

# Size Compositions and Sex Ratios of oceanic whitetip sharks and giant manta rays for Longline Fisheries in the Pacific Islands Region<sup>1</sup>

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## 1. Introduction

This document presents relevant life history, assessment, and summary plots of data available from Hawaii longline fishery observer data and the literature for oceanic whitetip shark (*Carcharhinus longimanus*) and giant manta ray (*Manta birostris*) catches by the longline (LL) fisheries in Hawaii and American Samoa from 2010 to 2016. This information is being provided at the request of the Pacific Islands Regional Office as both species are currently proposed to be listed as threatened under the Endangered Species Act (ESA). The Hawaiian longline fishery is represented in two parts, the Shallow Set (SS) and Deep Set (DS). Deep sets are classified as containing 15 or more hooks per float and that fishery has a target of 20% observer coverage annually; shallow sets are any number of hooks below 15 and that fishery has mandated 100% observer coverage (Walsh and Brodziak, 2016). The American Samoa longline fishery is presented as a single entity. For each fishery, we summarize the relevant life history and assessment information to aid the reader in interpreting the presented data. We provide summary tables and histograms describing the estimated (non-empirical) sex ratio and length composition of observed catch through the time period examined. There are far fewer observed catches of giant manta ray and thus that data is presented for each individual.

## 2. Oceanic whitetip shark

### Relevant life history and assessment information

In the Hawaii SS and DS and American Samoa longline fisheries, oceanic whitetip shark (Food and Agriculture Organization species code OCS) are considered bycatch. The individuals caught by these fisheries are considered part of the western Pacific stock by the Western and Central Pacific Fisheries Commission. In the western Pacific, OCS is a generally non-targeted bycatch species of the longline fishery. The stock, which extends from the western to central Pacific Ocean, underwent an assessment (Rice and Harley, 2012), which included a compilation of available life history information. However, such information is not extensive. There is notably little known about the reproductive biology of OCS.

#### *Growth*

In terms of somatic growth, OCS is considered slow-growing compared to other shark species (Branstetter, 1990). The literature presents disparate estimates of maximum length ranges; Bigelow and Schroeder (1948) estimated 11.9–12.9 feet (ft), whereas a more recent paper (Seki et al., 1998) provided growth parameters resulting in a maximum length of 8 ft, obtained at age 36 years, for both sexes. The latter and more recent values were used in the 2012 assessment (Rice and Harley, 2012). However, subsequent reports (Clarke et al., 2015) have considered estimates used in the 2012 assessment derived from Seki et al. (1998) as “unreliable” and re-estimated basin-specific longevity between 20.7 and 22.1 years in the Pacific. The maximum length obtained by a sexed female in Hawaii Longline Observer records was estimated visually to the nearest foot at 6 ft for the shallow set and 5 ft for the deep set. For males, this value was 6 ft in the shallow set and 6 ft in the deep set. For unsexed individuals across both Hawaii Longline fisheries, the maximum observed size was 9 ft. The American Samoa longline observer records presented maximum lengths of 5 ft, 7 ft, and 7 ft, for females, males, and unsexed sharks, respectively.

To convert length to weight, readers are referred to the table of regression coefficients (Curran and Bigelow, 2016), as derived from FishBase (Froese and Pauly, 2011) used to convert the length of bycatch into weight for a National Bycatch Report for Pelagic Longline Fisheries in Hawaii and American Samoa (National Marine Fisheries Service 2013, 2016). The conversion is for weight units in grams and fork lengths in centimeters, as follows. Note that the data presented in this report and in the Hawaii and American Samoa Longline Logbooks are in feet.

$$weight = 1.7 \times 10^{-5} \times fork\ length^{2.98}$$

In conjunction with their low fecundity (see below), the recent assessment (Rice and Harley, 2012) suggested that the slow growth of this species will result in low resilience to fishing pressure, as the mechanisms for compensation may be low given the species’ life history.

#### *Reproduction*

Like many shark species, OCS are considered to be low-fecundity, which means that even mature females produce relatively few offspring (average of 6) per spawning season, with a 9–12 month gestation period (Seki et al., 1998). Estimated length-at-maturity used in the assessment (Rice and Harley, 2012) was not sex specific at 5.5–6.5 ft (Seki et al., 1998). This value lies just above the median captured length for the Hawaii Longline Observer records (deep and shallow sets combined, all sexes) of 5 ft (Shallow-set median: 6 ft; Deep-set median: 5 ft). For American Samoa,

the median value was 4 ft.

Because the overwhelming majority of observed OCS catches which have length estimates are unsexed, and the estimated length-at-maturity in the literature is not specific to females, it is uncertain whether the length composition of observed longline catch is above, at, or below the specific length at maturity for females, which would provide further insight into the fisheries' effect on OCS reproduction. There is no empirical information on sex ratio of the OCS stock in the western Pacific, although the 2012 assessment (Rice and Harley, 2012) assumed the sex ratio was 50:50.

### *Biomass Estimates*

The 2012 assessment (Rice and Harley, 2012) found total estimated biomass and spawning biomass to have declined consistently throughout the 1995–2009 modeled period. The estimated most recent biomass in tons (for 2009) was 7,295 t (90% CI 3,864–26,001 t), and the spawning stock biomass was 229 t (90% CI 112–820 t). The authors noted a lack of catch information outside of observer records, which were also the assessment's source of length-frequency information (Rice and Harley, 2012).

Bycatch estimates have been computed for OCS in terms of both numbers and biomass, though the data availability does not cover all fisheries for all years. The National Marine Fisheries Service Observer Program webpage<sup>4</sup> reports the numbers of OCS bycatch listed in Table 1 (National Marine Fisheries Service, 2013, 2016). Additional bycatch estimates in pounds of sharks are listed in Table 2. Note that for the Hawaii Shallow-Set, observer coverage is at 100%, therefore the bycatch is known. For HI deep-set and AS longline fisheries, the estimates are for bycatch where the bycatch is assigned to the year the trip was landed. For the shallow-set fishery, the catch (retained and/or discarded) is reported where catch is assigned to the haul year.

