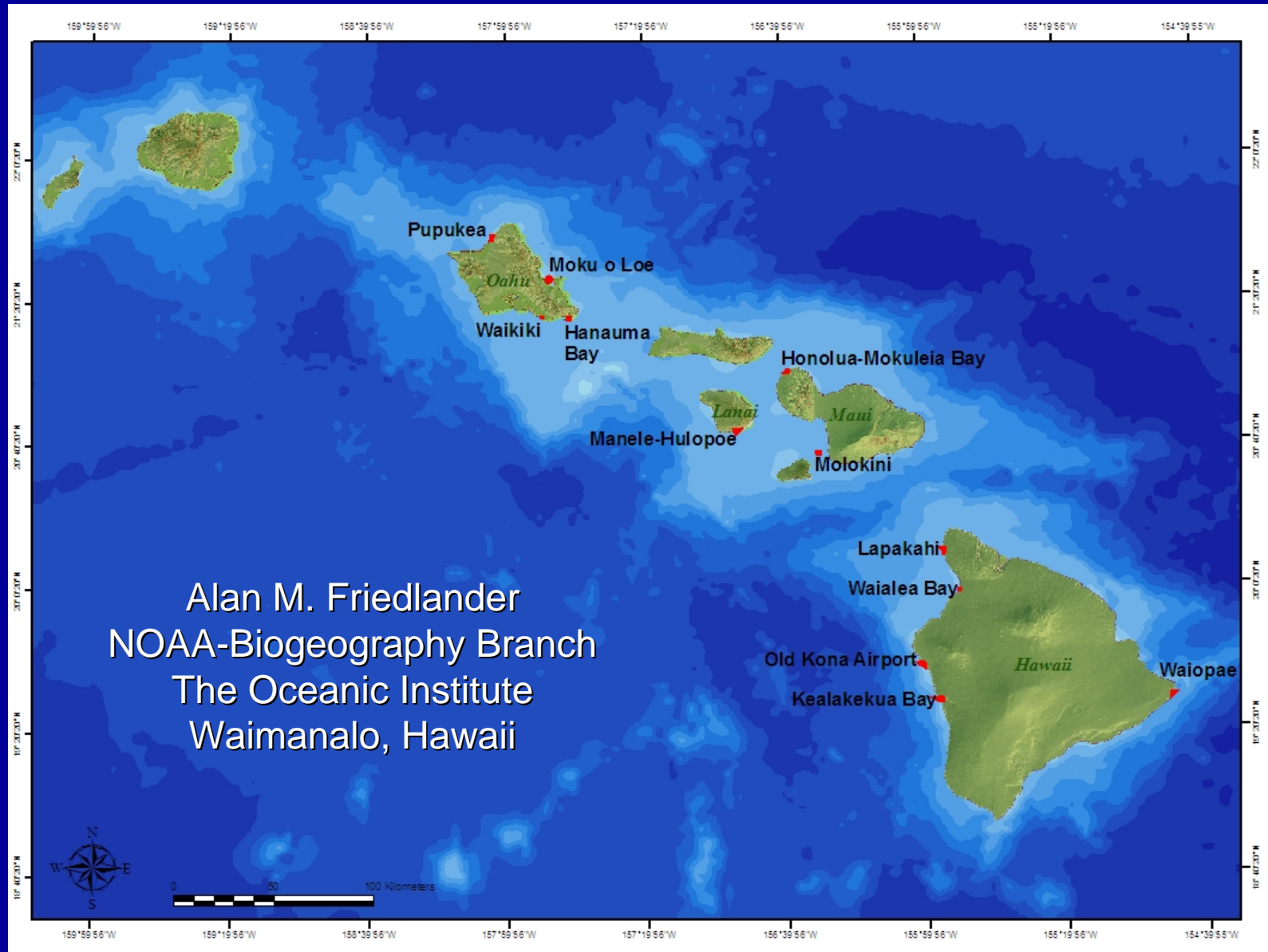


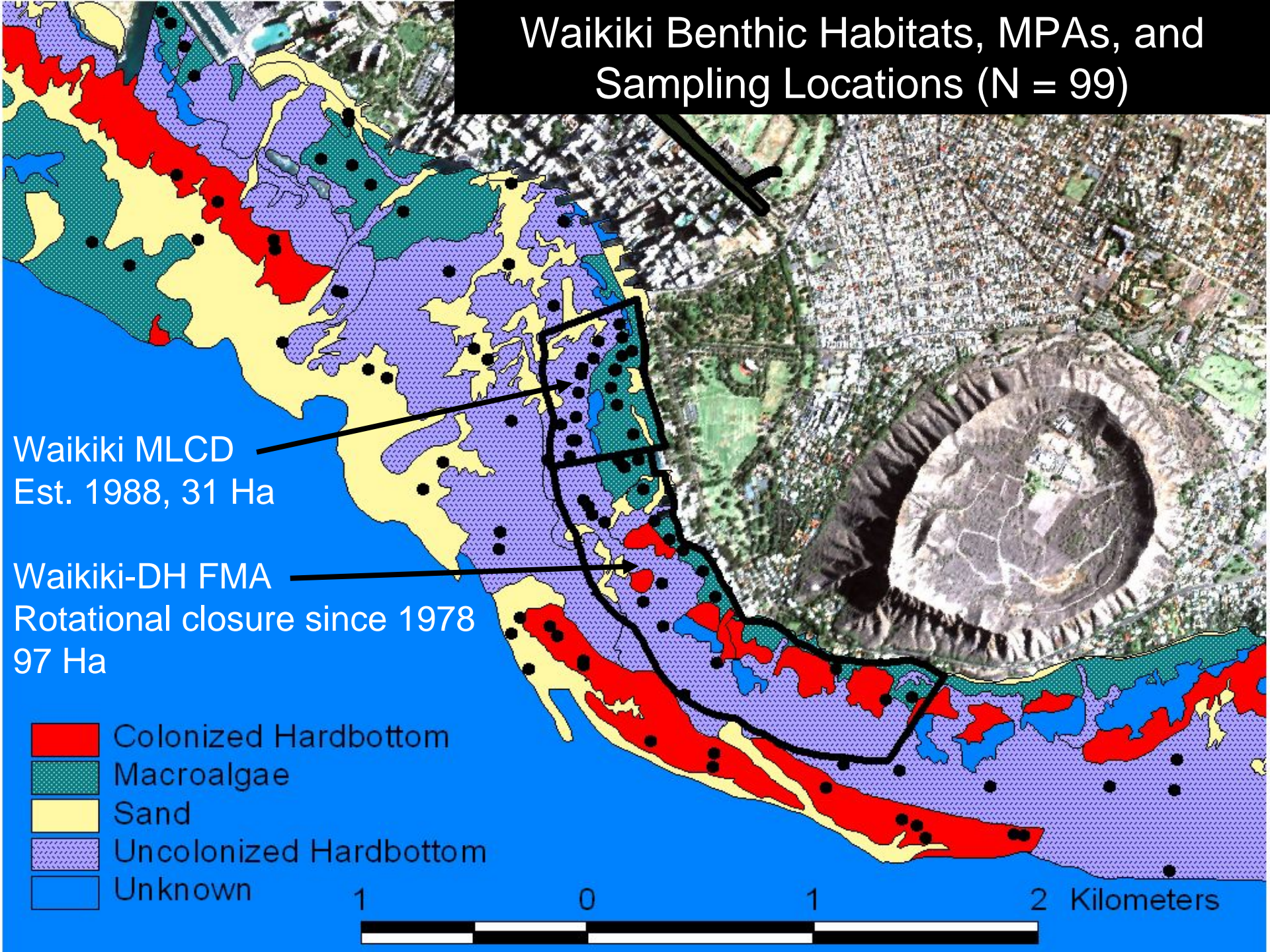
Efficacy of Marine Protected Areas in Hawaii



Size, Age, and Level of Protection of Various MPAs in Hawaii

Island	Protected area	Ha	Year est.	Protection
Hawaii	Kealakekua	128	1969	Mod
Lanai	Manele	125	1976	Mod
Hawaii	Old Kona Airport	88	1992	Mod
Maui	Molokini	85	1977	High
Oahu	Pupukea	72	1983* (03)	High
Hawaii	Lapakahi	59	1979	Low
Oahu	Hanauma Bay	41	1967	High
Hawaii	Waiopae	34	2000	High
Oahu	Waikiki	31	1988	High
Oahu	Moku o Loe	30	1967	High
Maui	Honolua	18	1978	High
Hawaii	Waialea Bay	14	1985	Low

