UNIVERSITY OF CALIFORNIA SAN DIEGO

The Evolution of Sea Turtle Conservation in Mexico: A Literature Perspective

A thesis submitted in partial satisfaction of the requirements for the degree Master of Science

in

Marine Biology

by

Julie Adriana Barrios

Committee in charge:

Octavio Aburto-Oropeza, Chair
Lisa T. Ballance
Carolyn Kurle
Jeffrey A. Seminoff

2020

The Thesis of Julie Adriana Barrios is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Chair

University of California San Diego

2020

DEDICATION

This work is dedicated to my mom and dad. Thank you for all your hard work to provide for me and my siblings and most of all for your love and support. I love you both very much. In addition, thank you to everyone that I have had the privilege to work with and to learn from.

TABLE OF CONTENTS

LIST OF SUPPLEMENTARY FILES

File 1: Database of literature collected for this analysis. The title, authors, and date published is listed on this document; LiteratureDatabase_Barrios_2020.excel

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

I would like to thank Scripps Institution of Oceanography for funding my studies and research project through the SIO MS Research Scholarship 2019, Summer 2019 MS Stipend Program, Fall 2019 TA position under Dr. Lihini Aluwihare and Dr. Michael Landry, and the SIO Travel Grant to the International Sea Turtle Symposium in Cartagena, Colombia 2020. Thank you, Dr. Octavio Aburto, for letting me be part of your laboratory and for pushing me to think. Also, thank you, Dr. Jeff Seminoff, for sharing with me your passion and knowledge of sea turtles and Baja. Thank you to my committee members, Dr. Lisa Balance and Dr. Carolyn Kurle. In addition, I am grateful for the support and encouragement from my labmates. Finally, thank you to Maryana Avagyan Magee from the UC San Diego Library for providing me with scanned documents for this literature collection.

ABSTRACT OF THE THESIS

The Evolution of Sea Turtle Conservation in Mexico: A Literature Perspective

by

Julie Adriana Barrios

Master of Science in Marine Biology

University of California San Diego, 2020

Professor Octavio Aburto-Oropeza, Chair

This study focuses on a historical and literature analysis of sea turtle conservation in Mexico by quantifying conservation efforts based on ten conservation Aichi Biodiversity Targets. Conservation effort was measured by using systematically selected scientific literature published between 1973 and 2018. In addition, a comparison was made on how conservation priorities and effort have shifted over two timeframes (1960 – 1999; 2000 – 2018), representing the beginning of the conservation movement and as well as current conservation views. The results showed that over the last three decades there has been a positive shift in research effort in sustainable marine management and public awareness, as well as protected areas and extinction prevention have continued to be a Very High priority with a High amount of research effort in both conservation timeframes. However, not a lot of research effort has gone into high priority conservation

strategies that pertain to ecosystem and habitat management and climate change mitigation. The majority of the research comes from the northwest region of Mexico, more specifically, Baja California Sur; most likely due to having the longest coastline compared to other states, accessibility to sea turtle, several marine biology research institutions, and community-based conservation groups. Tamaulipas and Oaxaca are two sites that have over six decades of research due to their conservation camps being established in the late 1960s, which has supported the monitoring and collection of long-term nesting data. Overall, because most of the efforts have been centered on one part of the sea turtle's life cycle (the prevention of sea turtle and egg harvest on beaches was banned on 1990), Mexico is not meeting the ten Aichi targets in terms of sea turtle. However, the illegal take of sea turtles and eggs persists in some regions while at the same time there are new challenges and threats that sea turtles are facing at other life stages and habitats, such as environmental degradation, bycatch, pollution, invasive species, and the negative side effects from climate change. This analysis allows for identification of knowledge gaps or imbalance in conservation efforts in Mexico and gives a better picture of which species and locations could benefit from greater financial, scientific, and community support to improve the conservation of sea turtles along the coasts of Mexico.

1. Introduction

Long-lived migratory marine species, such as whales, sea birds, sharks, and sea turtles have been greatly impacted by the increase in human population and fishing pressure (Lewison et al., 2014). Due to their long migrations across the oceans around the world, marine megafauna encounters various anthropogenic threats (Žydelis et al., 2009). These potential threats range from overexploitation, incidental capture, boat strikes, reduction of habitat and food, and more recently pollution and impacts from climate change (Žydelis et al., 2009; Stelfox et al., 2016; Fuentes et al., 2016). One group of animals that has experience major declines in their populations over the last century are sea turtles; although they have had an increase in conservation programs in the last few decades (Dutton et al., 2002; Tapilatu et al., 2013; Mazaris et al., 2017).

Sea turtles have been roaming the oceans for around 110 million years. They not only survived the big asteroid that ended the Cretaceous period, but since then became more diverse and adapted to the new environment (Spotila, 2004). In the last few decades, their populations have been declining and reaching close to extinction levels due to exploitation and indirect threats (Seminoff, 2004; Abreu-Grobois & Plotkin, 2008Mortimer & Donnelly, 2008; Wallace et al., 2013; Bevan et al., 2016; Hart et al., 2019). At the same time, it has been demonstrated that sea turtles have had a cultural, economic, and environmental significance (Marquez, 1976; Campbell, 2003), and numerous populations around the world are recovering from these historic declines

For this study, I want to quantify sea turtle conservation efforts based on how much Mexico is meeting ten Aichi Biodiversity Targets. I expect to see research effort move in the direction of new conservation priorities. As conservation researchers test and learn which conservation strategies are more efficient at recovering ecosystems, more interest and research will follow those ideas. This analysis will be performed by systematically selecting literature that focused on sea turtle research that was done in Mexico. By analyzing the studies that focus on the various factors that are impacting sea turtles, their life history, and conservation programs, I will provide a better picture of how successful the conservation of these species has been.

2. Mexico's Biodiversity

Mexico is known for its natural heritage which include both the terrestrial and aquatic environments. It is also known for its iconic species such as, the grey whale, vaquita, monarch butterfly, jaguar, and leatherback sea turtle, who are also considered endangered or face threats to their populations (Olivera, 2018). In addition, Mexico has 35 World Heritage sites and six of them are natural sites, representing terrestrial and aquatic sanctuaries that protect unique plant and animal species, including those iconic species mentioned earlier (https://whc.unesco.org/en/statesparties/mx). The terrestrial sanctuaries include, The Pinacate and Gran Altar Desert Biosphere Reserve and the Monarch Butterfly Biosphere Reserve designed for the monarchs, *Danaus plexippus*. For the marine sites they are the Whale sanctuary of El Vizcaino Biosphere Reserve in the Baja California Peninsula, which is a very important breeding site for the gray whale, *Eschrichtius robustus*, and the coral reefs in Sian Ka'an Biosphere Reserve in the Caribbean that protects many marine species. Also included are the Islands and Protected areas of the Gulf of California with around 244 islands, islets, and coastal areas providing protection for different habitats within the Gulf of California, and most recently the establishment of the Revillagigedo Archipelago National Park that contributes to the protection of many special species such as sea birds and pelagic marine species (UNESCO, 2018).

The increase in human population, habitat fragmentation, climate change, and human pressure on the environment for fisheries and agriculture has put an extra stressor on the survival of many species. Even with these large protected areas, there is still more to be done especially for those species and habitats that are left unprotected when not inside the managed areas. In a review from the Center for Biological Diversity (Olivera, 2018), it highlights the 10 most iconic endangered species of different ecoregions in Mexico. The purpose of this report was to inform the general public on current potential extinctions and making the issue more real and personal in order to ignite a conservation mindset among the citizens. From the 10-iconic species mentioned, the leatherback sea turtle, *Dermochelys coriacea*. is the only sea turtle species listed. This is a pelagic species whose populations numbers have greatly declined and continues to be impacted by incidental capture in longline and gillnet fisheries in the high seas (Eckart and Sarti, 1997; Lewison et al. 2004). In Mexico, six of the seven species of sea turtle can be found at different life stages either nesting, reproducing, feeding, and migrating in the Pacific and Atlantic coasts (PACE, 2008, 2009, 2011a, 2011b, 2012, 2013) Given that Mexico is known as a sea turtle hotspot and one of the participating nations in the Biological Convention, it gives the nation the opportunity to have a positive impact in the conservation of sea turtles at different life stages and habitats while at the same time achieving their international agreement.

3. Mexican Historical Sea Turtle Conservation Milestones

Historically, researchers in Mexico have been aware of the decline of sea turtle populations and began studying nesting populations since the late 1960s. At the same time, from 1967 – 1968, it was the highest peaks of the industrial take of sea turtles in Mexico (Marquez, 1976). From 1966 – 1967, conservation experimental programs were established on nesting beaches in the Gulf of Mexico and central Pacific; Tamaulipas, Guerrero, Oaxaca, and Jalisco; these programs began recording nesting behavior, female nesting population data, and preventing poaching of sea turtles and eggs on those beaches (Marquez et al., 1990). Some of these experimental conservation programs became long-term programs and continue to monitor and protect sea turtle nesting populations to this day. In the nesting beach of Rancho Nuevo, Tamaulipas, the conservation efforts began in 1966 for the mass nesting or *arribadas* of Kemp's ridley, *Lepidochelys kempii*, and through the 1980s and 1990s the camp expanded to other nearby beaches in order to protect more nests; later it became the first sea turtle sanctuary in Mexico in 1977 (Marquez et al., 1990). In 1978, biologists from the Mexican government agency, Instituto Nacional de Pesca (INP), Rene Marquez and Manuel Sanchez, the Mexican navy, and with collaboration of the United States began protecting the beaches in Tamaulipas with the purpose of relocating nests to protected corrals and approximately 500,000 hatchlings were released that season (Marine Fisheries Review,1988). Another long-term nesting camp that was part of the 1966 – 1967 experimental camps that has been successful and continues to be in place is La Escobilla, Oaxaca where mass nesting events of olive ridleys, *Lepidochelys olivacea*, take place (Marquez et al., 1990). After the establishment of the experimental nesting camps in 1966, additional nesting conservation camps emerged along both oceanic coasts of Mexico and either have been successful in having continuous monitoring and increases in sea turtle population numbers and other camps only lasted a couple seasons most likely due to lack of funding or personnel.

In 1986, sixteen additional sea turtle sanctuaries were declared with the purpose to protect, conserve, and increase population numbers by focusing on hatchling development (Marquez et al., 1990). The president declared a decree in 1990 banning the harvest of sea turtles in all the republic of Mexico (Diario Oficial, 1990) and in this year there were 36 nesting camps nationally with a total of 450 personnel which included civilians and military (Marquez et al., 1990). Additional protection for sea turtles was established in the following years with important legislation that haas focused on bycatch mitigation for sea turtles. In 1993, Turtle Excluder Devices (TEDs) were mandatory for shrimp and trawl boats in the Gulf of Mexico and Mexican Caribbean (NOM-EM-002-PESC-1993) and in 1996 the legislation expanded to the trawl fisheries in the Mexican Pacific including the Gulf of California (NOM-EM-001-PESC-1996). More recently, in order to continue to address and prevent drowning of sea turtles from fishing gear, in 2006 the ban on the use of drift nets was put in place and changing J-hooks for circle hooks was also established (NOM-029-PESC-2006).

It is interesting and impressive that the state of Tamaulipas and Oaxaca which were once areas of intense sea turtle fisheries and egg harvest and in the last multiple decades have shifted towards the conservation of sea turtles. In an analysis by Marquez (1976), during the late 1940s the annual sea turtle catch averaged at 500 tons, doubling in the 1960s, and finally reaching its maximum peak at 14,500 tons in 1968. It is remarkable to see the conservation success in Tamaulipas, Oaxaca, and Michoacán where nesting numbers have increased over the decades of beach patrolling and egg relocation to protective corrals to reduce poaching and mortality of hatchling. Additionally, protection of sea turtles has not only come from conservation camps but also community involvement and education, involving school children to fishers that contribute to sea turtle conservation plans and actions (PACE, 2011b). The Baja California Peninsula, Michoacán, and the Yucatan Peninsula have been regions of high community involvement and non-governmental organizations (PACE, 2009; 2011a; 2011b). However, in some species we continue to see slow population growth numbers or the increase in mortality, mostly on species that have been greatly impacted by incidental capture such as the Leatherback sea turtle, which continues to be the most threatened species (Wallace et al., 2011; Tapilatu et al., 2013). Most recently the high mortality rates of loggerhead sea turtles has sparked negative attention and concern in the Baja California Peninsula Nichols, 2003b; Peckham et al., 2008; PACE, 2011a). Since sea turtles are highly migratory and do not comply to borders, they encounter multiple dangers and are not aware of what areas are meant to be safe and provide protection specifically for them. Lastly, some nesting camps have not been as successful in continuous monitoring and protection and eventually starts to suffer from high levels of poaching and habitat degradation because lack of economic resources and personnel (PACE, 2011a).

4. Evolution of Conservation

Conservation biology has not been constant since the beginning of its origin. The priorities have changed or evolved over time as more knowledge is obtained and conservation biologist better understand how the natural environment functions and adapts to different factors that are causing shifts in the stability of ecosystems and their species. In an analysis by Mace (2014), she uses a framework to discuss the changes of the key ideas in conservation over time. The timeline begins in the 1960s with changing priorities for each decade (Figure 1). In the early times of conservation, the main priority was based on conserving for "esthetic and focusing on single species" and it has recently evolved to a more "holistic" and interconnected system rather than just centered on single species (Vogt et al., 2013). Over time and based on new information for better management the focus has shifted on to entire ecosystems with humans taken into considerations, which has been named ecosystem-based management (McLeod & Leslie, 2009). Most recently the approach to conservation has been from a holistic point of view where biodiversity and human well-being are mutually necessary for the long-term and success of conservation, and where local community involvement are part of the solution not problem

(McLeod & Leslie, 2009; Vogt et al., 2013; Dobson et al., 2013). In the present time biodiversity has become the key focus of modern conservation since it allows for better adaptation and resilience among species, especially as current and near future effects from climate change will impact marine environments (Worm & Lotze, 2009). The importance of preserving biodiversity and better understanding of ecosystem services for human well-being has become main goals in international environmental agreements, such as the Aichi Biodiversity Targets of 2020. As more anthropogenic pressures push ecosystems and human communities to their limits it becomes critical to establish goals where both humans and natural ecosystems can adapt and thrive in this changing world.

5. 2020 Aichi Biodiversity Targets

The tenth conference of the Convention on Biological Diversity Conference took place in Nagoya, Japan in October 2010. Here the involved nations agreed on modifications to the 2011-2020 Strategic Plan for Biodiversity, which included the Aichi Biodiversity Targets. Preceding the conference, varies meetings took place, such as COP-1, the United Nations General Assembly, where there was talk of the importance of biodiversity. Input from nations involved in the Convention on Biological Diversity Conference was also taken into consideration before the draft of the 2011- 2020 Strategic Plan for Biodiversity (CBD, 2017).

This agreement was brought together under the United Nations Convention on Biological Diversity where 194 nations drafted and agreed to meet the 20 targets by the year 2020. These 20 Aichi Biodiversity Targets were known to be “ambitious conservation goals to safeguard global biodiversity” based on five strategic goals (Table 1 & 2). The 20 Aichi Biodiversity Targets are not strict guidelines but instead they should be used as a framework for each nation to create their own national targets for biodiversity. Each country will have a different approach in achieving these 20 targets due to the uniqueness of their ability and main concerns with biodiversity in their nation. Some might prioritize different targets based on their current limitations; these might be based on financial and priority situations.

This plan is based on the concept that biological diversity will reinforce all the benefits that humans obtain from a healthy ecosystem. The ecosystem services that allow for humans to continue to obtain food, live in a healthy and clean environment, and therefor influence positively to their livelihoods at a local level. The plan will benefit those that greatly depend on their natural environment for sustenance and economic stability, which greatly impacts the reduction of poverty levels. The main ideas for this plan are to either stop or reduce human pressures, restore ecosystems, and increase sustainability use of natural resources in order to promote resilience in the ecosystems. In addition, the plan includes the use of policies with implementations, scientific research, making the biodiversity concerns publicly available and part of the common conversations (CBD, 2018).

