Coastal Resilience in the Baja California-San Diego Region

An Assessment of Science Assets, Gaps, and Priorities

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Contents

		Page
I.	Introduction	3
II.	Methods Used to Develop the Assessment	5
III.	Coastal Resilience Actors and Fields of Work	7
IV.	Existing Binational Science Collaborations and Alignment	10
V.	Knowledge Gaps, Opportunities, and Priority Needs	18
VI.	Next Steps	22
VII.	References	23
VIII.	Appendix	25

I. Introduction

The coastal environment and people of San Diego California, and Baja California are deeply connected. This unique border region shares a diverse array of ecosystems with rich biodiversity including deserts, forests, beaches, rivers, and estuaries. Some of these ecosystems overlap directly at the border (e.g., the Tijuana River and estuary) while others are geographically linked bioregions (e.g., the California Current Marine Ecosystem) where species interact and migrate across the region. The people within this region are also closely connected. Despite increasing challenges with crossing the border, over 100,000 people commute daily through the San Ysidro Port of Entry. While most of these are people commuting to San Diego for work or school, some are also students traveling to Baja California for higher education (Solis, 2023). Many of these people have family and ancestry from both sides of the border including, Indigenous peoples that remain in the area and whose ancestors inhabited the region long before the establishment of the modern-day border.

The coastal landscape and resources of this border region are integral to the livelihoods of the people that reside there. Therefore, the resilience of the coast and how we help it adapt and withstand the stressors of climate change is of binational significance. For example, increasing ocean acidification is adversely affecting marine ecosystems and the seafood industry on both sides of the border (Marshall et al., 2017; Schlenger et al., 2021). The last two decades have also seen more marine heatwaves which threaten kelp habitat, fisheries, and marine food webs across the overall California Current Marine Ecosystem (Cheung & Frölicher, 2020; Fumo et al., 2020; Lonhart et al., 2019). At the shoreline, coastal erosion, inundation of low-lying areas, and increased coastal flooding are common issues of concern for many in the border region. These impacts are expected to grow as sea levels rise and combine with more intense rainfall and coastal storms (IPCC, 2023). These impacts, combined with increasing coastal development and growing population numbers, will put additional stress on coastal habitat and biodiversity, as well as community access to coastal areas and resources.

I. Introduction

To combat and address these impending and future threats, communities, universities, and organizations on both sides of the border are investing in climate resilience projects and research. While these are commendable, they are often isolated projects or studies with little to no support or directives for sharing the learned knowledge and data so it can be replicated and/or benefit others in the region. Given the expected acceleration of climate change impacts, there is a tremendous need to bolster science learning and sharing to significantly enhance capacity and expertise for coastal resilience in the border region.

This assessment represents the first phase of addressing this need. The goal was to identify relevant binational expertise and assets valuable to coastal resilience efforts, gather input on science needs and priorities, and summarize all of this into a report that will inform the development of a binational research agenda and outreach framework. Paramount to this effort was understanding and recognizing the perspectives of local communities and people because their insights, concerns, and priorities play a pivotal role in developing effective strategies for coastal resilience. Engaging these groups in a collaborative dialogue not only fosters a sense of ownership over the solutions, but also ensures that adaptation efforts align with the unique needs and values of the region, shedding light on the urgent need for adaptive strategies that consider both ecological and human dimensions.

Photo credit Meliza Le

II. Methods Used to Develop the Assessment

Several methods were used to identify and catalog existing binational knowledge holders, coastal resilience activities, and science needs for this assessment. These are described below.

1. Development of an inventory of knowledge/science centers and organizations

An inventory was developed by identifying key scientific research centers, universities, and non-profit organizations focusing on coastal resilience and climate change within the study area that encompasses the coastline of the Pacific from Oceanside, California to San Quintín, Baja California. Organizations were identified through internet-based searches of researchers and San Diego or Baja California-related coastal resilience publications. The inventory also leveraged several lists of working groups or networks serving the San Diego-Baja California region. These included the Climate Science Alliance Binational Working Group, the San Diego Regional Climate Collaborative Sea Level Rise Working Group, and a database of non-profits working on climate resilience compiled by the San Diego Regional Climate Collaborative, Civicwell, and Resilient Cities Catalyst. Entities that applied to the 2023 Binational Resilience Fund Grant Funding were also included. In total, the inventory currently includes 254 individuals that represent 121 entities such as research institutions, non-profits, Tribes, and local governments.

2. Interviews with individuals and workshop dialogues

A total of 64 interviews were subsequently conducted, either virtually or in-person when possible. These one-on-one conversations provided in-depth insights into specific coastal resilience research and projects, challenges, and needs. This phase also served to facilitate the establishment of initial contact with researchers who expressed interest in binational collaboration. This process was expanded through interactions at various binational meetings, workshops, and restoration events.

These included the EPA Border 2025 Regional Managers Meeting, the US-Mexico Cross Border Sewage Crisis event, California Estuarine Research Society Conference, a binational nature-based solutions workshop led by the Tijuana River National Estuarine Research Reserve (TRNERR), the II Simposio Mexicano de Contaminación por Plásticos, Festival de la Pesca y Acuacultura Artesanal, Climate Science Alliance youth outreach event at Sierra Juarez with Tipey Joa, the 2023 San Diego Climate Summit, Taller de Macroalgas event, and the Headwaters to Ocean 2023 Conference.

3. Online

Complementarily, an online survey was disseminated through working groups such as the Binational Working Group from the Climate Science Alliance and the San Diego Regional Climate Collaborative, yielding 45 individual responses from participants.
The online survey sought detailed information about the respondents' affiliations, the nature of their work, and their specific projects related to coastal resilience, including their geographical focus, challenges, and areas of improvement. This was to identify the range and depth of scientific assets and expertise present in the region.

