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Water Policy

Framing the Crisis Unfolding at the Salton Sea

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HIGHLIGHTS

- **Diverse environmental problems at the Salton Sea are severe and require immediate action in the short term and science-based planning for the intermediate and long term.**
- **Regional water policy decisions will have the greatest impact on the fate of the Salton Sea, as urban water districts, agricultural irrigation and natural ecosystems all compete for California's allotment of water from the Colorado River.**
- **Management plans that are enacted without a better understanding of the natural, physical, biological, chemical, and ecological systems in and around the Salton Sea—and how those systems interact with local communities—will be uninformed at best.**
- **A competitive, interdisciplinary research program open to researchers at universities and non-profits is needed to guide policymakers, government scientists, and contractors.**

The Salton Sea is shrinking, and salinity is rising—leading to the demise of once abundant fish and invertebrate populations and the loss of a vital feeding, resting, and nesting site for millions of birds migrating along the Pacific Flyway (Figure 1.1). The rapid shrinkage of the Sea is generating toxic gases and micron-sized particulate dust (Cohen et al., 2006; Buck et al., 2011; Frie et al., 2019) that threatens the health of hundreds of thousands of Californians, many of whom live in disadvantaged and vulnerable low-income communities. Beginning in January 2018, some of the water flowing into the Sea was diverted to urban water districts, accelerating the decline to -236.4 feet by the end of 2020 (SSMP, 2021). Despite vast investments of time and an ample planning horizon, adequate solutions addressing the full range of problems have failed to materialize in implementation or

BLACK-NECKED STILTS foraging along the receding shoreline near North Shore Yacht Club. Jonathan Nye

concept. Indeed, more than two decades have transpired since the introduction of the water transfer between the Imperial Irrigation District and the San Diego County Water Authority that would become the 2003 Quantitative Settlement Agreement (Littleworth and Garner, 2019), yet little has been accomplished.

More recently, funds have been appropriated to design and implement a 10-year interim Salton Sea Management Plan (SSMP, 2018). The passage of California's $7.5-billion Proposition 1 bond in 2014 allocated slightly over $80 million for the Salton Sea—funding primarily for the design and documentation of the interim plan with some allocations for construction projects. In 2018 California voters passed Proposition 68, with $200 million earmarked for mitigation of dust and other environmental problems emanating from the Salton Sea. In total, with the enactment of the 2020–2021 state budget, California has appropriated $345.3 million for Salton Sea–related activities; the federal government has appropriated $1.4 million (SSMP, 2021). These legislative actions provide funding for mitigation and restoration—but not research.

Including some additional, smaller appropriations towards Salton Sea restoration activities, the funding to date has focused almost exclusively on design-and-build projects for dust mitigation and habitat restoration in and around the Salton Sea. Although such efforts are necessary, little funding has been available for basic research based on the evolving environmental conditions at the Sea over that same period. Barnum et al. (2017) summarized research gaps based on a study conducted in 2014. Many of the concerns in that study are still pertinent today and underscore the urgent need for an adaptive, science-based approach to management. The UC Riverside (UCR) Salton Sea Task Force was created to address this omission and provide guidance to policy makers on what we still need to know to solve the growing environmental and human health crisis. Although support for increased funding to manage the Salton Sea is gaining traction, we caution that policies and strategies not supported by up-to-date, evidence-based science may lead to ineffective, costly, and unsustainable outcomes—in effect, poor investments.

Water Rights

THE SALTON SEA is shrinking primarily because regional water policy—indirectly—is providing it a significantly smaller share of water from the Colorado River (Box 1A). The Salton Sea's main water source has always been the Colorado River, which flows through some of the driest portions of the United States. Water released from upstream dams on the Colorado River in Colorado, Utah, and Arizona is earmarked for use by seven states and a myriad of water districts. California holds senior water rights on much of this water, most of which in turn is allocated to the Imperial Irrigation District, which supports the agricultural production of the Imperial Valley to the south of the Salton Sea. Much smaller portions of California's share go to other irrigation and municipal water districts in the region (Thrash and Hanlon, 2019). Colorado River water makes its way to the Salton Sea as irrigation run-off from the agricultural fields of the Imperial Valley. That reliable water source was curtailed after a protracted legal battle finalized the 2003 Quantification Settlement Agreement (QSA), which allowed Imperial Irrigation District to sell a sizeable amount of its Colorado River water allocation to San Diego County Water Authority (Figure 1.2).