Part of the convention agreement states that each nation has to develop a National Biodiversity Strategies and Action Plans (NBAPs), Article 6 of the convention. Up to this date, the majority, 191out of 196, of the nations have submitted a NBAPs (CBD, 2020). The NBAPs should include how the nation plans to achieve these 5 goals based on their own national conditions and include their strategy with steps on how they will accomplish the 20 targets (CBD, 2019). Mexico was one of the nations that participated in the Convention in 2010 and on Nov. 3, 2016 they submitted a report on National Biodiversity and the Action Plan. Overall it is an international agreement on the importance of biodiversity and how it will positively impact the health of the environment and survival of the human species in order to coexist sustainably and their resilient to withstand current and not too far away changes and side effects from anthropogenic pressures.

6. Thesis Purpose

The purpose of this study is to better identify and quantify where most the focus of sea turtle scientific knowledge has been in Mexico and to point out patterns in the literature. This type of investigation is beneficial because it will be a way to quantitatively assess the positive sea turtle conservation efforts and expose where there are opportunities for more attention in order to continue protecting sea turtle populations as best as possible in Mexico. In addition, it gives an idea of where Mexico stands in terms of meeting the 2020 Aichi Biodiversity Targets. This study is novel, as it is the first to take the Aichi Biodiversity Targets and used them to assess sea turtle conservation by from the last six decades

METHODS

1. Literature Collection

Two literature databases were used to obtain literature on the topic of sea turtles in Mexico; they were the Aquatic Sciences & Fisheries Abstracts (ASFA) and Web of Science. Two key word search combinations were used for both literature databases. For ASFA and Web of Science the first search was a combination of "sea turtle" and "Mexico" and second combination were "sea turtles" and "Mexico". The time range selected for ASFA was from "anytime" to the year "2018". The "location" was selected to include areas of studies in the country of Mexico. For the ASFA literature database, the first search was selected to include "scholarly Journals" and produced 85 peer-reviewed and 232 non-peer-reviewed articles. Then "Scholarly Journals" was excluded and 5 peer-reviewed and 56 non-peer-reviewed articles were outputted. The same methodology was performed on the "sea turtles" and "Mexico" search on ASFA. When including "Scholarly Journals", 97 peer-reviewed and 151 non-peer-reviewed articles were outputted and when excluding "Scholarly Journals", only 7 peer-reviewed and 32 non-peer-reviewed articles were outputted. For the Web of Science literature database, the time range selected was from 1900 – 2018 and for the "Location" Mexico was selected. The articles obtained from Web of Science were all peer-reviewed, 74 papers where outputted from the search that included "sea turtle" and 103 from "sea turtles".

After generating the six lists of papers from both databases the articles were then analyzed if they were fit for this analysis based on their abstract information. If the paper mainly focused on any sea turtle species in any location in Mexico, it was kept for the analysis. Another way that papers were selected or eliminated was if the paper was already listed in any of the generated. The final number of papers from ASFA were 328 and from the Web of Science were 74. That gave a total of 402 papers that fit the criteria for this analysis. An electronic copy on the papers was obtained or, if it was one of the older documents, then it was scanned and sent to me from the University's journal storage. The total number of papers that I had access to and used for this analysis was 398. The 398 documents were read, and information was extracted from each paper manually. The information consisted of the year it was published, sea turtle species, location with coordinates if possible, origin of the authors and their institutions, and whether the paper focused on any of the ten Aichi Biodiversity targets. The ten Aichi Biodiversity Targets were used to separate the papers into categories and additional data was recorded on the specific topics associated with each Aichi Biodiversity Target. (See attached excel sheet)

2. Literature Review

a. Sea Turtle Species

For this study, the green sea turtle species, *Chelonia mydas*, was split into two sub-species. The sea turtle species was considered the east pacific green, *Chelonia mydas agassizii*, or green sea turtle, *Chelonia mydas mydas*, when described as so in the literature collected or by its geographical description. The east pacific greens were those in the pacific coast of Mexico and the green sea turtles were those inhabiting the Caribbean and Gulf of Mexico waters (Spotila, 2004). The label "sea turtle" was given to those studies that focused on general sea turtle information with no specific species of focus, these types of studies mainly focused on education and outreach about sea turtles with no specific species in mind.

b. Field Site Coordinates:

From the 398 papers sampled, some studies either gave a coordinate of the location, (the start and end of the beach sampled), the name of the site or closest town, or a map without specific geographic coordinates. To make a relative comparison, only one coordinate was recorded for each sample location described. If the start and end of a beach was given, only the first coordinate will be taken into consideration when pooling. If the name of the location was only provided, then the geographic coordinate was estimated by using Google Earth which were based on previously described sites from other studies; therefore, they remain as fixed coordinates for the unknown locations. In some cases, some locations were indeterminable, so they were not part of the pooling.

c. States Representing the Four Mexican Marine Regions

For this analysis, Mexico was divided into four geographic regions: Northwestern Mexico, Mexican Pacific, Mexican Caribbean, and Gulf of Mexico. The states belonging to Northwestern Mexico are Baja California, Baja California Sur, Sonora, and Sinaloa. The Mexican Pacific is composed of Nayarit, Jalisco, Colima, Michoacán, Guerrero, Oaxaca, and Chiapas. The Mexican Caribbean includes Yucatan and Quintana Roo. Lastly, the Gulf of Mexico consists of Tamaulipas, Veracruz, Tabasco, and Campeche.

d. Research Institutions, Government Agencies, and Non-governmental Organizations

The authors' origins were recorded for the analysis' 398 papers. However, the authors with Mexican origin were further explored. The authors were separated into three categories or sectors: research institution, government agency, or non-governmental organizations. It did not matter if the first author was from a foreign country or of Mexican origin; all the authors from all the papers were taken into the pooling if their sector was of Mexican origin. The coordinates for the sectors were estimated based on addresses stated in the literature.

3. Aichi Biodiversity Targets

From the 20 Aichi Biodiversity Targets, ten were chosen because they directly impact the conservation success of sea turtles. These ten Aichi Biodiversity Targets were used as categories for the conservation measurement (Table 3).

a. Conservation Timeframes (1960 – 1999 and 2000 – 2018):

"The Changing Views of Nature and Conservation" framework by Mace (2014) was used as the baseline for determining the conservation priorities of the Aichi Biodiversity Targets over time. I split the framework timeline into two timeframes to understand the views in sea turtle conservation priorities in time. In the two timeframes, the ten Aichi Biodiversity Targets were separated into four categories of conservation priority: Low, Medium, High, and Very High (Table 4).

b. Research Effort and Conservation Priority Shifts

The value of research effort was determined by adding the tallies for each of the ten Aichi Biodiversity Target categories. A paper could fit the category of one target, multiple targets, or none which meant the study focused on something not pertaining to the targets (11th category). These papers focused on the biology, migration, or other type of knowledge of sea turtles. The literature collection was split into two groups: those published before the year 1999 and after 1999. The mean of the eleven categories was calculated in order to make a relative comparison of the research effort. All the values were converted to log scale because of the large differences between the values and for better visualization. Categories that obtained a zero were kept as a zero and not converted to log scale.

RESULTS

1. Literature Review

   a. Papers Over Time with Aichi Biodiversity Targets

The number of papers published has increased over the last six decades with some high peaks whose research topics correspond to at least one of the ten Aichi Biodiversity Targets (Figure 2). There are two peaks in the literature collection over time: in the year 2006 (n=61) and 2008 (n=75). Figure 3, shows which of the ten Aichi Biodiversity Targets were the main research topics of the papers for 2006 and 2008—they were (Target 11) protected areas, (Target 12) extinction prevented, and (Target 1) public awareness. However, (Target 15) ecosystem restoration/resilience and (Target 9) invasive species were research topics that were absent for both years, and only (Target 10) climate change/human pressure was a zero for the year 2008. Table 5 lists Baja California Sur as the state with the most papers published for the years of 2006 (n=22) and 2008 (n=12), followed by Tamaulipas (n=10) (Table 6). For the years of 2006 and 2008 in Baja California Sur, other Aichi target research topics included (Target 6) sustainable marine management, (Target 8) pollution, (Target 10) climate change/human pressure, and (Target 13) genetics, with at least one paper (Table 7). Other research topics in these years were not related to the Aichi Targets (Table 7).

   b. Species by Species

Most of the papers focused on two species: the olive ridley (n= 104) and the east pacific green turtle (n=102). The species with the lowest number of research interest was the leatherback sea turtle, *Dermochelys coriacea*, with 41 papers (Figure 4).

2. Field Sites

a. Distribution of field sites

Figure 5 shows that 24% (n = 94) of the papers come from the state of Baja California Sur. The states following include Tamaulipas (n= 48), Michoacán de Ocampo (n= 42), Quintana Roo (n= 42), and Oaxaca (n= 40). Figure 6 displays the geographic distribution of the top five field site states: representing four distinct bodies of water surrounding Mexico. In figure 7, the two field sites that have been repeatedly used over the years were in Tamaulipas and Oaxaca. Tamaulipas' field site, Rancho Nuevo (23.19625, -97.672930), was used forty times (Figure 2). In Oaxaca, La Escobilla (15.72610, -96.746370) came up in the literature twenty-two times (Figure 2).

b. Aichi Targets with Their Corresponding Field Site Coordinates

Target 1, awareness increase, had the most research effort in Northwestern Mexico with fifty-seven field sites, and with the least amount of effort occurring in the Mexican Caribbean (n=6) and the Gulf of Mexico (n=1) (Figure 8A). For target 11, protected areas, the Mexican Pacific had the greatest number of field sites with 125 coordinate points (Figure 8G). In the Northwestern Mexican region, target 6, sustainable marine management had the most research sites (n=59) compared to the other three regions (Figure 8C). For extinction prevented (Target 12), most of the field sites were in the Mexican Pacific (n=57), followed by the Gulf of Mexico (n=42) and the Mexican Caribbean with 39 field sites (Figure 8H). The Aichi Targets with the fewest research sites were habitat loss reduced (Target 5), ecosystem restoration/resilience (Target 15), and invasive species (Target 9); these targets had 0 – 4 field sites present in the four geographic regions (Figure 8B, 8J, 8E). The rest of the targets had a slightly higher number of field sites in specific regions, such as pollution (Target 8) in Northwestern Mexico (n=21), climate change (Target 10) in the Mexican Caribbean (n=17), and genetics (Target 13) in the Mexican Pacific (n=23) (Figure 8D, 8F, 8I).

3. Research Institutions, Government Agencies, and Non-governmental Organizations Contribution to The Literature

The Mexican research institutions or universities with the highest amount of publications were the Universidad Nacional Autonoma de Mexico (UNAM) in Mexico City with 31 papers, followed by the Instituto de Ciencias del Mar y Limnologia in Mazatlan, Sinaloa (n=30) and Universidad Autonoma de Baja California Sur (UABCS) (n=27)), representing both the Northwestern Mexico and the Mexican Pacific regions (Figure 9). The highest contribution in the literature from government agencies occurred in the Mexican Pacific from CRIP-INAPESCA in Mazanillo, Colima (n=21) and in Mazunte, Oaxaca (n=14) (Figure 10). For the non-governmental organization contribution, Grupo Tortuguero de las Californias in La Paz, Baja California Sur (n=20) in Northwestern Mexico followed by Pronatura Peninsula Yucatan (n=11) in the Mexican Caribbean, had the most literature contribution (Figure 11).

4. Research Effort and Conservation Priority Shift Quadrant

In the 1960 – 1999 timeframe, six Aichi Biodiversity Targets were determined to be a High or Very High conservation priority compared to the current time frame of 2000 – 2018 with the ten targets assigned a High or Very High conservation priority (Table 4). In the pre-1999 timeframe, the High – Very High priority targets with a conservation effort greater than the average log score of 1.01 were protected areas (Target 11) with a log score of 1.66 and extinction prevented (Target 12) with a log score of 1.46 (Figure 12). In addition, public awareness (Target 1) was at the average threshold (Figure 12). When comparing the conservation effort to the post-

1999 timeframe there were two High – Very High priority targets that had a positive shift in conservation effort (Figure 13). The average conservation priority log score increased for the post-1999 timeframe to 1.64, with public awareness (Target 1) shifting over the average threshold with a log score of 1.77 as well as sustainable marine management (Target 6) with a log score of 1.66 (Figure 13). Both protected areas (Target 11) and extinction prevented (Target 12) continued to hold the highest research effort, with a log score of 2.22 and 1.99, respectively (figure 13). In table 8, the number of papers for each target based on their conservation timeframe is listed from highest to lowest. The targets with the lowest research effort were invasive species (Target 9) (n=3) and ecosystem restoration (Target 15) with zero papers in the post-1999 timeframe (Table 8).

DISCUSSION

1. Conservation Priority Shift (1960 – 1999; 2000 – 2018)

Over the last six decades, there has been shifts in conservation priorities and conservation effort (Figure 12 & 13). When using ten Aichi Biodiversity Targets as categories for research topics in sea turtle research in Mexico, four targets stood out as being High conservation priorities and having a High research effort (Figure 13). The target focused on protected areas (Target 11) (Figure 13) had the greatest research effort because most of the sea turtle data collection takes place on actively protected nesting beaches or surrounding areas. Research and data collection is more convenient at nesting beaches due to the sea turtle's unique life history, where only females come out of the water to lay their eggs on sandy beaches of the tropics and subtropics (Probert & Probert, 2017). Sea turtles are known to return to their natal beaches to reproduce and lay eggs, also known as philopatry, by using the earth's magnetic fields as directional guidance (Lohmann et al., 2008). In addition, there are 17 sea turtle sanctuaries since 1986 in Mexico (Marquez et al. 1990) and multiple nesting camps that monitor and protect sea turtles during the nesting seasons, which allow for easier interactions and protection of adult sea turtles and hatchlings by researchers. The target with the second greatest research effort is extinction prevented (Target 12) (Figure 13), which goes hand in hand with protected areas (Target 11). The association between Targets 11 and 12 is predominant in actively protected nesting beaches, where female sea turtles and their eggs are more vulnerable to harvest and predation as they come onshore to the beaches multiple times per season to lay eggs which can be prevented or reduced by establishing actively protected and monitored areas.

However, the protection of the nesting females and hatchlings is one part of different critical life stages in sea turtles. Not much is known about where hatchlings and young sea turtle go during their first years of life, but recent studies have found that juveniles and sub-adult sea turtle populations move into coastal regions where lagoons, estuaries, and mangroves provide food and shelter (Seminoff et al. 2000; Seminoff et al., 2003; Gaus et al., 2011). Other individuals have been found floating in the open ocean on kelp mats where Nichols et al. (2001) documented an east pacific sea turtle displaying this behavior. Some species of sea turtles may embark in long migrations across the ocean to reach their feeding grounds (Probert & Probert, 2017) and will not return to their natal beaches decades later to reproduce until they are sexually mature (Lohmann et al., 2008). The third target with High research effort is public awareness (Target 1) (Figure 13), which plays a big role in integrating sea turtle conservation initiatives and plans with coastal communities that share the natural habitat with sea turtles. Outreach and public communication have been a big push in conservation biology to educate residents on the value of preserving species and the aid of data collection for their community.

The fourth target that barely passed the threshold into the high research effort category was sustainable marine management (Target 6; Figure 13). This is mainly due to the contribution of studies that took place in the Baja California Peninsula pertaining to documentation of incidental capture and mitigation of sea turtles in fisheries, (Figure 8) due to high mortality rates of loggerhead sea turtles, *Caretta caretta*, in the last decades (Nichols, 2003). Although sea turtle harvest is illegal, they continue to be negatively impacted by fisheries, suffering from injuries and drowning in fishing gear being that they are air-breathing marine reptiles. In a global case study, it was estimated that 85,000 individuals were bycaught in longlines, gillnets, and trawls between 1990 – 2008, but probably underestimated by 2 orders of magnitude due to low observations and reporting efforts (Wallace et al. 2010). Overall, the High research effort in these four Aichi Biodiversity Targets demonstrate that Mexico has had a great starting point in the conservation of sea turtles, both by focusing on increasing population numbers since the establishment of nesting camps in the 1960s and by shutting down the sea turtle harvest in 1990; however, other ongoing, unaddressed potential threats have been increasing in the recent decades due to lack of management that directly and indirectly impact the mortality of sea turtles.

