

Assessing Landscape Suitability for Public Access at the Salton Sea



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Cover Photo

Local leaders gathered at a nature viewing area on Rock Hill Trail at the Sonny Bono National Wildlife Refuge. Photo: Camila Bautista/Audubon

Additional Resources

For more information, visit the Audubon Salton Sea resources [website](#) or scan the QR code.



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Contents

- Executive Summary5
- Introduction.....7
 - Study Area8
- Methods.....9
 - Study Extent9
 - Landscape Suitability Analyses.....9
 - Select Predictor Variables.....10
 - Develop Spatial Data for Analysis10
 - Weight Variables.....11
 - Suitability Models.....11
 - Ground Truthing.....11
 - Land Ownership Prioritization.....12
 - Consensus Maps.....12
- Results.....12
- Discussion14
 - Limitations14
 - Informing Specific Types of Public Access15
 - Informing Public Access in the Context of Land Ownership Complexities.....16
 - Informing Multi-use Public Access Planning17
 - Implications to Current SSMP Projects and Long-Range Planning17
- Conclusion20
- Citations21
- Figures and Tables.....22



A flock of birds flying over a wetland area at the Salton Sea State Recreation Area, with a Great Egret perched in the foreground. Public Picnic and BBQ areas shown in the background. Photo: Camila Bautista/Audubon

Executive Summary

The Salton Sea is shrinking, which has resulted in detrimental effects to the environment, economy, and health of surrounding communities. The California Natural Resource Agency's Salton Sea Management Program (SSMP) was implemented to address and mitigate poor air quality and threats to the ecosystem, promote habitat restoration, and improve public health. As the SSMP implements habitat and dust suppression projects, enhancing public access for local communities, scientists, and tourists will be important. To contribute to long-range planning and related public access needs, including implementation of the SSMP 10-year Plan, we conducted surveys in communities surrounding the Salton Sea, and with local agencies, to understand their preferred choices regarding services and activities at the Salton Sea. Based on the results of this community survey and engagement with local agencies, we selected three public access uses that best reflect high value and importance: picnic/BBQ areas, nature and wildlife viewing areas, and boat ramps.

We created landscape suitability models to assess suitable locations for implementing each of the three public access types. The models required identifying predictor variables that contribute to suitability of the area for public access, developing spatial data for each predictor variable, determining the weight of each predictor variable in the analysis, and combining all weighted predictor variables. We separated each suitability model into three priority tiers according to land ownership: publicly owned lands (Tier 1), local water district lands (Tier 2), and Bureau of Indian Affairs (BIA), private, and unknown ownership lands (Tier 3). Finally, we created a consensus suitability model to assess the overlap of these suitability models.

The landscape suitability models show areas that are more or less suitable for picnic/BBQ areas, nature viewing areas, and boat ramps. For each landscape suitability model, we included three sets of maps: 1) overall landscape suitability maps, 2) suitability maps prioritized by landownership tiers, and 3) suitability maps focused on Salton Sea project sites. We also included two sets of consensus suitability

maps encompassing the top suitability locations for multi-use areas. One set of consensus maps includes overlapping top suitability scores for all three landscape suitability models (picnic/BBQ, nature viewing, and boat ramps) and the other includes top overlapping scores from only nature viewing and picnic/BBQ suitability scores.

These Salton Sea landscape suitability models are the first to assess suitable areas for public access around the Salton Sea based on spatial data currently available. Suitable locations to implement picnic/BBQ and nature viewing areas were near wetlands, communities, roads, rivers, and/or birding spots. Boat ramp suitability was driven by shoreline steepness, sediment composition, access to roads, and proximity to rivers. Creating more developed public access areas in locations highlighted in the landscape suitability models could have positive public health and economic outcomes for local communities around the Salton Sea. These models highlight locations such as Desert Shores, Salton City, and Salt Creek as areas highly suitable for implementing public access projects. Additionally, these models highlight locations along the west shore that are more suitable for public access. Implementing more formally developed public access areas on the western shores of the Salton Sea, adjacent to existing communities, could have positive social and economic benefits in an area with fewer well developed public access opportunities. The landscape suitability models also assess suitability in areas that already have public access in place. In addition to implementing new public access projects, expanding existing or planned public access in areas with high public access suitability like Sonny Bono National Wildlife Refuge, the Species Conservation Habitat project, and the Salton Sea State Recreation Area may offer fewer challenges and more quickly increase public access around the Salton Sea. By providing improved and additional public services and activities in locations that are already known and visited, there may be greater incentives for community members and tourists to more frequently visit the Salton Sea.

The products and analyses presented in this report quantify suitability of areas for public access around the Salton Sea to guide federal, state, and local planning. Public access can provide multiple benefits for local communities, researchers, and visitors alike. As the SSMP plans and implements habitat restoration and dust suppression projects, incorporating nature viewing and research/educational access areas will provide local communities with the opportunity to comfortably enjoy and learn about the critical habitats around the Salton Sea. Implementing picnic/BBQ areas will offer communities and visitors alike a place to congregate and recreate outdoors. The addition of boat ramps could offer access to the Salton Sea for research, nature viewing, and recreational opportunities like hunting. These models will help federal, state and local agencies and stakeholders to unlock these benefits for Salton Sea communities and visitors.

Introduction

The Salton Sea has been shrinking for decades, which has resulted in thousands of acres of dry lakebed. This has had detrimental effects on the environment, economy, and health of surrounding communities at the Salton Sea. As water levels continue to recede, salinity levels have increased (Jones et al. 2019), impacting fish populations and food sources for migratory birds that depend on this critical resource in the Pacific Flyway (Jones et al. 2019; Bradley et al. 2022). In addition, exposed lakebed sediments contribute to dust pollution and public health issues in the surrounding communities (Johnston et al. 2019; Doede & DeGuzman 2020; Biddle et al. 2022).

Communities adjacent to the Salton Sea are disadvantaged and many are highlighted by CalEPA as being in the top 25% of CalEnviroScreen (OEHHA 2010). Many of these communities are also highlighted by the U.S. Council on Environmental Quality's Climate and Economic Justice Tool as disadvantaged (White House Council on Environmental Quality 2022). Community members are predominantly underrepresented, and many are undocumented non-English speakers. There is a significant need for resources and public services for community members surrounding the Salton Sea. Providing public access as a part of long-range planning at the Salton Sea could help create greater equity, opportunities, and public health benefits.

The State of California is implementing the Salton Sea Management Program (SSMP) 10-year Plan to address and mitigate poor air quality and ecosystem threats, while promoting habitat restoration, improvements to public health at the Salton Sea. As the state implements habitat and dust suppression projects as a part of this plan, public access must be considered an important factor to create access for local communities, scientists, school groups and universities, and tourists alike. Integrating community input and landscape prioritization to identify optimal areas for public access surrounding the Salton Sea is imperative to inform the State of California's 10-year and long-range plan within the SSMP.

To inform the State of California's ongoing Salton Sea Management Program (SSMP) and future habitat restoration and community access projects, we conducted surveys in communities surrounding the Salton Sea as well as outreach with local agencies to understand their preferred choices regarding services and activities at the Salton Sea (Orr et al. 2023). Specifically, we surveyed community members to better understand *1) how community members value nature and outdoor recreation, 2) how community members value the Salton Sea, 3) what activities and services do community members value at the Salton Sea, and 4) what does the community's vision for a future Salton Sea look like*, all in the context of public access to the Salton Sea. Based on the results of this community survey and engagement with local agencies, we selected three public access uses that stood out as having high value and importance for local communities and agencies: picnic/BBQ areas, nature and wildlife viewing areas, and boat ramps (Orr et al. 2023).

To guide public access project planning around the Salton Sea focused on priority access types, we performed landscape suitability analyses to assess and model suitable locations for implementing each of the three identified public use types: picnic/BBQ areas, nature and wildlife viewing areas, and boat ramps. Land ownership at and surrounding the Salton Sea is complex and includes state, federal, private, and local water district lands. This can present barriers and complications when planning and designing habitat and public access projects. For each landscape suitability model, we created a tiered priority level based on land ownership to guide public access project planning with regard to land ownership complexities. Finally, to inform multi-use public access project planning we created a consensus suitability model to assess the overlap of public use suitability models. The products and models



Snow Geese flock over the Salton Sea. Photo: Michael Schulte

developed here can serve as a vital resource to guide Federal, State and local agency and stakeholder planning on implementation of public and research access into existing and future projects at the Salton Sea, given the current environment and infrastructure.

Audubon California strives to ensure the protection and restoration of habitats at the Salton Sea for millions of migratory birds and the health of more than 650,000 community members from Coachella and Imperial Valley and other communities around the Salton Sea through science, advocacy, policy, and community engagement. We engage with hundreds of local elementary school, high school, and college students as well as community members annually through Audubon's Salton Sea education program. In addition, the Audubon California science team has been collecting spatial data at the Salton Sea for years and has a Salton Sea Program team on the ground focused on science and community engagement, and therefore is uniquely positioned to use available data and create new data to perform landscape suitability analyses. By engaging with marginalized communities and performing spatial analysis using available Salton Sea data, Audubon California provides a useful product for the State of California to better understand suitable public access areas.

STUDY AREA

The Salton Sea is California's largest lake, spanning around 35 miles in length and around 15 miles in width. The Salton Sea is located within Imperial and Riverside counties and is a part of the Salton Trough, a geologic basin formed by the San Andreas Fault System that extends from southeast California to Baja Mexico. The Salton Sea lacks outflows, and its inflows have been reduced due to decreased water inflows from rivers, water diversions from agricultural to municipal uses in Southern California as a part of the Quantification Settlement Agreement (QSA) (Barnum et al. 2017; Bradley et al. 2022), and increased evaporation due to climate change (Bradley et al. 2022). As the Salton Sea surface elevation has decreased, the water quality and air quality at the Salton Sea have worsened, significantly impacting the health of communities and ecosystems surrounding the Salton Sea (Jones et al. 2019; Johnston et al. 2019; Biddle et al. 2022).

The Salton Sea is a part of an arid desert environment composed of emissive sediment including lacustrine sediment from Holocene and Pleistocene periods and exposed lakebed sediment (playa) (Babcock 1974). The Salton Trough has one of the highest levels of particulate matter with aerodynamic diameter <10 (PM₁₀) in the country (United States Environmental Protection Agency 2021; Dickey et al. 2023). Receding water levels expose playa that contribute to dust pollution that have been correlated to

public health issues among communities surrounding the Salton Sea (Johnston et al. 2019). In addition, the terminal nature of the Sea compounded with agricultural runoff and evaporation have caused salinity levels to increase to 74 PPT (U.S. Bureau of Reclamation 2020), compared to average salinity levels of about 35 PPT for the ocean.

Methods

To assess areas most suitable for public access surrounding the Salton Sea, we analyzed landscape suitability for three priority public access types: picnic/BBQ areas, nature viewing areas, and boat ramps. We selected these priority public access types based on engagement with local agencies and findings in the Salton Sea Public Access Survey Report (Orr et al. 2023). The selected public access types stood out as having high value and importance to community members, as well as for local, state, and federal stakeholders.

Data for the landscape suitability analyses was available from internal Audubon California databases, community survey data derived by Audubon California, Imperial and Riverside County websites, the USGS, and California State data listed in [Table 1](#).

STUDY EXTENT

Picnic/BBQ, nature viewing, and boat ramp areas have different study extents based on feasibility of design and implementation. Picnic/BBQ and nature viewing areas can be implemented within a broader area along the shorelines of and surrounding the Salton Sea, whereas boat ramps are limited to the Salton Sea shoreline area.

To determine the study extent for picnic/BBQ and nature viewing landscape suitability analyses, we measured distances from the 2022 Salton Sea shoreline to centers and features around the Sea such as the Salton Sea State Recreation Area, Sonny Bono National Wildlife Refuge, Imperial Wildlife Wister Unit, and the Salton Sea North Shore Yacht Club. We extracted the maximum distance from the shoreline to a feature of interest (4.8 kilometers) and used this value as an outward buffer distance surrounding the Salton Sea shoreline. The area in between the Salton Sea shoreline to 4.8 kilometers outward of the shoreline represented the study area for picnic/BBQ and nature viewing landscape suitability analyses.

Designing and implementing boat ramps at the Salton Sea can present challenges due to the high rate of shoreline recession in the northern and southern portions of the Salton Sea. To account for Salton Sea shoreline recession in the boat ramp landscape suitability analysis, we incorporated areas of the Salton Sea that are projected to be exposed in the next 10 years. Specifically, we extracted the 10-year contour from a bathymetric model of the Salton Sea using the median SALSA2 model projection for 2032, -252.9 ft (NAVD 88 datum; CH2M 2018). We used the area in between the 2022 Salton Sea shoreline location to the extracted 10-year projected shoreline location as the study area for the boat ramp landscape suitability analysis.

LANDSCAPE SUITABILITY ANALYSES

To assess public access landscape suitability surrounding the Salton Sea, we identified predictor variables, developed spatial data for analyses, determined the weight of each variable in the analysis, and combined all weighted variables to create landscape suitability models. We used ArcGIS Pro 3.1.1 for all spatial analyses.

Select Predictor Variables

For each landscape suitability analysis, we selected spatial variables that influence the suitability of that public access type. These variables were used as predictors in the landscape suitability models.

For picnic/BBQ and nature viewing suitability analyses, we selected the following predictor variables: proximity to roads, rivers, birding spots (Jones et al. 2019), campgrounds, communities, and vegetation and wetlands. Roads are important to allow for easy access by community members and tourists; campgrounds are areas where people are already gathering and would benefit from more activities and services; rivers, birding spots, and vegetation/wetlands are nature and wildlife areas available locally which were valued by community members (Orr et al. 2023) and used by hunters in designated areas. Public access near communities can create more equitable and ease of access to the outdoors, encouraging more visitation and could lead to positive economic impacts in those communities.

For the boat ramp suitability analysis, we selected proximity to roads, proximity to rivers, slope of the shoreline, and sediment composition as predictor variables. Shoreline steepness as well as sediment composition is critical to consider when designing boat ramps, as steeper and harder shorelines make for more suitable conditions. Specifically, sandy sediment generally results in a more suitable foundation for boat ramps than silt or clay, therefore, areas with a higher proportion of sand likely make for more suitable areas. The proximity to rivers feeding into the Salton Sea is also important to consider for boat ramp implementation. Rivers feeding into the North and South of the Salton Sea will be dredged and will likely continue to be deep water locations for boat access.

Develop Spatial Data for Analysis

We developed continuous numerical spatial data for each predictor variable at 50-meter resolution for picnic/BBQ and nature and wildlife viewing suitability analysis. We selected this size as a generalized cell size that we felt would be useful to inform public access planning with regard to siting potential public access areas. Because boat ramps can be built on a smaller scale, we developed continuous numerical spatial data for each predictor variable at 5-meter resolution for the boat ramp suitability analysis. These data were then reclassified into final predictor variables.

For proximity predictor variables we calculated the Euclidean distance from features representing roads, rivers, birding spots, campgrounds, local communities, and vegetated/wetland areas (Table 1). These were used to develop spatial data representing distance from each given feature to be used for developing final predictor variables.

We used kriging interpolation to create a DEM of Salton Sea bathymetry from the Salton Sea 1 ft. Contour Depth Profile (Table 1) at 1 meter resolution. From the DEM we created a spatial data layer of the slope of the Salton Sea from the 2022 shoreline to the 2032 projected shoreline.

We used USGS sediment data (Table 1) and kriging interpolation to derive spatial data representing the proportion of sand (out of sand, silt and clay) from the 2022 shoreline to the 2032 projected shoreline.

We reclassified these spatial data to a numeric continuous common suitability scale from 0, less suitable, to 1, more suitable. Areas closer in proximity to rivers, roads, birding spots, campgrounds, vegetation/wetlands and communities are relatively more suitable, thus reclassified to have values closer to 1. In addition, areas that have steeper slopes and areas with harder sediment composition (as represented by greater proportion of sand vs. silt and clay) are relatively more suitable, thus were reclassified to have values closer to 1.



Audubon California Salton Sea Program Director Frank Ruiz leading a group of local students and community members birding at the Salton Sea State Recreation Area. Photo: Camila Bautista/Audubon

Weight Variables

We categorized the predictor variables as having low, medium, and high importance in the landscape suitability analyses. The importance of each variable is reflected as a weight in the landscape suitability analyses on a continuous numerical scale of 0 (low importance) to 1 (high importance) (Table 2). Although picnic/BBQ and nature viewing suitability analyses used the same predictor variables, they differ in importance. For example, the weight of proximity to roads was categorized as high for the picnic/BBQ landscape suitability analysis, but medium for the nature viewing landscape suitability. This is because vehicle access to picnic/BBQ areas for community members is highly important, however, immediate car access to nature viewing areas is not as crucial, as nature or wildlife viewing sites may be accessed by trails or boardwalks. Additionally, the weight of proximity to birding areas is classified as high in the nature viewing landscape suitability analysis and low in the picnic/BBQ landscape suitability analysis. This is because birding areas are associated with and conducive to nature viewing areas, however, this is not necessarily as important in selecting picnic/BBQ areas. These assigned weights of predictor variables influence the final landscape suitability models.

Suitability Models

We combined the predictor variables with their corresponding weighted value into a linear model for each landscape suitability analysis (Table 3). This produces a landscape suitability model for each of the priority public access types.

Ground Truthing

We visited sites across the Salton Sea over a 4-day period in January 2023. We targeted areas associated with predictor variables to assess the accuracy of our underlying data. These included the presence of roads, wetlands, birds, campgrounds and other public access areas.

