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ADAPTATION PLANNING AND UNDERSTANDING DATA NEEDS IN THE TIJUANA RIVER VALLEY

Tijuana River National Estuarine Research Reserve

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Tijuana River Valley is a sizable, diverse region that contains relatively intact beach, dune, salt marsh, riparian, and upland ecosystems. Despite the threats from development, population growth, erosion, and fragmentation, these habitats have endured for decades and are vital for many organisms and local communities within the Tijuana River Valley. However, the variability and severity of climate change impacts have the ability to affect the long-term health of the ecosystems in the valley. These impacts include sea-level rise, riverine flooding, temperature variations within the estuary, and social and economic responses to these changes. In order to ensure the resiliency and future health of the Tijuana River Valley ecosystems, the Tijuana River National Estuarine Research Reserve (TRNERR) has been tasked with identifying adaptation strategies for the region.

Various monitoring programs exist within the Tijuana River Valley such as measuring river plumes, dissolved oxygen, salinity, and river flow. This data informs management decisions to address a number of issues within the watershed. Although this data is useful to decision-makers and planners, identifying triggers, or environmental thresholds, could streamline this management process in the future. Triggers are pre-negotiated and dictate management strategies once a threshold has been crossed. In addition to improving the efficiency of management efforts and avoiding the lengthy decision-making processes, agreeing on triggers for a specific ecosystem ensures political accountability for the various actors involved (Schultz et al., 2012).

The needs assessment conducted for this capstone indicate that there are currently data gaps and communication inefficiencies within the Tijuana River Valley that impede current monitoring decisions. As a result of these information and communication gaps, managers and researchers have limited capacity to plan for future climate variabilities. Monitoring is essential to filling data gaps and allowing managers to create adaptation plans for ecosystems such as the Tijuana River Estuary. Every needs assessment participant stated that more monitoring needed to be done, whether it is to study human, biotic, or abiotic impacts in the river valley. Understanding how this

research and monitoring informs decision-making is critical for filling data gaps and creating an effective strategy for meeting current and future management goals. One of the key findings from this needs assessment is that many managers and decision-makers do not interact directly with the various sources of data on a regular basis. Instead, these stakeholders receive their data and information once it has already been analyzed or put into a user-friendly format such as a report or a graphical representation. For the most part, the interviewees agree that data presented in a map or other visualization format is more user-friendly and caters to a wider audience rather than just a select few. Continuing this needs assessment with additional interviewees will allow TRNERR staff to have a variety of perspectives on what is currently missing and necessary to create a usable and effective data tool to aid decision-making and planning processes in the region.

INTRODUCTION

Throughout the Tijuana River Valley, various organizations, agencies, and researchers have monitored and managed a number of components to ensure the overall health of the ecosystem. Among the organizations and agencies involved in this collaborative effort are WiLDCOAST, Surfrider Foundation, Tijuana River National Estuarine Research Reserve, San Diego Coastkeeper, City of Imperial Beach, Waterkeeper Alliance, International Boundary and Water Commission, the United States Environmental Protection Agency, the County of San Diego, and the City of San Diego. In addition, scientists and researchers at Scripps Institution of Oceanography (SIO), UC San Diego, and San Diego State University have also contributed a great deal of information and data to understand the watershed and Tijuana River Valley ecosystem better.

Much of the monitoring and research in the region is geared towards understanding the ecosystem's vital signs, including biotic and abiotic factors. This monitoring includes tracking the health of endangered bird species that reside in the estuary and constantly measuring temperature, salinity, and dissolved oxygen within the estuarine waters. Managers, planners, and scientists focus on natural resources, water quality, sediment, flooring, inlet health, public health, public safety, public access, and cultural resources in and around the valley. Water is fundamental to the processes within the ecosystem and to the health of the estuary. This resource is relatively scarce in the region, and clean water is a particular concern for many organizations and agencies surrounding the river valley. Precipitation events in the Tijuana River Watershed lead to runoff containing urban debris, sediments from erosion, and various other pollutants. There is a wide range of contamination sources including industrial waste, agricultural runoff, and faulty wastewater treatment plants. A growing population and increased development have led to a decreased rate of water infiltration into the ground, resulting in these runoff events. During these precipitation events, dated and inadequate wastewater treatment facilities cannot adequately treat the runoff, and this mostly untreated water then enters the estuary and ocean (Safran et al., 2017). Water quality

and resource management is a growing concern as cities continue to expand and industries along the border region flourish, especially when considering outlying communities with even less waste management infrastructure. Pollution and contamination issues create management concerns in the areas of public health, safety, and access. Within the last two years, there have been 320 sewage spills, leading to hundreds of beach closures and an increase in the incidence of waterborne illnesses. The most recent development is the increased risk of illness, injury, and chemical burns for border patrol agents. The types of contamination range from chemical and toxic waste to large debris, and agents at the border work in and around the Tijuana River and Estuary. The impacts of this pollution and poor water quality create concerns for populations within and around the watershed but have a significant effect on flora and fauna in the ecosystem as well. The agricultural, urbanization, and land use changes of the river valley have degraded the estuarine habitat, making it harder for the biology to adapt and survive in a rapidly changing environment (Tijuana River Watershed, 2013).

