operated in conformance with a QAPP developed and implemented by the ICAPCD.

Analysis

Should monitoring be warranted, continuously monitored H₂S concentrations would be averaged over 1-hour periods and forwarded to ICAPCD for initial quality-assurance review and then to CARB.

Hourly H₂S data would be loaded onto the publicly accessible CARB AQMIS system within 20 minutes following the end of each hour. After validation, these data will be used by air-quality agency staff, researchers, and the general public to assess information on existing H₂S and NH₃ levels around the Salton Sea.

Average values would be computed by each data logger and stored in batch files for monthly uploading to a CARB FTP site. These batch files should be available for any researcher on a request basis.

Other Considerations

Constraints and other considerations include those discussed previously. In addition, ecosystem restoration projects at the Salton Sea are not expected to significantly contribute to region wide H₂S emissions in the Salton Sea Air Basin. Ecosystem restoration projects at the Salton Sea are not expected to significantly contribute to region-wide H₂S concentrations in the Salton Sea Air Basin.

4.3.3 Surface Meteorological Data

Rationale

In conjunction with ambient air pollutant concentration monitoring, surface meteorological monitoring will allow for evaluations of pollutant transport to support the siting, design, and management of SSMP projects.

Metrics

- Wind direction (U, V, and W vectors at the 10-meter height on each meteorological tower)
- Wind speed
 - Two- and three-dimensional at the 10-meter height on each meteorological tower by using a sonic anemometer
- Temperature
 - At the 3-meter inlet to each Tapered Element Oscillating Microbalance (TEOM)
 - At the 10-meter height on each meteorological tower
 - At the 2-meter height on each meteorological tower
- Relative humidity (at the 3-meter inlet to each TEOM sampler and at the 2-meter height on each meteorological tower)
- Barometric pressure (at the 3-meter inlet to each TEOM sampler)
- Solar radiation (at the 1-meter height on each meteorological tower)

Instruments to measure precipitation and evaporation rates would also be installed if these data are needed to support focused investigations.

From the monitoring data, the following meteorological parameters should be calculated by each station data logger and stored:

- Wind direction (scalar and vector at the 10-meter height on each meteorological tower)
- Wind speed (2-dimensional and 3-dimensional scalar and vector at the 10-meter height on each meteorological tower)
- Sigma theta (standard deviation of 2-dimensional and 3-dimensional wind directions at the 10-meter height on each meteorological tower)
- Delta-T (temperature difference between 2-meter and 10-meter heights on each meteorological tower)

Available Data Sources/Responsible Entity

Surface meteorological data are currently collected at the six Salton Sea monitoring locations. Meteorological data are also currently collected at monitors deployed during high wind events at select field scale pilot studies adjacent to the Salton Sea.

Wind speed scalars at the 1-meter, 2-meter, and 10-meter heights on each meteorological tower were recorded from 2010 through 2017 using cup anemometers. This data was used for the quantification of the roughness height of surfaces surrounding each station, which is needed for plume dispersion modeling). Since surface roughness does not change substantially over time, the data recorded from 2010 through 2017 is sufficient for surface roughness and no additional data for surface roughness is needed.

Locations

Surface meteorological data will be collected at the six current Salton Sea monitoring locations and at monitors deployed during high wind events at select field scale pilot studies adjacent to the Salton Sea (refer to *Locations* in Section 4.3.1 for a description of the locations). Localized meteorological data should be collected at all permanent and temporary monitoring locations.

Timing/Frequency

Continuous

Methods

Surface meteorological instruments will be operated in conformance with a QAPP developed and implemented by the IID or their approved contractor.

Analysis

One-hour average values should be computed by the data logger at each monitoring station and reported to the publicly accessible CARB AQMIS system within 20 minutes after the end of each clock hour of monitoring. Five-minute average values should be computed by each data logger and stored in batch files for monthly uploading to a CARB FTP site. These batch files should be

available for any researcher on a request basis. Datasets for monitors deployed during high wind events at select field scale pilot studies adjacent to the Salton Sea are available for download at the publicly accessible SSAQMP Data Portal.

Other Considerations

Constraints and other considerations include those discussed previously for air quality monitoring.

4.4 Biological Resources

Biological monitoring is focused on birds, fish, and aquatic food web (primary productivity, plankton, macroinvertebrates, and microbial metrics), as well as special-status species that occur in the study area (**Table 4-4**). Monitoring will characterize the current status of biological resources at the Salton Sea, which can be used to identify trends, guide future management actions, and serve as a basis of comparison to evaluate restoration projects. The seasonal monitoring schedule is summarized in **Table 4-5**.

4.4.1 Birds

Bird monitoring includes general waterbird surveys along the shoreline; surveys of piscivorous, colonial breeding, marsh, and colonial roosting birds; and surveys for dead and sick birds.

Rationale

As the Salton Sea ecosystem and its functions change, monitoring the abundance and distribution of the bird community will inform the need for construction of different habitat types by the SSMP, and provide a basis of comparison for evaluating the program's effectiveness at benefiting overwintering, migratory and breeding birds that depend most directly on the Salton Sea.

Waterbird Shoreline Survey

Metrics

Abundance (number of birds) by species by season and location. Environmental conditions (date, location in GPS, substrate, water depth, distance from shore) will be recorded contemporaneously.

Available Data Sources/Responsible Entity

CDFW and USFWS performed surveys of waterbirds along the shoreline from 2000 to 2015 by airboat. CDFW focuses on the northern portions of the Salton Sea, while USFWS focuses on the southern portions. Oasis Bird Observatory conducts weekly bird surveys of the north shore from 2014 to present (Orr et al. 2018). Since 2016, with the loss of boat access, surveys have been conducted on foot and all-terrain vehicle (Audubon 2019). Audubon California is currently conducting monthly surveys and Point Blue (formerly Point Reyes Bird Observatory [PRBO]) is currently conducting an annual shoreline survey on one day between November 15 and December 15 (S. Przeklasa, CDFW, pers. comm. 2021).

Indicator/Metrics	Priority	Method	Timing, Frequency	Location(s)	Entity
Waterbirds along shoreline and nearshore	Primary	General Waterbird Shoreline survey	5 or 6 times annually to capture seasonality during the late winter (January to February), spring migration (March to May), breeding season (February to October), early fall (September to October), and early winter (December to January)	30 existing monitoring stations, with an additional monitoring location proposed near the southern portion of the Wister Unit of the Imperial Wildlife Area	CDFW USFWS
Piscivorous Birds	Primary	Aerial survey using fixed wing aircraft	5 or 6 times annually during the late winter (January to February), spring migration (March to May), breeding season (February to October), early fall (September to October), and early winter (December to January)	26 existing aerial survey transect points around the perimeter of the Sea, and four aerial survey zones	CDFW
Colonial Breeding Birds	Primary	Aerial survey using fixed wing aircraft	Annually during peak breeding season (March to May)	26 existing aerial survey transect points around the perimeter of the Sea, and four aerial survey zones	CDFW
Marsh Birds	Primary	Marsh bird survey (Conway 2011)	3 times annually during the peak of breeding season (February to September)	80 existing survey points located within the Wister Unit of the Imperial Wildlife Area. Additional survey locations can be added for other marsh habitat in the future.	CDFW USFWS
Colonial Roosting Birds	Secondary	Aerial survey using fixed wing aircraft, followed by on-the- ground surveys (Shuford et al. 2000)	Annually during wintering season (January to March)	26 existing aerial survey transect points around the perimeter of the Sea, and additional survey locations can be added in the future	CDFW
Dead and Sick Bird Count	Secondary	Incidental observations during surveys on-foot or via airboats	Triggered by any mass-mortality event. Observations incidentally with other surveys performed	Anywhere in the Salton Sea area	CDFW
General Fish Survey	Primary	Seines, or gill nets with greater than 2-inch mesh	Triennially during the summer (July and August)	3 estuarine (river mouth) and 6 near- shore existing locations, as well as future constructed habitat ponds. Co-located with water quality nearshore sampling sites.	CDFW
Phytoplankton	Secondary	3-meter integrated sampler, Van Dorn water-collection device	Quarterly, concurrent with water quality sampling	Open water and shoreline locations at 3 estuarine and 8 near-shore locations. Co-located with water quality nearshore sampling sites.	CDFW

TABLE 4-4 BIOLOGICAL MONITORING

Indicator/Metrics	Priority	Method	Timing, Frequency	Location(s)	Entity
Zooplankton	Secondary	Plankton net	Quarterly, concurrent with water quality sampling	Open water and shoreline locations at 3 estuarine and 8 near-shore locations. Co-located with water quality nearshore sampling sites.	CDFW
Water-Column Macroinvertebrate	Primary	Plankton net to collect pelagic invertebrates, then sort and identify in lab	Quarterly, concurrent with water quality sampling	Open water and shoreline locations at 3 estuarine and 8 near-shore locations, as well as future constructed habitat ponds. Co-located with water quality nearshore sampling sites.	CDFW
Benthic Macroinvertebrate	Primary	Mini-Ponar or Ekman dredge to collect benthic sample, then sort and identify in lab	Quarterly, concurrent with water quality sampling	Open water and shoreline locations at 3 estuarine and 8 near-shore locations, as well as future constructed habitat ponds. Co-located with water quality nearshore sampling sites.	CDFW
Desert Pupfish	Primary	Baited minnow traps	3 times a year (April through October)	Mouths of major rivers, creeks, constructed habitat ponds and numerous drainages along the northern and southern perimeters of the Salton Sea	CDFW
Southwestern Willow Flycatcher	Primary	Protocol surveys for Southwestern Willow Flycatcher (USGS 2010b)	Annually (3 surveys; May to July)	Locations will be based on five existing IID survey locations, and future survey locations may be considered based on habitat mapping of riparian woodland areas at the Salton Sea	CDFW USFWS
Western Snowy Plover	Primary	Protocol surveys for Snowy Plover Surveys at the Salton Sea (Shuford et al. 2000).	Winter (January and November) when plovers are flocking and easiest to detect, and in breeding season (May)	Comprehensive surveys of the entire shoreline	CDFW

Resource Category	Indicator/Metrics	J	F	м	A	М	J	Ι.	J	A	S	0	N	D	Frequency per Year
Bird	General Bird Shoreline Surveys		Х		Х				Х		Х			х	5 times during the late winter (Jan–Feb), spring migration (Mar–May), breeding season (Feb–Oct), early fall (Sep–Oct), and early winter (Dec–Jan)
	Piscivorous Bird Surveys		Х		Х				Х		х			х	5 times during late winter (Jan–Feb), spring migration (Mar–May), breeding season (Feb–Oct), early fall (Sep– Oct), and early winter (Dec–Jan)
	Colonial Breeding Bird Surveys				Х										Once during peak breeding season (Mar–May)
	Marsh Bird Surveys			Х	Х	Х									3 times during peak breeding season (Feb–Sep)
	Colonial Roosting Bird Surveys		Х												Once during wintering season (Jan–Mar)
	Dead and Sick Bird Counts														Incidentally with other surveys performed
Fish	General Fish Surveys									Х					Triennially during the summer (Jul–Aug). May be conducted concurrent with
Plankton and	Phytoplankton and Zooplankton			Х			Х	(Х			Х	Quarterly, concurrent with water quality sampling
Macroinvertebrates	Water-Column Macroinvertebrate			Х			X	(Х			х	Quarterly, concurrent with water quality sampling
	Benthic Macroinvertebrate			Х			X	(Х			х	Quarterly, concurrent with water quality sampling
	Chlorophyll a			Х			X	(Х			х	Quarterly, concurrent with water quality sampling
Special-Status	Desert Pupfish				Х				Х			Х			3 times a year (Apr–Oct)
Species	Willow Flycatcher and Southwestern Willow Flycatcher					Х	X	ζ.	х						Annually (3 surveys; May–Jul)
	Western Snowy Plover	Х				X							Х		Winter (Jan and Nov) when plovers are flocking and easiest to detect, and in breeding season (May)

TABLE 4-5 BIOLOGICAL MONITORING SCHEDULE

NOTES:

Shaded areas indicate monthly or seasonal ranges in which biological monitoring surveys should occur.

"X" indicates specific intervals for surveys, but may be adjusted based on monthly or seasonal ranges specified in the "Frequency" column.

Responsible entities will be CDFW and USFWS. CDFW and USFWS can work in collaboration with other partners, such as Audubon California or Point Blue, to conduct surveys or supplement data.

Locations

Survey locations should be stratified amongst geographic areas (i.e., north and south) and habitat zones with consideration of future SSMP projects to provide baseline and/or reference data. Locations use the 30 existing monitoring stations used by CDFW and USFWS, with an additional monitoring location proposed near the southern portion of the Wister Unit of the Imperial Wildlife Area (**Figure 4-3, Bird Shoreline Survey Locations**). Since some of the existing monitoring stations along the Salton Sea shoreline are no longer near the water, these point locations should be expanded to be "zones" with parameters to adjust seaward at a right angle to the shore toward the receding shoreline. Any adjustments in sampling locations should be recorded using GPS.

Of the 31 monitoring locations, 16 monitoring stations are proposed as primary priority, and the remaining 15 monitoring stations are proposed as secondary priority (Figure 4-3). Priority monitoring locations have been identified based on proximity to other sampling locations, proximity to planned habitat impoundments and dust suppression projects, and consideration of potential constraints and limitations (e.g., staffing, budget, and/or accessibility, either physically or logistically due to landowner restrictions).

These existing monitoring stations were selected to take advantage of the data that has already been collected by previous surveys and can be used as a basis for comparison with future data. However, additional locations can be added in the future to capture future SSMP project areas and/or representative habitat areas not already encompassed that could provide additional important information on avian species composition, abundance, distribution, and their general use of habitat.

Timing/Frequency

The frequency of current shoreline surveys is monthly. However, if staffing and budget constraints are limiting factors, this frequency could potentially be reduced to five to six times annually to capture the seasonality of composition, abundance, and distribution during the late winter (January to February), spring migration (March to May), breeding season (February to October), early fall (September to October), and early winter (December to January) to assess variability during each season (USGS 2013; S. Przeklasa, CDFW, pers. comm. 2021).

Frequency could be further reduced to three times annually to reflect the months with the highest levels of bird use at the Salton Sea between 2016 to 2018 in fall (September), winter (February), and spring (April) (Audubon 2018; A. Jones, Audubon, pers. comm. 2021).


SOURCE: NAIP Imagery, 2020; CDFW, 2020; DWR, 2021.

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Methods

Avian surveys along the shoreline will be based on the methodology in *Area-Search Protocol for Surveying Shorebirds along Transects* (Point Blue Conservation Science 2014) for Area Search Transects. For each diurnal survey, surveyors will estimate of the number of birds using the shoreline areas (within 1.0 kilometer of the shoreline and 25 meters inland). Surveys will be conducted with the aid of binoculars and spotting scopes.

Now that boat access has been lost due to the declining water elevation, surveys are mainly conducted from the shore traveling by vehicle or on-foot depending on accessibility (Audubon 2019). The coordinates of each location will be recorded by using GPS. All birds observed will be identified to the species level (or lowest taxon possible) and enumerated. In addition, approximate locations where bird use is concentrated will be identified and recorded to the extent practical by using GPS, a combination of GPS and compass bearings (and distance determined by using a precision rangefinder) from known locations, or other reliable means.

When feasible, it would also be useful to note where the actual bird usage of habitat was and their distance to the shore (e.g., within open water, foraging along shoreline, within upland). Qualitative habitat information should be collected and permanent photo points established to detect long-term changes in habitat quality. Important microhabitat characteristics (e.g., deep water, water-shoreline interface, upslope) should also be recorded. Prominent habitat features (e.g., islands, isolated snags, levees, pilings and platforms, exposed rocky reefs, exposed sandbars, and shoreline pools) and other environmental attributes (e.g., substrate or vegetation type) thought to be important for bird use will be identified and noted, and their location recorded, during the surveys. Weather conditions, including ambient temperature, wind speed, wind direction, and sky condition will be recorded at the time of the survey.

Analysis

Survey data will be used to describe bird use (species composition, abundance, and distribution) on a seasonal and annual basis at the Salton Sea and to assess status and trends over time. Prior to sampling, the environmental attributes that are most likely to influence bird use of shoreline areas should be identified, and the selected environmental attributes and how they correspond to survey locations should be described in the detailed monitoring notes to help establish correlates of bird use with other ecological variables. Data collected for areas of concentrated bird use and data for associated environmental attributes will be used to guide management at the Salton Sea, such as the construction and management of habitats beneficial to birds.

Other Considerations

Landowner access may be difficult in some locations as private lands may require permission to access, and even some public lands, such as IID lands, may require encroachment permits. Some locations may also be physically inaccessible due to limited boat launch sites for access by water, and shorelines that are not traversable by vehicle or by foot due to sands, mud, and muck.

Although qualitative habitat information will be recorded, updating vegetation mapping via remote sensing (Section 4.2.1, Land Cover) is recommended every 1 to 3 years, as feasible.

Aerial Surveys (Piscivorous Bird)

Metrics

Abundance (number) of piscivorous birds by species, observation date, and location (transect and survey zone)

Available Data Sources/Responsible Entity

The CDFW has performed aerial counts for select waterbirds and waterfowl that may supplement this monitoring activity, but surveys were ceased 2019–2021. Ongoing CDFW aerial surveys have concentrated on enumerating cormorants and pelicans that use open water areas. Aerial waterfowl surveys performed by USFWS have not included offshore areas (USGS 2013).

The responsible entity will be CDFW. CDFW can work in collaboration with other partners, such as USFWS, Audubon California, or Point Blue, to conduct surveys or supplement data.

Locations

Piscivorous bird surveys will utilize existing aerial transect locations, which include 26 aerial survey station transect points around the perimeter of the Salton Sea, and four aerial survey zones in the north, south (Finney and Ramer Lakes), and east (Wister Unit of Imperial Wildlife Area) (**Figure 4-4, Bird Aerial Survey Locations**). These existing survey points were selected to take advantage of the data that has already been collected by previous surveys and can be used as a basis for comparison with future data. As the shoreline recedes, if some of the existing aerial survey station transect points and aerial survey zones are no longer near the water, these point locations and aerial survey zones can be adjusted seaward at a right angle to the shore toward the receding shoreline. Any adjustments in sampling locations should be recorded using GPS.

Timing/Frequency

Piscivorous bird surveys should be conducted five times annually to capture composition, abundance, and distribution during the late winter (January to February), spring migration (March to May), breeding season (February to October), early fall (September to October), and early winter (December to January) to assess variability during each season (USGS 2013; S. Przeklasa, CDFW, pers. comm. 2021).

However, if staffing, budget, and/or weather constraints (e.g., when it is cool enough to fly) are limiting factors, frequency could be reduced to three times annually to reflect the months with the highest levels of bird use at the Salton Sea between 2016 to 2018 in fall (November), winter (January), and spring (March) (Audubon 2018).

Methods

Piscivorous bird surveys will be conducted by aerial surveys using fixed—wing aircraft (plane). From the airport, the plane will meander across the aerial survey zones along the northern part of the Sea, then continues counterclockwise around the perimeter of the Sea along shoreline to each of the aerial survey station transect points. The plane will also meander across the aerial survey zones along the south and east.



SOURCE: NAIP Imagery, 2020; CDFW, 2020; DWR, 2021.