4. Indigenous community outreach

A separate approach was undertaken to obtain feedback specifically from Indigenous communities. In collaboration with the Climate Science Alliance Tribal Working Group, a special coastal gathering was held on Kumeyaay lands in October 2023 to explore reflections on what the coast and ocean mean to Indigenous communities and peoples from Southern California. Representatives of Indigenous communities in the San Diego and Baja California regions were present.

5. Analysis of data and input from the above methods

Data collected through the research, interviews, and survey was then filtered and evaluated to identify common binational priorities, needs, and representation in coastal resilience science and activities. The results were then summarized into this report as a high-level overview of binational coastal resilience knowledge, partners, and opportunities.

Photo Credit Anna López


Photo Credit Meliza Le

III. Coastal Resilience Actors and Fields of Work

To understand the diversity of actors and knowledge holders that are currently involved in coastal resilience in the San Diego-Baja California region, we first categorized entities and individuals by type of affiliation (Table I). It is important to note that some individuals identified as a member of more than one affiliation. For example, the same individual may serve both in academia and as a consultant in some government agency or non-profit organization.

The "Other" category included less represented affiliations such as consultant, activist, and ecotourism industry. Of the 254 representatives identified in the inventory, 57% were primarily working in San Diego County and 43% were primarily working in Baja California (Figure 1).

Table I. Affiliations of Binational Coastal Actors

Affiliation	*San Diego*	*Baja California*
Non-profit / non-governmental organization	35	44
Academia	38	46
Governmental	48	4
Indigenous Affiliation	4	1
Graduate or undergraduate student	2	4
Other	22	8
Sub Total Representatives	149	107
Total Representatives	254	

Academic institutions appeared as the most representative group. Most of these actors were affiliated with Scripps Institution of Oceanography, Universidad Autónoma de Baja California (UABC), and San Diego State University. We acknowledge that there may be even more academics involved in coastal resilience in the region, particularly students and independent consultant researchers. While we attempted to reach and recruit responses from a wider group of academics, the timing of surveys and requests for interviews proved difficult for many.

Non-profit organizations were the second most representative group. These entities are typically more mission-driven and are highly involved in community engagement and advocacy.

Many of these organizations are working directly with communities being affected by climate change along our coasts, and at the same time collaborating with other sectors such as the government and academia. Staff involved with these organizations are very open to participating in this type of surveys and initiatives, as they recognize the value of shared knowledge and collective action.

The respondents from the interview and survey mentioned a variety of fields that they worked in related to coastal resilience and these were assigned to 10 categories to summarize the breadth and range of work fields (Figure 2).

Scientific fields of work that were prominent were biology and ecology (21.3%), physical oceanography and geomorphology (11.4%), social sciences (6.8%), and fisheries (4.4 %). This demonstrates the significance of understanding ecological systems and physical dynamics of coastal areas for effective resilience planning.

While less prominent, the representatives that specifically highlighted work in social sciences related to the coast also signified the understanding that there are important socio-economic and cultural aspects to coastal resilience work.

Ecoregions of the Baja California-San Diego Region

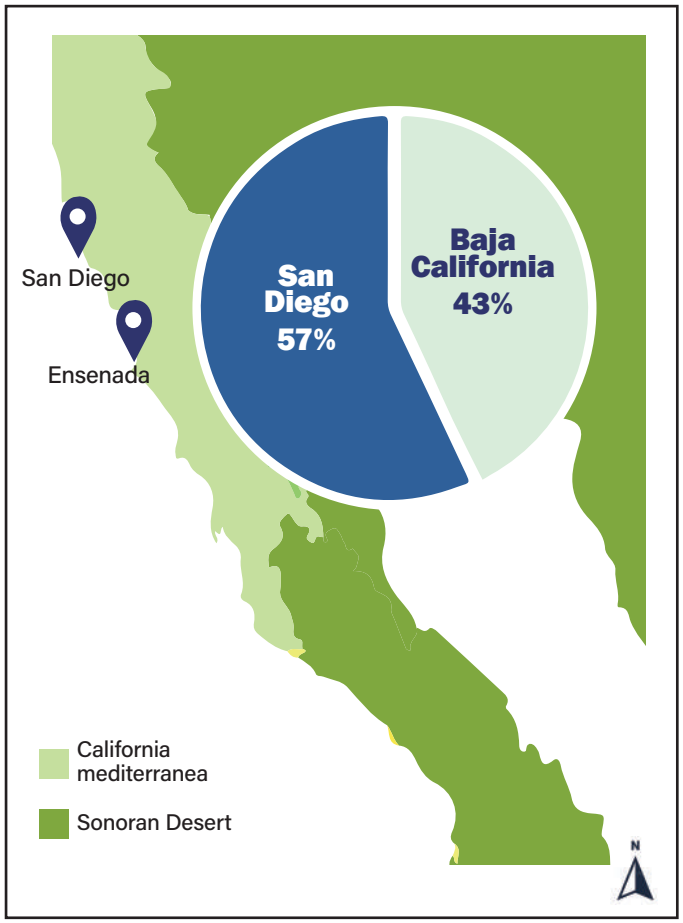

Figure 1. Pie chart with percentage of San Diego and Baja California entities represented in the inventory. ***Map credits:*** CONANP, Esri, TomTom, FAO, NOAA, USGS, EPA

More specialized fields of research such as Climatology and Biogeochemistry were less represented. In particular, the Baja California region appears to have fewer experts in these fields compared to the number of those dedicated to these sciences in San Diego. It may be that experts in these fields are based at other universities in Mexico not located in Baja California and/or there are fewer resources for these types of research fields.