Waikiki Benthic Habitats, MPAs, and Sampling Locations (N = 99)



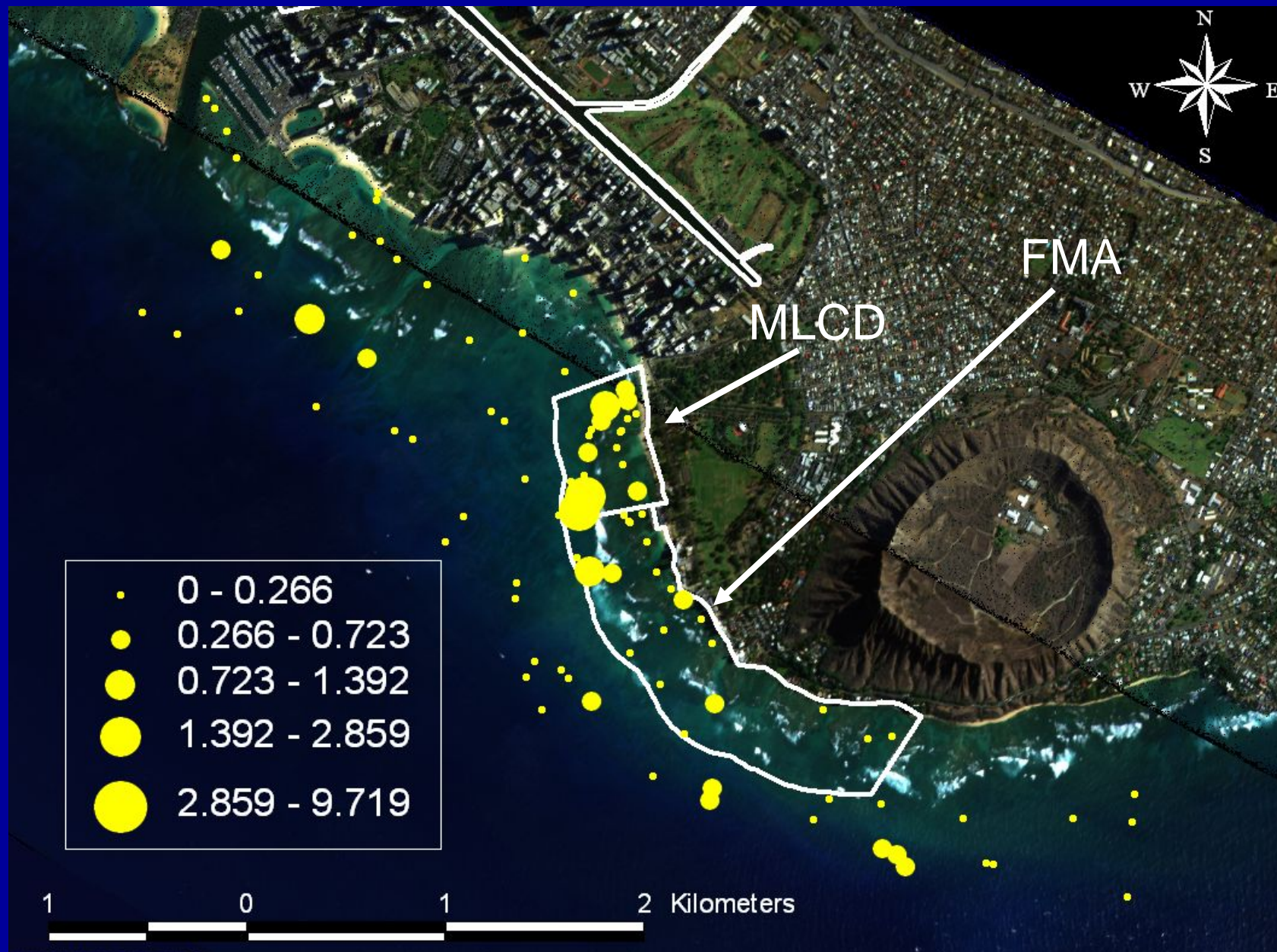
Waikiki MLCD
Est. 1988, 31 Ha

Waikiki-DH FMA
Rotational closure since 1978
97 Ha

- Colonized Hardbottom
- Macroalgae
- Sand
- Uncolonized Hardbottom
- Unknown

1 0 1 2 Kilometers

Fish biomass ($t\ ha^{-1}$) by transect (N=99) for Waikiki including Waikiki MLCD and Waikiki-Diamondhead FMA.

