HyspIRI Coral Reef Assessment: Information Content vs. SNR

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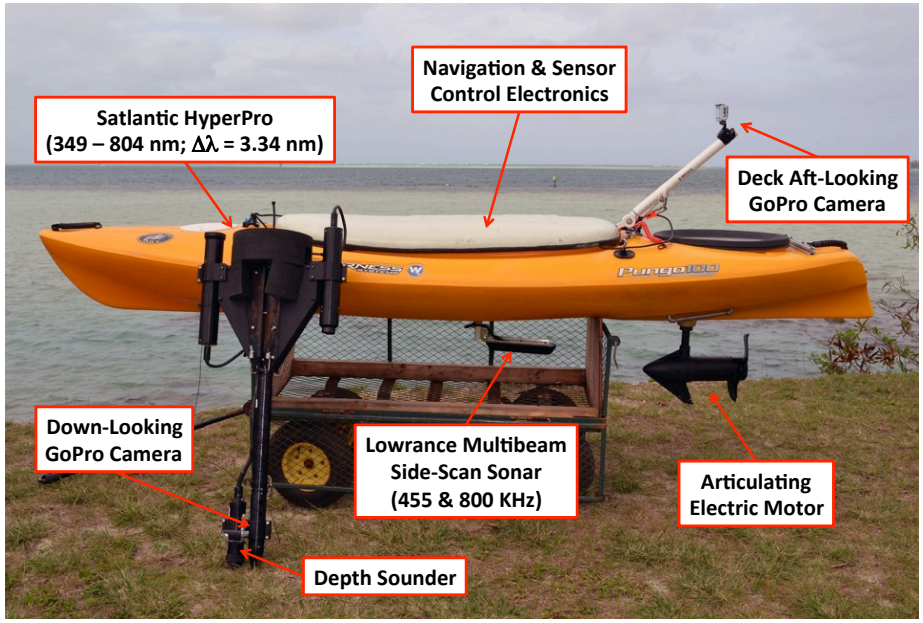
U.S. NAVAL RESEARCH LABORATORY

In Situ



Remote Sensing

Data Sets: Kaneohe Bay (Coconut Isl. PR)

12 Feb 2017
18 Feb 2017

Data Sets: Kaneohe Bay

08 Feb 2017 (GSD = 16.5 m)

22 Feb 2017 (GSD = 16.8 m)

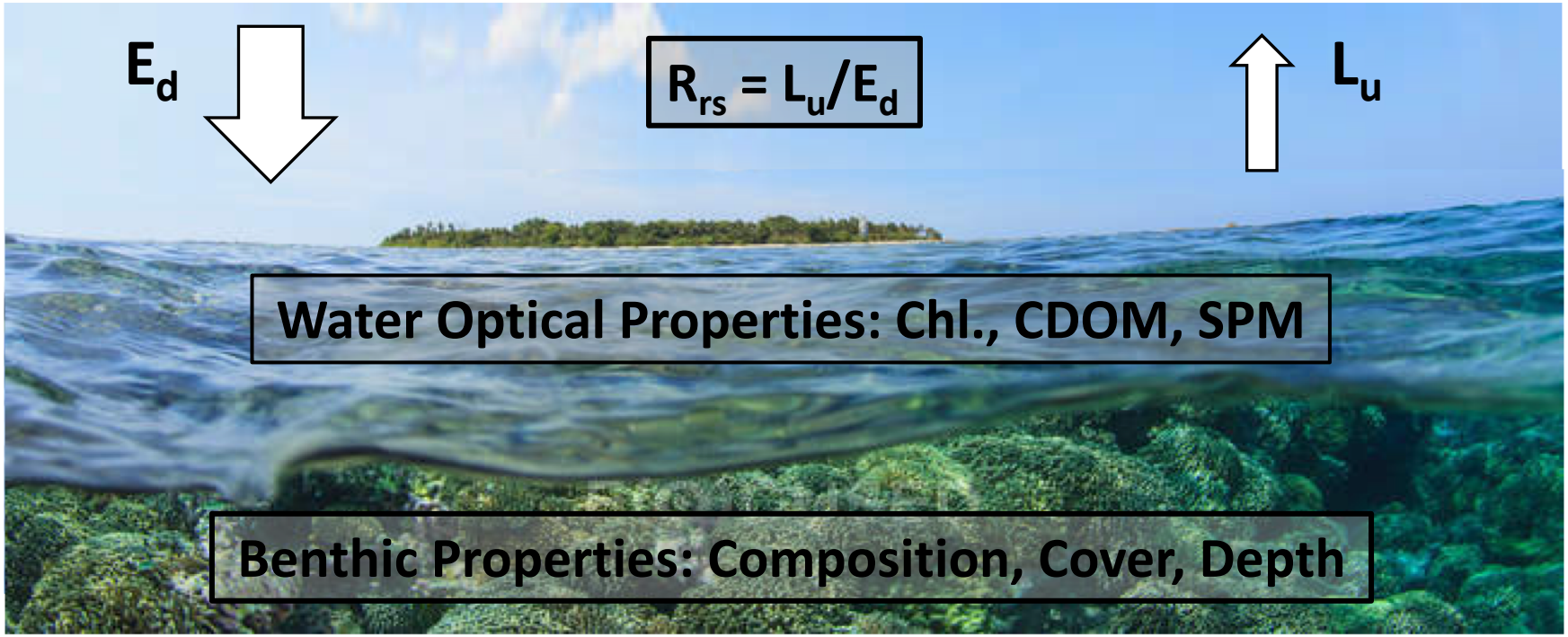
03 Mar 2017 (GSD = 7.3 m)