Beyond traditional academic fields, over 12.13% of the interview and survey respondents noted that they worked on education and outreach related to coastal resilience, reflecting the importance many are placing on the dissemination of knowledge and engaging communities in the rising resilience efforts across the region. 14.4% also said they were specifically working on coastal adaptation and 6% on Local Ecological Knowledge.

While these relate to the traditional science fields, they underscore the value of place-based understanding of knowledge communication and engagement. Those who specified their work in coastal adaptation also signified the expanding use of integrated physical and social science concepts to mitigate coastal vulnerabilities.

Within the 23 non-profit organization responses, there was also a clear pattern. 12 of them included Community Science as one of their fields of work.

This demonstrates that these groups are engaged in extensive work to enhance community participation in coastal research and land management.

6.8% also worked in Social Sciences, suggesting a growing recognition of the need for more inclusive and participatory methods in environmental studies, ensuring that the voices of local communities are heard and valued in the process of developing and implementing resilience strategies.

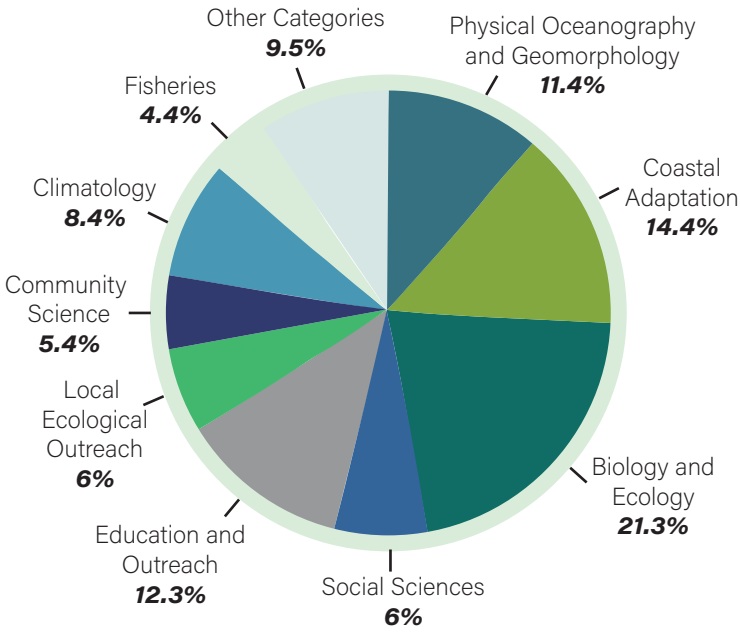

Figure 2. Fields of Work for the 254 Binational Representatives

IV. Existing Binational Science Collaborations and Alignment

As part of the interview and research component of this assessment, one objective was to identify existing areas of collaboration related to coastal resilience. These included projects, research and monitoring, education, and community engagement. Below is a summary of several themes that were discovered in this process including examples of specific collaborations.

1. Coastal habitat resilience and adaptation

There are several notable projects and ongoing collaborations between California and Baja California designing climate adaptation strategies to protect critical habitats for endangered species against threats such as sea level rise and loss of biodiversity.

Estuaries

One coastal habitat that has strong binational engagement and focuses on its resiliency is coastal estuaries. Estuaries are highly dynamic ecosystems where freshwater blends with saltwater. These habitats are crucial for diverse species as they serve as nursery and foraging areas for many species (West et al., 2021). In the same way, these habitats serve many functions for humans as we have settled along estuary regions for fishing, shipping, and recreation. Estuaries also hold essential functions such as filtering pollutants and mitigating flood impacts. This also means that they face significant threats from climate change, including sea level rise, drought, and ocean acidification (Cai et al., 2021).

The high importance of these ecosystems is evident, and a key binational focus area has long been the Tijuana River National Estuarine Research Reserve (TRNERR), where estuary resilience is intimately related to the watershed of the Tijuana River that crosses the international borderline. TRNERR has a dedicated binational liaison and is involved in broader estuarine research that involves partners in Baja California, from universities and many Tijuana-based non-profit organizations.

Photo Credit Laura Ibarra

Other areas of existing collaboration include a partnership between Terra Peninsular, ProEsteros, and the California Department of Fish and Wildlife (CDFW) to support standardized data collection methods to strengthen the conservation of the shared lagoon systems in the United States and Mexico.

There is also a broad network of wetland ecologists (researchers and students) involved in the California Estuarine Research Society (CAERS). CAERS helps to foster and facilitate knowledge-sharing among these researchers and includes both San Diego and Baja researchers on its leadership team. In April 2023, CAERS sponsored an annual conference featuring presentations on both human and climate impacts on estuarine habitats across the entire Southern California Bight extending down to San Quintin, Baja California.

Dunes

Coastal dunes are also increasingly a focus of binational coastal resilience research and projects. Dunes act as natural barriers against storm surges, high winds, and coastal erosion. By absorbing the impact of waves and providing a buffer zone, coastal dunes mitigate the effects of natural disasters like hurricanes and tsunamis, thereby safeguarding human settlements, ecosystems, and infrastructure along the coast (Engeman et al., 2021).

Coastal dune conservation and restoration are being seen more and more as essential not only for preserving biodiversity but also for their role as nature-based solutions for addressing increasing sea-level rise and shoreline erosion. These types of strategies are being planned and implemented on both sides of the border sometimes in conjunction with traditional infrastructure, to mitigate coastal hazards while delivering environmental and socio-economic benefits.

