Lāna`i Aquatic Invasive Species Assessment

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Contents

EXECUTIVE SUMMARY

Aquatic invasive species (AIS) prevention, early detection, and management are essential for conserving and restoring marine biodiversity in Hawai`i. As an effort to conduct follow-up AIS surveys in Lāna`i, the Division of Aquatic Resources in collaboration with Conservation International and Pūlama Lāna`i conducted an AIS Assessment in April 2016. The survey focused on detecting newly established non-native seaweed and harbor invertebrates; two of the most common AIS in the Hawaiian Islands. Benthic surveys were conducted along the Northeast coast and settlement panels were deployed in Mānele harbor to assess fouling organisms. Survey results revealed no new incidents of invasive seaweed. *Acanthophora spicifera*, was the only invasive seaweed reported, however this was not a new occurrence and total biomass and distribution was relatively low compared to native macroalgae. Harbor biofouling species are still being analyzed, but the level of fouling invertebrates appear to be less than what has been observed by similar surveys on O'ahu. Based on the findings of this assessment, the key management recommendations focus on AIS prevention and early detection: Continued monitoring surveys should be conducted on Lāna`i and span larger areas; Harbors and adjacent reefs should be monitored closely for non-native organisms; and AIS outreach should be conducted with Lāna`i community members for early detection of nuisance species and alien species. These actions will help prevent AIS from becoming established and preserve the rich and abundant biodiversity of Lāna`i's marine resources. These efforts could benefit fisheries resources, tourism, and resilience to the effects of climate change.

INTRODUCTION

Marine invasive species pose a major threat to biodiversity, industry (e.g. tourism), food security, and human health (Bax et al. 2003). The Hawaiian Islands are one of the most remote places on earth, however Hawaii's marine resources are not immune to biological invasion via global shipping, mariculture, marine debris, and fisheries enhancement. The primary source of non-native species introductions to Hawai`i arrive via ship biofouling - the animals and seaweeds attached to submerged portions of ship hulls (Davidson et al. 2014). The invasion rate in Hawai`i has been steadily increasing since the 1800's with the increase in globalization and shipping traffic to Hawai`i (Davidson et al. 2014). It's been estimated that approximately 346 introduced and cryptogenic species have established in Hawai`i, and up to 78% of these species were introduced through biofouling and ballast water (6%) (Davidson et al. 2014). Established non-native species originate primarily from the indo-Pacific and the Philippine Islands region (Eldridge and Carlton 2002). Species such as snowflake coral (*Carijoa riisei*), Christmas tree hydroid (*Pennaria disticha*), and prickly seaweed (*Acanthophora spicifera*) were introduced via biofouling and ballast water (Carlton and Eldridge 2009).

Although shipping has contributed to the highest number of species introductions in Hawai`i, some of the most nuisance alien species were introduced or spread intentionally. Invasive seaweed has become a major issue for Hawai`i's coral reefs. Species such as *Gracilaria salicornia*, *Eucheuma denticulatum*, and *Kappaphycus alvarezii* were introduced and spread for mariculture production and experimentation (Doty 1977, Smith et al. 2002). These species impact Hawai`i's reefs by overgrowing and smothering corals leading to coral death, and monopolization of reef habitats (Conklin & Smith 2005, Martinez et al. 2012). As a result, the State of Hawai`i has spent millions of dollars in control efforts. The south shore of Moloka`i (approximately 10 miles from Lāna`i) has a high density of three species of invasive seaweed (*G. salicornia, A. spicifera*, and *Hypnea musciformis*). *G. salicornia* was introduced to fish ponds in Moloka`i for mariculture purposes and has since spread throughout the southern coastline (DAR unpublished data 2015).

Fisheries enhancement has also contributed to a number prevalent non-native marine fish species in Hawai`i including the peacock grouper or roi (*Cephalopholis argus*), blacktail snapper or To`au (*Lutjanus fulvus*), and bluestripe snapper or Ta`ape (*Lutjanus kasmira*). These species were introduced for fisheries enhancement purposes between 1955 and 1961 and have since become established throughout the main Hawai`ian Islands. There is a wide range of opinions as to the level and type of impacts that these fishes impose on native ecosystems.

Marine debris also have the ability to transport non-native species. This has recently been documented in Hawai`i on debris arriving from Japan as a result of the 2011 Tōhaku earthquake and tsunami. Hundreds of suspected items have washed ashore throughout Hawai`i including boats, fish totes, and wooden signs. Over seventy non-native invertebrates and seaweed have been documented rafting on this debris (DAR unpublished data). Although the area of Japan impacted by the tsunami is a temperate region, there is still concern of potential establishment of nonnative species associated with this debris.