**Table 1. Reported (for Shallow-set) and estimated bycatch in numbers of oceanic whitetip shark, 2010–2016. Numbers in parentheses indicate standard error, where applicable. All values are rounded to the nearest hundredth. Bycatch estimates not yet available for American Samoa in 2016. Source: PIFSC Internal Reports IR-11-023, IR-15-004, IR-15-005.**

Year	HI.Shallow.Set	HI.Deep.Set	AS.Longline
2010	90	1191.90 (158.10)	1154.41 (134.34)
2011	78	1168.20 (140.04)	314.27 (37.17)
2012	24	875.32 (110.50)	462.82 (76.63)
2013	27	967.76 (177.17)	392.82 (69.65)
2014	21	1670.00 (162.66)	464.00 (124.64)
2015	22	2654.00 (197.56)	827.00 (151.18)
2016	32	2188.00 (130.80)	N/A

<sup>4</sup> <https://www.st.nmfs.noaa.gov/observer-home/first-edition-update-2>

**Table 2. Reported (for Shallow-set) and estimated bycatch (alive or dead) in pounds of oceanic white shark, 2010–2015. Standard errors were not available for these data. All values are rounded to the nearest hundredth. Bycatch estimates were only available for years 2010, 2011, 2012, and 2013, though were not available for American Samoa in 2010.**

Year	HI.Shallow.Set	HI.Deep.Set	AS.Longlin
2010	3,665.70	43,887.43	N/A
2011	13,275.90	41,312.00	8,813.00
2012	4,017.70	30,845.40	12,995.00
2013	4,716.40	34,068.60	11,030.30

Source: <https://www.st.nmfs.noaa.gov/observer-home/first-edition-update-2> Tables 7.5.1a, 7.5.2a, 7.5.3a 8.1.

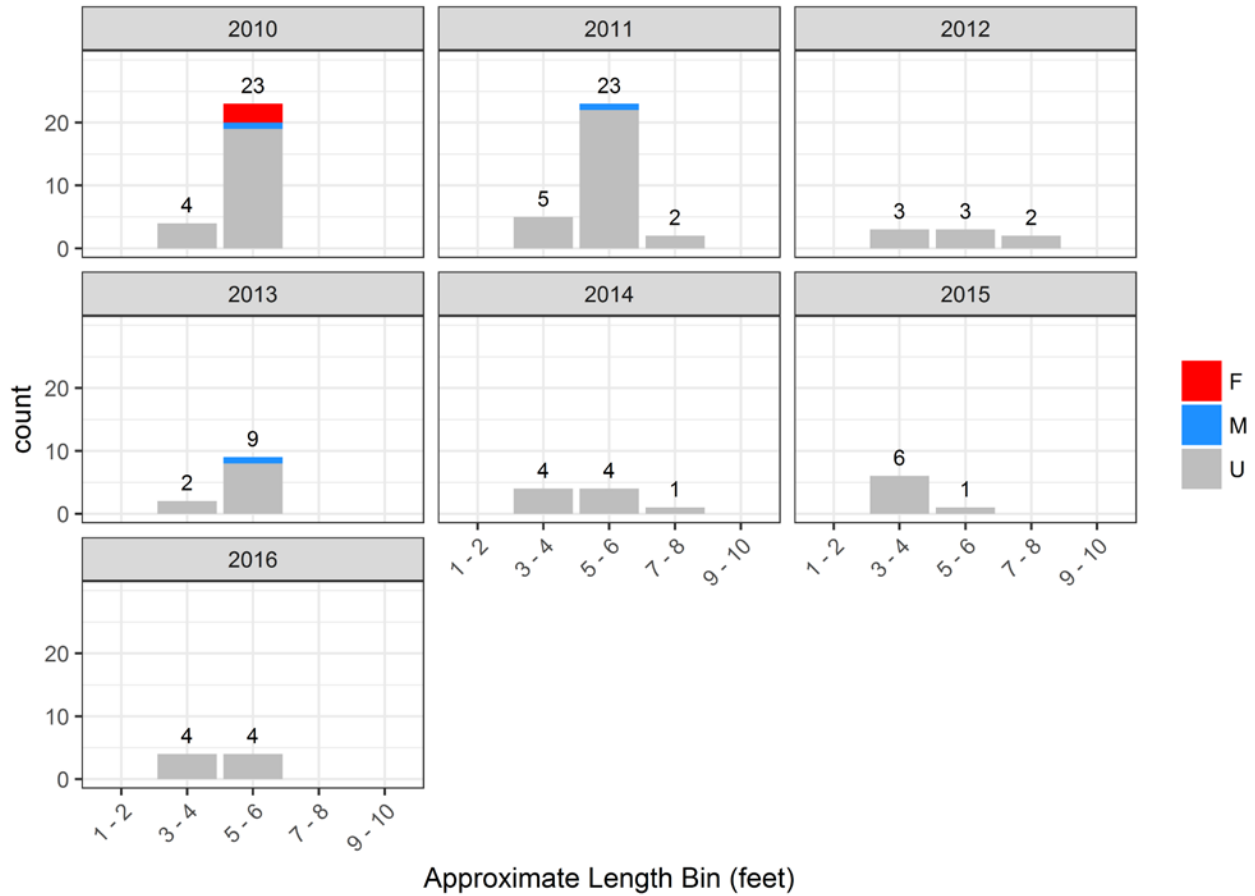
## Hawaii Shallow-set Longline Fishery

### *Sex ratio from 2010 – 2016*

**Table 3. Sex composition of oceanic whitetip shark data available from the Hawaii Shallow-set observer records, 2010–2016. N refers to number of individuals. The reader is advised that this represents all observed sharks (with 100% observer coverage) in the available data, only a sub-selection of which may have length measurements available.**

Year	N	Male	% Male	N Female	% Female	N Unsexed	% Unsexed	Total N
2010		3	3.33	7	7.78	80	88.89	90
2011		1	1.28	1	1.28	76	97.44	78
2012		0	0	0	0	24	100	24
2013		1	3.7	0	0	26	96.3	27
2014		0	0	0	0	21	100	21
2015		0	0	0	0	22	100	22
2016		1	3.12	0	0	31	96.88	32

