Photo-Identification of the Manta Ray, Manta birostris, in the Revillagigedo Islands, Mexico.

Kumli, Katherine R.; Rubin, Robert D., Oct 2011

Santa Rosa Jr. College, Santa Rosa, California U.S.A.

Abstract:

Photographic samples have been obtained for a population of oceanic manta rays (Manta birostris) from the past three decades. Based on differences in color and marking pattern we have established the presence of two forms, referenced here as chevron and black morphs. Chevron and black animals compose 72.4 and 27.6% of the known population and do not differ significantly in either size or sex ratio. Unique markings occur in individuals of both morphs and do not appear to change over time. The use of a four-point grid matching technique of the ventral surfaces has allowed identification of 369 individuals to date. One hundred and twenty-one (32.8%) animals have been resighted and a single individual has been seen eighteen times. Thirteen individuals are known for periods of between fifteen and nineteen years. The intervals between resighting range from one to 15.4 years. Nine individuals have exceeded ten years (mean = 13.0) between sightings, suggesting that the population is temporally and perhaps spatially broad. Females represent 50.8% and males 49.2% of the sexed individuals (n= 185). The known population consists primarily of immature males and mature females, only two of which have been perceptibly pregnant. Neonates are not known. Individuals (n=34) travel between the three most proximate islands, of which two are known both from the Revillagigedos and Isla Cerralvo, suggesting that the range of this population extends into the Gulf of California. These findings, coupled with the protective status of the Revillagigedos and the decline of manta rays in the Sea of Cortez have important conservation implications.

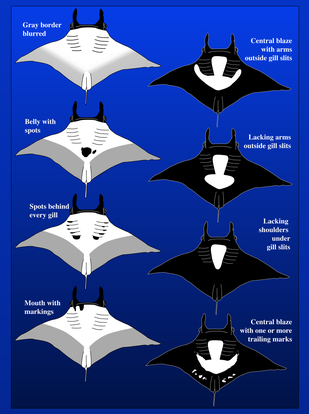
Chevron & black morphs

This population contains animals of two distinct morphs: black and chevron. Black mantas have a completely black dorsal surface, while chevron mantas' dorsals are black with three white features: shoulder epaulets, wingtips, and the chevron in front of the dorsal fin. The ventral surfaces of both morphs, shown below, are used for identification purposes due to lack of variation in the chevron dorsal markings, and uniformity in the black dorsals. Chevron dorsals are used to distinguish between populations of mantas, described in the third section of this poster.
Chevron mantas' ventrals have a wider diversity of physical features than those of the black mantas, hence we match each morphs by different criteria: chevron mantas by four features, and black mantas by three variations of the major mark, plus variation in a second feature.

Four-point matching technique, chevron mantas:

The figure on the right shows four ventral surface features used to categorize chevron mantas. Photographs of individual animals are visually compared and matched using natural variation in contours of the coloration pattern within each of these features.

1. Posterior margin: a gray border of uniform width, banding the span of the trailing edge of the disc from the posterior edge into the white belly region.
   - Presence of clear demarcation line
   - Absence of clear demarcation line (blurred transition from gray to white)
2. Belly: an area between the last gill openings and leading edge of the posterior margin, with dark spots on a white background.
   - Presence or absence of markings
   - Markings separate or overlapping
   - Number of distinct spots in the grouping
3. Gill slits: dark irregular markings that extend back from gill slits.
   - Number of gill slits with marks
4. Mouth: region beneath ventral mouth, outlined by dark margin.
   - Trailing peninsula(s), continuous with mouth band
   - Separate markings, discontinuous with mouth band
   - Smudges without clear demarcation lines



Four-point matching technique, black mantas:

The figure on the left shows the features used to categorize black mantas: one major mark with treee variations, and one other feature in which variability occurs.

Black mantas' major mark is a central white "blaze" between the gill slits, generally with "arms" extending forward around the lateral edge over "shoulders". The white areas may contain distinct black spots. Photographs of individual animals are visually compared and matched using the natural variation in contours of the coloration pattern of the blaze within each of these features.