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For each aerial survey, at least two observers (counting on both sides of the plane) will estimate the number of piscivorous birds observed within a band approximately 300 meters on each side of survey transects (USGS 2013). Surveys will be conducted with the aid of binoculars. All birds observed will be identified to the lowest taxon possible and enumerated. Transects will be followed by using GPS, and approximate locations where bird use is concentrated will be identified to the extent practical by using GPS or other reliable means. In addition to observations of bird use (species, numbers, and spatial distribution), qualitative habitat information should be collected, important microhabitat characteristics where bird use is observed should be noted, and any prominent habitat features (e.g., islands, isolated snags, levees, pilings and platforms, exposed rocky reefs, exposed sandbars, and shoreline pools) and other environmental attributes (e.g., general substrate or vegetation type) in areas of concentrated use should be recorded. Photo points should also be taken at each aerial survey station transect point and aerial survey zones to detect long-term changes in habitat quality. Weather conditions, including ambient temperature, wind speed, wind direction, and sky condition, will be recorded at the time of the survey.

Analysis

Survey data will be used to describe piscivorous bird use (abundance and distribution) on a seasonal and annual basis at the Salton Sea and to assess status and trends over time. Data collected for areas of concentrated bird use and associated environmental attributes will be used to guide management, such as the design and creation of habitats beneficial to birds.

It is possible that individual birds can be counted in more than one stratum during coordinated monitoring activities. Thus, the analysis should consider reconciling these counts, or using data from various surveys to supplement each other (without overestimating abundance through duplicative counts) and develop the best estimate of overall bird abundance at the Salton Sea.

Other Considerations

During aerial surveys, there can be challenges in identifying birds to the species level and discriminating birds from other floating objects.

Colonial Breeding Bird Surveys

Metrics

Abundance (number) of colonial breeding birds by species, observation date, and location (transect and survey zone).

Available Data Sources/Responsible Entity

Breeding herons, egrets, ibises, and cormorants were monitored annually by the USFWS (Sonny Bono National Wildlife Refuge) between 1986 and 1999 (Molina and Sturm 2004). The Los Angeles County Natural History Museum performed long-term annual monitoring of breeding larids (gulls and terns) at the Salton Sea since 1992 (Molina 2004). Monitoring should be coordinated with other efforts carried out by the CDFW, USFWS, and Point Blue.

CDFW will be the responsible entity and can collaborate with other partners, such as USFWS, Los Angeles County Natural History Museum, Audubon California, or Point Blue, to conduct surveys or supplement data.

Locations

Colonial breeding bird surveys will utilize existing aerial transect locations, which include 26 aerial survey station transect points around the perimeter of the Salton Sea, and four aerial survey zones in the north, south, and east (Figure 4-4). These existing survey points were selected to take advantage of the data that has already been collected by previous surveys and can be used as a basis for comparison with future data. As the shoreline recedes, if some of the existing aerial survey station transect points and aerial survey zones are no longer near the water, these point locations and aerial survey zones can be adjusted seaward at a right angle to the shore toward the receding shoreline. Any adjustments in sampling locations should be recorded using GPS.

Timing/Frequency

Colonial breeding bird surveys will be conducted three times annually during the peak of breeding season (February to September), and can be conducted concurrently with piscivorous bird surveys as timing requirements allow. Surveys performed from February to March target great blue heron and double-crested cormorant colonies, and May target herons and egrets, which nest later (USGS 2013). Conducting multiple counts of a breeding colony during the breeding season is recommended to estimate peak abundance and variability, especially where birds nest in vegetation that may hinder detectability (Pacific Flyway Council 2013).

Methods

Colonial breeding bird surveys should minimize disturbance to breeding colonies. Because of the extreme conditions at the Salton Sea, investigator disturbance to the colonies could subject eggs and chicks to exposure and extreme heat, and under these conditions, even relatively short periods away from the nest by adult birds can result in mortality. Thus, the reproductive success of colonial breeding birds should be cautiously weighed against the benefits associated with the surveys and the potential for increased investigator disturbance to the colonies (USGS 2013; Pacific Flyway Council 2013).

It is recommended that adult birds should not be off a nest more than 10 to 30 minutes, and surveyors should exercise caution in the following conditions:

- Wind chill temperature is less than 65°F
- Conditions are sunny and air temperature is greater than 80°F
- Conditions are cloudy and air temperature is greater than 90°F
- It is raining or there is a high probability of rain
- Egg or chick predators are present and appear able to approach exposed nests
- The majority of the colony is in the nest-building or early incubation stage (USFWS 2008)

Colonial breeding bird surveys to locate nesting colonies will be conducted by aerial surveys using fixed-wing aircraft along shoreline and habitat areas, following existing protocol from *A Monitoring Strategy for the Western Population of Double-crested Cormorants within the Pacific Flyway* (Pacific Flyway Council 2013). As described in the piscivorous bird surveys above, from the airport, the plane will meander across the aerial survey zones along the northern part of the

Sea, then continue counterclockwise around the perimeter of the Sea along shoreline to each of the aerial survey station transect points. The plane will also meander across the aerial survey zones along the south and east. Flight altitudes may range between approximately 150 to 400 meters above the colony; however, altitudes may need to be adjusted to comply with local regulations or if flights cause disturbance to the colony (Pacific Flyway Council 2013).

For each aerial survey, an observer will locate nesting colonies. Surveys will be conducted with the aid of binoculars. Transects will be followed by using GPS, and approximate locations where bird use is concentrated will be identified to the extent practical by using GPS or other reliable means. Once a nesting colony is located, high-resolution photos or videos should be taken during aerial surveys for subsequent analysis to estimate the number of breeding pairs, as direct aerial counts can be unreliable. Aerial photographs can consist of a single photo of an entire island or nesting colony (usually using a 50 mm lens) or overlapping, close-up photos of colonies (using a 200 mm or 300 mm lens) (Pacific Flyway Council 2013). The aerial surveys can also be followed by aerial photography surveys via manned (fixed-wing) or unmanned (drone) flights or by ground or boat-based surveys (Pacific Flyway Council 2013, 2018). Qualitative habitat information should be collected and any prominent habitat features (e.g., islands, isolated snags, levees, pilings and platforms, exposed rocky reefs, exposed sandbars, and shoreline pools) and other environmental attributes (e.g., general substrate or vegetation type) in areas of concentrated use should be recorded. Photo points should also be taken at each aerial survey station transect point and aerial survey zones to detect long-term changes in nesting habitat quality. Weather conditions, including ambient temperature, wind speed, wind direction, and sky condition will be recorded at the time of the survey.

When enumerating nests from photographs, two or more independent counts of the image should be conducted. All observed nests will be identified to the lowest taxon possible. If the breeding status cannot be determined from aerial photographs, the location should be visited, if possible, to verify breeding status (Pacific Flyway Council 2013).

Analysis

Survey data will be used to describe colonial breeding bird use (species composition, abundance, and distribution) on an annual basis at the Salton Sea and to assess status and trends over time. Data collected for areas of concentrated bird use and data for associated environmental attributes will be used to guide management at the Salton Sea, such as the construction and management of habitats beneficial to birds.

It is possible that individual birds can be counted in more than one stratum during coordinated monitoring activities. Thus, the analysis should consider reconciling these counts, or using data from various surveys to supplement each other (without overestimating abundance through duplicative counts), and develop the best estimate of overall bird abundance at the Salton Sea.

Other Considerations

Landowner access may be difficult in some locations as private lands may require permission to access, and even some public lands, such as IID lands, may require encroachment permits. Some

locations may also be physically inaccessible due to limited boat launch sites for access by water, and shorelines that are not traversable by vehicle or by foot due to sands, mud, and muck.

Although qualitative habitat information will be recorded, updating vegetation mapping via remote sensing (Section 4.2.1, Land Cover) is recommended every 1 to 3 years, as feasible.

Marsh Bird Surveys

Metrics

Species composition, abundance, and distribution of marsh birds by habitat type, location, and date.

Available Data Sources/Responsible Entity

The Imperial Wildlife Area is managed by the CDFW and consists of three separate management units: Wister Unit (5,243 acres), Hazard Unit (639 acres), and Finney-Ramer Unit (2,047 acres). Approximately 4,000 acres of the Imperial Wildlife Area are managed as ponds that are seasonally flooded (October through late March or April) to support waterfowl. At the Wister Unit, 700 to 1,500 acres of permanently flooded impoundments are managed for rails (USGS 2013).

The Sonny Bono Salton Sea National Wildlife Refuge is managed by USFWS, and about 900 acres are managed as a mosaic of emergent freshwater vegetation and open water. The refuge has an established program to manage about 200 acres of its freshwater marsh area for Yuma clapper rail (and to a lesser extent, California black rail), and about 75 acres are managed as brackish water ponds near the Salton Sea shoreline for use by gull-billed terns and black skimmers. The refuge also has a pond that will be managed for desert pupfish, which were introduced in 2021. The remaining acreage of freshwater marsh is managed as seasonal marsh for use by waterfowl, and remains flooded from September through March or April, as well as for approximately 6 weeks in the summer to promote the growth of vegetation to provide forage for waterfowl during the fall (USGS 2013).

The responsible entities will be CDFW and USFWS. CDFW and USFWS can work in collaboration with other partners, such as IID, SCH, Audubon California, or Point Blue, to conduct surveys or supplement data.

Locations

The proposed marsh bird survey region uses 80 existing survey points located within the Wister Unit of the Imperial Wildlife Area (**Figure 4-5**, **Marsh and Riparian Bird Survey Locations**). This existing survey region was selected to take advantage of the data that has already been collected by previous surveys and can be used as a basis for comparison with future data. These locations may be selectively thinned out to align with the spacing outlined in the methods below (i.e., 400-meter spacing to minimize chances of double-counting individuals) as well as to help distribute marsh bird survey efforts throughout other marsh bird habitat areas that have established surrounding the Salton Sea. As the shoreline recedes, if some of the existing survey points are no longer comprised of marsh habitat, these point locations can be adjusted seaward at a right angle to the shore to encompass new areas of marsh habitat that may establish. Any adjustments in sampling locations should be recorded using GPS.



SOURCE: NAIP Imagery, 2020; CDFW, 2020; DWR, 2021.

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Other marsh habitat areas were identified and mapped by CDFW, which included managed marshes within wildlife refuges and created habitat (e.g., Imperial Wildlife Area – Wister Unit, Sonny Bono National Wildlife Refuge, IID Managed Marsh, SCH) as well as unmanaged marshes at the perimeter of the Salton Sea. Unmanaged marsh areas could be ground-truthed to determine habitat suitability for marsh bird species. Additional survey locations can be added in the future to capture future SSMP project areas and/or representative habitat areas not already encompassed that could provide additional important information on marsh bird species composition, abundance, distribution, and general use of habitat. Based on where other areas of marsh habitat may exist or establish, any additional future marsh bird survey locations should be conducted in a randomly selected subset of sampling points along marsh-upland interfaces and marsh-open water interfaces (placed 400 meters apart to minimize chances of double-counting individuals), and, where feasible, in proximity to SSMP projects.

Timing/Frequency

Marsh bird surveys should be conducted annually during peak breeding season (i.e., March to May). Survey timing should be conducted in accordance with the *Standardized North American Marsh Bird Monitoring Protocols* (Conway 2011) and consist of three replicate surveys, each consisting of a 10-day window, since three replicates per season provides data on temporal variation in numbers counted. Each of the 10-day windows should be separated by at least 7 days. The first survey should be conducted when migratory passage is over but prior to breeding. To estimate trends over time in the number of breeding adults, all three annual surveys should be completed prior to the initiation of juvenile vocalizations.

Vocalization probability is typically highest in the hour surrounding sunrise and the hour surrounding sunset. Survey routes can be either morning or evening survey routes, as long as each survey route is consistently surveyed during the same period (morning or evening) every year. Morning surveys begin 30 minutes before sunrise (first light) and must be completed by 10:00 AM, while evening surveys begin 4 hours before sunset and must be completed by dark.

Methods

Marsh bird surveys should follow the methodology in the *Standardized North American Marsh Bird Monitoring Protocols* (Conway 2011) using broadcast calls to elicit vocalizations, since many marsh birds are secretive, seldom observed, and vocalize infrequently. Birds observed during a passive period prior to broadcasting calls will also be recorded.

Once the survey area is selected, the surveyor should choose the initial survey point randomly based on all possible locations of marsh-upland interfaces and marsh-open water interfaces, and subsequent survey points should be at regular intervals of 400 meters. Some marshes may be more effectively surveyed by boat (with survey points on the open water-emergent interface) and others more effectively surveyed on foot (with survey points on the upland-emergent interface). Surveys on foot typically minimize travel time between adjacent points, reduce trampling vegetation within the marsh, and may increase the distance at which observers can hear vocalizing birds due to increased elevation relative to the marsh vegetation.

At each survey point, the surveyor will record all primary species (rails, bitterns, and pied-billed grebe) detected during both a 5-minute passive period prior to broadcasting recorded calls, and during a period in which pre-recorded vocalizations are broadcast into the marsh. The broadcast includes calls of the primary marsh bird species that are expected breeders in that area. The surveyor should record when each individual is detected during any of the initial 1-minute passive segments, and/or during any of the 1-minute call-broadcast periods. The surveyor should also estimate the distance from each individual bird to the survey point (using the location when it is first detected birds will approach the call broadcast) to use distance sampling to estimate density for each species in each habitat type. The distance between adjacent survey points should be 400 meters or greater to avoid the risk of double-counting individual birds as well as to increase the total area covered by monitoring efforts in a local area. Use of passive recorders may also be effective to detect marsh birds.

Qualitative habitat information should be collected, and the surveyor should visually estimate the proportion of each major habitat type within a 50-meter radius circle around each survey point. Important microhabitat characteristics where bird use is observed (e.g., in water, tules) should also be recorded. Aerial photographs will be used to periodically determine the amount of each major habitat type to detect long-term changes in habitat quality. Weather conditions, including ambient temperature, wind speed, wind direction, and sky condition will be recorded at the time of the survey.

Analysis

Survey data will be used to describe marsh bird use (species composition, abundance, and distribution) on an annual basis at the Salton Sea and to assess status and trends over time. Data collected for areas of concentrated bird use will be used to guide management at the Salton Sea, such as the construction and management of habitats beneficial to birds.

It is possible that individual birds can be counted in more than one stratum during coordinated monitoring activities. Thus, the analysis should consider reconciling these counts, or using data from various surveys to supplement each other (without overestimating abundance through duplicative counts) and develop the best estimate of overall bird abundance at the Salton Sea.

Other Considerations

Landowner access may be difficult in some locations as private lands may require permission to access, and even some public lands, such as IID lands, may require encroachment permits. Some locations may also be physically inaccessible due to limited boat launch sites for access by water, and shorelines that are not traversable by vehicle or by foot due to sands, mud, and muck.

Although qualitative habitat information will be recorded, updating vegetation mapping via remote sensing is recommended every 1 to 3 years, as feasible.

Colonially Roosting Bird Surveys

Metrics

Number of colonially roosting birds by species, location, and year.

Available Data Sources/Responsible Entity

The USFWS currently completes annual roost surveys for sandhill cranes (USGS 2013).

The responsible entity will be CDFW. CDFW can work in collaboration with other partners, such as USFWS, to conduct surveys or supplement data.

Locations

Monitoring locations for colonial roosting bird surveys will follow the locations outlined for piscivorous bird surveys and colonial breeding bird surveys and will also be based on past survey results and local information on roosting site locations. If other roosting areas are discovered or changes in roosting behavior are identified, additional sites can be added. Roosting locations could be located in the shoreline, halophytic scrub, agricultural land, or created freshwater impoundment geographic strata (USGS 2013). Any adjustments in sampling locations should be recorded using GPS.

Timing/Frequency

Colonial roosting bird surveys will be conducted annually during wintering season (January to March).

Methods

Colonial roosting bird surveys will follow the methods outlined for piscivorous bird surveys and colonial breeding bird surveys. Once located from aerial surveys, on-the-ground colonial roosting bird surveys will be conducted based on the methodology in the *Avifauna of the Salton Sea: Abundance, Distribution, and Annual Phenology* (Shuford et al. 2000) for Comprehensive Shoreline Survey at the Salton Sea to provide an estimate of the number of waterbirds roosting in areas near the Salton Sea on the days of the survey. Bird counts will be taken simultaneously at three to six sites on each survey. At least two observers will be in place 1.5 hours before dusk to count the number of great blue herons, egrets, white-faced ibises, and sandhill cranes that arrive or depart from each site before nightfall. The survey will end either when birds stop arriving or once it becomes too dark to make observations. To calculate the net total use of the roost site while reducing the likelihood of double-counting birds that leave sites before dark to eventually roost at another site, the departures will be subtracted from the total sum of those birds present at the onset of the count and those birds that arrived during the survey.

All roosting birds observed will be identified to the species level (or lowest taxon possible) and enumerated to estimate of the number of roosting birds at individual roost sites. Habitat characteristics of the roost sites and important microhabitat characteristics where bird use is observed will also be recorded at the time of the survey.

Analysis

Survey data will be used to describe colonial roosting bird use (species composition, abundance, and distribution) and to assess status and trends over time. Data collected for areas of concentrated bird use and data for associated environmental attributes may be used to help identify attributes that support successful roosting, which could inform restoration projects or

habitat creation. Note that survey results provide a "snapshot" of bird use on the day of each survey and does not provide precise quantitative estimates of comprehensive bird use at roost sites around the Salton Sea.

Other Considerations

Landowner access may be difficult in some locations as private lands may require permission to access, and even some public lands, such as IID lands, may require encroachment permits. Some locations may also be physically inaccessible due to limited boat launch sites for access by water, and shorelines that are not traversable by vehicle or by foot due to sands, mud, and muck.

Although qualitative habitat information will be recorded, updating vegetation mapping via remote sensing is recommended every 1 to 3 years, as feasible.

Dead and Sick Bird Counts

Metrics

The specific metrics include dead and sick bird species composition, abundance, and distribution to detect outbreaks of disease, and is considered a secondary priority for monitoring.

Available Data Sources/Responsible Entity

CDFW and USFWS currently track bird mortality events at the Salton Sea (USGS 2013). The responsible entity will be CDFW. CDFW can work in collaboration with other partners, such as USFWS, to continue ongoing efforts or supplement data.

Locations

Disease outbreaks can occur anywhere in the Salton Sea area and within any of the geographic strata. However, most sick and dead birds have been observed near the river mouths and other freshwater areas around the Salton Sea (K. Riesz, CDFW, pers. comm. 2011), and detection of these outbreaks is most likely in the visible open water and shoreline areas of the Salton Sea (USGS 2013). Once dead or sick birds are detected, monitoring will be conducted in the locations where the disease outbreak occurred. Any locations where dead or sick birds are found should be recorded using GPS.

Timing/Frequency

Surveys will be conducted incidentally with other surveys performed to detect disease outbreaks. Once a disease outbreak is detected, the frequency of sampling can be increased as necessary where significant mortality has been detected.

Methods

Dead and sick birds will be collected, identified to the species level (or lowest taxon possible), and enumerated. Samples will be retained from diseased birds and analyzed to determine the causal agent and mode of transmission. Access and methodology to retrieve dead or sick birds will depend on location, but will likely be either on foot or via airboats; however, other collection methods can be used as appropriate. Habitat and microhabitat characteristics will also be recorded at the time of the survey.

Analysis

Data from counts of dead and sick birds will be used to describe and to assess changes in the incidence of avian disease outbreaks (timing, magnitude, and species affected) on an annual basis. This data can be used in combination with data collected from other surveys, such as other environmental attributes that may influence avian health, abundance, and distribution, to identify factors that affect the incidence of avian disease outbreaks at the Salton Sea. This information could be used to guide management activities at the Salton Sea and possibly the construction and management of created habitats.