Despite the many issues surrounding AIS throughout Hawai`i, few AIS survey efforts have occurred on Lāna`i. Early detection of introduced species can greatly increase the chance of spread and establishment and save valuable resources or remediation costs. The first and most comprehensive near-shore marine survey for Lāna`i was conducted by Coles et al. (2006) as part of an effort by the Bishop Museum to conduct baseline surveys in harbors and coral reefs throughout the Hawaiian Islands. They surveyed eight locations on Lāna`i including: East Mānele Bay, West Mānele Bay, Kaumalapau Harbor, Kaumalapau Reef, Kalaeahole Bay, Kamala Bay, Shipwreck Reef, and an area near Shipwreck beach called Bottomless (Coles et al. 2006). They documented 16 non-native or cryptogenic species in the Lāna`i baseline survey. The number of non-native species inhabiting the harbors were much lower than what they had observed in other Hawaiian harbors (Coles et al. 2006). Additional fisheries based surveys have been conducted by the University of Hawai`i Fisheries Ecology Research Laboratory and NOAA's Coral Reef Ecosystem Program (CREP). These surveys have documented the presence of invasive fish and macroalgae species on Lāna`i's surrounding coral reefs.

As part of an effort to conduct early detection surveys for invasive algae and non-native invertebrates, the DAR invasive species team conducted a survey of Lāna`i marine areas in cooperation with Conservation International and Pūlama Lāna`i. The objectives of this survey were to: (i) survey areas for potential establishment of invasive seaweed, (ii) monitor Lāna`i's harbors for non-native invertebrates and seaweed establishment, (iii) create an AIS inventory for Lāna`i, and (iv) make management recommendations for control and/or prevention of AIS establishment on Lāna`i.

SURVEY SITE

The northeast coastline was selected as the primary site for shoreline surveys based on accessibility and the likelihood of invasive algae colonization (i.e. high sedimentation and proximity to affected areas on Moloka`i). The northeast coastline was subdivided into 0.75 km survey sectors every 1.6 km, distributed across a distance of ~10 km (Fig. 1). Each 0.75 km section was divided further into three habitat zones: 1) intertidal/shallow reef flat, 2) outer reef flat and, 3) the reef crest/fore reef. For habitat zone 1 of Sites A and B, habitat mapping surveys were conducted to obtain widespread algae and substrate cover (Fig. 1). For habitat zones 1, 2 and 3, line-point intercept (LPI) surveys coupled with timed fish surveys were used to get a more detailed assessment of the benthic habitat, algae species present, and fish species and abundance.

