

Summary of 2016 Reef Fish Surveys around Kahoolawe Island ¹

Results and information presented here summarize data gathered by the Coral Reef Ecosystem Program (CREP) of NOAA's Pacific Islands Fisheries Science Center and partners during 2 days of reef fish and habitat surveys around Kahoolawe Island in July/August 2016. Surveys were conducted as part of the NOAA National Coral Reef Monitoring Program.

Surveys were conducted using a standard sampling design and method implemented by NOAA's Pacific Reef Assessment and Monitoring Program (Pacific RAMP) since 2009. In brief, pairs of divers record numbers, sizes, and species of fishes inside adjacent 15m-diameter 'point-count' cylinders and estimate benthic cover by functional groups (e.g. 'coral', 'sand').

Because it is unpopulated and protected, Kahoolawe is an important reference location in the main Hawaiian Islands and may also be a significant source of larvae and fish recruits for other parts of Maui-nui and perhaps beyond. Therefore, CREP hopes to routinely survey Kahoolawe reefs during future monitoring efforts. However, as 2016 was the first year for Kahoolawe surveys, we have a relatively small sample size there - 24 sites - in comparison to other Main Hawaiian Islands (MHI: between 107 and 257 survey sites per island).

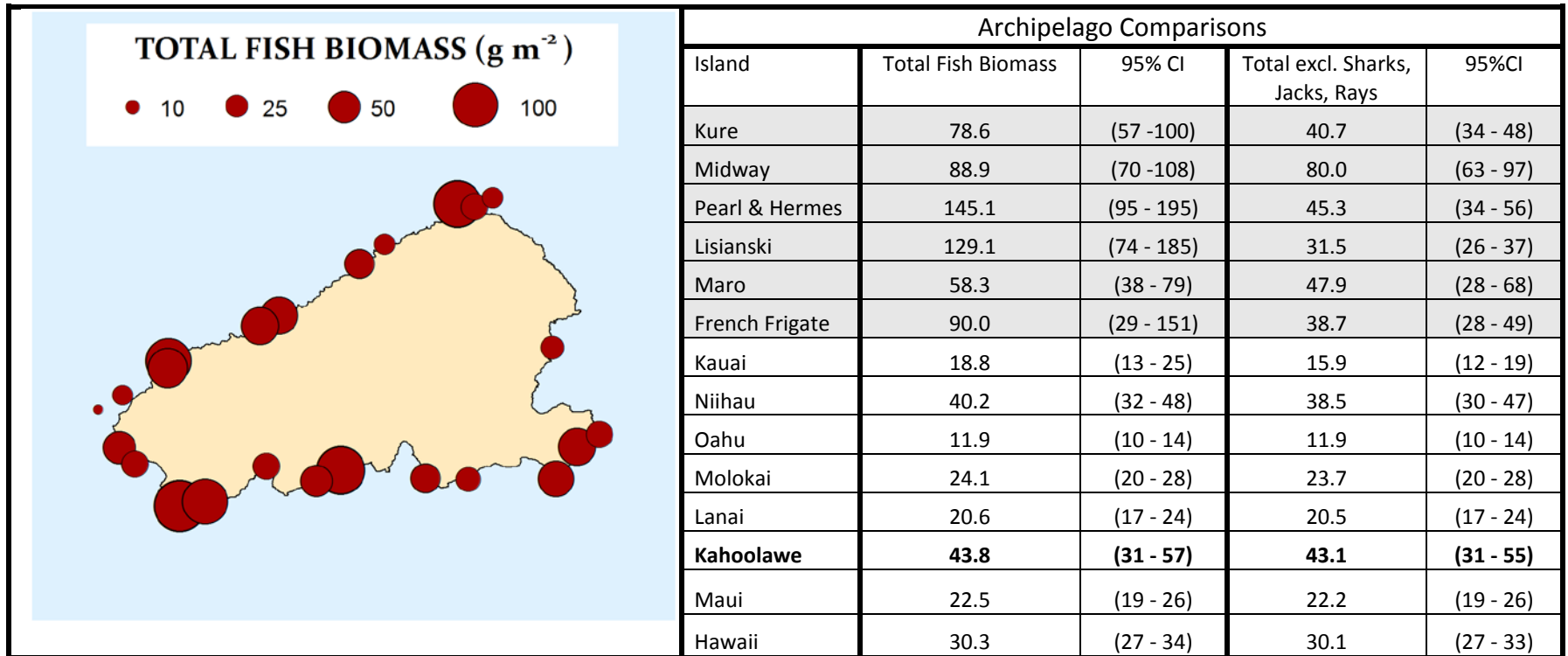
Main conclusions and observations:

- Reef fish biomass was high at most sites we visited in Kahoolawe, with mean island-wide biomass higher than at any other of the MHI, although only marginally higher than at Niihau. Biomass tended to be slightly higher at sites along the southern section of the island. Excluding sharks and jacks, reef fish biomass at Kahoolawe was similar to what is typical for CREP surveys at reefs in the Northwestern Hawaiian Islands.
- Reef sharks and jacks are difficult to accurately count in small-scale visual surveys, but they are likely considerably more abundant in the NWHI than anywhere in the MHI. However, compared to other parts of the MHI, sharks and giant trevally, *ulua*, were seen more frequently at Kahoolawe than elsewhere in the MHI. Specifically, though Kahoolawe sites comprised less than 10% of the total sites surveyed during the 2016 Pacific RAMP cruise (24 of 256), more than half the sightings of *ulua* (5 of 8) and reef sharks (5 of 9; one whitetip, one blacktip, three gray reef) were at Kahoolawe sites.
- There were clear differences in reef type and coral growth between north and south Kahoolawe. Reefs in the north tended to have more abundant coral (mean cover ~30%), whereas reefs in the south were mostly rock and boulder habitats with patchy coral.

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Reef Fish Biomass

Fish Biomass (g/m²) – Estimated total weight of all fishes recorded during surveys. Note that all survey data are estimates that have a mean (best estimate) and a measure of uncertainty. The 95% confidence intervals (CI) show the range of biomass values within which the true value lies with 95% certainty. Note that this is ‘instantaneous’ fish biomass, which is biomass gathered in the snapshot portion of fish surveys. More information on indicators used in this report is given in the ‘Indicator Notes’ section below.