Other Considerations

Landowner access may be difficult in some locations as private lands may require permission to access, and even some public lands, such as IID lands, may require encroachment permits. Some locations may also be physically inaccessible due to limited boat launch sites for access by water, and shorelines that are not traversable by vehicle or by foot due to sands, mud, and muck.

4.4.2 Fish

General Fish Surveys

At one time, the Salton Sea supported a robust marine sport fishery that included orangemouth corvina, Gulf croaker, and sargo (Hurlbert et al. 2007; USBR 2016). Increasing salinity eliminated the marine fishery, leaving only the euryhaline tilapia. Tilapia numbers in the Salton Sea have declined greatly in recent years as salinity levels exceed 60 g/L (CDFW and USFWS 2017).

Rationale

Increasing salinity has altered the fish community composition and abundance, which in turn has affected several species of piscivorous birds that depend on fisheries resources in the Salton Sea. Information about the spatial distribution, abundance, and size distribution of fishes and the environmental factors that support them would be useful in the design and evaluation of habitat ponds.

Metrics

Standardized (per unit effort) abundance (number) by species, length, date, and location.

Available Data Sources/Responsible Entity

The CDFW previously performed seasonal gillnet sampling at the Salton Sea until boat launching access deteriorated in 2008 (CDFG 2008). In 2017 CDFW and USFWS conducted gillnet sampling to determine whether the tilapia population was still viable in 2017 (CDFW and USFWS 2017).

CDFW will be the responsible entity, working in collaboration with other partners to conduct surveys or supplement data.

Location

Six sampling locations (three estuarine locations near river mouths and three near-shore locations) are priority sites (**Figure 4-6, Fish and Aquatic Resources Survey Locations**) (CDFW and USFWS 2017). These locations were prioritized from the original set of sampling locations (CDFW 2008; CDFW and USFWS 2017; S. Keeney CDFW pers. comm. 2021). These sites were selected on the basis of most productive sampling locations, most efficient use of resources and effort, and potential constraints and limitations (e.g., due to accessibility from limited boat launch sites, adequate boats/equipment, staffing, and/or budget).

To the extent feasible, sampling locations should be similar in depths and substrates to locations previously sampled by the CDFW during their quarterly gillnet sampling (CDFG 2008). However, this may not be feasible if gear is switched to seines. Sampling locations may be adjusted seaward at a right angle to the shore as necessary to successfully deploy the nets. Any adjustments in sampling locations should be recorded using GPS.

Timing/Frequency

Fish surveys should be conducted during the summer (July and August), or possibly fall (October and November) for better conditions for fish, although winds may be more challenging in the fall, especially if accessing sampling locations via an airboat. Fish surveys are recommended once every three years (triennially).

Methods

Two methods are proposed to provide operational flexibility: beach seining (which may minimize risk of take for desert pupfish) and gill netting (the traditional method of Salton Sea fish surveys, (CDFW and USFWS 2017)).

Sampling should be conducted by seines deployed from shore or using a small boat. Depending on the length of the seine net and the site conditions, two different methods may be used. Nearshore sampling will use a beach seine (e.g., a 3-foot by 10-foot seine with 1/8-inch [3-millimeter] mesh, or similar). Two biologists will each hold a pole attached to one end of the seine net with the float line on top and the lead-weighted line on the bottom. One biologist will stand near the water's edge while the other biologists will walk perpendicular from the shore into shallow water (no deeper than 3 feet). Both biologists will then walk parallel to the shoreline. At the end of a seine haul (approximately 30 feet depending on site conditions), the nearshore biologist will stop and the offshore biologist will pivot and drag the net toward shore. When the shoreline is reached, both biologists will push the net bottom up onto shore while keeping the float line elevated so captured fish will not escape under or over the net back into the water. For each seine haul, the area sampled will be quantified.

Although beach seining is very effective for nearshore small fishes, it is not as effective for larger, faster fish that tend to use deeper/open water. Thus, a longer bag seine net (e.g., up to 100-foot by 6-foot) deployed via a small boat may be used to sample deeper water and enclose larger areas and would be an effective method for capturing multiple size classes of bottom-oriented, mid-water, and near-shore species. Additionally, this method (i.e., bag seine net deployed via small boat) may be used if sampling of the nearshore environment is impractical on foot due to substrate conditions such as deep mud.



SOURCE: NAIP Imagery, 2020; CDFW, 2020; DWR, 2021.

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Alternatively, sampling may follow previous methodology using gill nets (CDFW and USFWS 2017). Sampling by gill nets should only be conducted in areas of deeper water by deploying multi-panel monofilament gill nets (e.g., 6-foot by 30-foot panels) of 2-, 3-, and 4-inch mesh. Due to the potential for desert pupfish to occur within the Salton Sea and its tributaries, mesh size smaller than 2 inches should not be used to avoid any potential incidental take of this federal and state endangered species. Two nets should be set at all sites at the water's surface, spaced far enough apart to allow for a boat to maneuver to set and retrieve the nets (e.g., approximately 100 to 200 meters). Nets at near-shore and estuarine sites should be set in 2.5 to 4.5 meters of water, typically 200 to 300 meters from the shore. Nets should be set at one or two sites in the morning, then hauled in after approximately 24 hours. The exact number of hours each net is set should be recorded to the nearest quarter-hour.

When nets are retrieved the following day, fish should be removed. For population surveys, fish will be kept alive in aerated containers of ambient water, measured, and released. For fish caught for selenium accumulation, the fish will be caught and immediately stored on ice to be preserved for tissue analysis. Data for fish should be recorded immediately (i.e., day of capture), including species and number. If any tilapia are caught, the following data should also be recorded: length (fork length), sex, physical condition, and reproductive status. Lengths of fish under 50 centimeters should be recorded to the nearest millimeter, and lengths of fish over 50 centimeters should be recorded to the nearest centimeter.

At the time of each sampling event or gillnet set and retrieval, data should be recorded for water depth, water temperature, conductivity, salinity, and dissolved oxygen. Qualitative habitat information should be collected, important microhabitat characteristics where fish use is observed should be noted, and any prominent habitat features (e.g., river mouths, islands, levees) and other environmental attributes (e.g., general substrate or vegetation type) in areas of concentrated use should be recorded. Photo points should also be taken to detect long-term changes in habitat quality.

Analysis

Catch-per-unit-effort (CPUE) calculated from the catch and effort data, or other indices of abundance of fish at the Salton Sea, will be used to assess status and trends in fish populations on an annual basis. Data collected from the fish surveys can be used in combination with other information, such as other environmental attributes and data collected during other surveys, to guide management activities at the Salton Sea, such as the design and management of saline water bodies to conserve fish and wildlife, and the potential inoculation of created ponds with larger fish from the Salton Sea (e.g., tilapia, mollies) that could be a food source for terns and other piscivorous birds.

Other Considerations

Access may be difficult in some locations due to limitations with boat launching sites. Sampling locations will likely depend on accessibility to the Sea. The timing of fish surveys (summer period July-August) could be adjusted to be concurrent with other aquatic sampling of plankton, invertebrates, and water quality in the Salton Sea.

4.4.3 Plankton and Macroinvertebrates

Rationale

Phytoplankton, zooplankton and macroinvertebrate organisms form the foundation of the aquatic food chain, which supports fishes and birds (USGS 2013). The aquatic community will continue to change in response to increasing salinity, both in terms of species composition and abundance (such as the decline of pileworms and increase in more saline-tolerant species such as brine flies and brine shrimp) and trophic relationships (such as loss of fish predators, change in invertebrate grazers and predators, and effects on phytoplankton community and density). Monitoring information could support the conservation of fish and birds by informing the design and management of created impoundments.

Phytoplankton

Metrics

Chlorophyll a concentration is the first indicator of primary productivity. If chlorophyll a levels are lower than expected, or if the zooplankton community appears to be food-limited, then that could trigger a more in-depth analysis using phytoplankton community composition and density.

Available Data Sources/Responsible Entity

There are currently no similar monitoring activities underway at the Salton Sea, although researchers at San Diego State University have previously collected and analyzed samples for phytoplankton (e.g., Tiffany et al. 2007).

CDFW will be the responsible entity and may collaborate with other partners to conduct surveys or supplement data.

Locations

Phytoplankton sampling will be conducted at the same locations as fish survey sites. The locations in the open-water stratum will be selected where depths exceed 9 meters. The locations in the shoreline stratum will be in depths of 2 to 8 meters and randomly distributed around the perimeter of the lake or stratified to include representative sampling sites with consideration to physical accessibility. Sample locations will be identified in the field by using GPS.

Timing/Frequency

Sampling will occur quarterly (seasonal sampling) to capture variations in biota (Hill et al. 2016).

Methods

Phytoplankton samples will be collected in the open-water stratum by using a 3-meter integrated sampler (tube or other appropriate device) to collect samples from the 0- to 3-meter, 3- to 6-meter, and 6- to 9-meter depth ranges, as described in Tiffany et al. (2007). Samples will be mixed in the field, and samples for analysis will be taken from the composite.

Assuming the shallow shoreline areas are adequately mixed to provide a good estimate of average conditions throughout the vertical water column, the shoreline stratum will be sampled by using a

Van Dorn (or similar) water-collection device of known volume to collect phytoplankton from the middle of the vertical water column. Samples will be preserved with Lugol's iodine solution for later analysis (IEP 2017b).

Separate samples for analysis of chlorophyll a concentration will be taken from the composite, filtered in the field, and preserved by freezing of the intact filter for later analysis. An adequate number of replicates will be collected and analyzed at each station to allow for an estimate of sample variability. All organisms will be identified to the lowest taxonomic level practical, and species that are difficult to identify can be analyzed as a group (e.g., small flagellates).

At each sampling location, environmental attributes will be recorded, including water depth, conductivity, temperature, dissolved oxygen and turbidity. Prominent habitat features and other environmental attributes will also be recorded.

Analysis

Phytoplankton species composition and density will be used to assess status and trends over time. Replicate samples will be used to assess sample variability to compare changes in phytoplankton density over time. Monitoring data collected, in combination with other surveys, will help to identify important ecological variables that affect phytoplankton populations at the Salton Sea and guide management activities, such as the construction and management of created saline impoundments.

Other Considerations

Access may be difficult in some locations due to limitations with boat launching sites.

Zooplankton

Metrics

Composition and density of taxonomic groups by location and date.

Available Data Sources/Responsible Entity

Zooplankton studies were conducted in 1997–1999 in the open water of the Salton Sea at lower salinities (43,000 mg/L) and in 2004 at the USGS/USBR saline impoundments (Miles et al. 2009), but no similar monitoring is currently underway. CDFW will be the responsible entity, and may collaborate with other partners to conduct surveys or supplement data.

Locations

For sampling efficiency and comparison across the aquatic community, zooplankton sampling will be conducted at the same locations as fish survey sites around perimeter of the Sea. Sampling will be conducted in open water and shoreline locations. The locations in the open-water stratum will be selected where depths exceed 9 meters. The locations in the shoreline stratum will be in depths of 2 to 8 meters and stratified to include representative sampling sites with consideration to physical accessibility. Sample locations will be identified in the field by using GPS.

Timing/Frequency

Sampling will occur quarterly (seasonal sampling) to capture variations in biota (Hill et al. 2016).

Methods

In the open-water stratum, zooplankton can be sampled by performing vertical tows from near the bottom to the surface of the lake by using a standard, 80-µm mesh zooplankton net or with a Schindler-Patalas trap (or other suitable collection device with a known volume) at specific intervals in the water column (Tiffany et al. 2002). A flow-meter will be installed in the net to estimate the sampled volume.

In the shallower shoreline stratum, samples can be collected by using a suitable collection device with a known volume (for example, Schindler-Patalas trap) to collect zooplankton from the middle of the water column; however, an alternative sampling device, capable of sampling the entire water column, could be necessary. Alternatively, samples could be collected by pulling a hand-held net through the water at a constant speed for 20 seconds (Miles et al. 2009).

Replicate samples will be collected and analyzed at each station, and all organisms identified to the lowest taxonomic level practical. Some species that are difficult to identify could be analyzed as a group. Samples will be preserved for later analysis. An adequate number of replicates will be collected for an estimate of sample variability.

At each sampling location, environmental attributes will be recorded, including water depth, conductivity, temperature, dissolved oxygen and turbidity. Prominent habitat features and other environmental attributes will also be recorded. Water grab samples will be collected near the surface for analysis of phytoplankton and nutrients.

Analysis

Zooplankton community composition and density will be used to assess status and trends over time. Replicate samples will be used to assess sample variability to compare changes in phytoplankton density over time. Monitoring data collected, in combination with other surveys, will help to identify important ecological variables that affect zooplankton populations at the Salton Sea and guide management activities, such as the construction and management of created saline impoundments.

Other Considerations

Access may be difficult in some locations due to limitations with boat launching sites.

Water-Column Macroinvertebrates

Metrics

Species composition and abundance of water-column macroinvertebrates by location and date.

Available Data Sources/Responsible Entity

There are currently no similar monitoring activities underway at the Salton Sea, although researchers at San Diego State University have previously collected and analyzed samples for macroinvertebrates (e.g., Detwiler et al. 2002).

The responsible entity will be CDFW. CDFW may work in collaboration with other partners to conduct surveys or supplement data.

Locations

For sampling efficiency and comparison across the aquatic community, water column macroinvertebrate sampling will be conducted at the same locations as fish survey sites around perimeter of the Sea. Sampling will be conducted in open water and shoreline locations. The locations in the open-water stratum will be selected where depths exceed 9 meters. The locations in the shoreline stratum will be located in depths of 2 to 8 meters and be stratified to include representative sampling sites around the Salton Sea perimeter with consideration to physical accessibility. Sample locations will be identified in the field by using GPS.

Timing/Frequency

Sampling will occur quarterly (seasonal sampling) to capture variations in biota (Hill et al. 2016).

Methods

Water-column macroinvertebrate samples will be collected by using a large mesh (approximately 1 millimeter), large diameter (0.5 meters) plankton net towed through the water column (or other suitable collection device, such as a Schindler-Patalas trap). Deep-water samples will be collected by using vertical tows from the bottom to the surface of the Sea, or by trapping at specific water depths. Shallow-water samples will be collected by using horizontal, mid-water tows or by trapping along a transect. A flow meter will be installed in the net to estimate the sampled volume, and samples will be preserved for later analysis. An adequate number of replicates will be collected and analyzed at each station to allow for an estimate of sample variability. All organisms will be identified to the lowest taxonomic level practical, and species that are difficult to identify can be analyzed as a group.

At each sampling location, environmental attributes will be recorded, including water depth, conductivity, temperature, dissolved oxygen and turbidity. Prominent habitat features and other environmental attributes will also be recorded. Water grab samples will be collected near the surface for analysis of phytoplankton and nutrients.

Analysis

Water-column macroinvertebrate community composition, abundance, and distribution will be used to assess status and trends over time. Replicate samples will be used to assess sample variability to compare changes in macroinvertebrate community composition, density, and abundance over time. Monitoring data collected, in combination with other surveys, will help to identify important ecological variables that affect water-column macroinvertebrate populations at the Salton Sea and guide management activities, such as the construction and management of created saline impoundments.

Other Considerations

Access may be difficult in some locations due to limitations with boat launching sites.

Benthic Macroinvertebrates

Metrics

Species composition and abundance of benthic macroinvertebrates by location, substrate and date.

Available Data Sources/Responsible Entity

There are currently no similar monitoring activities underway at the Salton Sea, although researchers at San Diego State University have previously collected and analyzed samples for macroinvertebrates (e.g., Detwiler et al. 2002).

The responsible entity will be CDFW. CDFW may work in collaboration with other partners to conduct surveys or supplement data.

Locations

In years when fish surveys occur, benthic macroinvertebrate sampling will be conducted concurrently at the same locations for sampling efficiency and comparison across the aquatic community (6 locations, Figure 4-6). Sampling will be conducted in shoreline locations, because it is unlikely that benthic invertebrates would be thriving in deep anoxic waters. The samples in the shoreline stratum will be taken in depths of 2 to 8 meters and stratified to include representative sampling sites with consideration to physical accessibility. Sample locations will be identified in the field by using GPS.

Timing/Frequency

Sampling will occur quarterly (seasonal sampling) to capture variations in biota (Hill et al. 2016; Detwiler et al. 2002).

Methods

Benthic macroinvertebrate samples taken will be collected from soft substrates by using a mini-Ponar or Ekman dredge in deeper waters, or a steel corer for very shallow depths (Detwiler et al. 2002). Samples will be taken from the top 10 to 20 centimeters of sediment over a known surface area. Samples will be sieved in the field with a 0.5-millimeter mesh sieve, and collected for analysis. Hard substrates will be sampled with a scraper (Detwiler et al. 2002) or other suitable collection device, and samples from barnacle shell substrates will be collected by using a suitable coring device. Three replicate samples will be collected at each station to provide an estimate of sample variability. Samples will be preserved in the field with a solution of buffered 3.4 percent formaldehyde with rose Bengal added (Detwiler et al. 2002).

At each sampling location, environmental attributes will be recorded, including water depth, conductivity, temperature, dissolved oxygen and turbidity. Prominent habitat features and other

environmental attributes will also be recorded. Water grab samples will be collected near the surface for analysis of phytoplankton and nutrients.

In the laboratory, each sample will be subsampled and organisms sorted from associated debris. Sediment properties such as particle size, nutrients and organic carbon will be measured. All organisms will be identified to the lowest taxonomic level practical, and species that are difficult to identify can be analyzed as a group.

Analysis

Benthic macroinvertebrate community composition, abundance, and distribution will be used to assess status and trends over time, and any associations with environmental conditions at the time of collection (water quality, sediment). Replicate samples will be used to assess sample variability over time and among sites. Monitoring data will help to identify ecological variables that affect benthic macroinvertebrate populations, which can inform siting and design of created impoundments.

Other Considerations

Access may be difficult in some locations due to limitations with boat launching sites.

4.4.4 Special-Status Species

Special-status species documented in the Salton Sea area include desert pupfish and numerous birds and reptiles. Monitoring of birds and fish in general is described in Section 4.4.1, Birds, and Section 4.4.2, Fish. Additionally, the following special-status birds would be encompassed within monitoring surveys already described, including Yuma Ridgeway's rail and California black rail (in *Marsh Bird Surveys*), American white pelican and California brown pelican (in *Piscivorous Bird Surveys* and *Colonial Breeding Bird Surveys*), and gull-billed tern (in *General Bird Surveys*).

This section describes monitoring specifically for desert pupfish, and two special-status birds, southwestern willow flycatcher and western snowy plover.

Ongoing ecosystem change coupled with management actions such as playa dust control and restoration projects are likely to affect habitat availability and quality for desert pupfish, southwestern willow flycatcher, and western snowy plover. Monitoring these species' distribution and abundance will reduce impacts by identifying existing populations and habitats, informing the design of projects, and monitoring the program's effectiveness at benefiting these species.

The construction and management of restoration projects could also affect other special-status species found within the vicinity of the Sea (e.g., Colorado Desert fringe-toed lizard, flat-tailed horned lizard, and burrowing owl, among others). Therefore, although these species are not dependent on the aquatic and shoreline habitats of the Salton Sea, data collected via incidental observations during monitoring surveys to document their distribution, which could support their conservation by informing avoidance and minimization of impacts during management of existing habitats and construction of restoration projects. However, it is anticipated that prior to implementation of restoration projects, habitat assessments and appropriate surveys (e.g., protocol

surveys, pre-construction surveys) for special-status species with potential to occur would be conducted as needed for project-specific areas.