frontiers in Marine Science 2017

Autonomous Coral Reef Survey in Support of Remote Sensing

What is the detection and classification uncertainty as a function of sensor noise (SNR)?

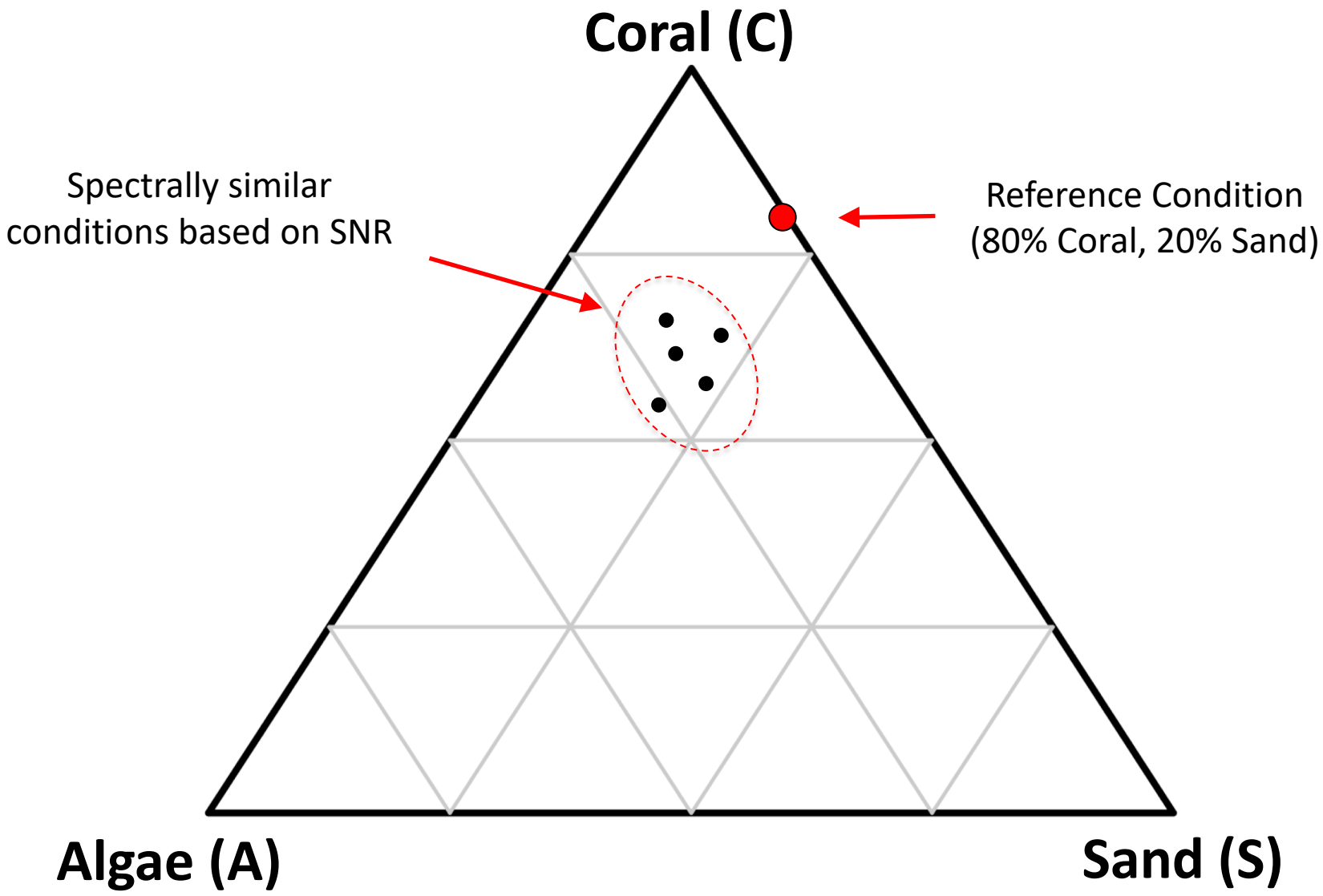
SNR Model



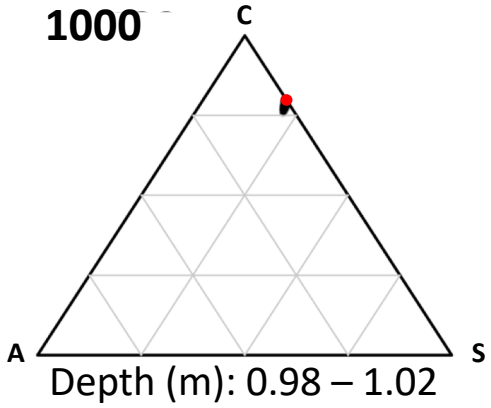
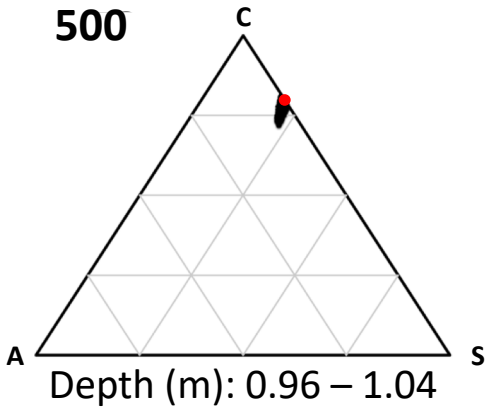
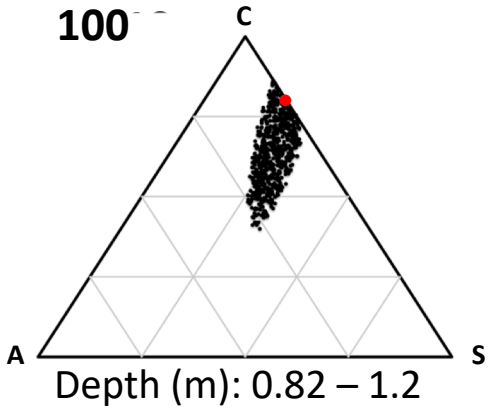