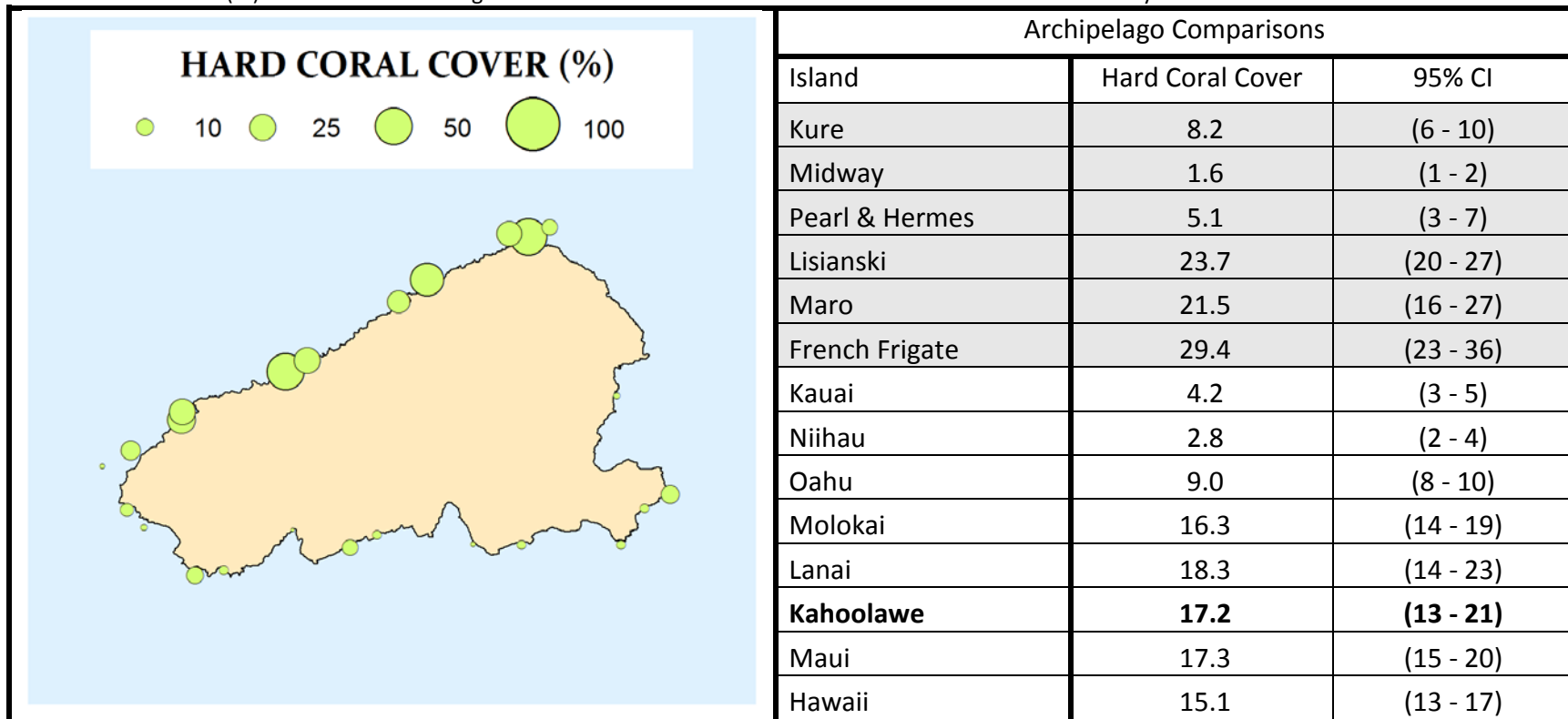
Sharks and jacks make up a very large part of estimated fish biomass in the Northwestern Hawaiian Islands (NWHI) but are infrequently recorded during surveys in Main Hawaiian Islands (MHI). Archipelagic comparisons shown above are for ‘all fishes’ and for ‘all fishes excluding sharks, jacks and rays’ to allow for comparisons excluding those families.

Summary:

There was no clear pattern in the spatial distribution of reef fish biomass around the island, which was moderate to high at nearly all sites. Overall, total reef fish biomass was higher at Kahoolawe than the other MHI, although the difference with Niihau was small. Excluding sharks, jacks and rays, fish biomass at Kahoolawe was similar to values that are typically recorded at sites in the Northwestern Hawaiian Islands.

Coral Cover %

Coral Cover (%) – Visually estimated by divers during surveys. Data presented include the mean (best estimate) and a measure of uncertainty - the 95% confidence intervals (CI) - which show the range of cover values within which the true value lies with 95% certainty.