The six other Aichi Biodiversity Targets had Low research efforts and all fall under High or Very High conservation priorities (Figure 13). If the research effort were to increase in these targets, it could potentially encompass protection and restoration of critical habitats used by juveniles and adult sea turtles in lagoons, estuaries, coral reefs, as well as the open ocean where the majority of their life is spent and where they encounter numerous threats. By addressing these other Aichi Targets, it would positively impact other marine species that inhabit the different sea turtle habitats—both terrestrial and aquatic environments.

2. Location of High Research

The top five states with the most research papers represent the four main water regions surrounding Mexico: Northwestern Mexico, Mexican Pacific, Mexican Caribbean, and the Gulf of Mexico (Figure 6). The top five states representing four different oceanic regions surrounding Mexico suggests that sea turtle nesting and coastal protection, outreach, and protected areas in these regions have been occurring at some point over the last six decades. However, this protection and monitoring may be beneficial for certain species that nest or inhabit the near shore marine environments in these five states—potentially leaving out other species that might either occasionally or rarely nest on those high research beaches or have a broader marine habitat range.

The state with the greatest research effort is Baja California Sur; potentially due to a strong research institution presence such as UABCS, which has the third highest number of contributions to the literature (n=27) and CIBNOR (n=24) (Figure 9) as well as having non-governmental organization involvement such as Grupo Tortuguero (n=20) (Figure 11). Additionally, Baja California Sur has the longest coastline compared to any other state in Mexico and it is surrounded by critical coastal habitat for juvenile sea turtles. Lagoons, estuaries, and mangroves on the Pacific side of the Baja California Peninsula which function as a refuge for juveniles and sub-adult loggerhead sea turtles (Nichols, 2003; Seminoff et al., 2006) and the east pacific green, olive ridley, and hawksbill, *Eretmochelys imbricate*, sea turtles also utilize the feeding habitats in the Gulf of California (Seminoff et al., 2000; Seminoff et al., 2003; Gaos etl., 2011). Baja California Sur also contributes to two noticeable high peaks in the number of research papers published over time in years 2006 (n= 61) and 2008 (n= 75), figure 2. In a literature analysis performed by the Universidad Autonoma del Carmen in Campeche, Mexico that focused on sea turtle conservation and knowledge in Mexico, concluded that the highest field sites by state, were Quintana Roo followed by Baja California Sur and Yucatan. The results by Cuevas Flores et al. (2019), disagree with our findings given that they did not use a systematic method in the collection of literature and rather requested research studies. However, Cuevas Flores et al. (2019) acknowledges data gaps, specifically from the Mexican Pacific, from states were sea turtle have been documented but did not make it into their literature analysis.

The two most studied field sites in my analysis were, La Escobilla, Oaxaca and Rancho Nuevo, Tamaulipas (Figure 7). These two sites are to long-term conservation sea turtle nesting camps that were established in 1966 (Marquez et al., 1990). La Escobilla beach is one of the major *arribada* (mass nesting) beaches for the olive ridley sea turtle. According to Spotilla (2004), there are ten *arribada* beaches left in the world were synchronize nesting occurs currently. The olive ridley sea turtle was once one of the main turtles harvested in Mexico;

representing almost 90% of the nation's production of sea turtles, where cooperatives had a quota of 23,000 – 24,000 in 1987, and the sea turtle slaughterhouse ran an incubation program (PACE, 2012a; Marine Fisheries Review, 1988). Unfortunately, their unique characteristic of mass nesting, *arribada,* made olive ridleys more vulnerable and an easy target for mass exploitation, whose impacts on the population can be observed even decades later in various nesting beaches. One of these nesting sites is Mismaloya beach in the state of Jalisco were the number of nesting females dropped from being between 20,000 and 30,000 in the 1970s (PACE, 2012a) to 800 individuals in 2004 (Castellanos Michel et al. 2004). However in La Escobilla, Oaxaca there have been observations of 450,000 nesting females (Spotilla, 2004) and during an at-sea population study off the eastern Tropical Pacific an averaged of at least 1.39 million male and female individuals were estimated in a five years between 1988 – 2006 (Eguchi et al., 2007).

The beach of Rancho Nuevo, Tamaulipas is one of the main nesting beaches for the quasi-endemic, Kemp's ridley sea turtle, with estimates of 90% of its global nesting centered in this region (PACE, 2013). During the different stages of the Kemp's ridley's life cycle it can be found in the Gulf of Mexico and either migrating in two directions; to the southeastern regions of the United States in the Atlantic Ocean and following the Gulf Stream up to the state of Massachusetts or moving south into the Yucatan Peninsula (Dutton et al., 2002; Spotila, 2004). The Kemp's ridley also engages in mass nesting events, similarly to the olive ridley sea turtle, and in 1940s the first documentation of an *arribada* was filmed by Andres Herrera with estimations of 40,000 nesting females (PACE, 2013). The nesting conservation camp in Rancho Nuevo is known as a conservation success story because of the binational collaboration between the Mexican and American government agencies that began in 1977 with the MEX-US Gulf Program in order to manage and prevent the extinction of Kemp's ridley (Dutton et al., 2002).

The management plan consisted of protecting the nesting area with military presence and relocation of nests to corrals with the purpose of increasing hatchling development rates (Dutton et al., 2002). In addition, since 1993 (NOM-EM-002-PESC-1993) it is required for trawling and shrimp boats to use Turtle Excluder Devices (TEDs), in addition to temporal closures to prevent sea turtle mortality from fishing gear (Dutton et al., 2002). With binational conservation programs and bycatch mitigation over the decades there has been ups and downs in nesting population numbers; for example in 2003 there were 5,373 nests (Marquez et al., 2005) and in 2009, 20,00 nests were documented, then dropping to 15,000 nests the following year in Tamaulipas (PACE, 2013). The observations of low population numbers and delayed effects from intense harvest, even after decades of protection, demonstrate that the recovery for these long-lived species will be gradual and will require years for noticeable positive changes as mentioned by Dutton et al. (2002). Based on increases in populations from recent data collected it is possible.

3. Aichi Biodiversity Target Distribution

   a. Mexican Pacific

The geographic distribution of the ten Aichi Biodiversity Targets was analyzed based on the four geographic regions in Mexico that were mentioned previously. The Mexican Pacific region had the greatest number of field sites focusing on protected areas (Target 11) and extinction prevented (Target 12) (Figure 8G & 8H), which is linked to sea turtles nesting along the coast of the seven states and ten of the 17 sea turtle sanctuaries present in this region. Within the protected nesting beaches is where most of the female sea turtles and their hatchlings are being protected from poaching and predation. In addition, Target 13, which focuses on genetics was mostly present in this region perhaps due to the accessibility to sampling nesting females during the nesting season. It is also in the Mexican Pacific where most of the government agencies' contribution to the literature took place, with CRIP-INAPESCA in the states of Colima and Oaxaca (Figure 10), where they support conservation camps and data collection.

As mentioned earlier, the state of Oaxaca has a long-term nesting camp focused on the olive ridley sea turtles and the state of Michoacán has also had a grand contribution to sea turtle conservation, with twenty-three nesting camps and seven of those focused on the east pacific green turtle population since 1978 (PACE, 2011b). Major nesting beaches for the east pacific green sea turtles occur in Colola and Maruata, Michoacán. In a small scale literature analysis by Cuevas Flores et al. (2019), the green sea turtle and olive ridley were the species with the most studies, which is similar to my results of the olive ridley having the highest number of studies followed by the east pacific green sea turtle (Figure 4). If I were to consider the two sub-species of green sea turtles one species, then my results would have agreed with Cuevas Flores et al. (2019). The east pacific sea turtle and olive ridley have the greatest number of papers, potentially due accessibility to their nesting beaches and feeding habitats; the nesting beaches are either monitored during nesting seasons, or part of the sea turtle sanctuary system along the Pacific Coast of Mexico (Marquez et al., 1990), and their coastal feeding habitats that are in the Gulf of California region (Seminoff et al., 2000; Seminoff et al., 2003; Gaos etl., 2011) .

b. Northwestern Mexico

Public Awareness (Target 1) and sustainable marine management (Target 6) have the greatest number of field sites distributed along the Northwestern Mexican coast (Figure 8A & 8C). The most involved non-governmental organization within the literature analyzed was Grupo Tortuguero de las Californias from La Paz, Baja California Sur (Figure 11). Grupo Tortuguero has been a successful conservation model for collaboration between academia, communities, and government bodies that facilitate knowledge exchange from a "non-traditional" approach in conservation (Pesenti et al., 2008). Sustainable marine management studies (Target 6) have also been mainly occurring in the Northwestern Mexican coast; most recently due to the documentation of high mortality rates of loggerhead sea turtles in the western coast of Baja California Sur, where this population originates from their natal beaches in the Japanese Archipelago (Bowen et al., 1995). In 1997, a high mortality of the population in the Baja California Peninsula became visible when sea turtle carcasses began washing up on Lázaro beach, between López Mateos y Punta San Lázaro in Baja California Sur (PACE, 2011a). The following years the number of sea turtle strandings along the beach continued to rise, and later associated with incidental captures from the local fisheries in that region (Nichols, 2003b).

To better understand the situation and reduce the bycatch level in this region, Proyecto Caguama started surveying Lázaro beach (PACE, 2011a). In a study by Peckham et al. (2008) it was determined that between years 2003 – 2007, about 477 carcasses were washing up on the beach every year in the 43 km shore line; that is about one turtle every four kilometers per day during the summer fishing season. In addition, the project placed tags on 30 loggerheads and concluded that sea turtle clustering areas coincided with floating fishing nets (Peckham et al., 2007) and aerial-surveys carried out in 2005 – 2007 also confirmed the interactions (Seminoff et al., 2014). In the same study by Peckham et al (2008) in 2005 and 2006 the bycatch mortality was estimated to be between 1,500 to 2,950 individuals based on observations from 2 bottom-set gillnet fishing fleets. Based on these recent documentations, it highlights the elevated mortality rate of juvenile and sub-adult loggerheads in coastal areas where small scale fishing takes place. Another aspect of studies focused on bycatch are on reducing the incidental capture by testing fishing gear, quantifying catches, and understanding community perspectives on the consumption and protection of sea turtles. In addition, pollution (Target 8) was predominantly present in Northwestern Mexico (Figure 8), which was unexpected since the Gulf of Mexico and Mexican Caribbean coasts are areas of oil exploration, which may negatively impact marine wildlife when oil spills occur. The most recent major oil spill was in 2010, when the Deepwater Horizon oil spill impacted the nesting population of Kemp's ridleys in the Gulf of Mexico (Gallaway et al., 2016).

c. Mexican Caribbean

Even though, not a lot of focus has been on climate change and human pressure, most of the studies were in the Mexican Caribbean coast (Figure 8F). Climate change is predicted to impact the timing and intensity of hurricanes (Michener et al., 1997; Lugo, 2000) which will influence the beach composition, as well as hatchling development and survival, putting the nesting habitat of the species in this area at risk. On the other hand, the Mexican Caribbean is a paradise destination with a growing hospitality and tourism industry, which leads to modification of beach dunes and coral reefs, buildings, and artificial lighting which may lead to preventing nesting, reduces hatching survival, and potentially destroy feeding habitats of sea turtles in the region. In a case study by Oliver de la Esperanza et al. (2016) beach obstruction, human presence, and artificial lighting negatively impacted the nesting selection by loggerhead females and the hatchling survival in the "eco-hotel" region of Kanzul beach in Tulum, Quintana Roo.

In the state of Quintana Roo there are eight index nesting beaches which have long-term monitoring since 1989 (PACE, 2011a), In the mid-1990s there were between 1,331 and 2,166 nests per year in Quintana Roo (Zurita et al, 1993), making it one of the critical nesting habitats for loggerhead sea turtle population in Mexico. Unfortunately, other nesting beaches have not had the constant data collection or supervision due to shortages in economic resources, distribution of information, or lack commitment to the long-term agreements (PACE, 2011a). Over the years the nesting populations of loggerhead sea turtles have experienced declines, most noticeable between 1995 and 2006 (PACE, 2011a). The nesting population in the Mexican Caribbean of loggerhead, green, and hawksbill sea turtles are impacted by egg poaching and incidental capture from fisheries (PACE, 2009; 2011a; 2001b). Unfortunately, in the state of Quintana Roo, the most poaching occurs inside protected areas, such as in Sian Ka´an Biosphere Reserve, Tulum National Park, and Cozumel Reefs National Park, due to lack of personnel for monitoring and protection (Salazar-Vallejo et al., 1992). The green sea turtle nesting protection programs also initiated in the 1980s in Campeche and Yucatan, extending monitoring in Gulf of Mexico, in Tamaulipas and Veracruz, and the most recent time in state of Quintana Roo (PACE, 2011b). The green sea turtle has a serrated lower jaw which is a specialized adaptation for cutting sea grasses and algae (PACE, 2011b), however their diet also includes invertebrates species such as some medusas, sponges, and tunicates (Seminoff et al., 2002), occupying an ecological niche. In Mexico, this species is considered in danger of extinction, NOM-059-SEMARNAT-2010.

Another sea turtle species that inhabits the Mexican Caribbean and has experience extreme declines in their global population is the hawksbill sea turtle (Amorocho, 1999; Wallace et al., 2011). In Mexico, they are considered a species “in danger of extinction” under the NOM-059-SEMARNAT-2001. The hawksbill is known for its unique shell pattern and coloration, know as tortoiseshell, which is harvested and carved into jewelry and other accessories (Groombridge & Luxmoore 1989), which has driven the high direct harvest of this species. Along the eastern coast of Mexico there have been long-term conservation programs as well; the Yucatan peninsula has more than 20 years collecting data and observing increasing and decreasing trends in population over the years (PACE, 2009). The program with the most uninterrupted data is in the islands of the Coral Reef National Park of Veracruz, in Veracruz (PACE, 2009). The hawksbill has a very specialized diet consisting of sponges and other invertebrates; it can be considered to have an ecological control function in the coral reefs and hard-bottom habitats, by limiting the sponge populations and allowing other species to attach and successfully survive (Gulko and Eckert, 2004; McClenachan et al., 2006).

It is important to note that habitat loss reduced (Target 5), ecosystem restoration/resilience (Target 15), and invasive species (Target 9) had the lowest number of field sites or none at all (Figure 8B, 8E & 8J). The Aichi Biodiversity Targets that are associated with preventing and restoring environmental degradation can be more difficult to achieve being that it requires more financial and personnel support, as well as collaboration between the different sectors utilizing the habitat.

4. Low Research Effort Species

The least studied species in the literature analysis by Cuevas Flores et al. (2019) were the leatherback and Kemp's ridley sea turtles, which would have agreed with my analysis, if I were to consider the green sea turtle as a single species (Figure 4). In my analysis the hawksbill, green, and leatherback sea turtles were the species with the least amount of focus, even to the general sea turtle (Figure 4). In an global analysis by Wallace et al. (2011), it was concluded that the hawksbill and leatherback sea turtle received a High Risk- High Threat score in the East Pacific Ocean, warranting more interest in research and protection of this species in Mexico. Potential reasons for the low research effort of leatherback sea turtles in Mexico may be due to low population number and lack of accessibility to the species in the natural environment.

In Mexico, the leatherbacks suffered an immense egg harvest pressure and at some beaches the take or harvest reached 100% with observations of a 95% reduction in nesting populations in 1980s and 1990s (PACE, 2008). In the 1970s it was the first time the main nesting beaches for leatherback sea turtles in the Mexican Pacific were registered; they included Tierra Colorada, Guerrero; San Juan Chacahua, Oaxaca; and Mexiquillo, Michoacán (Márquez et al., 1981). Other nesting beaches are in Cahuitán and Barra de la Cruz in the state of Oaxaca (PACE, 2008). Unfortunately, compared to the other sea turtle species the leatherback hatchling development success is commonly lower (Sarti et al., 2007). Conservation nesting projects were established, and the most uninterrupted database is in Mexiquillo, Michoacán which began its conservation program in 1982 (PACE, 2008).