Habitat fragmentation poses a significant threat for the species that reside in the estuary and nutrient-rich water that enters the estuary during runoff events results in large plumes, which can lead to hypoxia or oxygen-depleted zones (Hypoxia during inlet closing). The plants and primary producers in the estuary and nearby ocean need oxygen to survive, and these nutrient-rich, cloudy waters that are a result of pollution can be harmful to the overall health of the ecosystem (Safran et al., 2017).

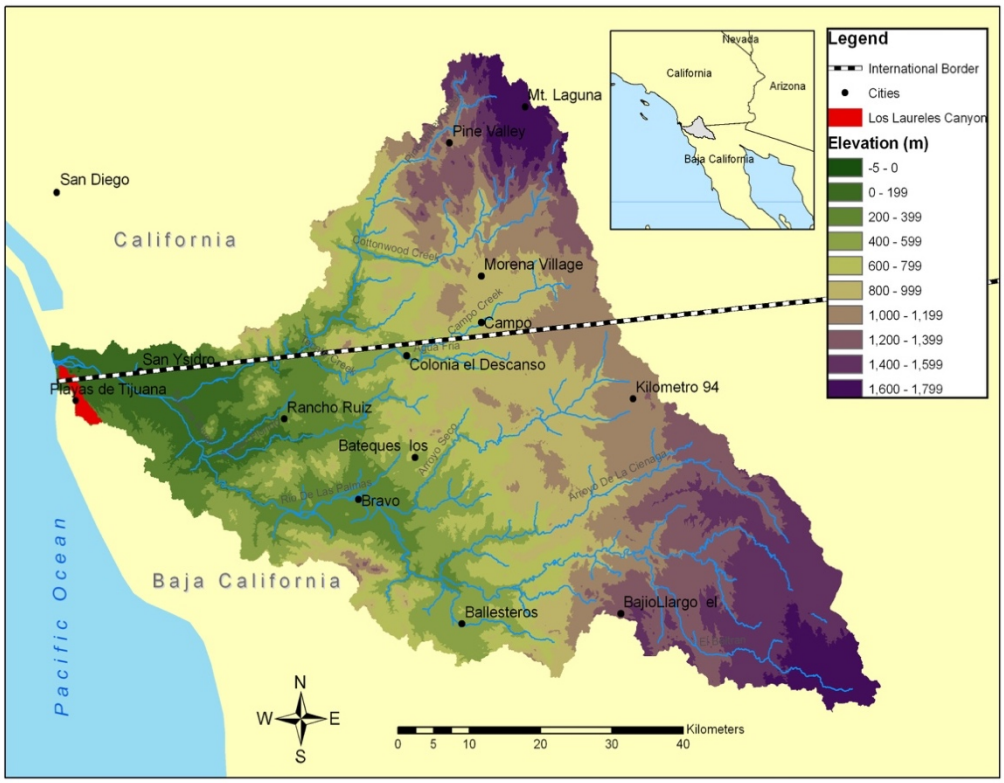
Climate change also poses a significant threat to water resources in the Tijuana River Valley and has the potential to exacerbate existing issues. Scientists expect higher atmosphere and ocean temperatures as a result of climate change. In the shallow estuarine environment, these warmer air and water temperatures threaten species that reside in the region. Climate models suggest that there will be changes in precipitation in the Southwestern portion of North America. It is expected that precipitation will occur in sporadic, more intense events, directly impacting the amount of runoff flowing through the watershed. These precipitation and runoff changes will impact the amount of available water and the quality of the water that is reaching the estuary and adjoining

ocean. The estuary may not have the capacity to filter the increased runoff that may occur in the intense precipitation events, leading to more pollutants reaching the ocean. A rising sea-level, more extreme storm events, and intensified coastal flooding will contribute to increased erosion. A detailed discussion of the expected climate impacts is located in the "Significance of Problem" section.

Many challenges come with managing resources, reducing harm to biology and human populations, and planning for future impacts within and around the Tijuana River Watershed. Future tasks for the Tijuana River region include increasing cooperation between the United States and Mexico, funding larger scale waste reduction and waste processing facilities, educating communities and raising public awareness about the efforts manage water quality, and planning for potential impacts of climate change. As climate change advances, modeling and measured data will need to address this issue. Planners must decide how to prepare for future problems and how to address the additional stressors in and around the watershed ecosystem. Moving to a more preventative approach will enable planners and regulators to prepare for future challenges that may occur in the border region.

This capstone addresses the need for planning for future uncertainties through implementing adaptation plans and understanding the data and information needed to make decisions now and in the future. The following paper will discuss the context surrounding the ecosystem and management challenges in the Tijuana River Valley, the significance of the issues, the literature related to adaptation planning and triggers, the process of conducting a needs assessment, and a summary of the findings from the capstone as a whole.