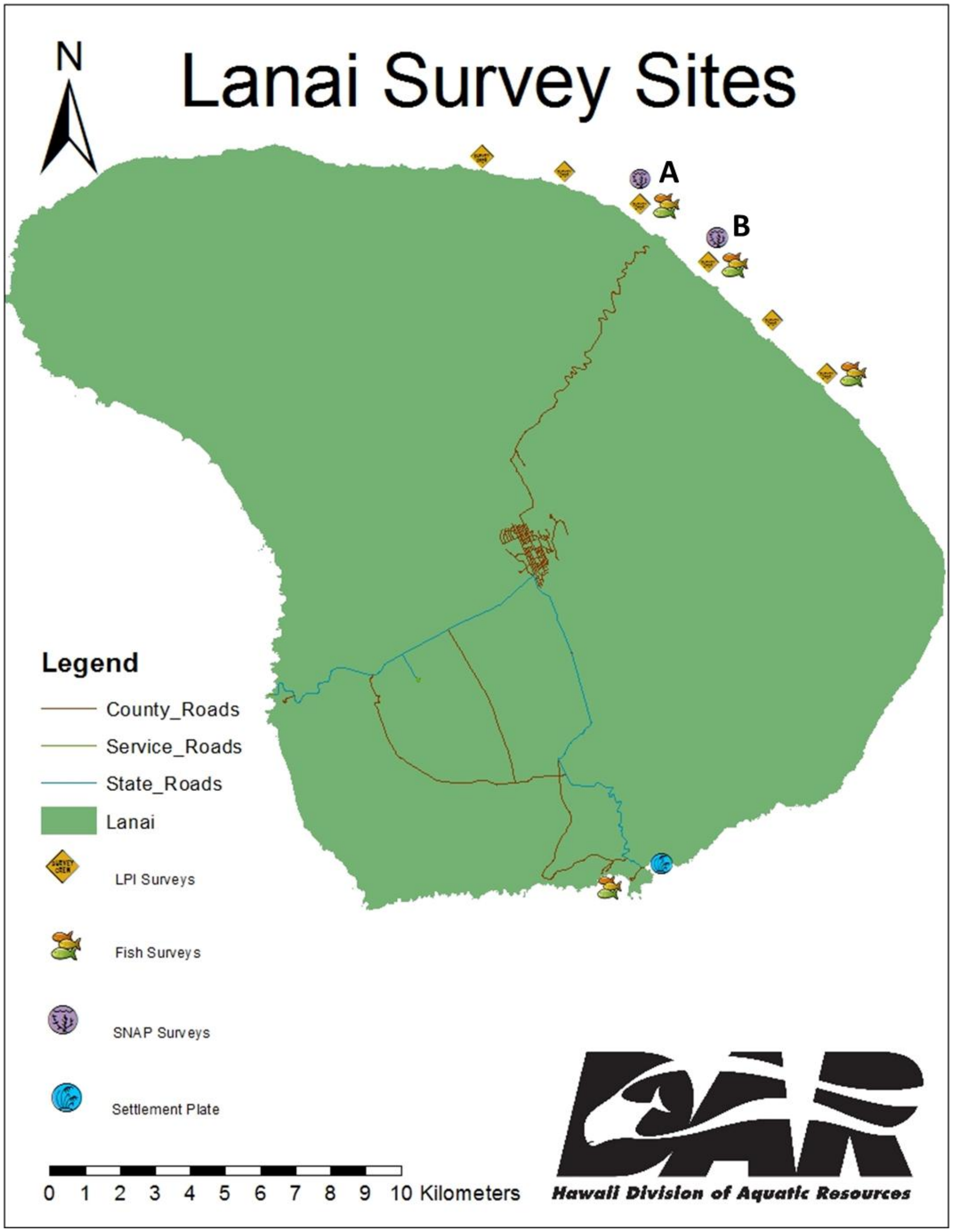

Figure 1. Survey type and location. A and B corrispond to the two benthic habitat locations.

METHODS

Benthic Habitat Mapping

Benthic habitat mapping surveys were conducted at sites A and B along the Northeast coastline using techniques described in the "Kāneʻohe Bay Snap-Assessment Report" (Neilson et al. 2014), modified for shallow water surveys. Surveyors were spaced ~15 m apart and walked transects parallel to the shore taking a GPS waypoint every 15 m. At each waypoint macroalgae cover, substrate type, and live coral cover were recorded into percent cover bins at each survey point (0%, 1 – 10%, 11 – 50%, 51 – 75%, 75 – 100%). This data was inputted into a database and macroalgae, coral, and substrate type were mapped using ArcGIS software. Interpolated raster coverage maps of macroalgae were created using the ArcGIS inverse distance weighting (IDW) tool, which averages each 1 m^2 pixel based on the 12 closest surrounding survey data points.

Line Point Intercept (LPI) and Fish Surveys

LPI and fish surveys were completed along the Northeast coastline. An additional fish survey was conducted in Mānele Bay (Figure 1). A pair of randomly generated waypoints were selected in both reef flat and fore reef habitat zones for the start point of the LPI and fish surveys. Surveyors laid a 25 m transect along a randomly generated bearing. Timed (10-minute) fish surveys were conducted along the transect recording all fish occurring within a 5 m belt and identified to species and sized by 5 cm bins (0 – 5 cm, 6 – 10 cm, 11 – 15 cm, 16 – 20 cm, 20+cm). For LPI surveys, divers recorded the benthic cover along the same 25 m transect (coral, macroalgae, CCA) at 0.2 m intervals (n = 126 samples per transect). In addition, a population count of all echinoderms within a 1 m transect belt was performed. Replicate transects were conducted along the same bearing with a start point 5 m after the end of the previous transect when time allowed. The same procedure was followed on the second paired transect.

Settlement Panels

Settlement panels were deployed within the Mānele Small Boat Harbor on April 5, 2016. Ten PVC settlement panels (14 cm^2) were secured to a brick, hung from docks, and submerged ~1 m below the surface. Approximately 90 days after deployment, the panels were retrieved and transported back to the lab for analysis. Samples were preserved in 95% pure non-denatured ethanol and separated by taxonomic group. Initial IDs were made to the lowest possible taxonomic level and sent to specialists for further identification.

RESULTS

Benthic Habitat Mapping

Benthic habitat surveys spanned approximately 1.5 km. Sand/silt bottom was the predominate substrate in zone 1 (near shore) and transitioned to hard bottom or coral in habitat zones 2 and 3 (Fig. 2). Macroalgae cover was highest in areas where substrate was classified as hard bottom or coral. No invasive algae species were detected in either mapping sites surveyed (Fig. 2, 3, Appendix B).

Very little to no macroalgae occurred in areas of sand/silt substrate. Live coral colonies were detected during the habitat mapping survey, but composed very little of the total benthic substrate composition (Appendix B). Pale to moderately bleached *Montipora capitata* colonies were observed in all three habitat zones.

