Marine ecological assessment of Hāʻena's reef habitats

Preliminary results of July 2013 surveys

25 November 2013

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INTRODUCTION

The rural community of Hāʻena on Kauaʻi's north shore has long sustained themselves through taro farming and fishing the area's fringing reefs and lagoon areas (Andrade 2008). Up into the 1960s, people supported themselves through the traditional ahupuaʻa system. However, contemporary social-ecological systems have disrupted the customary sharing of natural resources within the Hāʻena community, impacting exchange of food, cultural perpetuation and self-reliance, and strength of social networks (Vaughan and Vitousek 2013). The Hui Makaʻainana o Makana was formed in 1998 by key members of the community in Hāʻena, with the goal of restoring Hawaiian values and stewardship practices within the area (Friedlander et al. 2013).

In 2006, Governor Lingle signed into law SB2501 SD1 HD1 CD1: "A Bill for an Act Relating to Fishing" (Act 241), thus establishing, "a community-based subsistence fishing area for the ahupuaʻa of Hāʻena." The goal of the Hāʻena Community-Based Subsistence Fishing Area is to sustainably support the consumptive needs of Hāʻena's people through culturally rooted, community-based management that recognizes and responds to the connection between land and sea and strives to restore the necessary balance of native species (Friedlander et al. 2013).

Historically, nearshore reefs in Hāʻena, Kauai have provided valuable habitat for many resource species of reef fishes, such as o'io, uhu, and ʻomilu. Reef ecosystems provide food and habitat structure necessary for supporting fish populations. Backreef areas, between the reef crest and the shore, serve as important habitat for juvenile fishes as they are protected from swell and predators. Juvenile fish habitat is crucial for the maintenance of adult fish populations. With increased stressors on reef fishes (overfishing, pollution, anthropogenic damage to reef, climate change), it is important to create a baseline knowledge of present fish populations, and to assess areas that might be particularly critical for juvenile fishes. Identification of areas that serve as juvenile habitat is a valuable step in marine resource management efforts.

The objectives of this study were to conduct a marine ecological assessment of the nearshore reef habitats of Hāʻena, Kauai to provide scientific information in order to support ongoing efforts to designate a marine community managed area (CMA). A specific goal was to determine the ecological importance of Makua backreef in comparison with other backreef habitats at Hāʻena, and to assess its role as a nursery habitat, or puʻuhonua.

METHODS

Fish surveys were conducted on Makua and Kēʻē reefs in Hāʻena, Kauai using belt transect methods. Randomly located transects were placed in the backreef area (area between the reef crest and the shoreline) and the forereef area (area on the outer side of the reef crest) for each reef. A diver swam a 25 x 5 m transect at a constant speed and identify to the lowest possible taxon all fishes visible within 2.5 m to either side of the centerline (125-m^2 transect area). Swimming duration varied from 10–15 min, depending on habitat complexity and fish abundance. Total length (TL) of fish was estimated to the nearest centimeter.

After swimming the transect once to quantify adult fishes, surveyors then swam the same transect again to record juvenile fishes within 2 m to the left of the centerline. Fishes less than or equal to 5 cm total length were classified as juveniles for all fishes except butterfyfishes, surgeonfishes, triggerfishes, and roi, which were classified as juveniles at 10 cm or less.

Length estimates of adult fishes from visual censuses were converted to weight using the following length–mass relationship: $W = a(TL)^b$ where the parameters a and b are constants for the allometric growth equation, TL is total length in centimeters, and W is mass in grams.

RESULTS

Surveys

A total of 55 transects were conducted on Kēʻē and Makua reefs from 8-14 July 2013 (Fig. 1). Of this total, 24 transects were conducted in the forereef habitat, and 31 transects in the backreef habitat. Transect surveys were split nearly evenly between Kēʻē (N = 15) Makua (N = 16, Table 1). Average depth for the forereef surveys was 4.8 m (± 1.9 sd) and 1.2 m (± 0.8 sd) for the backreef.