*Length composition from 2010 to 2016*



**Figure 1. Yearly size distributions for oceanic whitetip sharks in the Hawaii Shallow-set longline fishery observer records (with 100% observer coverage), for which an approximate length measure was available, 2010–2016. Centered numbers indicate sample sizes. This figure presents the same information as Table 2.**

**Table 4. Binned length composition (in feet) of oceanic whitetip shark data available from the Hawaii Shallow-set observer records from 2010 to 2016. N refers to number of individuals. This table presents the same information as Figure 1.**

Year	Sex	Length Bin (ft)	N	Percent	Year	Sex	Length Bin (ft)	N	Percent
2010	F	1 - 2	0	0%	2011	F	1 - 2	0	0%
2010	F	3 - 4	0	0%	2011	F	3 - 4	0	0%
2010	F	5 - 6	3	11.11%	2011	F	5 - 6	0	0%
2010	F	7 - 8	0	0%	2011	F	7 - 8	0	0%
2010	F	9 - 10	0	0%	2011	F	9 - 10	0	0%
2010	M	1 - 2	0	0%	2011	M	1 - 2	0	0%
2010	M	3 - 4	0	0%	2011	M	3 - 4	0	0%
2010	M	5 - 6	1	3.7%	2011	M	5 - 6	1	3.33%
2010	M	7 - 8	0	0%	2011	M	7 - 8	0	0%
2010	M	9 - 10	0	0%	2011	M	9 - 10	0	0%
2010	U	1 - 2	0	0%	2011	U	1 - 2	0	0%
2010	U	3 - 4	4	14.81%	2011	U	3 - 4	5	16.67%
2010	U	5 - 6	19	70.37%	2011	U	5 - 6	22	73.33%
2010	U	7 - 8	0	0%	2011	U	7 - 8	2	6.67%
2010	U	9 - 10	0	0%	2011	U	9 - 10	0	0%
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Year	Sex	Length Bin (ft)	N	Percent	Year	Sex	Length Bin (ft)	N	Percent
2012	F	1 - 2	0	0%	2013	F	1 - 2	0	0%
2012	F	3 - 4	0	0%	2013	F	3 - 4	0	0%
2012	F	5 - 6	0	0%	2013	F	5 - 6	0	0%
2012	F	7 - 8	0	0%	2013	F	7 - 8	0	0%
2012	F	9 - 10	0	0%	2013	F	9 - 10	0	0%
2012	M	1 - 2	0	0%	2013	M	1 - 2	0	0%
2012	M	3 - 4	0	0%	2013	M	3 - 4	0	0%
2012	M	5 - 6	0	0%	2013	M	5 - 6	1	9.09%
2012	M	7 - 8	0	0%	2013	M	7 - 8	0	0%
2012	M	9 - 10	0	0%	2013	M	9 - 10	0	0%
2012	U	1 - 2	0	0%	2013	U	1 - 2	0	0%
2012	U	3 - 4	3	37.5%	2013	U	3 - 4	2	18.18%
2012	U	5 - 6	3	37.5%	2013	U	5 - 6	8	72.73%
2012	U	7 - 8	2	25%	2013	U	7 - 8	0	0%
2012	U	9 - 10	0	0%	2013	U	9 - 10	0	0%
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Year	Sex	Length Bin (ft)	N	Percent	Year	Sex	Length Bin (ft)	N	Percent
2014	F	1 - 2	0	0%	2015	F	1 - 2	0	0%
2014	F	3 - 4	0	0%	2015	F	3 - 4	0	0%
2014	F	5 - 6	0	0%	2015	F	5 - 6	0	0%
2014	F	7 - 8	0	0%	2015	F	7 - 8	0	0%
2014	F	9 - 10	0	0%	2015	F	9 - 10	0	0%
2014	M	1 - 2	0	0%	2015	M	1 - 2	0	0%
2014	M	3 - 4	0	0%	2015	M	3 - 4	0	0%
2014	M	5 - 6	0	0%	2015	M	5 - 6	0	0%
2014	M	7 - 8	0	0%	2015	M	7 - 8	0	0%
2014	M	9 - 10	0	0%	2015	M	9 - 10	0	0%
2014	U	1 - 2	0	0%	2015	U	1 - 2	0	0%
2014	U	3 - 4	4	44.44%	2015	U	3 - 4	6	85.71%
2014	U	5 - 6	4	44.44%	2015	U	5 - 6	1	14.29%
2014	U	7 - 8	1	11.11%	2015	U	7 - 8	0	0%
2014	U	9 - 10	0	0%	2015	U	9 - 10	0	0%
<hr/>									
Year	Sex	Length Bin (ft)	N	Percent					
2016	F	1 - 2	0	0%					
2016	F	3 - 4	0	0%					
2016	F	5 - 6	0	0%					
2016	F	7 - 8	0	0%					
2016	F	9 - 10	0	0%					
2016	M	1 - 2	0	0%					
2016	M	3 - 4	0	0%					
2016	M	5 - 6	0	0%					
2016	M	7 - 8	0	0%					
2016	M	9 - 10	0	0%					
2016	U	1 - 2	0	0%					
2016	U	3 - 4	4	50%					
2016	U	5 - 6	4	50%					
2016	U	7 - 8	0	0%					
2016	U	9 - 10	0	0%					