1. Three variations in the major mark used to categorize black mantas:
   A. Two arms contiguous with blaze.
   B. Blaze lacking arms. The blaze extends laterally under the gill slits but does not continue forward.
   C. Blaze lacking both arms and shoulders. The blaze does not extends laterlly under the gill slits.
2. White trailing markings following the blaze, often parallel to the trailing edge of the pectoral fins.

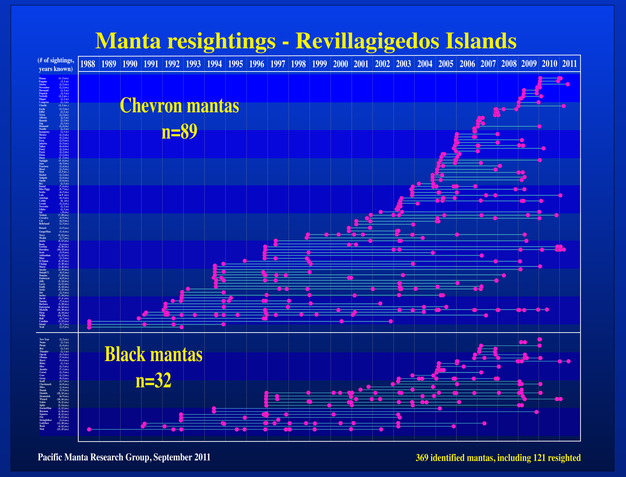
Resighting patterns of individual mantas

In the figure to the right, resighted animals are arranged by morph and date of first sightings. Of 369 identified mantas from this region, 121 (34%) have been sighted more than once: 89 chevrons (72.6%) and 32 black mantas (26.4%). Each point represents a single sighting of the animal named on its left. Horizontal blue bars underneath the points indicate the amount of time the animal is known. Each year is scaled to 12 months in order to represent the sequence of sightings with visual accuracy, permitting comparison between individuals.

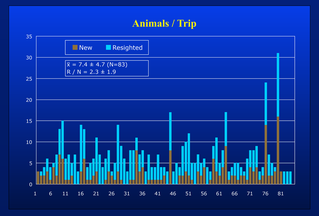
Safe boating season in the Revillagigedos runs from November through May. Sightings dated by year exclusive of month are placed at July 15 to avoid the temptation to assign the sighting to the season ending in the spring or beginning in the fall.

Notice the long intervals between sightings of some mantas, whereas others are sighted more frequently.

Image collection methods are entirely opportunistic, with photographers offering collections to us as they hear of our work. Currently two dive boats are operating in the area, incleasing the rate of collection since fall 2004.



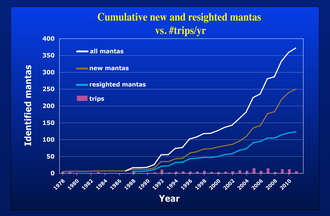
Population trends



The figure above depicts 83 trips in which three or more mantas were sighted and identified. Each vertical bar represents a single trip, with the y-axis showing the number of mantas sighted. Sightings of animals which have to date been seen only once are depicted in brown (N=248), sightings of resighted animals N=121) are in blue.

Illustrated here are 814 sightings, of which 548 (67.3%) are of the 121 resighted animals.

Compare this figure, which represents sightings, with that to the right, which represents individual animals.

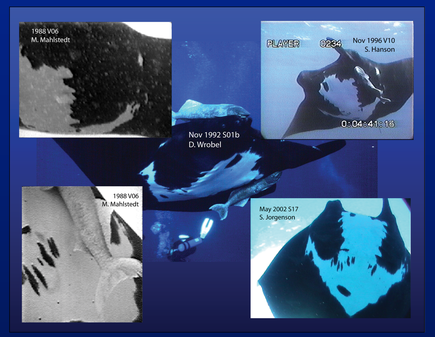


The figure above compiles trips and mantas by year. The pink bars indicate the number of trips reporting to us each year. The white curve represents the cumulative number of mantas known at the close of the year, with the number of new animals in brown, resighted animals in blue.

Notice the sharp increase in the number of new mantas from 2002-2005, corresponding with a plateau in resighted mantas.

Compare this figure, which represents animals, with the one to the left, which represents sightings.