Table 1. Total number of transect surveys in each stratum

	Reef			
Habitat		Kēʻē	Makua	**TOTAL**
	Backreef	15	16	**31**
	Forereef	12	12	**24**
	TOTAL	**27**	**28**	**55**

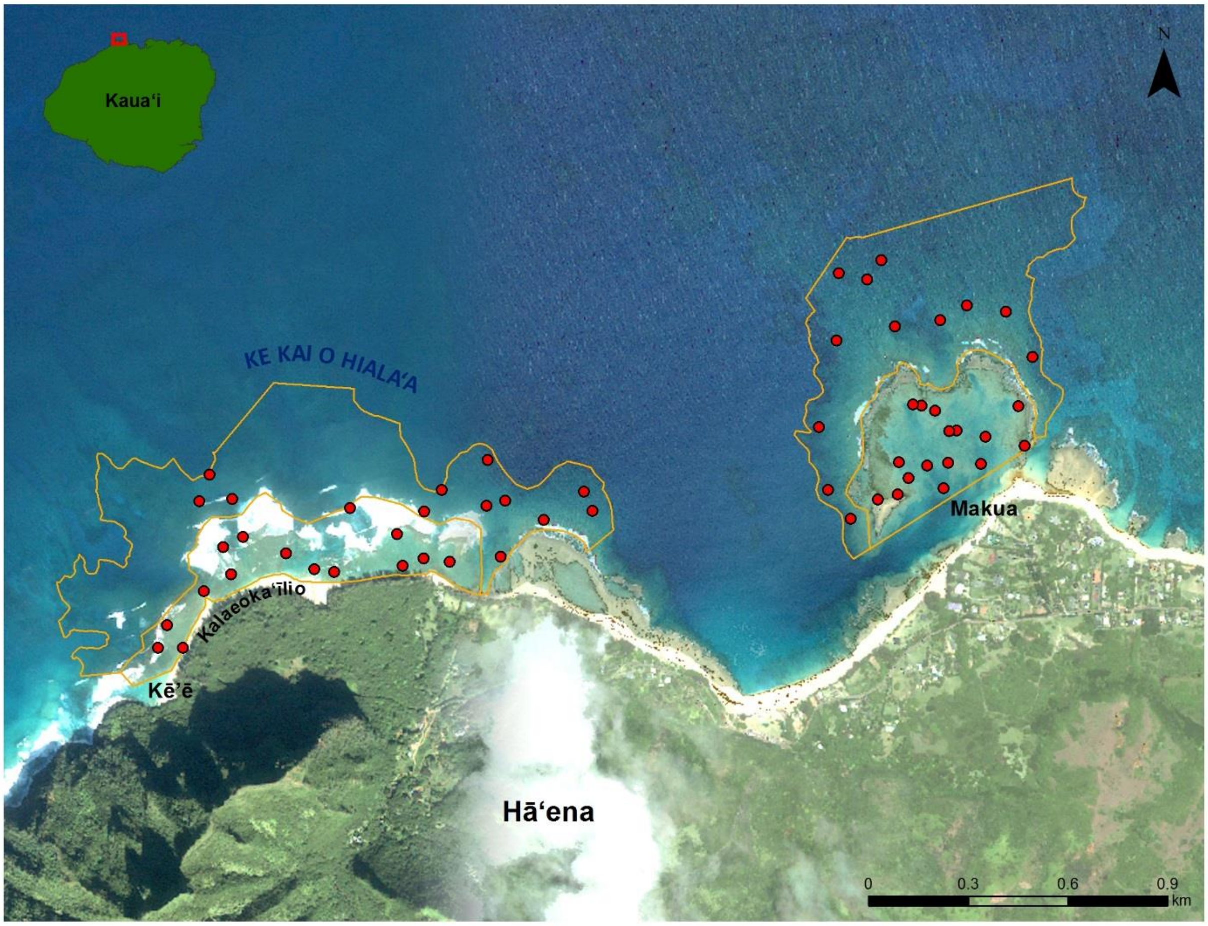

Figure 1. Survey locations for marine assessments in Hāʻena.