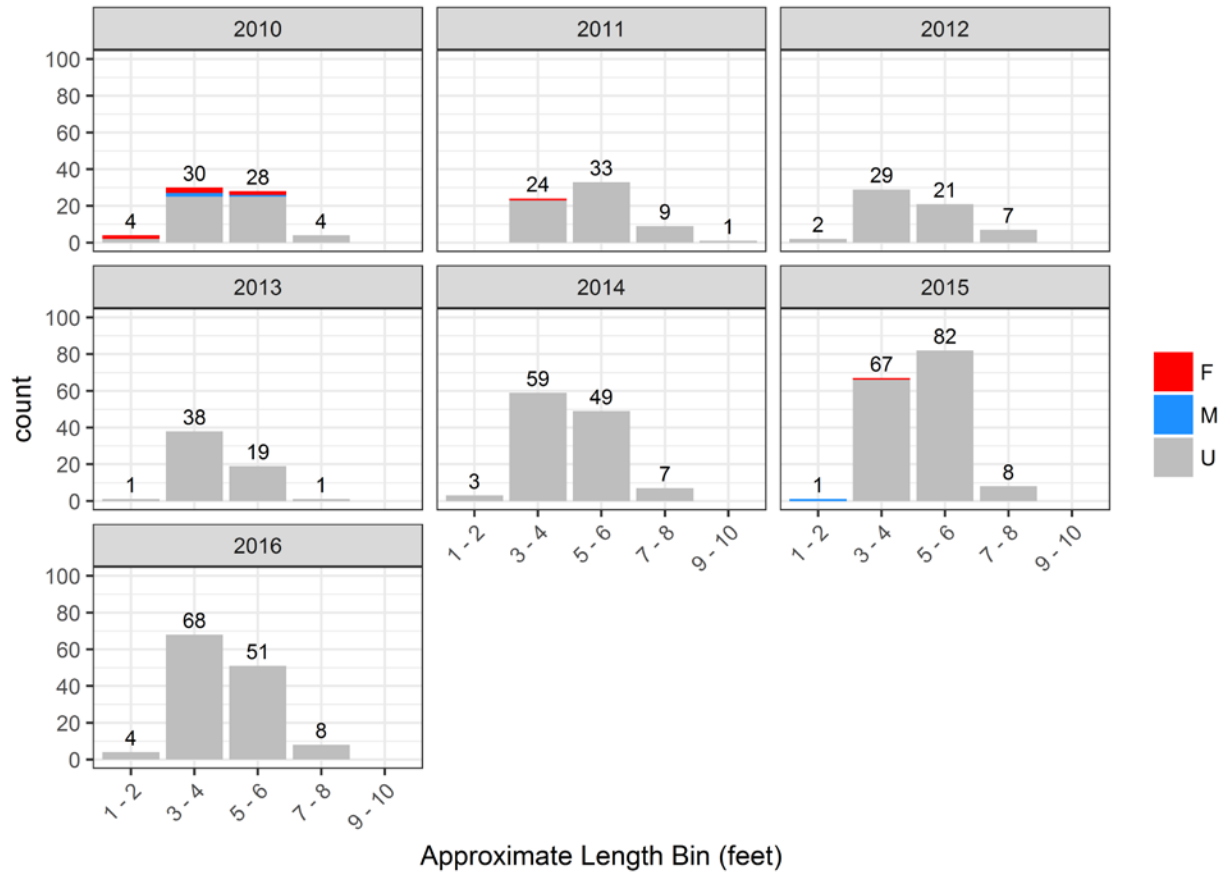
**Hawaii Deep-set Longline Fishery***Sex ratio from 2010 to 2016*

**Table 5. Sex composition of oceanic whitetip shark data available from the Hawaii Deep-set observer records, 2010–2016. N refers to number of individuals. The reader is advised that this represents all observed sharks in the available data, only a sub-selection of which may have length measurements available.**

<b>Year</b>	<b>N Male</b>	<b>% Male</b>	<b>N Female</b>	<b>% Female</b>	<b>N Unsexed</b>	<b>% Unsexed</b>	<b>Total N</b>
2010	8	3.27	18	7.35	219	89.39	245
2011	5	2.21	8	3.54	213	94.25	226
2012	5	2.79	7	3.91	167	93.3	179
2013	2	1.04	3	1.55	188	97.41	193
2014	7	1.9	10	2.72	351	95.38	368
2015	11	2.08	17	3.22	500	94.7	528
2016	9	2.12	16	3.76	400	94.12	425



*Length composition from 2010 to 2016*



**Figure 2. Yearly size distributions for oceanic whitetip sharks in the Hawaii Deep-set longline fishery for which an approximate length measure was available, 2010–2016. Centered numbers indicate sample sizes. This figure presents the same information as Table 4.**

**Table 6. Binned length composition (in feet) of oceanic whitetip shark data available from the Hawaii Deep-set observer records, 2010–2016. N refers to number of individuals. This table presents the same information as Figure 2.**