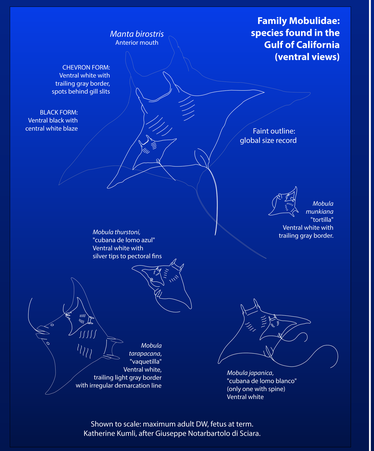
Temporal stability of markings



Black manta Nick has been sighted 12 times since 1988. This is the only animal in the population to have lost a cephalic fin, which serves as an unfortunate but unmistakable verification of identity apart from the coloration pattern.

Note that swimming distorts the body into a non-planar posture, resulting in a visual repositioning of markings. Therefore accurate photographic analysis requires a comparison of markings in more than one feature.

Manta vs. Mobula: body plan



Shown to scale: maximum adult DW, fetus at term.
Katherine Kumli, after Giuseppe Notarbartolo di Sciara.

A working hypothesis: Biogeographical Morphology

Based on our observations and those made by colleagues working in different systems, we find that distinct geographical populations of manta rays can be separated on the basis of differences in coloration pattern and adult body size.

Chevron morph variations:

As a member of the subclass Elasmobranch, the rate of evolutionary change in mantas is very slow. Worldwide the chevron morph appears to be the single pattern type of most populations. Figure 1 compares the dorsal surface of this morph from three different geographical locations: *Manta birostris* of Revillagigedos (Sub tropical Eastern Pacific); two groups of *Manta alfredi*: Yap Island (Tropical Western Pacific, and the Maldives (Tropical Indian Ocean), where researchers have maintained long-term photographic records. With some limited variation, each pattern is geographically specific. Well-defined differences can be observed in:

- shape, orientation and outline of "shoulder" patches.
- presence of white in "wing" tips and trailing edge of dorsal fin.
- shape and extent of chevron ("V" at the anterior margin of dorsal fin).
- presence of white "dots" and streaks between "shoulder" patches.

Black morph variations:

The black morph (fig. 2, bottom) is well-established in the subtropical regions of the Gulf of California, the Tres Marias (Mexico) the Revillagigedos, and Cocos (Costa Rica), where they occur together with the chevron form; each of these populations is *Manta birostris*. In the latter two locations black mantas occur in a 1:3 ratio and do not differ in size or sex when compared to chevron forms. Their occurrence is known elsewhere. It is interesting to note that this distribution coincides with colder, oceanic islands that lack coral reef systems and are potentially richer in nutrients and zooplankton.

Figure 1

Figure 2

Body size/sexual maturity:

A comparison of body size suggests that mantas from tropical coral reef habitats (*Manta alfredi*) are smaller in size (disc width) than animals from more temperate seas characterized by seamounts and deep, rocky reef systems (*Manta birostris*). Moreover, based on clasper size and mating behavior, *M. alfredi* appear to reach reproductive maturity at smaller sizes as well.

- These size differences may be a form of character displacement resulting from differences in nutrient availability or a result of competition with sympatric members of the genus Mobula. It is interesting to note that in the Gulf of California when Manta occurs with four different species of Mobula, a size gradient separates successively larger species by approximately 1.5 body masses. Similar relationships have been shown for cetaceans and pinnipeds. (Rubin, unpublished data), small terresterial vertebrates (Brown, 1973), and African ungulates (Jarman 1974).
- Two photographic images of interest are of a large black manta and a chevron manta (fig 2), both *M. birostris*, taken by Keller Laros and Scott Hanson (unpublished data). Each represents a single event of an animal moving rapidly well beyond the outer reef in the blue water of Kona, Hawaii. In both cases the markings are remarkably similar to the mantas of the Revillagigedos, and the chevron manta (black mantas are not known in Hawaii) varies significantly from the typical Hawaiian coloration of *M. alfredi*. It is possible that there are two ecotypes of Manta, one of which is resident around tropical reefs and another more pelagic (transitory) form that moves across large expanses of open ocean. Similar patterns are known for cetaceans (Bigg, et. al., 1987), and our data supports the possibility of long distance movements by manta rays (Rubin, et. al. 2008).