An example of binational collaboration in this area is the post-doctoral research fellowship sponsored by the San Diego Natural History Museum (SDNHM). The Baja California-based postdoctoral scholar, Natalia Rodríguez Revelo, focused on coastal dunes entomology within Baja coastal dunes as a method for identifying the most ecologically valuable dunes and the threats they face. This is only one example of the many ongoing research that the SDNHM is conducting in conjunction with many researchers across the Baja California peninsula towards conservation. Results from these long-term collaborations can be seen in the Baja Expedition exhibition at the museum.

Another example is the 2023 webinar hosted by the California Coastal Dune Science Network that promoted the work of five Baja California dune researchers. The webinar was well received and fostered researcher-practitioner connections for supporting the Punta Banda dune restoration project, where Fauna del Noroeste and the San Diego Audubon Society are responsible for the ecological restoration while Dr. Amaia Ruiz from UABC will provide her advice in coastal processes such as the role of sediment transport for dune retention.

Photo Credit Gabriela Euhan

Pollution Impacts to Coastal Habitats

It is widely recognized that within the border region, estuaries and coastal waters face significant pollution challenges, impacting both the environment and human health. Stormwater runoff is a primary source of contamination, carrying sediment and pollutants like fertilizers, heavy metals, debris, and sewage into streams and estuaries (Landrigan et al., 2020). This runoff leads to the degradation of habitats and adjacent waters and is exacerbated by increasing warming waters and extreme rainfall patterns (Glamore et al., 2016).

Most of the binational collaboration around addressing coastal pollution revolves around the watershed of the Tijuana River. For example, in 2021, WILDCOAST installed a floating barrier used to capture and collect trash in Los Laureles Canyon, Tijuana. Additionally, they have been working with local communities to foster behavioral changes related to single-use plastic consumption. More recently, TRNERR launched the first Marine Debris Leadership Academy with 40 participants from non-governmental organizations, federal agencies, and private sector entities from Mexico and the United States. The Environmental Protection Agency and other intergovernmental entities are also supporting efforts to mitigate watershed and beach pollution issues in the border region through initiatives such as the Engage America 2023: The U.S. - Mexico Cross Border Sewage Crisis event held in April 2023.

Shorebird Habitat

The protection and management of estuaries, wetlands, and coastal dunes across the United States-Mexico border plays a critical role in the conservation of migratory shorebirds as this area supports a large network of stopover sites for these birds. One of the most significant and long-term large-scale collaborations in the region (and even the continent) focuses on the protection and resilience of endangered coastal birds, particularly the Snowy Plover and the Least Tern.

Currently, a several number of academic, non-profit, and citizen science organizations such as California State and Parks, Instituto de Planeación Ambiental y Calidad de Vida, AC (INPACVI), ProEsteros, Point Blue, San Diego Audubon, Mujeres en Parvada, Pajareando y Conservando, and many others are actively collaborating to monitor these bird populations and generate information on their health and resilience. This effort is directed towards establishing a knowledge baseline that will enable the protection of these birds and their habitats. The ultimate goal is to create public policies that safeguard these critical habitats and to design effective management and conservation strategies.

Photo Credit Laura Ibarra

2. Understanding contemporary and future coastal hazard risks

A second common theme among San Diego and Baja California researchers and organizations was collaborations to expand understanding of contemporary and future physical coastal impacts from sea level rise and coastal storms. These impacts are primarily coastal flooding and shoreline erosion, including beaches, coastal cliffs, and dune systems. While this topic was expressed as a priority and an area of alignment by interviewees on both sides of the border, there has been very limited binational collaboration up to this point.

The "Climate Change and the Baja California Peninsula" report (2021) undertaken by the Climate Science Alliance summarizes available downscaled climate knowledge for the entire Baja California peninsula including temperature, precipitation, sea surface temperature, and sea-level rise as well as significant research gaps. The report distinctly notes that "regionally-specific data on sea-level rise is needed to improve research efforts and local management of the coastal areas" (Ezcurra et al., 2021).

One closely related and significant instance of cross-border cooperation in addressing erosion is the EPA-funded binational project (2014–2018) on stream channel erosion region of the US-Mexico border that mapped and modeled runoff and sediment loads from Los Laureles Canyon, using methods like 3D stream imaging, and drone mapping. This project involved several Southern California researchers and a now UABC-based researcher, Napoleon Gudiño.

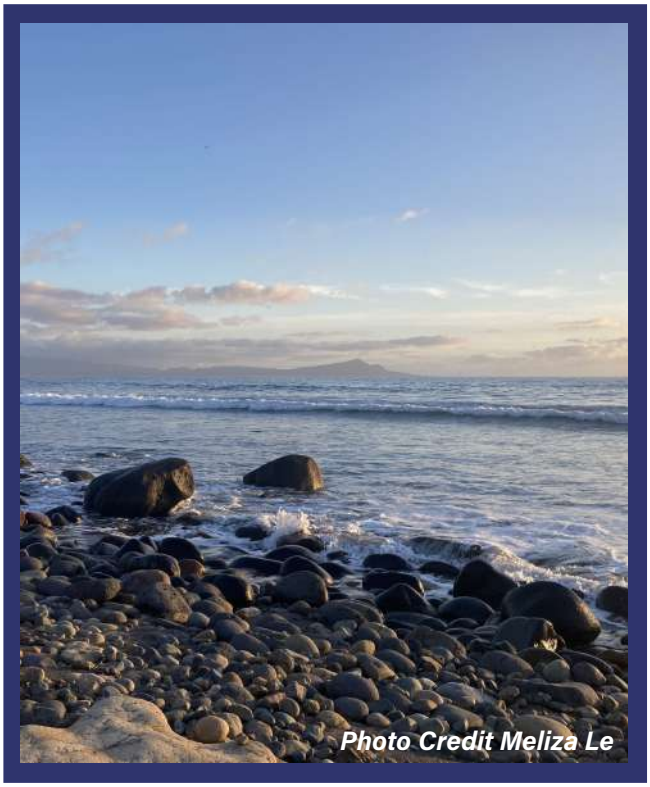

Photo Credit Meliza Le

In the last few years, Baja California and San Diego researchers discussed ways to expand and integrate beach erosion monitoring spanning from San Diego to Ensenada and attempted to secure funding to support this effort but were not successful.