LAND OWNERSHIP PRIORITIZATION

To account for landownership complexities in our analyses, we separated each suitability model into three priority tiers: publicly owned lands (Tier 1), local water district lands (Tier 2), and Bureau of Indian Affairs (BIA), private, and unknown ownership lands (Tier 3). Using this approach, no land was excluded, and more or less suitable areas for boat ramps, nature viewing areas, and picnic/BBQ areas can be assessed while controlling for land ownership complexities.

CONSENSUS MAPS

To understand the most suitable locations to implement multi-use public access areas, we synthesized two separate consensus models representing the overlap of the top 10%, top 20%, top 30%, and top 50% suitability scores between picnic/BBQ and nature viewing suitability models, and between picnic/BBQ, nature viewing, and boat ramp suitability models. The geographic distribution of the boat ramp suitability model is different than, but overlapping with, the other models and so we chose to include two separate consensus models, one with the boat ramp suitability model and one without. For each landscape suitability model, we calculated the 90th, 80th, 70th, 50th percentile values using zonal statistics, then reclassified the landscape suitability models using these percentile values as thresholds to output top 10%, 20%, 30%, and 50% suitability areas. We extracted the areas of overlap among the top 10%, 20%, 30% and 50% suitability for nature viewing and picnic/BBQ areas to create a consensus model of the highest multi-use suitability with regard to nature viewing and picnic/BBQ areas (Table 4). This process was repeated to include boat ramp suitability in a second consensus model (Table 4).

Results

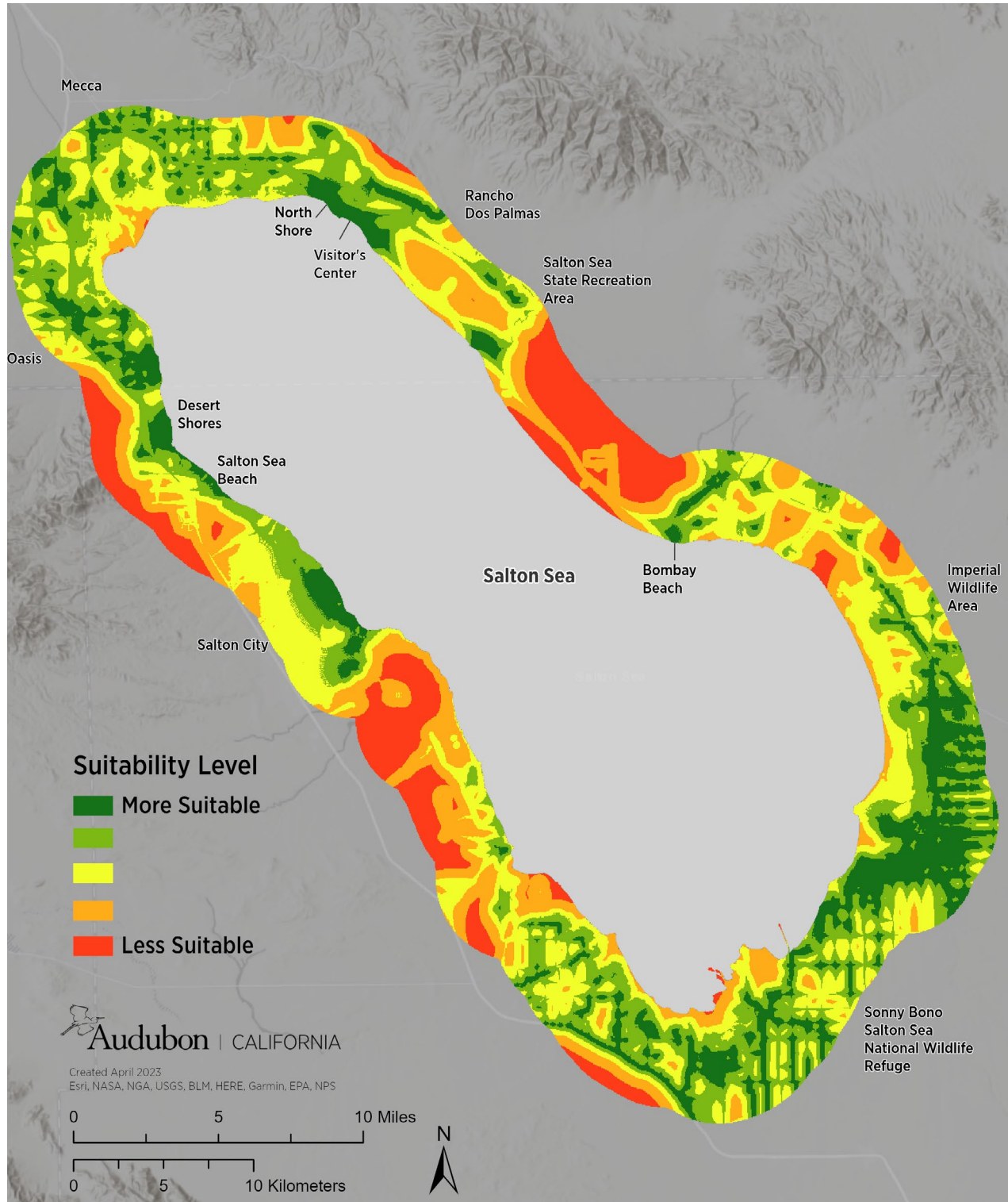
The landscape suitability models show areas that are more or less suitable for picnic/BBQ areas, nature viewing areas, and boat ramps based on our analyses. Suitability scores can range on a continuous scale between 0 and 1 with lower values being less suitable than higher values. Actual results varied between suitability models. Suitability scores for picnic/BBQ areas ranged between 0.198 - 0.930 (Figure 1), nature viewing suitability scores ranged between 0.174 - 0.932 (Figure 3) and boat ramp suitability ranged between 0.092 - 0.590 (Figure 4; Table 3). Suitability scores were organized into five classes for visualization and interpretation using Natural Breaks (Jenks) classification. This is a commonly used classification method that organizes data into groups based on natural breaks in data. For each landscape suitability model we include three sets of maps: 1) overall landscape suitability maps (Figures 1, 3 & 4), 2) suitability maps prioritized by landownership tiers (Figures 5-13), and 3) suitability maps focused in on Salton Sea project sites (Figures 14-16, 18-27).

We also included two sets of consensus suitability maps encompassing the top suitability locations for multi-use areas. One set of consensus maps includes overlapping top suitability scores for all three landscape suitability models (Figures 2, 23-27) and the other includes top overlapping scores from only nature viewing and picnic/BBQ suitability scores (Figures 17-22). From each consensus model we calculated acreage totals for the top 10%, 20% and 30% categories (Table 4).

Ground truthing predictor variables confirmed reliability of our underlying data sources and results. This led to the inclusion of an additional birding site on the western shore of the Salton Sea for the birding sites predictor variable.

FIGURE 1. Overall landscape suitability for picnic/BBQ areas surrounding the Salton Sea.

Suitability is driven by proximity to roads, rivers, birding spots, campgrounds, communities, and vegetation and wetlands. Green represents more suitable locations and orange/red represent less suitable locations for implementing picnic/BBQ areas.





Loma Linda University graduate students and partners head out to survey the northern side of the Salton Sea near the White Water River mouth. Photo: Andrea Jones/Audubon

Discussion

As California State SSMP projects are implemented, it is critical to address the need for formal public access developments surrounding the Salton Sea. These Salton Sea landscape suitability models are the first to assess suitable areas for public access around the Salton Sea based on spatial data currently available. These models can guide federal, state and local agency and stakeholder planning for the implementation of public access projects. Different models can be used to guide different planning objectives. Suitability models for each specific public access type (picnic/BBQ, nature and wildlife viewing, boat ramp areas) can be used by federal, state, and local stakeholders in planning public access projects for each specified type of access. Land ownership tier models can inform implementation planning with regard to landownership complexities. Finally, the consensus models can be used to guide multi-use public access planning.

LIMITATIONS

The models presented here are meant to guide public access project planning and exploration. These models do not incorporate elements of permitting beyond the land ownership publicly available. For example, we did not include proximity to protected or endangered species. They do describe the suitability relative to infrastructure and natural features present. These analyses were based on current conditions and data available, and do not account for future changes, aside from shoreline recession. Specifically, the boat ramp, picnic/BBQ area, and nature viewing landscape suitability is informed by on the ground infrastructure, such as current roads, and does not account for future infrastructure plans. Some of the Salton Sea SSMP projects, such as the Bombay Beach Wetland Project, have plans to incorporate infrastructure, which would likely improve the suitability of these areas for public access. For example, the Bombay Beach Wetland Project plans to build a road and drainage corridor, which would likely increase the suitability level for public access in this project area due to greater accessibility. Roads constructed within the SCH project site or within other habitat or dust suppression project areas would likely also improve suitability levels.

Uncertainty in future rates of shoreline recession influences the boat ramp suitability analysis. The boat ramp suitability analysis incorporated the lakebed area projected to be exposed by 2032 based on SALSA2 hydrologic model projections (CH2M 2018). However, projections of shoreline locations are subject to change, depending on Colorado river allocations, so suitability levels could change if the Salton Sea receives more or less water than predicted.

INFORMING SPECIFIC TYPES OF PUBLIC ACCESS

The suitability models for each specific type of public access show the relative suitability across the Salton Sea study areas for implementing each type of public access (Figures 1, 3 & 4). Suitable locations to implement picnic/BBQ and nature viewing areas are near wetlands, communities, roads, rivers, and birding spots. Boat ramp suitability is driven by shoreline steepness, sediment composition, access to roads, and proximity to rivers.

Based on the surrounding environment, road access, and proximity to communities, there are sections of land classified as more suitable on all shores of the Salton Sea (Figures 1 & 3). The southern portion of the Salton Sea, which includes the Species Conservation Habitat (SCH) project, Sonny Bono National Wildlife Refuge (NWR), and Imperial Wildlife Area, contains more suitable areas for nature viewing and picnic/BBQ areas relative to other areas surrounding the Salton Sea (Figures 1 & 3). This higher level of suitability is driven by greater vegetation and wetland density, proximity to birding spots, proximity to the New and Alamo rivers that feed into the Sea, proximity to communities such as Westmorland, and a higher concentration of existing roads.

On the west shore of the Salton Sea, areas around the communities of Desert Shores, Salton Sea Beach, and Salton City stand out as being more suitable for implementing nature viewing and picnic/BBQ public access (Figures 1 & 3). On the east shore, the North Shore, the Salton Sea Visitor's Center, Salt Creek and Bombay Beach stand out as being more suitable for picnic/BBQ and nature viewing areas (Figures 1 & 3). While the east side of the Salton Sea has the Salton Sea State Recreation Area as well as various State Park campgrounds, the west shore has more communities but has fewer formal public access developments. The west shore includes several birding spots (Johnson's Landing, Capri Lane, 84th Avenue), where there is an abundance and diversity of birds, as well as wetlands and vegetation that are easily accessible. Thus, with accessible birding spots and nearby communities, highlighted areas along the west shore comprise convenient locations that would be ideal for community gatherings or tourists to enjoy the Salton Sea. In addition, providing immediately accessible outdoor spaces for communities such as Desert Shores would likely have positive economic, social, and public health outcomes for members of the community.

The boat ramp landscape suitability analysis reveals a multitude of shoreline areas to the east and west of Salton Sea that are more suitable for boat ramps (Figure 4). Specifically, Bombay beach, Desert shores, the North Shore, and Salton Sea Beach are among locations that stand out as more suitable for boat ramps. This is due to shoreline steepness and access to roads, which are important predictors of boat ramp suitability. In addition, shoreline sections in the Southern Salton Sea are highlighted as more suitable, largely due to the Alamo River and the New River that are continuously dredged access points to the Sea (Figure 4). Although the southern section of the Sea has a high rate of shoreline recession (due to the shallow slope of the lakebed), locations in close proximity to rivers are more suitable for implementing boat ramps, as these will likely remain deep water locations adequate for launching small boats. Boat ramp suitability in the southern part of Salton Sea decreases in areas where the shoreline is projected to recede the most. This is due to the shallow slope and the increasing distance to current infrastructure. Unless plans to design boat ramps are in the Alamo or New River, implementation of boat



Local community members gathered under shaded picnic areas at the Salton Sea State Recreation Area (SSRA). This is one of the few shaded areas around the Salton Sea. Photo: Camila Bautista/Audubon

ramps in the Southern Salton Sea would have to account for a high rate of shoreline recession, which may involve more technical and advanced design, and may be more costly and time consuming. The most suitable locations to implement boat ramps are either in steeper areas along the west or east shores or in dredged locations along river mouths.

INFORMING PUBLIC ACCESS IN THE CONTEXT OF LAND OWNERSHIP COMPLEXITIES

Suitability models for each type of public access were split into prioritization tiers based on land ownership. This was done with several assumptions. First, implementing public access on public land would offer the fewest challenges. Second, that implementing public access on local water district lands (Imperial Irrigation District, and Coachella Valle Water District) would present more challenges than public lands in implementing public access projects and third, that private lands, and Native American lands would offer significant challenges to implementing public access projects. In these tiered models (Figures 5–13) the first tier is suitability within public lands. The second tier represents suitability within local water district lands, and the third tier represents suitability within private, Native American and unknown ownership (here on assumed to be private) lands. These tiered models indicate that Imperial Wildlife area, areas within the Species Conservation Habitat (SCH) Project, sections of Bombay Beach, the North Shore and the Salton Sea visitor’s center, are among regions that stand out as suitable locations for implementing picnic/BBQ and nature viewing areas and are situated within public land (Figures 5 & 8). In addition, the southern area of the Sea within the SCH, a section of Bombay Beach, a large proportion of North Shore, portions of the shoreline around Salton City, and select shoreline areas in the North are among more suitable locations for picnic/BBQ areas and within local water district land (Figures 6 & 9). These areas could be explored further with the understanding that there may be more land ownership complexities than within public lands but with potentially fewer complexities than within other private lands or Native American lands. These are areas to further explore as feasible and convenient public access implementation sites, as they may be associated with fewer landownership complexities than within private or Native American lands (Figures 6, 7, 9, 10).

Tiered boat ramp suitability models (Figures 11–13) show areas south of Salton Sea beach on the west shore and a large portion of the east shore north of Bombay Beach are within publicly owned lands having high suitability for implementing boat ramps (Figure 11). In the north and south of the Salton

Sea, there is a greater proportion shoreline sections owned by IID or Coachella Valley Water District that display higher suitability for boat ramps (Figure 12). Notably, areas around the Whitewater River mouth, Desert Shores and Salton Sea Beach show high suitability for implementing boat ramp access but are associated with private or Native American lands (Figure 13).

INFORMING MULTI-USE PUBLIC ACCESS PLANNING

Consensus models include the overlap of the most suitable areas from each specific type of public access suitability model. These are organized into categories that represent the top 10th, 20th, 30th and 50th percentile of each individual suitability model and where those percentiles overlap across the Salton Sea landscape. Because of the differences in scale and geographic distribution between the boat ramp suitability model and the other suitability models we synthesized one consensus model with only picnic/BBQ and nature and wildlife viewing suitability models (Figure 17) and another that included all three suitability models (Figure 2). These consensus suitability models represent the most suitable areas to implement multi-use public access projects based on our analyses. These models reveal locations around Desert Shores, Salton City, the North Shore, Salton Sea Visitor's Center, Bombay Beach, and Sonny Bono National Wildlife Refuge that contain top 10% suitability areas for picnic/BBQ and nature viewing areas (Figure 17). Similarly, shoreline areas around Desert Shores and north of Desert Shores, Salton Sea Beach, Salton City, Bombay Beach, the North Shore, Salton Sea Visitor's Center, Salt Creek, areas within Sonny Bono National Wildlife Refuge, and the seawall located between Young Road and Grubel Road are within top 10% suitability for boat ramps, picnic/BBQ, and nature viewing areas (Figure 2). These consensus models can inform and guide multi-use public access project planning and implementation around the Salton Sea.

