Population Structure and Conservation of

Oceanic Manta Rays in the Indo-Pacific

A Scripps Institution of Oceanography collaborative research project.

Table of Contents

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Introduction

Oceanic manta rays, a poorly understood, charismatic marine megafauna, are under increasingly intense fishing pressures around the world. One of several species of Mobulid rays whose gill rakers have recently been adopted as a remedy in Traditional Chinese Medicine, manta rays are targeted in developing countries such as Sri Lanka and Indonesia for the feathery appendages that allow them to strain zooplankton from seawater. Thousands of mantas are being caught and killed each year, and due to extremely low reproductive rates, populations are unlikely to sustain high levels of exploitation. On the other hand, it has been shown that ecotourism directed towards manta rays has a far greater economic return for coastal communities than the gill raker trade.

Oceanic manta rays (*Manta birostris*) are one of two species in the genus Manta (*M. birostris* & *M. alfredi*, Marshall et al., 2009). Like all eleven species of mobulid rays (*Myliobatidae*), oceanic manta rays are filter feeders, using specially-adapted gill rakers to strain zooplankton from the water. Manta rays give birth to a single offspring per pregnancy (Notarbartolo-di-Sciara 1988) every 2-5 years, and reach sexual maturity at 8-10 years of age (Marshall et al., 2011), making them particularly vulnerable to exploitation due to low reproductive rates. Reef manta rays (*M. alfredi*) are found in tropical and sub-tropical waters throughout the Pacific and Indian oceans and are often found to be resident to productive near-shore areas such as islands, atolls and coastlines (IUCN, 2012). Oceanic manta rays (*M. birostris*) are found circumglobally in tropical and temperate waters. While photo-ID databases have been relatively successful in estimating population sizes of reef manta rays, which often have known home-ranges, population estimates based on photo-ID databases have been less useful for oceanic manta rays, which have a widespread distribution. In regions where photo-ID databases exist for oceanic mantas, such as Ecuador, Indonesia, Mozambique and Mexico, the number of identified individuals in each region ranges from about 100-800 (Graham et al., 2008; Marshall et al., 2011; Heinrichs et al., 2011), while surveys of oceanic manta ray fisheries estimate over 1,000 individuals being caught per year in Sri Lanka (Fernando & Stevens, 2011), and over 1,300 per year in Indonesia (White et al., 2006; Heinrichs et al., 2011). Significant fisheries are also known to exist in India (Raje et al., 2007), Peru, and China (Heinrichs et al., 2011). To date, all manta ray fisheries have been found to target oceanic manta rays, suggesting the need to focus on this species as opposed to the more resident and less-threatened reef manta ray.

Demand for manta and mobula gill rakers has been increasing in the last decade in Traditional Chinese Medicine practices. Used in a pseudo-remedy called 'Peng Yu Sai,' manta gill rakers anecdotally boost the immune system and help 'purify the body' by reducing toxins, fevers, and enhancing blood circulation (Heinrichs et al., 2011), although this is medically unproven. Gill rakers are sourced from regions such as Sri Lanka, Indonesia, East Africa and India, dried, and shipped to China where they are sold in retail dried-seafood markets. Based on interviews with fishermen, middle-men and retailers, conservation organizations have suggested that gill rakers travel from source to sale-point through the same networks as shark fins, and may have been obtained and sold opportunistically as a result of reduced availability of shark fin supply (Heinrichs, pers. comm.). The gill raker trade has resulted in targeted fisheries for manta rays in regions where they have historically been caught only as opportunistic bycatch or in small-scale, artisanal fisheries, leading to increasing pressures on manta ray populations and, in many regions, evidence of population declines (Notarbolarto di Sciara, 1995; Homma et al., 1999; Alava et al., 2002; White et al., 2006; Fernando & Stevens, 2011; Marshall et al., 2011; Heinrichs et al., 2011).

Manta rays generate significant revenue in regions where they occur in abundance and dive or snorkel ecotourism has been developed. Individual manta rays have been valued as high as USD $1 million over the course of their lifetimes in ecotourism applications (e.g. Yap, Micronesia, Heinrichs et al. 2011), while the maximum yield from a dead manta for its meat and gill rakers is estimated to be only USD $500 for a fisherman. As such, manta rays have proven to be a significant motivator for marine protected area creation due to their ability to generate tourism revenue and thus support enforcement activities (e.g. UNESCO World Biosphere Reserve, Maldives; Raja Ampat Shark & Ray Sanctuary, Indonesia).

While the conservation status of manta rays has recently been upgraded by the IUCN to Vulnerable, to date minimal research has been conducted on the population size, structure and dynamics of oceanic manta rays. Understanding basic life-history strategies (e.g. migratory routes, trophic level, and feeding & breeding behaviors) and population dynamics (e.g. population size, structure, ranges, connectivity, and gene flow), is absolutely necessary in developing effective conservation strategies that protect the species' critical habitats, food sources, migratory corridors and the animals themselves, while avoiding blanket management techniques that have limited scope and results in application. Furthermore, effective conservation strategies will protect not only manta rays, but also diverse and productive marine ecosystems which might not otherwise be able to financially support management and enforcement initiatives through ecotourism revenues.