Researchers on both sides of the border also mentioned that they are performing complimentary testing of CoastSnap community photo stations to expand observations of beach change after storms and over time. These efforts provide a timely opportunity to share experiences, and best practices in processing this type of photo data and engaging community citizens in coastal resilience science.

3. Marine ecosystem restoration and monitoring

Within this topic, there is strong recognition that both Baja California and San Diego marine ecosystems are part of an interconnected California Current Marine Ecosystem. Therefore, there are also many common issues of concern for marine ecosystem health, including marine heatwaves, ocean acidification, tropicalization of species, and harmful algal blooms.

Comprehensive monitoring of marine ecosystems, including aspects like oceanographic conditions and climate change (e.g., marine heat waves) and biological indicators (e.g., fish and plankton) is critical for identifying harmful events and cascading effects on fisheries, ecosystem resilience, and marine-dependent industries and workforce.

Ocean Monitoring

California Cooperative Fisheries Investigations and Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE)- Investigaciones Mexicanas de la Corriente de California (IMECOCAL) have been collaborating to establish common monitoring indicators and protocols and share data results for over two decades to shed light on these increasing trends. The focus is on long-term ecosystem health and resilience, and ultimately develop strategies for adaptation to climate change impacts. Capacity for monitoring and collaboration of these programs is highly vulnerable to funding availability; however, relationships between the programs continue to be maintained.

Harmful Algal Blooms

Beyond these existing binational collaborations, we found there were also common programs that have significant alignment and could potentially benefit from a supported initiative to share knowledge, resources, and results. These include the Sistema de Alerta Temprana (SiAT) and the Southern California Coastal Ocean Observing System (SCCOOS) which share a focused alignment in their research, particularly in the areas of marine environmental monitoring and the study of harmful algal blooms (HABs).

Both organizations emphasize the importance of monitoring and early warning systems for HABs, recognizing their significant impact on public health, animal health, and the economy. SiAT, with its pilot program in Baja California, aims to develop a national plan addressing the recurrent HAB issues in the region, while SCCOOS highlights similar concerns through its coverage of events like the massive marine mammal stranding and the potential impacts of oceanic phenomena in Southern California.

Kelp Forest

Kelp forest loss and its cascading effects on biodiversity is a topic of growing alarm on both sides of the border. Both sides are trying to expand monitoring to understand depth of loss, testing various restoration and conservation approaches including implementation of climate-smart marine protected areas, novel reforestation techniques, herbivore removal, and researching kelp survival propensity to various temperature and oceanographic stressors.

In California, scientists from diverse research centers and organizations have been engaged in long-term monitoring of key habitats both inside and outside Marine Protected Areas (MPAs). Similarly, in Baja California, the Monitoring Ecosystems Across the Californias (MexCal) program led by UABC has been conducting long-term monitoring along the Pacific coastline. Last year, the Binational Resilience Initiative funded a partnership between Reefcheck and MexCal to build capacity among commercial and sports divers to preserve and protect the kelp forest.

These academic efforts have expanded to include collaborations with state governments on both sides of the border. In California, these efforts led to the establishment of a statewide Kelp Recovery Research Program, coordinated by California Ocean Protection Council and California Sea Grant in conjunction with the CDFW to address the kelp crisis.

In Baja California, the Frente de Permisionarios Organizados del Sector Social Pesquero de Baja California, AC, a collective of fishing cooperatives, has been crucial in developing strategies for kelp forest recovery. This group of fishermen partnered to initiate pilot reforestation activities and established a connection with Baja California's Secretary of Fisheries to start a state-level plan.

Photo Credit Anahí Bermúdez

Marine Protected Areas

Another collaborative effort, led by Stanford University, University of California, Los Angeles, UABC, the Federation of Fishing Cooperatives of Baja California (FEDECOOP), and Comunidad y Biodiversidad, focuses on identifying climate refugia and supporting resilience in MPAs in Baja California. This project involves a diverse group of researchers from institutions such as CICESE, Universidad Autónoma de Baja California Sur, University of Arizona, and various other research centers and non-profits (Arafeh-Dalmau et al., 2023). Together, they are working to assess climate adaptation and transboundary management for marine protected areas within the California Current system.

4. Community Engagement and Education

The livelihoods of many coastal communities depend on the sustenance provided by the ocean and coast, and these resources, along with their habitats, are subject to existing and future threats, such as school and road closures due to flooding and changes in marine commercial species availability (Cheung & Frölicher, 2020; Bravo & Schmiedeberg, 2024). Responding to these challenges through a multifaceted approach that integrates science, community involvement, and policy advocacy is crucial to enhancing the resilience of these coastal areas. This has gained significant importance in our border region, as evidenced by the numerous projects encountered during the interviews and survey, particularly from non-profits dedicated to social sciences and community engagement.