IMPLICATIONS TO CURRENT SSMP PROJECTS AND LONG-RANGE PLANNING

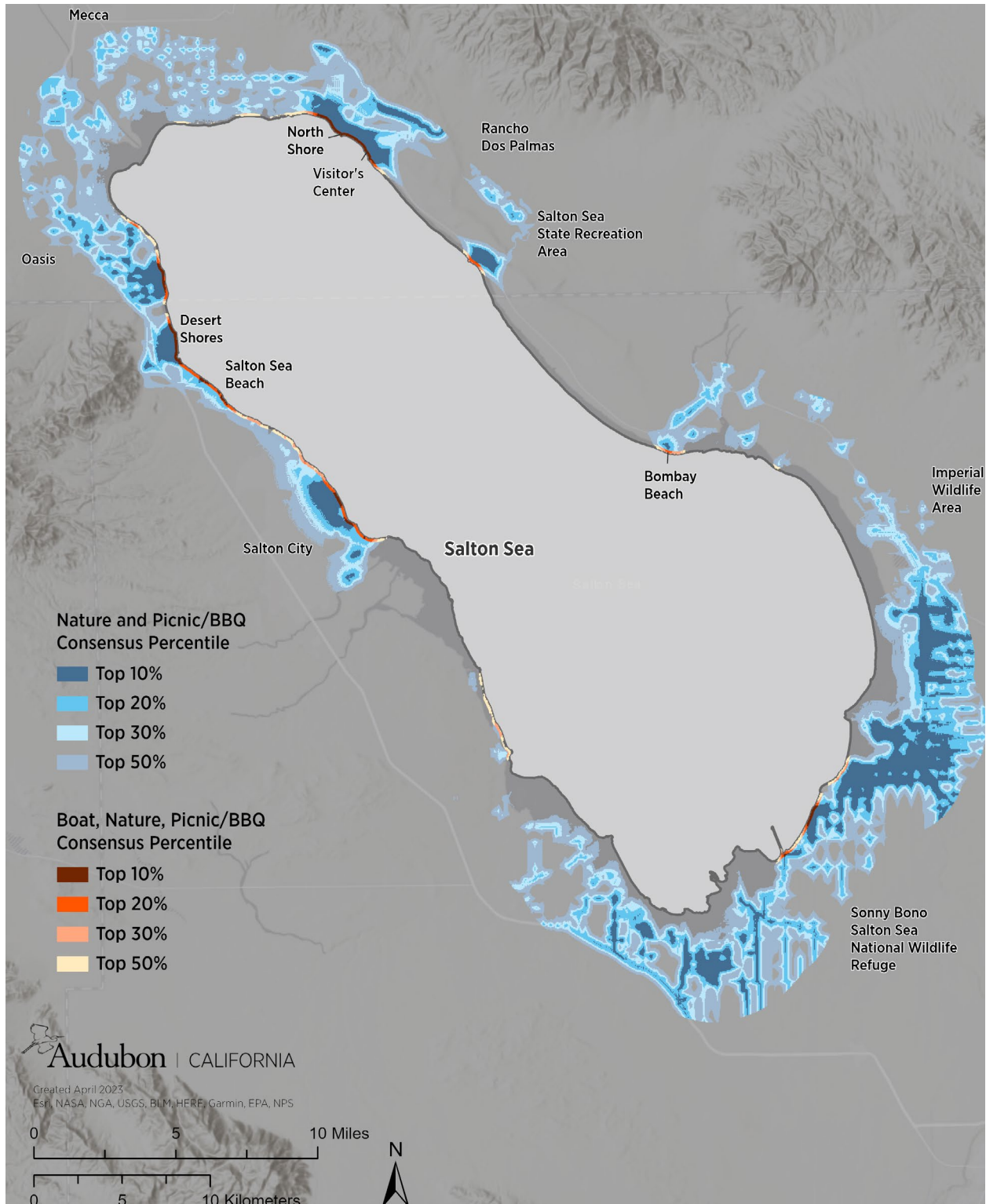
These landscape suitability models for public access, in relation to current and future SSMP projects, can support existing plans for or guide new implementation of public access. In the project site maps (Figures 14–16), we focus on public access landscape suitability within the SCH Project, North Lake Concept, and Bombay Beach Wetland (BBW) project.

The SCH project area, with land managed by public agency and local water district entities, comprises suitable locations for implementing picnic/BBQ and nature viewing areas given the current infrastructure and environment (Figures 14A & 14B). Specifically, areas located in the west of the SCH project site stand out as being more suitable and are owned by public agencies or local water districts. As the SCH Project plans to restore thousands of acres of critical habitat for fish, birds, and other wildlife, and construct roads, this would be an optimal place to incorporate public access for communities to visit the habitat and view wildlife. While there are plans to implement a viewing area in the west side of the SCH, this site is small relative to the areas revealed to be suitable for nature viewing and picnic areas within the SCH (Figures 14A & 14B). Expanding public access in these suitable areas would allow communities in the south of the Salton Sea such as Westmorland, Brawley, and El Centro, as well as tourists, to enjoy the diversity and abundance of birds and wildlife that will hopefully use these restored habitats.

More suitable areas for implementing boat ramps are situated within the northern shoreline area of the SCH project boundary (Figure 14C). During and after construction of the SCH, water quality monitoring within and outside the SCH will likely be necessary, thus understanding best places to install boat ramps is important. Areas highlighted as more suitable are situated around the New River, which is

FIGURE 2. Consensus suitability maps representing the overlap of the top 10%, top 20%, top 30%, and top 50% suitable areas between picnic/BBQ and nature viewing suitability models (dark to light blue), and between picnic/BBQ, nature viewing, and boat ramp suitability models (dark red to yellow).

The geographic distribution of the boat ramp suitability model is different than, but overlapping with, the picnic/BBQ and nature viewing models so we chose to include two separate consensus models, one with the boat ramp suitability model and one without.



predominantly owned by Imperial Irrigation District. Shoreline sections on the west side of the SCH are also classified as more suitable and publicly owned. The most suitable locations for implementing boat ramps in or around the SCH are likely surrounding the New River.

The plan for the North Lake Concept is to create a lake that serves as critical habitat for fish and birds by pumping water from the Salton Sea over exposed lakebed sediment. The west and east portions of the North Lake Concept area are more suitable for picnic/BBQ and nature viewing areas (Figures 15A & 15B) due to proximity to the communities of Desert Shores and North Shore, accessibility to roads, proximity to existing birding spots (Johnson's Landing, Capri Lane, etc.), campgrounds near the visitor's center, and large wetland areas on the northwest shore. Sections within the North Lake Concept area are also suitable for implementing boat ramps (Figure 15C), due to road access and shoreline steepness. Sections of land on the northeast shore are publicly owned, while larger sections distributed throughout the North Lake Concept Area are owned by local water districts. Implementing public access and boat ramps in publicly owned or local water district owned lands within the North Lake Concept area may be more feasible than within private or Native American lands.

The BBW project area, with land managed by public agencies and Imperial Irrigation District (IID), includes locations that are more suitable for implementing picnic/BBQ and nature viewing areas (Figure 16A & 16B) due to proximity to roads, access to birding areas, surrounding wetlands and vegetation, and the nearby community of Bombay Beach. Areas within the western portion of the project site are more suitable for nature viewing and picnic/BBQ areas and within public lands, while the eastern portion of the project site has more suitable implementation locations with land owned by IID. There are no private or Native American lands within the BBW project boundary that would prevent public access. The shoreline section within the BBW project area is also a suitable place for boat ramp implementation, specifically in the wetland expansion shoreline area (Figure 16C). Plans for adding infrastructure and expanding wetland habitat will further improve suitability for public access and boat ramps in this area.

These suitability models highlight areas such as Desert Shores, Salton City, and Salt Creek as locations to consider implementing multi-use public access projects. Creating more developed public access areas could have positive public health and economic outcomes for local communities around the Salton Sea. Additionally, implementing more formally developed public access areas on the western shores of the Salton Sea, adjacent to existing communities, could have positive social and economic benefits in an area with fewer well developed public access opportunities. In addition to implementing new public access projects, expanding existing or planned public access in areas with high public access suitability like Sonny Bono National Wildlife Refuge, the Species Conservation Habitat project, and the Salton Sea State Recreation area may offer fewer challenges and quickly increase public access around the Salton Sea. By providing improved and additional public services and activities in locations that are already known and visited, there may be greater incentives for community members and tourists to more frequently visit the Salton Sea.

Outcomes of habitat restoration projects around the Salton Sea would be the suppression of emissive dust and the creation of more and larger vegetated wetland areas that would promote a greater diversity and abundance of birds and other wildlife. This outcome would in turn increase public access suitability levels, due to the addition of wildlife and wetlands that the community and tourists could enjoy. SSMP long range habitat projects have the potential to greatly increase public access project suitability and generate opportunities to create greater and more equitable access to nature and the outdoors around the Salton Sea.



Local volunteer birders at 84th Ave, an Audubon Salton Sea bird survey location, on the western shoreline of the Salton Sea. This area was highlighted as more suitable for implementing picnic/BBQ areas, nature viewing areas, and boat ramps. Photo: Camila Bautista/Audubon

Conclusion

The models, and resulting maps presented here, serve as a vital resource for the State of California to identify suitable areas for public access planning and implementation around the Salton Sea. We provide maps and models to guide planning for specific types of public access as well as multi-use access, such as access for school groups and scientists. Notably, these analyses incorporated public and agency input and also use the locations of communities as a variable influencing suitability outcomes. As the State of California plans and implements habitat restoration and dust suppression projects, incorporating public access viewing and nature areas will provide local communities with the opportunity to comfortably enjoy and learn about the critical habitats around the Salton Sea. Implementing picnic/BBQ areas offer communities and visitors alike a place to congregate and recreate outdoors. Additionally, boat ramp access could offer access to the Salton Sea itself for research, nature viewing as well as recreational opportunities like hunting. The models presented here offer an opportunity for the State to engage local communities in the public access planning process through participatory mapping exercises and public engagement. These models can be used to narrow the focus of these sorts of planning exercises. They can also be used to find overlapping opportunities where new or current habitat or other project development opportunities are arising. These models can guide planning and implementation to help federal, state and local agencies and stakeholders unlock these benefits for Salton Sea communities, scientists, and visitors.

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Figures and Tables

TABLE 1. Predictor Variables Used in Public Access Landscape Suitability Analysis.

| VARIABLE | SOURCE |
|---------------------|--|
| Roads | U.S Census Bureau, Department of Commerce TIGER/Line shapefiles for Imperial County and Riverside County |
| Rivers | California Natural Resources Agency Rivers Shapefile |
| Campgrounds | University of Redlands Salton Sea Database |
| Birding Spots | Derived from Jones et al. 2019 “Status of Birds at the Salton Sea” Report |
| Vegetation/Wetlands | Created by Audubon California Geospatial Team using aerial imagery from January 2022 |
| Slope | Derived from Salton Sea Bathymetry (State of California [ds426] 1-foot bathymetric shapefile) |
| Sediment | Sediment survey data for the Salton Sea was provided by USGS (Agrarian Research). From the sampling locations, Audubon California interpolated fractions of sand reported by the survey into a raster covering the entire Sea. |
| Communities | State of California Department of Technology- CA Geographic Boundaries. US Census Bureau’s 2016 MAF/Tiger Database. |

TABLE 2. Continuous predictor variables and their associated weights categorized as high (H), medium (M), or low (L) importance in each landscape suitability analysis (picnic/BBQ, nature viewing, and boat ramps).

| CRITERIA | PICNIC/BBQ | NATURE VIEWING | BOAT RAMP |
|---------------------------------|------------|----------------|-----------|
| Distance to Roads | 0.35 (H) | 0.2 (M) | 0.35 (H) |
| Distance to Rivers | 0.05 (L) | 0.05 (L) | 0.35 (H) |
| Distance to Campgrounds | 0.05 (L) | 0.05 (L) | NA |
| Distance to Birding Spots | 0.15 (M) | 0.325 (H) | NA |
| Distance to Vegetation/Wetlands | 0.35 (H) | 0.325 (H) | NA |
| Slope | NA | NA | 0.25 (M) |
| Sediment | NA | NA | 0.05 (L) |
| Distance to Communities | 0.05 (L) | 0.05 (L) | NA |

TABLE 3. Statistics for each Salton Sea landscape suitability model.

| MODEL | MINIMUM | MAXIMUM | MEDIAN | MEAN | STANDARD DEVIATION |
|----------------------------|---------|---------|--------|-------|--------------------|
| Picnic/BBQ Suitability | 0.197 | 0.930 | 0.563 | 0.546 | 0.131 |
| Nature Viewing Suitability | 0.173 | 0.931 | 0.474 | 0.467 | 0.126 |
| Boat Ramp Suitability | 0.091 | 0.590 | 0.268 | 0.205 | 0.060 |

TABLE 4. Acres of top 10%, top 20%, and top 30% suitable areas for each consensus model (Nature Viewing and Picnic/BBQ, and Nature Viewing, Picnic/BBQ, and Boat Ramp).

| CONSENSUS MODEL | TOP 10% | TOP 20% | TOP 30% |
|--|----------|----------|----------|
| Nature Viewing and Picnic/BBQ | 13,580.9 | 30,492.2 | 48,062.6 |
| Nature Viewing, Picnic/BBQ, and Boat Ramps | 483.0 | 861.1 | 1,216.3 |

FIGURE 3. Overall landscape suitability for nature viewing areas surrounding the Salton Sea.

Landscape suitability is driven by proximity to roads, rivers, birding spots, campgrounds, communities, and vegetation and wetlands. The distance to birding spots variable was weighted heavier and the distance to roads not weighted as heavily for this nature viewing suitability model. Green represents more suitable locations and orange/red represent less suitable locations for implementing nature viewing areas.

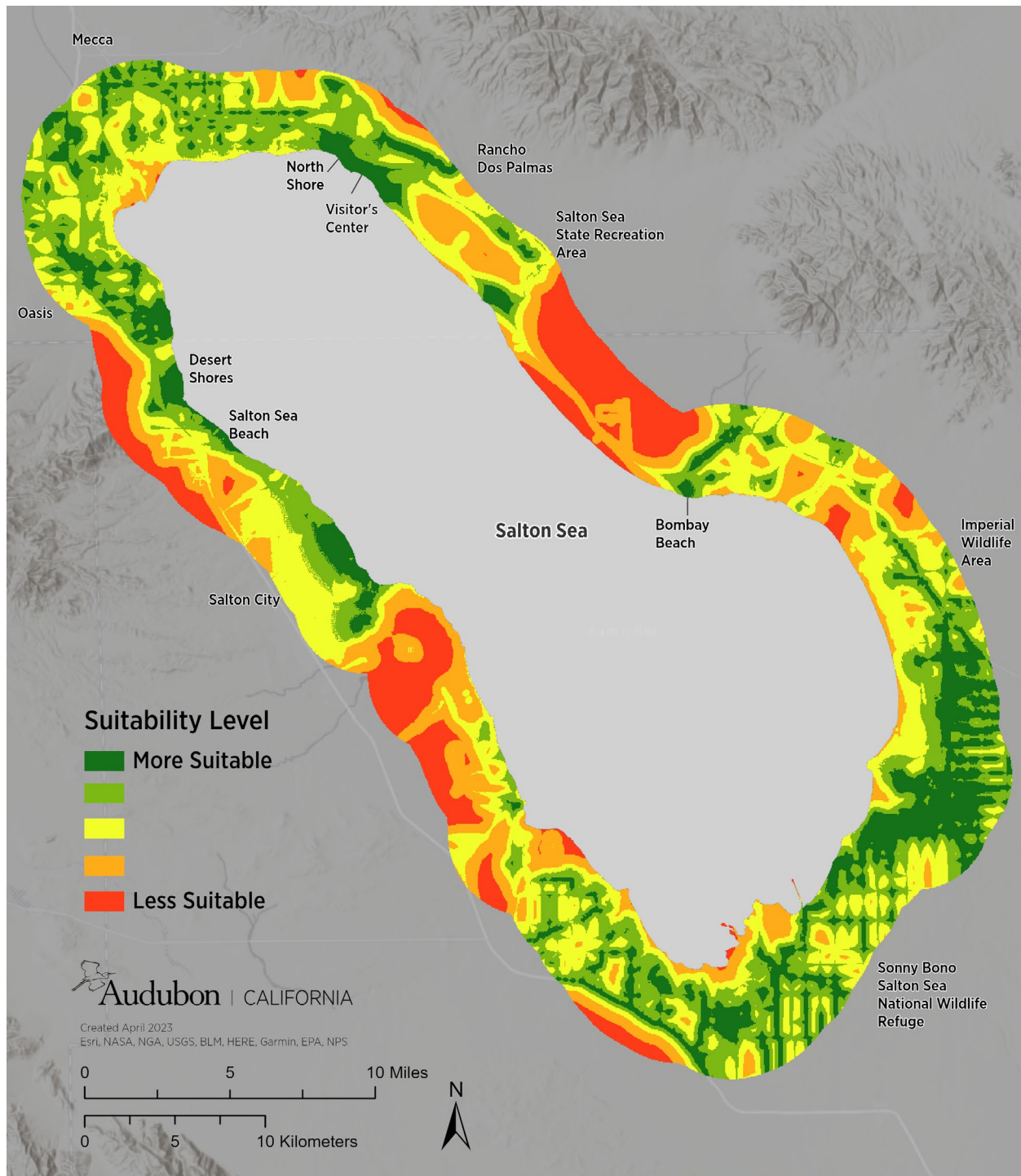


FIGURE 4. Overall landscape suitability for boat ramp implementation.

Boat ramp suitability is driven by proximity to roads, proximity to rivers, steepness of the shoreline, and sediment composition. Green represents more suitable locations and orange/red represent less suitable locations for implementing picnic/BBQ areas. To account for shoreline recession, the 10-year projected contour (-252.9 ft in 2032) from the SALSA2 model (CH2M Hill 2018) was extracted and used as the innermost extent for the analysis. The current Salton Sea shoreline location is the outermost extent for the analysis.