BACKGROUND



Natural Landscape

The Tijuana River Watershed covers 1,750 square miles in Southern California, Tijuana, and Baja California. Seventy-five percent of the watershed is south of the Mexican border, and the landscape of the watershed is characterized as steep and hilly with a transitional Mediterranean-type climate (Jennings et al., 2018). The region is bordered by a tropical wet-dry climate to the south and a Mediterranean climate to the north (San Diego, California, n.d.). Due to the relatively dry climate of the region, San Diego County only receives an average of 10 inches annually. The watershed acts as a drainage basin and despite the fact that rain is a rare occurrence in the Tijuana River Valley, the hilly terrain contributes to flooding and erosion even during the smallest precipitation events. The four reservoirs in the river valley supply water for human benefits but also act as an obstacle for incoming sediments. Therefore, sands that would naturally flow to the coast are inside blocked by these reservoirs. This, in addition to

urban development and subsequent erosion disrupt, disturb, and displace native estuarine habitats and wildlife. More than half of the basin is 400-1,800 meters above sea-level, and precipitation flows downstream through some of the most densely populated regions in Tijuana. The runoff is carried to the west via the Tijuana River and empties into the Tijuana River Estuary before entering the Pacific Ocean (Tijuana River Watershed, 2013).

Social Landscape

According to the 2015 census, about 1.7 million people live within the Tijuana River watershed region, and about 97% live south of the border. Additionally, San Diego County has an estimated population of 3.3 million in 2015. In total, there are more than 4 million people that live in the border region (Williams, 2005; Jennings et al., 2018). The city of Tijuana is growing at a rapid pace of 400,000 people between 2000 and 2010. The reason for this growth is the movement of Mexican people from the interior of the country to the northern border near California. It is estimated that the population in Tijuana will double in size from 1.2 million in 2000 to 2.4 million in 2030. This will lead to rapid industrialization and urbanization in the Tijuana, Tecate, and San Diego regions. Because of the increased development, there will be a spike in demand for land and natural resources, and populations will continue to expand outward towards the other underdeveloped cities such as Mexicali, Nogales, Laredo, and Naco (Tijuana River Watershed, 2013).

Estuary Importance

Estuaries around the globe serve a variety of purposes. They provide a habitat for coastal populations of flora and fauna and serve as nurseries for a variety of fish populations. Specifically, in the Tijuana River Estuary, the numerous species present are specific to the region. Some of these species are threatened or endangered, and the estuary serves as the last remaining habitat for these plants and animals. Estuaries are beautiful and aesthetically pleasing environments, and the enjoyment and research

benefits that estuaries provide are part of its value to humans. While it is hard to assign a monetary value to the aesthetic and research values that these ecosystems provide, there are certain services that estuaries offer that have a definite economic value. These so-called “ecosystem services” come as a benefit to the human populations surrounding the estuaries. Estuaries serve as a vital carbon sink and sequester 84-233 million tons of carbon from the atmosphere every year, a rate ten times greater than the carbon uptake in the global forests(Coastal Blue Carbon, 2016). They act as natural filters, purifying the polluted and sediment-ridden water that comes from upstream before it reaches the ocean. Estuaries also provide a natural barrier to flooding and sea-level rise. Land directly inland of estuarine systems are protected from wave and storm events which would otherwise put pressure on development and infrastructure (San Diego, 2050 is Calling, 2015). They also provide a natural space for recreation and fishing activities, and fisherman may rely on the biota within these estuaries as their primary source of income. Unfortunately, estuarine environments are threatened by climate change, population growth, and urban runoff, which increase pressure on already vulnerable habitats, such as the Tijuana River Estuary (Basic Information about Estuaries, 2016). These estuaries need to be protected and managed to ensure the health of the ecosystem and prolong the positive ecosystem services they provide to the surrounding human populations.

SIGNIFICANCE OF PROBLEM

The Tijuana River Estuary is the largest coastal wetland in Southern California, and the river valley contains a State Park, National Wildlife Refuge land, and a National Estuarine Research Reserve (NERR). The NERR System contains 29 reserves nationwide and is established by the National Oceanic and Atmospheric Administration to monitor, research, and educate people about estuaries and coastal regions throughout the nation. The Tijuana River NERR (TRNERR), which was established in 1982, "preserves, protects, and manages" both natural and cultural resources in southern San Diego County (Tijuana River Watershed, 2018). The TRNERR faces a multitude of issues including natural resource management, sediment management, public health and safety, wastewater treatment in the waterways, and increasing development pressures. The estuary provides one of the last remaining salt marsh habitats in the region, but over 90% of the wetland habitat has been lost to development projects. To address the many issues in the estuary and watershed now and into the future, researchers and decision-makers are faced with developing and implementing proactive management strategies to ensure the resilience of the river valley.