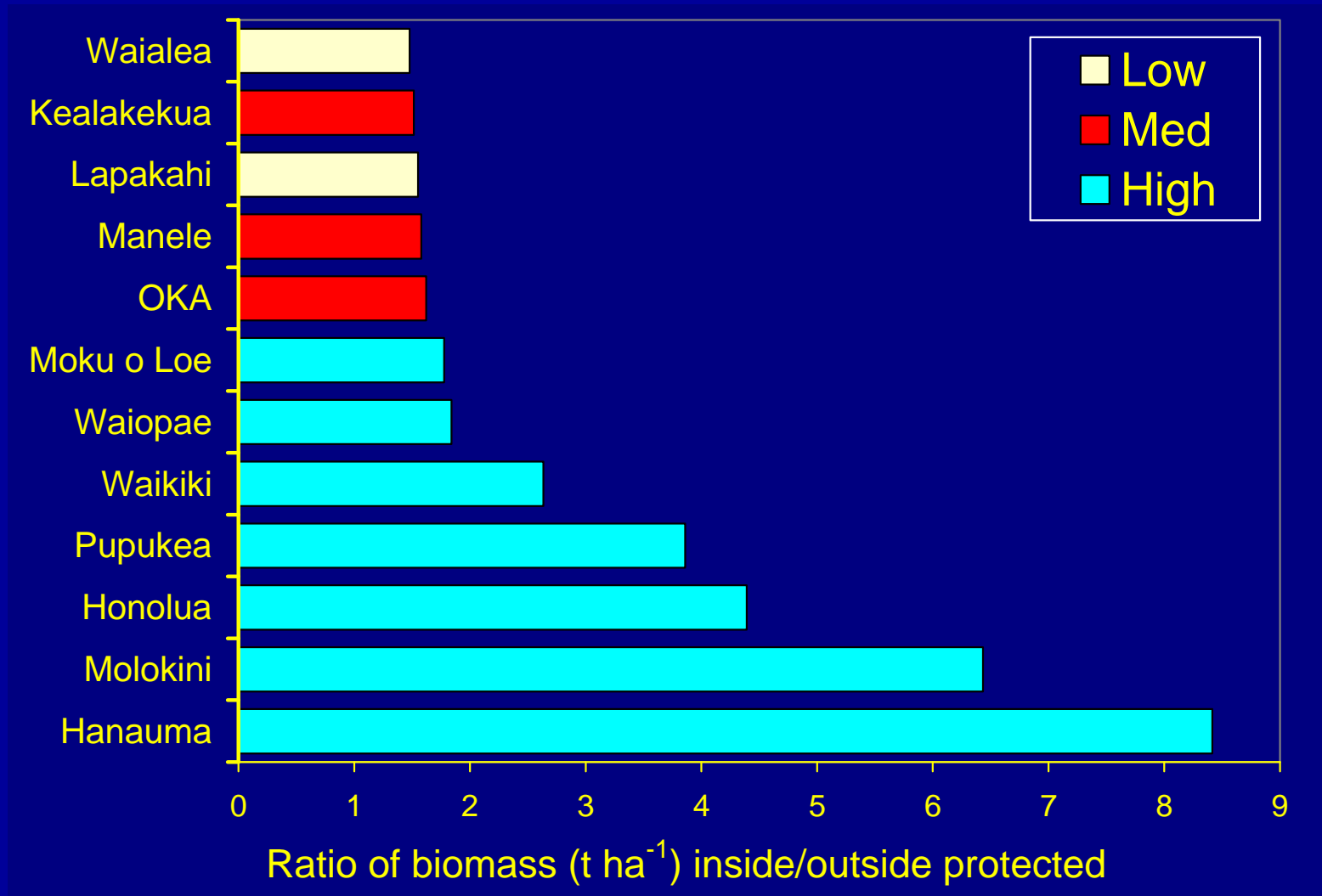


Ratio of biomass (t ha^{-1}) inside MPAs vs. outside areas open to fishing