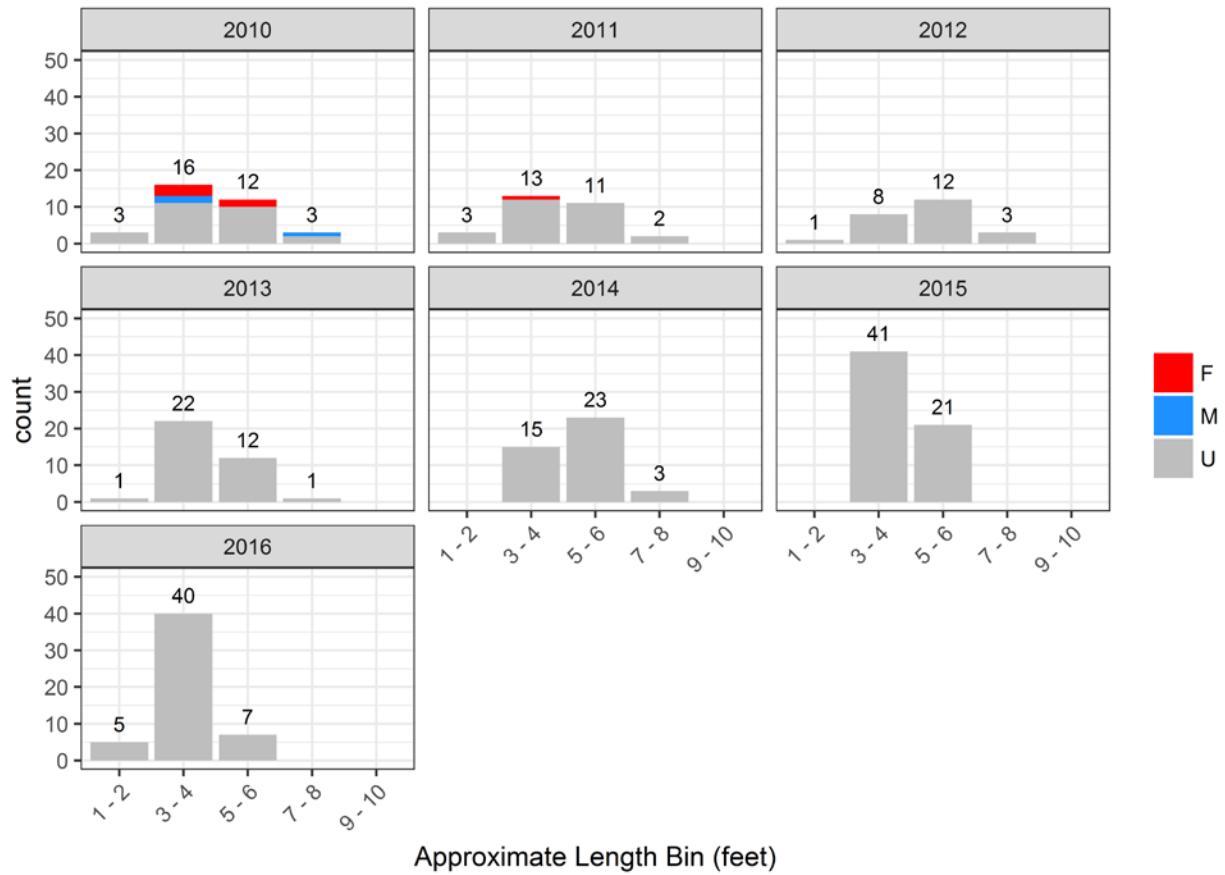
Year	Sex	Length Bin (ft)	N	Percent	Year	Sex	Length Bin (ft)	N	Percent
2010	F	1 - 2	2	3.03%	2011	F	1 - 2	0	0%
2010	F	3 - 4	3	4.55%	2011	F	3 - 4	1	1.49%
2010	F	5 - 6	2	3.03%	2011	F	5 - 6	0	0%
2010	F	7 - 8	0	0%	2011	F	7 - 8	0	0%
2010	F	9 - 10	0	0%	2011	F	9 - 10	0	0%
2010	M	1 - 2	0	0%	2011	M	1 - 2	0	0%
2010	M	3 - 4	2	3.03%	2011	M	3 - 4	0	0%
2010	M	5 - 6	1	1.52%	2011	M	5 - 6	0	0%
2010	M	7 - 8	0	0%	2011	M	7 - 8	0	0%
2010	M	9 - 10	0	0%	2011	M	9 - 10	0	0%
2010	U	1 - 2	2	3.03%	2011	U	1 - 2	0	0%
2010	U	3 - 4	25	37.88%	2011	U	3 - 4	23	34.33%
2010	U	5 - 6	25	37.88%	2011	U	5 - 6	33	49.25%
2010	U	7 - 8	4	6.06%	2011	U	7 - 8	9	13.43%
2010	U	9 - 10	0	0%	2011	U	9 - 10	1	1.49%
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Year	Sex	Length Bin (ft)	N	Percent	Year	Sex	Length Bin (ft)	N	Percent
2012	F	1 - 2	0	0%	2013	F	1 - 2	0	0%
2012	F	3 - 4	0	0%	2013	F	3 - 4	0	0%
2012	F	5 - 6	0	0%	2013	F	5 - 6	0	0%
2012	F	7 - 8	0	0%	2013	F	7 - 8	0	0%
2012	F	9 - 10	0	0%	2013	F	9 - 10	0	0%
2012	M	1 - 2	0	0%	2013	M	1 - 2	0	0%
2012	M	3 - 4	0	0%	2013	M	3 - 4	0	0%
2012	M	5 - 6	0	0%	2013	M	5 - 6	0	0%
2012	M	7 - 8	0	0%	2013	M	7 - 8	0	0%
2012	M	9 - 10	0	0%	2013	M	9 - 10	0	0%
2012	U	1 - 2	2	3.39%	2013	U	1 - 2	1	1.69%
2012	U	3 - 4	29	49.15%	2013	U	3 - 4	38	64.41%
2012	U	5 - 6	21	35.59%	2013	U	5 - 6	19	32.2%
2012	U	7 - 8	7	11.86%	2013	U	7 - 8	1	1.69%
2012	U	9 - 10	0	0%	2013	U	9 - 10	0	0%
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Year	Sex	Length Bin (ft)	N	Percent	Year	Sex	Length Bin (ft)	N	Percent
2014	F	1 - 2	0	0%	2015	F	1 - 2	0	0%
2014	F	3 - 4	0	0%	2015	F	3 - 4	1	0.63%
2014	F	5 - 6	0	0%	2015	F	5 - 6	0	0%
2014	F	7 - 8	0	0%	2015	F	7 - 8	0	0%
2014	F	9 - 10	0	0%	2015	F	9 - 10	0	0%
2014	M	1 - 2	0	0%	2015	M	1 - 2	1	0.63%
2014	M	3 - 4	0	0%	2015	M	3 - 4	0	0%
2014	M	5 - 6	0	0%	2015	M	5 - 6	0	0%
2014	M	7 - 8	0	0%	2015	M	7 - 8	0	0%
2014	M	9 - 10	0	0%	2015	M	9 - 10	0	0%
2014	U	1 - 2	3	2.54%	2015	U	1 - 2	0	0%
2014	U	3 - 4	59	50%	2015	U	3 - 4	66	41.77%
2014	U	5 - 6	49	41.53%	2015	U	5 - 6	82	51.9%
2014	U	7 - 8	7	5.93%	2015	U	7 - 8	8	5.06%
2014	U	9 - 10	0	0%	2015	U	9 - 10	0	0%
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Year	Sex	Length Bin (ft)	N	Percent					
2016	F	1 - 2	0	0%					
2016	F	3 - 4	0	0%					
2016	F	5 - 6	0	0%					
2016	F	7 - 8	0	0%					
2016	F	9 - 10	0	0%					
2016	M	1 - 2	0	0%					
2016	M	3 - 4	0	0%					
2016	M	5 - 6	0	0%					
2016	M	7 - 8	0	0%					
2016	M	9 - 10	0	0%					
2016	U	1 - 2	4	3.05%					
2016	U	3 - 4	68	51.91%					
2016	U	5 - 6	51	38.93%					
2016	U	7 - 8	8	6.11%					
2016	U	9 - 10	0	0%					