Desert Pupfish Surveys

The desert pupfish is a federal and state endangered species that inhabits small tributaries and irrigation drains, as well as shoreline pools at the end of the tributaries and agricultural drains (Saiki et al. 2010). Desert pupfish populations in and near the Salton Sea are influenced by changes in water quality, water quantity (habitat desiccation is occurring at scattered locations throughout the Salton Basin due to invasive vegetation, climate change, seismic activity, canal lining, and lowering of the groundwater table), water surface elevation at the Salton Sea, interactions with non-native fish species, and possibly by habitat creation associated with restoration.

Metrics

Abundance (presence and number) and size distribution of pupfish by survey location within the tributaries and shoreline of the Salton Sea.

Available Data Sources

From 2014 to 2019, CDFW performed desert pupfish sampling on an annual, bi-annual, monthly, and more frequent basis (depending on habitat) at selected drains at the north and south ends of the lake, at the marina and other shoreline areas, at washes near Hot Mineral Springs, at San Felipe Creek, at Salt Creek (lower and upper), and at refuge (artificial) habitats (Keeney 2009; Idrisi 2019). The USGS also has performed desert pupfish sampling in drains, ponds, creeks, and created saline impoundments in the Imperial Valley and Coachella Valley (Martin and Saiki 2005, 2009; Saiki 1990; Saiki et al. 2008, 2011).

Responsible Entity

The responsible entity will be CDFW. CDFW can work in collaboration with other partners, such as USFWS, to conduct surveys or supplement data.

Locations

Desert pupfish sampling sites can be co-located with general sampling sites for fish monitoring near the mouths of the Whitewater River, New River, Alamo River, North Shore Marina, and Salt Creek. Sampling should also include additional locations at San Felipe Creek, Varner Harbor, and Hot Mineral Springs, as well as numerous drainages along the northern and southern perimeters of the Salton Sea (e.g., CVWD and IID drains) (Figure 4-6).

Timing/Frequency

Pupfish monitoring will occur three times a year (April through October). Spring sampling should occur from April to May and would provide an index of abundance after overwintering mortality. Summer sampling should occur from June to August and should consider site-specific conditions (e.g., desiccation occurs during the mid to late summer at Salt Creek so sampling of pupfish in this location cannot occur at this time). Early fall sampling should occur from September to October and would provide an assessment of reproductive success and recruitment.

Methods

Desert pupfish surveys will be conducted using baited minnow traps in selected tributaries, irrigation drains, refuges (artificial habitat), shoreline pools/ponds, and the Salton Sea. No gill netting should be conducted for desert pupfish surveys. Seining is less effective, due to underwater snags and difficulties landing a seine, as well as pupfish escape behavior of diving into soft sediment under the seine's lead line (Keeney 2016). Also, seining is more stressful to juveniles, and is potentially destructive to eggs and habitat.

The preferred capture method for desert pupfish is baited minnow traps, specifically Gee's minnow trap (9-inch by 17.5-inch, with 1/8-inch-square mesh and double funnel-mouth entrances) of galvanized steel wire. The mesh size should be no larger than 1/8-inch mesh to capture juvenile and adult desert pupfish. Traps should not be of the collapsible type as these may cause injury or kill desert pupfish if fish are trapped in corners of minnow traps (S. Keeney, CDFW, pers. comm. 2021). The traps are baited with perforated plastic bags, each filled with 1 ounce of fish-flavored canned cat food. The traps are typically deployed in water at least 9 inches deep, sufficient to cover the entire trap.

Traps are set only during the day since pupfish are most active during the day. The preferred duration of trap sets is a minimum of 2 hours, unless traps need to be pulled because of deteriorating conditions (e.g., very low dissolved oxygen, high water temperature) that could jeopardize the pupfish. Overnight sets may result in pupfish mortality due to changes in water quality and sometimes water quantity, presence of too many fishes in traps, vandalism, theft of traps, storm events, and other possible causes. Spacing can be variable due to difference in habitats surveyed, but in the drains, traps should generally be spaced 25 to 50 feet apart.

Dip netting can also be used, especially in isolated small areas. Fish capture will be conducted with care taken to minimize the amount and duration of handling and stress as well as exposure to heat, low dissolved oxygen, and crowding. Fish handling will be kept to the minimum necessary to remove fish from the trap or net. Biologists will maintain captured fish in water to the maximum extent possible during trapping/netting, handling, and transfer for release. Individuals handling fish will ensure that their hands are free of harmful products, including but not limited to sunscreen, lotion, and insect repellent.

Captured fish will be placed in lidded coolers (preferred), buckets, or holding tanks that are fitted with aerators to provide well-oxygenated water. Small coolers that are light-colored, lidded, and fitted with a portable aerator are preferred over buckets. Containers should be well-rinsed and free of any chemicals or detergent residues. Biologists will ensure that water quality conditions are adequate in the containers used to hold captured fish, and that conditions in the holding containers are monitored frequently and operations adjusted appropriately to minimize fish stress. Containers should be placed in the shade, if possible, to prevent increases in water temperature (ESA 2017).

Desert pupfish numbers and lengths will be measured. If conditions are stressful (e.g., very high temperatures), biologists may discontinue length measurements, especially for the more vulnerable juvenile pupfish. Scales, bony structures, or whole fish will be collected to assess the

age distribution of each species' population, and when possible, the breeding condition of individuals will be determined and recorded (USGS 2013). Marking of desert pupfish and other fish species can be performed to assess movement between and among habitats (USGS 2013). The surveying biologist will record conditions, including specific locations of capture and release, date and time trap was set and pulled, water depth, water temperature, dissolved oxygen, salinity, turbidity, species and number of fish captured, and observations of substrate type and vegetation.

Qualitative habitat information should be collected, important microhabitat characteristics where fish use is observed should be noted, and any prominent habitat features (e.g., river mouths, islands, levees) and other environmental attributes (e.g., general substrate or vegetation type) in areas of concentrated use should be recorded. Surveys should also specifically assess and document connectivity (or lack of connectivity) to other pupfish habitat and whether habitat is occupied by pupfish, not occupied but has potential to support pupfish, or could have potential with the restoration or enhancement of specific habitat features. Photo points should also be taken to detect long-term changes in habitat quality. Incidental observation of the presence and abundance of non-native fishes and crayfishes should also be recorded.

Analysis

Catch data can be used to evaluate the abundance and distribution of desert pupfish in the Salton Sea and its tributaries to assess status and trends in desert pupfish populations on an annual basis. When possible, information on trap efficiency will be developed and used to estimate population sizes in selected habitats. Mark-recapture methods can be used to evaluate movement of desert pupfish between areas or habitats.

Data collected from the desert pupfish surveys can be used in combination with other information, such as other environmental attributes and data collected during other surveys, to understand the factors influencing desert pupfish survival and movement, and to guide management activities at the Salton Sea, such as the design and management of created habitats. The results of water quality monitoring activities, such as selenium in agricultural drainage, should be integrated into the analysis of environmental attributes that may affect desert pupfish populations.

Other Considerations

Access may be difficult in some locations due to limitations with boat launching sites and landowners that will not allow access for surveys. Land access to drains will need to be coordinated with landowners (e.g., IID, CVWD).

Southwestern Willow Flycatcher Surveys

The southwestern willow flycatcher is a federally and state endangered species. This species inhabits riparian woodland habitat near the Salton Sea.

Metrics

Abundance (presence/number of birds) by survey location and year.

Available Data Sources/Responsible Entity

IID conducted southwestern willow flycatcher in nine locations around the southern portions of the Salton Sea and within potentially suitable habitat south along the New and Alamo Rivers in 2017 (IID 2017). Only five locations were within 5 kilometers of the Salton Sea.

The responsible entities will be CDFW and USFWS. CDFW and USFWS can work in collaboration with other partners to conduct surveys or supplement data.

Locations

Southwestern willow flycatcher surveys will be based on five existing IID survey locations around the southern portions of the Salton Sea (IID 2017) (Figure 4-5). The addition of future survey locations may be considered based on habitat mapping of riparian woodland areas at the Salton Sea and surrounding vicinity (Section 4.2.1, Land Cover, or as noted during other survey efforts in the Salton Sea area).

Timing/Frequency

Southwestern willow flycatcher surveys will be conducted each year, with three surveys conducted within three survey periods (USGS 2010b). At least one survey will be conducted during Survey Period 1, from May 15 through May 31, to coincide with the period of high singing rates in newly arrived males. At least one survey will be conducted during Survey Period 2, from June 25 through July 17, when the earliest arriving males may already be paired and are singing less, but later arriving males are still singing strongly. At least one survey will be conducted during Survey Period 3, from June 1 through June 24, when migrant willow flycatchers should no longer be passing through the southwest and therefore any willow flycatchers detected are likely to be either territorial or non-breeding floaters.

Methods

Southwestern willow flycatcher surveys will be conducted in accordance with the protocol detailed in *A Natural History Summary and Survey Protocol for the Southwestern Willow Flycatcher* (USGS 2010b). A biologist who holds a permit to survey for southwestern willow flycatcher will begin surveys at first light (e.g., about 1 hour before sunrise) and end by about 9:00 AM to 10:30 AM. The surveyor will broadcast a series of call-playback recordings, which will generally elicit a response from any nearby territorial willow flycatchers increasing their detectability. Surveys should be conducted from within suitable riparian woodland habitat (i.e., not from the perimeter unless habitat is inaccessible), while minimizing damage to habitat and vegetation or disturbing any nests.

Qualitative habitat information should be collected, important microhabitat characteristics where bird use is observed should be noted, and any prominent habitat features and other environmental attributes in areas of concentrated use should be recorded. Photo points should also be taken to detect long-term changes in habitat quality.

Analysis

Survey data will be used to describe southwestern willow flycatcher use (presence, abundance, and distribution) on an annual basis within riparian woodland habitat at the Salton Sea and to assess status and trends over time. Data collected for areas of concentrated bird use will be used to guide management at the Salton Sea, such as the construction and management of habitats beneficial to birds.

Other Considerations

Landowner access may be difficult in some locations as private lands may require permission to access, and even some public lands, such as IID lands, may require encroachment permits. Some locations may also be physically inaccessible due to areas that are not traversable by vehicle or by foot due to sands, mud, and muck.

Although qualitative habitat information will be recorded, updating vegetation mapping via remote sensing (Section 4.2.1, Land Cover) is recommended every 1 to 3 years, as feasible.

Western Snowy Plover Surveys

The western snowy plover is federally threatened species and state species of special concern. However, the federally threatened designation only applies to the coastal population of this species, as the inland population (including the Salton Sea population) is not considered listed. The Pacific Coast distinct population segment of the western snowy plover is defined as those individuals nesting adjacent to tidal waters within 50 miles (80 kilometers) of the Pacific Ocean, including all nesting birds on the mainland coast, peninsulas, offshore islands, adjacent bays, estuaries and coastal rivers (USFWS 2011). This species inhabits sandy beaches, salt pond levees, and shores of large alkali lakes, and nests in shallow depressions in sandy, gravelly, or friable soils (CDFW 2014, 2021). Western snowy plovers feed on insects, such as brine flies, and although many populations of this species migrate, western snowy plovers at the Salton Sea may remain year-round (CDFW 2014).

Metrics

Abundance (presence and number) of snowy plovers by date and survey location.

Available Data Sources/Responsible Entity

Snowy plover surveys were conducted by Point Blue in 1999 (Shuford et al. 2000).

The responsible entity will be CDFW. CDFW can work in collaboration with other partners, such as USFWS, Audubon California, or Point Blue, to conduct surveys or supplement data.

Locations

Western snowy plover surveys will be conducted based on potential locations identified during the general bird surveys along the shoreline of the Salton Sea, particularly adjacent to drainages. There are four locations of particular importance along the shoreline around the perimeter of the Salton Sea, including from Iberia Wash south through the northern portion of the Salton Sea Test Base and San Felipe Creek Delta and the shoreline, breached impoundments, and the sand spit paralleling Davis Road and the Wister Unit of Imperial WA (Shuford et al. 2000).

Timing/Frequency

Western snowy plover surveys will follow the timing and frequency outlined in the *Avifauna of the Salton Sea: Abundance, Distribution, and Annual Phenology* (Shuford et al. 2000) for Snowy Plover Surveys at the Salton Sea. Surveys of the shoreline should be conducted in winter (specifically, January and November) when plovers are flocking and easiest to detect, and in breeding season (May).

Methods

Western snowy plover surveys will be conducted based on the methodology in the *Avifauna of the Salton Sea: Abundance, Distribution, and Annual Phenology* (Shuford et al. 2000) for Snowy Plover Surveys at the Salton Sea.

Qualitative habitat information should be collected, important microhabitat characteristics where bird use is observed should be noted (e.g., presence and abundance of wrack for foraging on insects), and any prominent habitat features and other environmental attributes in areas of concentrated use should be recorded. Photo points should also be taken to detect long-term changes in habitat quality.

Analysis

Survey data will be used to describe western snowy plover use (abundance and distribution) on an annual basis at the Salton Sea and to assess status and trends over time. Data collected for areas of concentrated bird use will be used to guide management at the Salton Sea, such as the construction and management of habitats beneficial to birds.

Other Considerations

Landowner access may be difficult in some locations as private lands may require permission to access, and even some public lands, such as IID lands, may require encroachment permits. Some locations may also be physically inaccessible due to areas that are not traversable by vehicle or by foot due to sands, mud, and muck.

Although qualitative habitat information will be recorded, updating vegetation mapping via remote sensing (Section 4.2.1, Land Cover) is recommended every 1 to 3 years, as feasible.

4.5 Socioeconomics

The objectives of socioeconomic monitoring (**Table 4-6**) include the following: (1) evaluating the effectiveness of public engagement in terms of its accessibility, transparency, and ability to inform the public of the purpose and progress of the SSMP program and projects; (2) tracking the extent to which SSMP projects provide recreational benefits and amenities to surrounding communities; and (3) tracking economic conditions in the communities around the Salton Sea to inform the prioritization of management actions.

Metric	Priority	Method(s)	Timing, Frequency	Location(s)	Entity
Public Engagement – Meeting Participation	Primary	Provide sign-in sheets with community/organization column Participant evaluations Meeting/event questionnaire to characterize participation	At all meetings and events; summary reporting annually	Local communities	SSMP Public Outreach Committee
Public Engagement – Digital participation	Primary	Website clicks and visit statistics Cal Natural Resources Agency newsletter clicks	Quarterly	Online (Program website and newsletter)	DWR, SSMP web manager, Cal NRA newsletter host
	Secondary	Report on social media engagement and identify areas of misunderstanding or need for better outreach/education	Quarterly	Online (Facebook, Instagram, YouTube)	DWR
Public Engagement – Non-digital outreach	Primary	Log books and pens at community boards Postage-paid comment cards	Quarterly or as-needed	Local communities	SSMP Public Outreach Committee
Public Engagement – Understanding of Program and Projects	Primary	Surveys at public engagement events, in newsletters, and on website. Concepts include agree/disagree slider bars, token voting such as with Feedback Frames.	Survey as needed when outreach occurs Annual summary	Local communities	SSMP Public Outreach Committee
	Focused Study	Focus groups with key community representatives.	Annual	Local communities	SSMP Public Outreach Committee
Community Benefits – Direct job creation	Primary	Track local jobs created by direct hiring/ spending by DWR	At completion of each project	Local communities	DWR
Community Benefits – Indirect/induced job creation	Secondary	IMPLAN multipliers based on direct spending Ground-truth with regional job data from Employment Development Department	At completion of each project	Local communities	DWR
Community Benefits – Infrastructure	Primary	Track to what extent projects include components to increase recreation, access, and other community infrastructure.	At completion of each project	Local communities	DWR
Economic Indicators – Census Bureau American Community Survey 5-year data	Secondary	Median income Statistics on poverty, unemployment, and families using SNAP benefits	Biennial	Local communities/census tracts	DWR

TABLE 4-6 Socioeconomic Monitoring

4.5.1 Public Engagement and Public Perception **Rationale**

Evaluating the effectiveness of public engagement, including how accessible it is and how well it follows the public engagement plan, is important, as it may inform further refinements of the public engagement plan. Better public engagement will elicit public input that will contribute to prioritizing and refining management actions. Monitoring public engagement over time will allow for an evaluation of whether engagement efforts are meeting the intended outcomes. Tracking what level of engagement occurs with different forms of public outreach will allow for adjustments to outreach and engagement efforts to focus on techniques that reach the widest possible diversity of community members. Qualitative reflection on public engagement as projects go through design and implementation will allow for an evaluation of whether community input is being incorporated into the design and implementation of projects and how responsive agencies are to public input.

Additionally, it is important to monitor public perception and understanding of the SSMP to measure how well the program is communicated to the public and how well the public understands their potential participation in the process. Additionally, tracking public values and preferences for the program can help program managers implement project elements that better satisfy stakeholder needs.

Metrics

Specific metrics to evaluate public engagement and perception include assessment of the level (quantity and quality) of participation and a qualitative assessment of public stakeholders' understanding of the program and associated projects.

Available Data Sources/Responsible Entity

There are currently no similar comprehensive monitoring activities of public engagement underway at the Salton Sea. The responsible entity for most of these monitoring efforts will be the SSMP Public Outreach Committee. The monitoring of digital participation activities would be conducted by DWR and the Cal NRA newsletter host, in which case data would be shared with the SSMP Public Outreach Committee.

Locations

The monitoring of digital participation metrics would not occur in specific communities and would occur online through the program website and newsletters as well as Facebook, Instagram, and YouTube.

Timing/Frequency

Participation would be monitored at all meetings and events, the results of which would be included in an annual summary report. Digital participation would be monitored quarterly. Non-digital participation would be monitored quarterly or on an as-needed basis. Surveys designed to monitor the understanding of program and projects would be conducted on an as-needed basis as

outreach occurs. The results would be included in an annual summary. Focus groups would be conducted annually.

Methods

The level of public participation will be measured at meetings and events by providing sign-in sheets, conducting head counts, and having staff at meetings or events fill out a standardized questionnaire to characterize participation. The questionnaire may include information such as apparent diversity of participants, language translation needs, and how the meeting/event format did or did not facilitate questions and discussion. Additionally, engagement with outreach materials should be recorded quarterly. This should be measured by tracking the number of website clicks and visits and the number of clicks on emailed newsletters. Engagement with social media posts can be tracked by briefly reviewing and reporting about the degree of participation and the nature of comments. One community in particular has expressed interest in YouTube videos; if such content is created, the number of views and any comments should be given to use of non-digital forms of engagement, such as posting of printed notices, newsletters, or other communications at community centers, and how to track engagement with these formats (e.g., providing a log book to collect comments or giving out postage-paid comment cards).

To track the public's understanding of the program and associated projects, brief and accessible surveys should be distributed at public engagement events, in newsletters, and on the website. Surveys should be distributed on an as-needed basis as outreach occurs and should be designed to encourage broad response by asking few or single questions at one time and providing respondents with simple, engaging methods for response (e.g., slider bar to express agreement/disagreement with a single statement [web-based], use of physical tools such as Feedback Frames¹⁰).

Analysis

Data gathered monthly and quarterly (or on a per-event basis) to track levels of participation and the understanding of the program and associated projects will be presented in an annual report that tracks trends in public participation and analyzes the public's understanding of the program and projects. Changes in the levels of public participation and the extent to which outreach materials are transparent and assist the public's understanding of the SSMP and associated projects will be analyzed. Feedback collected from the public throughout the various engagement efforts can identify areas of misunderstanding or the need for better outreach and education. Information from meeting questionnaires will be used to inform outreach and the format of future meetings/events. The report will identify whether clicks/website visits increase after meetings, newsletter blasts, and other outreach efforts to determine if these efforts drive individual engagement and research online. An annual summary of survey findings will be developed to track changes in public perception throughout the year; statistical methods are not necessary, and summaries can qualitatively discuss the level of participation and the nature of survey responses. The annual report will include recommendations to refine the public outreach strategy based on the findings of public engagement and perception monitoring.