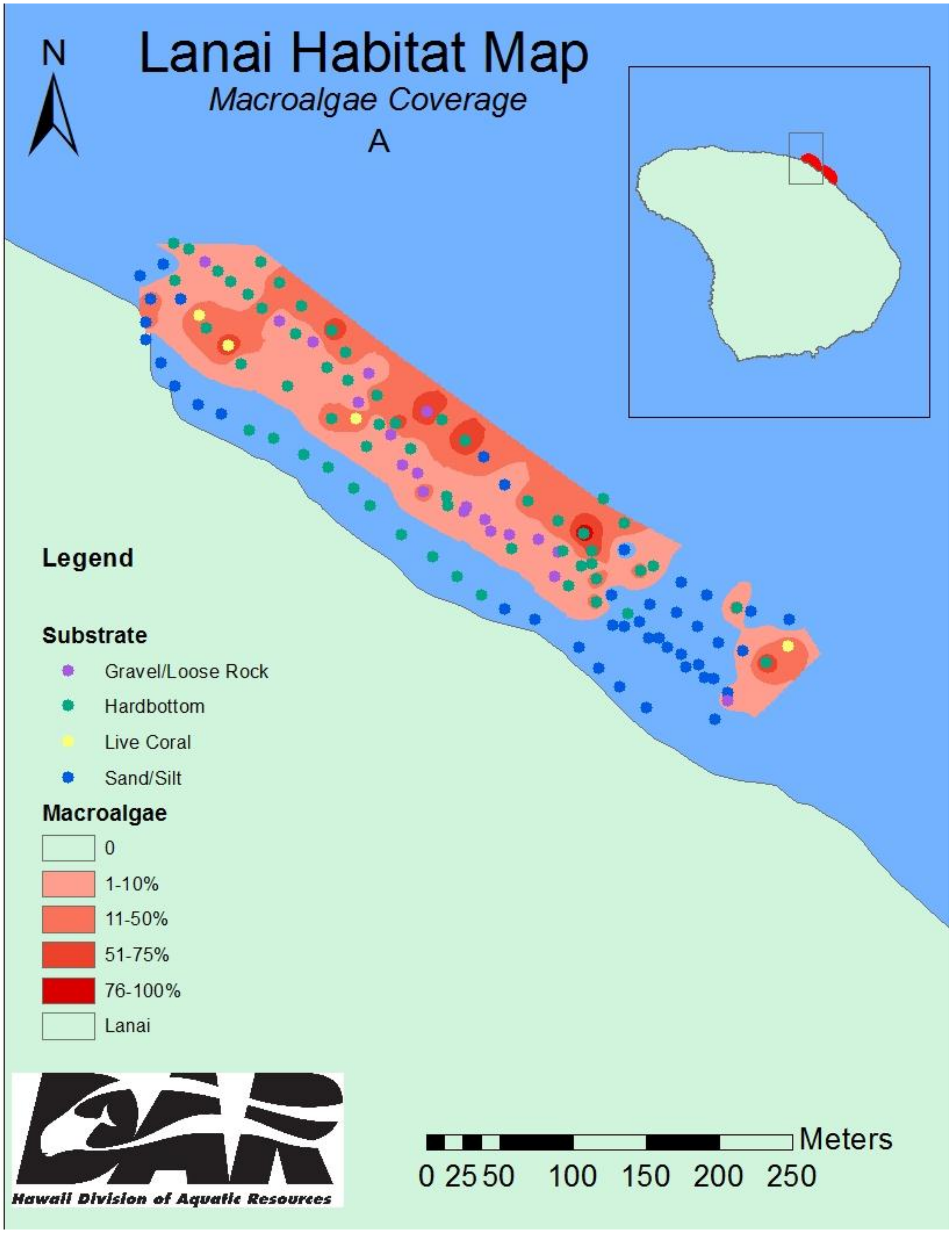

Figure 2. Benthic habitat composition and macroalgae abundances in survey Section A.