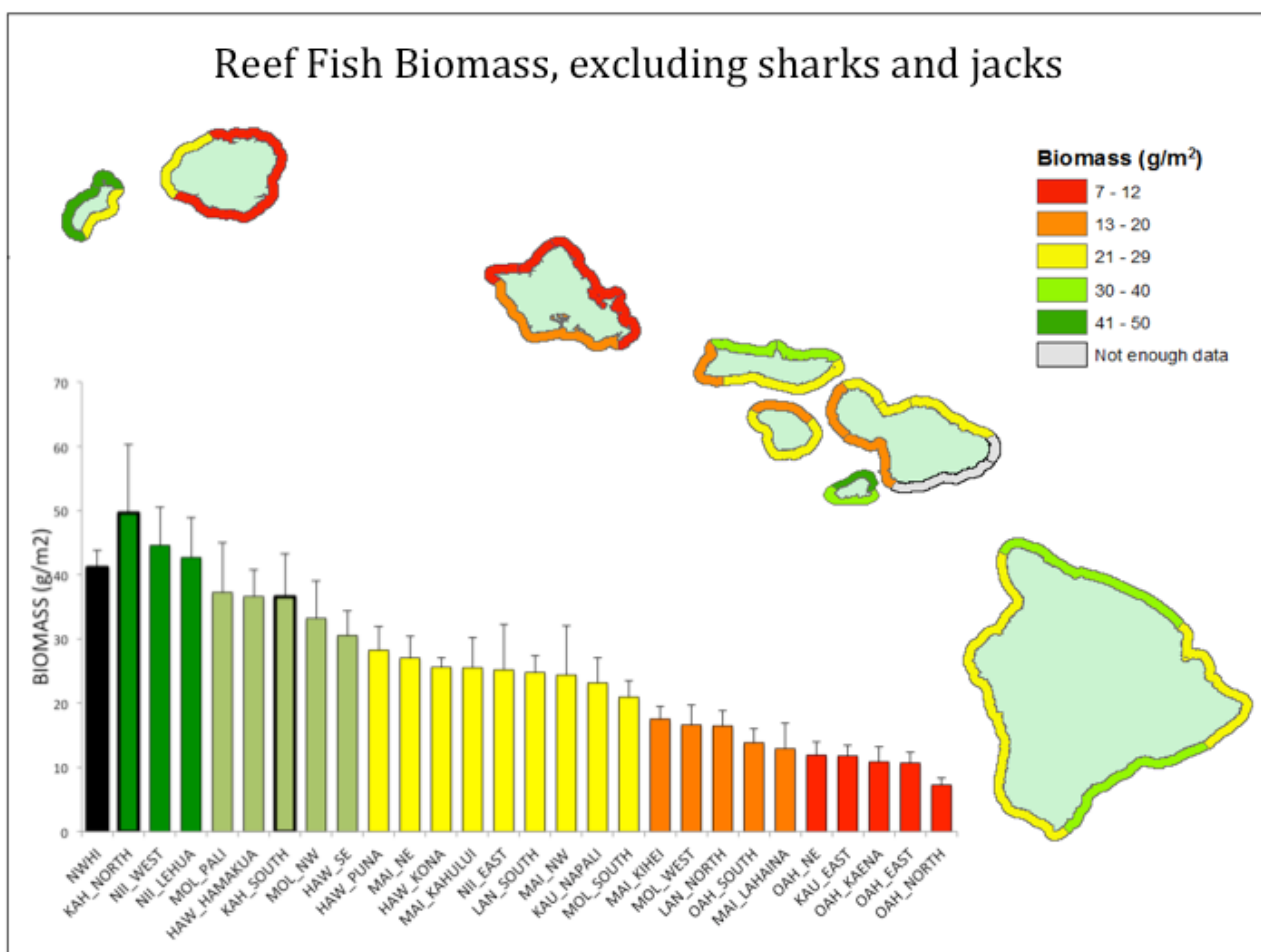
Summary:

Coral cover was much higher at sites along the northern coastline (averaging approximately 30% there) than along the south shore (averaged approximately 5%). However, southern reefs were generally complex boulder or rocky environments that are capable of supporting large fish populations. Overall, island-scale coral cover at Kahoolawe was similar to elsewhere in Maui-nui and the Big Island.

How does Kahoolawe compare to other reef areas in the MHI?

Coral reefs and fish assemblages vary naturally from one area to another, due to differences in reef type and natural and human impacts. In order to represent this spatial variability within islands, we have also pooled data at sub-island scale into 'sectors' (2 to 5 per island). For the 2012-2016 time-period, we have data from 29 of those sectors (see figure below). Each sector contains a section of coastline with broadly similar reef habitat, wave exposure, and proximity to human populations. Kahoolawe was divided into 'north' and 'south' sectors. The north sector is a largely coral-dominated habitat, whereas the southern sector is mostly rock and boulder habitat.

Reef fish biomass (g/m²) per sector, excluding biomass of sharks, jacks and rays, which are not well sampled by small-scale surveys. Sectors are ordered from highest to lowest biomass (left to right). Columns representing Kahoolawe sectors are emphasized by black outlines. The black column at the left of the figure is mean biomass for the Northwestern Hawaiian Islands. All data gathered 2012 to 2016.