Juvenile fishes

Juvenile fish surveys across study sites showed backreef habitat to have significantly higher abundance of juvenile fishes than the forereef habitat ($t_{47.1}$ = -4.9, P<0.001, Fig. 2). Backreef transects also had, on average, more species of juvenile fishes than forereef transects (Fig. 3 and 4). There is no evidence to suggest that Makua backreef habitat has higher abundance of juvenile fishes than Kēʻē backreef habitat ($t_{27.8}$ = -0.4, P = 0.7, Fig. 5). However, in our surveys Makua backreef did have a greater average number of species of juvenile fishes than Kēʻē backreef habitat (Fig. 6).

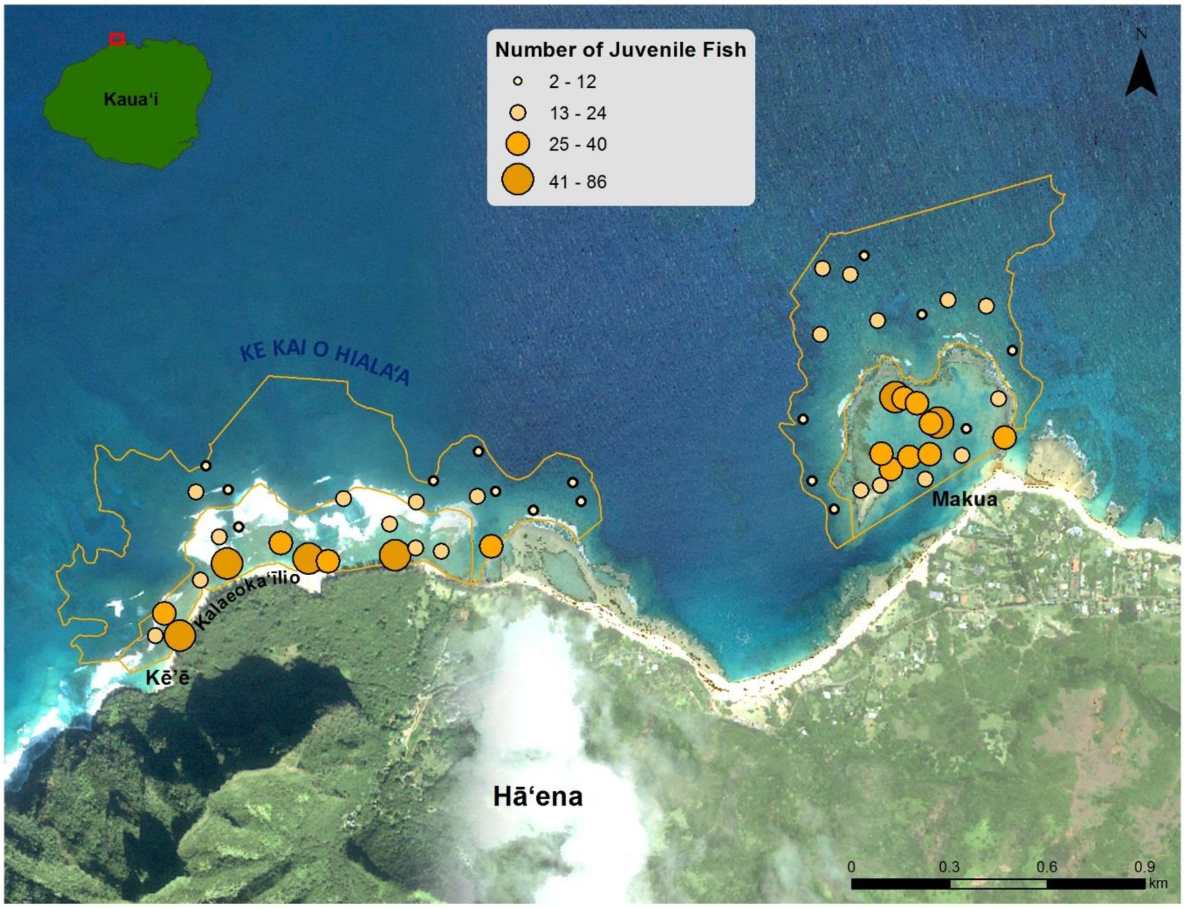

Figure 2. Juvenile fish abundance by site.