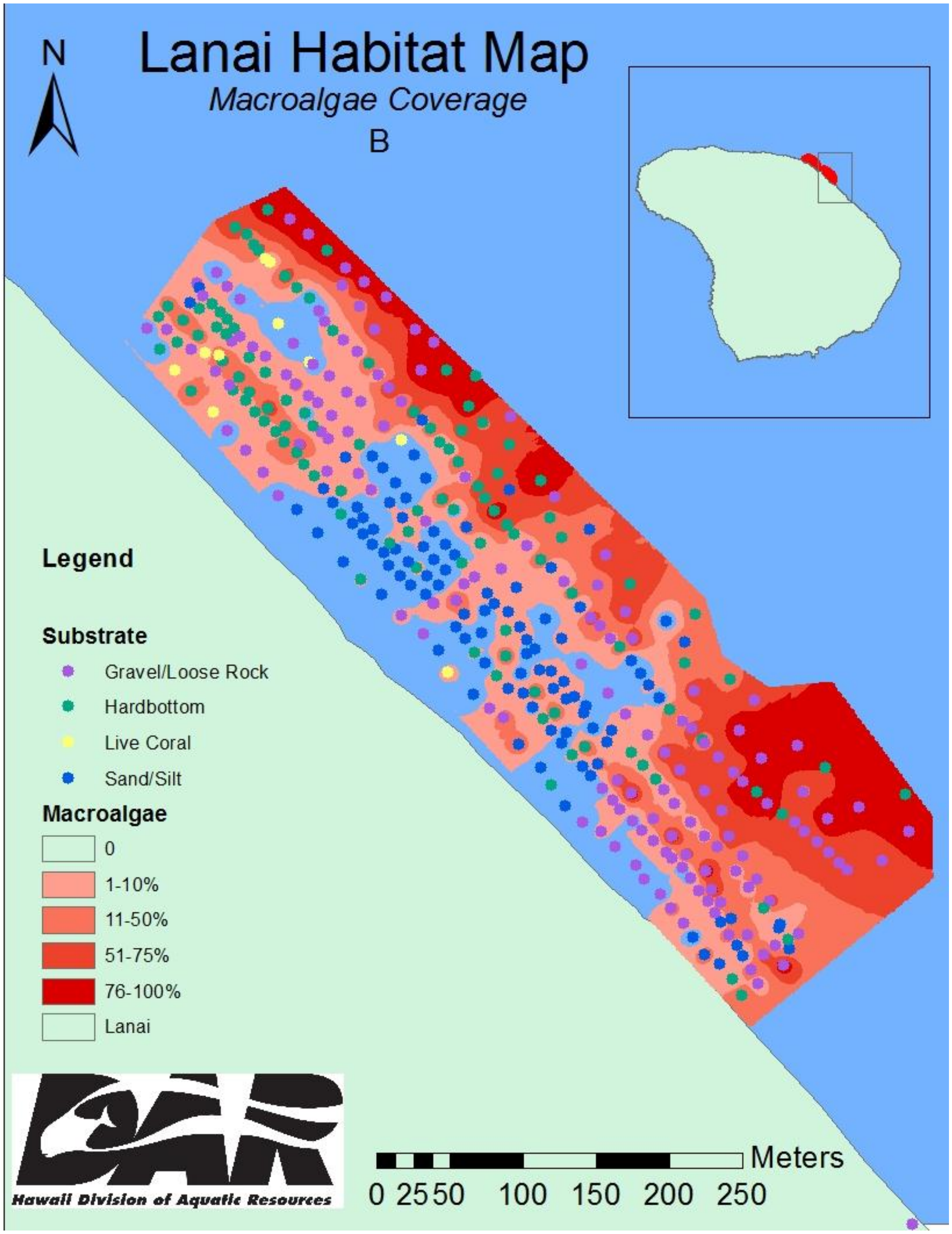

Figure 3. Benthic composition along with the abundance of macroalgae in survey section B.

LPI Surveys

A total of 38 line point intercept (LPI) transects were surveyed in six 0.75 km survey areas (sectors) spanning ~13 km of the northeast shore of Lāna`i (Fig. 1). Of these surveys, six were conducted in the intertidal, 21 in the reef flat zone and 11 in the fore reef zone. One non-native algae species was detected (*Acanthophora spicifera*) (Fig. 5, Appendix B), but occurred at relatively low levels in the intertidal (0.13%) and reef flat zone (0.07%) compared to native macroalgae which had a higher occurrence in the intertidal (9.3%) and reef flat zone (15.1%) (Fig. 4). Intertidal and reef crest habitat zones had relatively high macroalgae prevalence at 9.5% and 15.1% respectively. Macroalgae species diversity was highest in the intertidal zone (13 species). All three habitat zones were dominated by abiotic substrate which ranged from 55.2% in the fore reef to 48.5% in the intertidal zone. The highest coral cover and crustose coralline algae was found in the fore reef zone at 24.8% and 15.4% respectively. The fore reef zone also hosted the highest diversity of corals with nine species observed.

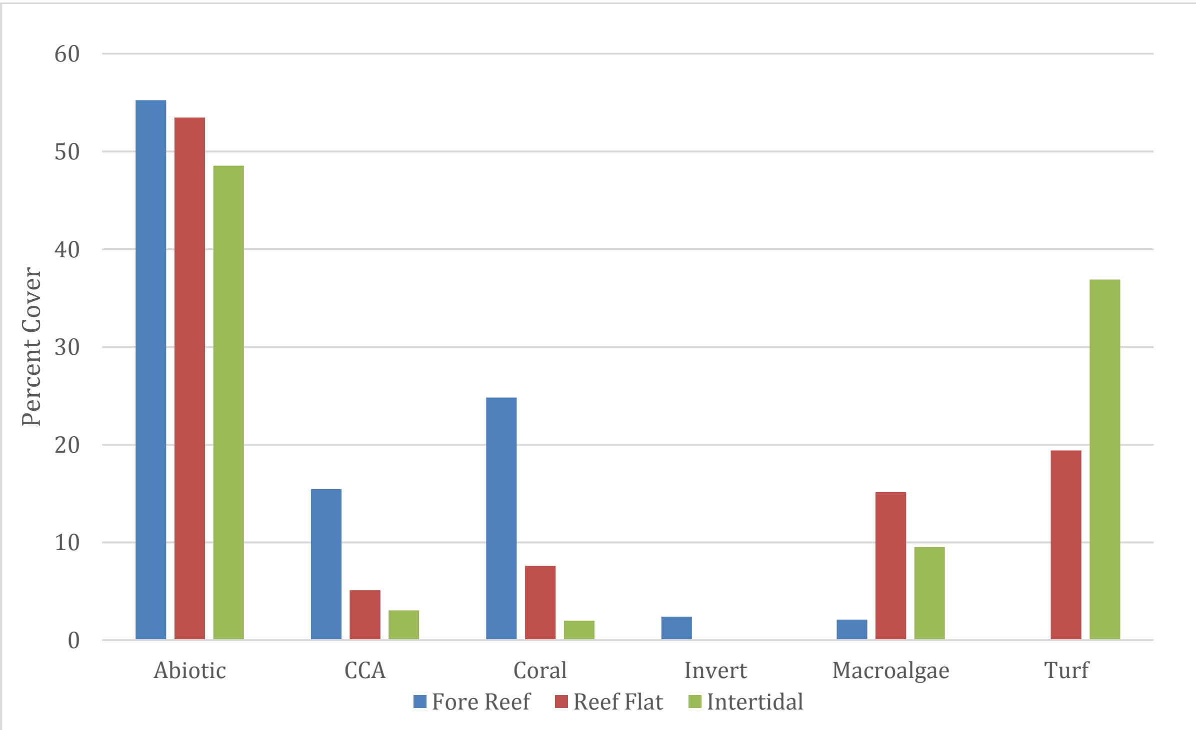

Figure 4. Benthic percent cover within three habitat zones: intertidal, reef flat, and fore reef. Benthic cover is composed of abiotic (pavement, rubble, sand) CCA (crustose coralline algae), live coral, invert (invertebrates), macroalgae, and turf (turf algae).