The variability of future climate predictions and disagreement among models makes it difficult to know the exact sea-level rise, precipitation, and temperature changes that will occur in the region. In the current climate of the San Diego region, summer temperatures in the interior valleys can exceed 95°F (35°C) and coastal temperatures stay below 80°F (26.6°C) for the most part. However, climate models suggest that warming will increase annual average temperatures by 4-9°F by the end of the 21st century. The amount of warming will depend on the extent of greenhouse gas mitigation done to avoid catastrophic climate disruption (Jennings et al., 2018). This warming will, in turn, warn the coastal waters, especially in these shallow estuarine environments (Tijuana River Watershed, 2013). In addition, observations from other regions suggest that warmer overall temperatures will cause local species to shift to higher elevation ranges and poleward latitudes. Climate models predict an increase in the frequency of extreme weather events such as heat waves, which may exceed the tolerance of certain

species in the region. Extreme events may interfere with a species' ability to survive and can ultimately lead to mortality among human, plant, and animal populations.

Thermal expansion of water, which will occur globally as a consequence of warmer ocean temperatures, and land-based glacial melt both contribute to a rising sea-level. Scientists expect sea-levels to rise anywhere between 5 and 24 inches by 2050, but many agree that levels may rise to about 12 inches when compared to sea-level in 2000. The low-lying land in the San Diego region, including the Tijuana River Estuary, will face the most impacts as a result of this sea-level rise. Increased water levels within the estuary will reduce the estuary's filtering and storm-buffering capacities. Storm surges and extreme high tides will accompany this sea-level rise, which will increase coastal flooding and advance beach and bluff erosion (San Diego, 2050 is Calling, 2015).

In San Diego's Mediterranean-type climate, there tremendous precipitation variability between seasons and from one year to the next. The region may experience periods of drought and extraordinarily wet periods, and this variability from one year to the next is higher than any other location in the continental United States (Jennings et al., 2018). Although the annual rainfall average for the region is about 10 inches, the mean annual precipitation ranges from 8-36 inches due to the topographical differences in the region (Jennings et al., 2018; Zedler et al., 1992). Climate models project an overall increase in the number of dry days with more infrequent and intense rain events by the middle of the 21st century. Future temperature and precipitation changes could exacerbate issues in an already dry climate as soils become drier and moisture in the land's surface is lost. In this region, rainfall is already limited, and increasing the time between precipitation events will reduce the availability of water and increase the region's risk to drought and wildfires (Jennings et al., 2018).

Uncertainty among future climate predictions makes it difficult to know the precise temperature, sea-level rise, storm frequency, and precipitation changes that will occur in the region. These changes will have an impact on the estuarine ecosystem, and whether the biology can adapt quickly enough is a primary concern for climate scientists and planners alike (Robinson et al., 2013). These climate uncertainties, in addition to

the unique jurisdictional and geographical considerations of the watershed, make management especially challenging.

For many transboundary rivers such as the Tijuana River, lack of cooperation and political immobility arise from the economic, political, social, and structural differences between the basin countries. Nations within the same watershed may have unique resource demands, rates of population growth, environmental policy, and cultural norms, to name a few (LeMarquand, 1976). Both Mexico and the United States have their own set of actors, including the general public, farmers, and industry, that utilize the river and contribute to the various pollution issues throughout the watershed. Successful cooperation and management between the two boundary countries is challenging, yet not impossible, despite the number of differences the two nations may have. Historically, many decisions concerning resource management and conservation have taken a reactive approach rather than a proactive one. With this approach, only select issues are addressed or resolved at one time. If ecosystems are harmed or degraded enough, there is no guarantee that a reactive approach will restore the environment to its previous state. Management and mitigation measures are costly and may not occur until damages have become irreversible (Sinclair, 1986). Additionally, mitigation and restoration projects do not plan for the future health of the ecosystem. To address future impacts from climate change and potential unintended consequences from various projects in the region, planners and managers are now looking to adaptation planning as a more proactive approach to management.

REVIEW OF LITERATURE & STATEMENT OF PURPOSE

Adaptation planning is a ubiquitous tool used in land management throughout the world. This planning strategy aims to provide a framework of decision-making in instances of considerable uncertainty. Throughout the current literature and plans that implement adaptation strategies, there are a few common themes. The most important component of adaptation planning is the need for flexibility (Haasnoot et al., 2013; Ranger et al., 2013; Schultz et al., 2012). Plans can be created and adjusted over time to meet the changing needs and demands of a particular ecosystem. Multiple authors clarify that adaptive management is not a "trial and error" approach. Instead, it is a method that takes new scientific understandings and information and incorporates those into the existing plans. Much of the literature on this management technique emphasizes the importance of vigilance in addition to this flexibility. Careful and consistent monitoring allows the planners and decision-makers to understand the specific changes happening in an ecosystem. This diligence will be useful in any scenario, whether something requires immediate or future action. Thus, the ability to streamline the decision-making and management process is a common theme throughout adaptation planning. Having a plan in place to guide decisions even when uncertainties exist saves time and resources in the long run.