FIGURE 1.1 Viewing the Salton Sea in its western North America regional context reveals its critical position for water birds migrating lake-to-lake along the Pacific Flyway as well as the vastness of irrigated agricultural lands to the south. Credit: Sarah Simpson. Source: Google Earth.

To generate the water for transfer and sale, Imperial Irrigation District engaged in several activities to reduce the amount of water used for irrigation, including the fallowing of agricultural lands in the Imperial Valley early in the program, to be followed up later by improved irrigation efficiency. Both water-saving approaches conveyed the known side effect of drastically reducing inflows to the Salton Sea. To mitigate the certain impact on Salton Sea volume and provide time for a solution, the QSA stipulated that a total of 800,000 acre-feet of "mitigation" water to be sent to the Salton Sea from 2003 through 2017. Although inflows to the Salton Sea remained somewhat constant during that period, Salton Sea water elevation declined (Chapter 2). The decline accelerated at the beginning of 2018, due to the cessation of this mitigation water.

The QSA served several purposes, including mandating a reduction in California's overall Colorado River water use from 5.2 million acre-feet annually to its legal cap of 4.4 million acre-feet. The agreement also provided San Diego a reliable water source—even though it had the lowest priority water rights for Colorado River water. However, the potential costs associated with these transfers and the consequent effects on the Salton Sea and surrounding communities are exorbitant (Cohen, 2014).

In an effort to avert potentially substantial externalities to both environmental and human health, the Salton Sea Authority created a 10-year management plan. Numerous governments, non-governmental organizations, and local stakeholders prepared this plan, which relies on a mixture of new wetland construction and water quality control (Forney, 2018). Wetlands naturally grow as the shoreline recedes. These vegetated wetlands are supplied primarily by surface water inflows from the New and Alamo rivers and expected to support invertebrates, rails, and migrating geese. Intentional construction of estuarine wetlands or impoundments are being developed on the northern and southern shorelines with freshwater combined with the Sea's already salty water in the hope of supporting fish and fish-eating birds. In the future, more extreme measures may be taken to control salinity and water quality. Desalination plants could be

BOX 1A

California's Share of the Colorado River

NO WATER IS DIRECTED INTENTIONALLY TO THE SALTON SEA, yet its existence depends on unintended water transfers from the Colorado River (yellow box). In the federal tiered system of water rights, Palo Verde Irrigation District and the U.S. Bureau of Reclamation have first dibs on California's annual allotment of the Colorado River, which is 4.4 million acre-feet. Next in line is Imperial Irrigation District (IID), which provides water to about 500,000 acres of farmland in the Imperial Valley. Irrigation run-off and drainage from the Imperial Valley provides more than 90 percent of the Sea's annual inflow. A regional water policy called the 2003 Quantification Settlement Agreement authorizes IID to transfer some of its water to urban users in San Diego County and other parts of southern California, limiting water available to the Sea.