The Climate Science Alliance is notable for its community-led initiatives focusing on building resilience, capacity, and sustained engagement. These have extended into the border region where they are building local capacities and knowledge. For example, their Binational Working Group hosts regular meetings that highlight research, education, and community action, developed the “Climate Change and the Baja California Peninsula” report (2021), and funded seven small grants for professional development, research, and outreach efforts. While these small grants supported a broad array of partners and projects across the Baja California region, they did include support for coastal resilience knowledge and efforts.

The Climate Science Alliance is also supporting indigenous connections and capacity-building across the border region through their Tribal Working Group. This workgroup hosted several events focused on coastal connections that provided valuable binational indigenous input and insight for this report. Both of these workgroups demonstrate the effectiveness of this model in fostering a sense of ownership and responsibility among community members, encouraging active participation in conservation and resilience-building efforts.

One notable member of the Tribal Working Group is an emerging international grass-roots organization called Tipey Joa Native Warriors. Tipey Joa works with Yuman groups that include the Kumeyaay nation that spans Baja California and San Diego. The mission of Tipey Joa is to promote cultural preservation and social justice in various Indigenous communities. They also encourage the outside community to participate in bringing health and wellness through various programs and cultural events.

The Coastal Training Program at the Tijuana River National Estuarine Research Reserve is another exemplary model for education and capacity building. It offers training in various aspects of coastal management, including stakeholder engagement, science translation, habitat restoration, and climate adaptation.

Entities like the International Community Foundation (ICF) are also instrumental in building capacity and citizen participation. One example of their binational support for community resilience is their partnership with Baja Waterkeepers to protect the 75 watershed ecosystems along the Baja California peninsula through building local awareness by conducting beach cleanups and youth leadership programs.

ICF is also a key partner in the Binational Resilience Initiative (BRI) in partnership with the San Diego Foundation. In 2022 –2023, the BRI program funded a number of additional organizations committed to community engagement and education. These include the Ecofrontera Foundation with Tijuana Calidad de Vida AC who are empowering Tijuana residents through a community-led approach to improving coastal resilience and addressing impacts of rainwater runoff.

Photo Credit Climate Science Alliance

Another grantee is the Permanent Forum of Binational Waters and Proyecto Fronterizo de Educación Ambiental, AC who are generating and disseminating accessible information about coastal water quality and erosion in the San Diego, Tijuana, and Rosarito regions through an open-science and citizen participatory approach.

Additionally, Waste for Life and Centro de Comunidad AC were funded to improve local economies and ecological health by removing plastic from the waste stream, thus reducing plastic pollution in the Tijuana River estuary in the United States. (See Appendix A for a full list of the BRI grantees).

V. Knowledge Gaps, Opportunities, and Priority Needs

A second objective of this assessment was to identify where there are common coastal resilience research needs where strategic investment, capacity building, and knowledge-sharing could contribute to enhancing coastal resilience in the San Diego-Baja California border region. Based on information collected in the interviews, we summarized the science needs and opportunities into several key topics (Table II). We also made an estimate of the level of current binational collaboration (none to high). The list of opportunities and key needs will be shared with the interviewees and other representatives from the region to form the basis for the regional coastal resilience research framework to be completed by December 2024.

Photo Credit Anahí Bermúdez

Table II. Priority coastal resilience topics, level of existing binational collaborations, and binational collaboration enhancement opportunities

Topic	Existing binational collaboration (None, low, medium, high)	Opportunities for Enhancement of Collaboration(None, low, medium, high)
Coastal dunes	**Low**	*Expand data on habitat change and loss *Integrate San Diego -Baja data on habitats and prioritize sites for habitat resilience *Share restoration and nature-based adaptation approaches
Coastal estuaries	**Medium**	*Share trends and data on habitat change and loss *Share innovative methods for low-cost monitoring *Share restoration and adaptation approaches *Prioritize sites for habitat resilience
Coastal hazard predictions	**None**	*Share software and computer processing capabilities for advancing regional models *Share and integrate data *Expand field observations to support regionally down-scaled climate predictions *Support community science monitoring and data compilation
Kelp forest	**Medium**	*Expand canopy loss surveys and data sharing *Support fisheries impact research *Experiment with restoration strategies *Support research on kelp survival to increasing temperature ranges

Topic	Existing binational collaboration (None, low, medium, high)	Opportunities for Enhancement of Collaboration
Technology transfer and innovation	**None-Low**	*Implement additional harmful algal bloom sensors, particularly in Baja *Share experiences and training for using satellite data for coastal, offshore monitoring *Expand capacity and training for drone surveys (coastal and offshore) *Expand testing and use of automated gliders for water quality and ocean health
Ocean acidification, carbon sequestration	**None-Low**	*Expand monitoring of carbon trends in various environments *Share and integrate data on hypoxia trends *Support communication tools for ocean-dependent industries, fisheries and stakeholders
Education	**Medium**	*Share graduate, postdoc, fellowship positions *Support educators, particularly in Baja, with coastal resilience focused activity ideas, materials, supplies *Build career and workforce opportunities through trainings, restoration projects, and research collaborations
Community science	**Medium**	*Expand community engagement in plant, animal, coastal surveys (iNaturalist, Border Bioblitz, CoastSnap, and other networks) *Ehare data and new approaches for community-based monitoring *Share and replicate successful models for training volunteers for kelp, intertidal surveys, beach surveys, etc.
Indigenous engagement, leadership	**Low**	See details below

Indigenous-specific Priorities, Gaps, and Opportunities

The feedback session with Indigenous communities highlighted several critical challenges and needs specifically related to connecting with their ancestral coastal homelands. One of the primary concerns is the highly restricted access to coastal areas, which significantly impacts various traditional practices such as fishing, harvesting, gathering, and conducting ceremonies and cultural events. These activities are integral to maintaining their cultural heritage and connection to sacred sites.