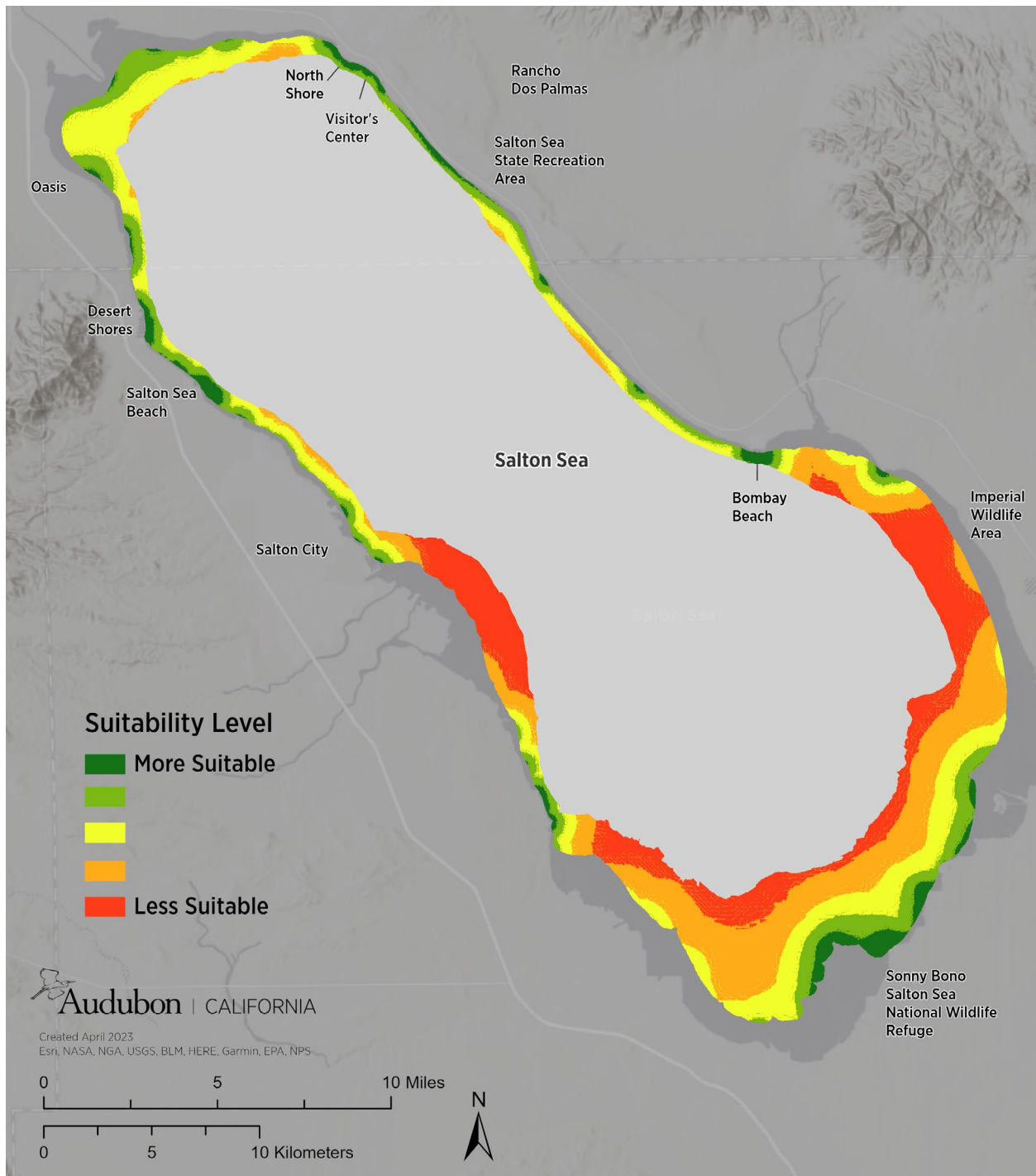


FIGURE 5. Picnic/BBQ landscape suitability within landownership Tier 1: public lands.

Dark blue areas represent locations that are more suitable for implementing picnic areas and where implementing this public access would likely present minimal challenges.

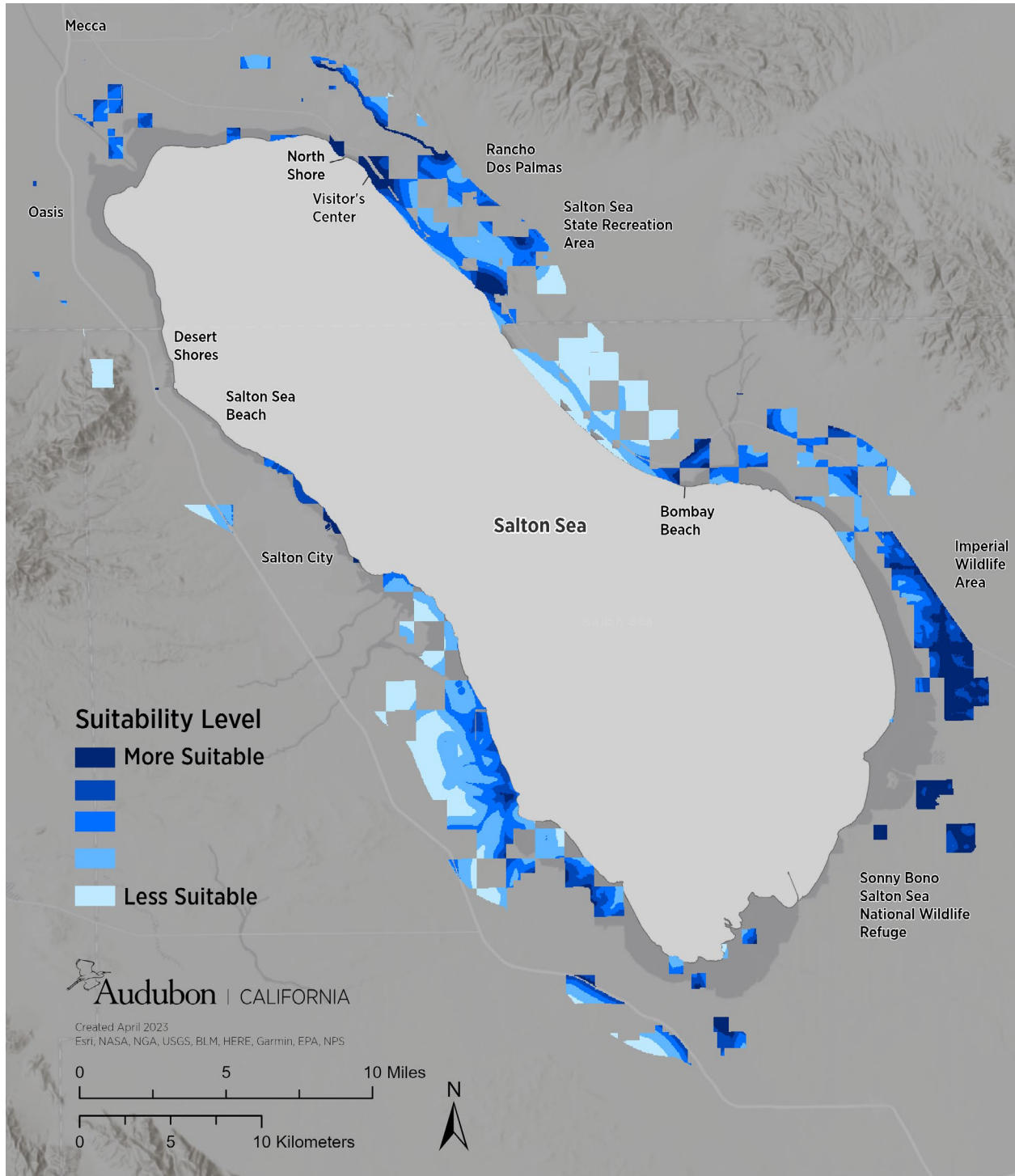


FIGURE 6. Picnic/BBQ landscape suitability within landownership Tier 2: local water district lands.

Dark brown areas represent locations that are more suitable for implementing picnic/BBQ areas and would likely present less challenges than within privately owned lands but may present more challenges than within publicly owned lands.

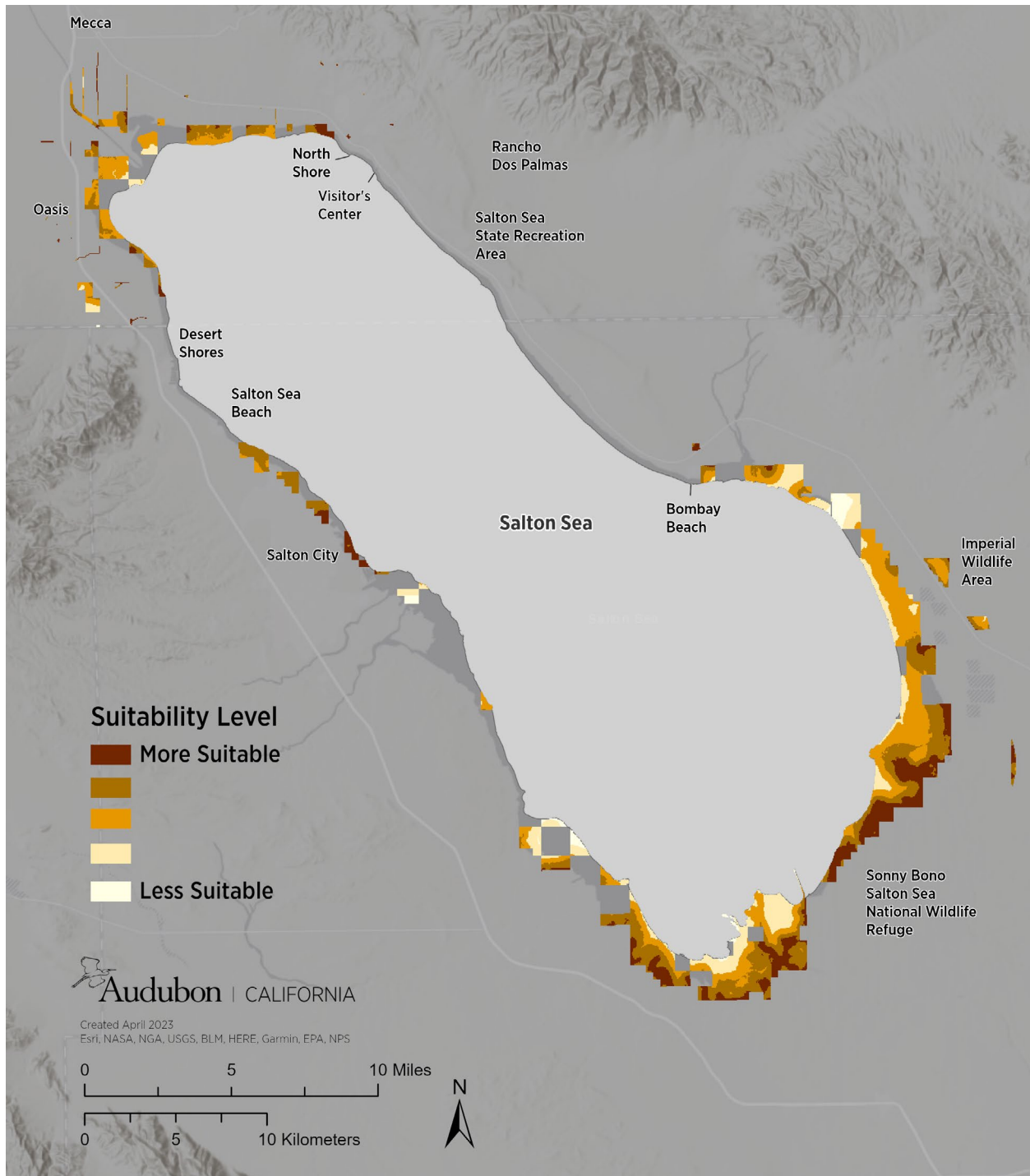


FIGURE 7. Picnic/BBQ landscape suitability within landownership Tier 3: Bureau of Indian Affairs, privately owned, or unknown land.

Dark red areas represent locations that are more suitable for implementing picnic/BBQ areas but implementing public access within these lands may present significant challenges.

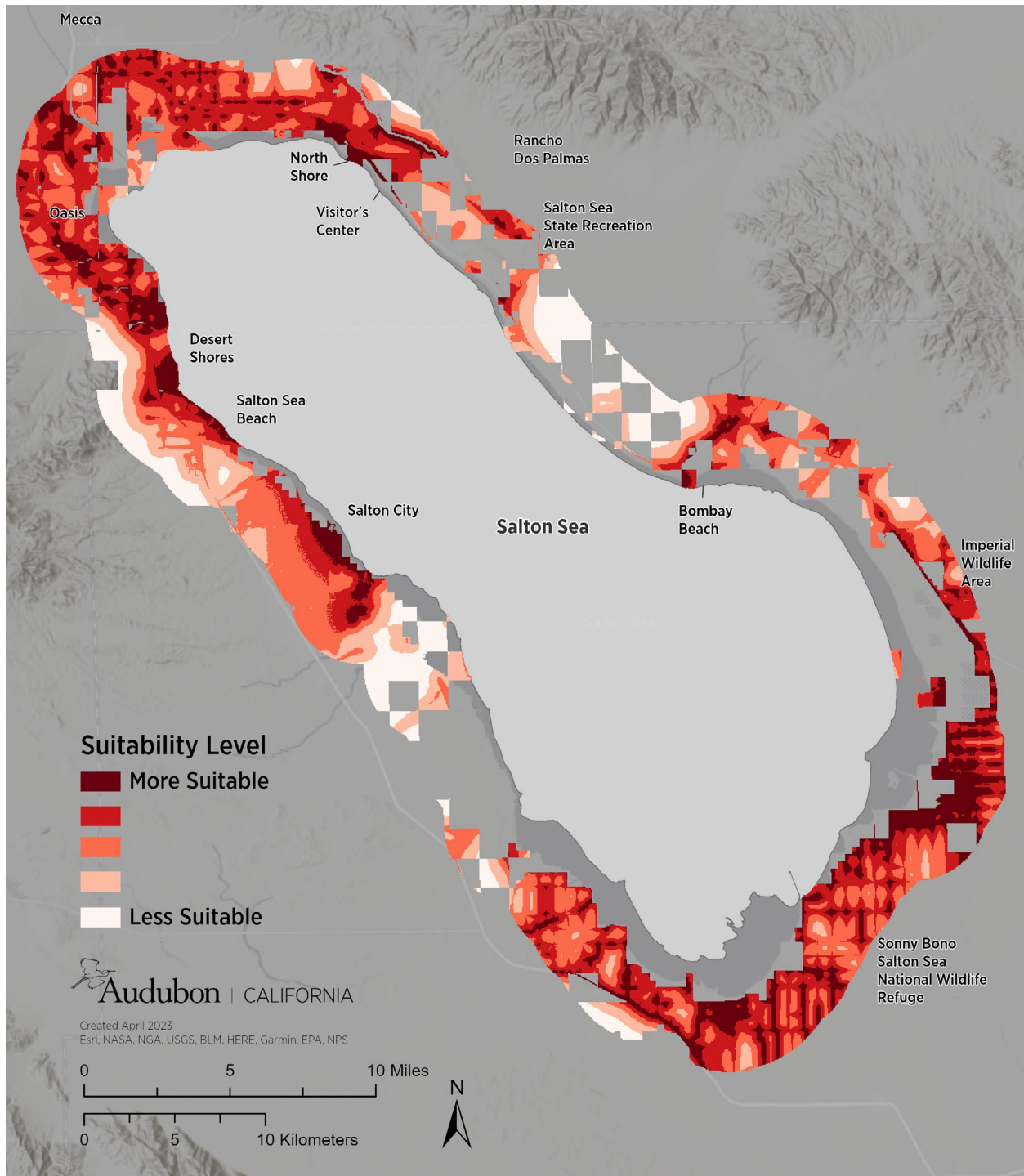


FIGURE 8. Nature viewing landscape suitability within landownership Tier 1: public lands.

Dark blue areas represent locations that are more suitable for implementing nature viewing areas and where implementing this public access would likely present minimal challenges.

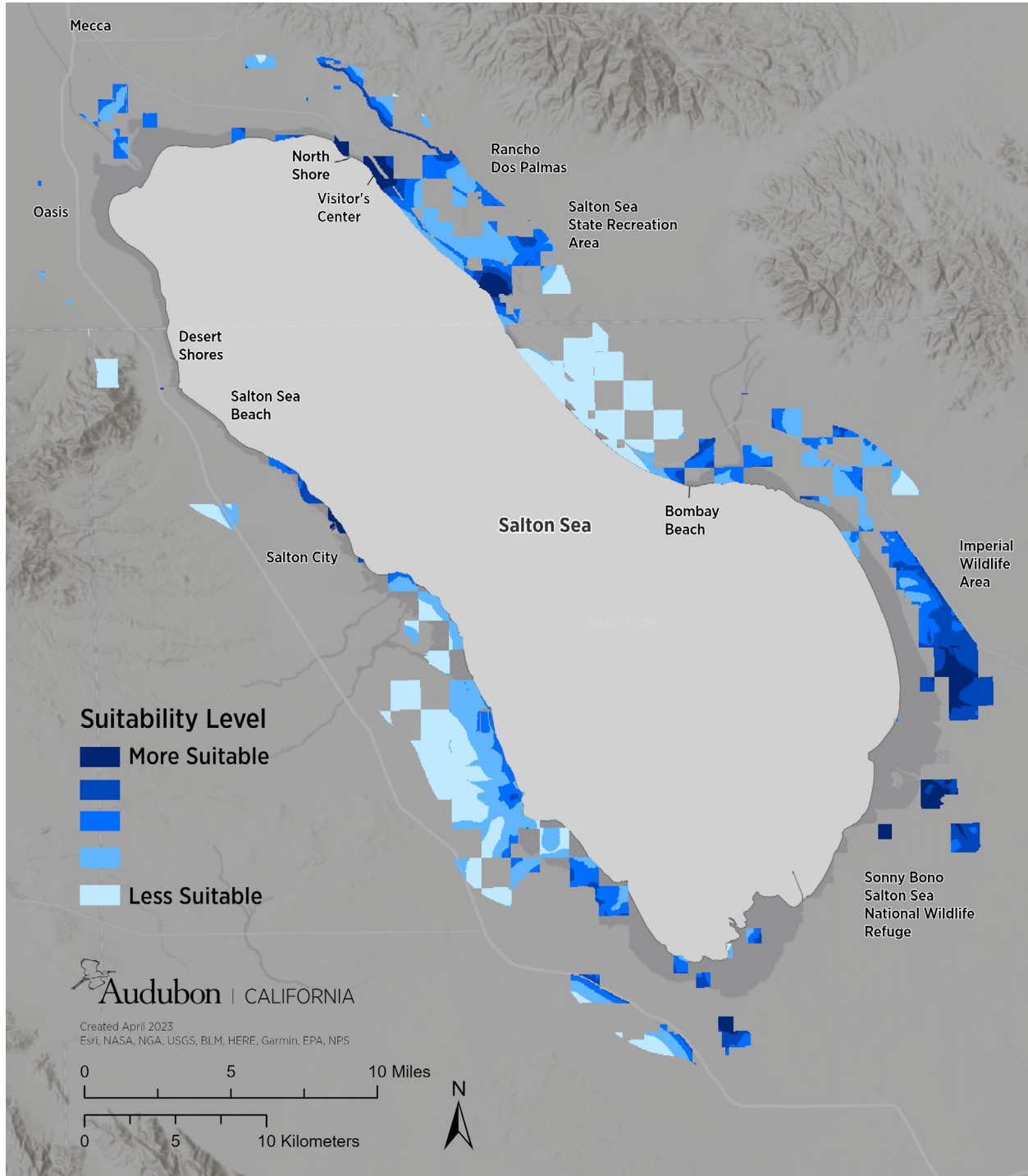


FIGURE 9. Nature viewing landscape suitability within landownership Tier 2: local water district lands.