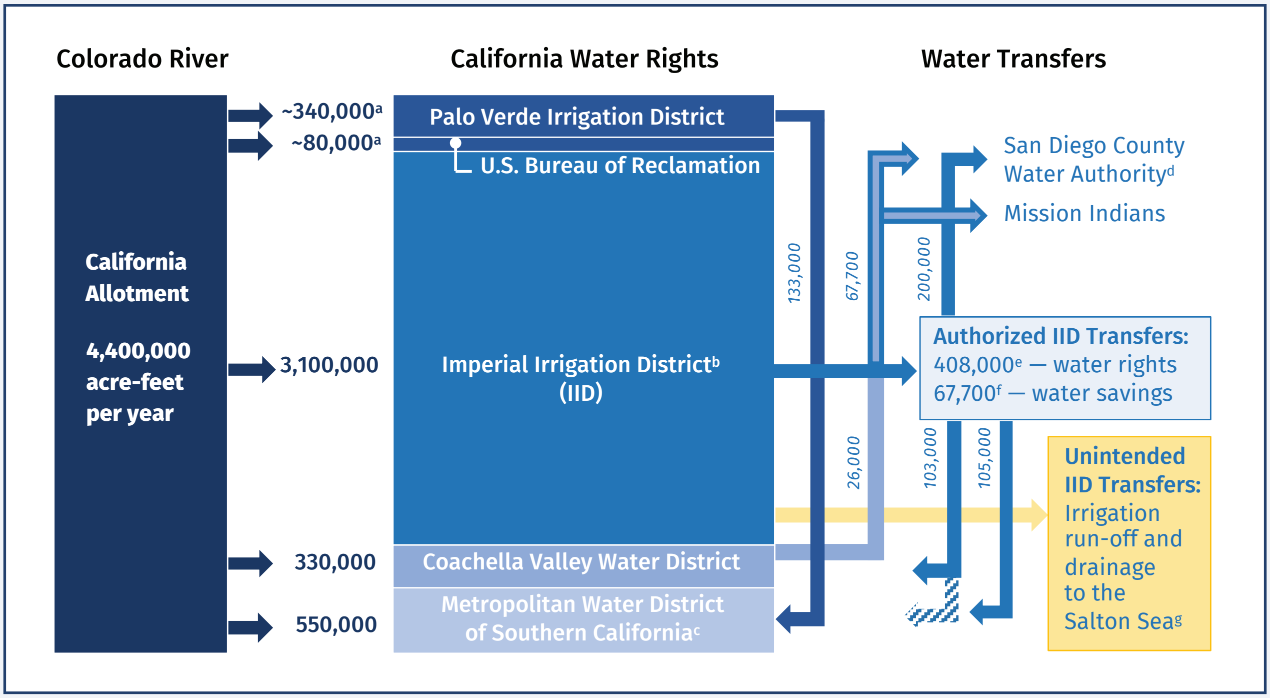

FIGURE 1.2 Annual Colorado River water allotments.
a Estimates are based on Palo Verde Irrigation District's right to irrigate 104,500 acres and the Bureau of Reclamation's right to irrigate 25,000 acres for its Yuma Project; agreements do not specify quantity of water or crop type.
b The 2003 Quantification Settlement Agreement (QSA) requires Imperial Irrigation District (IID) to stay within its limit of 3.1 million acre-feet per year and authorizes the agency to transfer a specified amount of its water rights and water savings to other agencies. The QSA also set 330,000 acre-feet per year as the maximum allotment for Coachella Valley Water District (CVWD).
c If Colorado River inflows to California drop below 4.4 million acre-feet, Metropolitan Water District (MWD) will be the first agency required to reduce usage.
d San Diego County Water Authority, which had no rights to California's 4.4-million-acre-feet limit before 2003, is now guaranteed water ahead of MWD.
e The QSA authorizes IID to transfer up to 408,000 acre-feet of its water rights to other users, including 103,000 acre-feet to CVWD; if unused, that amount can be transferred instead to MWD (striped arrow).
f IID and CVWD achieved annual water savings of 93,700 acre-feet by lining their two main canals to prevent leakage. The QSA stipulates that the water conserved by these projects be passed on to San Diego County Water District and several bands of Mission Indians in San Diego County. IID's All American Canal generates annual water savings of about 67,700 acre-feet; CVWD's Coachella Canal generates annual savings of about 26,000 acre-feet.
g The QSA required IID to direct an average of 53,000 acre-feet of mitigation water to the Salton Sea each year from 2003 to 2017, when mitigation transfers ceased.

Credit: Sarah Simpson. Sources: Littleworth and Garner, 2019; San Diego County Water Authority, 2020; Water Education Foundation, 2021.

GREAT EGRETS and other birds foraging in the Imperial Valley south of the Salton Sea. Jonathan Nye

constructed, or freshwater flows could be diverted to the shoreline while allowing the central basins to increase in salinity. Proposals for pumping in fresh water or desalinated water from elsewhere—even possibly from the Gulf of California—are currently under consideration with the Salton Sea Management Program.

People who live in the region initially wanted to preserve the Sea's shorelines as they were in 2006, or even earlier. The initial, ambitious plan proposed by the Salton Sea Authority included developing the northern half of the Sea as a recreational fishing and boating destination. California deemed that plan too expensive and then took another decade to produce the current Salton Sea management plan, introducing a significantly scaled-back effort limited primarily to the north and south shorelines along with dust mitigation in targeted areas (2020a, b). The $400 million estimated capital cost to implement the Phase I of the interim Salton Sea Management Plan pales in comparison to the estimated costs associated with declining air and water quality, the endangerment of certain species of fish and birds, and the health threats to those living around the Salton Sea (Cohen, 2014). To the extent state and/or federal governments may assume liability for such damages—either voluntarily or through lawsuits—the mitigation and restoration costs will likely seem insignificant.