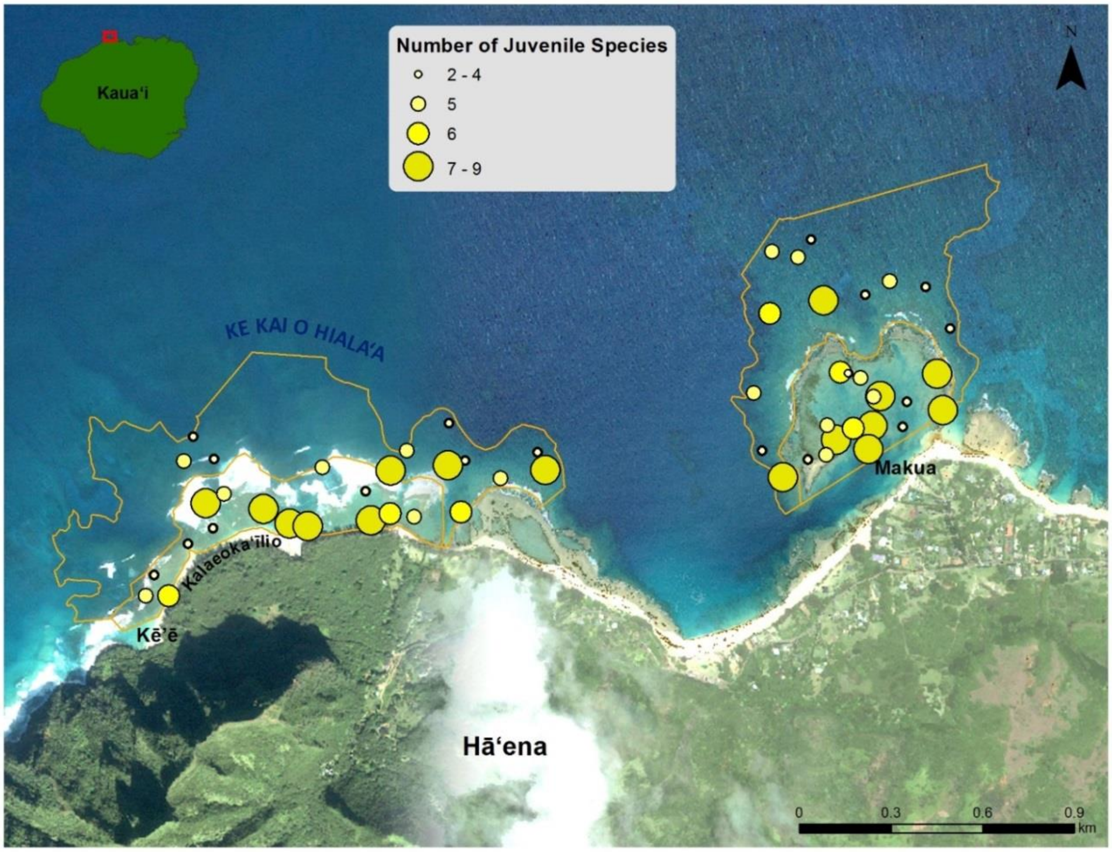

Figure 3. Number of juvenile fish species

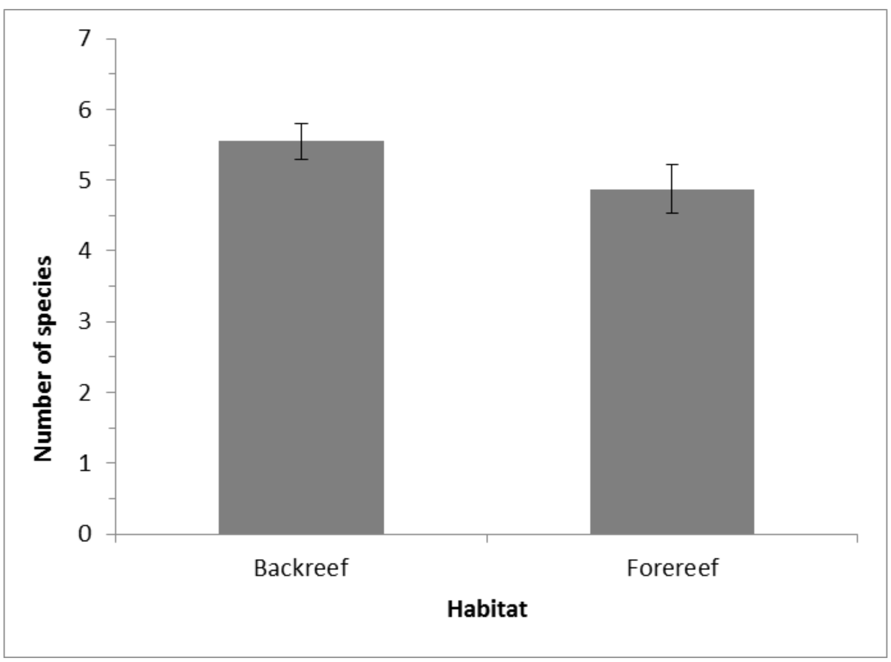

Figure 4. Average number of species