**American Samoa Longline Fishery***Sex ratio from 2010 to 2016*

**Table 7. Sex composition of oceanic whitetip shark data available from the American Samoa longline observer records, 2010–2016. N refers to number of individuals. The reader is advised that this represents all observed sharks, only a sub-selection of which may have length measurements available.**

<b>Year</b>	<b>N Male</b>	<b>% Male</b>	<b>N Female</b>	<b>% Female</b>	<b>N Unsexed</b>	<b>% Unsexed</b>	<b>Total N</b>
2010	8	5.48	8	5.48	130	89.04	146
2011	0	0	4	3.96	97	96.04	101
2012	3	4.17	1	1.39	68	94.44	72
2013	0	0	2	2.06	95	97.94	97
2014	4	3.88	1	0.97	98	95.15	103
2015	5	2.69	3	1.61	178	95.7	186
2016	11	6.51	5	2.96	153	90.53	169

*Length composition from 2010 to 2016*



**Figure 3. Yearly size distributions for oceanic whitetip sharks in the American Samoa longline fishery for which an approximate length measure was available, 2010-2016. Centered numbers indicate sample sizes. This figure presents the same information as Table 6.**

**Table 8. Binned length composition (in feet) of oceanic whitetip shark data available from the American Samoa longline observer records, 2010–2016. N refers to number of individuals. This table presents the same information as Figure 3.**

Year	Sex	Length Bin (ft)	N	Percent	Year	Sex	Length Bin (ft)	N	Percent
2010	F	1 - 2	0	0%	2011	F	1 - 2	0	0%
2010	F	3 - 4	3	8.82%	2011	F	3 - 4	1	3.45%
2010	F	5 - 6	2	5.88%	2011	F	5 - 6	0	0%
2010	F	7 - 8	0	0%	2011	F	7 - 8	0	0%
2010	F	9 - 10	0	0%	2011	F	9 - 10	0	0%
2010	M	1 - 2	0	0%	2011	M	1 - 2	0	0%
2010	M	3 - 4	2	5.88%	2011	M	3 - 4	0	0%
2010	M	5 - 6	0	0%	2011	M	5 - 6	0	0%
2010	M	7 - 8	1	2.94%	2011	M	7 - 8	0	0%
2010	M	9 - 10	0	0%	2011	M	9 - 10	0	0%
2010	U	1 - 2	3	8.82%	2011	U	1 - 2	3	10.34%
2010	U	3 - 4	11	32.35%	2011	U	3 - 4	12	41.38%
2010	U	5 - 6	10	29.41%	2011	U	5 - 6	11	37.93%
2010	U	7 - 8	2	5.88%	2011	U	7 - 8	2	6.9%
2010	U	9 - 10	0	0%	2011	U	9 - 10	0	0%
2012	F	1 - 2	0	0%	2013	F	1 - 2	0	0%
2012	F	3 - 4	0	0%	2013	F	3 - 4	0	0%
2012	F	5 - 6	0	0%	2013	F	5 - 6	0	0%
2012	F	7 - 8	0	0%	2013	F	7 - 8	0	0%
2012	F	9 - 10	0	0%	2013	F	9 - 10	0	0%
2012	M	1 - 2	0	0%	2013	M	1 - 2	0	0%
2012	M	3 - 4	0	0%	2013	M	3 - 4	0	0%
2012	M	5 - 6	0	0%	2013	M	5 - 6	0	0%
2012	M	7 - 8	0	0%	2013	M	7 - 8	0	0%
2012	M	9 - 10	0	0%	2013	M	9 - 10	0	0%
2012	U	1 - 2	1	4.17%	2013	U	1 - 2	1	2.78%
2012	U	3 - 4	8	33.33%	2013	U	3 - 4	22	61.11%
2012	U	5 - 6	12	50%	2013	U	5 - 6	12	33.33%
2012	U	7 - 8	3	12.5%	2013	U	7 - 8	1	2.78%
2012	U	9 - 10	0	0%	2013	U	9 - 10	0	0%
2014	F	1 - 2	0	0%	2015	F	1 - 2	0	0%
2014	F	3 - 4	0	0%	2015	F	3 - 4	0	0%
2014	F	5 - 6	0	0%	2015	F	5 - 6	0	0%
2014	F	7 - 8	0	0%	2015	F	7 - 8	0	0%
2014	F	9 - 10	0	0%	2015	F	9 - 10	0	0%
2014	M	1 - 2	0	0%	2015	M	1 - 2	0	0%
2014	M	3 - 4	0	0%	2015	M	3 - 4	0	0%
2014	M	5 - 6	0	0%	2015	M	5 - 6	0	0%
2014	M	7 - 8	0	0%	2015	M	7 - 8	0	0%
2014	M	9 - 10	0	0%	2015	M	9 - 10	0	0%
2014	U	1 - 2	0	0%	2015	U	1 - 2	0	0%
2014	U	3 - 4	15	36.59%	2015	U	3 - 4	41	66.13%
2014	U	5 - 6	23	56.1%	2015	U	5 - 6	21	33.87%
2014	U	7 - 8	3	7.32%	2015	U	7 - 8	0	0%
2014	U	9 - 10	0	0%	2015	U	9 - 10	0	0%
2016	F	1 - 2	0	0%	2016	F	3 - 4	0	0%
2016	F	3 - 4	0	0%	2016	F	5 - 6	0	0%
2016	F	5 - 6	0	0%	2016	F	7 - 8	0	0%
2016	F	7 - 8	0	0%	2016	F	9 - 10	0	0%
2016	M	1 - 2	0	0%	2016	M	3 - 4	0	0%
2016	M	3 - 4	0	0%	2016	M	5 - 6	0	0%
2016	M	5 - 6	0	0%	2016	M	7 - 8	0	0%
2016	M	7 - 8	0	0%	2016	M	9 - 10	0	0%
2016	M	9 - 10	0	0%	2016	U	1 - 2	5	9.62%
2016	U	1 - 2	5	9.62%	2016	U	3 - 4	40	76.92%
2016	U	3 - 4	40	76.92%	2016	U	5 - 6	7	13.46%
2016	U	5 - 6	7	13.46%	2016	U	7 - 8	0	0%
2016	U	7 - 8	0	0%	2016	U	9 - 10	0	0%
2016	U	9 - 10	0	0%					