Summary:

Among MHI sectors, reef fish biomass was highest on reefs adjacent to remote, inaccessible, and lightly populated shorelines, including Niihau, north Molokai, Hamakua, and Kahoolawe. Lowest biomass was recorded around heavily populated and urbanized areas such as Oahu.

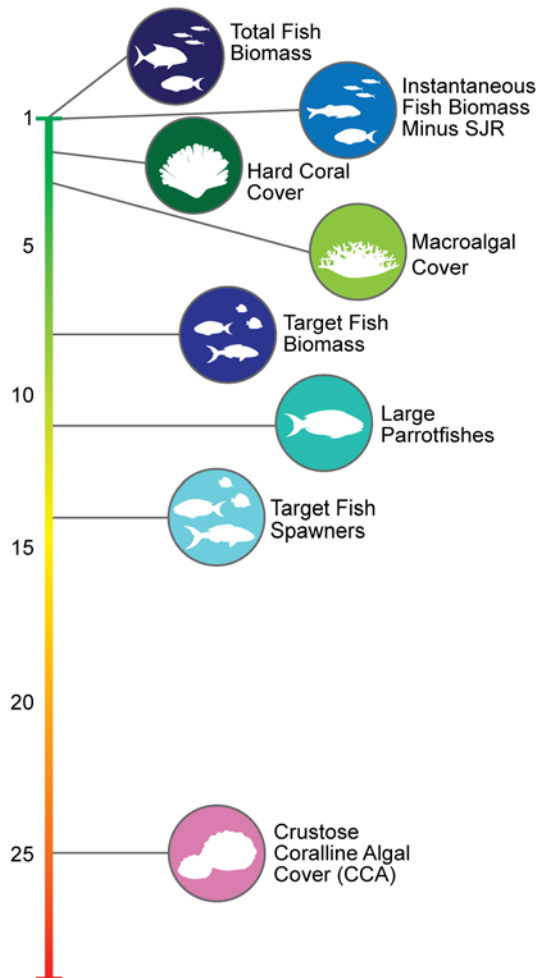
- Sharks and jacks comprise a large portion of fish survey counts in the NWHI, but excluding those, reef fish biomass at remote MHI locations, including Kahoolawe, is comparable to what has been recorded in the NWHI. Biomass of these reef fishes other than sharks and jacks was higher at 'Kahoolawe north' than at any other MHI sector.

Additional sector comparisons among MHI – for other fish and benthic condition metrics – are shown on following pages.

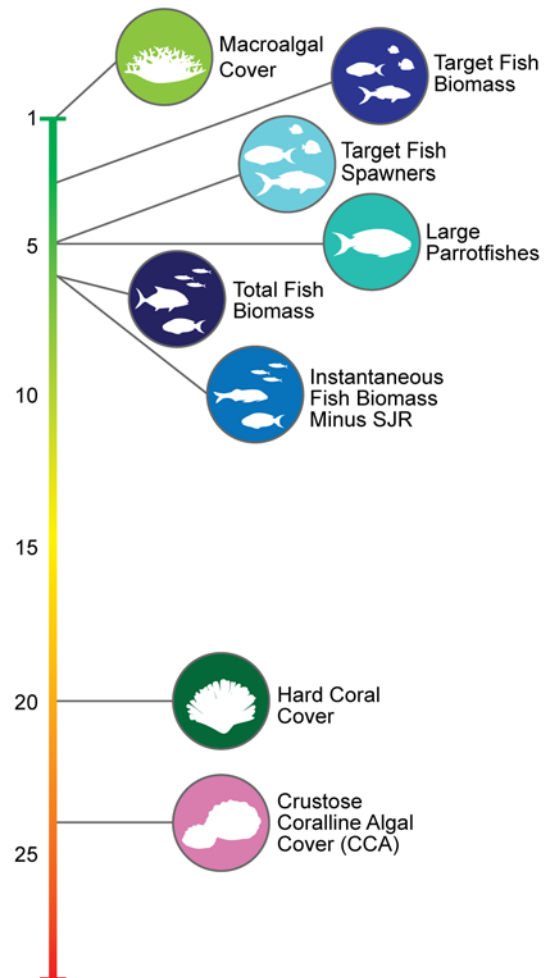
Condition Indicators Summary

As described in more detail below, the indicators shown here were chosen to represent different aspects of condition of reef and benthic communities. Each indicator is ranked relative to values for the other 29 MHI sectors for which we have data. One is considered the ‘best’ value (e.g. desirable states are high fish biomass but low macroalgal cover); thus, values near top of the range are among the best in the MHI.