of juvenile fishes by habitat

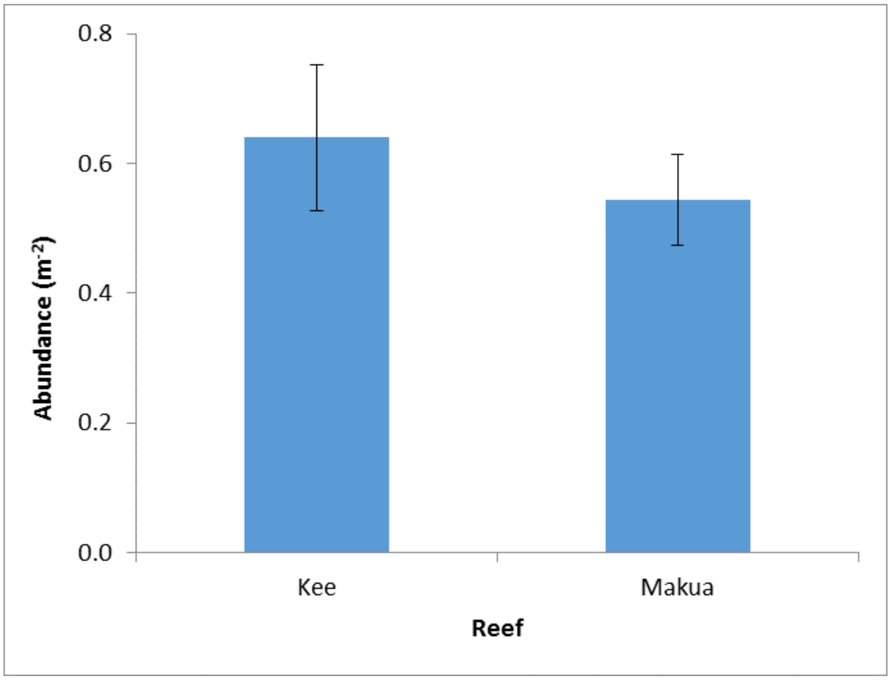

Figure 5. Average number of juvenile fishes (per m^2) in backreef habitat, by reef.