Throughout the literature on adaptation planning strategies, the use of triggers is a common strategy in the face of "deep" uncertainty (Haasnoot et al., 2013; Ranger et al., 2013). This "deep" uncertainty comes with differing model predictions, variation in distribution and severity of certain impacts, and diverse ideas of what the correct solution to address these impacts would be (Roberts, 2012). Various authors describe the resulting challenges that come with planning for future climate variabilities, and the Tijuana River Estuary is subject to a handful of climate change impacts, as previously discussed. However, triggers, which are defined as environmental thresholds or the point at which intervention occurs, are now used in planning to prepare for significant changes to ecosystems. An agency or regulating body will agree on a variety of triggers and the management actions that will be taken once a certain indicator has occurred. If a

threshold is crossed, regulators automatically have authority to take action or streamline the process of implementing a mitigation strategy. The importance of having these predetermined commitments and management strategies emphasize the common themes of adaptation planning in general. Triggers allow decision-makers and regulators to be flexible, ensure that they are vigilant in their monitoring, and help streamline management processes once a threshold has been crossed (Australia, State of NSW, 2015; Haasnoot et al., 2013; Ranger et al., 2013; Schultz et al., 2012). A common concern in adaptation planning and the flexibility it allows is that agencies are often not held accountable for their management actions. Since, by nature, adaptation planning allows decision-makers to use their discretion in managing an ecosystem, many people often criticize that it is a way for agencies to overlook or postpone mitigation efforts. Proponents of triggers claim that they offer political accountability to the adaptation planning procedure because they require multilateral commitments among the stakeholders involved (Schultz et al., 2012). Whether triggers are legally binding or simply provide a framework for action, they provide a sense of responsibility for any agency utilizing adaptive management strategies. Specifically for the TRNERR, reviewing the literature and existing practices surrounding adaptation planning and triggers in various local governments will help to identify possible triggers for the estuary itself.

The critical component of adaptation planning and creating triggers is constant monitoring. Monitoring allows agencies and organizations to improve their understanding of the dynamics of an ecosystem and enables these entities to respond more effectively and efficiently. Enhancing monitoring efforts and creating a better understanding of how systems will adapt to changes allows managers to adjust current strategies to best fit the needs of the environment (Schultz et al., 2012). Monitoring also creates robust data resources for managers to use to inform decisions they make regarding a particular ecosystem. These data sources provide a foundation for current policy implementation and management decisions, and they also provide a basis for future planning. Managers can examine and compare current and future data trends to determine if preventative measures can be taken to avoid a specific outcome that

happened in the past. The importance of monitoring, understanding what data and information currently exist, and what additional monitoring needs to be done is the driving force behind the needs assessment. Therefore, the needs assessment will be the first step in the adaptation planning process because it creates a framework to steer future data collection, research, and delivery.

In general, a needs assessment is conducted to understand the priorities of an agency or organization and how this influences the way in which an entity makes decisions (Memmott, 2014). For this capstone's needs assessment, the primary goal is to determine how individuals in various roles relating to the Tijuana River Valley use information and data to inform their work. Understanding what information is used and needed in the future will help create an effective adaptation plan for future changes in the river valley. Through a needs assessment, interviewees identify the gaps in data production or where data is not presented in the most comprehensible way. The results of the data assessment inform management decisions and expand the usability and capacity of the current data that is collected at the TRNERR. Keeping in mind the triggers management technique, the questions asked will focus on the connection between what is already monitored and tracked, what is the efficacy of the current data delivery methods, and what decisions are being made with this data. To prepare for future scenarios and adaptive management strategies, the needs assessment will also evaluate what data may be needed for future decision-making, particularly in the context of climate change and sea-level rise.

METHODOLOGY

Reviewing the current literature and understanding the techniques in place for making decisions under deep uncertainty is necessary for planners and decision-makers. During this process of creating an adaptation plan for the future, it is essential to understand the data and information that influence how decisions are made in the Tijuana River Valley. In order to understand how individuals and agencies evaluate data and information, a small-scale needs assessment was conducted as part of this capstone project. The objectives of the assessment are listed below:

- To better understand how monitoring data is currently utilized in decision-making in the Tijuana River Valley to inform future monitoring and communication strategies.
- To identify data/communication gaps that impede effective decision-making in the context of current and future management priorities.

These goals are specified in each survey included in the Appendices and were stated during each interview.

Once the objectives of the needs assessment were established, the next step was to create a list of possible interviewees with a broad range of backgrounds. In order to gain as much insight and knowledge into the various decision-making processes, the interviewees include city, governmental, and nonprofit staff as well as scientists and researchers. Thus far, the needs assessment has included eight interviews with a variety of professionals who interact with data and decision-making within the Tijuana River Valley.

The next step was to establish a list of questions for the needs assessment survey. Overall, the questions were formed to develop an understanding of what data is useful for understanding the potential threats of climate change. Knowing the necessary data and making this information accessible to a variety of stakeholders is the main goal of the TRNERR staff. The list of questions was tailored to fit each group of interviewees- the decision-makers and the researchers. Appendix A includes the survey questions tailored

for the decision-makers in various organizations and agencies. Appendix B includes the list of questions presented to the researchers and scientists.