### 3. Giant Manta Ray

#### Relevant life history and assessment information

In the Hawaii SS and DS and American Samoa longline fisheries, giant manta ray (*Manta birostris*) are bycatch. The population's range is known to extend throughout the Indo-Pacific, in addition to the Gulf of Mexico as well as the Atlantic (Miller and Klimovich, 2016). Relatively few life history studies of Giant manta around Hawaii and American Samoa have been undertaken. The status of Giant manta was described in a status review report in response to a petition received in support of listing *M. birostris* and its congener, *M. alfredi*, as endangered or threatened under the ESA (Miller and Klimovich, 2016). The report suggested that Giant manta's oceanic nature may render it more vulnerable to commercial and larger-scale artisanal fishing operations versus coastal or inshore manta species, which are typically not exposed to large-scale fishing operations due to fishing regulations and logistical barriers. Similarly, this characteristic makes it more difficult to identify, estimate and monitor populations on a scale relevant to management. The reader is advised that all manta rays were identified as *M. birostris* prior to 2009, when *M. alfredi* was defined as a distinct species.

#### Growth

Of available life history parameters, Giant manta in the Pacific (Japan) are estimated to obtain a maximum disc width of 5 meters (m) and 4.65 m for females (Yanagisawa, 1994; Uchida 1994, as cited in Deakos, 2010). The estimated weight of the aforementioned 5 m individual was 774 kg. Length-at-maturity is only available for the Indian Ocean and is estimated as 4.7 m for females and 4 m for males (Kunjipalu and Boopendranath, 1981; White et al., 2006). Survival rates for mature individuals are high, though the population growth rate was estimated to be among the lowest of 106 Chondrichthyes at  $r_{max} = 0.116$  (Dulvy et al., 2014) This estimate applies to all manta rays, including *M. birostris*, *M. alfredi* and others. Of the very few (3) measured individuals, the Hawaiian deep-set longline fishery presented a median approximate length of 5 ft, and the shallow set presented a single measured manta of 3 ft. The American Samoa longline fishery also only had one measured individual of 6 ft approximate length. Length-weight conversion estimates for Hawaii could not be obtained.

#### Reproduction

Giant manta are considered to have extremely low-fecundity. It is assumed that larger females are more fecund, with synchronous mating that can vary widely in periodicity (e.g. biennially in the Maldives, 3–4 years in Japan (Matsumoto and Uchida, 2008)). Both the Hawaii and American Samoa longline observer data sets do not contain sexed individuals, rendering an estimate for the sex ratio in these fisheries impossible.

#### Biomass Estimates

No estimate of Giant manta's global abundance has been made, with only anecdotal regional reports ranging from 100–1500 individuals (Miller and Klimovich, 2016); one such report indicated 29 recorded individuals off Kona, Hawaii (Clark, 2010). Among other Pacific records, this is the lowest, with recorded observations of 42 in Japan (Kashiwagi, Ito, and Sato, 2010), 72 in Indonesia (Miller and Klimovich, 2016) and > 288 in Thailand (Miller and Klimovich, 2016) – though the latter two are from unpublished and/or non-profit sources such as Manta Matcher, which maintains a Facebook page for individuals to report sightings. A thesis conducted in 2010 sought to characterize the abundance, home range, and movement patterns of Giant manta off the Kona

(Hawaii) coast, where aggregations of mantas are promoted as a tourist attraction (Clark, 2010). The study noted high site fidelity in tandem with large coastal ranges, with mantas often switching areas seasonally. This could imply that Giant manta in Hawaii exhibit more coastal movement patterns than other populations, with attendant impacts on population vulnerability.

Bycatch estimates have been computed for Giant Manta in terms of both numbers and biomass, though the data availability does not cover all fisheries for all years. Materials on the National Marine Fisheries Service Observer Program webpage<sup>5</sup> indicate the numbers of bycatch listed in Table 9 (National Marine Fisheries Service, 2013, 2016). Additional bycatch estimates in pounds of rays are listed in Table 10. Note that for the Hawaii shallow-set, observer coverage is at 100%, therefore the bycatch is known. For HI deep-set and AS longline fisheries, the estimates are for bycatch where the bycatch is assigned to the year the trip was landed. For the shallow-set fishery, the catch (retained and/or discarded) is reported where catch is assigned to the haul year.

**Table 9. Reported (for shallow-set) and estimated by catch in numbers of giant mantra ray, 2010-2016. Numbers in parentheses indicate standard error, where applicable. All values are rounded to the nearest hundredth. Bycatch estimates not yet available for American Samoa in 2016. Source: PIFSC Internal Reports IR-11-023, IR-15-004, IR-15-005.**

Year	HI.Shallow.Set	HI.Deep.Set	AS.Longline
2010	6	91.91 (46.67)	11.00 (13.32)
2011	3	5.16 (4.72)	10.71 (7.42)
2012	0	10.77 (6.90)	29.00 (16.80)
2013	0	5.20 (4.70)	8.00 (10.57)
2014	1	11.00 (7.41)	2.00 (2.50)
2015	0	10.00 (5.79)	3.00 (3.32)
2016	0	22.00 (11.56)	N/A

**Table 10. Reported (for shallow-set) and estimated bycatch (alive or dead) in pounds of giant manta ray, 2010–2015. Standard errors were not available for these data. Bycatch estimates were only available for years 2010, 2011, 2012, and 2013; records not available for American Samoa in 2010.**

Year	HI.Shallow.Set	HI.Deep.Set	AS.Longline
2010	396.83	8,113.01	N/A
2011	264.00	440	968
2012	0.00	968	2552
2013	0.00	440	704

<sup>5</sup> <https://www.st.nmfs.noaa.gov/observer-home/> first-edition-update-2.