¹⁰ https://feedbackframes.com/

Other Considerations

If needed and if funding allows, focus groups can be recruited from among the Salton Sea communities to assess specific questions around public perception and stakeholder priorities. The annual report should identify any needs for this method of data gathering; for instance, longer lead times may be necessary to convene a focus group than for other methods. Other creative methods for assessing public perception and the effectiveness of public education may include sponsoring community and/or school art contests related to interpretations of the Salton Sea's relationship to the community, or teaming with existing organizations to tap into community relationships to gather feedback.

4.5.2 Community Benefits

Rationale

Monitoring community benefits related to the SSMP and associated projects will document the extent to which community stakeholders are informing project design and the extent to which projects are addressing diverse community needs and interests. This information will be used to guide community outreach and engagement in the siting, design, and management of future SSMP projects.

Metrics

Monitoring community benefits experienced by the communities around the Salton Sea would include tracking the direct and indirect community benefits and amenities that these communities experience as a result of the SSMP. This element should track to what extent projects directly and indirectly create jobs (e.g., number of jobs per project) and include components to increase recreation (e.g., number of parks, miles of trails), access (e.g., number of physical access points or miles of sidewalk created) and digital access (e.g., number of households provided with high-speed internet), education (e.g., number of wildlife viewing opportunities created), and other community infrastructure that enhances interaction with the Salton Sea and its associated resources. Over time as more data are collected, specific metrics for community benefits may be identified to track annually such as miles of trails created or number of physical access points created. At this time predicting which indicators will be the most appropriate to track on a continual basis is premature.

Available Data Sources/Responsible Entity

There are currently no similar comprehensive monitoring activities of community benefits underway at the Salton Sea. Monitoring of community benefits would be conducted by DWR.

Locations

Community benefits will be monitored as projects are completed and will occur in local communities around the sea. The communities included will depend on the size and location of each project.

Timing/Frequency

Monitoring of community benefits will occur at the completion of each project.

Methods

Community benefits will be monitored by tracking the local jobs created by SSMP projects as well as indirect and induced job creation (as reported by contractors, estimated using IMPLAN multipliers, and checked against Employment Development Department data). This category will also track whether any recreational, educational, transportation, or other community infrastructure and amenities, are added or improved by SSMP projects or by outside funding that is identified and facilitated by DWR. Infrastructure projects created by SSMP projects or facilitated by DWR will be tracked using DWR project reporting. The metrics used to track project benefits will depend on the community benefits that result from SSMP projects, but could include miles of trails created, number of educational opportunities created and the recreational and community infrastructure created by SSMP projects should be evaluated and reported at the completion of each SSMP project. Changes in the use of recreational and community infrastructure created by SSMP projects and/or facilitated by DWR with non-SSMP funding will also be evaluated and reported over time (e.g., annually).

Analysis

An analysis of the community benefits provided by SSMP projects and/or by outside funding facilitated by DWR should be conducted to determine whether the SSMP projects and DWR are increasing recreational access and other community benefits and infrastructure. This annual report should consider whether public engagement efforts are informing project design and the inclusion of community benefits in the project design.

Other Considerations

DWR may be able to leverage/connect with non-SSMP funding opportunities to create and monitor recreation and community access benefits even if bond funding for SSMP projects cannot be used for recreation or public access projects.

4.5.3 Economic Indicators

Rationale

Gathering economic indicator data will allow the SSMP to establish existing economic data for the communities around the Salton Sea and track economic indicators. While it is not anticipated that near-term implementation of management actions to control dust and restore habitat will directly, measurably affect these parameters, information about general economic conditions will provide better context for understanding the economic needs and overall socioeconomic health of the communities surrounding the Salton Sea. This will inform prioritization and implementation of management actions.

Metrics

Metrics used to track economic conditions in the communities around the Salton Sea include median income, poverty, employment, and use of public assistance (SNAP).

Available Data Sources/Responsible Entity

There are currently no similar comprehensive monitoring activities of economic indicators underway at the Salton Sea. Monitoring of select economic indicators would be conducted by DWR. The data source used for economic indicator monitoring would be the American Community Survey 5-year estimates produced by the U.S. Census Bureau.

Locations

Monitoring will occur at the census tract level in communities around the Salton Sea.

Timing/ Frequencies

Economic indicators will be tracked biennially as the indicator data will not change quickly and the 5-year American Community Survey estimates will include some overlap.

Methods

Data from the U.S. Census Bureau American Community Survey 5-year estimates will be used to determine: (1) median household income; (2) the percentage of people with family incomes below the poverty thresholds; (3) the percentage of people with family incomes below 200 percent of poverty thresholds (a common economic indicator for high-cost-of-living states such as California); (4) percentage of unemployment; and (5) percentage of families using public assistance (SNAP).

Analysis

A report will identify changes in economic indicators and make recommendations as to whether observed changes should inform prioritization of management actions.

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CHAPTER 5 Data Management

5.1 Data Management Purpose and Approach

The data associated with monitoring activities will range widely in complexity, format, and size, from geospatial databases containing large volumes of longitudinal data, to tabular data with both quantitative and qualitative measures, to written reports, maps, photos and other types of documents and images. The purpose of the data management guidance and recommendations in this chapter is to ensure these large and diverse data are stored and maintained accurately and sustainably over time by using consistent collection methods and quality assurance protocols, common data standards, and interoperable data structures and storage formats.

Because SSMP leaders and researchers will need to integrate data collected by a range of public agencies and partner organizations, and it is important to maintain historical continuity of many of these data, the program will be best served by establishing a cloud-based data hub that provides centralized access to all the data while maintaining distributed ownership of many individual datasets. To accomplish this, it is essential that common data standards be put in place at the start, and that a single authoritative system of record (see Section 5.3.2, Datasets from New Monitoring Activities) be identified for the data associated with each indicator and metric. In addition, unique identifiers and other key relational fields, such as location information, collection dates, units of measure, etc., along with standard documentation requirements, must be established and included consistently across all datasets. Such systems and standards will facilitate user access to the full range of indicator data, integrated data analysis, and transferability across data management platforms.

To carry out this work, the SSMP will need to invest in personnel for ongoing data stewardship and interagency coordination, as well as technology to build and maintain a central data hub.

5.2 Data Management System Requirements and Best Practices

5.2.1 Open Data Requirements

The California Open Data Policy together with the Open and Transparent Water Data Act (AB 1755) set forward requirements and guidelines for state data to be made publicly available through centralized online data portals. AB 1755 provides additional guidance specific to water-related data. These open data requirements include protocols for data sharing, documentation, quality control, and development of open-source platforms that allow users to search quickly through hundreds of datasets based on key words, to view simple descriptive

information, to visualize and download data. To meet open data requirements, the state operates the California Open Data Portal (https://data.ca.gov/) which includes the CNRA Open Data platform (https://data.cnra.ca.gov) to hold to data managed by CDFW, DWR and other CNRA subsidiary agencies. Most data to be collected as part of the MIP will be subject to California open data requirements.

5.2.2 Systems of Record

A system of record is the database or data management system that houses and serves as the authoritative source for a given dataset. The purpose of establishing systems of record is to maintain and update data accurately and consistently to ensure a "single source of truth" for data to be used by multiple different entities. As detailed in Section 5.3.1, the system of record for many MIP indicators is already established as a state or federal agency database. In those cases, it will be important to maintain data continuity by using the agency's existing data standards, structures and formats as the starting point for the MIP metrics, then make enhancements as needed to support SSMP data integration (see Section 5.3.5). If there is not a pre-existing system of record for a MIP indicator, one should be established.

Each system of record should have a designated staff person to serve as data steward responsible for quality assurance and maintenance of the datasets housed in that system. Further, documentation for each indicator of standards and practices for data collection, quality assurance and management should be stored together with the data in the designated repository for that indicator. The SSMP should maintain a master list of systems of record for each indicator with data steward contact information.

5.2.3 Data Standards and Metadata

Data standards describe how a data element is defined, measured and organized, its units, data structure, field naming conventions and formats, and other features that assure all users will have a common understanding of what is represented by the data and how to maintain it accurately over time. A well-functioning SSMP data management system will require establishment of data standards for each indicator and metric, and for key data fields, metadata documentation and quality assurance practices that will be implemented systemwide to support data integration and interoperability.

As referenced above, some MIP indicators are continuations of existing data collection efforts that have data standards fully developed, while others will need standards to be created. In addition, a systemwide data dictionary should be created to provide standards for metrics and fields that are common across datasets, as well as for unique identifier fields that will need to be added to datasets to ensure they can be cross-referenced and joined based on geographic areas, projects and other key relational elements (**Table 5-1**). Where standards for the same data elements are not aligned across systems of record, a single SSMP standard should be developed and incorporated into system of record data structures to support SSMP data integration.

Monitoring Element	Collection Location (lat/long)	Publication Date
Indicator type	Collection date and time	System of record
Metric name	Update frequency	Database location
Project name/code	Datum and projection (for spatial data)	Data steward contact information
Unit of measure	Collected by (name, organization)	Data confidentiality/access restrictions (if any)

 TABLE 5-1

 EXAMPLES OF SYSTEMWIDE STANDARD DATA FIELDS

Standards that are updated or newly developed for each indicator and metric should conform with state and national data standard guidelines, such as those described by the Federal Geographic Data Committee (FGDC) and state agencies (e.g., CDFW BIOS Metadata Guidelines, DWR Spatial Data Standards).

5.2.4 Quality Assurance Practices

The MIP describes detailed methods and protocols for data collection specific to each monitoring metric, including measurement procedures and equipment, prescribed locations and frequency of observations, and data assessments/statistical tests to identify possible error or biases in the data. These data quality standards and protocols should be documented in a consistent format and stored with the data as well as summarized in metadata for each metric. Any preferred reporting formats and data visualizations should also be included in this documentation.

In addition to quality assurance/quality control (QA/QC) procedures applied during the data collection process for each metric (e.g., calibration of equipment), general quality assurance checks should be applied by system of record data stewards before and after data are transferred into authoritative data repositories. Such checks include confirming that fields follow standard naming conventions and formats, all data have valid values/codes, geographic locations (and projections for spatial data) are correct, etc. This QA process should be followed by a final QC check before data are linked or uploaded to the SSMP central data hub, particularly to ensure that key unique identifier relational fields are included and data are in permitted compatible formats. Initially, the SSMP master data steward may need to run these QC checks manually, but the SSMP should work towards the development of automated QC tools that can be run within the data hub.

5.3 Data Types and User Needs

5.3.1 Existing Datasets and Repositories

The SSMP data hub will need to be able to manage common file formats containing geospatial and tabular databases, text documents, maps, photos and other graphics. As shown in **Table 5-2**, much of the monitoring activity to be conducted is a continuation of activity already underway by state and federal agencies with established data standards, structures and storage repositories. For example, CDFW operates the Biogeographic Information and Observation System (BIOS), a data warehouse holding authoritative datasets on special status species and many other environmental

and biological resources in California, and USGS operates the National Water Information System (NWIS) to collect and distribute real-time stream flow and other authoritative water data. Some of these data sources are already setup with web services or other APIs (Application Programming Interface) that provide open access to pull the data into other systems. Others have more limited data exchange capabilities and will require API development or use of manual procedures to be uploaded and refreshed in their respective system of record.

Agency Currently Monitoring	Resource Category	Indicators
U.S. Geological Survey	Hydrology	Inflow – rivers
(USGS)		Lake elevation
U.S. Bureau of	Water Quality – Surface Water	Dissolved oxygen
Reclamation (USBR)		Nutrients (N, P)
		pH
		Salinity
		Selenium
		Temperature
		Total Suspended Solids, Total Dissolved Solids,
		Turbidity
California Dept. of Fish and Wildlife (CDFW)	Biological Resources – Fish	General fish species composition, abundance, and distribution
	Biological Resources – Special-	American white pelican, brown pelican
	Status Species	Burrowing owl
		Desert pupfish
		Gull-billed tern
		Yuma Ridgeway's rail, California black rail
	Biological Resources – Birds	Colonial nesting birds
		Dead and sick birds
		General bird species composition, abundance, and distribution– Shoreline area survey
		Marsh bird surveys
Imperial Irrigation District	Hydrology	Groundwater levels
(IID)	Water Quality – Surface Water	Dissolved oxygen
		pH
		Salinity
		Selenium
		Temperature
		Turbidity
	Geography	Land cover
		Playa area extent
		Playa emissivity potential
		Surface characteristics
	Air Quality	Ambient air quality (particulate matter)
		Meteorology/ Climate
		Playa emissions

TABLE 5-2 MONITORING INDICATORS BY LEAD AGENCY

Agency Currently Monitoring	Resource Category	Indicators
	Biological Resources – Special- Status Species	Southwestern willow flycatcher
Audubon Society	Biological Resources – Birds	General bird species composition, abundance, and distribution– Shoreline area survey
Oasis Bird Observatory (OBO)	Biological Resources – Birds	General bird species composition, abundance, and distribution– Shoreline area survey
Special Study	Air Quality	Particulate matter chemistry
Unspecified	Hydrology	Hydrodynamics Inflow – direct drains Inflow – small tributaries (San Felipe Creek, Salt Creek)
	Water Quality – Surface Water	Groundwater quality Other contaminants (not Se)
	Biological Resources – Plankton and Macroinvertebrates	Cyanobacteria Macroinvertebrates (water column and benthic) Microbial loop Phytoplankton Primary productivity (chlorophyll a) Zooplankton
	Biological Resources – Special- Status Species	Flat-tailed horned lizard Western snowy plover
	Biological Resources – Birds	Colonial roosting Piscivorous bird species composition, abundance, and distribution – Aerial Survey
	Socioeconomics	Community benefits Economic indicators Public Participation at SSMP events

5.3.2 Datasets from New Monitoring Activities

For newer monitoring efforts for which there are not already established lead agencies and data management systems, the SSMP should determine whether these data are appropriate to have stored and managed in the long run as authoritative data held by CDFW, DWR or other existing state or federal systems. A key question is whether there will be datasets that will not have an authoritative owner beyond the SSMP and then what data repository SSMP will use for such data. For all new (and pre-existing) datasets, the SSMP should take the lead to ensure that a standard data structure is developed for each metric, including standard fields and unique identifiers to support cross-referencing and data integration, and that data formats and metadata comply with California open data requirements.

5.3.3 Data User Needs

MIP data users include scientists involved in carrying out and analyzing the findings of monitoring activities, SSMP staff, state and local public officials, environmental and community organizations, local residents, and other stakeholders working to protect regional health and

ecology. These users will have many potential data management needs over time. The most immediate and fundamental need is for a well-organized data repository that provides ample storage and ease of access to individual datasets that are quality assured and well documented, with varying user access levels depending on use cases. Users should be able to view and download data that are held in all of the systems of record for MIP indicators, primarily by connections to web services or other APIs that pull data from those systems. Users should be able to search data by standard search keys (e.g., indicator type, location, agency) as well as do custom searches. The system should also have functions for system of record data stewards and other registered users to upload new data, with protocols for the SSMP master data steward to quality check and approve data before it is published for broader use. A key outstanding question is whether some of the MIP indicator data will require SSMP to have its own independent data repository, or if all data will have a designated system of record within an existing authoritative system, such as CDFW BIOS.

Once common standards and a data repository are established to ensure coordination of the most immediate data collection activities, the SSMP should undertake a user needs assessment to determine additional priority user needs and create a longer-term custom system development strategy. Additional functionalities envisioned for a complete SSMP data management system include: automated tools for quality assessment, visualization and reporting, including for longitudinal and integrated data analysis, display of real-time monitoring data (e.g., air quality sensor data related to performance of the planned dust suppression projects), and public-facing report dashboards.

5.4 Development of a Central Data Hub

5.4.1 Cloud-Based Data Portal

A centralized SSMP data hub should be cloud-based with API integration capabilities to provide direct access for all stakeholders to access all datasets (with secure access restrictions as appropriate). While further assessment is merited to determine if it can deliver all SSMP critical functions at this stage, ArcGIS Hub by ESRI appears offers the core capabilities needed for an initial SSMP data repository. Further, it is aligned with the systems already in use to operate state of California open data portals and could be launched quickly by leveraging existing CNRA, CDFW or DWR hosting capabilities and building on technical protocols already established by those agencies.

5.4.2 Dedicated Data Stewards

Dedicating staffing resources to data management, preferably a full-time position within the SSMP leadership team to serve as the master data steward, is essential to build a successful data management system in a timely manner. A master data steward is needed to convene partners, develop and manage implementation of an action plan to create a central data hub, including documenting and disseminating systemwide policies and standards. The master data steward is also needed to coordinate entry of data into the central hub, ensure QA/QC procedures are followed, and manage technology system maintenance and updates over time. In addition, each

system of record must identify a data steward responsible for QA/QC and maintenance of the data for each indicator and the services and workflows that feed data to the central hub.

5.4.3 Technical Workgroup

Building a central SSMP data hub requires significant technical coordination upfront to develop the common data management policies, standards and data sharing agreements needed to operate consistently across multiple organizational entities. Immediate establishment of a technical workgroup is recommended to bring together representatives from state and federal agencies and other data collection and research partner organizations with the charge to:

- Confirm or identify the system of record for each critical dataset;
- Examine existing data standards for MIP indicators and recommend SSMP common data standards needed to harmonize and cross-reference information across different data types and repositories;
- Assess suitability of ArcGIS Hub and develop implementation action plan with CDFW (or other host agency);
- Work with data stewards of each system of record to update data structures, develop APIs, and create data sharing agreements as needed to support access through the centralized data hub;
- Develop and disseminate QA/QC standards and practices;
- Oversee a user needs assessment to determine requirements to build additional data management system capabilities to support visualization, analysis, progress tracking and reporting; and
- Provide ongoing technical guidance and interagency coordination to support the SSMP master data steward.

5.4.4 Data System Maintenance and Reporting

The SSMP data management system should be reviewed annually to confirm that standards are being applied consistently, datasets have been updated at their expected frequency, and appropriate technology updates have been installed. Annual reviews can also provide opportunity to identify and plan for any changes, additions, or retirement of existing metrics and datasets. A summary of the findings of the annual review should be published in an annual data management progress report. This page intentionally left blank

CHAPTER 6 Data Assessment, Reporting and Adaptive Management

6.1 Summary of Priority Monitoring

This MIP provides a set of prioritized indicators and accompanying sampling methods, timing, and locations to monitor the status and trends of various physical, biological and socioeconomic resources at the Salton Sea, as summarized in **Table 6-1**. This framework serves as a guide for individual projects and monitoring efforts so that each can collect standardized data and integrate the results across the Salton Sea region.

6.2 Data Assessment

Data assessment is used to foster the integration, consolidation, and review of data, updating of the conceptual models, answering of key questions, reporting, and providing management recommendations within an adaptive management framework (USGS 2013).

The type of analysis will depend on the monitoring question or hypothesis (Table 2-4) and the sampling design (Section 3.2). Types of analyses can include comparisons through time on a site, comparisons across or among sites (including "reference" sites), or comparisons with a target condition (IEP 2017a). The first step in analysis is exploring the data and its distribution (exploratory statistics) (Zuur et al. 2010; IEP 2017a). If the data meet assumptions of other statistical tests, then questions can be evaluated using inference (traditional hypothesis testing) or Bayesian statistics (IEP 2017a).