Low human use

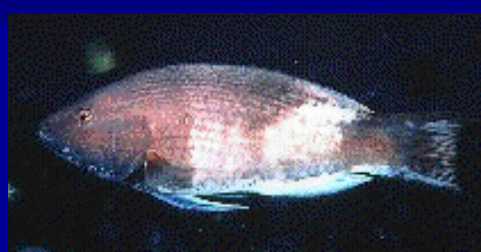
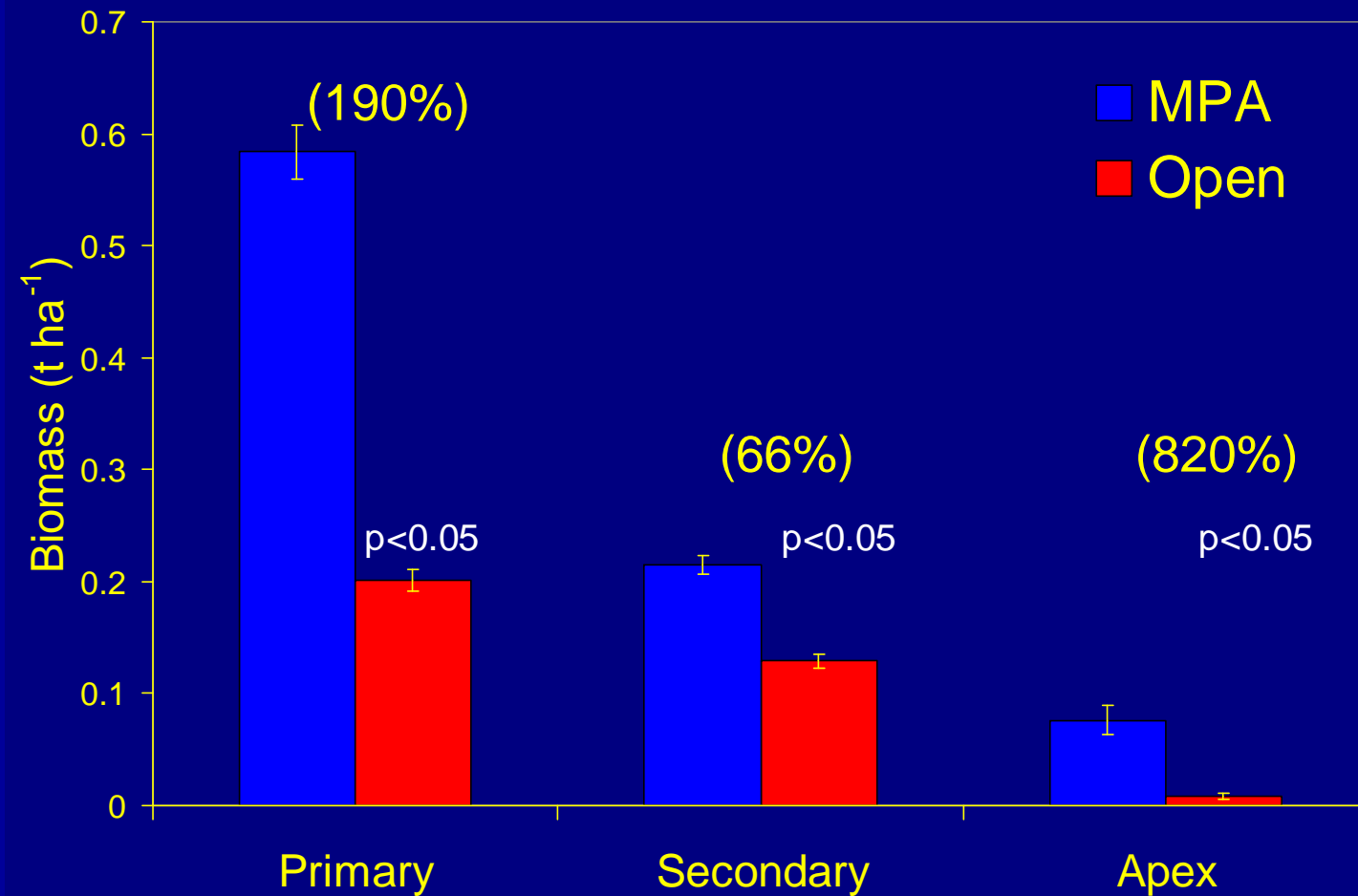