Dark brown areas represent locations that are more suitable for implementing nature viewing areas and would likely present less challenges than within privately owned lands but may present more challenges than within publicly owned lands.

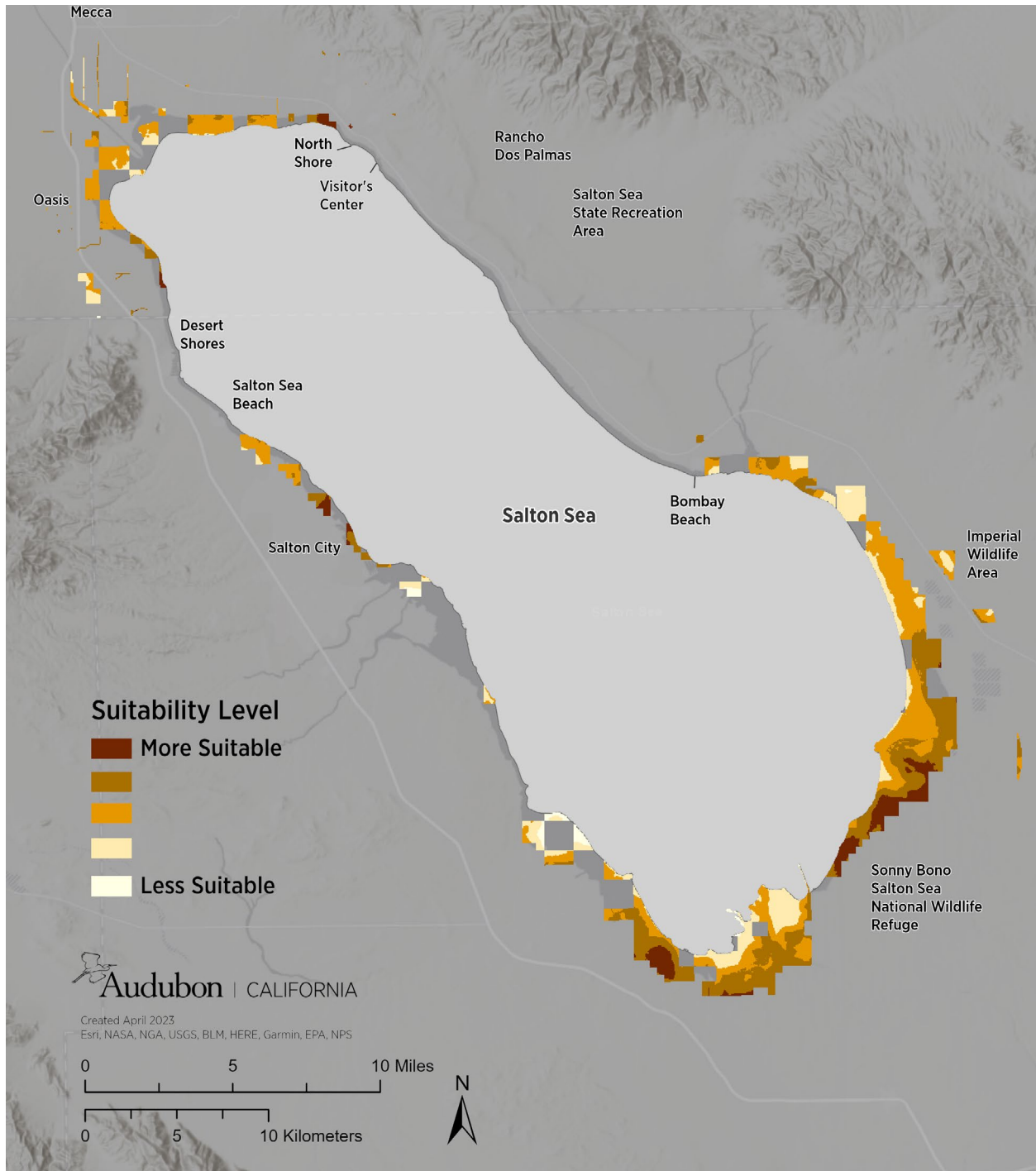


FIGURE 10. Nature viewing landscape suitability within landownership Tier 3: Bureau of Indian Affairs, privately owned, or unknown land.

Dark red areas represent locations that are more suitable for implementing nature viewing areas given the infrastructure and environment, but implementing public access within these lands may present significant challenges.

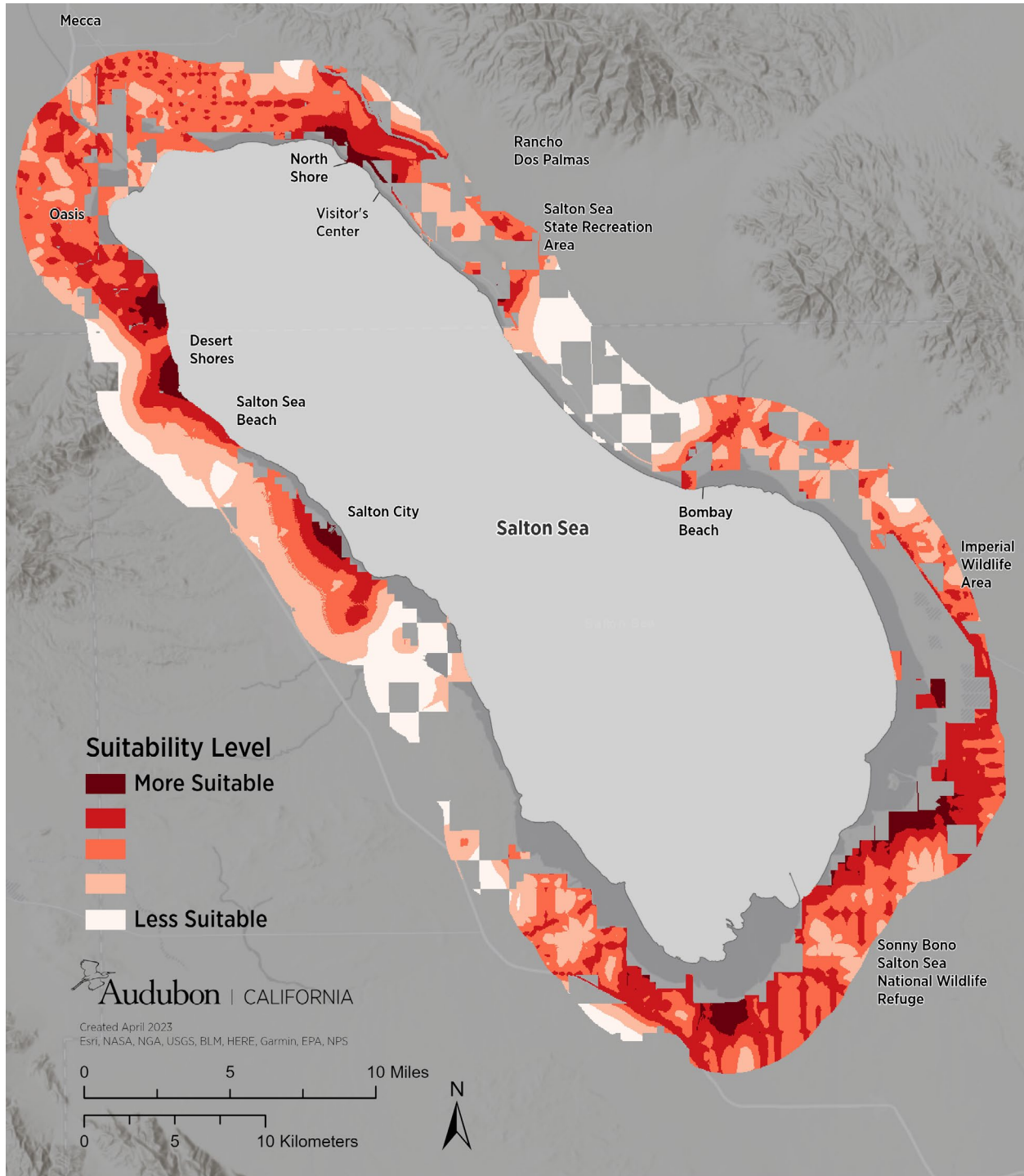


FIGURE 11. Boat ramp suitability within landownership Tier 1: public lands.

Dark blue areas represent locations that are more suitable for implementing boat ramps and would present minimal challenges. To account for shoreline recession, the 10- year projected contour (-252.9 ft in 2032) from the SALSA2 model (CH2M Hill 2018) was extracted and used as the innermost extent for the analysis. The current Salton Sea shoreline location is the outermost extent for the analysis.

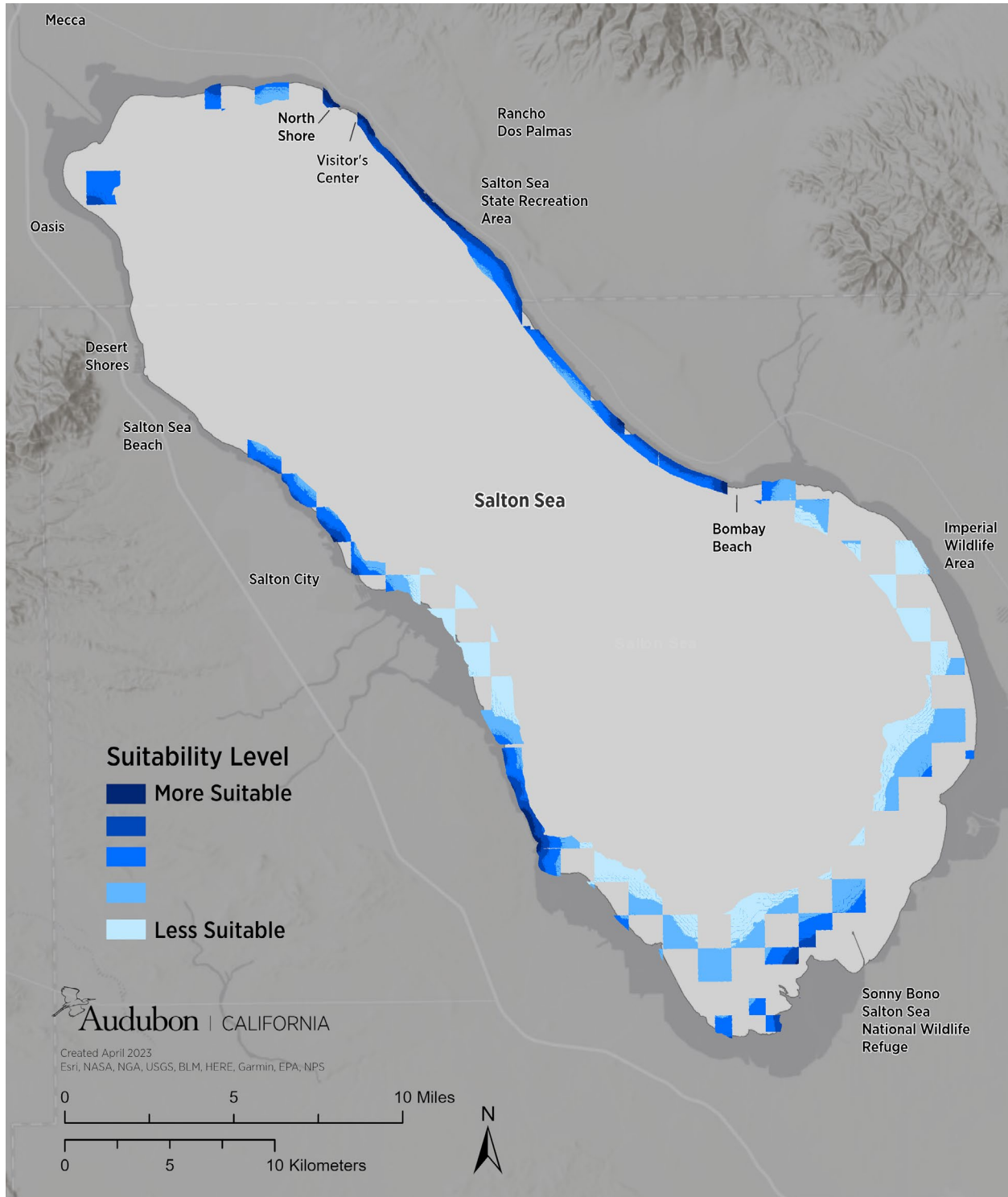


FIGURE 12. Boat ramp suitability within landownership Tier 2: local water district lands.

Dark brown areas represent locations that are more suitable for implementing boat ramps and would likely present less challenges than within privately owned lands but may present more challenges than within publicly owned lands.

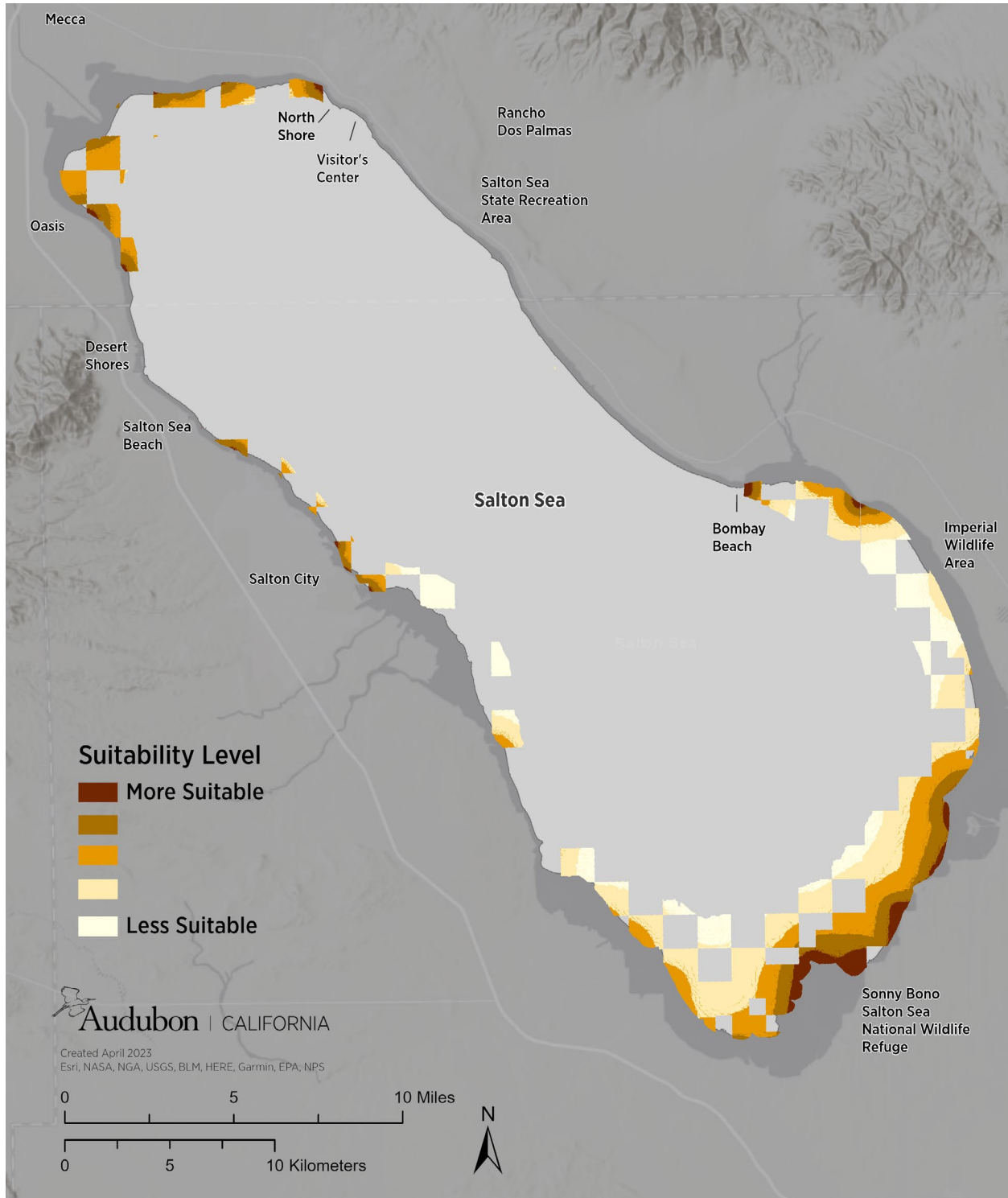


FIGURE 13. Boat ramp suitability within landownership Tier 3: Bureau of Indian Affairs, privately owned, or unknown land.