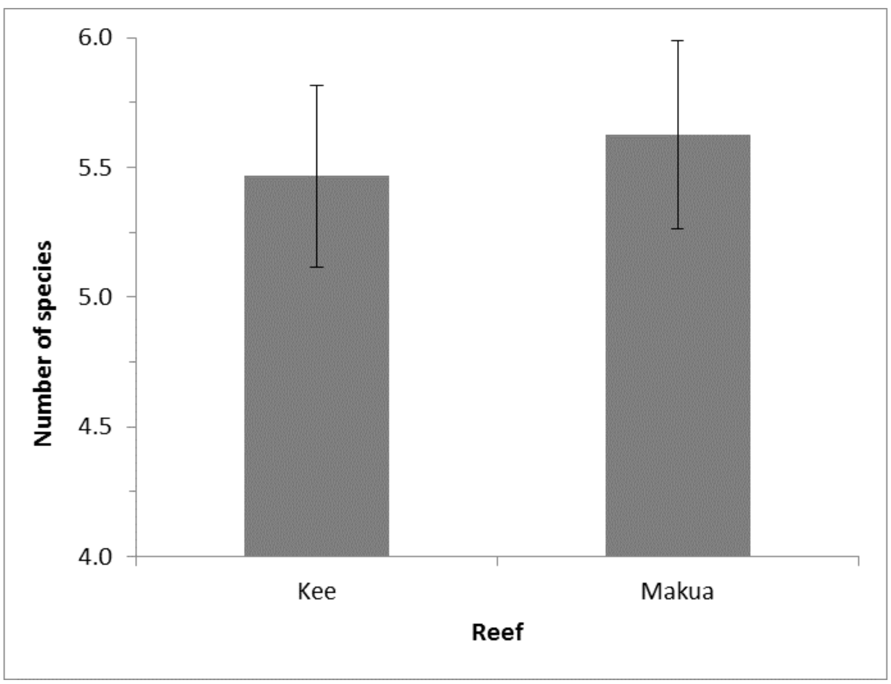

Figure 6. Average number of juvenile fishes in backreef habitat, by reef.

Adult fishes

Based on surveys of adult fishes, forereef habitats at Makua and Kēʻē reefs had significantly greater biomass than backreef habitats ($t_{41.6}$ = 2.7, P = 0.005, Fig. 7), by nearly three times as much. Average abundance was slightly higher at Makua compared to Kēʻē but these differences were not significant (t = 0.37, P = 0.36, Fig. 8). In looking at just the backreef habitat for the two sites, Makua had significantly higher numbers of fish species than did Kēʻē ($t_{28.8}$ = 1.7, P = 0.048, Fig. 9).

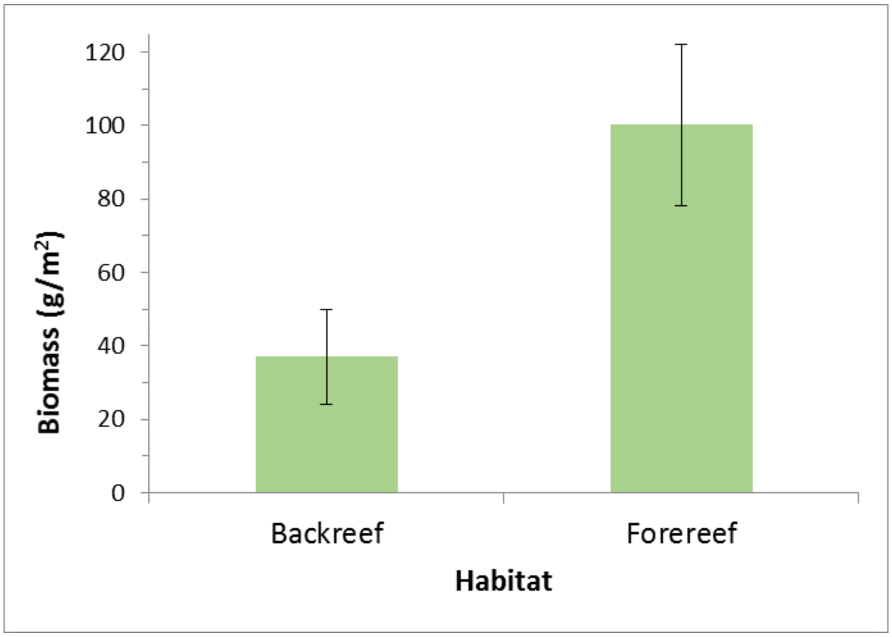

Figure 7. Average biomass of fishes per m^2 in backreef and forereef habitats.