High human use

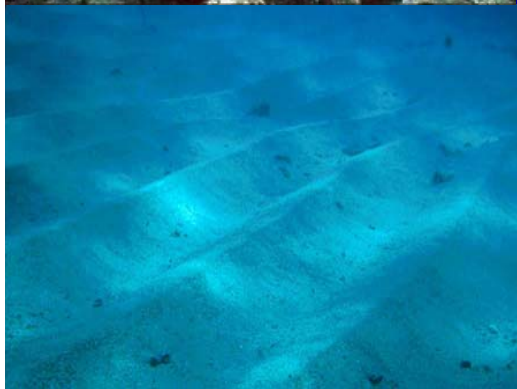
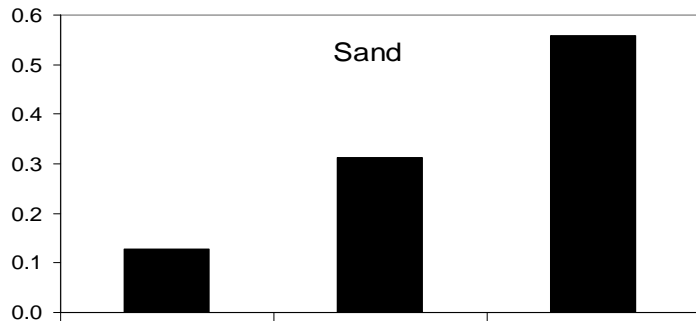
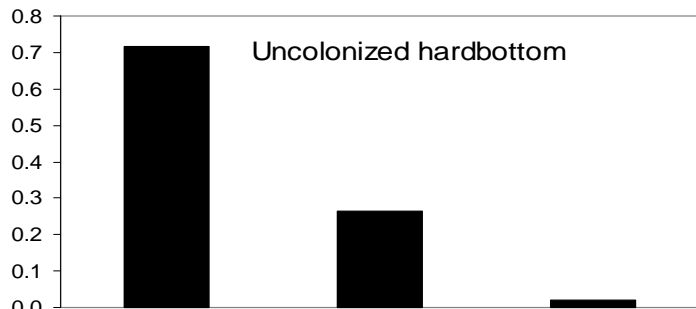
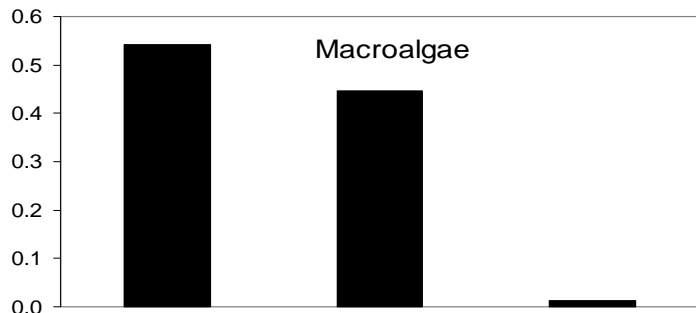


Ratio of biomass (t ha^{-1}) inside/outside protected

Mean biomass per transect ($t\ ha^{-1}$) by Consumer guild and management regime on hardbottom habitats