Objectives

Photo © Paul Hilton | *Manta Ray of Hope*

Regional fisheries will affect oceanic manta populations very differently if there is a single, mixing, pan-global population, or if there are distinct regional populations with limited connectivity and gene flow. Genetically isolated, regional populations with restricted home ranges would be far more vulnerable to targeted exploitation, as populations would likely be smaller and would not benefit from a regular influx of genetic diversity and mature individuals in the event of depletion. As such, this project aims to evaluate evidence for broad-scale population structure of oceanic manta rays throughout the Pacific and Indian oceans, and identify critical habitats and migratory routes that can be targeted to effectively protect the species.

Two pieces of information currently hint at population structuring in oceanic mantas: 1) our re-analysis of geographically-limited data from a recently published paper on the Manta genus suggests possible geographic population structuring of oceanic manta rays, and 2) personal observations of differing morphology, behavior and symbiotic species in these regions support this theory. Genetic evidence of isolated subpopulations based on a broad and comprehensive sampling strategy would indicate greater vulnerability of regionally distinct populations to exploitation, and would inform regional conservation strategies as well as international agreements and restrictions on manta ray fisheries. Additionally, the identification of regional subpopulations would encourage greater local protection of mantas as an economically important species in local ecotourism applications.

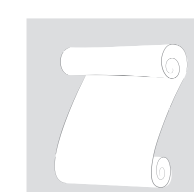
Identify population structure of oceanic manta rays in the Indian and Pacific oceans. We will collect tissue samples from oceanic manta rays at key sites throughout the Indo-Pacific to determine the amount of genetic variation within and between different regions with abundant oceanic manta rays. Variations in DNA sequences will be analyzed to indicate if distinct subpopulations exist, the extent of these subpopulations in relation to ocean basins and important geographic features, and the amount of genetic flow between subpopulations.

Identify migratory corridors, critical habitats, and geographic range of oceanic manta subpopulations, as well as extent of connectivity between subpopulations. Using satellite telemetry, we will remotely track oceanic manta rays from research locations throughout the Indo-Pacific to identify regional productivity hotspots and other critical habitats that manta populations are using. Satellite tracks analyzed in conjunction with sea surface temperature and primary productivity maps will indicate regions and key oceanographic features that oceanic manta rays use or visit, such as coastal upwelling areas, high-productivity regions, seamounts and islands (e.g. cleaning stations). Analyzed in conjunction with genetic data, telemetry will indicate the geographic extent of subpopulations and geographic connectivity between populations, explaining the presence or absence and degree of genetic flow. Migratory corridors and important oceanographic features frequented by manta rays can then be used to develop effective ecosystem-based management strategies for the species.

Identify trophic level and resource use through stable isotope analysis. Using the same tissue samples collected from research sites for genetic analysis of population structure, we will analyze stable isotope ratios as indicators of resource use and trophic level. Differences in resource use between research sites will be used as further indicators of population structuring, and can be used to determine what habitats oceanic mantas forage in (e.g. pelagic vs. benthic; offshore vs. near-shore; high latitudes vs. low latitudes). Stable isotope data will be used to further analyze satellite tracks to determine the importance of regions with high-visitation (e.g. identify foraging areas, cleaning stations, migratory routes, and possible breeding grounds or mating areas). Furthermore, we will analyze the trophic level of oceanic manta rays to determine their role in marine ecosystems and intrinsic value to marine food webs.

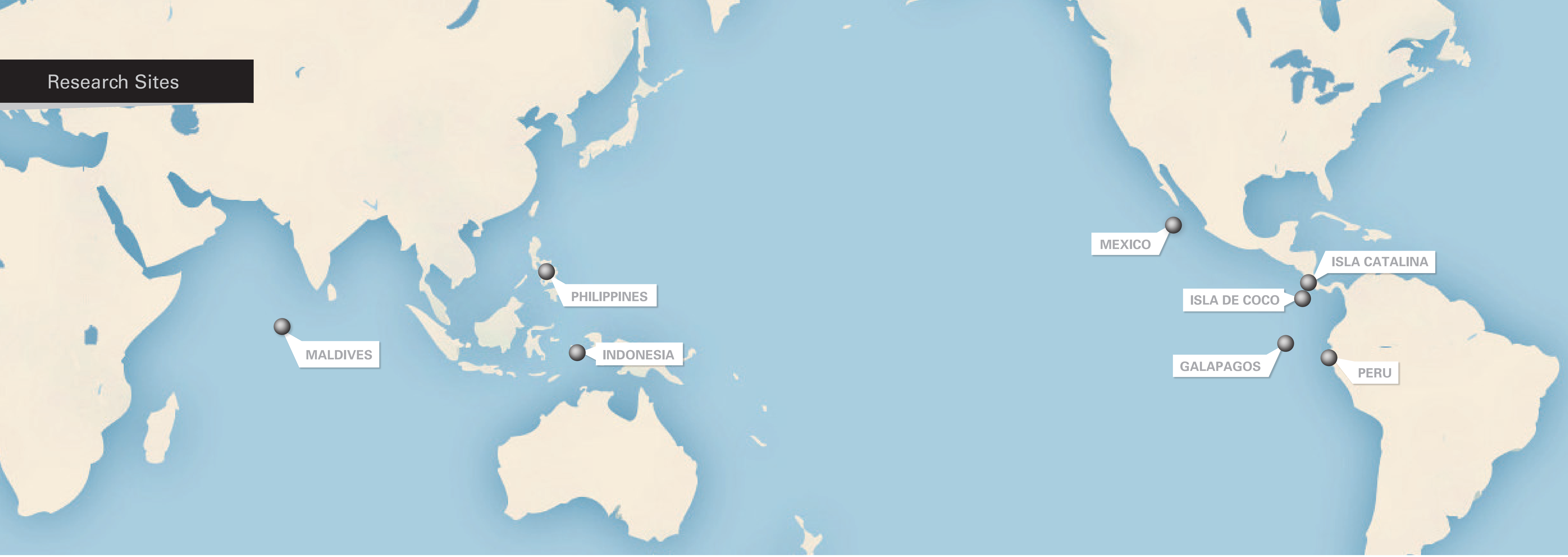
Develop conservation strategies for oceanic manta rays. Based on our findings of the regional extent of oceanic manta populations, we will determine how vulnerable the species is to regional fisheries pressures. Smaller, genetically isolated subpopulations would be far more susceptible to overexploitation due to low reproductive rates, while a global, mixing population may be more resilient to anthropogenic impacts. The identification of population structure throughout the Indo-Pacific will improve the accuracy of population estimates conducted locally by determining the geographic range of populations. Improved accuracy of population estimates will allow fisheries pressures to be quantified, and will support impact assessments of regional targeted fisheries.