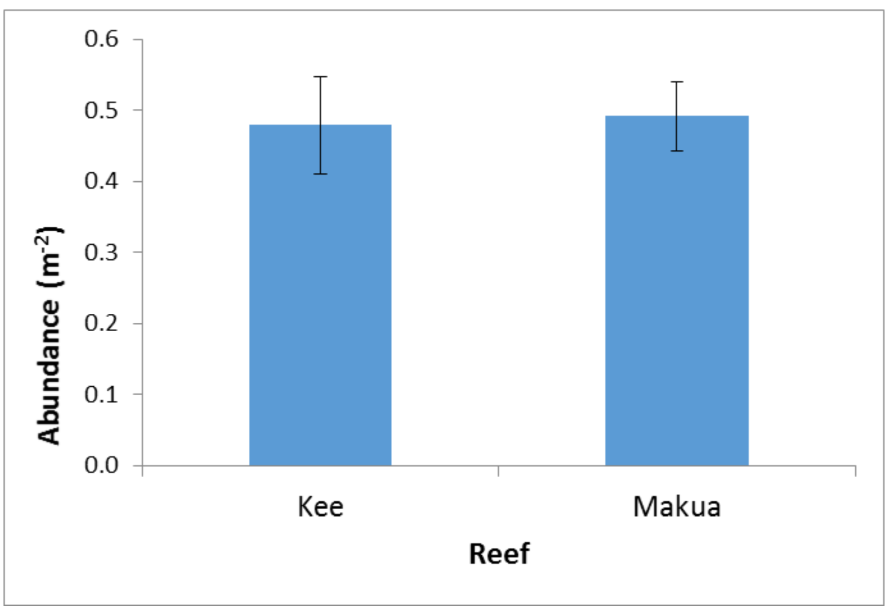

Figure 8. Average number of fishes per m^2 in Kēʻē and Makua reefs.

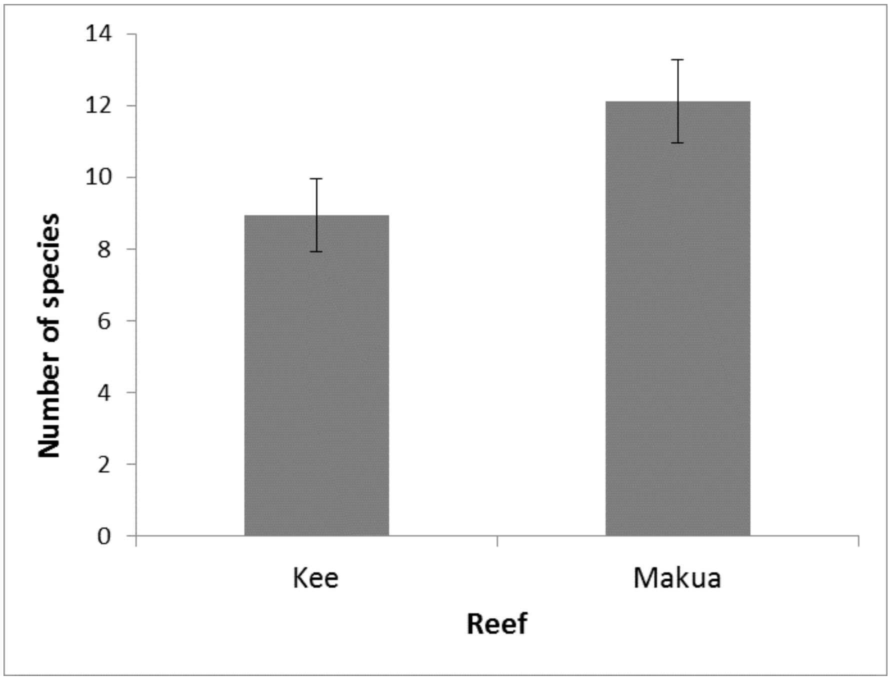

Figure 9. Average number of species of adult fishes in backreef transect surveys.

Species composition

The belted wrasse (‘omaka) was the most important species in the backreef habitat, accounting for 36% of the total numerical abundance (Table 2), followed by convict tang (manini – 25%), saddle wrasse (hinalea lauwili – 14%), and bird wrasse (hinalea 'i'iwi, 8%). In the forereef habitat, saddle wrasse were most abundant, accounting for 24% of the total in this habitat type. This was followed by brighteye damsel (20%), belted wrasse (18%), and shortnose wrasse (6%).