To improve access, several practical measures were suggested. These include providing parking passes for Indigenous people along the coast, facilitating permits for fishing, harvesting, and collection, and incorporating historical context and land acknowledgments in coastal areas. Additionally, ensuring privacy for gatherings and ceremonies is crucial, as is re-learning and strengthening the indigenous relationship with the ocean and its resources.

Looking forward, community members expressed a desire to see projects that reinforce their connection to coastal waters. These projects include research on the significance of coastal waters to Tribes, the ability to teach history, a strong emphasis on the protection of sacred, village, and burial sites along the coast, and passing down traditions to all Tribal members. Innovative ideas like using QR codes for visitors to access language and historical information about the land and coast were proposed.

Resources and Knowledge-sharing Needs

Overcoming the needs and gaps for advancing coastal resilience comes with a number of challenges as interviewees and survey participants noted, spanning funding constraints, policy-making and governance issues, and restricted coastal access (Figure III). Funding struggles, particularly acute in Baja California, are a known barrier so we left this intentionally off our survey to solicit responses other than funding needs.

Stakeholders from various affiliations, including academia, government, NGOs, and local communities, highlighted the need for improved networking and knowledge-sharing. They advocate for the creation of collaborative platforms and forums, which are essential for facilitating resource sharing.

This is particularly important given the wide range of expertise and projects in the region, from coastal erosion studies to wetland restoration and cultural reconnections with the coast. Effective collaboration and networking are not just about connecting experts in sciences; it involves engaging different communities and Tribes and integrating local knowledge in the resilience-building process.

For the border region, important aspects to fostering knowledge-sharing include services to overcome language differences, access and funding capacity to attend meetings, and capacity to receive and manage grant funding.It is noteworthy that some organizations are conducting their work in remote locations, which inherently presents additional challenges in terms of accessibility and resource allocation. This pattern underscores the importance of interdisciplinary collaborations in bridging resource gaps and bringing expertise to diverse and sometimes remote coastal areas, although it also highlights the potential challenges and the need for effective local partnerships.

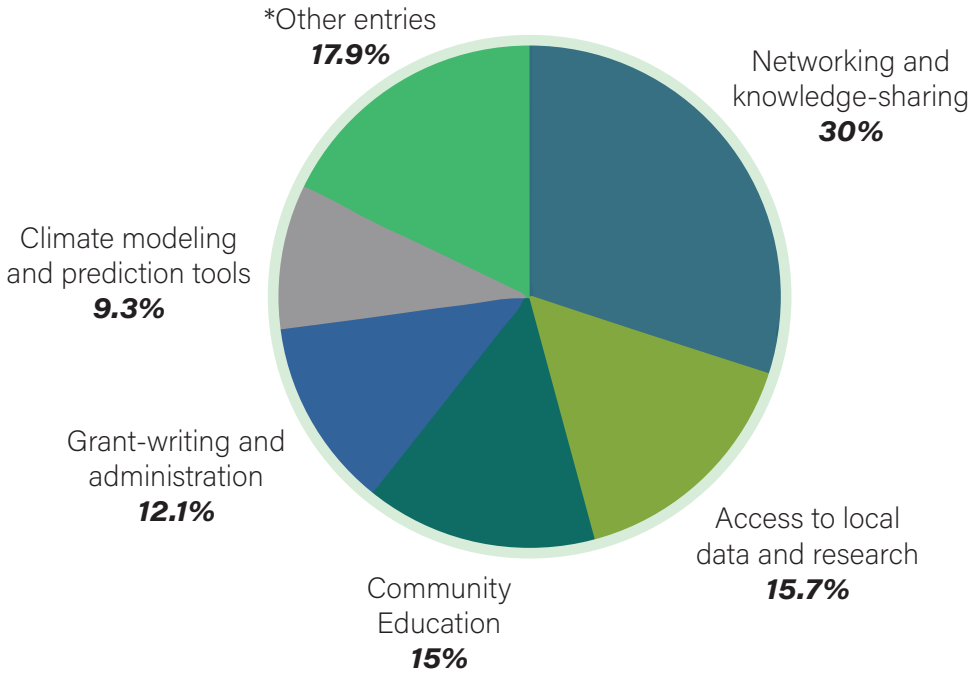

Figure 3. Responses from survey participants about resources to improve coastal resilience efforts in the San Diego - Baja California region. *Other entries included: Directory of collaborators, Equipment and software, and Interdisciplinary workshops.

VI. Next steps

This science needs assessment represents an intentional and timely effort opportunity to develop a binational regional research agenda and collaborative framework to support coastal resilience efforts in the San Diego-Baja California region. In 2024, this assessment will be shared and disseminated to seek feedback and further develop ideas for building San Diego-Baja California coastal resilience science partnerships and capacity. This will occur through more interviews, workshops, and binational events. The project will also explore ideas for reaching a broader constituency of Baja California and San Diego coastal communities, especially those that have historically lacked significant science resources. Finally, the final regional research agenda will identify opportunities for students and community members to engage in science-based learning in their own backyard and contribute to equitable coastal solutions in this region.

