Mantas of the Maldives
Part 2: Manta populations in the Maldives

By Dr. Anne-Marie Kitchen Wheeler
Project Founder
Manta Ecology Project
Mantas are reported **throughout the Maldives** although there are **few reports from southern atolls**:  
- Thaa,  
- Laamu,  
- Huvadhoo
Mantas Distribution in the Maldives

Sightings correlate with leeside to monsoonal winds
Mantas Distribution in the Maldives

Sightings correlate **with leeside to monsoonal winds**

NORTHEASTERN MONSOON

SOUTHWESTERN MONSOON
Seasonality of manta sightings in the Maldives

Lankan:
East side of Male

Kalhandi:
West side of Ari
Seasonality of manta sightings in the Maldives

**LANKAN:**
East side of Male

**NORTHEASTERN MONSOON:**
No/Few Mantas

**SOUTHWESTERN MONSOON:**
Increasing in number of sightings
Seasonality of manta sightings in the Maldives

**NORTHEASTERN MONSOON:**
Many sightings of mantas

**SOUTHWESTERN MONSOON:**
No/Few mantas

**KALHANDI:**
West side of Ari

![Graph showing manta sightings per month at Kalhahandi](image)
Seasonality of manta sightings in the Maldives

Taking into the account the ratio of surveys between leeward and windward sites:

Leeward: 2674 manta encounters/272 surveys vs.
Windward: 6 encounters/84 surveys i.e. 3.23:1 ratio of surveys):

if the same proportion of leeward and windward surveys were performed the encounter ratio of manta rays leeward side to windward side would be 138:1
Island Mass Effect
(Doty and Oguri 1956; Gilmartin and Revelante 1974; Sengupta and Desa 2001).

- Cross-section of the Maldives plateau (central atolls), to contrast the height of main plateau and depths of seawater to east and west of chain (2000 m+) with the relatively shallow depth (350 m) between chains. Between fringing reefs and islands within the atolls depths are between 30 and 100 m. Some ocean-facing reefs slope gently to 150-350 m, creating a step, before dropping off steeply (Purdy and Bertram 1993).
False colour images showing chlorophyll-a concentrations, estimated from remote sensing data obtained from NASA's ocean colour satellite SeaWiFS.

The datasets used for the study were 9 km, monthly Global Area Coverage (GAC) standard mapped images.

Monthly fields of chl-a were binned to generate seasonal maps of chl-a for the NE monsoon (Dec. 2006 to Mar. 2007), and SW monsoon (June to Sept. 2000).

The images were prepared by Helga do Rosario Gomes and Joaquim Goes (Anderson et al. 2011).
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In Summary:

Manta rays are **typically sighted on the leeside of atolls** to the monsoonal winds.

Sightings are **less predictable during changeover months** as wind strength and direction becomes less consistent.

Sightings are due to the **presence of increased productivity** i.e. presence food Individual mantas are sighted on both sides of atolls in opposite seasons.

It may be deduced that **individual mantas migrate from one side to the other** with changes in monsoonal wind direction.

There are some locations (e.g. Rasdhoo atoll, Addu atoll) where **sightings might not be considered leeward** but these areas are never directly windward for extended periods of time. Addu is also subject to different weather systems as South Indian monsoon is moderated by Equatorial currents etc.
Discovery curve of cumulative number of manta rays seen at both sides of North Male atoll with number of surveys at Boduhithi. A linear regression line forced through the origin indicates that for every 10 surveys at the less visited site of Boduhithi, on average another 27 manta rays are identified as having migrated from the better studied east side.

If the number of surveys at Boduhithi were to equal the number on the east side (192), then the regression predicts that 518 manta rays would have been recorded from both sides of the atoll. Estimated total population of manta rays in North Male to be 537 (SE±53.2) (Kitchen-Wheeler et al. 2012).
North Male movements

If the number of surveys at Boduhithi were to equal the number on the east side (192), then the regression predicts that 518 manta rays would have been recorded from both sides of the atoll. Estimated total population of manta rays in North Male to be 537 (SE±53.2) (Kitchen-Wheeler et al. 2012).
Site affinity and other movements

During the study the **most productive cleaning stations were visited most frequently.**

Range of number of mantas connected with a site is **1 (Helengeli thila) to 604 (Table Thila) animals** (2014 review).
Site affinity and other movements