**Hawaii Shallow-set Longline Fishery***Sex ratio from 2010 to 2016***Table 11. Sex composition of giant manta ray data available from the Hawaii shallow-set longline fishery observer data, 2010–2016. N refers to number of individuals. The reader is advised that this represents all observed rays (with 100% observer coverage) in the available data, only a sub-selection of which may have length measurements available.**

Year	N Male	% Male	N Female	% Female	N Unsexed	% Unsexed	Total N
2010	0	0	0	0	7	100	7
2011	0	0	0	0	5	100	5
2014	0	0	0	0	2	100	2
2015	0	0	0	0	2	100	2
2016	0	0	0	0	3	100	3

*Length composition from 2010 to 2016***Table 12. Binned length composition (in feet) of giant manta ray data available from the Hawaii Shallow-set longline fishery observer data. N refers to number of individuals. Only a single measured animal was available, for year 2010, and thus additional years (of 2011–2016) are omitted.**

Year	Sex	Length Bin (ft)	N	Percent (%)
2010	F	1–2	0	0
2010	F	3–4	0	0
2010	F	5–6	0	0
2010	F	7–8	0	0
2010	F	9–10	0	0
2010	M	1–2	0	0
2010	M	3–4	0	0
2010	M	5–6	0	0
2010	M	7–8	0	0
2010	M	9–10	0	0
2010	U	1–2	0	0
2010	U	3–4	1	100
2010	U	5–6	0	0
2010	U	7–8	0	0
2010	U	9–10	0	0



**Hawaii Deep-set Longline Fishery***Sex ratio from 2010 to 2016***Table 13. Sex composition of giant manta ray data available from the Hawaii deep-set longline fishery observer data, 2010–2016. N refers to number of individuals. The reader is advised that this represents all observed mantas in the available data, of which only a sub-selection may have length measurements available.**

Year	N Male	% Male	N Female	% Female	N Unsexed	% Unsexed	Total N
2010	0	0	0	0	18	100	18
2011	0	0	0	0	3	100	3
2012	0	0	0	0	3	100	3
2013	0	0	0	0	1	100	1
2014	0	0	0	0	7	100	7
2015	0	0	0	0	7	100	7
2016	0	0	0	0	7	100	7

*Length composition from 2010 to 2016***Table 14. Binned length composition (in feet) of giant manta ray data available from the Hawaii deep-set longline fishery observer data, from 2010 to 2016. N refers to number of individuals. Measured animals were only available for years 2012, 2015, and 2016, and thus additional years (of 2010-2011 and 2013-2014) are omitted.**

Year	Sex	Length Bin (ft)	N	Percent (%)
2012	F	1–2	0	0
2012	F	3–4	0	0
2012	F	5–6	0	0
2012	F	7–8	0	0
2012	F	9–10	0	0
2012	M	1–2	0	0
2012	M	3–4	0	0
2012	M	5–6	0	0
2012	M	7–8	0	0
2012	M	9–10	0	0
2012	U	1–2	0	0
2012	U	3–4	0	0
2012	U	5–6	0	0
2012	U	7–8	1	100
2012	U	9–10	0	0
2015	F	1–2	0	0
2015	F	3–4	0	0
2015	F	5–6	0	0
2015	F	7–8	0	0
2015	F	9–10	0	0
2015	M	1–2	0	0
2015	M	3–4	0	0
2015	M	5–6	0	0

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<b>Year</b>	<b>Sex</b>	<b>Length Bin (ft)</b>	<b>N</b>	<b>Percent (%)</b>
2015	M	7-8	0	0
2015	M	9-10	0	0
2015	U	1-2	0	0
2015	U	3-4	0	0
2015	U	5-6	1	100
2015	U	7-8	0	0
2015	U	9-10	0	0
2016	F	1-2	0	0
2016	F	3-4	0	0
2016	F	5-6	0	0
2016	F	7-8	0	0
2016	F	9-10	0	0
2016	M	1-2	0	0
2016	M	3-4	0	0
2016	M	5-6	0	0
2016	M	7-8	0	0
2016	M	9-10	0	0
2016	U	1-2	0	0
2016	U	3-4	1	100
2016	U	5-6	0	0
2016	U	7-8	0	0
2016	U	9-10	0	0

**American Samoa Longline Fishery***Sex ratio from 2010 to 2016*

**Table 15. Sex composition of giant manta ray data available from the American Samoa longline fishery observer data from 2010 to 2016. N refers to number of individuals. The reader is advised that this represents all observed mantas in the available data, of which only a sub-selection may have length measurements available.**

<b>Year</b>	<b>N Male</b>	<b>% Male</b>	<b>N Female</b>	<b>% Female</b>	<b>N Unsexed</b>	<b>% Unsexed</b>	<b>Total N</b>
2010	0	0	0	0	18	100	18
2011	0	0	0	0	3	100	3
2012	0	0	0	0	3	100	3
2013	0	0	0	0	1	100	1
2014	0	0	0	0	7	100	7
2015	0	0	0	0	7	100	7
2016	0	0	0	0	7	100	7

*Length composition from 2010 to 2016*

**Table 16. Binned length composition (in feet) of giant manta ray data from the American Samoa longline fishery observer data. N refers to number of individuals. Only a single measured animal was available, for year 2011, and thus additional years (of 2010, 2012, and 2016) are omitted.**

Year	Sex	Length Bin (ft)	N	Percent (%)
2011	F	1-2	0	0
2011	F	3-4	0	0
2011	F	5-6	0	0
2011	F	7-8	0	0
2011	F	9-10	0	0
2011	M	1-2	0	0
2011	M	3-4	0	0
2011	M	5-6	0	0
2011	M	7-8	0	0
2011	M	9-10	0	0
2011	U	1-2	0	0
2011	U	3-4	0	0
2011	U	5-6	1	100
2011	U	7-8	0	0
2011	U	9-10	0	0

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<sup>7</sup> <http://www.st.nmfs.noaa.gov/observer-home/first-edition-update-1>.

<sup>8</sup> <http://www.st.nmfs.noaa.gov/observer-home/first-edition-update-2>.