Dark red areas represent locations that are more suitable for implementing boat ramps given the infrastructure and environment, but implementing public access within these lands may present significant challenges.



FIGURE 14. Landscape suitability within and surrounding the SCH project boundary for picnic/BBQ areas (A), nature viewing areas (B) and boat ramps (C) and within landownership Tier 1 (blue, left), Tier 2 (orange, center), Tier 3 (red, right).

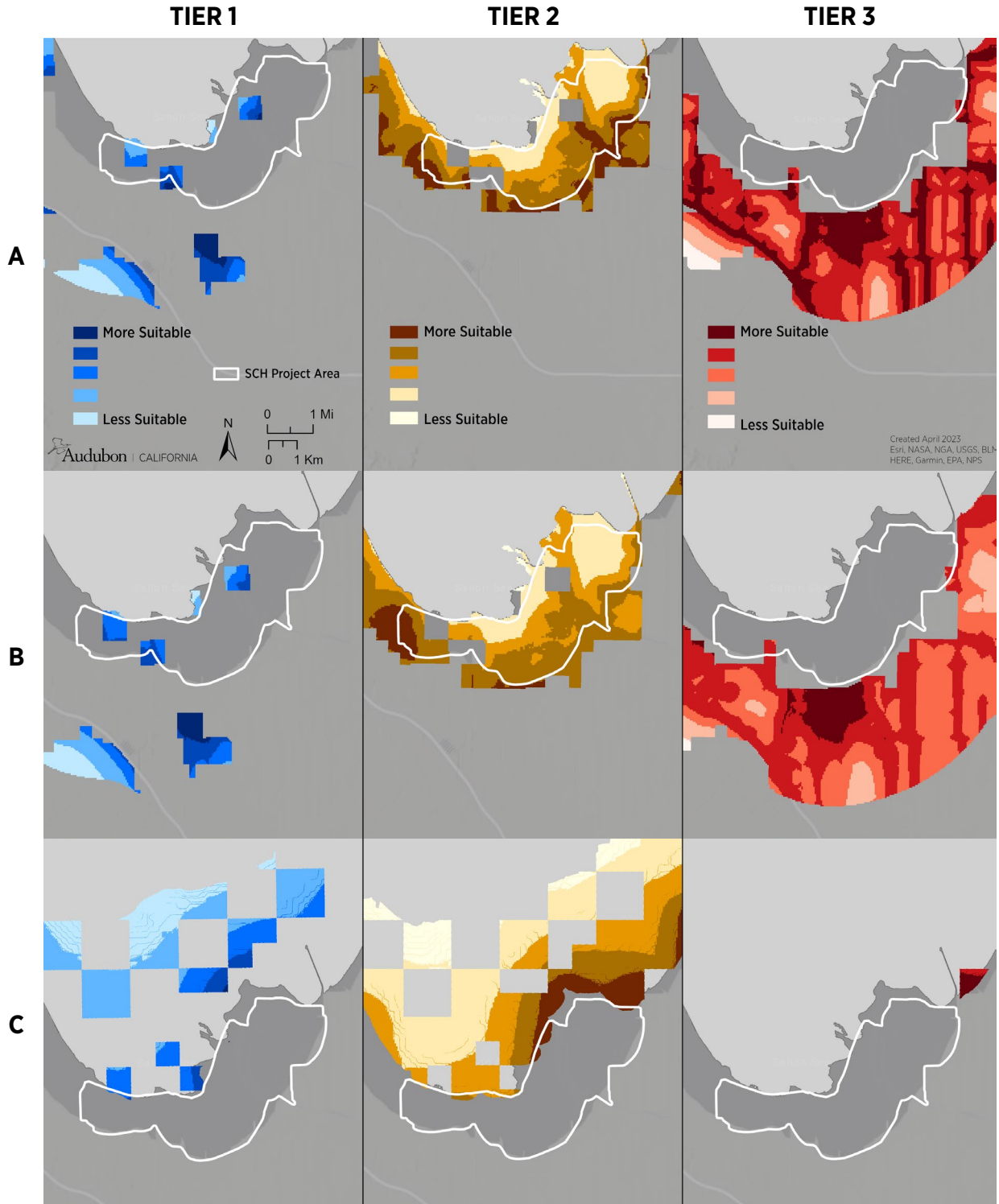


FIGURE 15. Landscape suitability within and surrounding the North Lake Concept boundary for picnic/BBQ areas (A), nature viewing areas (B) and boat ramps (C), within landownership Tier 1 (blue, left), Tier 2 (orange, center), Tier 3 (red, right).

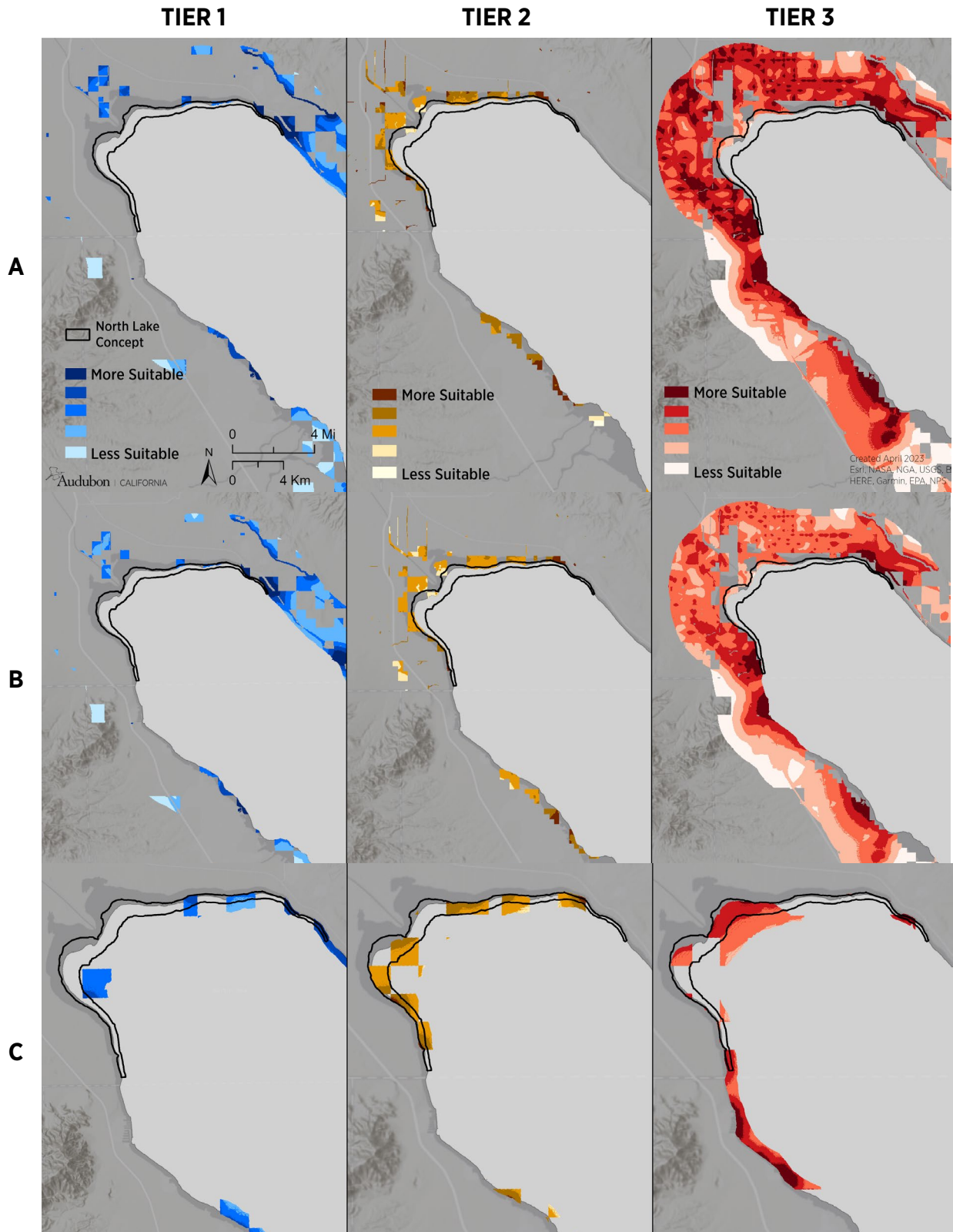


FIGURE 16. Landscape suitability within and surrounding Bombay Beach Wetland project boundary for picnic/BBQ areas (A), nature viewing areas (B) and boat ramps (C), within landownership Tier 1 (blue, left), Tier 2 (orange, center), Tier 3 (red, right).

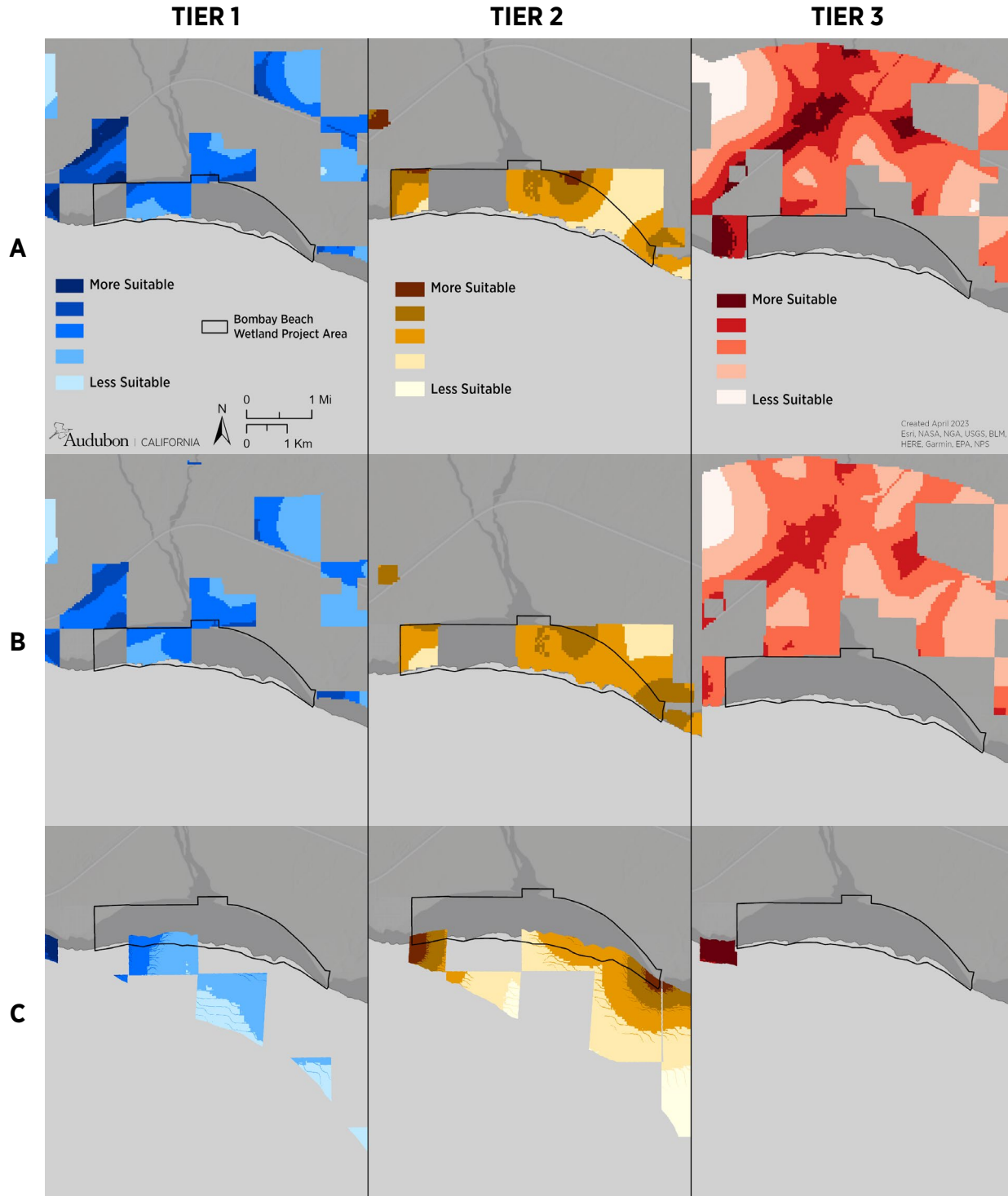


FIGURE 17. Consensus suitability map displaying the overlap of top 10%, 20%, 30%, and 50% suitable locations for nature viewing and picnic/BBQ areas.

To understand the most suitable locations to implement multi-use public access areas, we synthesized a consensus model representing the overlap of the top 10%, top 20%, top 30%, and top 50% suitability scores between picnic/BBQ and nature viewing suitability models.

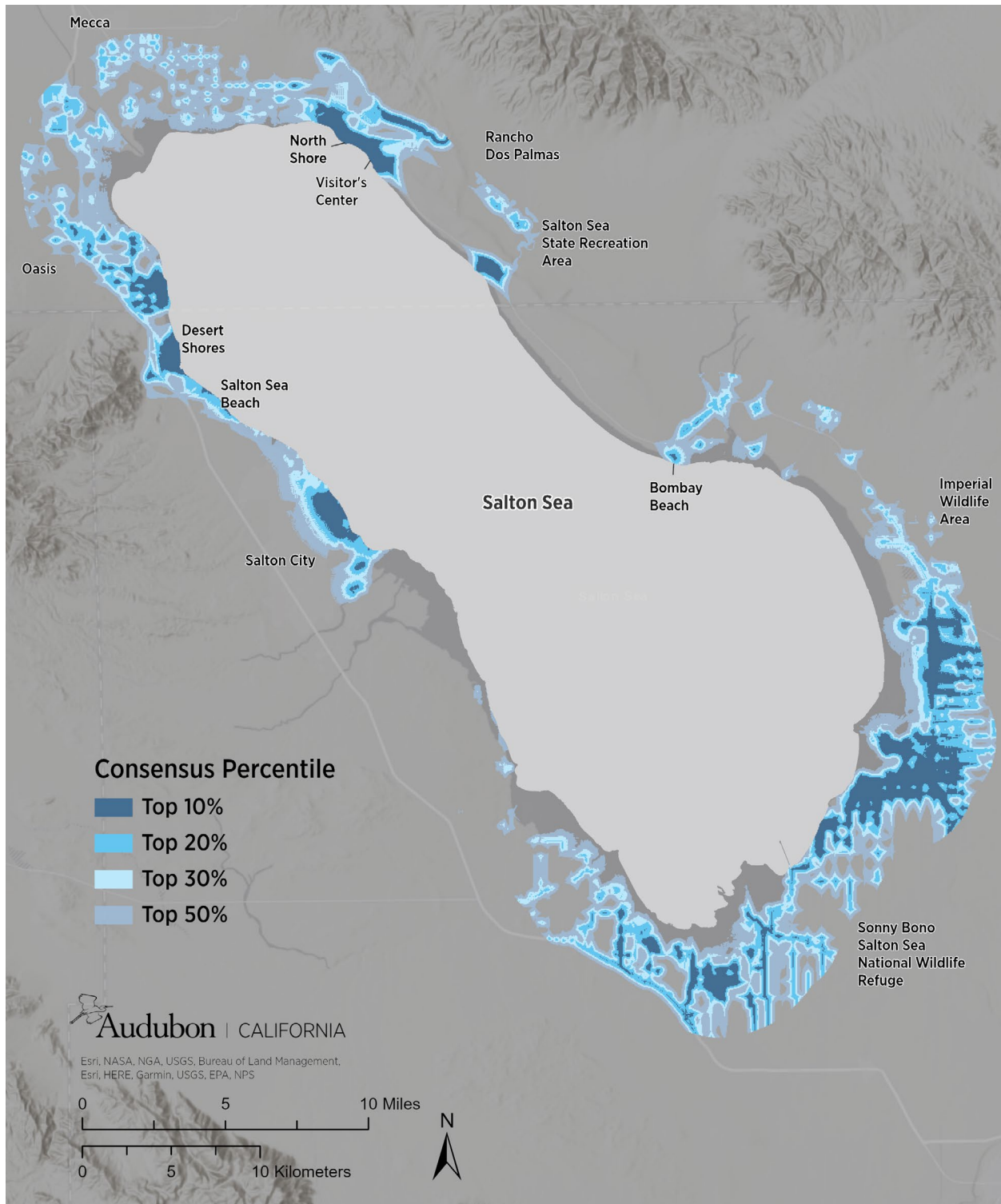


FIGURE 18. Consensus suitability map displaying the overlap of top 10%, 20%, 30% and 50% suitable locations for nature viewing and picnic/BBQ areas within and surrounding Sonny Bono National Wildlife Refuge.