Additionally, we will use satellite tracking data and stable isotope ratio results to determine critical habitats, migratory corridors and other important habitats or regions that can be targeted to protect critical life-history stages of the species. Protection of these regions will also benefit a diversity of species that may not otherwise receive protection due to their limited application in ecotourism or commercial fisheries. This has the potential to benefit species with minimal economic value, but which play an important role in the local marine ecosystem and thus have a high intrinsic value.



Encourage local, regional and international protection for oceanic manta rays. Working with our global and local conservation partners, we will disseminate the results of our study to governments and international conservation and management agencies to support policy protecting oceanic manta rays. Special focus will be given to the value of manta rays in ecotourism applications as compared to the cost of management and enforcement.

Research Sites



Oceanic manta rays are often difficult to find reliably, making in-situ research efforts difficult. For this study, global oceanic manta aggregation sites have been selected to enable sufficient sample sizes for population and spatial ecology studies.

SOUTHERN MALDIVES.

The Maldives is considered one of the most reliable locations to see reef manta rays, with perhaps the largest population in the world (estimated >5,000 individuals). A unique feeding aggregation of reef manta rays found in Hanifaru Bay has resulted in the creation of a UNESCO World Biosphere Reserve, and the Maldives has banned the export of any shark and ray products due to the high value of elasmobranchs in dive and snorkel ecotourism applications (USD $8.1 million per year from manta rays alone; Anderson et al., 2010). While reef mantas are seen throughout the country, oceanic mantas are most often observed in the southern atolls. Reports from dive operators have suggested the possibility of breeding aggregations of oceanic manta rays, indicating that the Maldives may be a critical location for the oceanic mantas in this region. The neighboring country of Sri Lanka has one of the most extensive fisheries for oceanic manta rays and mobula rays in the world, which may also be severely impacting the population found in the Maldives. Almost all of the oceanic mantas found in markets in Sri Lanka are juveniles, suggesting there may be a nursery ground for the species in the region. Because it is almost impossible to find live manta rays in Sri Lankan waters, the mantas found in the Maldives provide a critical opportunity to study the population and determine the impacts regional fisheries may be having.

MALAPASCUA ISLAND, PHILIPPINES

Malapascua Island is well known for its ecotourism industry surrounding thresher sharks, but oceanic manta rays are also regularly sighted around the island. There is great potential for developing the oceanic manta ecotourism focus on Malapascua and encouraging marine protected area creation in the region. Manta ray fisheries exist in the Bohol Sea, Philippines, south of Malapascua, which likely threaten the local oceanic manta population.

RAJA AMPAT, INDONESIA

Raja Ampat is considered by many to be the most biodiverse marine region in the world, with 1,309 documented species of fish and 537 species of coral. The Raja Ampat region has been declared a shark and ray sanctuary by the local government, banning any fishing of elasmobranchs within a 17,000 mi² area. However, some illegal fishing targeting elasmobranchs is still observed in the region, and marine protected areas protecting reef habitats have largely been developed by private interests and NGOs. Raja Ampat is unique in that it is one of only two areas in the world where both oceanic and reef manta rays can be observed together at sites such as cleaning stations. In addition, the lack of overlap of oceanic manta photo-ID databases from sites only 100 miles apart has sparked questions about the possibility of fine-scale population structuring of the species in the region.

REVILLAGIGEDO ARCHIPELAGO, MEXICO.