Literature Cited:

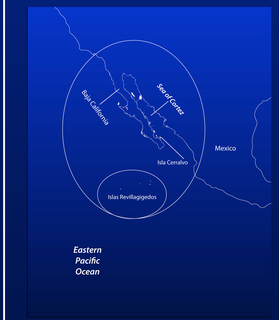
Bigg, M.A., G.M. Ellis, J.K.B. Ford, and K.C. Balcomb. 1987. Killer whales: a study of their identification, genealogy and natural history in British Columbia and Washington State. Phantom Press and Pulls, Nanaimo, BC, Canada.
Brown, J.H. 1975. Geological ecology of desert rodents. In M.L. Cody and J.M. Diamond (eds.), Ecology and evolution of communities. Harvard Univ. Press, Camridge and London.
Jarman, P.J. 1974. The social organization of antelope in relation to their ecology. Behaviour 47-48: 215-265.
Rubin, R.D., G. Chilcott, and K.R. Kumli. 2008. Dive characteristics and movement patterns of acoustic and satellite-tagged manta rays (Manta birostris) in the Revillagigedos Islands of Mexico. Annual Meeting, American Elasmobranch Society. Montreal, Canada.

Geographic region and travel

The Revillagigedo Archipelago, four volcanic seamounts, arise from a depth of approximately 900 meters in the open ocean. Mantas have been sighted at the 3 closest islands, separated by 51 to 133 km. The nearest landmass, the tip of the Baja Peninsula, is 424 km, distant, and Isla Cerralvo, where two mantas were photographed, is 613. km away.

When we began our study, apart from the Mexican Navy which has bases on Socorro and Clarion, only the occasional private recreational boat was to be found in the area, and divers from those boats began our image collection. A commercial dive boat from Cabo San Lucas, the Solmar, began operation in 1992, followed by another from La Paz, the Nautilus Explorer in 2002, after which we began to receive images from a larger number of contributors.

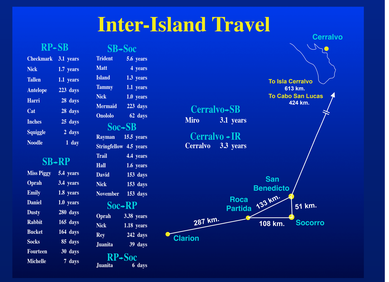
Out of the lanes of commercial shipping, the islands have been the victims of commercial fishing. In 1994, the Mexican government created the Reserva Biosfera Archipiélago de Revillagigedo, extending out 12 nm from each of the 4 islands. This offers a bit of protection - should the offenders be seen - to the mantas that stay home.



Initial analysis suggested that the animals were site-specific for individual islands. An expanded database allowed us to match individuals with more than one island, demonstrating that (with the exception of Clarion, from which we have no data) animals in this population move freely between islands. The figure to the right shows locations, travel distances, and calculated time interval for 24 mantas.

Satellite tagging data collected for two animals in 2003 demonstrated that during a 12-day period one individual traveled 2462 km., and the other 1063 km., between the Revillagigedos and the southern tip of the Baja peninsula (Rubin et. al 2008). Long distance migrations by manta rays have not been documented. As such, these results demonstrate the potential for rapid, long distance movements away from land masses in open water. These findings are particularly noteworthy as they suggest the possibility of a population continuum between the Revillagigedo and the Gulf of California, the latter of which has experienced a drastic decline in manta ray numbers resulting from careless fishing practices.

Inter-Island Travel



Our work began in the late 1970s in the Sea of Cortez when manta rays were frequently encountered around oceanic islands and seamounts. By the mid 1980s mantas were rare, if at all present at these locations. One of us (Rubin) last observed a manta ray inside the Gulf of California in 1986. We hear from time to time of an animal or two sighted in that area.

In 2001 Paul Ahuja photographed two animals from the southern end of Cerralvo Island, which were later matched with photographs of the same individuals, one taken in 2004 by Rey Castillo and the other by Erick Higuera in 2007, both in Revillagigedo.

These two matches establish the exchange between the two locations and as such provides the basis for the reestablishment of a population in the Gulf of California that is on the brink of disappearance. In addition, they define the critical nature of these habitats and underscore the importance of defining manta travel routes, which may serve as significant elements in management and conservation policy development.

Special thanks to all the photographers who have contributed to our database:

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