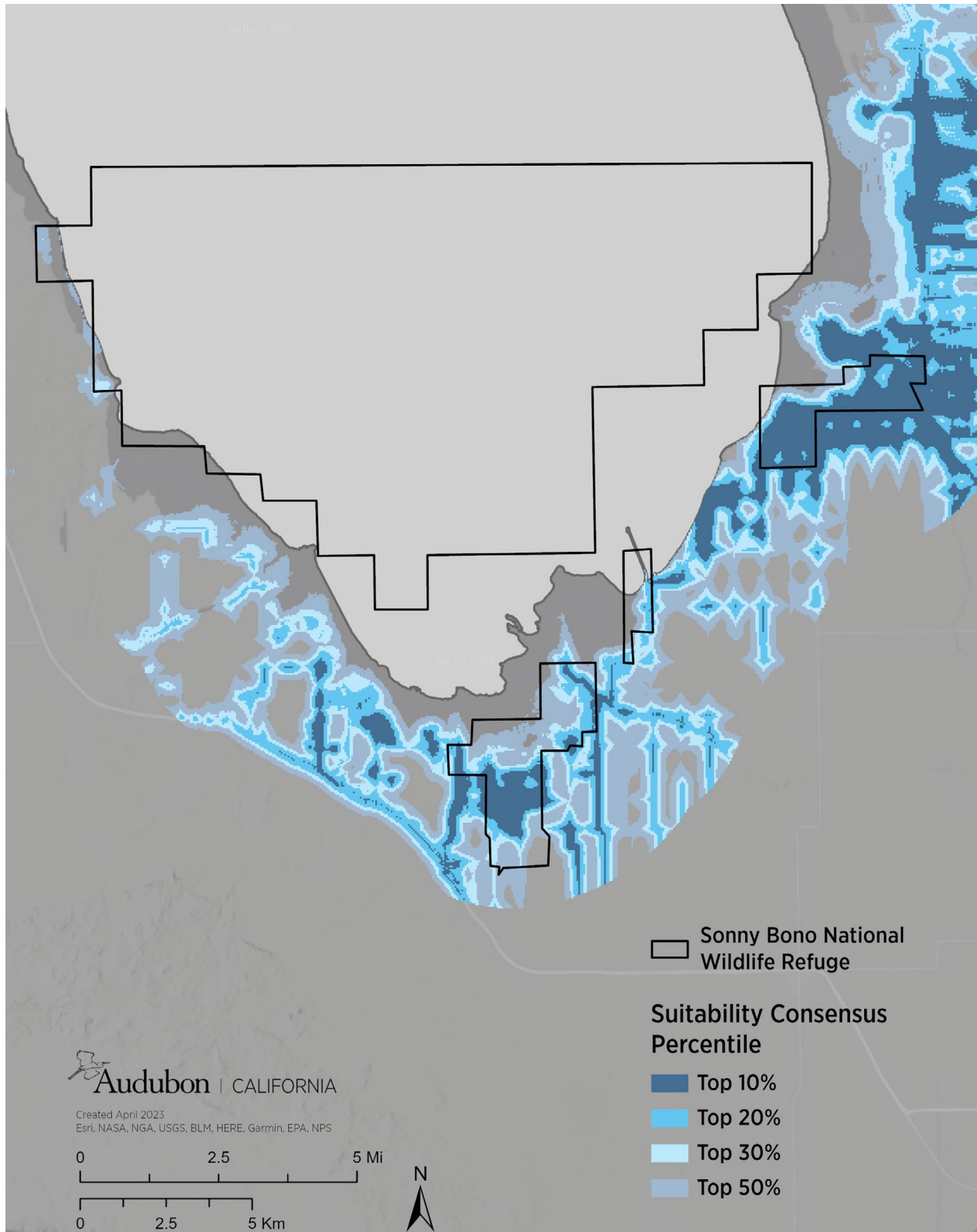


FIGURE 19. Consensus suitability map displaying the overlap of top 10%, 20%, 30%, and 50% suitable locations for nature viewing and picnic/BBQ areas within and surrounding the Species Conservation Habitat Project (SCH) area.

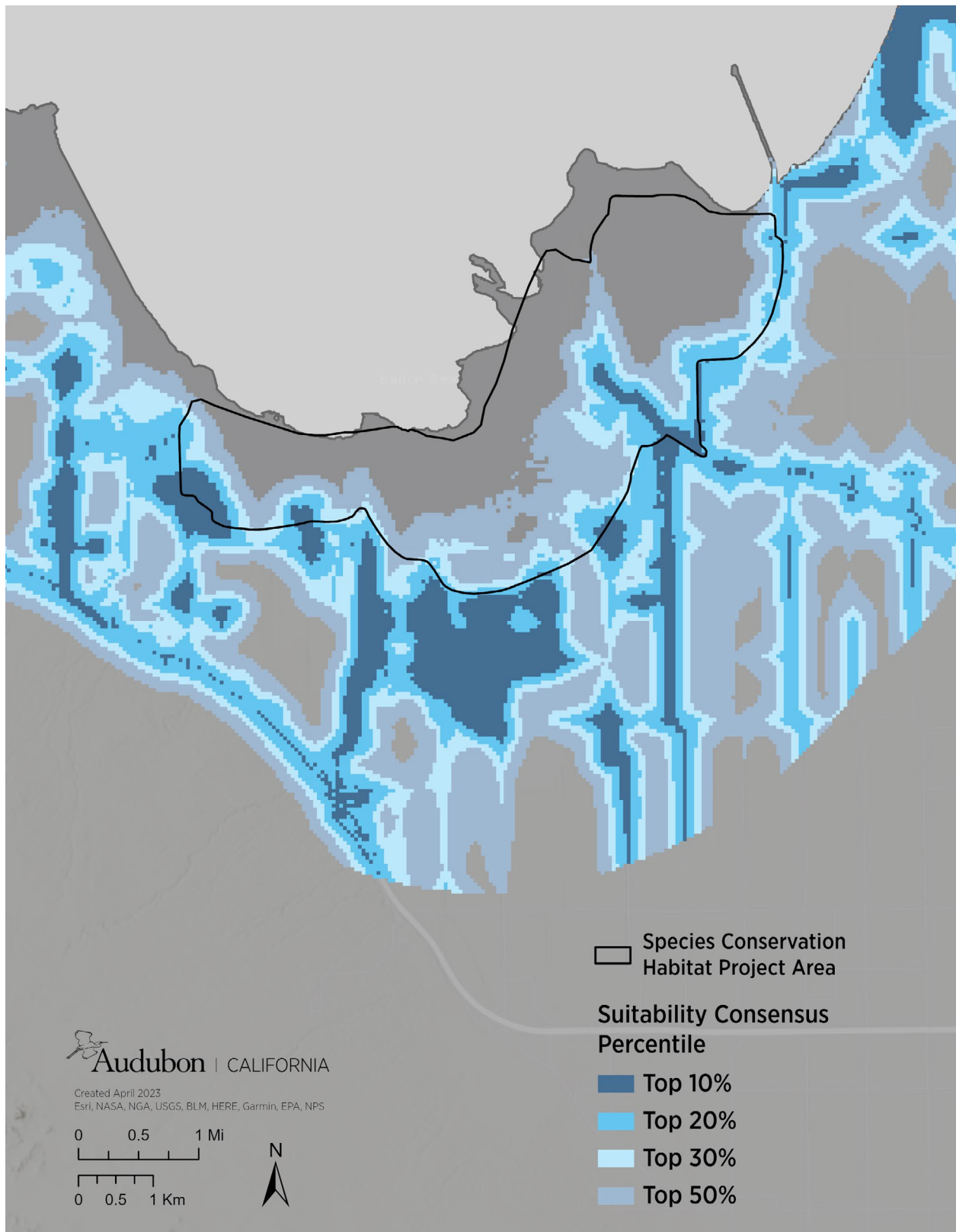


FIGURE 20. Consensus suitability map displaying the overlap of top 10%, 20%, 30% and 50% suitable locations for nature viewing and picnic/BBQ areas within and surrounding the Bombay Beach Wetland Project area.

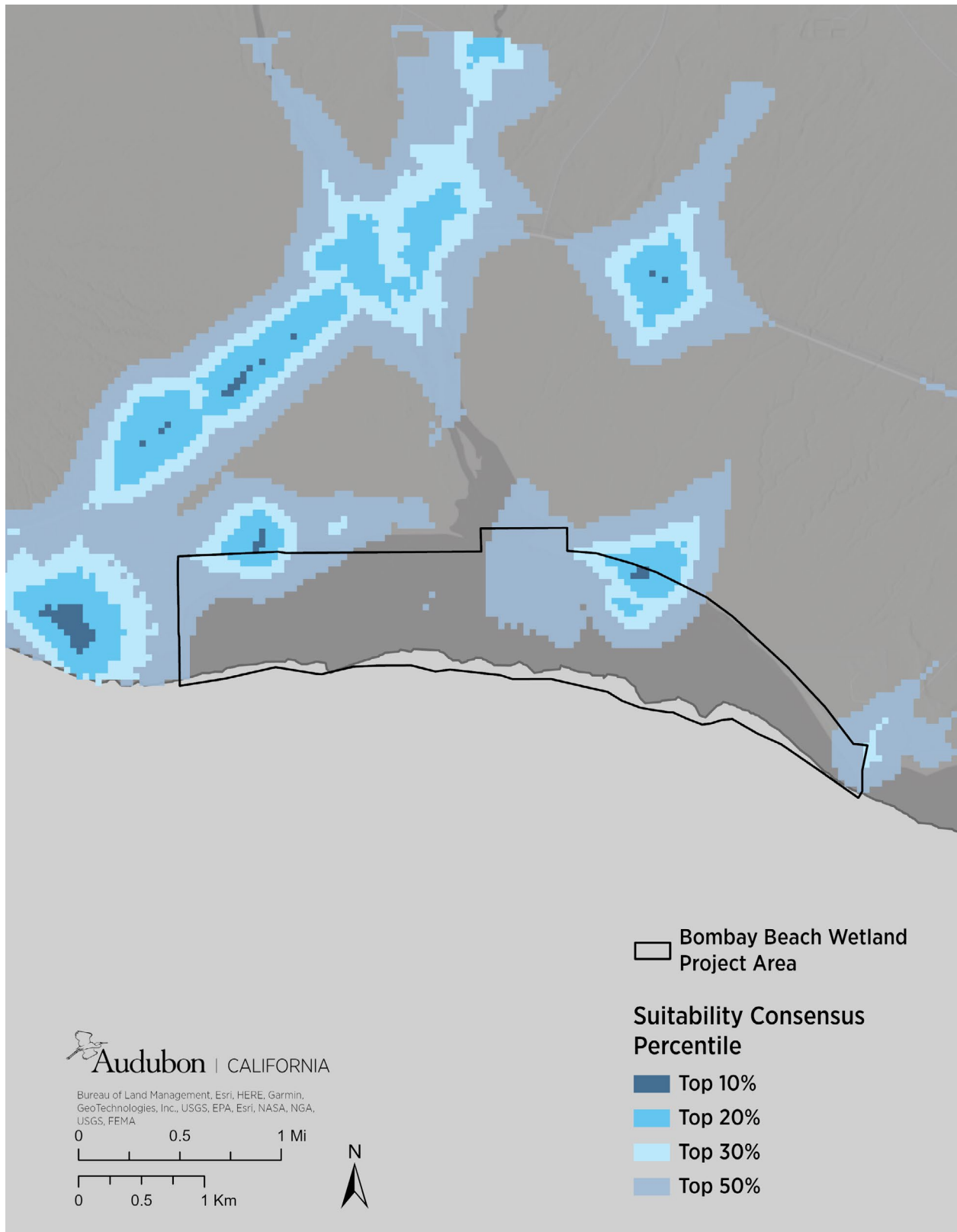


FIGURE 21. Consensus suitability map displaying the overlap of top 10%, 20% 30%, and 50% suitable locations for nature viewing and picnic/BBQ areas within and surrounding the North Lake Concept.

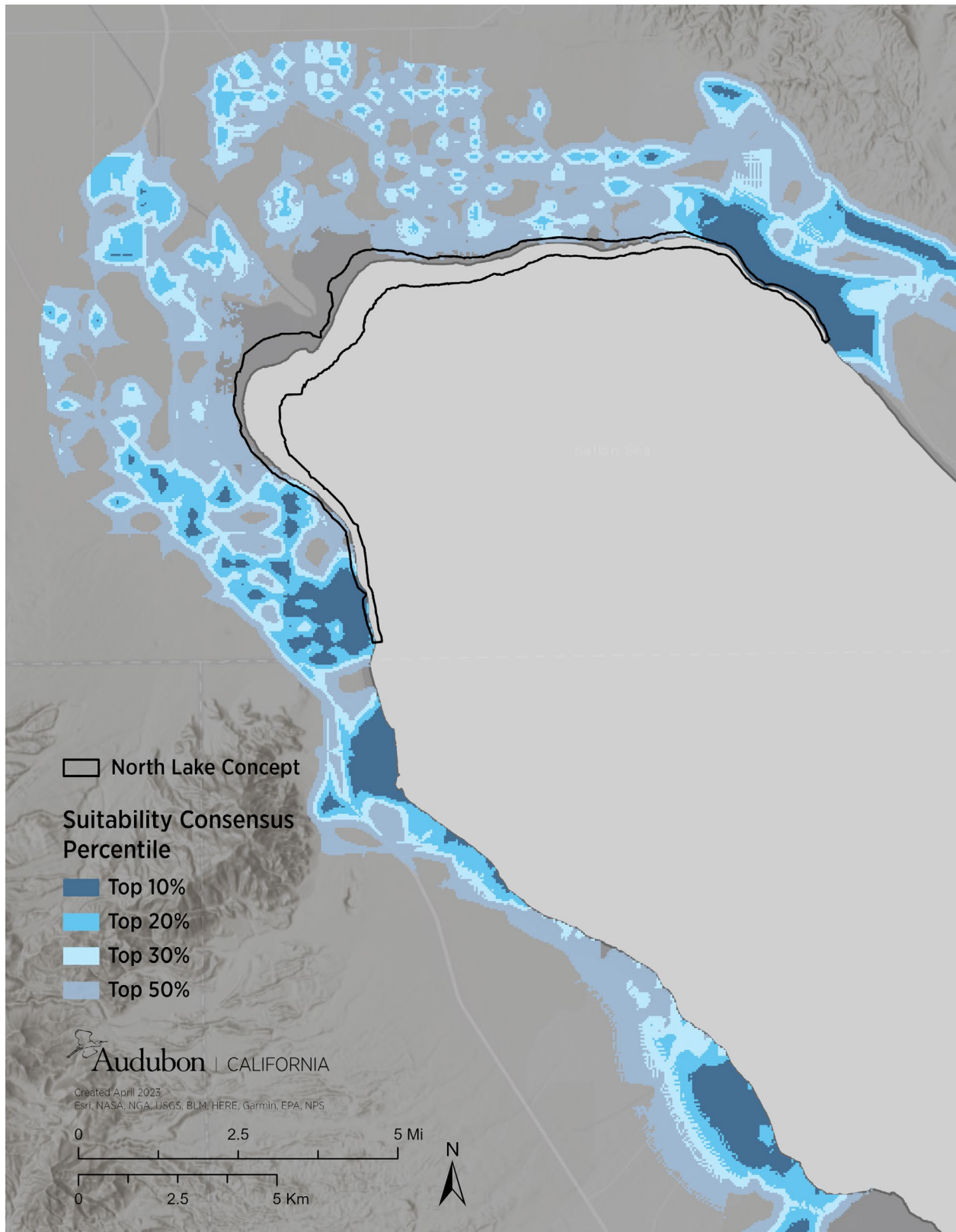


FIGURE 22. Consensus suitability map displaying the overlap of top 10%, 20% 30%, and 50% suitable locations for nature viewing and picnic/BBQ areas within and surrounding the North Lake Concept area.

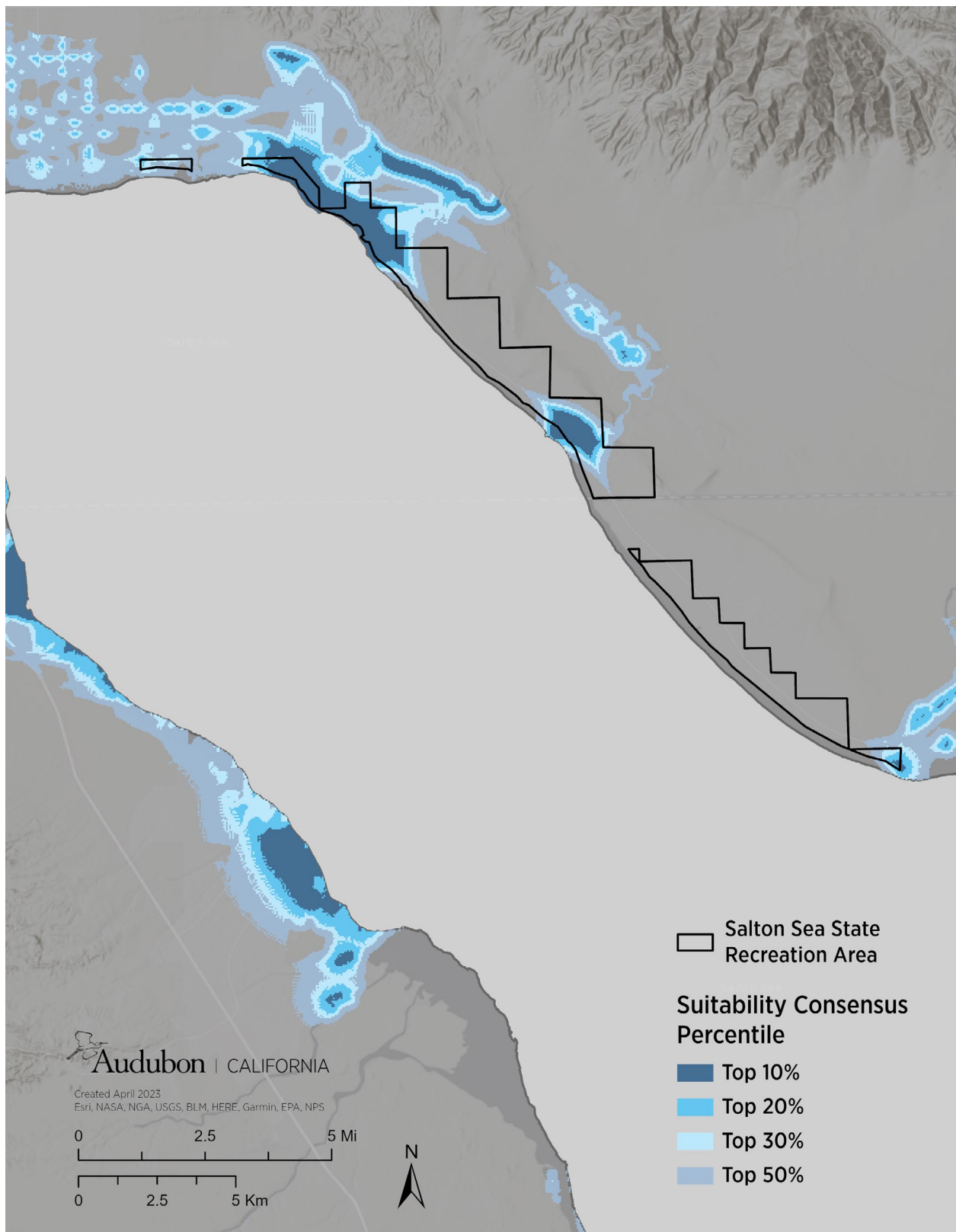


FIGURE 23. Consensus suitability map displaying the overlap of top 10%, 20%, 30%, and 50% suitable locations for nature viewing areas, picnic/BBQ areas, and boat ramps within and surrounding the Sonny Bono National Wildlife Refuge.