Re-sightings rate is dependant on survey frequency but in atolls where only one season is well studied (Ari, Baa, Lhaviyani etc.) re-sightings rate is low.
Site affinity and other movements

Individual mantas are still being re-sighted after an interval of 10-12 years.
Site affinity and other movements

Low re-sightings rate is due to low survey rate. A recent investigation of cleaning frequency suggests that mantas clean approximately once weekly. (Kitchen-Wheeler and Edwards, in review)
Site affinity and other movements

- Initial investigations into site affinity suggest high site affinity by individual animals.
- The map indicates the number of individuals known at pairs of sites linked by a line when database reviewed in 2007.
- Current IUCN project should test this in more depth with larger samples from outer atolls.
- Strongest pairing was Lankan-Boduhithi (or Sunlight-Boduhithi): a NE and SW monsoon site pairing.
Site affinity and other movements

An east and a west paired site supports the hypothesis that individual mantas migrate across the atolls in the opposite monsoons.

These results suggest some movement north and south along the eastern, and western sides of atolls, and between atolls in a single monsoon.

The number of individuals moving between atolls is small (~1%) borne out by small number of North Male’ sighted mantas also seen in South Male’ atoll.
Site affinity and other movements

- Mapped migrations by individuals
- 1: common Lankan-Boduhithi seasonal movement
- 2: Inter-atoll SW monsoon movement plus N. Male’ pairing
- 3: West Ari to East N. Male’
- 4/5: SW Ari, W. Nilandhe and eastern N. Male’
- 6: Inter atoll west sites
- 7: 300 km one-way movement from Ari to Haa Alifu. A similar one way movement from Baa to Addu has also been reported.
MA is known to cross expanses of deep water (>600 m deep) and travel hundreds of kilometres one-way. Likely to travel to Chagos, to SW India/Lakshadweeps and possibly Sri Lanka and Seychelles.
MB in the Maldives

- *Manta birostris* is infrequently sighted in the Maldives, but sighted at same cleaning stations to where MB is sighted
- Whilst some sites are on edges of atoll, close to deep water, MB has also been sighted inside Hanifaru
- No individual MB have been re-sighted so we should consider individuals as transient visitors, not residents
MA Population in the Maldives

Discovery curves plus Petersen’s and Jolly-Seber methods were used to estimate manta populations in North Male’, Ari and Baa atolls.

Petersen’s assumes a closed population during the period of sampling (~4 years).

The Jolly-Seber open model encompasses additions (recruits and immigrants) and deletions (deaths and emigrants).
MA Population in the Maldives

Samples were taken from sightings of manta rays visiting cleaning stations, therefore these methods only measure populations of mantas which visited these cleaning stations i.e. excluded juveniles.
<table>
<thead>
<tr>
<th>Model of population estimation</th>
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<th>Mean Population estimate (N)</th>
<th>Range of estimates</th>
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<td>Petersen’s method (1) (entire atoll as marked sample)</td>
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<td>716 (SD ± 68.9)</td>
<td>633-774</td>
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<td>Boduhithi) North Male</td>
<td>1441 (SD ± 465)</td>
<td>1051-1956</td>
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</tr>
<tr>
<td>(Combined) North Male</td>
<td>1026 (SD ± 474)</td>
<td>633-1956</td>
<td></td>
</tr>
<tr>
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Discovery Curves

- North Male’ atoll has maximum population of ~700 mantas
- Ari has population of at least 750 mantas
- Baa has population of at least 250 mantas
Population size estimates (N) assessed for atolls and sites by different estimation methods

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Note: SD represents standard deviation.
Regression of relationship between manta population and atoll area based on estimated populations for North Male, Ari and Baa atolls using more reliable Petersen’s 2 and Jolly-Seber estimate for North Male atoll.