6.3 Reporting

An annual progress report will summarize the data collected during that year and update prior reports in a cumulative fashion. At a minimum, the annual report should address the following elements:

- GIS maps showing locations of monitoring sites for each resource category.
- A summary of data collected during each year
 - Hydrological Average daily and monthly flow (discharge), average annual discharge, and peak instantaneous flow for stations with continuous recorders; average monthly flow for stations with field measurements; monthly elevations of Salton Sea surface water and groundwater stations; water quality field measurements and results of laboratory analysis for constituent concentrations.

					Location – Geographic Strata									
Resource	Indicator	Metric (Priority #)	Method	Timing, Frequency	Sea	Rivers near Sea	Drains, Creeks	Shore, Playa	Wetlands	Halophytic Scrub	Uplands, Riparian	Playa Dust Control	Created Impoundments	Partner Entity
Hydrology	Surface Water	Lake elevation (1)	Gaging	Continuous	С									USGS
		Inflow – Rivers (1)	Gaging	Continuous		С								USGS
		Inflow – direct drains (1)	Pump rates or field measure	Continuous or monthly			C-M							IID, CVWD
		Inflow – San Felipe Cr., Salt Cr. (1)	Gaging	Continuous			С							USGS
	Groundwater	Groundwater levels (1)	Wells	Continuous				С				С	С	DWR
	Hydrodynamics	Hydrodynamics	Vertical profile (temperature, DO)	Quarterly	Q									USBR
Water Quality	Surface Water	Electrical Conductivity (Salinity), Temperature, Dissolved oxygen, pH, Turbidity (1)	Handheld sonde measure at surface, Vertical profile (Temp, DO, EC)	Quarterly in water bodies, Continuous at created ponds, Periodic with biological sampling	Q	Q	Q						С	USBR, DWR
		Nutrients, TDS, TSS (1)	Grab sample, lab analysis	Quarterly	Q	Q	Q						Q	USBR, DWR
		Contaminants (selenium, arsenic, boron, pesticides) (1)	Grab sample (water and sediment), lab analysis	Quarterly	Q	Q						Q	Q	USBR, DWR
	Groundwater	Groundwater quality	Grab sample, lab test	Quarterly				Q						DWR
Geography	Land Cover	Land cover and habitat types (1)	Aerial imagery	Every 1-3 years (triennial)	A-T	A-T	A-T	A-T	A-T	A-T	A-T	A-T	A-T	DWR, Audubon
Air Quality		Meteorology/ Climate (1)	Non-regulatory monitors	Continuous								С		IID, Torres Martinez.
		PM10 Concentrations (1)	Non-regulatory monitors	Continuous								С		IID, Torres Martinez
		H2S concentrations (2)	Non-regulatory monitors	Continuous								С		IID, Torres Martinez

 TABLE 6-1

 SUMMARY OF SALTON SEA PRIORITY MONITORING

Location – Geographic Strata												Pro	jects	
Resource	Indicator	Metric (Priority #)	Method	Timing, Frequency	Sea	Rivers near Sea	Drains, Creeks	Shore, Playa	Wetlands	Halophytic Scrub	Uplands, Riparian	Playa Dust Control	Created Impoundments	Partner Entity
Biological Resources	Birds	General Waterbird species, abundance, and distribution (1)	Waterbird Shoreline Survey	3–5 times per year or Monthly (ideal)	M-S			M-S						CDFW, USFWS
		Piscivorous birds (1)	Aerial Survey	5 times per year	S			S	S					CDFW
		Colonial nesting birds (1)	Aerial Survey	Once during breeding (Mar–May)	А			A			А		А	CDFW
		Colonial roosting birds (2)	Aerial Survey	Once during wintering (Jan–Mar)	А			A			А		A	CDFW
		Marsh birds (1)	Marsh Bird Survey	3 times during breeding (Feb–Sep)					S				S	CDFW, USFWS
		Dead and sick birds (2)	Surveys	Incidental with other bird surveys	Р			Ρ	Ρ				Р	CDFW,
	Fish	General Fish species, abundance, and distribution (1)	Seine or gillnet survey	Every 3 years (triennial), Annually in constructed ponds	Т	Т							A	CDFW
	Plankton and Macro-	Primary productivity (chlorophyll a) (1)	Grab sample, lab analysis	Quarterly	Q	Q								CDFW
	Invertebrates	Phytoplankton (2)	Grab sample, lab sorting	Quarterly	Q	Q								CDFW
		Zooplankton (2)	Net, lab sorting	Quarterly	Q	Q								CDFW
		Macroinvertebrates (1)	Net or dredge, lab sorting	Quarterly	Q	Q								CDFW

						Location – Geographic Strata							jects	
Resource	Indicator	Metric (Priority #)	Method	Timing, Frequency	Sea	Rivers near Sea	Drains, Creeks	Shore, Playa	Wetlands	Halophytic Scrub	Uplands, Riparian	Playa Dust Control	Created Impoundments	Partner Entity
	Special-Status Species	Desert pupfish (1)	Minnow Trapping	3 times per year (Apr– Oct)			S						S	CDFW
		Yuma Ridgeway's rail, California black rail (1)	Marsh Bird Survey	3 times during breeding (Feb–Sep)					S					CDFW
		Southwestern willow flycatcher (1)	Protocol Species Survey	3 times (May–July)							S			CDFW, USFWS
		American white pelican, brown pelican (1)	General shoreline survey, Aerial surveys	5 times per year	S								S	CDFW
		Western snowy plover (1)	Protocol Species Survey	3 times per year in winter (Nov, Jan) and breeding (May)					S					CDFW
		Gull-billed tern (2)	General shoreline survey, Aerial surveys	Once during breeding (Mar–May)	A				A				A	CDFW
		Burrowing owl, Flat-tailed horned lizard (3)	Protocol Species Survey, pre-construction survey	Seasonal depending on species						S	S	S	S	CDFW
Socio- economics		Public Engagement	Meetings and workshops	Semi-annually										SSMP
		Community Benefits	Meetings and workshops	Semi-annually										SSMP
		Economic Indicators	Census data	Biennial										SSMP

KEY:

1: Primary Indicator

2: Secondary Indicator

3: Focused Study lower priority

P: Periodic monitoring (triggered by an observed event)

S: Seasonal monitoring or semi-annually (a few times depending on target species) Q: Quarterly monitoring 4 times per year at regular intervals (3 months apart roughly) A: Annual monitoring once a year T: Triennial, once every 3 years C: Continuous monitoring

- Geography maps depicting updated land cover information, area of land cover types (especially playa and establishing vegetation).
- Air Quality meteorological conditions and pollutant concentrations at local monitoring sites.
- Biological Species composition, distributional patterns and relative abundance (e.g., number of birds observed, catch per unit effort of fish, density of plankton, concentration of chlorophyll a) among habitat types and sites (that is, mapped locations of observations) identified during the surveys.
- Socioeconomics summary of survey findings, economic data and other data collected.
- Sample variability based on replicate samples. Confidence intervals around all estimates, where appropriate, and methods used to generate estimates of variance
- Environmental information collected during sampling or observations.
- Monthly, seasonal, and annual trends in hydrological, air quality, land cover and biological indicators.
- Recommendations for improvement of the survey protocol, if any.

6.4 Adaptive Management

Adaptive management entails feedback between management practices and monitoring of responses in the ecosystem to measure the success of management actions and to fine-tune future actions accordingly (USGS 2013). In practice, this means that science is used to design the actions, and then monitoring results are provided to managers overseeing restoration so that adjustments can be made, if needed. This feedback works best if scientists are engaged in the design of restoration actions as experiments whose outcomes can be predicted and then measured.

6.5 Periodic Updates of MIP

In cooperation with technical and management staff, and with input from stakeholder groups, the assessment and analysis of data are anticipated to lead to periodic updates of this entire MIP (USGS 2013). Updates could be focused on specific resource areas or be applied to the entire plan. The plan is envisioned to be a living document and will need to remain flexible to respond effectively to unanticipated events. Monitoring will be refined as understanding increases or new issues emerge. As part of the annual reporting, indicators and methods will be reviewed periodically to make sure monitoring continues to address priority science and management needs. Adjustments may include type of indicators and metrics, sampling frequencies, sampling locations, and/or methods.

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CHAPTER 7 References

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Appendix A Inventory of Salton Sea Monitoring Efforts and Studies

APPENDIX A Inventory of Salton Sea Monitoring Efforts and Studies

Known monitoring and studies in the Salton Sea area were inventoried in fall 2019 (Table A-1).

Indicator / Monitoring Activity	Purpose	Туре	Methodology	Metrics	Location(s)	Frequency/ Timing	Sampling Years	Agency / Source
Hydrology								
Water surface elevation	Measure water surface elevation of the Salton Sea	Status & Trends	Gage USGS National Water Information System (NWIS)	Water surface elevation	Salton Sea near Westmorland (10254005)	Continuous, Year round	2017-2019 Ongoing	USGS NWIS
Stream inflow	Measure discharge (volume) and water elevation (gage height) in 3 main tributaries flowing into Salton Sea.	Status & Trends	Stream gage USGS National Water Information System (NWIS)	Discharge (flow cfs) Gage height	 3 stations on rivers Whitewater near Mecca (10259540) Alamo near Niland (10254730) New near Westmorland (10255550) 	Continuous, Year round	1988-present Ongoing	USGS NWIS
Drain & Canal Streamflow (Spill Dilution Monitoring)	Monitor flow rates in drains and canals	Status & Trends	Performed as part of IID's Selenium Provision Work Plan. Continuous hydrologic data are collected upstream of where canal spill enters the drain and downstream of where canal and drain water have sufficiently mixed for the drain and canal sites, with the exception of Poe Road Drain which has no spill and is sampled directly at the drain.	Velocity (fps) Flow (cfs)	Drains: Vail 3 Drain Vail 4 Drain Trifolium 23 Poe Road Drain Canals: Trifolium Extension (at Poe Road)	Continuous, Year round	2018	Imperial Irrigation District (IID 2018)
Water Quality								
Salton Sea & Tributaries Water Quality	Monitor salinity, selenium, nitrogen, phosphorus, and other water quality parameters status in water quality in the Salton Sea and main inflow tributaries	Status & Trends	Handheld sonde for in-situ measurements of physical parameters, with a vertical profile in Sea (temperature, DO, EC, pH, turbidity) Water samples for lab analysis of general chemistry (TDS, TSS, ions), nutrients (O-P, T- P, NO3, NO23, N, TKN), selenium (total Se, total dissolved Se, dissolved selenite, total Se sediment)	Physical parameters Salinity (EC and mg/l TDS, parts per thousand) lons Nutrients Selenium (water, sediment) Chlorophyll a	 Water Quality Monitoring Stations: Salton Sea (3) Alamo River New River Whitewater (Coachella Valley Stormwater Canal) Brawley Wetlands 	Quarterly (some quarters missed in some years)	1999; 2004- 2020	US Bureau of Reclamation (USBR 2020)

 TABLE A-1

 INVENTORY OF SALTON SEA MONITORING EFFORTS AND STUDIES

Indicator / Monitoring Activity	Purpose	Туре	Methodology	Metrics	Location(s)	Frequency/ Timing	Sampling Years	Agency / Source
Salton Sea Salinity	Monitor changes in salinity in the Salton Sea over time	Status & Trends	Unknown	Salinity (mg/l TDS)	Unknown location(s) in Salton Sea	End of year; appears annually since 2003	1950-2002	IID & USBR (CH2M Hill 2018)
Selenium in agricultural drains	Assess selenium in water, sediment, biota in IID's drains	Compliance	Measure selenium in water and sediments (29 drains), and biota (detritus, invertebrates, fish in 7 drains)	Selenium (water, sediment) Selenium in biota	29 drains	Biannual (April, October)	2005-2009	USGS & IID (May et al. 2007; Saiki et al. 2007, 2008, 2010)
Drain & Canal Water Quality (Spill Dilution Monitoring)	Monitor ambient water quality parameters in drains and canals	Status & Trends	Performed as part of IID's Selenium Provision Work Plan. Water sampling for total and dissolved Se and monitoring of ambient water quality parameters using a Hydroprobe. Continuous conductivity data are collected upstream of where canal spill enters the drain and downstream of where canal and drain water have sufficiently mixed for the drain and canal sites, with the exception of Poe Road Drain which has no spill and is sampled directly at the drain.	Total & dissolved selenium Water temperature Dissolved oxygen Conductivity pH Turbidity Oxidation reduction potential (ORP)	2018 locations: Drains: • Vail 3 Drain • Vail 4 Drain • Trifolium 23 • Poe Road Drain Canals: • Trifolium Extension (at Poe Road)	Twice monthly; with the exception of continuous for conductivity2	2018	IID (Formation 2019a)
Managed Marsh Water Quality & Selenium	Monitor selenium concentrations in created marsh habitat	Effectiveness	Requirement of IID's California Endangered Species Act permit. Protocols have varied historically. In 2017, IID sampled water and sediments and sent to a laboratory for Selenium analysis. Past surveys have also included tissue analysis. Revised annual sampling protocols were anticipated to be implemented in 2018.	Total selenium	Managed Marsh complex (variable locations) 8	Varies – proposed annually	2012, 2015, 2017	IID (IID 2018)

Indicator / Monitoring Activity	Purpose	Туре	Methodology	Metrics	Location(s)	Frequency/ Timing	Sampling Years	Agency / Source
Geography & Geo	ology							
Land cover	Satellite imagery, mapping.	Status & Trends	National Land Cover Database (NLCD) Landsat-based 30 m resolution land cover classification and change patterns from 2001 to 2019.	Land Cover (15 classes)	Contiguous United States	Every 2-3 years	2001, 2004, 2006, 2008, 2011, 2013, 2016, 2019	USGS NLCD (USGS 2021)
Land-surface elevation	Lidar	Status & Trends						
Land cover	Regional land cover of Imperial Valley.	Status & Trends	Imperial Valley Satellite imagery (Landsat). Showing vegetation and cities at low resolution scale.	Land Cover	Imperial Valley on the border of California and Mexico,	Occasional years, June- July	1973, 1992, 2011, 2019	USGS Earthshots
Playa Exposure	Map playa exposure	Status & Trends	Analysis of satellite imagery, USGS gage elevation data and high-resolution bathymetric data to map the playa into three sub-classes: bare playa, open water, and vegetation (IID, 2016).	Acres of exposed playa	Entire Salton Sea playa	Annually, end of year when the Sea is at lowest level	2002-2017	IID (Formation et al. 2018, Formation 2019b)

Air Quality & Meteorology

Ambient Air Quality	Measure ambient air conditions/ particulate matter.	Status & Trends	IID's air quality monitoring program. Collect 5-minute and 1-hour ambient air concentrations of PM10 and PM2.5. PM _{COARSE} is calculated by subtracting PM2.5 from PM10 concentration.	PM10, PM2.5, PM _{COARSE}	6 locations: Torres- Martinez, Salton Sea Park, Bombay Beach, Sonny Bono, Naval Test Station, Salton City	Continuous, year-round	2010-present Ongoing	IID (IID 2016)
Annual Dust Emission Inventory Model	Estimate annual dust emissions from the playa.	Status & Trends	IID's air quality monitoring program. Modeling incorporated playa exposure extent, surface characteristics, vegetation, PI-SWERL sampling results, and hourly meteorological variables (wind speed, direction, friction velocity) using the Weather Research and Forecasting Model (WRF).	PM10 (Total annual tons, tons per day, and maximum day playa dust emissions)	Salton Sea playa	Annual	2017 Ongoing	IID (IID 2018)

Indicator / Monitoring Activity	Purpose	Туре	Methodology	Metrics	Location(s)	Frequency/ Timing	Sampling Years	Agency / Source
Playa Surface Types Emission Potential	Measure the emissions potential of different playa surface types and characteristics.	Focused Study	IID's air quality monitoring program. Emission potential of specific playa surface characteristics was assessed along transects (from high elevation to low elevation / sea shoreline) at seven locations, monthly from November 2016 through May 2017 using the PI-SWERL. In addition, PI- SWERL samples were collected within and outside of dust source areas after high wind events to aid in the quantification of erosional areas throughout the season.	PM10	Salton Sea playa (7 locations)	Unknown	2017	IID (IID 2018)
Playa Surface Characteristics (Modeling)	Evaluate playa surface characteristics.	Focused Study	Part of IID's air quality monitoring program. Includes evaluation of salt crust surface and soil characteristics at 832 exposed playa locations. Ground-based surface evaluations included detailed characterization of surface properties related to erosion (e.g., crust type, loose surface sand, surface soil moisture). These datasets were used as calibration data to spatially map playa surface types using satellite-based imagery.	Surface types (acres)	Exposed Salton Sea playa (832 locations)	Unknown	2003-2017	IID (IID 2018)
Annual Off-sea Dust Emission Inventory (Model)	Estimate annual dust emissions from the desert areas around the Salton Sea and quantify any impacts on the Salton Sea Playa.	Focused Study	Performed as part of IID's air quality monitoring program. Modeling incorporated desert geomorphic surface characteristics, vegetation, PI- SWERL sampling results, and hourly meteorological variables (e.g., wind speed, direction, friction velocity) using WRF.	PM10 (Total annual tons, tons per day, and maximum day playa dust emissions)	Desert area	Unknown	2017	IID (Formation et al. 2018)

Indicator / Monitoring Activity	Purpose	Туре	Methodology	Metrics	Location(s)	Frequency/ Timing	Sampling Years	Agency / Source
Particulate Matter sources	Aerosol and soil chemistry	Focused Study	Sources of dust characterized according to chemical composition.	Air quality Dust chemistry	2 locations – Bombay Beach, Salton City	August 2015, February 2016	2015-2016	Frie et al. 2017
Particulate Matter Sources	Dust chemistry	Focused Study	Dust deposition at five sites around Salton Sea analyzed for composition and source.	Dust deposition Dust chemistry	5 locations – Sonny Bono SS NWR, Wister, Dos Palmas, Palm Desert, Boyd Deep	Cumulative monthly	April 2017- May 2018	Frie et al. 2019
Particulate Matter sources	Dust emission modeling	Focused Study	Weather Research Forecast model (WRF-Chem) used to estimate changes in dust aerosol emission and distribution in the Salton Sea region from 2000 to 2030.	PM10				Parajuli & Zender 2018
Climate	Local meteorological conditions	Status & Trends	Performed as part of IID's air quality monitoring program. Collected via meteorological instruments mounted on 10-meter-tall meteorological towers.	3-dimensional wind speed & direction, horizontal wind speed, ambient temperature, relative humidity, net radiation	Unknown	Daily	Unknown	IID (IID 2016)
Climate	Local meteorological conditions	Status & Trends	Meteorological data from stations located at airports in Salton Sea basin.	Air temperature, precipitation, possibly wind	Jacqueline Cochran Regional Airport (Thermal, Coachella Co) Imperial County Airport (Imperial) Naval Air Facility (El Centro, Imperial Co)	Daily	Pre-2000 – present Ongoing	NOAA
Climate -CIMIS (California Irrigation Management Information System)	CIMIS was designed to assist irrigators in managing their water resources more efficiently.	Status	CIMIS weather stations collect weather data on a minute-by- minute basis. Hourly data reflects the previous hour's 60 minutes of readings. Hourly and daily values are calculated and stored in the dataloggers. CIMIS data is retrieved every hour.	Evapotranspiration (ETo), solar radiation, air temperature, wind (speed, direction), precipitation, relative humidity	 Active stations: 136 Oasis (north) 181 Westmorland North (south) Historic (1994- 2012): 127 Salton Sea West, 128 Salton Sea East 	Hourly, Daily, Monthly	2014-present (2019) Ongoing	DWR CIMIS