KAHO‘OLAWE NORTH



KAHO‘OLAWE SOUTH



INDICATOR NOTES: 'Total Fish' is biomass of all fishes recorded during standard CREP SPC surveys.

'Large Parrotfishes' are parrotfishes estimated to have total length of 25cm or greater.

'Inst Fish Minus SJR' is 'instantaneous' biomass of all fishes recorded during surveys excluding sharks, jacks, and rays which are arguably not well counted by small-scale visual surveys. *Instantaneous* refers to the fishes present within the survey cylinders at the time of snapshot observations. 'Total fish' includes some observations of species that are present within the cylinder during the first 5 minutes of the count, but are gone when the diver tries to tally them (typically many of those are roving species).

'Target Fish' are goatfishes, surgeonfishes, parrotfishes, emperor, and soldierfishes, excluding some small-bodied species and including a few additional targeted species such as the green jobfish. Species classified as target species and recorded at Kahoolawe during these surveys are listed in Appendix B. below.

'Target Fish Spawners' are fishes of target species in mature size classes.

Benthic cover was visually-estimated by survey divers.

For these rankings, high cover of coral and CCA are considered desirable, whereas low cover of macroalgae is ranked highest. Rankings are based on survey data shown on following page.

Fish and benthic indicator values for the 2 Kahoolawe sectors. For purposes of comparison, mean values from reefs in the Northwestern Hawaii Islands are also shown. The rank of each value relative to the 29 sectors in the MHI with data are given in the final two columns. For sector ranks, 1 is the 'best' score in the MHI (e.g. highest fish biomass, lowest macroalgal cover).

<i>Fish Indicator (g/m²)</i>	Mean ± SE			Sector Ranking (1=highest)	
	Kahoolawe North (n=9)	Kahoolawe South (n=15)	NWHI (n=402)	Kah North	Kah South
Total Fish Biomass	61.0 ± 11.5	54.5 ± 10.0	158.9 ± 1.3	1	6
Instantaneous Fish Biomass Minus SJR	49.6 ± 10.7	36.6 ± 6.7	41.1 ± 0.7	1	6
Target Fish Biomass	18.7 ± 4.3	24.4 ± 6.0	38.3 ± 0.5	8	3
Target Fish Spawners	6.2 ± 1.4	13.2 ± 4.2	20.2 ± 0.4	14	5
Large Parrotfishes	2.7 ± 0.3	4.4 ± 2.0	5.9 ± 0.2	11	5
<i>Benthic Indicator (%)</i>					
Hard Coral Cover	29.5 ± 4.0	4.9 ± 1.1	21.1 ± 0.3	2	20
Macroalgal Cover	1.2 ± 0.3	0.7 ± 0.3	15.5 ± 0.5	3	1
Crustose Coralline Algal Cover (CCA)	1.7 ± 0.7	1.7 ± 0.3	9.1 ± 0.2	25	24

Conclusions

This data summary is based on the first survey visit conducted by NOAA=CREP at Kahoolawe. From these relatively few surveys we can draw some broad conclusions including that, at the time of the surveys:

- Reef fish biomass at Kahoolawe was among the highest in the Main Hawaiian Islands. The Kahoolawe north shore 'sector' actually had the highest biomass of the 29 surveyed 'sectors' in the MHI, but there were quite small differences among the top ranked sectors – which were all remote, inaccessible, or lightly populated areas (Niihau, north Molokai, Hamakaua).
- There were clear differences in coral communities between north and south Kahoolawe. Northern sites tended to have high coral cover (~30%, close to the highest in the MHI), whereas southern sites averaged only 5% coral cover (20th of 29 sectors in the MHI), comparable to what we observe at other wave-exposed areas elsewhere in the MHI (Niihau, north Molokai, Hamakua, NW Maui).
- Because southern reefs are generally structurally complex rock and boulder formations, they are still capable of supporting abundant reef fish populations in spite of low coral cover.
- Both macroalgae and crustose coralline cover were low at Kahoolawe compared to elsewhere in the MHI.