In 1995, the conservation project expanded to other primary and secondary nesting beaches, with 85% of the nesting occurring in the main beaches (PACE, 2008). In addition, the Proyecto Laúd was responsible for the population monitoring program which systemized the data collection methods on the beaches, while integrated metal and electronic tags, and working with the community in the conservation plans (Sarti et al., 2007). The most intense decline was experienced in the 2002 – 2003 nesting season; where only 120 nests were documented; (Sarti et al., 2007). In 2003, a tri-state convention was signed by the governors of Michoacán, Guerrero, and Oaxaca with the purpose of forming a collaborate effort founded on scientific data and with respect to socioeconomics, culture, and local environment for the conservation of the leatherback population and its habitat (Sarti et al., 2007; PACE 2008). Unfortunately, the leatherback population continues to decline even after decades of conservation initiatives and plans, and it is important to know about the leatherback's unique biological characteristic and evolutionary lineage to better understand and associate the causes of the population decline.

The leatherback sea turtle, as described in its name, does not have a hard shell as the rest of the sea turtle species. Instead, they possess a “mosaic of small dermic bones” and their skin is smooth and leathery, which allows it to be more flexible; each individual has a unique identification marker, a pink spot on the top of their head (PACE, 2008). Leatherback sea turtles are deep divers compared to the other hard-shell turtles, and have an adaption to colder temperatures by having a subepidermal fat layer and artery-vein countercurrent systems—allowing them to maintain their body temperature 18 degrees Celsius above ocean water temperature (Bostrom et al., 2010; PACE, 2008). As adults they embark on long migrations both vertically and horizontally across ocean basins in order to feed on medusas, salps, and other hydroids as well as fishes; however, not much is known about the post-hatchling and juvenile feeding and development habitats (PACE, 2008). Unfortunately, their population decline has been correlated with the increase in the sword fishing with longline and gillnet fishery off the coasts of Peru (Eckert y Sarti, 1997). Furthermore, as the most pelagic species of all the sea turtles, the data collection and monitoring may be more challenging and less accessible compared to other species that stay closer to shore during their migrations. In addition, the leatherback interactions with fisheries occur further offshore may go unnoticed or unrecorded, which may lead to direct harvest for illegal consumption or shark bait (PACE, 2008).

CONCLUSION

In this study, I analyzed the sea turtle conservation research effort over the last six decades in Mexico based on ten 2020 Aichi Biodiversity Targets. I used a systematic literature collection to analyze shifts in conservation priorities over time based on the ten categories. After categorizing 398 papers from field sites all over Mexico that focused on any of the six species of sea turtles; the analysis concluded that the highest research efforts have been centered on protected areas, extinction prevented, public awareness, and sustainable marine management. Other studies suggest that sea turtle nesting camps are a good starting point for conservation and preventing extinction of nesting females and hatchlings, because it increases the population input by protecting hatchling, which is one of the critical parts of their life cycle (Dutton et al., 2002).

Long-term conservation camps have been critical for collecting long-term data and active protecting the beaches from poaching and predation since 1966; in addition, since 1986, there are a total of seventeen sea turtle sanctuaries. Furthermore, outreach and conservation plans that include input from fishing and coastal communities has been a direct way to share the responsibility of sea turtle conservation, and not isolating conservation biologist to achieve this task on their own. The increase in sustainable marine management has been mostly due to the growing interest in quantifying and managing high-level mortality numbers of loggerhead sea turtles in the Baja California Peninsula. Due to only using two literature search engines for papers published up to the year 2018 and the time it takes to publish studies, there could be more research effort in other categories that had a lower score in the more recent years that was not documented in this analysis.

Over the last six decades there has been an increase in research interest in sea turtles more noticeably since the year 1990, when the presidential ban on sea turtle harvest was declared

(Figure 2). Following the ban, over the next decades bycatch prevention legislation regarding fishing gear and temporal-spatial closures, as well as conservation plan implementation arised (Figure 2). A big part of the research interest and effort has been based on the accessibility to sea turtle species and resources, such as research institutions focused on marine biology like the UABCS, government agencies (INAPESCA) providing resources and project planning, and non-governmental organizations, such as Grupo Tortuguero who have worked to establish connections between scientific data collection and the communities whose livelihood depend on the marine environment (Figure 9, 10 &11). Regardless, this study demonstrates that Mexico is not meeting the ten 2020 Aichi Biodiversity Targets in terms of sea turtle conservation; more effort should focus on conservation mitigation in other critical life stages, such as the juveniles and adults in coastal areas and in the open ocean whose habitats overlap with the fisheries, such as the leatherback sea turtle (Eckert and Sarti, 1997; Wallace et al., 2011). In addition, increase research effort and interest in other regions of Mexico that may be understudied based on the distribution of the Aichi Biodiversity Targets analysis performed in this study. Furthermore, it is time to invest in understanding and prevention of the degradation of the different critical habitats that are used throughout the different stages of sea turtle's life cycle. In addition, focus on restoration, invasive species, anthropogenic pressures, and climate change in order to preserve and increase biodiversity in these different critical habitats. The increase in biodiversity will have a positive impact in the survival and resilience of sea turtles and other neighboring species, as well continue to provide natural services for coastal human populations.

APPENDIX

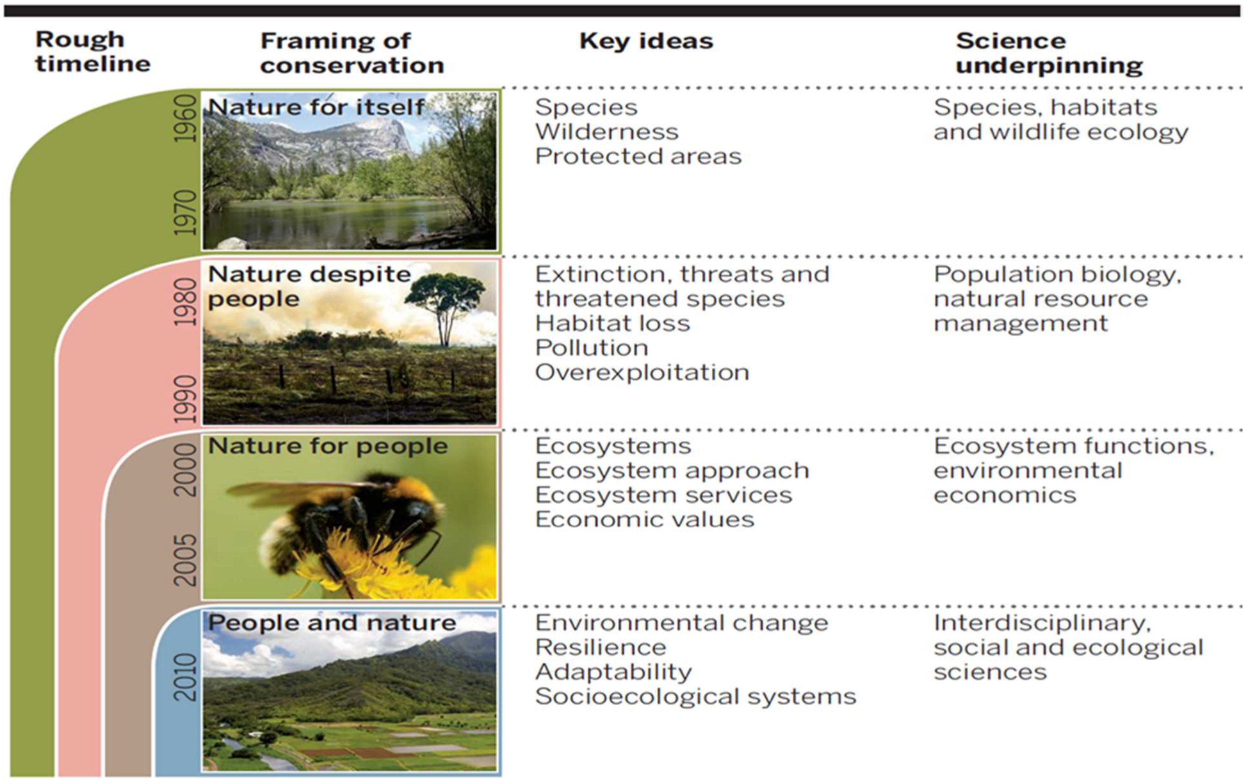


Figure 1: The Evolution of Conservation. Framework is from Mace's (2014) article on perspectives in conservation over time. This concept of changes in conservation was used for labeling the conservation priority of the ten Aichi Biodiversity Targets over two timeframes.

Table 1: The Five Strategic Goals Established by the Convention on Biological Diversity Conference. These goals five goals were the main ideas behind the 20 Aichi Biodiversity Target.

Strategic Goal A:	Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society
Strategic Goal B:	Reduce the direct pressures on biodiversity and promote sustainable use
Strategic Goal C:	To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity
Strategic Goal D:	Enhance the benefits to all from biodiversity and ecosystem services
Strategic Goal E:	Enhance implementation through participatory planning, knowledge management and capacity building

Table2: The Five Diversity Conservation Goals with Their Corresponding Aichi Biodiversity Targets. Each Aichi Biodiversity Target is listed with its objected established by the United Nations Convention on Biological Diversity. Ten targets were not used for this analysis because they did not directly impact sea turtle populations and they had a focus on human well-being and livelihood.

Goal A	Target 1	By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.
	Target 2	By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.
	Target 3	By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio economic conditions.
	Target 4	By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.
Goal B	Target 5	By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.
	Target 6	By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits
	Target 7	By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity
	Target 8	By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity
	Target 9	By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.
	Target 10	By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.
Goal C	Target 11	By 2020, at least 17 percent of terrestrial and inland water, and 10 percent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes
	Target 12	By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.
	Target 13	By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.
Goal D	Target 14	By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.
	Target 15	By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification
	Target 16	By 2015, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.

Table 2, Continued: The Five Diversity Conservation Goals with Their Corresponding Aichi Biodiversity Targets.

Goal E	Target 17	By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.
	Target 18	By 2020, the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels
	Target 19	By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.
	Target 20	By 2020, at the latest, the mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011-2020 from all sources, and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization, should increase substantially from the current levels. This target will be subject to changes contingent to resource needs assessments to be developed and reported by Parties.

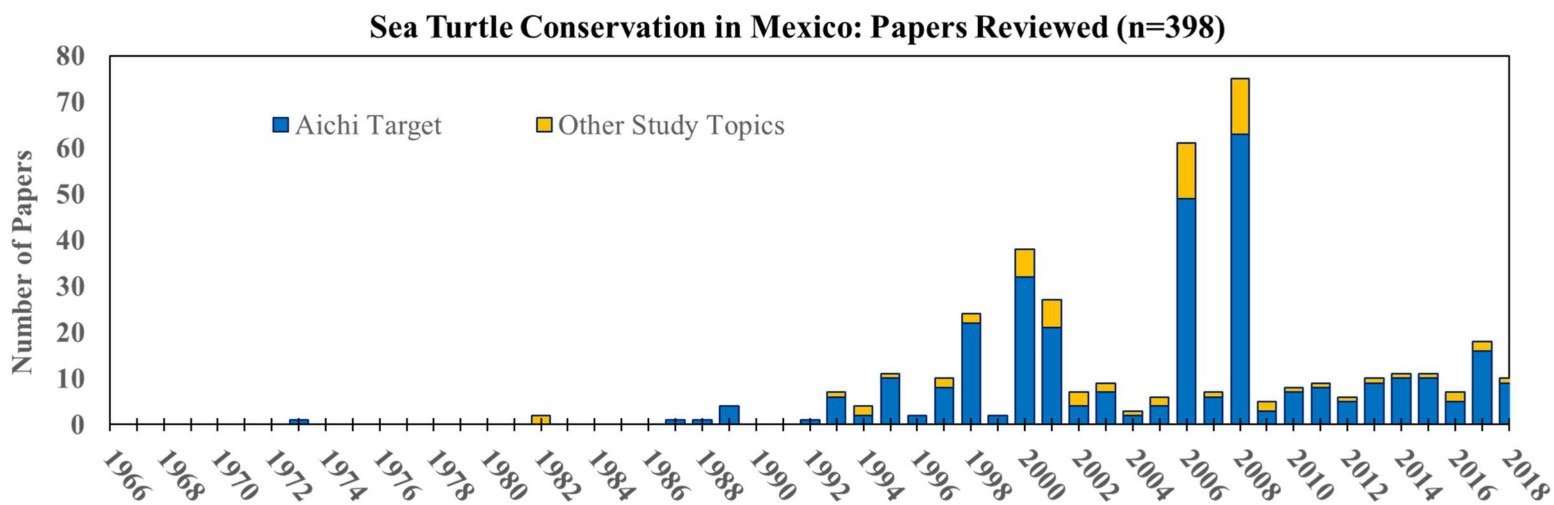
Table 3: The Ten Aichi Biodiversity Targets that Directly Impact the Conservation of Sea Turtles. Each Aichi Biodiversity Target is labeled with its corresponding Target number and description given by the United Nations Convention on Biological Diversity. The third column lists the research topics that are associated with each target and were used to separate the literature collected into various research categories.

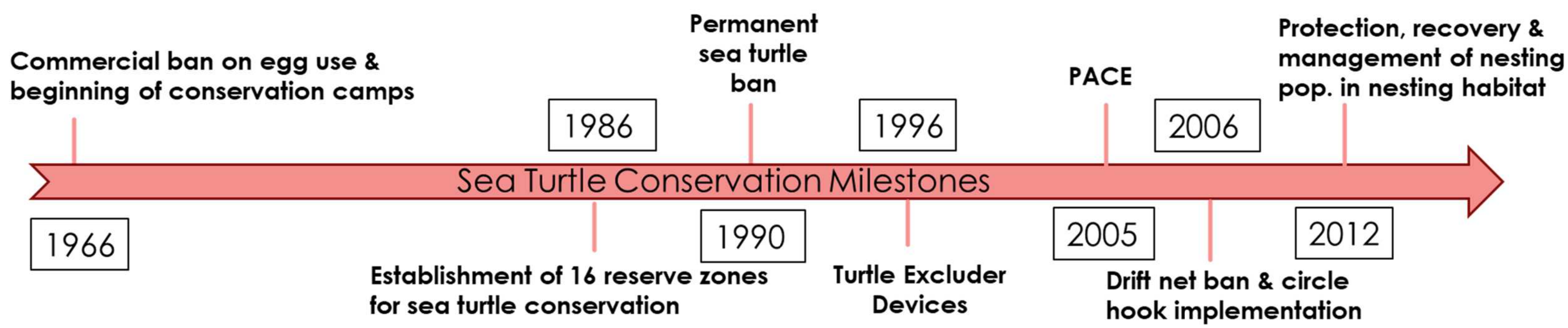
Target #	Aichi Biodiversity Goals	Research Related Topics
1: Awareness increased	By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.	Awareness, education, and outreach
5: Habitat loss halved or reduced	By 2020, the rate of loss of all-natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced	Habitat loss
6: Sustainable management of marine living resources	By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem-based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits	Bycatch, fishing gear, and consumptions
8: Pollution reduced	By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.	Chemicals, metals, inorganic waste
9: Invasive alien species prevented and controlled	By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.	Invasive species
10: Pressures on vulnerable ecosystems reduced	By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning	Climate change effects (temperature, sea level rise, ocean acidification, Human presence and disturbance
11: Protected areas increased and improved	By 2020, at least 17 per cent of terrestrial and inland water areas and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape	MPA, sea turtle sanctuaries, and reserves
12: Extinction prevented	By 2020, the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained	Conservation (nesting and hatchlings), Biology, and Ecology
13: Genetic diversity maintained	By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity	Genetic and population connectivity
15: Ecosystems restored, and resilience enhanced	By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks have been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification	Ecosystem restorations

Table 4: Conservation Priorities for Two Time Eras; 1960 – 1999 and 2000 – 2020. Each Aichi Biodiversity Target is labeled as Low, Medium, High, or Very High based on the conservation key ideas listed on Mace's article (2014).