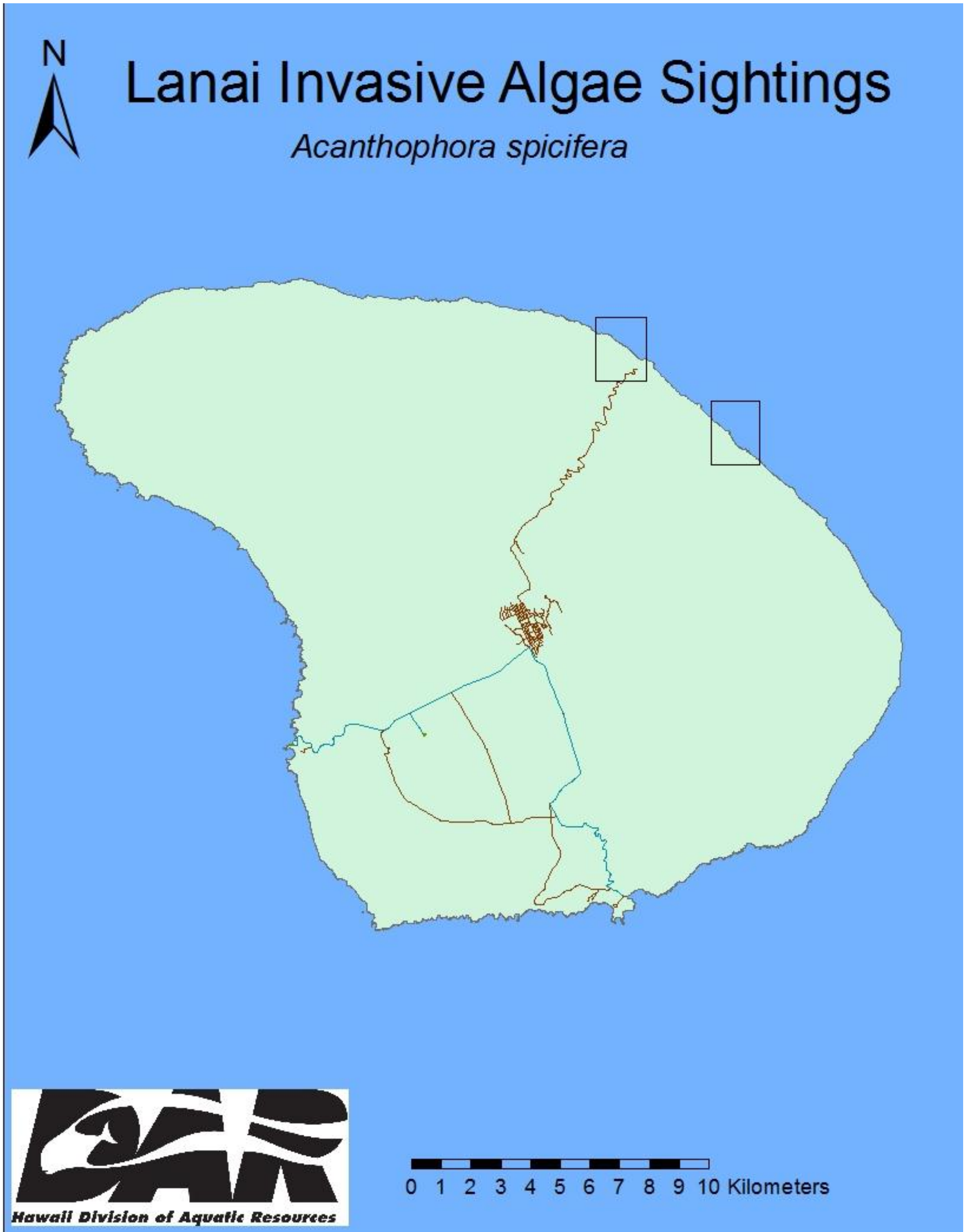

Figure 5. Location of invasive seaweed *Acanthophora spicifera*.

Fish and Echinoderm Surveys

A total of 14 fish transects were surveyed. Three were conducted in Mānele Bay and eleven along the Northeast coastline all within the fore reef habitat zone. The highest fish diversity was observed in Mānele Bay (45 species) while the Northeast fore reefs had 26 fish species (Appendix A). Two invasive fish species were present in the surveys, *Lutjanus fulvus* (Blacktail Snapper or To'au) found only at Mānele Bay and *Cephalopholis argus* (Peacock Grouper or Roi) which were found at both survey locations. Of the 1,360 total fishes surveyed, the invasive *L. fulvus* and *C. argus* made up only 0.59% and 0.37 % of total fishes observed respectively. The fore reef and reef flat had the highest number of Echinoderms, which were predominantly composed of the rock boring urchin *Echinometra mathaei* and the white-spotted sea cucumber *Actinopyga varians* (Appendix C).