Indicator / Monitoring Activity	Purpose	Туре	Methodology	Metrics	Location(s)	Frequency/ Timing	Sampling Years	Agency / Source
California Air Resources Control Board	Air Quality Index	Compliance Status & trends	Number of days of non- attainment of air quality standards (state and national).	Air Quality Index: PM10, PM2.5, Ozone (days exceeding standards)	Imperial County – 6 sites (Brawley, Calexico [2], Westmorland, El Centro, Niland) Salton Sea Basin			
IVAN	Air Quality Index alerts for neighborhoods in Imperial County, for environmental justice.	Status	IVAN (Identifying Violations Affecting Neighborhoods) is an environmental justice monitoring and reporting network of 40 air monitors located throughout Imperial County for more neighborhood-level data. These monitors measure current levels of particulate matter air pollution (PM2.5 and PM10). Data are not validated and cannot be used to determine if air quality standards are being met.	Community Air Quality Level: PM	40 stations, Imperial County	Daily, past 30 & 90 days	2013-2017 May be ongoing depending on funding	Comite Civico Del Valle, California Environmental Health Tracking Program (IVAN n.d.)
Imperial Valley Air Quality	Current air quality index and health advisory conditions.	Status	The Air Quality Index (AQI) is the United States Environmental Protect Agency's tool for communicating daily air quality. For each pollutant, an AQI value of 100 generally corresponds to an ambient air concentration that equals the level of the short-term national ambient air quality standard for protection of public health. AQI values at or below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is unhealthy: at first for certain sensitive groups of people, then for everyone as AQI values get higher. The ozone AQI is an 8-hour index; for particle pollution, it is a 24 hour index.	PM10, PM2.5, Ozone	Imperial Valley – 7 sites (Brawley, Calexico, Westmorland, El Centro, Niland, Holtville, Mexicali)	Daily	Ongoing	CARB, ICAPCD, USEPA

Indicator / Monitoring Activity	Purpose	Туре	Methodology	Metrics	Location(s)	Frequency/ Timing	Sampling Years	Agency / Source
Biological – Bird							·	
General Avian Surveys	Describe bird use on a seasonal and annual basis and assess changes	Status & Trends	Follows protocols used for 1999 comprehensive bird surveys. Survey methodology varies by strata <u>Shoreline:</u> By airboat at pre- selected survey points within the shoreline locations determined each year, representative of the shoreline segment. <u>Open water</u> : 600-m wide transects by boat <u>Created freshwater & saline impoundments:</u> Open water – Visual surveys at established points over a specified time span. Vegetated areas – North American Marsh Bird Monitoring Protocols (Conway 2011) <u>Agricultural lands:</u> Visual observations for 5 minutes at 11 points spaced 400-m along 4-km x 300-m transects <u>Halophytic scrub:</u> Landbird monitoring protocol (Ralph et al. 1993)	Species composition Abundance Seasonal patterns of use Spatial distribution of use	Salton Sea (open water) Salton Sea shoreline Created freshwater impoundments Created saline impoundments Agricultural lands Halophytic scrub	Seasonal: Late Winter (Jan-Mar) Spring Migration (Mar- May) Breeding Season (May- Aug) Early Fall (Aug- Oct) Early Winter (Nov-Jan)	Shoreline point counts conducted by USFWS and CDFW 2000- 2012	California Department of Fish & Wildlife (CDFW) and USFWS (CDFW n.d.1)
Colonial Breeding Bird Surveys	Establish conditions and trends for colony breeding birds	Status & Trends	Follows protocols used for USFWS Pacific Flyway colony nesting surveys and 1999 comprehensive bird surveys.	Number of nests Breeding success	Salton Sea shoreline Halophytic scrub Inland water- Ramer and Finney Lakes	Multiple observations during February -September	2014- Present (2019)	CDFW —submitting info to USFWS (CDFW n.d.1)
Roosting Bird Surveys	Quantify use at roosting areas and changes over time	Status & Trends	Follows protocols used for 1999 comprehensive bird surveys, which includes simultaneous counts at three to six sites by two observers at 1.5 hours before dusk.	Species Abundance	Salton Sea shoreline Created freshwater impoundments Agricultural lands Halophytic scrub	Biannual Spring Migration (Jan- Mar) Fall Migration (Aug-Dec)	Not conducted yet	CDFW (CDFW n.d.1)

Indicator / Monitoring Activity	Purpose	Туре	Methodology	Metrics	Location(s)	Frequency/ Timing	Sampling Years	Agency / Source
Dead and Sick Bird Counts	Identify incidence, magnitude, and vectors of avian disease outbreaks	Status & Trends	Dead and/or sick birds collected and enumerated to determine incidence, magnitude, and vectors of disease outbreaks.	Causal agent Mode of transmission Abundance Species	Salton Sea (open water) Salton Sea shoreline Created freshwater impoundments Created saline impoundments	Monthly, increased as needed	2005 – present (2019)	CDFW (CDFW n.d.)
Aerial Piscivorous Bird Surveys	Assess changes in piscivorous bird populations	Status & Trends	Aerial surveys using fixed wing aircraft of piscivorous birds (e.g. double crested cormorants, brown pelican, American white pelican). Aircraft travels in a counter- clockwise direction around the Salton Sea perimeter, and over wildlife areas.	Abundance of piscivorous birds	Salton Sea shoreline Halophytic scrub Nearby created habitats	6 surveys per year (November – May)	2005-present	CDFW (Idrisi 2019)
Comprehensive Shorebird Surveys	Assess shorebird presence at the Salton sea	Status and Trends	Recording all shorebirds along defined sections of the shoreline	Species Abundance	Entire Salton Sea Shoreline Sonny Bono Refuge Wister Wildlife Area	Annually (November 15- December 15)	2012-2018, 12/15/2021	PRBO/Point Blue
Waterbird surveys	Monitor the spatial and temporal patterns of waterbirds at Salton Sea	Status and trends	Visual count from shore of shoreline and offshore (within 1 km) zones.	Species Abundance	Mid and northern sections of Salton Sea (9 sites)	Weekly (7 sites), monthly (2 sites)	July 2014- June 2018	Oasis Bird Observatory (McKernan and McGaugh 2018)
Waterbird Survey	Monitor the spatial and temporal patterns of waterbirds at Salton Sea	Status & Trends Focused study	1 km ² survey box, 20 minute visual count per box. 9 survey dates total.	Species Abundance (count)	14 sites around entire shoreline	Nov 2016-Mar 2018: every 2 months Summer 2018 onward: monthly	Nov 2016-Mar 2018 Summer 2018- Present (2019)	Audubon California (Orr et al. 2018)
Avian usage/general wildlife surveys	Assess avian and wildlife usage of created marsh habitat	Effective- ness	Surveys concentrate on avian usage of Phase I and II, other wildlife sightings are also recorded. Site visits are conducted diurnally early in the morning, monthly over the course of the year.	Presence/ absence Behavior/ usage (qualitative)	Managed marsh complex (Phase I and Phase 2)	Monthly	2017	IID (IID 2018)

Indicator / Monitoring Activity	Purpose	Туре	Methodology	Metrics	Location(s)	Frequency/ Timing	Sampling Years	Agency / Source
Marsh bird call- back surveys	Assess marsh bird usage of created marsh habitat	Effective ness	North American Marsh Bird Survey Protocol (C. Conway)	Presence/ absence	Managed marsh (Phase I and Phase 2; 29 survey points) Wister Wildlife Area Sonny Bono Wildlife Refuge	Annually (March-May) requires 3-4 separate visits spaced 3 weeks apart	2017 CDFW - 2005- present (2019) USFWS- unknown	IID, CDFW, USFWS (IID 2018; ?)
Southwestern Willow Flycatcher Surveys	To determine habitat occupancy within the Imperial Valley and around the Salton Sea, and assess impacts/ compensatory mitigation requirements for water conservation and transfer actions	Baseline	Requirement of IID's California Endangered Species Act permit. Each site is visited several times and surveyed using taped breeding calls.	Presence/ absence	New River at confluence with Fig Lagoon New River north back at Imperial wetland (Rice Drain No. 3) New River delta Alamo River delta Southwest Salton Sea drainage ditch (Triflolium Dr. No. 1) Palm Wash 1 & 2 from Hwy 111 to Sea (south of Bombay Beach, CA) San Felipe Creek delta	Variable occurrence, between April 15-May 15. Prior to IID water conservation actions that could affect tamarisk (suitable habitat)	2016-2017	IID (IID 2018)
Audubon Christmas Bird Count (CBC)	Annual community science single day count to document species diversity, and relative abundance.	Status and Trends	15-mile-diameter survey circle. North – six or seven groups of citizen birdwatchers spread out over the count circle for a day of counting wintering birds around the north end of Salton Sea. Typically record 130-140 species.	Species Abundance	Salton Sea north (near Whitewater River) Salton Sea south (near SBSS NWR)	Annual (1 day in late December)	SS North 1965-present SS South 1939-present Ongoing	Audubon - San Bernadino Valley and San Diego chapters

Desert Pupfish (CDFW)	Evaluate desert pupfish occupancy and habitat conditions within the Salton Sea and relevant drains and tributaries	Status & Trends	Trapping surveys using minnow traps baited with canned cat food. Conduct in season when species is active.	Relative abundance (Catch per unit effort) Selected habitat conditions: dissolved oxygen, temperature, salinity	Selected tributaries, irrigation drains, refuges (artificial habitat), shoreline pools/ponds, and Salton Sea proper (primarily embayments), including San Felipe Creek, Upper Salt Creek, and Varner Harbor.	Ranges from quarterly to every 5-10 years. Season - Late March-Oct or early Nov.	2014-2019	CDFW (n.d.2; Keeney?)
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Indicator / Monitoring Activity	Purpose	Туре	Methodology	Metrics	Location(s)	Frequency/ Timing	Sampling Years	Agency / Source
Fish population Gillnetting	Monitor changes in fish populations over time	Status & Trends	Gill-netting using two 45-m- long, 5-panel monofilament gill nets set at the water surface. An additional two nets are set at the bottom of the water column at the pelagic sites. Nets are typically set at one or two sites in the morning and hauled in after 24 hrs.	Relative abundance (Catch per unit effort for gill netting) Species composition Size class	Sampling locations within Salton Sea pelagic, near-shore, and estuarine habitats. 8 historic: North Basin, North Desert Shores, The Dome, Inter-basin, The Cliffs, South Salton City, North Wister, & South Basin 6 new (2018): North Shore, Whitewater River delta, Bat Caves, Alamo River delta, New River delta, & Naval Test Base	2017-2018: Summer 2002-2008: Spring: April & May Summer: July & August Fall: October & November Winter: January & February	2002, 2003- 2008, 2017- 2018	CDFW & USFWS (CDFW 2017, CDFW n.d.2, Idrisi 2019

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Appendix B Monitoring Indicators and Priority by Resource Category

APPENDIX B Monitoring Indicators and Priorities by Resource Category

The Salton Sea Monitoring and Assessment Plan (MAP) outlined a comprehensive set of data needed to support long-term management of the Salton Sea, which, however, presents challenges with respect to cost, duration, and long-term data management (USGS 2013). It may not be feasible to sample all metrics with the required replication to make meaningful comparisons at all sites. In some cases, this may mean not measuring highly variable metrics, and instead using resources for monitoring less variable metrics (IEP 2017a). To focus MIP monitoring activities, indicators were defined and prioritized using a progression of criteria (USEPA 2015):

- 1. *Conceptual Relevance or Soundness*—Is the indicator relevant to the question and the resource at risk? Is the indicator correlated to environmental conditions and/or responses?
- 2. *Feasibility of Implementation*—Are the methods practical, technically feasible, cost-effective and efficient for use in in terms of funding, manpower, sample processing, and the complexity of analysis and data interpretation?
- 3. *Response Variability* Are human errors of measurement and natural variability over time and space sufficiently understood and documented? Is the indicator quantifiable and repeatable? Is the indicator ecologically responsive, with high signal-to-noise ratio and high discriminatory ability?
- 4. *Interpretation and Utility*—Will the indicator convey information on resource conditions that is meaningful to Salton Sea managers and decision-makers? Is the indicator understandable and relevant to stakeholders? Is the indicator currently monitored or likely to be easily monitored in the future? Can monitoring efforts be coordinated among federal, state, and local entities and communities?

Proposed indicators were reviewed by Working Group experts and assigned to one of the following priority categories:

- Primary Priority (Priority 1)—core indicators for understanding changing conditions and their relationship to SSMP actions. These indicators have well-understood and strong linkages or correlation with status and function of Sea resources. In addition, the methods of measurement are feasible and the analysis and interpretation is meaningful and actionable.
- Secondary Priority (Priority 2)—indicators that could improve understanding, but may have indirect linkage or weak correlation to ecosystem function, are less relevant to management decisions, and/or less feasible to measure (e.g., more expensive or logistically difficult).
- Focused Study (Priority 3)—indicators that may be considered for a distinct stand-alone study that may provide deeper understanding of causal mechanisms, but is not essential to track important long-term status and trends. This could include indicators that may be conceptually relevant but lack clear methods and means of interpretation at the present time, metrics that

are not strongly linked or responsive to changes in conditions at the Sea, or information that is not actionable by managers.

Indicators with their priority are listed in Table B-1.

Indicator	Conceptual Relevance	Feasibility of Implementation	Response Variability	Interpretation and Utility	Priority	Responsible Entity		
Hydrology								
Lake elevation	Direct driver of shoreline and playa location and area.	USGS has an established gage to measure elevation. If levels drop too far may need to move gage.	Analytical variability is minimal and known. Water surface elevation can be used with bathymetric mapping to reliably quantify the volume and area of the Sea, extent of exposed playa, length of shoreline, and depth, and other factors relevant to existing and future conditions.	Direct correlate of shoreline habitat and playa exposure. Necessary for understanding playa exposure for dust suppression projects, and available water for created saline impoundment projects	Primary	USGS (ongoing)		
Inflow – rivers	Inflows affect water level and volume, and are a key driver for water quality, aquatic habitat suitability within the Sea, and playa exposure. Rivers contribute over 90% of Sea inflow.	USGS maintains gages on the Alamo, New and Whitewater Rivers.	Inflow data are used by the SALSA2 model to predict salinity, shoreline elevation, and water depth, and to validate the predicted water surface elevations. The Whitewater River gage maxes out around 200 cfs and thus misses inflows from larger storm events.	Inflow data can be used to develop a refined water balance, which can then predict salinity, nutrient and selenium loading, shoreline locations, and water depth.	Primary	USGS (ongoing)		
Inflow – direct drains	Drains may provide habitat for pupfish and can support small riparian or wetland habitats emerging near the shoreline. Drains do not make a substantial contribution to the Sea's inflow.	Direct-drain flow monitoring should be coordinated with IID and CVWD. Some drains are already monitored, and information reported to RWQCB. Permission from IID and CVWD	CVWD collects flow data monthly. CVWD monitoring uses a Sontek flow meter or dedicated pump meter, depending on site conditions.	Direct drains contribute a very small proportion of the Sea's inflow. These drains may provide habitat for pupfish and could support small riparian or wetland habitats near the shoreline.	Primary	IID and CVWD (ongoing)		
Inflow – small tributaries (San Felipe Creek, Salt Creek)	The tributaries provide important habitat for desert pupfish.	The gage at San Felipe Creek is not functional.	Historical data could be used, as is currently in SALSA2 model (CH2M Hill 2018).	Small creek inflows contribute a very small proportion of the Sea's inflow. Small creek inflows have a major influence on local conditions. Monitoring these inflows would inform potential habitat creation and air-quality management. San Felipe Creek is located near proposed dust suppression projects and supports populations of desert pupfish.	Primary	USGS (San Felipe-historic, Salt Creek- active)		

 TABLE B-1

 MONITORING INDICATORS AND PRIORITY BY RESOURCE CATEGORY

Indicator	Conceptual Relevance	Feasibility of Implementation	Response Variability	Interpretation and Utility	Priority	Responsible Entity
Groundwater levels	Shallow groundwater levels or water table levels could influence playa emissivity by contributing to soil moisture.	Groundwater wells would be installed and depth measurements manually taken using a well depth sounder or other typical sensor. CVWD and partners may install wells on the east Coachella Valley/north side of Salton Sea More investigation is needed to identify locations that have sufficient water quality and pump rates that will be sustainable without causing negative impact to the aquifer. Security considerations for any permanent monitoring equipment at groundwater wells	Spatial variation is not known.	Shallow groundwater may be a water source for establishing vegetation to control dust. Total volume of groundwater is likely insufficient as a water source for constructed ponds.	Primary	IID
Hydro-dynamics	The purpose of current/velocity monitoring would be to monitor the circulation, stratification, and vertical mixing of the Salton Sea for its influence on water and sediment quality, which in turn affect fish and bird populations and the design and management of restoration projects.	Direct measurements of physical water quality (salinity, temperature, DO) using a handheld sonde at multiple depths is a simpler and efficient method to characterize stratification. Current (water velocity) measurements may be used to provide vertical water-velocity profile information to quantify stratification. Access to sampling sites in Sea may be constrained due to difficult boat access.	Vertical profiles of temperature, salinity and dissolved oxygen at multiple depths would be an easier method to quantify stratification.	Current (water velocity) measurements have also been previously considered for Salton Sea monitoring to calibrate hydrodynamic models of the Sea for stratification, mixing, and circulation. These hydrodynamic models formerly served the purpose of earlier restoration concepts aimed at reducing the size of the lake, however, there is not currently a direct effort to change the lake. Therefore, velocity monitoring is unnecessary for calibrating hydrodynamic models.	Focused Study	USBR (ongoing)

Indicator	Conceptual Relevance	Feasibility of Implementation	Response Variability	Interpretation and Utility	Priority	Responsible Entity			
Water Quality – Surface Water									
Salinity Temperature Dissolved oxygen (DO) pH Turbidity	These parameters are key drivers of biological processes and habitat suitability within the Sea. Salinity is a determinant of aquatic habitat suitability, due to physiological tolerances of most biota. Dissolved oxygen is an integrator of many water quality processes and directly relevant to aquatic species. Deeper waters can become anoxic, and lethal events can occur if those waters are mixed by wind. pH affects ecological productivity, Sediment (measured by turbidity and suspended solids) provides attachment for pollutants such as selenium, heavy metals, and bacteria;	Easily measured and among normal suite of measurements. Access to sampling sites in Sea may be constrained due to difficult boat access.	Analytical variability is minimal and known. Natural variability can be large (temperature, DO), but seasonality of signal is typically known and changes in seasonal DO minima could be detected.	Salinity is one of the benchmark measures and a key driver of the Sea's physicochemical condition. It is a long-standing metric, well understood by the public and managers. Salinity can be expressed as parts per thousand or mg per liter. There is information about species physiological tolerances to help predict future aquatic foodweb conditions based on salinity.	Primary	USBR (ongoing), IID (ongoing)			
Total Suspended Solids, Total Dissolved Solids,	Total Dissolved Solids (TDS) is a common measurement of salinity. Sediment (measured by turbidity and suspended solids) provides attachment for pollutants such as selenium, heavy metals, and bacteria;	Requires collection of water grab samples for lab analysis Access to sampling sites in Sea may be constrained due to difficult boat access.	Analytical variability is minimal and known.	TDS is a commonly used metric of salinity, expressed as milligrams per liter (mg/L). Salinity is also sometimes expressed as parts per thousand.	Secondary	USBR (ongoing)			
Nutrients (N, P)	Nutrients are a primary factor in eutrophication Affects dissolved oxygen, which is a factor for aquatic habitat suitability, especially for fish.	Requires collection of water grab samples for lab analysis Access to sampling sites in Sea may be constrained due to difficult boat access.	Analytical variability is minimal and known. Spatial/temporal variation is not known.	Necessary to inform whether treated water is necessary for built habitat. Useful for determining nutrient loads and the productivity of created habitats.	Primary	USBR (ongoing)			
Selenium	Selenium poses a bioaccumulation risk, particularly in higher trophic levels (e.g., piscivorous birds). Can interfere with reproductive success in certain waterbird species.	Requires collection of water and sediment grab samples for lab analysis Access to sampling sites in Sea may be constrained due to difficult boat access.	Analytical variability is minimal and known.	Selenium concentrations in water sources (river, irrigation drains, Sea) a consideration for constructed habitat ponds.	Primary	USBR (ongoing), IID (ongoing)			