Water Budget

COMPLEX MODELS for determining the interactions among the stakeholders of the region and the flows of waters into the Sea need more solid information to fully determine what the future will be for the Salton Sea and how policies should be developed to determine the best strategy for mitigation. Central to a model developed by Kjelland et al. (2019) are two factors: climate and local hydrology. Accordingly, the UCR Salton Sea Task Force has synthesized outstanding research questions facing this critical region and how the Salton Sea's changing environment might impact people living in the Imperial and Coachella Valley communities. This report will provide recommendations to managers at state and federal natural resource agencies to assist them in creating timely and relevant research agendas to complement the current management plan, and to California legislators, who will be developing and approving public policy.

California's current Salton Sea management plan calls for wetland restoration and dust suppression projects across 30,000 acres of shoreline to be implemented by 2028. For example, 755 acres of dust suppression projects were completed in 2020, and construction began on the 4,110-acre Species Conservation Habitat in January 2021 (SSMP, 2021). The northern and southern shores will have diked ponds fed by gravity flow from the three rivers flowing into the Sea, and wetlands will be allowed to develop as the shoreline recedes. These wetlands are intended to have much lower salinity than the main body of the Sea, possibly allowing for the growth of fish populations to attract pelicans and other fish-eating birds; however, the engineering plans are not based on current scientific knowledge of the Sea's ecosystem.

It is also important to note that current management plans do not call for any Colorado River allocations to be directed to the Sea, nor do they explicitly include any other new sources of water. Without intentional intervention, lake levels will continue to decline, even as wetlands are constructed on exposed lakebed. We are optimistic that this dropping-lake-level trend could be stabilized or partially reversed, however, if future decisions are made to direct water to the Sea. We therefore considered three plausible water budget scenarios facing the Salton Sea over the next two decades: (1) ongoing decline, (2) stabilization, and (3) recovery (Box 1B, Figure 1.3).

Hypothetical Future Scenarios for the Salton Sea

BOX 1B

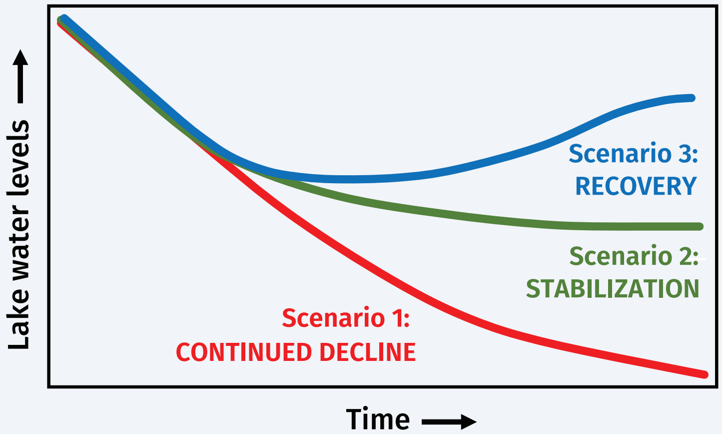

FIGURE 1.3 **Three possible outcomes for future Salton Sea water levels: continued decline (red), stabilization (green), and recovery (blue).** Credit: Sarah Simpson. Source: UC Riverside Salton Sea Task Force.

Continued Decline

WITHOUT INTERVENTION, water levels will continue to decline, even as wetlands are constructed on exposed lakebed. The lake level measured on December 31, 2020, was -236.4 feet (SSMP, 2021)—a drop of 8.4 feet since 2003. Without a change in inflows, another five feet of decline is expected by the end of 2025 (SSMP, 2021).

The exposure of additional lakebed on the southern shore has accommodated the start of construction of the 4,110-acre Species Conservation Habitat project, which broke ground in January 2021 (SSMP, 2021). Newly exposed lakebed may also be appropriate for construction of new geothermal power plants and lithium extraction facilities (Chapter 7).

Even as wetlands are constructed along the lakeshore, the Sea will continue to decrease in volume, and the deeper portions will increase in salinity, metals, and pesticides. Dead zones will become more prevalent.