Aichi Biodiversity Target #	Topic	Conservation Priority Pre-1999	Conservation Priority Post-1999
1	Public Awareness	Very High	Very High
5	Habitat Loss Reduced	Very High	Very High
6	Sustainable Marine Management	Medium	Very High
8	Pollution	Very High	High
9	Invasive Species	Low	High
10	Climate Change/Human Pressure	Low	Very High
11	Protected Areas	Very High	Very High
12	Extinction Prevented	Very High	Very High
13	Genetics	Low	High
15	Ecosystem Restoration/Resilience	Low	Very High

Figure 2: Sea Turtle Conservation in Mexico Based on Research Papers and Legislative Milestones. Number of papers published over the last 6 decades with the majority of the research topics falling into one or more of the ten Aichi Biodiversity Targets that were used in this analysis (n=365). The timeline highlights important conservation milestones where important legislations and regulations were established to banned harvest of sea turtles, protect nesting habitat and hatchlings, and prevent incidental capture and mortality in fisheries.


Sea Turtle Conservation in Mexico: Papers Reviewed (n=398)
Number of Papers
0
10
20
30
40
50
60
70
80
Aichi Target
Other Study Topics
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018


Sea Turtle Conservation Milestones
1966
Commercial ban on egg use & beginning of conservation camps
1986
Establishment of 16 reserve zones for sea turtle conservation
1990
Permanent sea turtle ban
1996
Turtle Excluder Devices
2005
PACE
2006
Drift net ban & circle hook implementation
2012
Protection, recovery & management of nesting pop. in nesting habitat

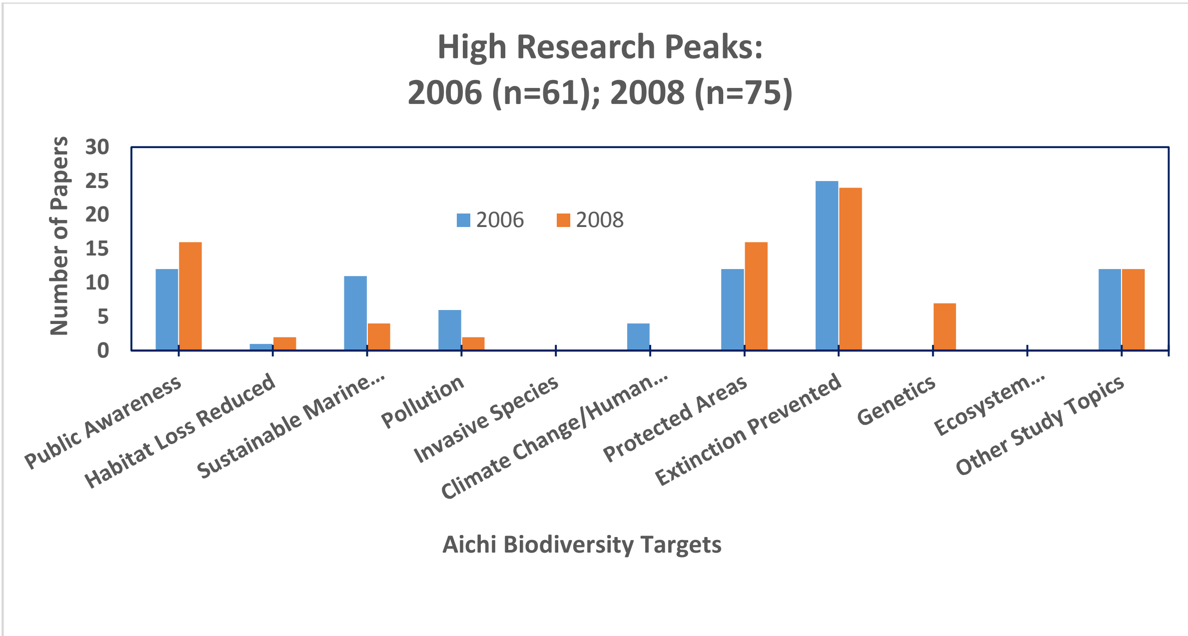


Figure 3: Research Topics of the Research Papers Published in 2006 and 2008. For each year, the number of papers that focused on each Aichi Biodiversity Target including other research topics that did not fall into the 10 categories.

Table 5: Number of Papers Published in 2006 Based on the State of Field Sites. The states are listed from the most to least number of papers. Some papers may not have a state location, or it can have multiple states, depending on the number of field sites per paper. Baja California Sur was the state with the most research papers (n=22).

State	Number of Papers (2006)
Baja California Sur	22
Sinaloa	9
Jalisco	7
Michoacán de Ocampo	5
Oaxaca	4
Baja California	3
Tamaulipas	3
Yucatan	3
Campeche	1
Guerrero	1
Nayarit	1
Quintana Roo	1
Sonora	1

Table 6: Number of Papers Published in 2008 Based on the State of Field Sites. The states are listed from the most to least number of papers. Some papers may not have a state location, or it can have multiple states, depending on the number of field sites per paper. Baja California Sur was the state with the most research papers (n=12).

States	Number of Papers (2008)
Baja California Sur	12
Tamaulipas	10
Quintana Roo	9
Michoacán de Ocampo	8
Oaxaca	8
Jalisco	6
Yucatan	4
Baja California	3
Campeche	3
Veracruz de Ignacio de la Llave	3
Sinaloa	2
Colima	1
Guerrero	1
Tabasco	1

Table 7: Aichi Biodiversity Targets from Baja California Sur Published in 2006 and 2008. The number of papers that focused on the ten Aichi Biodiversity Target. Some research papers focused on other topics that did fall into any of the target categories. The Aichi Biodiversity Targets are ordered by greatest to least amount of papers.

Targets	2006 (n= 22)	Targets2	2008 (n= 12)
Extinction Prevented	5	Public Awareness	4
Protected Areas	4	Extinction Prevented	2
Public Awareness	4	Sustainable Marine Management	1
Sustainable Marine Management	4	Pollution	1
Pollution	3	Protected Areas	1
Climate Change/Human Pressure	3	Genetics	0
Habitat Loss Reduced	0	Habitat Loss Reduced	0
Invasive Species	0	Invasive Species	0
Genetics	0	Climate Change/Human Pressure	0
Ecosystem Restoration/ Resilience	0	Ecosystem Restoration/ Resilience	0
Other Study Topics	7	Other Study Topics	5

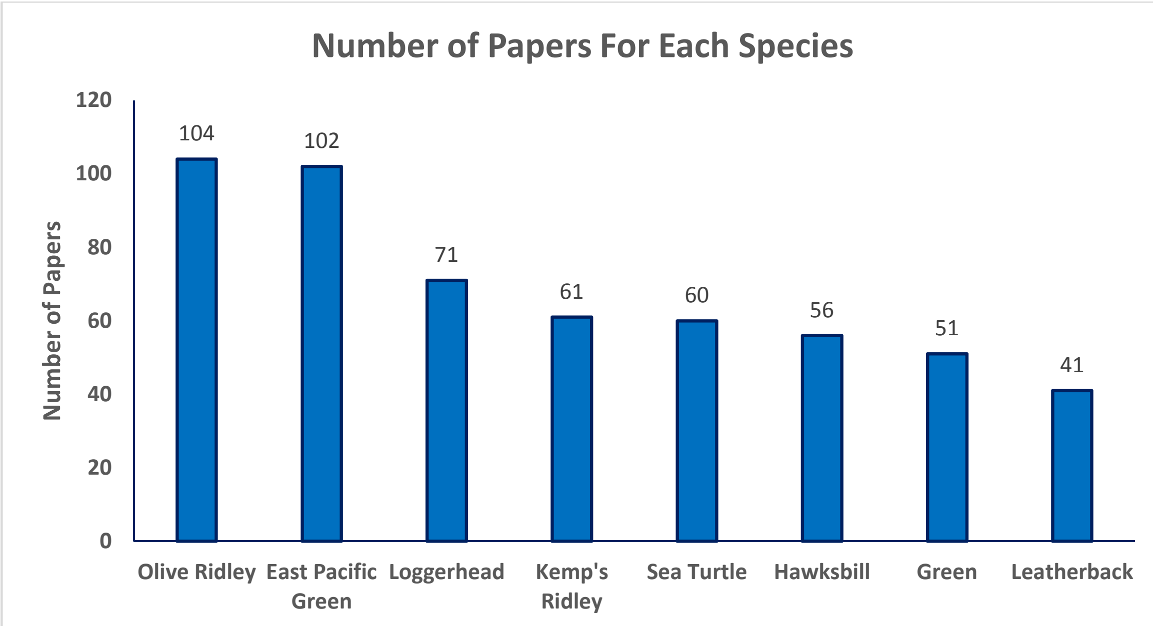


Figure 4: Number of Papers Based on Species of Interest. For my analysis the green and east pacific green sea turtles were considered two sub-species. A research paper could focus on more than one species or no specific species and those were labeled as “sea turtles”.

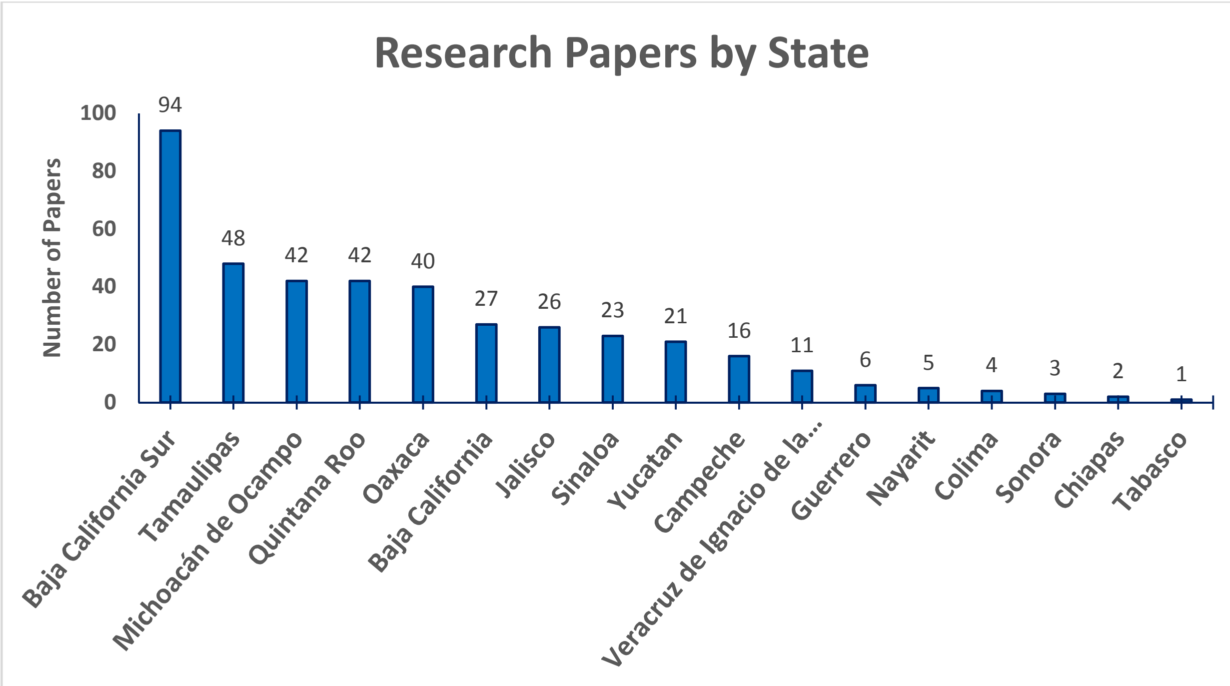
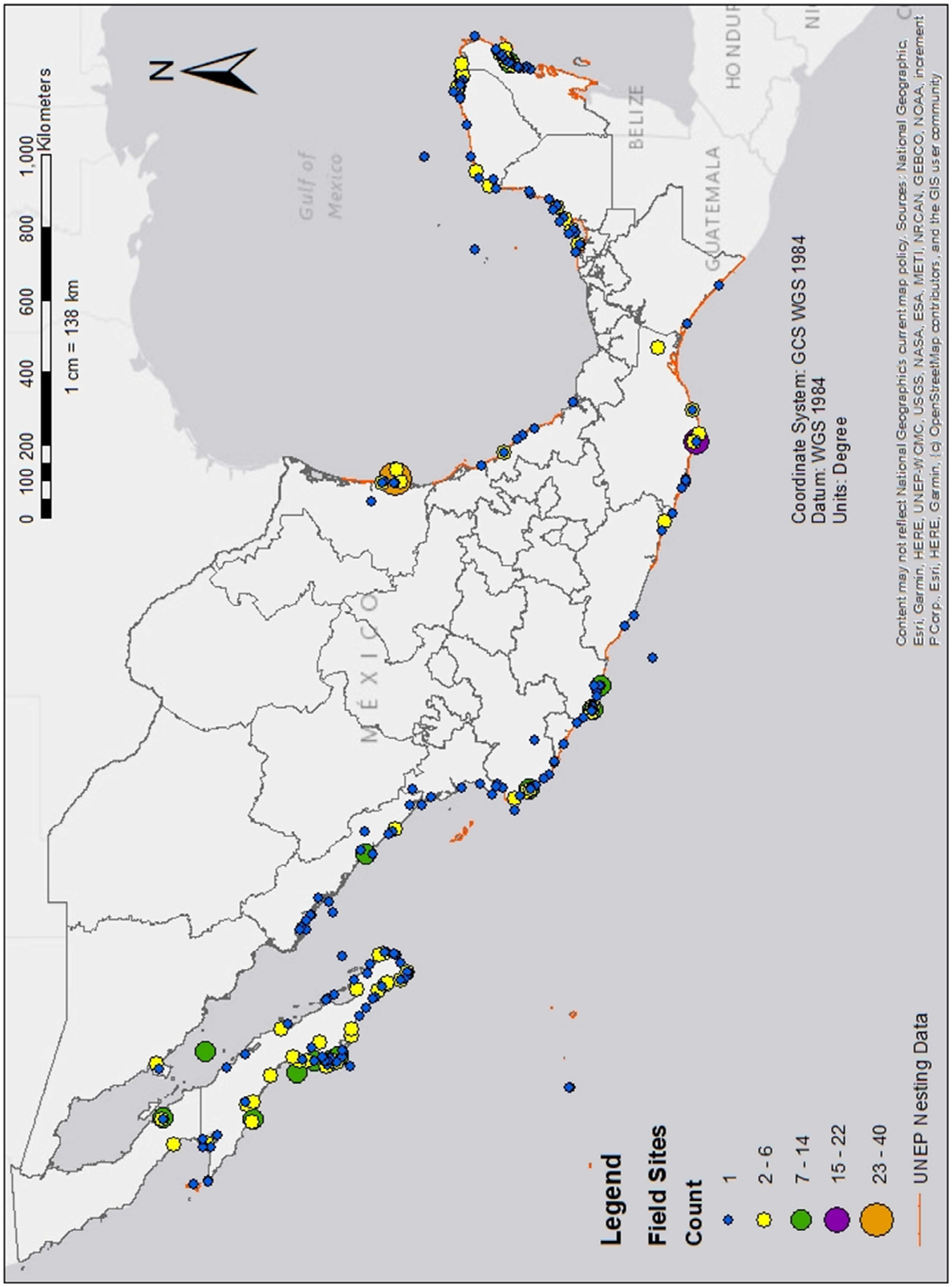


Figure 5: Number of Research Papers Based on the State of The Field Sites. A research paper could have multiple field sites within one state or among different states, but each state was only counted ones for each paper.

Figure 6: Top five Sates with the Highest Number of Research Papers. 1- Baja California Sur (n=94); 2- Tamaulipas (n=48); 3- Michoacán (n=42); 4- Quintana Roo (n=42); 5- Oaxaca (n=40).

Figure 7: Intensity of Field Site Use. Number of times a field site based on its coordinates was used is represented by a color and size of the bubble. The red lines describe sea turtle nesting sites from the UN Environment Programme data. The two highest research field sites were in the locations of Rancho Nuevo, Tamaulipas with 40 papers siting this site and in La Escobilla, Oaxaca with 22 paper.



Legend
Field Sites
Count
1
2 - 6
7 - 14
15 - 22
23 - 40
UNEP Nesting Data
0 100 200 400 600 800 1,000 Kilometers
1 cm = 138 km
N
Gulf of Mexico
MÉXICO
BELIZE
GUATEMALA
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp., Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

Figure 8: Aichi Biodiversity Targets by Field Site. The ten Aichi Biodiversity Targets were plotted individually based on their field sites. For further analysis, the Mexican coasts were separated into 4 geographic regions. The number of field sites were calculated for each geographic region.