The Revillagigedo Archipelago is a group of four islands that lie approximately 400 miles southwest of Baja California. In 1994 the archipelago was declared a Mexican Biosphere Reserve to protect both a number of endemic terrestrial species, as well as the diverse and healthy marine ecosystems of the islands. These islands attract oceanic manta rays seasonally from October through April every year, which are protected both by the biosphere reserve and by Mexican law prohibiting the catch of manta and mobula rays. Mantas visit cleaning stations near the islands, where they have parasites removed by Clarion Angel Fish and other commensal reef fishes. The Revillagigedo Archipelago is known for providing intimate encounters with oceanic manta rays, and as such has become a popular dive destination focused around manta dive tourism. A recent report estimated the value of manta ray tourism in the archipelago at USD $5 million. The archipelago is on the northern boundary of where oceanic mantas are seen frequently in the eastern Pacific, making it an important research site for identifying population structure and movements of oceanic manta rays in the region.

ISLA CATALINA, COSTA RICA.

Isla Catalina has large seasonal aggregations of oceanic manta rays. The island is just offshore in northern Costa Rica, and is perhaps the only reliable location in Central America to see oceanic manta rays on the Pacific coast, making it an important site in determining the connectivity of oceanic manta ray populations along the west coast of the Americas. Some diving tourism exists in the region, and there is potential to develop manta ray ecotourism around Isla Catalina, as well as the creation of MPAs that can be supported by ecotourism revenues.

ISLA DE COCO, COSTA RICA.

Cocos Island lies approximates 340 miles off the coast of mainland Costa Rica. Because of its importance to a number of large, pelagic marine species, Cocos Island was declared both a Costa Rican National Park, and a UNESCO World Biosphere Reserve. While Cocos Island is well known for its diversity of shark species, including schooling scalloped hammerheads, oceanic manta rays are also frequently seen around the island.

GALAPAGOS ISLANDS, ECUADOR.

Protected by an extensive marine reserve of approximately 51,000 mi², the Galapagos Islands are recognized as one of the world's most diverse and unusual marine regions. The Galapagos Islands are a UNESCO World Biosphere Reserve, but have often been the subject of controversy due to illegal fishing and other anthropogenic pressures both on terrestrial and marine ecosystems. Oceanic manta rays are seen frequently in the Galapagos, particularly near the northern islands of Darwin and Wolf.

NORTHERN PERU.

Just south of the Ecuador-Peru border, in the towns of Tumbes and Piura, local artisanal fisheries exist for manta and mobula rays. The meat is used in a local dish, and to date evidence of targeted fisheries for manta and mobula gill rakers has not been observed. Large local aggregations of manta rays are expected in the area, similar to those found just north in Ecuador. The region has excellent potential for developing manta ray ecotourism, which would provide an alternative economic source of revenue for manta rays. Local protection of manta rays and MPA creation also has great potential if ecotourism development is successful.

Methodology

Photo © Guy Stevens | *The Manta Trust*

Tissue Samples

Tissue samples will be collected from oceanic manta rays encountered on research dives at the locations above using custom-made biopsy tips on a Hawaiian-sling-style spear pole. Biopsy tips have been tested during fieldwork in Indonesia with a 100% success rate in collecting sufficient tissue for both DNA and stable isotope analyses. Oceanic manta rays frequently receive bites from triggerfish and other reef fish during visits to cleaning stations, and large shark bites on pectoral fins have been observed to heal almost completely within a matter of years (observed in photo ID databases in the Maldives). As such, small tissue biopsies (<1 ml) do not present concerns for the long-term wellbeing or survival of individual manta rays. In research areas where manta ray fisheries exist, tissue samples will be collected from fish markets in addition to in-water collection from live specimens. Tissue samples will be collected from at least 30 individuals at each research site to ensure sufficient sample sizes to detect genetic variation both within and between regions.

Satellite Tagging

Wildlife Computers Satellite Pop-off Archival Tags (PAT Mk10) will be used to remotely track oceanic manta rays. PAT tags collect temperature, depth, and light data and estimate latitude based on day length, and longitude based on sunrise and sunset times. As manta rays do not break the surface for long enough to regularly transmit data to ARGOS satellites, we have selected archival tags for this study, which store the data noted above until a predetermined pop-off time. At the end of the deployment, tags float to the surface and broadcast data to ARGOS satellites. Satellite tracks will be analyzed using 'R' software with the KFTrack analysis package in conjunction with sea surface temperatures and primary productivity maps.

DNA Analysis

Tissue samples will be analyzed at Scripps Institution of Oceanography. Mitochondrial gene ND5 will be sequenced from all individuals and used as the primary indicator of population structure. Microsatellites will also be used to analyze variation and to determine differences in population structuring between females and males (e.g. increased philopatry in females). Variation within and between regions will be analyzed using FST tests.

Stable Isotope Analysis

Tissue samples will be prepared and analyzed at Scripps Institution of Oceanography. Carbon 13 and Nitrogen 15 stable isotopes ratios will be examined. Carbon 13 isotopes will be used as an indicator of foraging grounds and feeding behaviors based on predictable regional C13 signatures (e.g. pelagic vs. benthic; onshore vs. offshore; high latitude vs. equatorial), and differences in C13 ratios between populations will be used to indicate differences in critical feeding grounds between regions, and thus as a further indicator of population structuring. N15 isotopes will be analyzed to determine the trophic level of sampled individuals, further indicating possible food sources (e.g. zooplankton vs. fish eggs) and differences in feeding behavior between regions. In short, C13 signatures will indicate if different populations are feeding in different locations or habitats, while N15 signatures will indicate if they are feeding at different trophic levels.