Settlement Panels

A total of 730 specimens in 15 different taxonomic groups were vouchered. The samples are awaiting expert taxonomist identification by the Bishop Museum in Honolulu, HI. Several occurrences of the introduced invertebrate *Pennaria disticha* (Christmas-tree hydroid) were observed attached to docks in Mānele Harbor.

DISCUSSION

Reef Surveys

Very few non-native or invasive species were detected in the reef surveys. Although several occurrences of the invasive seaweed *Acanthophora spicifera* were observed, it had been documented previously in Mānele Bay and Federation Camp in Lāna`i (Russel 1992) and is the most widely distributed invasive seaweed in the main Hawaiian Islands. However, it was undetected at Coles et al.'s (2006) survey sites. Although data is limited, *A. spicifera* does not appear to be spreading or dominating reef habitats. Invertebrate and fish grazer populations may be adequate in keeping *A. spicifera* levels low on the east side of Lāna`i. This was demonstrated in Kahekili Maui, where *A. spicifera* among other macroalgae species were significantly reduced after implementing management measures to protect herbivores (Williams et al. 2016). Sustaining Lāna`i's reef herbivore population may be an important component of keeping *A. spicifera* at manageable levels.

The large amount of sediment occurring within the nearshore areas is concerning not only for reef health, but also the potential for invasion by *Gracilaria salicornia* (gorilla ogo). For example, the nearshore areas of southern Moloka`i are also exposed to high sediment loads and this area is heavily dominated by *G. salicornia.* Therefore if *G. salicornia* is introduced to northeast Lāna`i, there is a potential for *G. salicornia* to thrive in these habitats.

Harbor Surveys

The biomass of settlement panels retrieved from Mānele Harbor showed low levels of biofouling compared to harbors sampled on O'ahu. One non-native species *Pennaria disticha* (Christmas-tree hydroid) was observed attached to docks in Mānele Harbor, indicating the susceptibility of Lana`I's marine areas to biofouling transport of non-native species. Coles et al. (2006) had documented *Carijoa riisei* (snow-flake coral), another common non-native biofouling species in Hawai`i, however no observations were made during this survey. It is important to note that several boats run daily ferry charters to Moloka`i and Maui that could act as vectors for spreading non-native species between islands. The close vicinity of these Islands coupled with the daily boat traffic between

Lāna`i and the other islands could be high risk vectors for introducing invasive seaweeds like *G. salicornia* and *Hypnea musciformis*.

In addition, commercial shipping traffic between Honolulu and Kaumalapau Harbor may be another potential pathway for non-native species to establish in Lāna`i. Kaumalapau harbor is considered the highest risk of non-native species introduction on Lāna`i due to regular shipping traffic with Honolulu harbor. Due to logistical restraints, we were unable to sample Kaumalapau Harbor, however we plan to conduct follow-up surveys in the near future. Once taxonomic analysis is completed, a comparison between Coles et al. (2006) survey will be made to detect any new non-native harbor species.

Management Recommendations

This assessment detected very few invasive or non-native species within the areas surveyed. Based on this assessment, Lāna`i remains one of the least invaded Hawaiian Islands. Therefore, Lāna`i is in the fortunate situation of focusing management attention towards prevention and early detection rather the much more costly and challenging alternative of eradication and control. Based on the findings of this assessment, we propose the following management actions:

- Continued monitoring of east Lāna`i , particularly for the presence of *Gracilaria salicornia* and *Hypnea musciformis*
- Continued harbor monitoring for fouling or ballast water species. Consider using molecular techniques for rapid detection of high risk species
- Monitor areas near marine debris accumulations
- Conserve herbivore populations to maintain invasive seaweed growth
- Perform community outreach pertaining to identification of non-native species and risks associated with moving fishing gear or boats between Molokai and Lanai
- Avoid any introductions of non-native seaweed species for mariculture
- Monitor high risk vessel traffic from foreign ports or boats arriving with heavy biofouling
- Continued monitoring in Lāna`i spanning a larger spatial scale

This AIS assessment serves as a follow-up survey for monitoring and detecting aquatic invasive species on Lāna`i. It's recommended that the Division of Aquatic Resources continues work with Lāna`i community members, Pūlama Lāna`i, Conservation International, and other partners to help carry out the above stated management recommendations. These actions will help preserve the unique and rich marine biodiversity of Lanai. In turn, these actions will help benefit tourism, local fisheries, and resilience to climate change stressors like coral bleaching.

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Appendix A. Fish species present by survey location and the proportion of the total fish assemblage by species and invasiveness (INV).