Stabilization

A CHANGE TO CURRENT water policy could intentionally direct a limited amount of Colorado River water to the Salton Sea, possibly by purchasing portions of river allocations currently devoted to agriculture (Levers et al., 2020). Such an effort could slow the decline, possibly stabilizing lake level at some point lower than it is today.

For this scenario to be effective, it would be critical to identify what specific lake level is necessary to avoid exposing the most toxic lakebed sediments, which concentrate in the deeper portions of the Sea (Chapter 3).

The Salton Sea Management Program projects the decline in lake levels will stabilize around -255 feet by 2030, but the computer model they use does not account for changing subsurface water flows, which may explain unexpected declines since 1995. Accurately projecting future water levels requires careful assessment of lake-groundwater interactions (Chapter 2).

Recovery

WITH LONG-RANGE PLANNING and significant capital investment, a significant new source of water could be pumped into the Salton Sea or adjacent historic wetlands from the Gulf of California or local groundwater sources. The Salton Sea Management Program is currently assessing water importation proposals to inform their long-term management plan, due for completion by the end of 2022 (SSMP, 2021). Another recovery option would be to negotiate significant Colorado River water purchases to direct to the Sea (Levers et al., 2020).

A goal of some stakeholders in the region is to increase Salton Sea water volume to the average historic water levels (1980–1995), which were stable at approximately -228 feet.

Recovery schemes that rely on imported water would take at least ten years to implement, so actions to mitigate human health hazards and ecological collapse must be made in the meantime.

Even if more water is directed to the Sea, there may be additional challenges to stabilizing lake water levels (Chapter 2). Overall Colorado River inflows may decline soon owing to lower snowpack and population growth upstream, for example. Higher evaporation rates are also expected as climate warms. There could also be unforeseen changes in subsurface water flow around the Sea, particularly if adjacent aquifers are pumped to supply water to the growing population expected in the Coachella Valley, to restore wetlands around the margins of the Sea, or to facilitate geothermal mineral extraction.

Motivations

THE MAJOR IMPETUS for promoting an active university research program at the Salton Sea is health problems due to the Sea's unstable ecology (Chapter 6). The population's average income is less than $35,000 annually, with the demographics roughly 80% Hispanic, 13.7% White/Hispanic, and 10.5% Black Americans (Marshall, 2017). It is not difficult to surmise that health problems may increase as the Sea's shorelines widen. Declining water quantity and quality is promoting harmful algal blooms that can be toxic to wildlife and people. Southern California deserts are projected to face increased temperatures and lower rainfall. Directly north, Palm Desert, Palm Springs and the other desert cities are home to 350,000 residents who enjoy clean desert air. Potential future Salton Sea scenarios may jeopardize that outcome.

Dust always affects air quality in deserts; however, in the Salton Sea region the chemical composition of that dust could be contributing to the particularly high incidence of asthma in children. Asthma from inhalation of dust has negative impacts on children (20% are estimated to have asthma) in the area as well as adults. Because Colorado River water has higher than average concentrations of metals such as selenium and molybdenum, dust originating from exposed shorelines could consist of higher, potentially toxic concentrations of metals (Buck et al., 2011; Frie et al., 2019; SSMP 2021). With lower lake levels, the unique salt crust that paves the bottom of the Sea will be revealed. Currently it is unknown whether this crust will be a stable surface or the degree to which it will contribute to particulate loads in the air. Wind patterns in the Salton Basin are variable and seasonal, resulting in dust composition that will be variable as well. The full complexity of atmospheric patterns and geochemistry of dust particles remains unknown (Chapter 4).

As the salinity increases, organisms living in the Salton Sea must adapt to living in extreme environments (Chapter 5). Tilapia—the major fish species remaining in the Sea—is struggling to survive as salinity has surpassed 74 parts per thousand, more than double the salinity of the Pacific Ocean (SSMP, 2021). The endangered desert pupfish will find its habitats increasingly isolated from one another. Bird populations that rely on these fish for food, such as brown and white pelicans, are declining, and migratory species from across North America are affected adversely (Lyons et al., 2018). Over the last 115 years since the current Salton Sea formed, migratory birds by the millions have made it an important stopover (Shuford et al., 2002). Some of the more than 400 bird species are on their way south along the Pacific Flyway, while others arriving from Canada and northern United States spend the winter months at the Salton Sea feeding on fish and invertebrates. Because wetlands have been destroyed over much of California, including Owens Lake, the Salton Sea has—now more than ever—become one of the most important habitats for these birds (Figure 1.1).