Indicator	Conceptual Relevance	Feasibility of Implementation	Response Variability	Interpretation and Utility	Priority	Responsible Entity
Other contaminants (not Se)	Arsenic – Bioaccumulation risk in fish; toxicity to biota Boron – Toxicity to plants; possible bioaccumulation Legacy Pesticides – Observed in sediments and fish tissue Current use pesticides – Can be toxic to aquatic organisms at low levels	Requires collection of water and sediment grab samples for lab analysis Can be expensive and intensive to get full suite of potential contaminants and to sample with sufficient frequency to cover spatial/temporal variation. Access to sampling sites in Sea may be constrained due to difficult boat access.	High spatial/temporal variation requires many/frequent samples	Information about metals and pesticides would be useful for identifying potential risk at future impoundment sites, but may not be something that can be managed.	Secondary (Primary for ponds)	To be determined
Groundwater quality – Salinity	Salinity measures potential for using groundwater as water supply to establish vegetation for dust control	Easily measured with sondes and inexpensive.	Analytical variability is minimal. Spatial/temporal variation is not known, but would be expected to be less variable than surface water.	If there is sufficient groundwater to consider using at a specific location for dust suppression, information about salinity or other contaminants would be needed to determine if groundwater was suitable for vegetation establishment.	Primary	To be determined
Geography						
Land cover	A measure of the type and amount of suitable habitat available to support fish and wildlife.			Useful for understanding and prioritizing placement of managed habitats and dust suppression projects;	Primary	IID (ongoing)
Playa area extent	The area and location of exposed playa is a key determinant of shoreline habitat availability and amount of potentially emissive surfaces.	Playa area can be measured from satellite aerial imagery	In conjunction with bathymetric information, water surface elevation can be used to reliably quantify the volume and area of the Sea, extent of exposed playa, length of shoreline, depth, and other factors relevant to characterizing existing and future conditions.	Exposed playa is a driver for particulate matter, the main air quality stressor in the Salton Basin Necessary for understanding the amount of exposed playa, and determining placement of managed habitats and dust suppression projects	Primary	IID (ongoing)
Surface characteristics	Characteristics of playa soils (e.g., crust, moisture) and topography are correlated with risk of particulate emissions, which is a known air quality stressor in the Salton basin.			Informs emissivity and habitat potential. Necessary for prioritizing and placement of managed habitats and dust suppression projects	Secondary	IID (ongoing)
Playa emissivity potential	Emissivity is a key factor of likelihood and volume of particulate emissions, which is a known air quality stressor in the Salton basin.			Informs emissivity potential; necessary for prioritizing and placement of managed habitats and dust suppression projects	Secondary / Focused Study	IID (ongoing)

Indicator	Conceptual Relevance	Feasibility of Implementation	Response Variability	Interpretation and Utility	Priority	Responsible Entity
Air Quality						
Meteorology/ Climate	Wind speed and direction are useful for understanding dust movement from exposed playa and prioritizing dust suppression projects Local meteorology (wind, air temperature) strongly affects hydrodynamics (turnover of anoxic high-sulfide deeper water), which in turn may be associated with odors from large-scale algae blooms, fish kills, or other biological decomposition events.	Requires installation of specialized instrumentation and approval by regulatory agencies.	High winds (>25 mph) are linked to high particulate matter mobilization	Focused studies have identified dust sources and likelihood of events based on wind direction, speed and frequency.	Primary	IID (ongoing)
Playa emissions, Ambient air quality (particulate matter)	Inhalable particulate matter is the principal air quality stressor in the Salton Sea Basin.	Requires installation of specialized instrumentation and approval by regulatory agencies.	High winds (>25 mph) are linked to high particulate matter mobilization	Necessary for prioritizing and placement of managed habitats and dust suppression projects. State and federal air quality standards for PM10 have been exceeded at the Sea. Standards for PM2.5 are not exceeded and the potential for significant increases in emissions in the future is low.	Primary (PM10) Secondary (PM2.5)	IID (ongoing)
Particulate matter chemistry	Helpful to understand particulate matter chemistry to evaluate sources and inform placement of managed habitats and dust suppression projects	Requires installation of specialized instrumentation and approval by regulatory agencies. Requires laboratory analysis of collected samples.	High winds (>25 mph) are linked to high particulate matter mobilization and potential for exposure to compounds	Focused studies would identify potential improvements to community health from dust suppression projects.	Focused Study	
Gaseous Pollutants	Relevant only if projects require substantial numbers of fossil-fueled equipment.	Requires installation of specialized instrumentation and approval by regulatory agencies.	Dependent on the number, types, and usage of fossil-fueled equipment.	Monitoring of ozone precursor and other combustion emissions (O ₃ , NO _x , SO ₂ , H ₂ S, and NH ₃) is deemed a low priority, unless very large-scale restoration activities with substantial numbers of heavy- duty equipment are contemplated.	Secondary	

Indicator	Conceptual Relevance	Feasibility of Implementation	Response Variability	Interpretation and Utility	Priority	Responsible Entity
Biological Resources	s – Birds					
General bird survey (shoreline area survey)	Salton Sea is a vital stopover and wintering site for migratory birds on the Pacific Flyway. Variation in migratory species abundance may reflect factors beyond the Salton watershed, such as habitat availability elsewhere on the Pacific Flyway.	Area surveys have been conducted from shore and boat. Access - In recent years there has been lack of boat access, which limits coverage. Surveys from shore depend on permission and accessibility by foot. Foot surveys from shore are labor- intensive to achieve sufficient coverage. MAP frequency is monthly; however, this frequency could potentially be reduced. Frequency could be reduced to 3 times annually to reflect the months with the highest levels of bird use at the Salton Sea between 2016 and 2018 in fall (September), winter (February), and spring (April) (Audubon 2018; A. Jones, Audubon, pers. comm. 2021). If additional monitoring is desired, 6 times annually would capture composition, abundance, and distribution during the late winter, spring migration, breeding season, early fall, and early winter.	Survey protocol can be expanded to collect qualitative habitat information and establish repeatable permanent photo points to detect long-term changes in habitat quality. Bird distribution can be highly variable spatially and temporally, and across years. Avian survey locations should be stratified amongst habitat types and geographic localities. Variation in migratory species abundance may reflect factors beyond the Salton watershed, such as habitat availability elsewhere on the Pacific Flyway.	Bird use of the Salton Sea is a restoration target. Information on sea-wide status and trends of bird species over time, including shifts in bird guilds, will guide management related to habitat projects (habitat design, performance monitoring). Survey locations should be stratified with consideration of future SSMP projects to provide reference data. One additional monitoring location near the southern Wister-Frink project area may be desirable.	Primary	CDFW (ongoing or historic); Audubon and Oasis Bird Observatory (ongoing)
Piscivorous bird surveys (aerial survey)	Piscivorous birds are a restoration target.	Aerial survey protocol is well- established. Cost factor.	May not detect smaller species from the plane.	Piscivorous birds are a restoration target. Data on status and trends of piscivorous bird populations before and after implementation of habitat projects will support effectiveness monitoring and inform need for construction of different habitat types.	Primary	CDFW (ongoing)

Indicator	Conceptual Relevance	Feasibility of Implementation	Response Variability	Interpretation and Utility	Priority	Responsible Entity
Colonial breeding bird surveys	Rocky outcrops on Mullet Island once provided important habitat for colonial breeding birds.	Aerial survey protocol is well- established. Cost factor.	Direct aerial count of breeding pairs can be unreliable. Nesting pairs would be estimated from photographs or videos.	Monitoring is necessary to document status and trends of nesting bird colonies during the breeding season before and after implementation of SSMP habitat projects, as well as to inform the need for construction of different habitat types to support nesting colonies.	Primary	CDFW (ongoing)
Colonial roosting bird surveys	Roosting habitat is a key habitat element for some colonial bird species. The locations could be located in the shoreline, halophytic scrub, agricultural land, or created freshwater impoundment geographic strata (USGS 2013).	Aerial survey protocol is well- established. Cost factor.	Surveys provide a "snapshot" of bird use on the day of each survey and does not provide precise quantitative estimates of comprehensive bird use at roost sites around the Salton Sea.	Monitoring could be informative to document status and trends of roosting bird colonies during the wintering season as species such as double-crested cormorants may utilize different habitats during winter. Monitoring would inform status and trends before and after implementation of SSMP habitat projects, as well as inform the need for construction of different habitat types to support roosting colonies.	Secondary	
Marsh bird surveys	Wetlands around the Sea provide important habitat for marsh birds, including sensitive species. Managed wetlands are minimally affected by Sea hydrology. Natural wetlands emerging on the exposed playa could provide more habitat for marsh bird species.	Marsh bird survey protocols are well-established. Surveys currently focused on managed wetlands. Protocol surveys are time/staff intensive.	Marsh bird survey protocols are well-established.	Yuma Ridgway's rail is a federal endangered species, and black rail is a state species of concern. Marsh bird data (presence, relative abundance, distribution) in managed marshes and wetlands emerging at/near restoration projects will be useful for management of these sensitive species. Marsh establishment may be a limiting factor in the development of SSMP projects due to the presence of fully protected species. Monitoring would characterize the existing marsh bird use (abundance and distribution) and identify status and trends in bird use of marsh areas at the Salton Sea, which would provide important information to help guide the future SSMP management actions. Monitoring before and after implementation of SSMP habitat projects would help	Primary	CDFW

Indicator	Conceptual Relevance	Feasibility of Implementation	Response Variability	Interpretation and Utility	Priority	Responsible Entity
				inform the need for construction of different habitat types.		
				Marsh habitat will be closely associated with SSMP projects because marsh habitat has become established on and/or adjacent to many SSMP proposed project locations.		
Dead and sick bird counts	Lower priority; CDFW is responsible for management actions related to avian disease, though not directly informative of SSMP projects. Salton Sea has historically had high frequency of avian disease outbreaks, and scientists have expressed concerns that disease outbreaks may increase as salinity increases in the Sea due to avian distribution patterns (e.g., high densities at freshwater inflows).	Access may be difficult in some locations such as private lands, or lands requiring encroachment permits. Some areas may be inaccessible due to limited access by water and shorelines due to sands, mud, and muck.		Monitoring would document trends in avian disease before and after implementation of SSMP habitat projects, and could potentially inform design and management of constructed habitats to minimize risk of avian outbreaks.	Secondary	

Biological Resources – Fish

General fish surveys	Provide forage base for fish-eating bird species. Abundance and size distribution is a key metric of fish population size and recruitment success.	Accessibility may be limited, thus sampling locations will depend on access to the Sea.	A combination of beach seining, longer bag seine net deployed via small boat, and gill netting may be used to sample a variety of fish.	Monitoring can be used to inform need for construction of different habitat types (e.g., ponds).	Primary	
	In the past, high abundance of tilapia (an omnivorous feeders of algae and water column invertebrates) may have affected the trophic structure of invertebrates and birds that feed on them.					
	Rising salinity and periodic anoxic events has depressed populations of fish in the open water.					

Indicator	Conceptual Relevance	Feasibility of Implementation	Response Variability	Interpretation and Utility	Priority	Responsible Entity			
Bio – Plankton and Macroinvertebrates									
Primary productivity (chlorophyll a is measured via water quality sampling)	Good general indicator of general primary productivity by green algae, which is a foundation of the aquatic foodweb.	Easily measured as part of water quality monitoring using a sonde or grab sample for lab analysis.		Good indicator of general productivity and eutrophication, which could inform design and management of created impoundments. Does not inform what species of green algae are present, nor presence of other primary producers (cyanobacteria).	Primary	CDFW			
Phytoplankton surveys	Indicator of Salton Sea ecosystem health; key food source for zooplankton.	Access may be difficult in some locations due to limitations with boat launching sites. Requires specialized lab analysis for species identification.	High seasonal variability likely		Secondary	CDFW			
Zooplankton surveys	Key food source for fish and invertebrate-foraging birds. Abundance and diversity can be indicative of water quality and prey availability.	Access may be difficult in some locations due to limitations with boat launching sites. Requires specialized lab analysis for species identification.	High seasonal variability likely		Secondary	CDFW			
Macroinvertebrates (water column and benthic) surveys	Macroinvertebrates (boatmen, pileworms if present, brine fly larvae, brine shrimp) are a key food source for birds and fish. Abundance and diversity can be indicative of water quality and prey availability.	Access may be difficult in some locations due to limitations with boat launching sites. Requires specialized lab analysis for species identification.	High seasonal variability likely	Certain species can be indicative of water quality as per State Water Resource Water Board's Surface Water Ambient Monitoring Program guidelines.	Primary	CDFW Audubon (ongoing with bird shoreline survey)			
Cyanobacteria	As salinity and air temperatures increases, the algal community may shift from phytoplankton (green algae) to cyanobacteria (blue-green algae).	Algal blooms would be noted visually as they occur.	Cyanobacteria blooms are episodic depending on conditions (warm, still water) and difficult to predict.	Cyanotoxins from harmful algal blooms can affect public health, avian health; algal blooms also affect aquatic productivity and habitat suitability for fish and wildlife	Focused Study	none			
Microbial loop	As salinity increases, the microbial community may become the dominant basis of the food chain. This is recommended as a focused study to better understand food web interactions.	Identification of microbiota requires specialized expertise.			Focused Study	none			

Indicator	Conceptual Relevance	Feasibility of Implementation	Response Variability	Interpretation and Utility	Priority	Responsible Entity
Biological Resources	s – Special-status Species					
Desert pupfish surveys	Desert pupfish are one of the only native fishes in the Salton Basin (shoreline pools, small tributaries, and drains).	Sampling with minnow traps in small tributaries and drains is a proven method. Placement of traps is dependent on access permission (irrigation drains) Requires federal collecting permit.	Many of the localities that support pupfish have highly variable flows (seasonal, spatial). Pupfish abundance and distribution can be highly variable.	Desert pupfish is a protected species (Federal and State endangered). Restoration projects should minimize impacts and where feasible contribute to recovery. Pupfish are expected to use created impoundments. Data on pupfish distribution and abundance/condition will be important to minimize impacts from projects (construction, operation and maintenance) and guide mitigation if necessary. Habitat information collected during pupfish surveys (flows, aquatic vegetation, other fish species) can be used to assess site suitability for supporting pupfish. Habitat conditions in constructed ponds are expected to be suitable for desert pupfish, which can contribute to species recovery. Although the primary purpose in some ponds (e.g., SCH ponds) is to provide forage fish for the piscivorous birds, not as a pupfish refuge, there are other ponds (e.g., 25-acre CVWD mitigation habitat)	Primary	CDFW (ongoing), IID (past periodically)
Southwestern willow flycatcher surveys	Nests in riparian woody habitat, which is expanding in some areas where drains discharge directly on the exposed playa.	Established survey protocol (e.g., USGS southwestern willow flycatcher protocol). Implemented annually by IID in managed marsh.		to create habitat for desert pupfish. Southwestern willow flycatcher is a Federally endangered species.	Primary	IID (ongoing)

Indicator	Conceptual Relevance	Feasibility of Implementation	Response Variability	Interpretation and Utility	Priority	Responsible Entity
Western snowy plover surveys	Salton Sea is key interior breeding habitat for this species. Species breeds along Salton Sea shoreline	Access may be difficult in some locations such as private lands, or lands requiring encroachment permits. Some areas may be inaccessible due to limited access by water and shorelines due to sands, mud, and muck.		The interior western snowy plover is not a population of concern under the federal ESA. Necessary to consider during project placement and design.	Secondary	
Socioeconomics						
Public Participation at SSMP events	Monitoring the effectiveness of public engagement (the accessibility and extent to which the goals of the SSMP are understood by the public) is important in understanding how surrounding communities understand the environmental conditions at the Sea and the goals and projects of the SSMP.	Attendance at meetings and events Use of electronic media (website visits, newsletters) Social media engagement (secondary) Surveys and focus groups These monitoring efforts will build on existing public engagement monitoring efforts conducted by DWR. An effort should be made to repeat methods of engagement in order to provide interpretable data. Changes in outreach methods that result from participation monitoring results should be documented.	These indicators are quantifiable and repeatable. Changes in the methods of public participation and the team tracking participation over time should be documented and included in reporting.	Evaluating the effectiveness of public engagement, including how accessible it is and how well it follows the public engagement plan, is important, as it may inform further refinements of the public engagement plan. Better public engagement will elicit public input that will contribute to prioritizing and refining management actions.	Primary	DWR
Community benefits	Tracking community benefits created by the SSMP will aid in further understanding the relationship of the surrounding community to SSMP projects and whether SSMP projects are addressing community interests and needs.	Track local jobs created by direct hiring/ spending by DWR. Induced job creation will be tracked using IMPLAN multipliers based on direct spending. Tracking community benefits will be done by DWR and will involve documenting project components that result in increases in recreation, access etc. These will be documented at the completion of each SSMP project.	As jobs indirectly created by DWR projects will be estimated using IMPLAN projections, this data may produce a completely accurate picture of local jobs created by DWR projects. Findings from IMPLAN modeling should be ground truthed by using annual, regional job data from Employment Development Department	The goal of monitoring community benefits that result from SSMP projects and or funding identified or facilitated by DWR will document the extent to which community stakeholders are informing project design and the extent to which projects are addressing diverse community needs and interests. This information will be used to guide community outreach and engagement in the siting, design, and management of future SSMP projects.	Primary	DWR

Indicator	Conceptual Relevance	Feasibility of Implementation	Response Variability	Interpretation and Utility	Priority	Responsible Entity
Economic indicators	Establish baseline understanding of economic conditions of the communities around the Salton Sea which may inform implementation of SSMP Projects. Near-term implementation of management actions to control dust and restore habitat are not expected to directly, measurably affect economic indicators, information about general economic conditions will provide better context for understanding the economic needs and overall socioeconomic health of the communities surrounding the Salton Sea. This will inform prioritization and implementation of management actions.	Census Bureau data is free and is available for communities of various sizes around the Salton Sea. 5-year estimates from the American Community Survey should be used in order to increase the statistical reliability of the data gathered while also gathering annual data.	Near term projects implemented by the SSMP are not expected to directly measurably affect indicators gathered from U.S. Census Bureau data forms. In order to increase the ability for this data to provide useful information about economic conditions in communities around the sea, data for a variety of geographies should be gathered (i.e., gather data at the County Scale, Census tract level, and community-wide level around the lake) in order to capture changes on both the regional and community-level and to capture changes in economic conditions in all communities around the lake,	Monitoring economic indicators may inform prioritization of SSMP actions with respect to economic need in the communities around the Salton Sea and maintain an up- to-date understanding of the overall socioeconomic health of the region to inform program implementation.	Secondary	DWR

Sources

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