The regression was forced through zero. The relationship Manta population = 0.2743 atoll Area was used to calculate estimated populations for each atoll.
<table>
<thead>
<tr>
<th>Area</th>
<th>Geographical combinations: atoll areas</th>
<th>Area (surrounded by reef)</th>
<th>Estimated population (= 0.2743 Area)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Haa Alifu, Haa Dhaalu, Maamakuudhoo atolls</td>
<td>1760 km²</td>
<td>483</td>
</tr>
<tr>
<td>2</td>
<td>Shaviyani</td>
<td>1859 km²</td>
<td>510</td>
</tr>
<tr>
<td>3</td>
<td>Noonu</td>
<td>1211 km²</td>
<td>332</td>
</tr>
<tr>
<td>4</td>
<td>Raa (north and south sections) Goidhoo atolls</td>
<td>1531 km²</td>
<td>420</td>
</tr>
<tr>
<td>5</td>
<td>Baa (north and south sections) Goidhoo atolls</td>
<td>1330 km²</td>
<td>365</td>
</tr>
<tr>
<td>6</td>
<td>Lhaviyani</td>
<td>863 km²</td>
<td>237</td>
</tr>
<tr>
<td>7</td>
<td>North Male, Kaashidhoo, Gaafaru atolls</td>
<td>2026 km²</td>
<td>556</td>
</tr>
<tr>
<td>8</td>
<td>South Male</td>
<td>514 km²</td>
<td>141</td>
</tr>
<tr>
<td>9</td>
<td>Ari, Rasdhoo, Thoddoo atolls</td>
<td>2770 km²</td>
<td>760</td>
</tr>
<tr>
<td>10</td>
<td>Felidhoo, Vattaru atolls</td>
<td>962 km²</td>
<td>264</td>
</tr>
<tr>
<td>11</td>
<td>Meemu</td>
<td>1092 km²</td>
<td>300</td>
</tr>
<tr>
<td>12</td>
<td>North Nilandhe</td>
<td>589 km²</td>
<td>162</td>
</tr>
<tr>
<td>13</td>
<td>South Nilandhe</td>
<td>723 km²</td>
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<td>253</td>
</tr>
<tr>
<td>16</td>
<td>Huvadhoo</td>
<td>3285 km²</td>
<td>901</td>
</tr>
<tr>
<td>17</td>
<td>Addoo, Foamullah atolls</td>
<td>208 km²</td>
<td>57</td>
</tr>
</tbody>
</table>
Maldives population estimation

This result suggests **the Maldives *M. alfredi* population is around 6,400 rays**. The graph shows the 95% CL range which is very wide as there is only 1 degree of freedom to estimate 95% CL from standard errors for population estimates for each atoll area.

If the upper 95% CL estimate for each atoll is used in calculations, **the Maldives population is estimated at ~10,000**. This might be considered an upper limit.
Manta Tourism

- Scuba diving and snorkelling with manta rays are economically important activities in the Maldives
- Anderson et al. (2010) suggested that the direct income from manta tourism exceeded US$8 million per year in direct revenue derived from US$45 or US $70 per scuba dive (depending on the site) and US$20 per snorkeler
Manta Tourism

• The tourist perception is of the Maldives as having a pristine marine environment and the expectation of experiencing interactions with marine megafauna (dolphins, turtles, sharks and mantas)

• The Maldives’ National Biodiversity Strategy and Action Plan (Ministry of Home Affairs Housing and Environment 2002) emphasised the importance of biodiversity conservation and called for economic evaluation of ecologically and socially important components of biodiversity
Diving with Friends

www.euro-divers.com

Maldives – 10 dive centres to choose and
a perfect place to watch mantas!

Club Med Kani          Velidhu Island Resort
Eriyadu Island Resort  Vilamendhoo Island Resort
Full Moon Maldives      White Sands Resort & Spa
Kurumba Maldives        M/S Atoll Explorer
Rhiheli Beach Resort   Kandooma Maldives

Maldives Tourism Promotion Board, 3rd Floor, H.Aage, 12 Boduthakurufaaru Magu, Malé, Republic of Maldives
Tel: (960) 321329, Fax: (960) 321329, Email: mtpb@visitmaldives.com
Summary

Both species of Manta ray are seen in the Maldives although *Manta alfredi* is the commonly reported species.
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Mantas are **long-lived, mature late (10-15 years of age)** and reproduce infrequently.
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MA is distributed throughout the Maldives, but individuals are mainly limited to a single atoll

In the central *atolls* individual animals migrate from one side of an atoll to the other with the changes in *monsoonal winds*, probably following their food. The effects of the monsoons are less distinct in the southern atolls.
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**Manta tourism is of importance to the Maldives economy** and to the perception of a pristine marine environment.
References

• Anderson RC, Adam MS, Goes J (2011) From monsoons to mantas: seasonal distribution of *Manta alfredi* in the Maldives. Fisheries Oceanography 20: 104-113
Thank you for your attention
contact details: amkw9@sky.com