Species	NE Fore Reef	Mānele Bay	Proportion of fish
Acanthurus nigrofuscus	x	x	26.25
Thalassoma duperrey	x	x	17.72
Scarus spp	x	x	14.49
Gomphosus varius	x	x	6.91
Stegastes marginatus	x	x	4.71
Chlorurus sordidus	x	x	4.34
Acanthurus triostegus	x	x	3.31
Naso lituratus	x	x	2.35
Acanthurus leucopareius	x	x	2.28
Chromis vanderbilti	-	x	2.28
Acanthurus xanthopterus	x	-	1.40
Abudefduf vaigiensis	x	-	1.03
Chaetodon lunula	x	x	1.03
Parupeneus multifasciatus	x	x	1.03
Naso unicornis	x	x	0.81
Stethojulis balteata	x	-	0.66
Lutjanus fulvus (INV)	-	x	0.59
Scarus psittacus	x	-	0.59
Chromis spp	-	x	0.59
Canthigaster jactator	-	x	0.51
Thalassoma trilobatum	x	x	0.51
Canthigaster amboinensis	x	x	0.51
Plectroglyphidodon imparipennis	x	x	0.44
Plectroglyphidodon johnstonianus	x	x	0.44
Cephalopholis argus (INV)	x	x	0.37
Chaetodon ornatissimus	x	x	0.37
Myripristis berndti	-	x	0.37
Paracirrhites arcatus	-	-	0.37
Abudefduf abdominalis	x	x	0.29
Chaetodon quadrimaculatus		x	0.29
Cirripectes vanderbilti	x		0.29
Melichthy vidua		x	0.29
Rhinecanthus rectangulus		x	0.29
Zanclus cornutus		x	0.29
Acanthurus guttatus		x	0.22
Acanthurus achilles	x		0.15
Asterropteryx semipunctatus		x	0.15
Kuhlia sandwicensis		x	0.15
Monotaxis grandoculis		x	0.15

Appendix A (Cont'd). Fish species present at each survey location and the proportion of the total fish assemblage by species and invasiveness (INV).

Species	NE Fore Reef	Mānele Bay	Proportion of fish
Parupeneus insularis		x	0.15
Unknown Kyphosus		x	0.15
Acanthurus olivaceus		x	0.07
Arothron hispidus		x	0.07
Arothron meleagris		x	0.07
Chaetodon unimaculatus		x	0.07
Cirrhitus pinnulatus		x	0.07
Fistularia commersonii		x	0.07
Forcipiger flavissimus	x		0.07
Gnatholepis cauerensis		x	0.07
Paracirrhites forsteri		x	0.07
Parupeneus porphyreus		x	0.07
Sargocentron spiniferum		x	0.07
Zebrasoma veliferum		x	0.07

Appendix B. Macroalgae species proportion and coral species by number of occurrence.

#	Species	Habitat Zone Intertidal	Reef Flat	Fore Reef	Proportion (%)
1	*Dictyota spp*	x	x	-	23.26
3	*Halimeda spp*	x	x	-	19.32
2	*Cyanophyta*	-	x	-	14.82
4	*Asparagopsis taxiformis*	x	x	x	10.69
6	*Neomeris spp*	x	x	-	9.19
5	*Padina spp*	x	x	-	6.57
7	*Microdictyon spp*	x	x	-	2.81
8	*Laurencia spp*	x	x	-	1.69
9	*Syridia filametosa*	x	x	-	1.69
10	*Dictyosphaeria cavernosa*	x	x	-	1.31
11	*Liagora spp*	x	x	-	1.31
12	*Chloroesmis caespitosa*	-	x	-	1.13
13	*Galaxaura spp*	-	x	-	0.94
14	*Martensia spp*	x	-	-	0.94
15	*Acanthopora spicifera*	x	x	-	0.75
16	*Bryopsis spp*	x	x	x	0.75
17	*Caulerpa spp*	-	x	-	0.75
18	*Dictyosphaeria versluysii*	-	-	x	0.56
19	*Amansia spp*	-	-	x	0.38
20	*Portieria hornemannii*	-	x	-	0.38
21	*Stypopodium flabelliforme*	-	x	-	0.38
22	*Halophila spp*	x	-	-	0.19
23	*Symploca hydoides*	-	x	-	0.19

Coral species by number of occurrence's per transect

#	Species	Habitat Zone Intertidal	Reef Flat	Fore Reef	Total
1	*Montipora capitata*	14	83	51	148
2	*Porites compressa*	1	66	76	143
3	*Porites lobata*		12	113	125
4	*Pocillopora meandrina*		6	51	57
5	*Montipora patula*		25	11	36
6	*Pocillopora damicornis*		1	27	28
7	*Pavona varians*			9	9
8	*Porites lutea*		4	3	7
9	*Cyphastrea ocellina*		3		3
10	*Montipora flabellata*			3	3
11	*Psammocora stellata*		1		1

Appendix C. Echinoderm species by number of occurrence per transect

		Habitat Zone			
#	Species	Intertidal	Reef Flat	Fore Reef	Total
1	*Echinometra mathaei*	-	61	99	160
2	*Actinopyga varians*	-	-	30	30
3	*Diadema paucispinum*	-	5	7	12
4	*Echinometra oblonga*	-	8	-	8
5	*Holothuria arta*	1	5	-	6
6	*Holothuria pervicax*	-	-	3	3
7	*Ophioconma erinaceus*	-	-	2	2
8	*Holothuria whitmaei*	-	1	-	1