Anticipated Outcomes

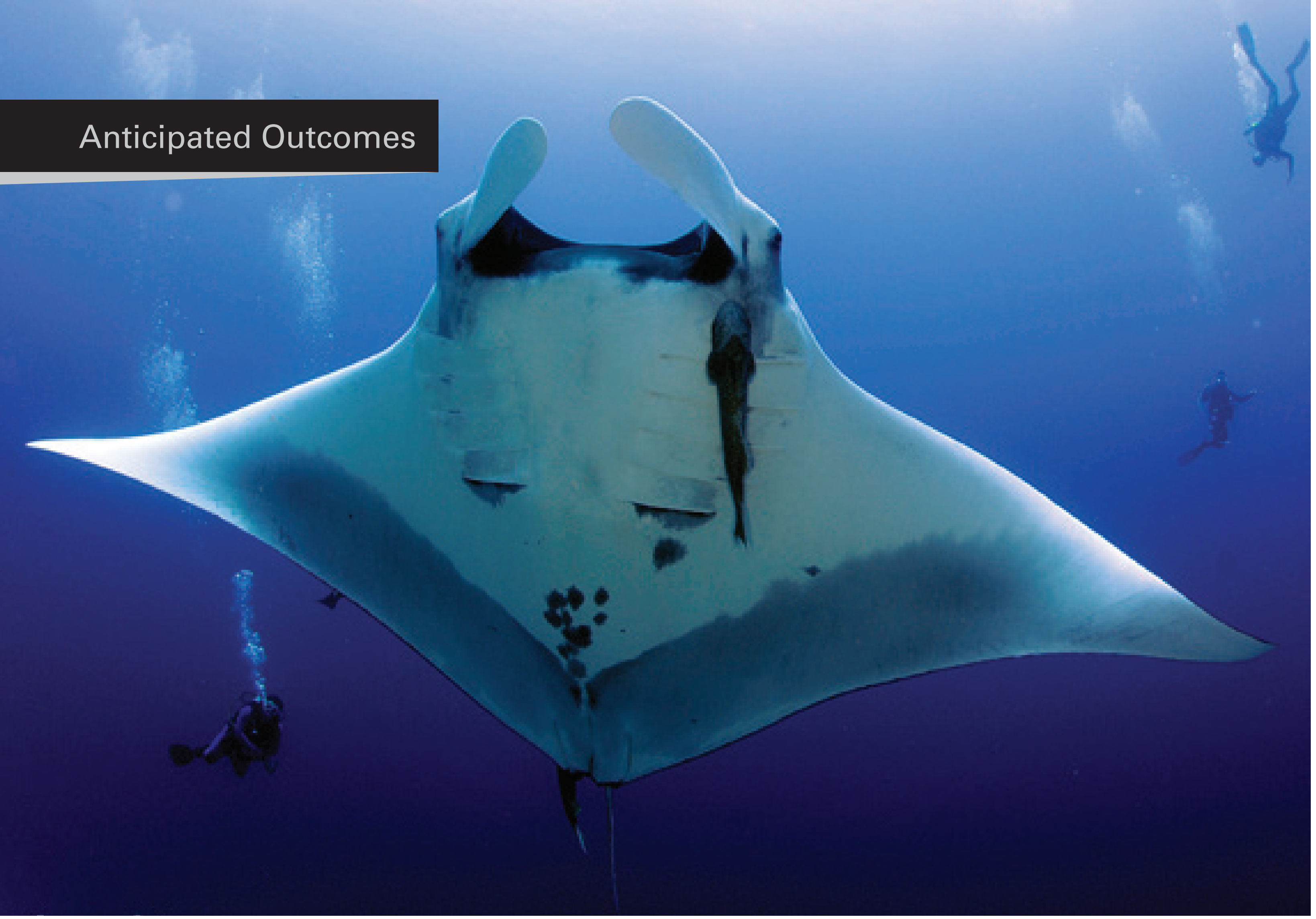


Photo © Guy Stevens | *The Manta Trust*

- **Identification of regional subpopulations of oceanic manta rays.** Given the large geographic distribution of oceanic manta rays and preliminary evidence, we anticipate the findings of our genetic study will indicate strong geographic population structuring of the species throughout the Indian and Pacific oceans. Understanding the range and extent of these subpopulations will be a critical first step in developing population size estimates, measuring the impact of fisheries on these populations, and determining sustainable catch rates or fisheries bans to prevent population decline.

- **At least 5 scientific publications in peer-reviewed journals.** The results of this study will be published in high-impact journals on the following topics: (1) Genetic evidence of population structuring of oceanic manta rays in the Indo-Pacific; (2) Foraging ecology of oceanic manta rays in the Pacific and Indian oceans; (3) Dietary variation in oceanic manta rays from the eastern Pacific, western Pacific, and Indian oceans; (4) Geographic range of oceanic manta ray subpopulations based on satellite telemetry; (5) Management strategies for oceanic manta ray populations.