Danielle Boudreau and Jeff Crooks at the TRNERR developed a list of potential interviewees for the needs assessment. Originally, they developed a list of three different stakeholder groups: Tijuana River Valley decision-makers, Regional Planners, and scientists. Due to time constraints, the interviews were primarily conducted with Tijuana River Valley decision-makers. The first interview was with Chris Peregrin, Manager at the Tijuana River National Estuarine Research Reserve, and he provided feedback regarding the specific questions and subjects for future interviews. With the comments that Chris offered, the questions were altered to remove repetition, encourage concise answers, and shorten the overall interviewing time. The subsequent interviews conducted with:

- Brian Collins, Refuge Manager at the United States Fish and Wildlife Service, San Diego National Wildlife Refuge,
- Paloma Aguirre, Coastal and Marine Director at WiLDCOAST,
- Chris Helmer, Environmental and Natural Resources Director at the City of Imperial Beach,
- Margarita Diaz, Director at Proyecto Fronterizo de Educación Ambiental (PFEA),
- Doug Liden, Environmental Engineer at the United States Environmental Protection Agency,
- Sarah Giddings, Assistant Professor and Researcher at SIO, and
- Keith Kezer, Program Coordinator for the Land and Water Quality Division at the County of San Diego's Department of Environmental Health.

Notes were taken during each interview but will not be disclosed due to the type of information shared during the interviews. Although not all stakeholder groups were interviewed for this capstone, there is now an effective interviewing method in place that can be effortlessly applied to future interviews by the incoming intern at the TRNERR. The needs assessment is the first step to establishing a framework to guide future data collection, research, and delivery.

RESULTS AND DISCUSSION

Among the many interviews conducted during this capstone's needs assessment, a few trends can be found regarding data collection, data communication and current and future data needs. Although each interviewee makes unique decisions or conducts research on a unique management area within the Tijuana River Valley, there were parallels throughout each interview. Firstly, every individual stated that climate change would have an impact on almost every on almost every resource and management area throughout the watershed. Of the management areas listed in Appendix A and B, the cultural resources area was the one area in which the interviewees weren't sure about the impact that climate change would have on management. Natural resources and water impacts were of particular concern to many of the stakeholders, but there was not a consensus about the exact way in which these resources would be affected. As stated above, there are numerous uncertainties about how climate change will impact water resources and sea-level rise-associated impacts. For this reason, it is difficult to know what consequences to expect and how to best plan for the various effects that may result. Thus, the importance of adaptation planning comes into play. Adaptation planning is implemented to meet the needs of a region even when uncertainties exist. Another agreement among the interviewees was that there is never enough data available. While there may be two sources of data for the same type of information, for example, it is still useful to have too much data than not enough. Various agencies and organizations monitor water quality in the Tijuana River estuary, but there are slight differences between each dataset depending on the primary concern of the particular entity. These small variations are useful to decision-makers in the region and allow them to compare similar information for accuracy and to reinforce their reasoning behind specific choices.

One of the most important outcomes of the interviews was learning about the way in which stakeholders interact with data. At the start of the interviewing process, a different interview was crafted depending on the professional role of each participant. The survey created for the Tijuana River Valley decision-makers (Appendix A) included questions about how data informs their decision-making process. These types of

questions were not included on the interviews for the researchers and scientists, however. In creating the survey questions for the scientists, the questions regarding decision-making and the political influence of data were omitted. Based on the assumption that scientists produce data and conduct research to inform influencers and decision-makers, the survey for the scientists (Appendix B) does not include questions about the decision-making process. While creating the survey for decision-makers, the committee did not consider the fact that individuals in this realm may not interact with raw data as previously thought. As interviews with these particular stakeholders continued, it was apparent that decision-makers do not have as much firsthand experience with data as previously thought. Rather, the individuals that make political and management decisions in the river valley often look at data once it has already been analyzed and put into a report or graphical representation. Scientists and data analysts are often hired by organizations and agencies to create clear, simplified reports, maps, or graphs to quickly convey the raw data to decision-makers. Therefore, decision-makers are often removed from the data analysis process, and they are dependent on other people to communicate the data to them effectively and compellingly. Once these stakeholders receive these reports and graphical representations of the data, they can then make rapid and informed management decisions. The difference between decision-makers and scientists and their relationship with data is significant in understanding how information and data are used to influence management decisions.

The way in which information and data is conveyed, whether it is to decision-makers or the general public, influences its effectiveness and usability. Since most decision-makers receive their information and data once it has already been analyzed, they had definite opinions about how the data was communicated to them. Most interviewees who are employed by organizations and agencies prefer visualizations in the form of maps and graphs, whereas the scientist prefers to look at raw data to inform her work. Many of the decision-makers expressed their preference for interactive data visualization tools, such as many of the NOAA mapping tools. Once the data is already analyzed and organized into such visualizations, the decision-making process becomes

streamlined and more efficient. Depending on the management area of each individual, certain data sources are necessary to emphasize the importance of accurately managing that specific area. Data and information are often used to provide the foundation for various projects within organizations and agencies. With data, scientists and decision-makers are able to confirm the need for directing appropriate funding and resources into management and research efforts. Needs assessment participants also mentioned their appreciation for datasets that cater to their individual needs. Data tools that can be individualized to meet a variety of interests and skill-levels allows for flexibility and facilitates the decision-making process. As one interviewee put it, data sources are most useful when the user can take their research as far as they wish. If they only wish to see a map that portrays their desired parameters, they are able to do that. However, if a user wishes to see the raw data that goes into making that visualization, then they can download that data for their own purposes.