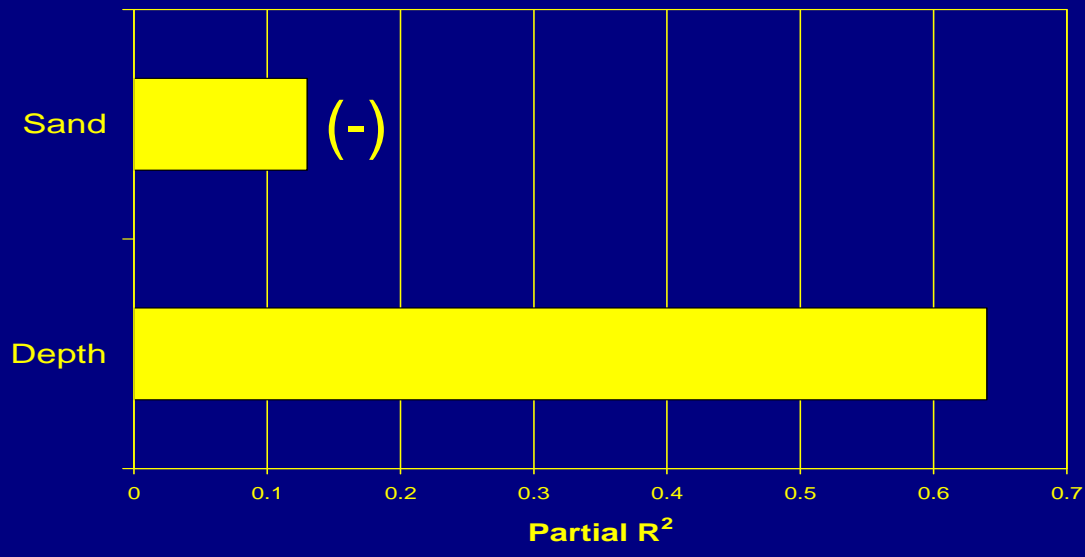
Proportion of total biomass



Trophic composition among major habitat types pooled across all locations

- Highest biomass of apex on colonized hardbottom
- Highest proportion on sand
- Sand important corridor
- Lowest on macroalgae and uncolonized hardbottom

Fish Species Richness

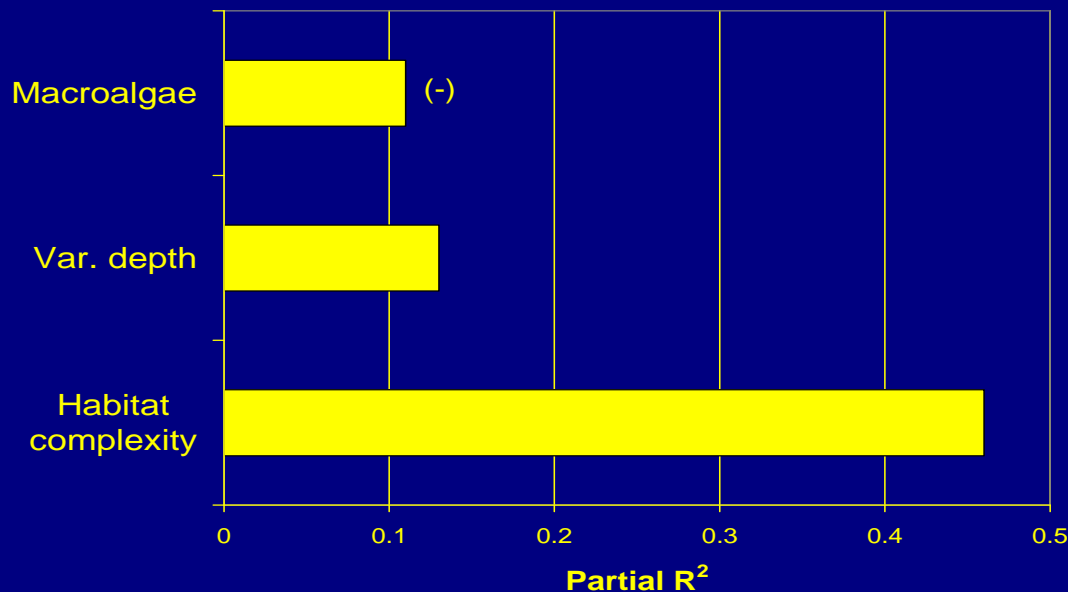


Habitat Variables Affecting Fish Assemblage Characteristics in MPAs

Stepwise multiple regression
Probability to enter model 0.25,
probability to leave 0.10
(hardbottom only)