A)Target 1: Northwestern Mexico (57); Mexican Pacific (16); Mexican Caribbean (6); Gulf of Mexico (1)

B)Target 5: Northwestern Mexico (1); Mexican Pacific (0); Mexican Caribbean (4); Gulf of Mexico (1)

C)Target 6: Northwestern Mexico (59); Mexican Pacific (12); Mexican Caribbean (9); Gulf of Mexico (13)

D)Target 8: Northwestern Mexico (21); Mexican Pacific (6); Mexican Caribbean (1); Gulf of Mexico (5)

E)Target 9: Northwestern Mexico (0); Mexican Pacific (1); Mexican Caribbean (2); Gulf of Mexico (0)

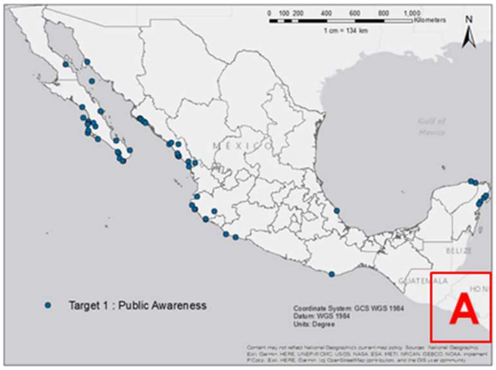
F)Target 10: Northwestern Mexico (5); Mexican Pacific (2); Mexican Caribbean (17); Gulf of Mexico (2)

G)Target 11: Northwestern Mexico (44); Mexican Pacific (125); Mexican Caribbean (64); Gulf of Mexico (72)

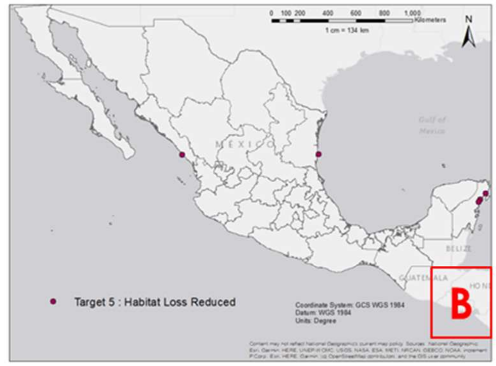
H)Target 12: Northwestern Mexico (24); Mexican Pacific (57); Mexican Caribbean (40); Gulf of Mexico (42)

I)Target 13: Northwestern Mexico (12); Mexican Pacific (22); Mexican Caribbean (5); Gulf of Mexico (6)

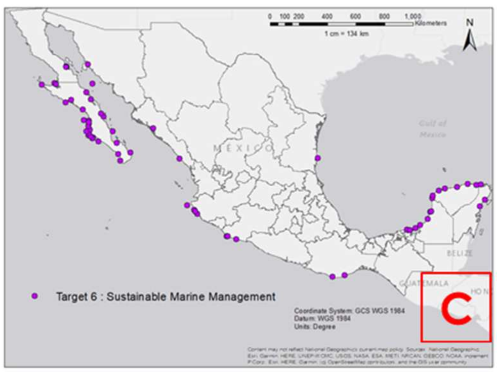
J)Target 15: Northwestern Mexico (0); Mexican Pacific (0); Mexican Caribbean (0); Gulf of Mexico (0)



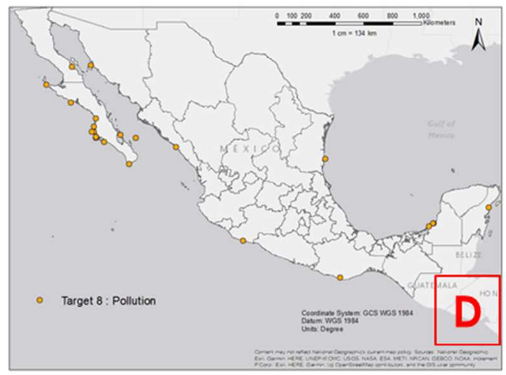
0 100 200 400 600 800 1,000 Kilometers
1 cm = 134 km
N
MEXICO
Gulf of Mexico
BELIZE
GUATEMALA
Target 1 : Public Awareness
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
A



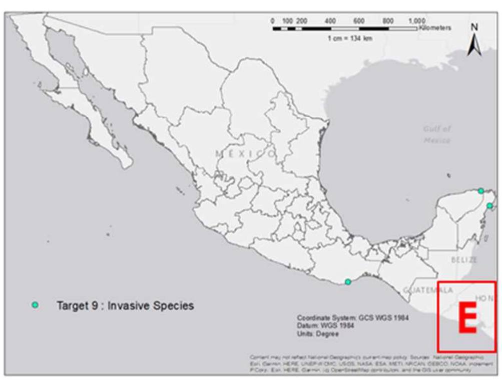
0 100 200 400 600 800 1,000 Kilometers
1 cm = 134 km
N
MEXICO
Gulf of Mexico
BELIZE
GUATEMALA
Target 5 : Habitat Loss Reduced
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
B



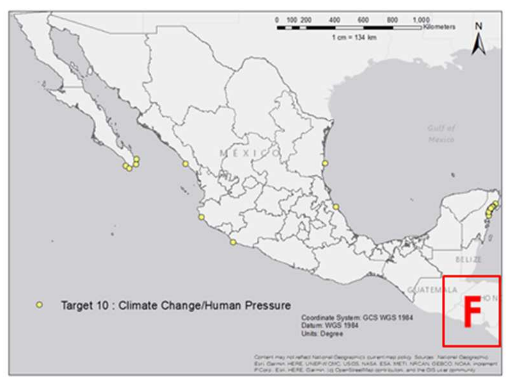
0 100 200 400 600 800 1,000 Kilometers
1 cm = 134 km
N
MEXICO
Gulf of Mexico
BELIZE
GUATEMALA
Target 6 : Sustainable Marine Management
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
C



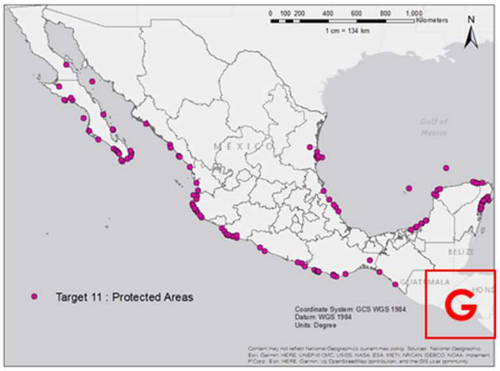
0 100 200 400 600 800 1,000 Kilometers
1 cm = 134 km
N
MEXICO
Gulf of Mexico
BELIZE
GUATEMALA
Target 8 : Pollution
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
D

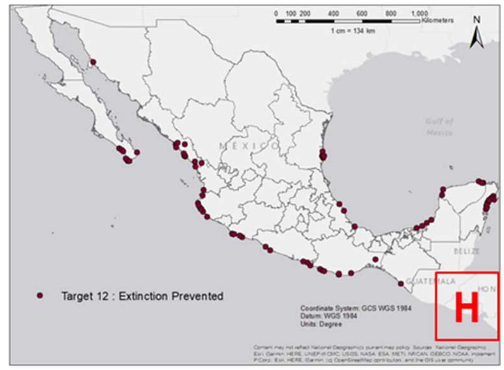


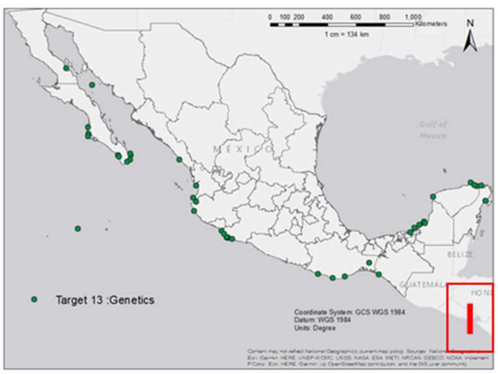
0 100 200 400 600 800 1,000 Kilometers
1 cm = 134 km
N
MEXICO
Gulf of Mexico
BELIZE
GUATEMALA
Target 9 : Invasive Species
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
E



0 100 200 400 600 800 1,000 Kilometers
1 cm = 134 km
N
MEXICO
Gulf of Mexico
BELIZE
GUATEMALA
Target 10 : Climate Change/Human Pressure
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
F


Target 11 : Protected Areas
G
Gulf of Mexico
MÉXICO
BELIZE
GUATEMALA
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
1 cm = 134 km
Kilometers


Target 12 : Extinction Prevented
H
Gulf of Mexico
MÉXICO
BELIZE
GUATEMALA
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
1 cm = 134 km
Kilometers


Target 13 :Genetics
I
Gulf of Mexico
MÉXICO
BELIZE
GUATEMALA
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
1 cm = 134 km
Kilometers

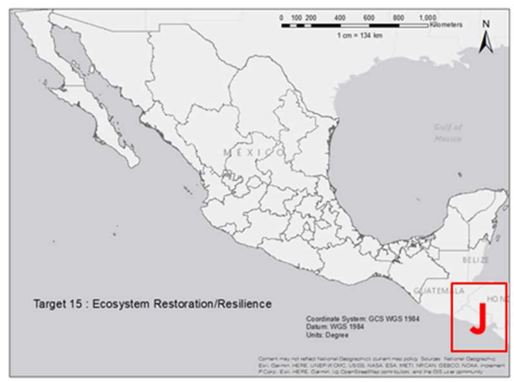

Target 15 : Ecosystem Restoration/Resilience
J
Gulf of Mexico
MÉXICO
BELIZE
GUATEMALA
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
1 cm = 134 km
Kilometers

Figure 9: Research Institutions Contributing to the Literature. The authors from the research papers collected that reported to belong to a research institution were plotted with the field sites. The greater the size of the bubble represents more contribution to the research papers. A research paper could have multiple authors representing different or the same institutions, however the institution was counted ones per paper. UNAM in Mexico City contributed to 30 research papers, which is one of the oldest institutions in Mexico, established in 1551 but re-founded in 1910. Two other institutions that stand out are Universdad Autonoma de Baja California Sur in La Paz (n=27) and the Instituto de Ciencias del Mar y Limnologia in Mazatlan, Sinaloa (n=27) representing the northwestern coast of Mexico.

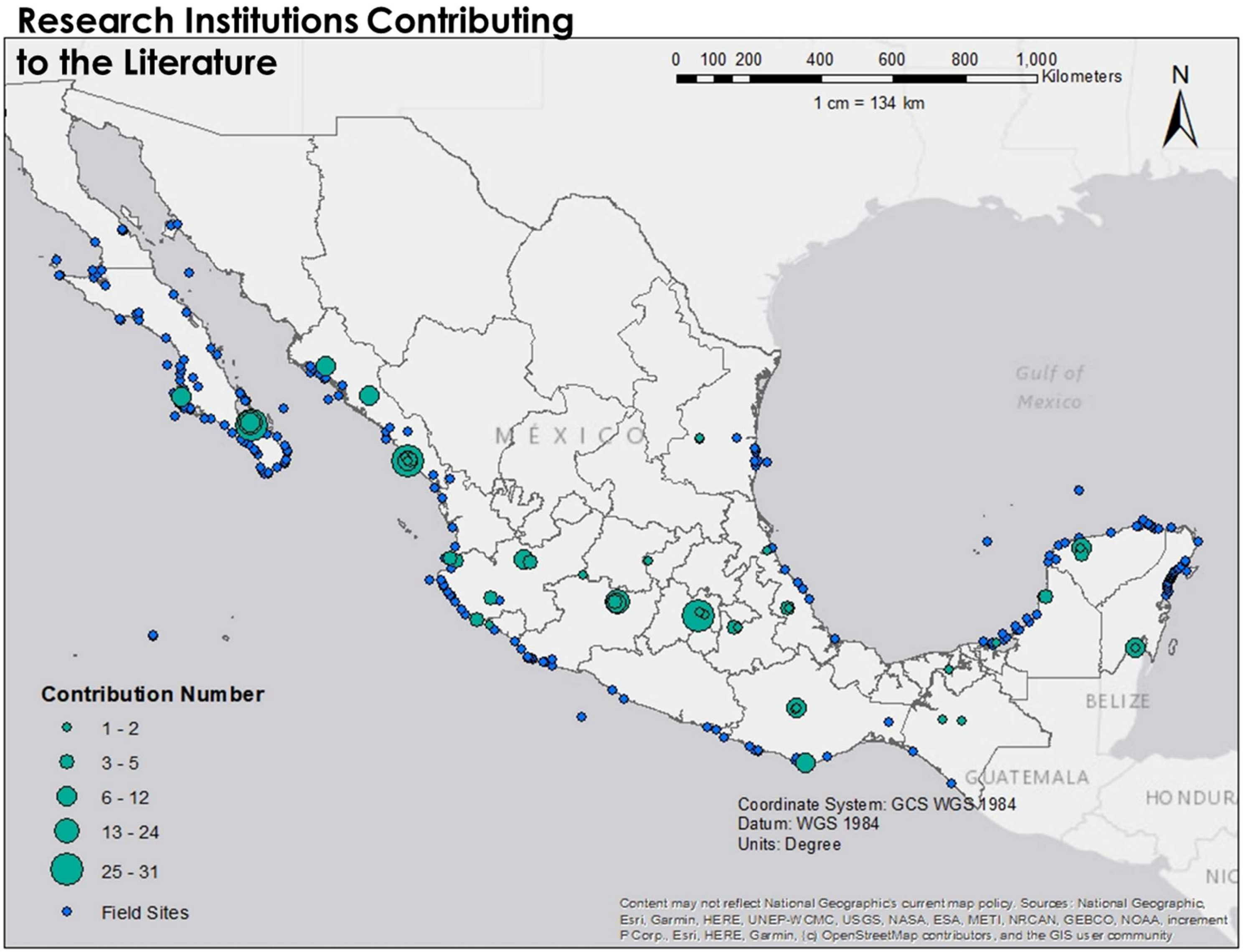

Research Institutions Contributing
to the Literature
0 100 200 400 600 800 1,000
Kilometers
1 cm = 134 km
N
Gulf of
Mexico
MÉXICO
BELIZE
GUATEMALA
HONDUR
NIC
Contribution Number
1 - 2
3 - 5
6 - 12
13 - 24
25 - 31
Field Sites
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp., Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

Figure 10: Government Agencies Contributing to the Literature. The authors from the research papers collected that reported to belong to a government agency were plotted with the field sites. The greater the size of the bubble represents more contribution to the research papers. A research paper could have multiple authors representing different or the same agencies, however the agency was counted ones per paper. The greatest contribution occurred in the Mexican Pacific from CRIP-INAPESCA in Colima (n=20) and Oaxaca (n=14).


Government Agencies Contributing to the Literature
0 100 200 400 600 800 1,000
Kilometers
1 cm = 134 km
N
Gulf of Mexico
MÉXICO
BELIZE
GUATEMALA
HONDUR
NIC
Contribution Number
1
2 - 4
5 - 14
15 - 21
Field Sites
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp., Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

Figure 11: Non-governmental Organizations Contributing to the Literature**.** The authors from the research papers collected that reported to belong to a non-governmental organization were plotted with the field sites. The greater the size of the bubble represents more contribution to the research papers. A research paper could have multiple authors representing different or the same organizations, however the organization was counted ones per paper. Grupo Tortuguero de las Californias in La Paz, Baja California Sur had the highest number of papers, with 20 contributions representing the northwestern coast of Mexico.