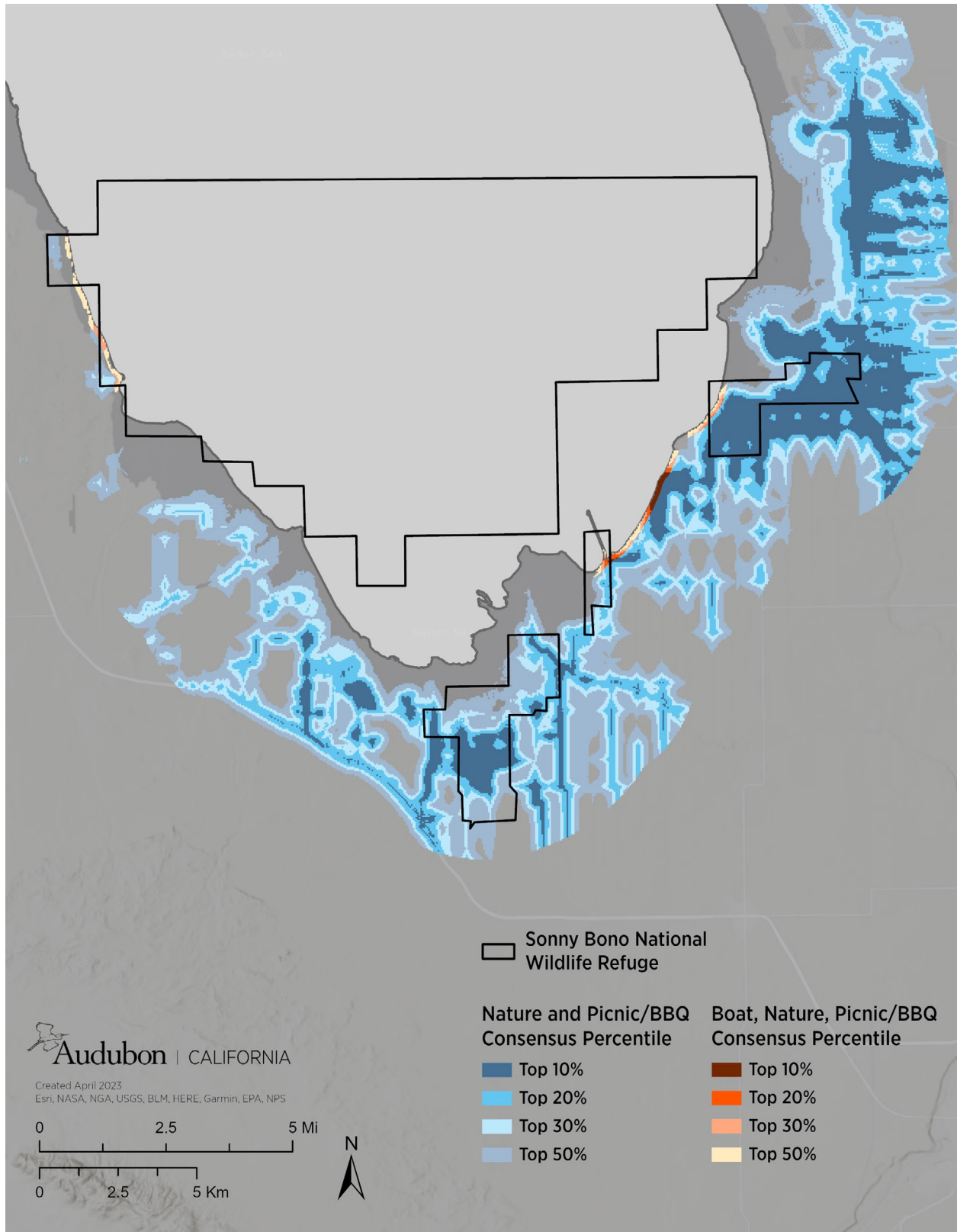


FIGURE 24. Consensus suitability map displaying the overlap of top 10%, 20%, 30%, 50% suitable locations for nature viewing areas, picnic/BBQ areas, and boat ramps within and surrounding the Species Conservation Habitat Project area.

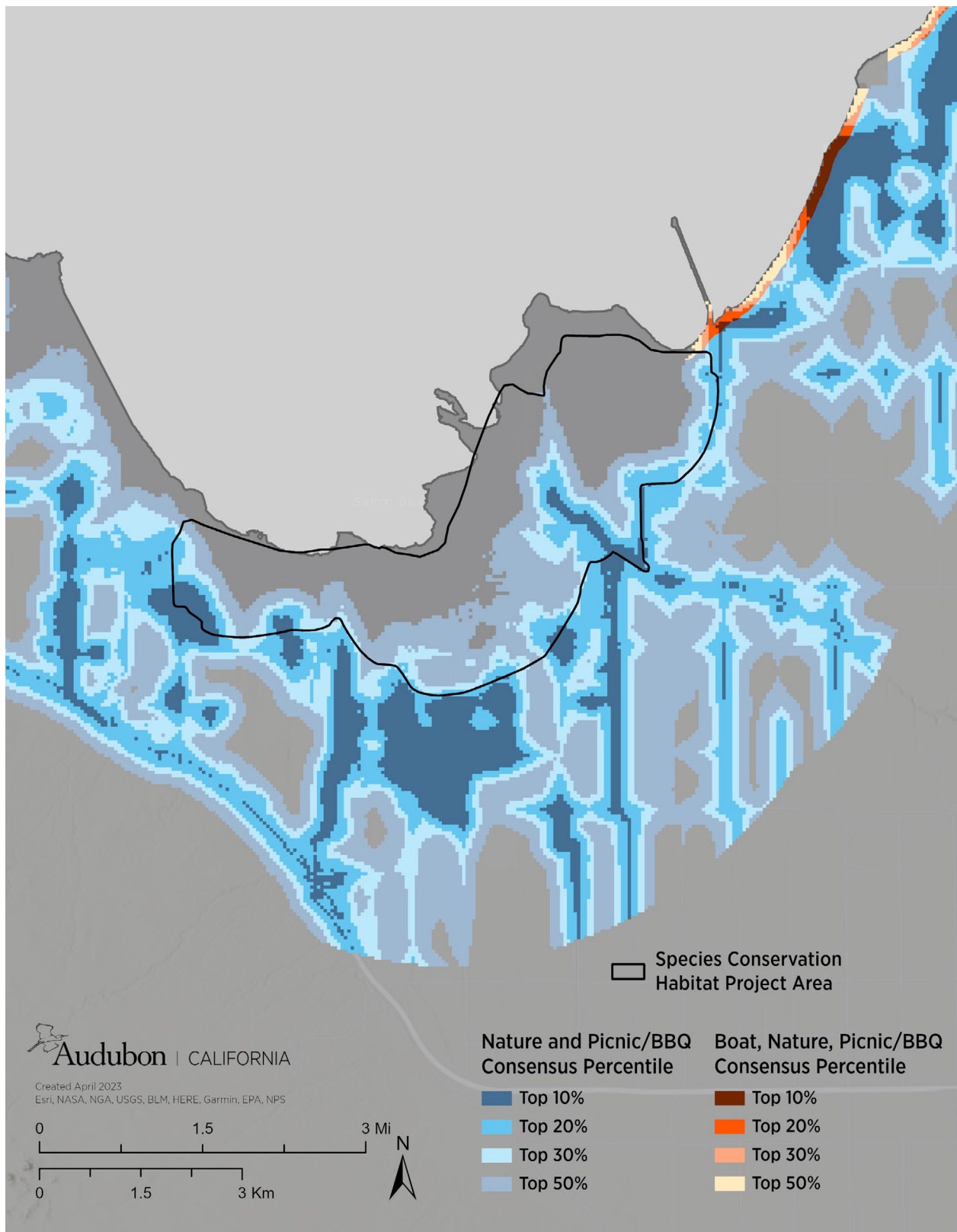


FIGURE 25. Consensus suitability map displaying the overlap of top 10%, 20%, 30%, 50% suitable locations for nature viewing areas, picnic/BBQ areas, and boat ramps within and surrounding the Bombay Beach Wetland project area.

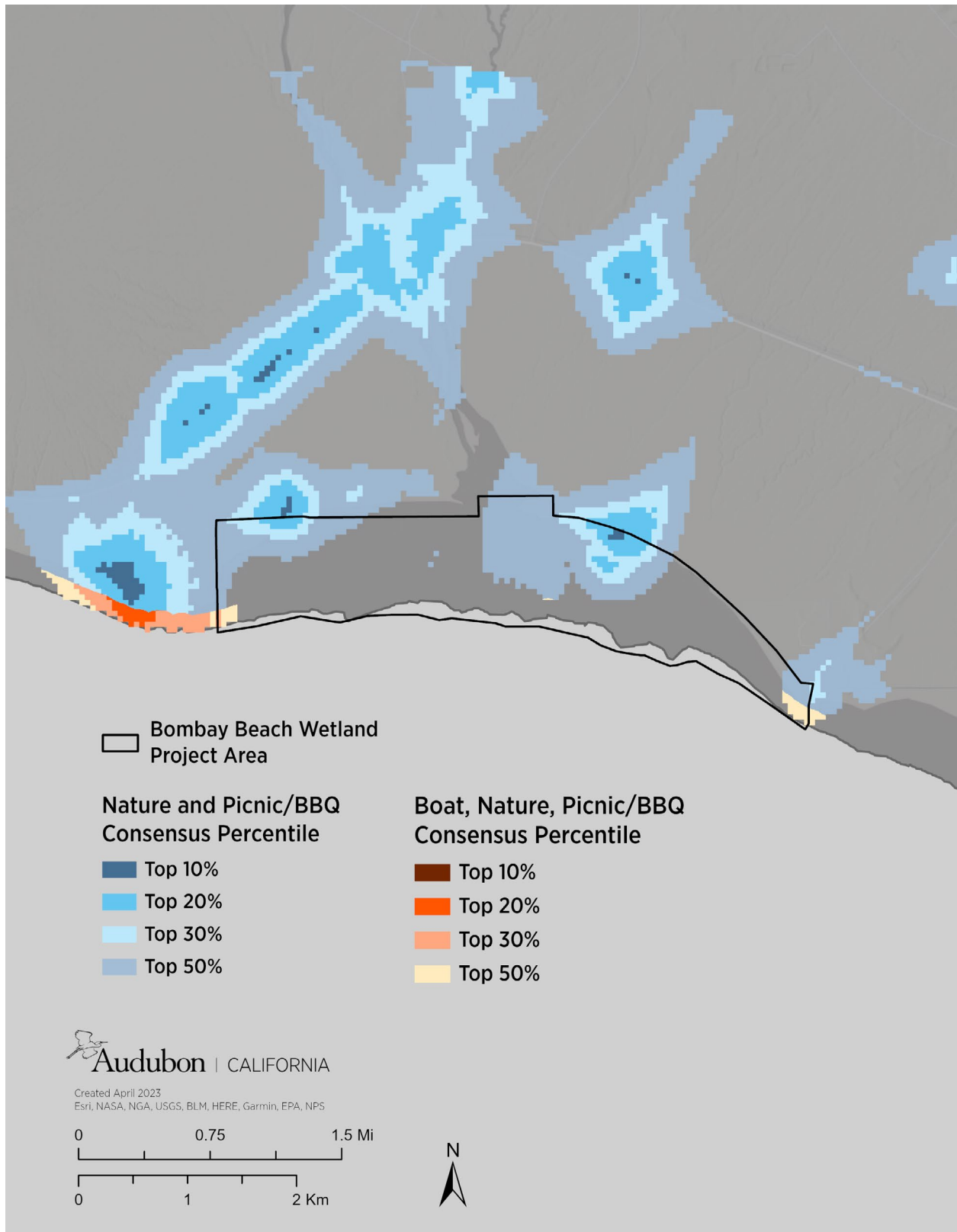


FIGURE 26. Consensus suitability map displaying the overlap of top 10%, 20%, 30%, and 50% suitable locations for nature viewing areas, picnic/BBQ areas, and boat ramps within and surrounding the North Lake Concept Area.

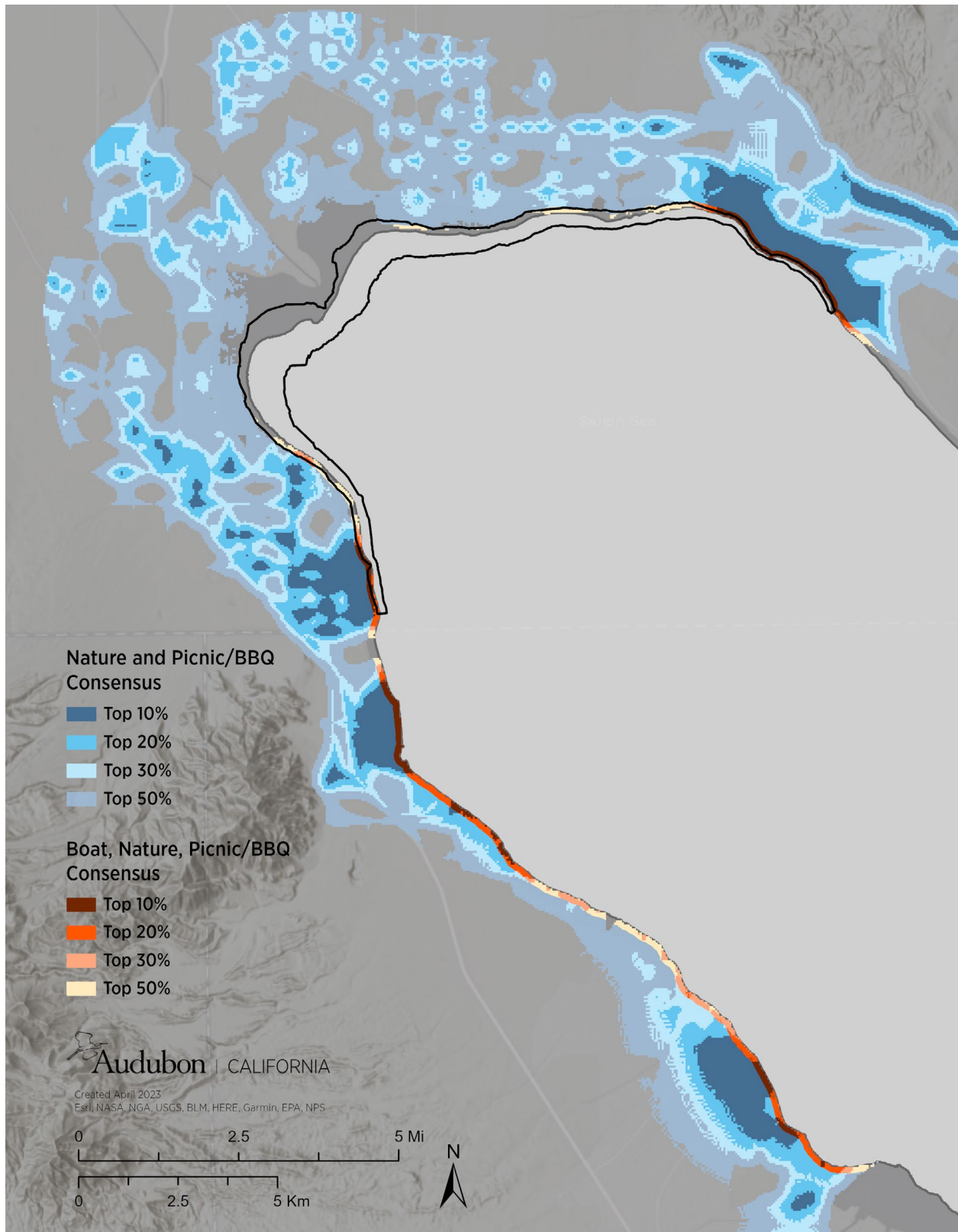


FIGURE 27. Consensus suitability map displaying the overlap of top 10%, 20%, 30%, 50% suitable locations for nature viewing areas, picnic/BBQ areas, and boat ramps within and surrounding the Salton Sea State Recreation Area.