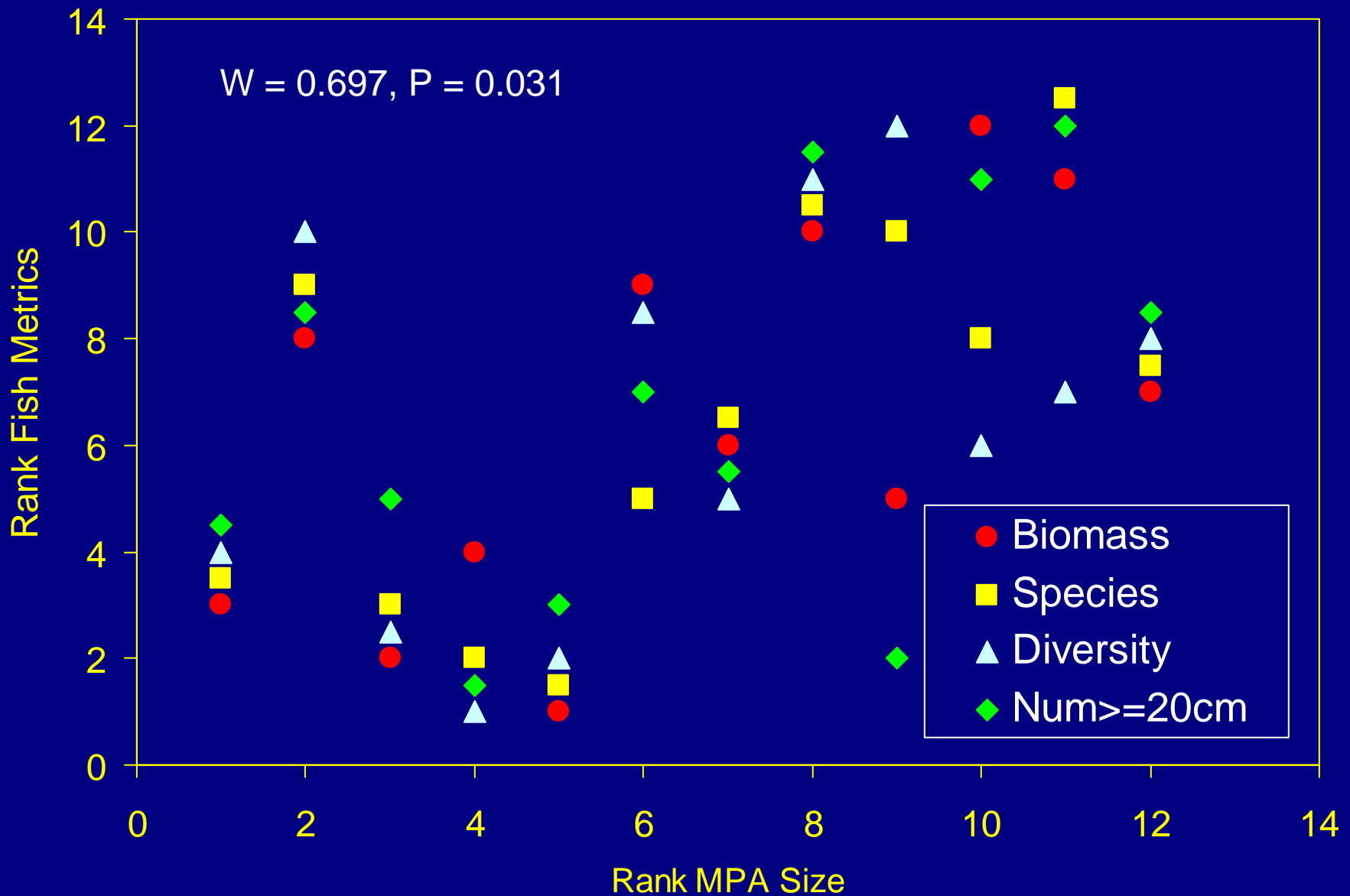
Species richness: $R^2 = 0.77$

Fish Biomass



Fish Biomass: $R^2 = 0.69$

Scatterplot of ranks of assemblage characteristics vs. ranks of MPA size



Design Criteria for Effective MPAs in Hawaii

- Range of habitat complexities
- Full protection from fishing or community-managed
- Shoreline to deep habitats
- Mosaic of habitats (sand corridors, etc.)
- Low macroalgae cover (invasives)
- Representative wave exposures