Non-governmental Organizations Contributing to the Literature

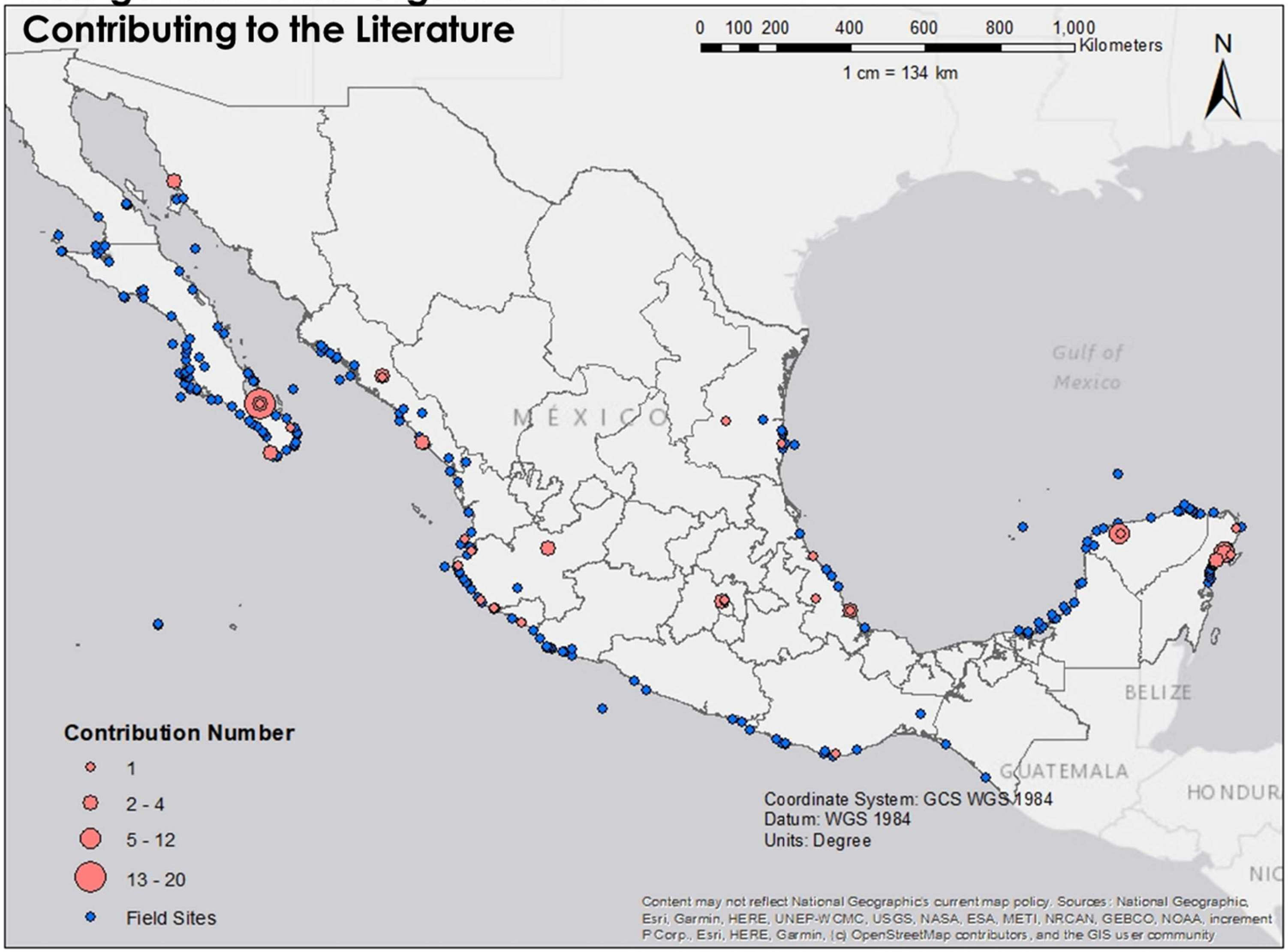
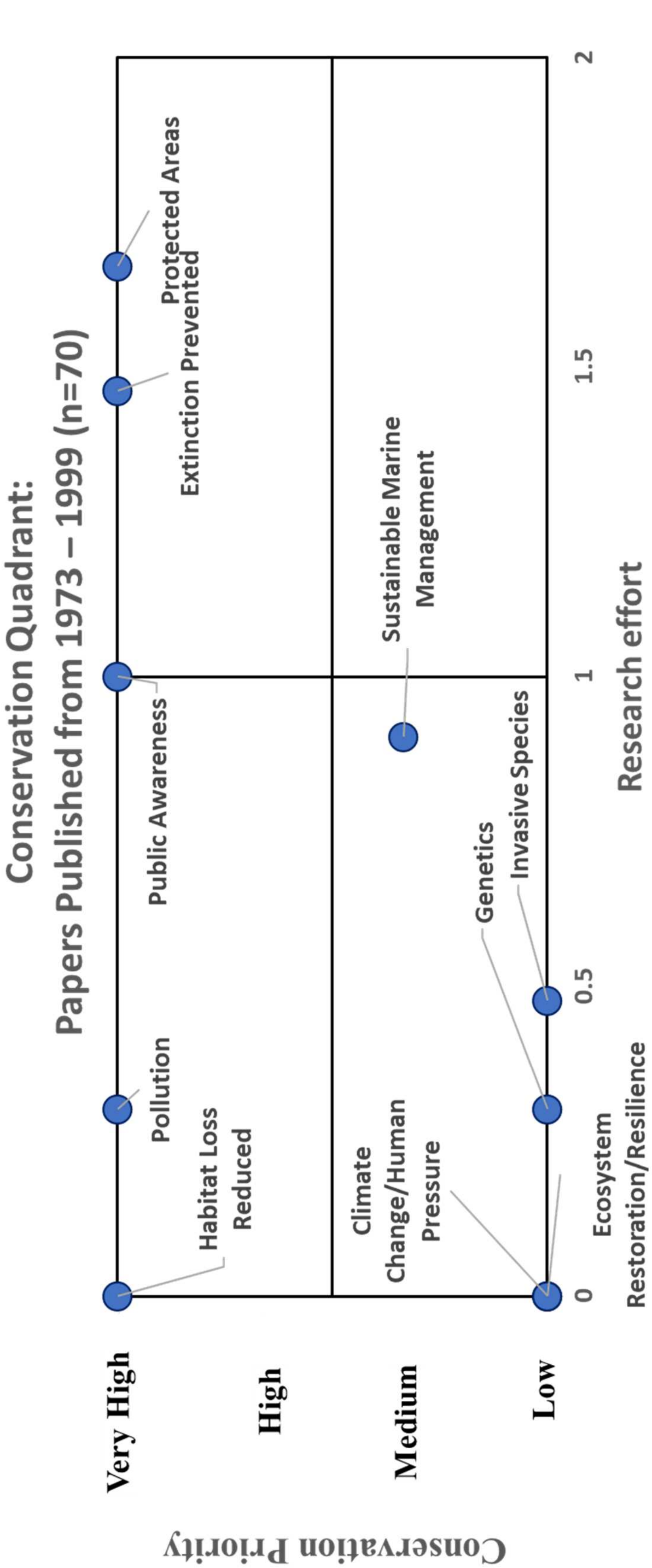


Figure 12: Conservation Quadrant: 1960 – 1999. Number of research papers published from 1973 – 1999 were used for the research effort analysis. The y-axis represents the conservation priority (Low – Very High) and the x-axis the log of the research effort, for each Aichi Biodiversity Target. Half of the targets were considered a Very High priority, but only protected areas and extinction prevented had a High research effort.



Conservation Quadrant:
Papers Published from 1973 – 1999 (n=70)
Conservation Priority
Very High
High
Medium
Low
Research effort
0
0.5
1
1.5
2
Habitat Loss Reduced
Pollution
Public Awareness
Extinction Prevented
Protected Areas
Climate Change/Human Pressure
Ecosystem Restoration/Resilience
Genetics
Invasive Species
Sustainable Marine Management

Figure 13: Conservation Quadrant 2000 – 2018. Number of research papers published from 2000 – 2018 were used for the research effort analysis. The y-axis represents the conservation priority (Low – Very High) and the x-axis the log of the research effort, for each Aichi Biodiversity Target. All the targets were considered to be a High or Very High conservation priority but only protected areas, extinction prevented, and public awareness, and sustainable marine management had a High research effort. Ecosystem restoration/resilience and invasive species had no research papers focused on those targets.

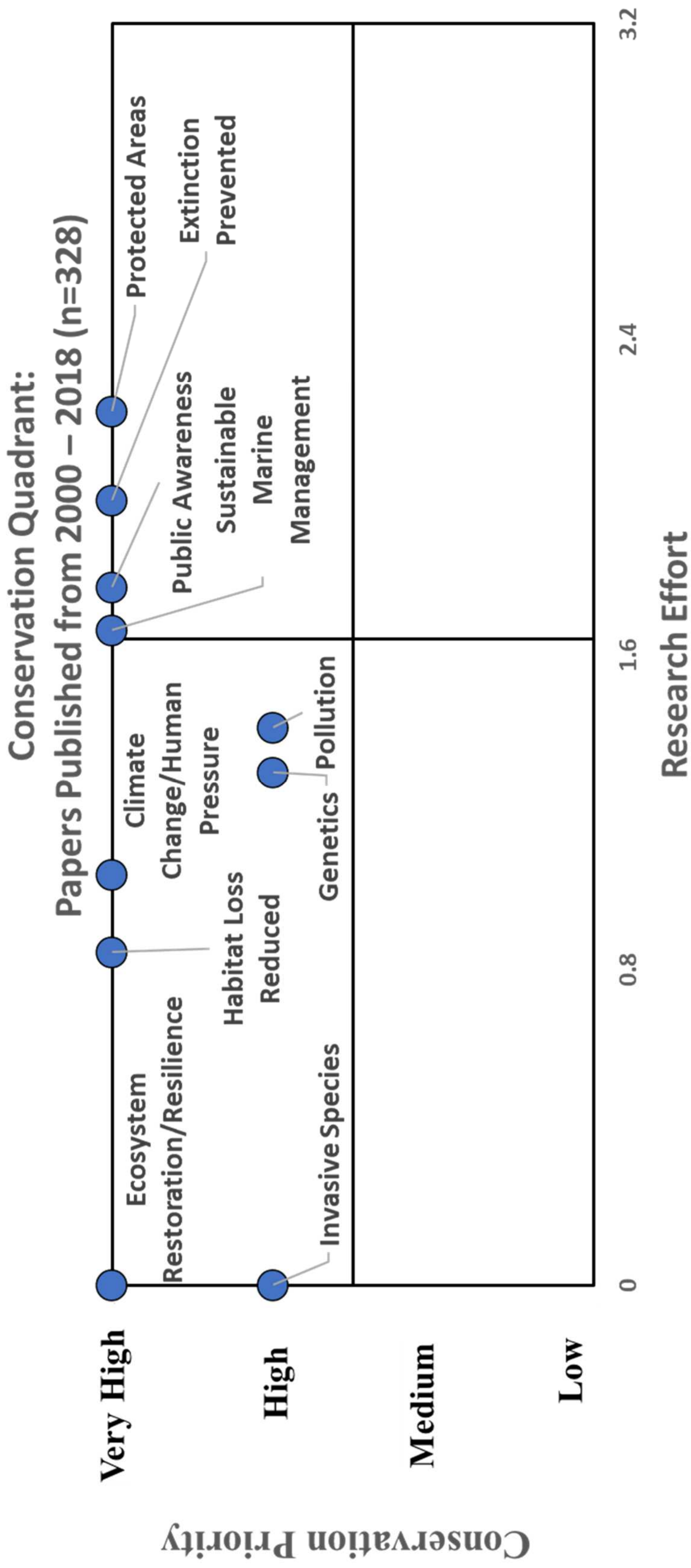

Conservation Quadrant:
Papers Published from 2000 – 2018 (n=328)
Conservation Priority
Very High
High
Medium
Low
Research Effort
0
0.8
1.6
2.4
3.2
Ecosystem Restoration/Resilience
Invasive Species
Habitat Loss Reduced
Climate Change/Human Pressure
Genetics
Pollution
Sustainable Marine Management
Public Awareness
Extinction Prevented
Protected Areas

Table 8: Number of Papers for Each Aichi Biodiversity Target Based on Their Conservation Era. The Aichi Biodiversity Targets are listed from having the most to the least number of research papers overall. For each conservation era, the conservation priority for each Aichi Biodiversity Target is listed along with the number of research papers for each target.

Number of Papers (n)	Aichi Biodiversity Target	< 1999 Conservation Priority	> 2000 Conservation Priority
211	Protected areas	Very High (n=46)	Very High (n=165)
127	Extinction Prevented	Very High (n=29)	Very High (n=98)
69	Public Awareness	Very High (n=10)	Very High (n=59)
54	Sustainable Marine Management	Medium (n=8)	Very High (n=46)
28	Pollution	Very High (n=2)	High (n=26)
22	Genetics	Low (n=2)	High (n=20)
12	Climate Change or Human Pressure	Low (n=1)	Very High (n=11)
8	Habitat Loss Reduced	Very High (n=1)	Very High (n=7)
3	Invasive Species	Low (n=3)	High (n=0)
0	Ecosystem Restoration or Resilience	Low (n=0)	Very High (n=0)

REFERENCES

Abreu-Grobois, A & Plotkin, P. (IUCN SSC Marine Turtle Specialist Group). (2008). *Lepidochelys olivacea*. The IUCN Red List of Threatened Species 2008: e.T11534A3292503. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T11534A3292503.en

Amorocho, D.F. and Network, W.C.S.T.C., 1999, November. Status and distribution of the hawksbill turtle, Eretmochelys imbricata, in the wider Caribbean region. In *Proceedings of the Regional Meeting "Marine Turtle Conservation in the Wider Caribbean Region: A Dialogue for Effective Regional Management", Santo Domingo* (pp. 16-18).Bostrom, B. L., Jones, T. T., Hastings, M., & Jones, D. R. (2010). Behaviour and physiology: The thermal strategy of leatherback turtles. PLoS ONE, 5(11). https://doi.org/10.1371/journal.pone.0013925

Bevan, E., T. Wibbels, B. M. Z. Najera, L. Sarti, F. I. Martinez, J. M. Cuevas, B. J. Gallaway, L. J. Pena, and P. M. Burchfield. (2016). Estimating the historic size and current status of the Kemp's ridley sea turtle (*Lepidochelys kempii*) population. Ecosphere 7(3):e01244. 10.1002/ecs2.1244

Bowen, B. W., Abreu-Grobois, F. A., balazs, G. H., Kamezaki, N., limpus, C. J., & Ferl, R. J. (1995). Trans-Pacific migrations of the loggerhead turtle *(Caretta caretta*) demonstrated with mitochondrial DNA markers (conservation genetics/mixed stock assessment/marine turtles). In Population Biology (Vol. 92).

Campbell, L. M. (2003). 2 Contemporary Culture, Use, and Conservation of Sea Turtles. 310–312.

Castellanos-Michel, R. Martínez-Tovar, C. & J. Jacobo-Pérez. (2004). Trend decrease for clutch size and corporal size in Olive Ridley Sea Turtles (*Lepidochelys olivacea*) nesting in the East Pacific, Jalisco, México. In: R. B. M. Mast, B. J. Hutchinson & A. H. Hutchinson (Comps.) Proceedings of the Twenty-fourth Symposium on Sea Turtle Biology and Conservation. Costa Rica. NOAA Technical Memorandum NMFS-SE¬FSC-567. 117–118.

Comisión Nacional de Áreas Naturales Protegidas. (2008). Programa de Acción para la Conservación de la Especie Tortuga Laúd (*Dermochelys coriacea*). Secretaría de Medio Ambiente y Recursos Naturales.

Comisión Nacional de Áreas Naturales Protegidas. (2009). Programa de Acción para la Conservación de la Especie Tortuga Carey (*Eretmochelys imbricata*). Secretaría de Medio Ambiente y Recursos Naturales.

Comisión Nacional de Áreas Naturales Protegidas. (2011a). Programa de Acción para la Conservación de la Especie Tortuga Caguama (*Caretta caretta*). Secretaría de Medio Ambiente y Recursos Naturales.

Comisión Nacional de Áreas Naturales Protegidas. (2011b). Programa de Acción para la Conservación de la Especie Tortuga Verde/Negra (*Chelonia mydas*). Secretaría de Medio Ambiente y Recursos Naturales.

Comisión Nacional de Áreas Naturales Protegidas. (2012). Programa de Acción para la Conservación de la Especie Tortuga Golfina (*Lepidochelys olivacea*). Secretaría de Medio Ambiente y Recursos Naturales.

Comisión Nacional de Áreas Naturales Protegidas. (2013). Programa de Acción para la Conservación de la Especie Tortuga Lora (*Lepidochelys kempii*). Secretaría de Medio Ambiente y Recursos Naturales.