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VIII. Appendix

Table A. Binational Resilience Initiative Award winners founded by the San Diego Foundation

Binational Resilience Initiative Award grantees (2022-2023)	Project general objective	Objetivo general del proyecto
Southwest Wetlands Interpretive Association	To improve coastal resilience through nature-based solutions and a pilot infrastructure project in Tijuana, Mexico.	Mejorar la resiliencia costera a través de soluciones basadas en la naturaleza y un proyecto piloto de infraestructura en Tijuana, México.
UCSD – SCRIPPS California Sea Grant	To build science and data collection capacity to support the coastal resilience needs of the San Diego-Baja community.	Desarrollar capacidad científica y de recopilación de datos para apoyar las necesidades de resiliencia costera de la comunidad de San Diego-Baja.
Via International	To strengthen binational, regional leadership by promoting sustainable development in under-resourced communities that are inequitably affected by climate chang.	Fortalecer el liderazgo binacional y regional mediante la promoción del desarrollo sostenible en comunidades de escasos recursos que se ven afectadas de manera desigual por el cambio climático.
WILDCOAST	To reduce plastics pollution in the binational lower Tijuana River watershed.	Reducir la contaminación por plásticos en la cuenca binacional del bajo río Tijuana.
4 Walls International Inc. and Universidad Autonoma de Baja California UABC	To study how an Environmental Impact Bond could address the shared environmental challenges related to pollution in the Tijuana River watershed.	Estudiar cómo un Bono de Impacto Ambiental podría abordar los desafíos ambientales compartidos relacionados con la contaminación en la cuenca del río Tijuana.
American Friends of Promotora De Las Bellas Artes	To support Mainly Mozart and Promotora de las Bellas Artes to develop a program on coastal-environmental education and music workshops for children, and youth from both sides of the border who participate in Mainly Mozart's Youth Orchestra and Chorus.	Apoyar a Mainly Mozart y a la Promotora de las Bellas Artes para desarrollar un programa de educación ambiental-costero y talleres musicales para niños y jóvenes de ambos lados de la frontera que participan en la Orquesta y Coro Juvenil de Mainly Mozart.

VIII. Appendix

Binational Resilience Initiative Award grantees (2022-2023)	Project general objective	Objetivo general del proyecto
Botanical Community Development Initiatives and EcoAlianza de Loreto/CEMA	To document the biodiversity and empower the people of the borderlands as community scientists using the iNaturalist/ Naturalista.	Documentar la biodiversidad y empoderar a la gente de la zona fronteriza como científicos comunitarios utilizando iNaturalist/Naturalista.
Climate Science Alliance and INPACVI AC	To support the network of experts working on the long-term conservation of shorebird species along the Cali-Baja coast and the first binational symposium on coastal resilience.	Apoyar la red de expertos que trabajan en la conservación a largo plazo de especies de aves playeras a lo largo de la costa Cali-Baja y el primer simposio binacional sobre resiliencia costera.
Ecofrontera Foundation and Tijuana Calidad	To empower Tijuana residents to work towards achieving environmental equity for themselves and future generations by focusing on a community-led,three-phase approach to improving climate resilience in vulnerable communities and address the negative impacts of rainwater runoff.	Empoderar a los residentes de Tijuana para lograr la equidad ambiental para ellos y las generaciones futuras, centrándose en un enfoque de tres fases liderado por la comunidad para mejorar la resiliencia climática en comunidades vulnerables y abordar los impactos negativos de la escorrentía de agua de lluvia.
Fleet Science Center and Colectivo Salud y Justicia Ambiental AC	To support environmental awareness and collective action efforts, and produce a museum exhibit that explores the impacts of climate change in the Cali-Baja region.	Apoyar los esfuerzos de acción colectiva y conciencia ambiental, y producir una exhibición para museo que explore los impactos del cambio climático en la región Cali-Baja.
Permanent Forum of Binational Waters and Proyecto Fronterizo de Educación Ambiental AC	To generate and disseminate accessible information about coastal water quality and coastal erosion in the San Diego, Tijuana, and Rosarito regions through an open-science and citizens' participatory approach.	Generar y difundir información accesible sobre la calidad del agua y la erosión costera en las regiones de San Diego, Tijuana y Rosarito a través de un enfoque de ciencia abierta y participación ciudadana.

VIII. Appendix

Binational Resilience Initiative Award grantees (2022-2023)	Project general objective	Objetivo general del proyecto
Reef Check Foundation and ECOCIMATI	To preserve and protect kelp forests along the Cali-Baja coastline.	Preservar y proteger los bosques de algas a lo largo de la costa de Baja California.
San Diego Audubon Society and Conservación de Fauna del Noroeste	To support capacity building and habitat resilience between Mexican and United States nonprofits.	Apoyar el desarrollo de capacidades y la resiliencia del hábitat entre organizaciones sin fines de lucro mexicanas y estadounidenses.
San Diego State University (Universidad Autonoma de Baja California-UABC and Colegio de la Frontera Norte-COLEF)	To help build the coastal resiliency of the San Diego-Tijuana region by conducting a host of binational, collaborative events and activities to start the development of a new coastal and climate resiliency vision for the next 50 years.	Ayudar a construir la resiliencia costera de la región de San Diego-Tijuana mediante la realización de una serie de eventos y actividades binacionales de colaboración para iniciar el desarrollo de una nueva visión de resiliencia costera y climática para los próximos 50 años.
Terra Peninsular and ProEsteros	To support standardized data collection methods to strengthen the conservation of the shared lagoon systems in the United States and Mexico, in partnership with the California Department of Fish and Wildlife.	Apoyar métodos estandarizados de recopilación de datos para fortalecer la conservación de los sistemas de lagunas compartidas en los Estados Unidos y México, en asociación con el Departamento de Pesca y Vida Silvestre de California.