The Sea also experiences extremes in chemical inputs, particularly as nutrient-rich and pesticide-laden

How will the cultural connections of the Torres-Martinez Desert Cahuilla community be affected by changes to the Salton Sea?

Although the modern Salton Sea is the result of an "accident" caused by humans, the Salton Basin has been the location of an ephemeral body of water going back thousands of years. The Torres Martinez Desert Cahuilla Indians have a long history in the area. Their federal reservation, established in 1876, is now partly flooded by the current Salton Sea. Approximately 40% of their 24,024 acres of land lies under the northern portion of the Sea, near Mecca. The concerns of this group should be addressed as lakebed exposure and mitigation plans unfold.

runoff from the irrigated agricultural fields of the Imperial Valley is its primary source of inflows. Excess nutrients cause algal blooms with species known to contain toxic compounds from cyanobacteria and dinoflagellates. As the species die off, oxygen depletion in the shallow waters occurs, creating dead zones that will become longer and more frequent as water volume decreases (Chapter 3). These anoxic conditions, particularly in summer and early fall, promote the activity of microorganisms that produce unpleasant toxic gases—hydrogen sulfide, for example—that emanate from the lake during windy days. The lack of oxygen also causes changes in the chemical state of toxic metals, like selenium and molybdenum. As the lakeshore dries further, these metals could be incorporated into a toxic dust. Alternatively, aerosol droplets of surface water could form small particles spreading metals in a much wider pattern throughout the region.

As the costs for mitigation and restoration of the Sea begin to be realized, funding for these projects will come under scrutiny. The region holds two possibilities for enhancing funding: increased geothermal power generation and lithium extraction (Chapter 7). California's energy policy requires 100% renewable energy sources by 2045, yet solar and wind energy cannot provide a full solution to power the grid during night or low-wind conditions. Geothermal energy can be supplied on a continuous basis with excess energy converted to hydrogen to be stored until needed (Elders et al., 2019). Furthermore, geothermal brines contain economic concentrations of lithium, a metal required for batteries and other industrial uses (McKibben and Williams, 1989). The region's mineral and energy wealth could provide a stream of revenue needed for an economically feasible environmental outcome, but the idea needs further study, including an assessment of the potential environmental impacts from increased geothermal plants and mineral extraction.

Research Needs

FURTHER RESEARCH is needed to develop a deeper understanding of how the Salton Sea system functions now and in the future (Box 1C). More sustainable approaches for mitigating toxic dust risk are needed, as well as to ensure birds continue to have a home in the area. Creating a competitive, interdisciplinary research program open to researchers at universities, non-profits, and government agencies would provide critical guidance to policymakers, government scientists, and contractors.

Outstanding Concerns

BOX 1C

- **What is needed to produce an accurate hydrological model that reflects the Salton Sea's status both today and in the future under different climate change scenarios and water supply and demand outcomes?**
- **Does the Salton Sea's playa or waters contribute more to the dust in one region relative to another? Which communities are most heavily impacted?**
- **How do the Salton Sea's shoreline crusts form? How stable are they, and what is their potential toxicity? Do they affect air quality in the region?**
- **How is the current Salton Sea ecosystem functioning today? What is its future?**
- **What will be the impact on biodiversity in the Sea and surrounding environments?**
- **How will the ecosystem in constructed marshlands relate to natural marshlands and adjacent nearshore communities?**
- **How has the metal (e.g., selenium) and nutrient cycling in Salton Sea's briny water habitats changed over the past 20 years? How will these biogeochemical cycles change with evolving lake levels?**
- **What will be the broad scale impacts if water is diverted back to the Salton Sea (e.g., development of San Diego, regional advantages, costs, and impacts of mitigation efforts to contain hydrogen sulfide releases)?**
- **What is the extent of the health problems in the region related to the Salton Sea?**
- **How does the Sea's unstable ecology affect human health?**
- **What is the connection between current health and past exposures to dust and noxious gases?**
- **How will the cultural connections of the Torres-Martinez Desert Cahuilla community be affected by changes to the Salton Sea?**
- **What is the potential for geothermal energy and mineral extraction (e.g., lithium) in this area? Are there other resources in this area that might improve the region's economy?**
- **What are the potential environmental impacts from increased geothermal plants and mineral extraction?**

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