Throughout the interviews, a few minor themes became clear about data sources and the meaning of the term "data." A few of the needs assessment participants mentioned the use and importance of having long-term or historical datasets so they can observe trends. These trends can then be used to inform future decisions and can create a better understanding of causal relationships in the estuarine system. The surveys included a list of monitoring data that is currently available for public use. The purpose of including this list was to learn if the participants recognize these sources and to discover information about their usefulness. Two participants did not recognize one of the sources, but for the most part, most of the stakeholders were aware that these datasets existed. This information is useful in determining what datasets are most recognized and familiar to decision-makers and scientists that work in the region. An additional theme that came up in the interviews was the way in which the word "data" was interpreted. In multiple interviews, the participant would immediately associate the word "data" with raw numbers collected from monitoring rather than as any type of informative facts, figures, and documents. Understanding these common themes is vital for learning more about and improving the regional decision-making process.

CONCLUSION

The results of this capstone indicate that, while there is an abundance of data sources and a multitude of data communication methods available for the Tijuana River Valley, there are still gaps that need to be filled in order to create management strategies for the future. In particular, gaps exist in monitoring biotic organisms, recording the types and sources of debris and pollution in the watershed, understanding the dynamics of the shoreline and beach regions, knowing the dynamics of the watershed system as a whole, and understanding how much of the flow from upstream actually reaches the estuary and connecting ocean. There are a few key themes and lessons that can be learned from the results of this capstone's needs assessment. First and foremost, all interviewees agree that climate change will have an impact on the decisions they make and on the research they conduct in the Tijuana River Valley if it hasn't already had an impact. The interviews provided insight into how data is accessed and how often the interviewees interacted with specific data sources. Generally, decision-makers interact with data less than researchers and scientists because many agencies hire data analysts to present the data to policy-makers in a digestible, user-friendly manner. The decision-makers that participated in this needs assessment prefer to use data tools that present information in a graphic of some kind, whether it is through maps, graphs, or interactive visualizations. Knowing this information is imperative for TRNERR staff to create a useful and practical data visualization tool in the future that will be used by decision-makers for management decisions.

Tasks for continuing this needs assessment include having additional interviews with scientists and regional planners to gain an extensive understanding of how a wide variety of stakeholders interact with data and information. Once the TRNERR staff has collected information from a variety of perspectives, then they are one step closer to creating a tool to circulate information to stakeholders effectively. The information and data provided will guide adaptation strategies and plans for the future, including creating triggers for the estuary itself. In addition, collaborating with regional planners, including SANDAG, local cities, and the county in their needs assessments or adaptation

planning efforts will inform best practices for the team at the TRNERR. To improve the usefulness of the needs assessment, future surveys should include social science aspects. It is clear that there are limited data sources on the social science aspects of the river valley and few people know about the sources that do exist. However, incorporating these sources into the surveys and asking interviewees about this aspect may be informative to both the interviewer and the interviewee. Next, future surveys need to include questions about each participant's current efforts to address climate change in their work, their driving forces behind these efforts, and the barriers they have faced in implementing aspects of climate change into their decisions, planning, and research. Going forward, surveys need to gauge current knowledge of the various adaptation strategies and approaches. This will help TRNERR staff learn about what other organizations and agencies are doing to adapt to climate impacts and what needs to be improved in terms of being prepared for temperature and precipitation changes, sea-level rise, and coastal impacts that may result from these changes.

The needs assessment conducted for this capstone project will inform future needs assessment processes as well as inform future monitoring efforts in the Tijuana River Valley. As the TRNERR scientists, planners, and decision-makers create adaptation plans to prepare for future changes that may impact the health of the ecosystem, they need to understand the useful data sources, the data gaps that impede decision-making, and how different stakeholders interact with data sources. Once this is understood, then managers and researchers can collaborate to create adaptation plans that build a resilient and healthy estuarine system that is interconnected to the surrounding communities.

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APPENDICES

Appendix A. Organization/ Agency Survey

Tijuana River Valley Needs Assessment

Understanding how monitoring data informs decision-making

Interview Objectives

- To better understand how monitoring data is currently utilized in decision-making in the Tijuana River Valley to inform future monitoring and communication strategies.
- To identify data/communication gaps that impede effective decision-making in the context of current and future management priorities.

Management Areas

- Natural resource management
- Water quality
- Sediment management
- Flood control
- Inlet management (e.g., open and closed river mouth)
- Public access (trails…)
- Public safety (emergency response)
- Public health (water quality)
- Cultural Resources
- Other management areas

Tijuana River Valley Datasets

- IBWC Tijuana River Flow
- IBWC Spill Notices (email)
- County Beach Report Card
- Water Board-related monitoring (e.g. SWAMP – Surface Water Ambient Monitoring Program)
- Scripps Tijuana River "Plume Tracker"
- Scripps data on wave conditions (CDIP – Coastal Data Information Program)
- TRNERR water quality data (Ph, DO, Temp, water levels)
- NOAA Tide Stations (e.g. Scripps Pier, San Diego Bay Broadway Pier)
- TRNERR weather data
- NOAA National Weather Service weather data
- TRNERR surface elevation tables
- TRNERR vegetation data
- TRNERR's faunal monitoring (birds, fish, invertebrates)
- Other available data

Decisions

1. Based on the provided list of management areas, in which of these areas do you make (or inform) decisions in your work? Please be specific and provide examples.
2. Given the decisions you just outlined, do you expect any of them to be impacted by climate change?