All coral reef survey data gathered by CREP are public data, available on request to nmfs.pic.credinfo@noaa.gov.

Appendix A—Kahoolawe Survey Sites

Survey Information						Visually Estimated Cover (%)				Fish Biomass (g/m ²)				
Site	Sector	Survey Date	Lat	Long	Depth (m)	Hard Coral	Macro-algae	CCA	Sand	All	Large Parrotfish	Inst. Fish Minus SJR	Target Fish	Target Fish spawners
KAH-00163	K_SOUTH	8/21/16	20.5262	-156.5307	23.5	11.5	3.0	2.5	10.0	34.4	2.2	23.8	6.8	3.2
KAH-00198	K_SOUTH	8/21/16	20.5107	-156.5459	14.7	3.5	0.5	0.5	0.5	64.7	14.8	45.9	32.2	16.5
KAH-00178	K_SOUTH	8/21/16	20.5138	-156.6211	19.7	3.5	3.5	1.0	22.5	114.6	16.4	90.2	74.6	54.8
KAH-00119	K_SOUTH	8/21/16	20.5152	-156.6470	4.5	0.5	-	0.5	1.0	37.3	-	19.5	8.2	4.6
KAH-00123	K_SOUTH	8/21/16	20.5028	-156.6682	4.8	3.5	1.5	4.0	11.5	100.7	21.6	77.2	67.1	41.4
KAH-00145	K_SOUTH	8/21/16	20.5161	-156.6927	9.3	1.5	-	0.5	12.5	35.7	-	21.4	10.4	0.9
KAH-00146	K_SOUTH	8/21/16	20.5566	-156.5471	22.0	1.5	-	0.5	22.5	27.2	-	17.4	12.2	2.0
KAH-00127	K_SOUTH	8/21/16	20.5219	-156.5386	5.2	3.0	-	2.5	0.5	70.9	2.9	63.1	23.1	16.9
KAH-00128	K_SOUTH	8/21/16	20.5107	-156.5765	13.5	3.5	-	2.5	-	29.4	-	18.9	10.1	1.8
KAH-00172	K_SOUTH	8/21/16	20.5109	-156.5913	5.2	1.0	-	3.0	-	41.7	-	34.2	22.0	13.3
KAH-00181	K_SOUTH	8/21/16	20.5098	-156.6294	22.3	8.5	-	2.0	18.5	50.9	6.5	20.8	28.3	6.5
KAH-00106	K_SOUTH	8/21/16	20.5013	-156.677	11.2	10.5	-	2.5	2.0	132.5	-	56.4	40.1	18.8
KAH-00173	K_NORTH	7/15/16	20.6086	-156.5680	23.0	9.0	0.5	0.5	45.0	21.0	-	16.7	3.1	-
KAH-00157	K_NORTH	7/15/16	20.6056	-156.5743	7.6	50.0	2.5	1.0	16.5	36.2	3.2	21.3	14.5	5.4
KAH-00195	K_NORTH	7/15/16	20.5925	-156.6055	5.6	40.0	0.5	0.5	12.5	22.5	2.2	20.0	8.6	4.6
KAH-00176	K_NORTH	7/15/16	20.5640	-156.6493	8.5	47.5	2.5	1.0	12.5	68.6	4.3	57.0	39.1	12.9
KAH-00105	K_NORTH	7/15/16	20.5494	-156.6814	5.0	27.5	2.0	2.5	6.0	76.4	4.0	60.1	29.9	10.4
KAH-00164	K_NORTH	7/15/16	20.5518	-156.6809	19.0	25.0	0.5	5.5	30.0	103.4	1.0	96.2	19.7	4.6
KAH-00185	K_NORTH	7/15/16	20.6065	-156.5803	19.4	22.5	-	-	32.5	108.4	0.9	105.3	27.0	5.5
KAH-00101	K_NORTH	7/15/16	20.5856	-156.6144	8.7	19.0	-	-	47.5	42.2	6.1	39.8	10.9	2.1
KAH-00187	K_NORTH	7/15/16	20.5677	-156.642	4.4	25.0	2.5	4.0	15.0	70.6	3.1	29.9	15.5	9.9
KAH-00174	K_SOUTH	7/15/16	20.5349	-156.7055	21.1	1.0	1.0	0.5	25.0	4.1	-	2.4	0.6	-
KAH-00188	K_SOUTH	7/15/16	20.5399	-156.6971	11.8	15.0	-	2.0	2.5	19.5	1.1	17.1	6.9	1.1
KAH-00167	K_SOUTH	7/15/16	20.5215	-156.6981	6.1	6.0	0.5	1.0	-	53.3	-	40.0	23.7	16.0