- **Development of comprehensive conservation and management strategies.** Based on our findings of population structure, spatial ecology and foraging ecology we will develop conservation strategies at local, regional and international scales. Based on our genetic findings we will identify genetically isolated subpopulations that are more vulnerable to fisheries and less likely to benefit from reestablishment in the event of population depletion. These vulnerable populations will be highlighted for special protection and management, while the effects of fisheries will be assessed for all identified regional subpopulations. Satellite tag data and stable isotope analyses will be used to identify critical habitats such as foraging grounds, breeding areas and migratory corridors. Management strategies will be developed to protect oceanic manta rays in these regions and habitats, such as bans on fishing techniques that have high rates of manta ray bycatch (e.g. gill net fisheries), as well as bans on targeted fisheries for manta rays. These management strategies would have significant positive effects on reducing targeted and indirect catch of manta rays, as well as reducing pressures on the local ecosystem.

- **Development of manta ray ecotourism industries at new sites or regions.** We anticipate satellite telemetry and fieldwork will identify new sites where ecotourism can be expanded to financially support management and enforcement efforts. Oceanic manta ray aggregation sites are typically associated with cleaning stations, and research sites often overlap with popular tourist destinations for manta ray ecotourism. In regions such as northern Peru where manta ray dive tourism is not yet popular, we will work with local dive operators and our conservation partners to develop sustainable and responsible ecotourism at sites we identify over the course of this research. Revenues from new and existing ecotourism can then be applied to management and enforcement of conservation policies.

- **Increased local protection for manta rays based on ecotourism value of regional populations.** We anticipate that in many cases we will find subpopulations of oceanic manta rays that remain within the Exclusive Economic Zone (EEZ) of a single or several countries. When combined with the high value of manta rays to ecotourism, the presence of local populations that can be managed locally or regionally on a small scale provides incentive for investment in conservation and the enforcement of management strategies. Investment in protection makes far more economic sense if the population in question can be shown to remain within a single management jurisdiction, rather than entering regions where it is susceptible to fisheries after a significant investment has been made in its local protection. In regions with resident reef manta ray populations that generate high ecotourism revenues, management action has often followed. For example, in the Maldives (USD $8.1 million/year in manta ray tourism revenues; Anderson et al., 2010) shark and ray exports are banned as a result of the value of these species to ecotourism. Hanifaru Bay, arguably the most popular site in the Maldives for tourists to see manta rays, was declared a UNESCO World Biosphere Reserve in 2011 due largely to a unique feeding aggregation of manta rays. In West Papua, Indonesia, a shark and ray sanctuary has been declared in the Raja Ampat marine region as a result of shark and ray tourism; in large part to protect two resident populations of reef manta rays. We anticipate that similar management action will result from the identification of local or regional populations of oceanic manta rays.

- **Increased local protection for marine communities with less economic importance.** Because manta rays are highly-susceptible to bycatch through fishing techniques such as the use of gill nets, we anticipate that the protection of critical manta ray habitats through fishing restrictions or marine protected area development will have dramatic positive impacts on a variety of other marine species and ecosystems. Banning destructive fishing practices to reduce bycatch of manta rays will also reduce the targeted catch of numerous pelagic fishes and other species such as marine mammals and turtles that would not otherwise receive targeted conservation and management attention due to their limited value in ecotourism applications and ability to generate revenue outside of fisheries. As such, we envision manta rays as a flagship species for marine conservation that can be used to inclusively protect ecosystems or species that have high intrinsic value but low economic value outside of fisheries.

- **Validation and expansion of current marine protected area expenses based on revenue generated by manta ray tourism.** Much of this research will be conducted in regions where marine protected areas have already been implemented to benefit manta rays and other marine species and habitats. The identification of oceanic manta ray subpopulations, and the geographic extent and critical habitats of the species that are covered by MPAs will validate current management efforts and expenses. We anticipate that in many cases our findings will also encourage expansion of current marine protected areas or policies to develop comprehensive protection of this economically valuable species.

- **Create a baseline for the genetic study of manta gill rakers in Asian markets.** Based on the identification of regional subpopulations of oceanic manta rays, we will develop a genetic map linking certain genetic signatures to certain geographic regions. It will then be possible to conduct genetic analyses of oceanic manta gill rakers available in dried-seafood markets throughout Asia that would indicate where the majority of gill rakers in retail markets are being sourced from. Firm evidence linking the volume of gill rakers with specific geographic regions would then allow us to determine where fisheries pressures are greatest, without relying solely upon information collected through interviews with gill raker traders. Based on this information, further conservation and management recommendations could be developed to protect regional populations under greater fisheries pressures.

- **Develop a model for studying other widely-dispersed marine pelagic megafauna.** The methods developed for this study will not only be applicable to oceanic manta rays. The population structure of many marine species is poorly understood, and we plan to develop a rapid-assessment protocol to study the structure, demography, spatial ecology and conservation considerations for wide-ranging, pelagic marine species currently under threat from anthropogenic pressures.

Anticipated Outcomes By Region

Southern Maldives.