Convention on Biological Diversity. (2017). Inputs to the process of revising and updating the CBD Strategic Plan 2002-2010. Retrieved from https://www.cbd.int/sp/inputs/

Convention on Biological Diversity. (2018). Key Elements of the Strategic Plan 2011-2020, including Aichi Biodiversity Targets. Retrieved from https://www.cbd.int/sp/elements/

Convention on Biological Diversity. (2020). National Biodiversity Strategies and Action Plans (NBSAPs). Retrieved from https://www.cbd.int/nbsap/

Convention on Biological Diversity. (2019). What is an NBSAP?. Retrieved from https://www.cbd.int/nbsap/introduction.shtml

Cuevas Flores, E.A., Guzmán Hernández, V., Guerra Santos, J.J., & Rivas Hernández, G. A. (2019). El Uso del Conocimiento de las Tortugas Marinas como herramienta para la restauración de sus poblaciones y habitats asociados México: Universidad Autónoma del Carmen.13–22.

Diaro Oficial de la Federacion. 1990

Dobson, A. P., Nowak, K., & Rodríguez, J. P. (2013). Conservation Biology, Discipline of. In *Encyclopedia of Biodiversity: Second Edition* (pp. 238–248). Elsevier Inc. https://doi.org/10.1016/B978-0-12-384719-5.00272-0

Dutton, P. H., Sarti, L., Marquez, R., & Squires, D. (2002). "Both sides of the Border: Transboundary Environmental Management Issues Facing Mexico and the United States". In Chapter V: Sea turtle conservation across the shared marine border. 429–446.

Eckert, S. A., & Sarti, L. (1997). Distant fisheries implicated in the loss of the world's largest leatherback nesting population. Marine Turtle Newsletter 78:2-7. (n.d.). http://www.seaturtle.org/mtn/archives/mtn78/mtn78p2.shtml

Eguchi, T., Gerrodette,T., Pitman, R., Seminoff, J.A., & Dutton. P.H. (2007). At-sea density an abundance estimates of the olive ridley turtle (*Lepidochelys olivacea*) in the eastern tropical Pacific. Endangered Species Research 3:191–203.

Fuentes, M.M., Chambers, L., Chin, A., Dann, P., Dobbs, K., Marsh, H., Poloczanska, E.S., Maison, K., Turner, M. and Pressey, R.L., 2016. Adaptive management of marine mega-fauna in a changing climate. *Mitigation and adaptation strategies for global change*, *21*(2), pp.209-224.

Gallaway, B. J., Gazey, W. J., Wibbels, T., Bevan, E., Shaver, D. J., & George, J. (n.d.). (2016). Evaluation of the Status of the Kemp's Ridley Sea Turtle After the 2010 Deepwater Horizon Oil Spill. In Gulf of Mexico Science (Vol. 2016, Issue 2).

Gaus, A. R., Lewison, R. L., Yañez, I. L., Wallace, B. P., Liles, M. J., Nichols, W. J., Baquero, A., Hasbun, C. R., Vasquez, M., Urteaga., & Seminoff, J. A. (2011). Shifting the life-history paradigm: discovery of novel habitat use by hawksbill turtles. Biology Letters 8, 54 –56. (doi:10.1098/rsb1.2011.0603)

Groombridge, B & Luxmoore, R. (1989). The green turtle and hawksbill (Reptilia: *Cheloniidae*): world status, exploitation and trade. United Nations Environmental Programme. Secretariat of the Convention on International Trade in Endangered Species of Wild Fauna and Flora. 352–355.

Gulko, D. A., and K. L. Eckert. (2004). Sea Turtles: An Ecological Guide. Mutual Publishing, Honolulu, Hawaii

Lewison, R. L., Freeman, S. A., & Crowder, L. B. (2004). Quantifying the effects of fisheries on threatened species: The impact of pelagic longlines on loggerhead and leatherback sea turtles. Ecology Letters, 7(3), 221–231. https://doi.org/10.1111/j.1461-0248.2004.00573.x

Lewison, R. L., Crowder, L. B., Wallace, B. P., Moore, J. E., Cox, T., Zydelis, R., McDonald, S., DiMatteo, A., Dunn, D. C., Kot, C. Y., Bjorkland, R., Kelez, S., Soykan, C., Stewart, K. R., Sims, M., Boustany, A., Read, A. J., Halpin, P., Nichols, W. J., & Safina, C. (2014). Global patterns of marine mammal, seabird, and sea turtle bycatch reveal taxa-specific and cumulative megafauna hotspots. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(14), 5271–5276. https://doi.org/10.1073/pnas.1318960111

Lohmann, K. J., Putman, N. F., & Lohmann, C. M. F. (2008). Geomagnetic imprinting: A unifying hypothesis of long-distance natal homing in salmon and sea turtles. www.pnas.orgcgidoi10.1073pnas.0801859105

Lugo, A. E. (2000). Effects and outcomes of Caribbean hurricanes in a climate change scenario. *Science of the Total Environment*, *262*(3), 243-251.

Mace, G. M. (2014). Whose conservation? In *Science* (Vol. 345, Issue 6204, pp. 1558–1560). American Association for the Advancement of Science. https://doi.org/10.1126/science.1254704

Marine Fisheries Review. Mexico's Sea Turtle Program. (1988). 70–72.

Marquez M. R., Vasconcelos, J., and Penaflores, C. (1990). XXV Anos de Investigacion, Conservacion y Proteccion De La Tortuga Marina. Instituto Nacional de la Pesca, Cnetro Regional De Investigaciones Pesqueras. La Paz, B.C.S., Mexico

Márquez M., R. (1994). Synopsis of biological data on the Kemp's ridley turtle, *Lepidochelys kempii* (Garman, 1880). NOAA Technical Memorandum. NMFS-SEFSC-343.

Marquez M. R., Burchfield M. P., Diaz F. J., Sanchez P. M., Carrasco A. M., Jimenez Q. C., Leo P. A., Bravo G. R., Peña V. J. (2005). Status of the Kemp's Ridley Sea Turtle, *Lepidochelys kempii.* Chelonian Conservation and Biology, 4(4), 761-766.

Márquez, R., Villanueva, A., & Peñaflores, C. (1981). Anidación de la tortuga laud *Dermochelys coriacea schlegelli* en el Pacífico mexicano. Ciencia Pesquera 1(1): 45-52 INP, México.

Márquez-M. R., Villanueva, A. & Peñaflores, C. (1976). *Sinopsis de datos biológicos sobre la Tortuga Golfina(Lepidochelys olivacea) (Eschscholtz, 1829).* FAO-INP Sinopsis sobre la pesca. (2):1-67.

Mazaris, A.D., Schofield, G., Gkazinou, C., Almpanidou, V., Hays, G.C. Global sea turtle conservation successes. Sci. Adv. 3, e1600730 (2017).

McClenachan, L., Jackson, J. B. C. and M. J. H. Newman. (2006). Conservation implications of historic sea turtle nesting beach loss. Frontiers in Ecology and Environment, 4(6): 290-296.

McLeod, K., & Leslie, H. (Eds.). (2009). *Ecosystem-based management for the oceans*. pp. 3-12. Retrieved from https://ebookcentral.proquest.com

Michener, W.K., Blood, E.R., Bildstein, K.L., Brinson, M.M. and Gardner, L.R., 1997. Climate change, hurricanes and tropical storms, and rising sea level in coastal wetlands. *Ecological Applications*, *7*(3), pp.770-801.

Mortimer, J.A & Donnelly, M. (IUCN SSC Marine Turtle Specialist Group). (2008). *Eretmochelys imbricata*. The IUCN Red List of Threatened Species 2008: e.T8005A12881238. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T8005A12881238.en

Nichols W. J. (2003). Biology and conservation of sea turtles in Baja California, Mexico, Ph.D. Thesis. Tucson, AZ .USA.

Nichols, W. J., Brooks, L., Lopez, M., & Seminoff, J. A. (2001). Record of Pelagic East Pacific Green Turtles Associated with Macrocystis Mats Near Baja California Sur, Mexico. www.seaturtle.org/mtn/archives/mtn93/mtn93p10.shtml

Nichols, W. J., Resendiz, A., Seminoff, J. A., & Resendiz, B. (2000). TRANSPACIFIC MIGRATION OF A LOGGERHEAD TURTLE MONITORED BY SATELLITE TELEMETRY. In BULLETIN OF MARINE SCIENCE (Vol. 67, Issue 3).

Oliver de la Esperanza, A., Arenas Martínez, A., Tzeek Tuz, M., & Pérez-Collazos, E. (2017). Are anthropogenic factors affecting nesting habitat of sea turtles? The case of Kanzul beach, Riviera Maya-Tulum (Mexico). Journal of Coastal Conservation, 21(1), 85–93. https://doi.org/10.1007/s11852-016-0473-5

Peavey, L. E., Popp, B. N., Pitman, R. L., Gaines, S. D., Arthur, K. E., Kelez, S., & Seminoff, J. A. (2017). Opportunism on the high seas: Foraging ecology of olive ridley turtles in the eastern Pacific Ocean. Frontiers in Marine Science, 4(NOV). https://doi.org/10.3389/fmars.2017.00348

Peckham S. H., Maldonado-Díaz, D., Koch, V., Mancini, a., & Gaos, A. (2008). High mortality of loggerhead turtles due to bycatch, human consumption and stranding at Baja California Sur, Mexico, 2003-2007. Endangered Species Research 5: 171-183.

Peckham S. H., Maldonado, D., Walli, A., Ruiz, G., Nichols, W. J., L. Crowder. (2007). Small-scale fisheries bycatch jeopardizes endangered Pacific loggerhead turtles. PLoS One 2: doi:10.1371/journal.pone.0001041.

Probert, P. K., & Probert, P. K. (2017). Marine Turtles. In Marine Conservation (pp. 167–185). Cambridge University Press. https://doi.org/10.1017/9781139043588.008

Pesenti, C., Nichols, W.J., Rangel-Acevedo, R., Laudino-Santillan, J., Medrano, B.M., Castro, M.C.L., Peckham, S.H. (2008). NOAA Technical Memorandum. U.S.A. NSFS-SEFSC (n. 582), 2008-12-01. 184–185.

Salazar-Vallejo S. I., González, N. E., & G. de la Cruz, G., (1992). La zona costera: ecología, conservación y turismo. pp 53-73 En: A. César-Dachary, D. Navarro y S. M. Arnaiz (eds.).Quintana Roo: Los retos del fin del siglo. CIQRO y Fund. Siglo XXI, Chetumal

Sarti-Martinez, L., Barragan, A. R., Muños, D. G., Garcia, N., Huerta, P., & Vargas, F. (2007). Conservation and Biology of the Leatherback Turtle in the Mexican Pacific. In Chelonian Conservation and Biology (Vol. 6, Issue 1). Chelonian Research Foundation.

Seminoff, J.A. (Southwest Fisheries Science Center, U.S.). 2004. *Chelonia mydas*. The IUCN Red List of Threatened Species (2004): e.T4615A11037468. http://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T4615A11037468.en

Seminoff, J. A., Resendiz S. Hidalgo, A., Resendiz de Jimenez, B., & Nichols, W. J. (2000). A preliminary Assessment of the Population Structure of Sea Turtles in Bahia De Los Angeles, Gulf of California, Mexico. Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation. U.S.A. NOAA Technical Memoranda. NMFS-SEFSC-477. 266–268.

Seminoff, J. A., Eguchi, T., Carretta, J., Allen, C. D., Prosperi, D., Rangel, R., Gilpatrick, J. W., Forney, K., & Peckham, S. H. (2014). Loggerhead sea turtle abundance at a foraging hotspot in the eastern Pacific Ocean: Implications for at-sea conservation. Endangered Species Research, 24(3), 207–220. https://doi.org/10.3354/esr00601

Seminoff, J. A., Resendiz, A., & Nichols, W. J. (2002). Society for the Study of Amphibians and Reptiles Diet of East Pacific Green Turtles (Chelonia mydas) in the Central Gulf of California. In Source: Journal of Herpetology (Vol. 36, Issue 3).

Seminoff, J. A., W. J. Nichols, A. Resendiz , & L. Brooks. 2003. Occurrence of hawksbill turtles, Eretmochelys imbricata, near Baja California. Pacific Sci. 57:9–16.

Seminoff J. A., Peckham, S. H.; Eguchi, T., Sarti-Martínez, A., Rangel-Acevedo, R., Forney, K. A., Nichols, W. J., E. Ocampo, E., & Dutton, P. (2006). Loggerhead turtle density and abundance along the Pacific coast of the Baja California Península, Mexico. En: Frick, M., A. Panagopoulou, A. F. Rees y K. Williams (Comps.). Book of Abstracts. Twenty Sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece. 376 pp.

Spotila, J.R. "Sea Turtles: a Complete Guide to Their Biology, Behavior, and Conservation". Johns Hopkins University Press, 2004.

Tapilatu, R. F., P. H. Dutton, M. Tiwari, T. Wibbels, H. V. Ferdinandus, W. G. Iwanggin, and B. H. Nugroho. (2013) Long-term decline of the western Pacific leatherback, Dermochelys coriacea: a globally important sea turtle population. Ecosphere 4(2):25. http://dx.doi.org/10.1890/ES12-00348.

United Nations Educational, Scientific and Cultural Organization. (2018). Retrieved from https://whc.unesco.org/en/statesparties/mx

Vogt, K. A., Scullion, J. J., Nackley, L. L., & Shelton, M. (2013). Conservation Efforts, Contemporary. In Encyclopedia of Biodiversity: Second Edition (pp. 249–262). Elsevier Inc. https://doi.org/10.1016/B978-0-12-384719-5.00312-9

Wallace, B. P., Lewison, R. L., Mcdonald, S. L., Mcdonald, R. K., Kot, C. Y., Kelez, S., Bjorkland, R. K., Finkbeiner, E. M., Helmbrecht, S., & Crowder, L. B. (2010). Global patterns of marine turtle bycatch. In Conservation Letters (Vol. 3, Issue 3, pp. 131–142). https://doi.org/10.1111/j.1755-263X.2010.00105.x

Wallace, B. P., DiMatteo, A. D., Bolten, A. B., Chaloupka, M. Y., Hutchinson, B. J., Abreu-Grobois, F. A., Mortimer, J. A., Seminoff, J. A., Amorocho, D., Bjorndal, K. A., Bourjea, J., Bowen, B. W., Dueñas, R., Casale, P., Choudhury, B. C., Costa, A., Dutton, P. H., Fallabrino, A., Finkbeiner, E. M., Girard, A., Girondot, M., Hamann, Mark., Hurley B. J., Lopez-Mendilaharsu, M., Marcovaldi, M. A., Musick, J.A., Nel, R., Pilcher, N. J., Troeng, S., Witherington, B., Mast, R. B. (2011). Global conservation priorities for Marine turtles. *PLoS ONE*, *6*(9). https://doi.org/10.1371/journal.pone.0024510

Wallace, B.P., Tiwari, M. & Girondot, M. 2013. Dermochelys coriacea. The IUCN Red List of Threatened Species. (2013): e.T6494A43526147. http://dx.doi.org/10.2305/IUCN.UK.2013-2.RLTS.T6494A43526147.en

Witzell, W. N., Burchfield, P. M., Peña, L. J., Marquez M, R., & Ruiz M, G. (2006). Nesting Success of Kemp's Ridley Sea Turtles, *Lepidochelys Kempi*, at Rancho Nuevo, Tamaulipas, Mexico, 1982–2004. Marine Fisheries Review. 69(1–4), 46–52.

Worm, B., & Lotze, H.K. (2009) Changes in marine biodiversity as an indicator of climate change. In: Lechter T(ed.) Climate Change: Observed Impacts on Planet Earth, pp.263–279. Amsterdam: Elsevier B.V.

Zurita Gutierrez, J. C., Herrera, R., & Prezas, B. (1993). Tortugas Marinas de Caribe. In Biodiversidad Marina y Costera de Mexico. Salazar-Vallejo S.I. and Gonzalez N.E. 735–751.

Žydelis, R., Wallace, B.P., Gilman, E.L., & Werner, T.B. (2009) Conservation of marine megafauna through minimization of fisheries bycatch. Conserv Biol 23:608–616

NOM-EM-002-PESC-1993

NOM-EM-001-PESC-1996

NOM-029-PESC-2006