Definitions of fish biomass columns are given in the Indicator Notes above.

Appendix B—Target Fish Species Observed During CRED 2016 Surveys at Kahoolawe:

Acanthurus achilles, *A. blochii*, *A. dussumieri*, *A. guttatus*, *A. leucopareius*, *A. nigroris*, *A. triostegus*, *A. xanthopterus*, *Aphareus furca*, *Aprion virescens*, *Calotomus carolinus*, *C. zonarchus*, *Chlorurus perspicillatus*, *C. sordidus*, *Cirrhitus pinnulatus*, *Ctenochaetus hawaiiensis*, *C. strigosus*, *Monotaxis grandoculis*, *Mulloidichthys flavolineatus*, *M. mimicus*, *M. pfluegeri*, *M. vanicolensis*, *Myripristis amaena*, *M. berndti*, *M. chryseres*, *M. kuntee*, *M. vittata*, *Naso annulatus*, *N. brevirostris*, *N. hexacanthus*, *N. lituratus*, *N. unicornis*, *Neoniphon samara*, *Oxycheilinus unifasciatus*, *Parupeneus chrysonemus*, *P. cyclostomus*, *P. insularis*, *P. multifasciatus*, *P. pleurostigma*, *P. porphyreus*, *Priacanthus meeki*, *Sargocentron ensifer*, *S. tiere*, *Scarus dubius*, *S. rubroviolaceus*, *Scomberoides lysan* & *Zebrasoma veliferum*.

Further Reference

Survey Methods

Ayotte, P, K McCoy, A Heenan, I Williams, and J Zamzow. 2015. "Coral Reef Ecosystem Division Standard Operating Procedures: Data Collection for Rapid Ecological Assessment Fish Surveys."
http://www.pifsc.noaa.gov/library/pubs/admin/PIFSC_Admin_Rep_15-07.pdf.

Methods and Survey Design Outline

https://www.pifsc.noaa.gov/cred/reef_fish_survey_methods_and_data.pdf

Diver Training Materials

https://www.pifsc.noaa.gov/cred/survey_methods/fish_surveys/rapid_ecological_assessment_of_fish-survey_method_training.php

Annual Data Reports available at

https://www.pifsc.noaa.gov/cred/monitoring_status_reports.php. Example 2015 surveys report:

K, McCoy, A Heenan, J Asher, P Ayotte, K Gorospe, A Gray, K Lino, J Zamzow, and I Williams. 2016. "Pacific Reef Assessment and Monitoring Program - Data Report - Ecological Monitoring 2015 - Reef Fishes and Benthic Habitats of the Main Hawaiian Islands, Northwestern Hawaiian Islands, Pacific Remote Island Areas and American Samoa." Honolulu, Hawaii.

<https://www.pifsc.noaa.gov/library/pubs/DR-16-002.pdf>.

NOAAs National Coral Reef Monitoring Program

Monitoring Plan available at:

http://docs.lib.noaa.gov/noaa_documents/CoRIS/CRCP/noaa_crmp_national_coral_reef_monitoring_plan_2014.pdf.