While manta ray ecotourism in the Maldives is well developed, it is focused largely around reef manta rays. By identifying critical habitats such as cleaning stations throughout the Maldives that are visited by oceanic manta rays, we will encourage the development of ecotourism focused on oceanic mantas. We will work with our local conservation partners to encourage the protection of these critical habitats, leading to increased protection of diverse reef ecosystems throughout the country. We will determine the geographic extent of the oceanic manta population that is found in the Maldives, indicating if the population is being impacted by targeted oceanic manta ray fisheries in neighboring Sri Lanka and India.

Malapascua Island, Philippines.

We will identify the spatial ecology of oceanic manta rays that visit Malapascua and other islands of the Philippines, and how this population relates to oceanic manta rays in nearby regions such as Thailand and Indonesia. We will assess the impact of manta ray fisheries in the Bohol Sea, Philippines, and how it might affect the oceanic manta population of the Philippines. We will work with local contacts to expand the ecotourism industry on Malapascua, which already exists for thresher shark diving, to include oceanic manta rays and encourage local protection of the species, which can be supported by ecotourism revenues.

Raja Ampat, Indonesia.

We will identify the spatial ecology of oceanic manta rays in the Raja Ampat marine region and how this population relates to oceanic manta rays in neighboring regions such as Thailand and the Philippines. We will determine if current MPAs such as the Raja Ampat Shark & Ray Sanctuary are sufficient for the local protection of this population, or if protection measures need to be expanded. We will assess the potential impact of manta fisheries in other regions of Indonesia, such as Lombok, on the oceanic manta ray population in Raja Ampat. We will identify the geographic extent of the oceanic manta population in Raja Ampat and determine the best strategy for managing the species throughout the Indonesian Archipelago, a region that presents unique challenges to managing marine species due to its size and diversity. Working with our conservation partners, we will push for the national protection of oceanic manta rays based on their high value to ecotourism in regions such as Raja Ampat, and encourage the development of manta ecotourism industries in regions where the only economic value of the species is currently in fisheries.

Revillagigedo Archipelago, Mexico.

We will determine the geographic extent of the population of oceanic manta rays found in the Revillagigedo Archipelago, validating the Biosphere Reserve as a critical step in protecting the species and indicating where further protection would be beneficial to the species (e.g. expansion of the reserve, specific fishing bans in adjacent regions). The degree of connectivity between the oceanic mantas from the archipelago and other sites in the eastern Pacific such as Cocos Island, the Galapagos Islands, and mainland Costa Rica, Ecuador and Peru will also be identified, indicating if larger-scale protection measures are necessary. Identifying the extent of the local population will also allow for more conclusive population estimates that will in turn allow for the assessment of the impact of incidental bycatch on oceanic manta rays in the region.

Isla Catalina, Costa Rica.

This study will identify the importance of Isla Catalina to the regional oceanic manta population, while encouraging ecotourism focused on oceanic manta populations. Seasonality of manta ray aggregations will be identified through satellite telemetry, providing detailed information that will assist with the growth of sustainable manta ray dive tourism in the region. Working with our local conservation partners, we will encourage the creation of a protected area that is supported through ecotourism revenue, and that recognizes the importance of Isla Catalina to the local or regional oceanic manta population.

Isla de Coco, Costa Rica.

We will determine the degree of connectivity between oceanic manta rays observed at Cocos Island and on mainland Costa Rica, and identify the importance of Cocos to oceanic mantas in the region (e.g. cleaning station, feeding area). This will increase the value of the Cocos Island MPA to the local marine ecosystem as well as reinforcing its importance to regional pelagic species such as oceanic manta rays.

Galapagos Islands, Ecuador.

We will identify the importance of the Galapagos Islands to local or regional populations of oceanic manta rays (e.g. cleaning station, feeding area), adding value to the extensive MPA around the islands and possibly encouraging greater enforcement of fishing restrictions. We will also determine if there is a link between the oceanic manta rays observed in the Galapagos and on the coast of mainland Ecuador, indicating the possible need for the protection of pelagic migratory corridors.

Northern Peru.

We will identify the extent of the oceanic manta population in Peru and its possible connection to oceanic manta rays observed in Ecuador and the Galapagos Islands, determining if protection of this population will require regional agreements between multiple countries. We will identify local aggregation sites in northern Peru that can be developed as ecotourism attractions and which warrant special protection in the form of MPAs and fishing bans. We will work with our local conservation partners to develop the ecotourism industry and encourage the creation of protected areas. By identifying the geographic extent of the population of oceanic mantas in Peru, we will enable accurate population estimates that will indicate the impact of local fisheries for mantas on the local or regional population. We will then develop conservation strategies to prevent population decline of the species in this region.