Data

3. Thinking about the decisions you just mentioned, what are the most useful datasets for you in your job? Be specific about sources of data.
    - What is your go-to dataset and why? In other words, is there one dataset that is particularly useful to you?
4. How often do you access the data sources you mentioned in the previous question (daily, weekly, monthly)?
5. Are you aware of redundant datasets or sources of information (e.g. two agencies collecting the same data)?
    - Do you find that useful? Or do they provide conflicting analyses?
6. Looking at the provided list of existing datasets, are there any that you do not recognize or have not used? Or are there datasets missing from the list that you think should be added?
7. What additional monitoring do you think would be useful to collect to improve your ability to make decisions? Think about both current and future conditions (i.e., climate change).

Communication & Access

8. How do you access the different data that you use (online portal, personal correspondence, email, etc.)?
9. Is the process for receiving updates on the data simple and efficient? Do you have suggestions for improving/ simplifying this process of accessing data?
10. Thinking about the various ways in which you access data and have interacted with different data delivery methods, what format do you find most useful and easy to understand (e.g. maps, tables, graphs, or web-based visualization)?
11. What is an example of a dataset that you believe is communicated particularly well? Please explain what sets it apart from other datasets. Feel free to provide an example from outside the TRV.
12. How does your agency/ organization circulate and communicate the data/ information it produces (if any)?

Wrap-up

13. Do you have any other thoughts about how you use data to inform decision-making? Is there anything you would want us to consider as we develop a monitoring strategy for the future?
14. Are there other people you think we should talk to (names and contact information)?

Appendix B. Scientist Survey

Tijuana River Valley Needs Assessment

Understanding how monitoring data informs decision-making

Interview Objectives

- To better understand how monitoring data is currently utilized in decision-making in the Tijuana River Valley to inform future monitoring and communication strategies.
- To identify data/communication gaps that impede effective decision-making in the context of current and future management priorities.

Management Areas

- Natural resource management
- Water quality
- Sediment management
- Flood control
- Inlet management (e.g., open and closed river mouth)
- Public access (trails…)
- Public safety (emergency response)
- Public health (water quality)
- Cultural Resources
- Other management areas

Tijuana River Valley Datasets

- IBWC Tijuana River Flow
- IBWC Spill Notices (email)
- County Beach Report Card
- Water Board-related monitoring (e.g. SWAMP – Surface Water Ambient Monitoring Program)
- Scripps Tijuana River "Plume Tracker"
- Scripps data on wave conditions (CDIP – Coastal Data Information Program)
- TRNERR water quality data (Ph, DO, Temp, water levels)
- NOAA Tide Stations (e.g. Scripps Pier, San Diego Bay Broadway Pier)
- TRNERR weather data
- NOAA National Weather Service weather data
- TRNERR surface elevation tables
- TRNERR vegetation data
- TRNERR's faunal monitoring (birds, fish, invertebrates)
- Other available data

Decisions & Data

1. What research do you conduct in the Tijuana River Valley? If none, what research do you conduct that you think may be applicable to the TRV? Please be specific and provide examples.
2. Given the research you just outlined, does any of it specifically relate to climate change?
3. In what management areas do you think your research is most helpful in informing decision-making? Refer to list of management areas.
4. Are you aware of redundant datasets or sources of information (e.g. two agencies/ organizations collecting the same data)?
   - Do you find that useful? Or do they provide conflicting analyses?
5. Looking at the provided list of existing datasets, are there any that you do not recognize? Or are there datasets missing from the list that you think should be added?
6. What additional monitoring do you think would be useful to collect to improve your ability to inform management or conduct research in the River Valley? Think about both current and future conditions (i.e., climate change).

Communication & Access

7. How often do you share your research and data directly with decision-makers (i.e., managers, planners) in the TRV (daily, weekly, monthly)?
8. How do you share your research and data with decision-makers in the Tijuana River Valley (journal articles, online portal, personal correspondence, email, presentations etc.)?
9. Is the process of sharing your research updates simple and efficient? Do you have suggestions for improving/ simplifying this process of accessing data?
10. Thinking about the various ways in which you access data and have interacted with different data delivery methods, what format do you think is most useful and easy to understand for decision-makers (e.g. maps, tables, graphs, or web-based visualization)?
11. What is an example of a dataset that you believe is communicated particularly well? Please explain what sets it apart from other datasets. Feel free to provide an example from outside the TRV.

Wrap-up

12. Do you have any other thoughts about how data/ research can better inform decision-making? Is there anything you would want us to consider as we develop a monitoring strategy for the future?
13. Are there other people you think we should talk to (names and contact information)?