Table 2. Fish species composition (numerical abundance) within backreef and forereef habitats.

			Backreef		**Forereef**	
Species	Common Name	Hawaiian Name	Num/m^2	%	Num/m^2	%
Stethojulis balteata	Belted Wrasse	'o_maka	0.215	36.4	0.045	18.3
Acanthurus triostegus	Convict tang	manini	0.145	24.6	0.007	2.7
Thalassoma duperrey	Saddle Wrasse	hinalea lauwili	0.083	14.1	0.060	24.4
Gomphosus varius	Bird wrasse	hinalea 'i'iwi, 'akilolo	0.047	8.0	0.002	0.7
Plectroglyphidodon imparipennis	Brighteye Damselfish		0.029	4.9	0.049	20.0
Stegastes marginatus	Pacific Gregory		0.028	4.8	0.014	5.8
Scarus rubroviolaceus	Redlip Parrotfish	palukaluka	0.010	1.6	0.002	0.7
Coris venusta	Elegant coris		0.009	1.5	0.000	0.0
Plectroglyphidodon johnstonianus	Blue-eye Damselfish		0.008	1.4	0.004	1.7
Acanthurus leucopareius	Whitebar Surgeonfish	ma_ikoiko	0.004	0.7	0.011	4.4
Macropharyngodon geoffroy	Shortnose Wrasse		0.003	0.5	0.016	6.4
Ctenochaetus strigosus	Goldring surgeonfish	kole	0.001	0.2	0.001	0.3
Parupeneus porphyreus	Whitesaddle Goatfish	ku_mu_	0.001	0.2	0.000	0.0
Thalassoma purpureum	Surge Wrasse	hou	0.001	0.2	0.000	0.0
Acanthurus blochii	Ringtail Surgeonfish	pualu	0.001	0.1	0.000	0.0
Acanthurus nigrofuscus	Brown Surgeonfish	mai'i'i	0.001	0.1	0.002	0.7
Asterropteryx semipunctatus	Halfspotted goby	'o'opu	0.001	0.1	0.000	0.0
Dascyllus albisella	HI dascyllus	'alo'ilo'i	0.001	0.1	0.000	0.0
Parupeneus multifasciatus	Manybar Goatfish	moano	0.001	0.1	0.001	0.3

Parupeneus pleurostigma	Sidespot Goatfish	malu	0.001	0.1	0.000	0.0

CONCLUSIONS

Backreef habitats in the Ha'ena nearshore reef systems are areas of high diversity and abundance of juvenile fishes. Juveniles were more numerous in backreef locations compared with forereef habitats. In backreef habitats, Makua Reef had significantly more species of adult fishes than Kēʻē Reef. In the Makua and Kēʻē reefs of Hāʻena, backreef habitat appears to be an important area for reef fishes, particularly for juveniles. Juveniles grow in the protected habitat of the backreef, and then move to adult populations, a critical process for maintaining high biomass in forereef habitats. As the backreef habitats of Ha'ena reefs provide critical habitat for juvenile reef fishes, measures should be taken to ensure that this habitat is maintained for continued contribution to adult populations.

In surveys of adult fish, Makua backreef had significantly higher numbers of fish species than Kee backreef. Makua reef exibits a variety of habitats including sand which is important for schooling species such as ʻoio and akule. Because of their mobility, populations of these fishes are difficult to measure using transect-based methods and our surveys took place on hard-bottom only. Based on our results and experience in the field, Makua backreef appears to be an important area for adult fish as well as juveniles. Due to its large channel and relatively deep water, predators have easy access to Makua backreef which may in part explain the lower abundance of juveniles compared to Ke'e. Benthic survey analysis and habitat mapping will highlight the diversity of habitats which occur in the Makua backreef. This explains the much higher number of fish species that were found here and confirms the high ecological value of this reef area. Biodiversity is an indicator of ecosystem health and a critical factor supporting coral reef resilience to human impacts and climate change. We recommend that Makua backreef be protected from fishing and other extractive, or destructive human uses.

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