Budget & References

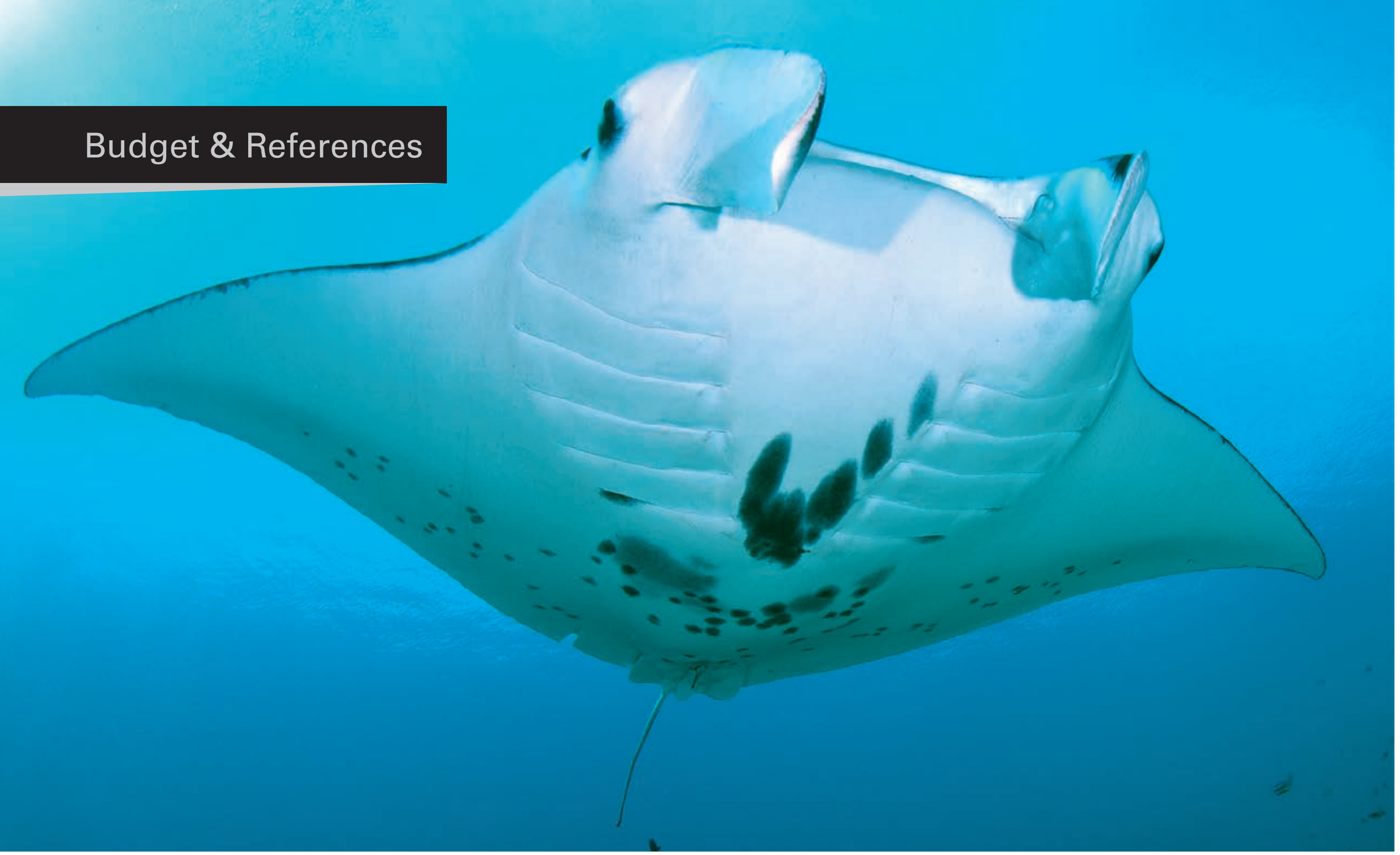


Photo © Mary O'Malley | *Manta Ray of Hope*

Full Project Budget	Satellite Tagging	DNA Analysis	Stable Isotope Analysis	Field Expenses	Boat Costs	Supplies	Outreach Costs	Region Total
Revillagigedo, Mexico	$132,000.00	$3,000.00	$3,000.00	$8,000.00	TBD	$1,250.00	$5,000.00	$152,250.00
Isla Catalina, Costa Rica	$132,000.00	$3,000.00	$3,000.00	$12,000.00	$8,000.00	$1,250.00	$5,000.00	$164,250.00
Cocos Island, Costa Rica	$132,000.00	$3,000.00	$3,000.00	$10,000.00	TBD	$1,250.00	$5,000.00	$154,250.00
Galapagos, Ecuador	$132,000.00	$3,000.00	$3,000.00	$12,000.00	TBD	$1,250.00	$5,000.00	$156,250.00
Northern Peru	$132,000.00	$3,000.00	$6,000.00	$12,000.00	$8,000.00	$1,250.00	$5,000.00	$167,250.00
Raja Ampat, Indonesia	$132,000.00	$3,000.00	$3,000.00	$16,000.00	$3,000.00	$1,250.00	$5,000.00	$163,250.00
Malapascua, Philippines	$132,000.00	$3,000.00	$3,000.00	$14,000.00	$2,000.00	$1,250.00	$5,000.00	$160,250.00
Southern Maldives	$132,000.00	$3,000.00	$3,000.00	$14,000.00	$5,000.00	$1,250.00	$5,000.00	$163,250.00
Project Total	$1,056,000.00	$24,000.00	$27,000.00	$98,000.00	$26,000.00	$10,000.00	$40,000.00	$1,281,000.00

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