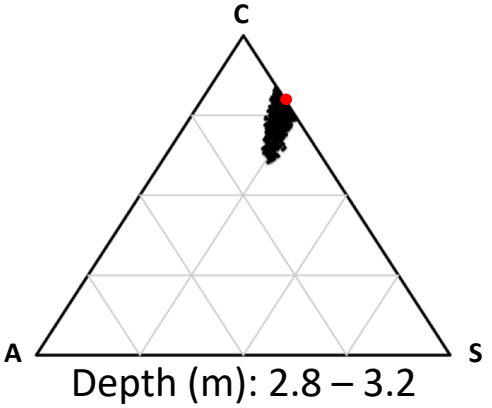
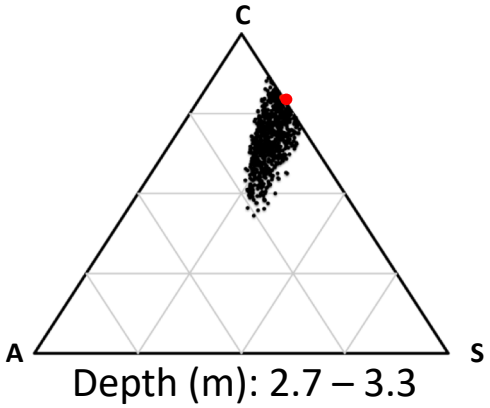
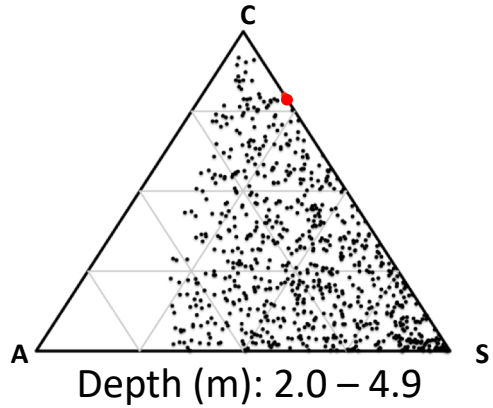
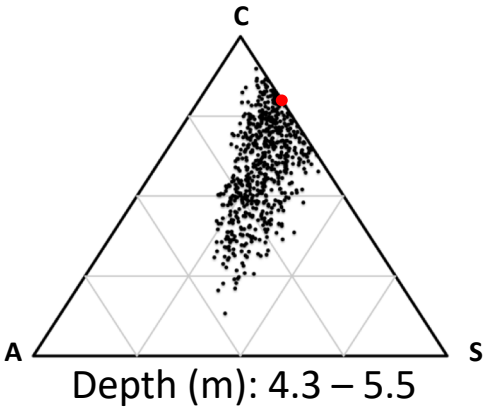
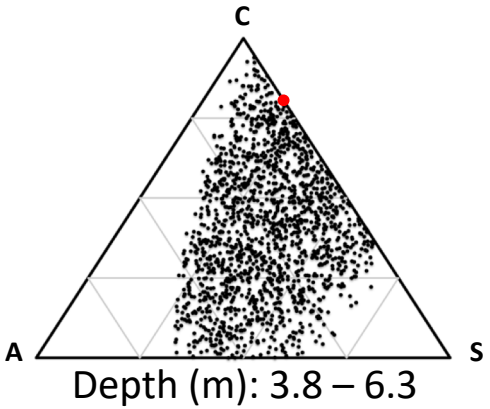
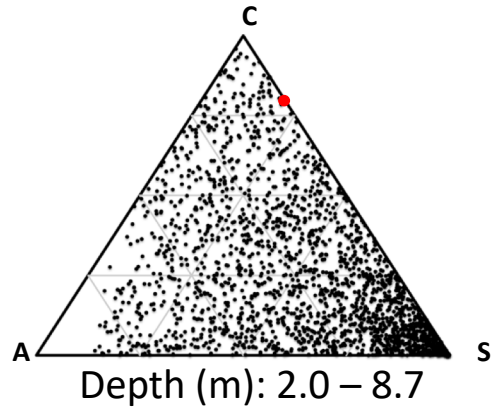
Noise: $R_{rs,noise} = (0.05/\pi)/[0.1*SNR]$

Difference: $\Delta R_{rs} = \left[\frac{1}{N}\sum_{400}^{720}[R'_{rs} - R_{rs}]^2\right]^{1/2} \leq R_{rs,noise}$

Results Format



Reference: 80% Coral, 20% Sand, Chl. = 0.2 mg/m^3, $a_{g,450}$ = 0.5 m^{-1}, SPM = 0.5 g/m^3

SNR:	1000	500	100
Depth (m			
1	 Depth (m): 0.98 – 1.02	 Depth (m): 0.96 – 1.04	 Depth (m): 0.82 – 1.2
3	 Depth (m): 2.8 – 3.2	 Depth (m): 2.7 – 3.3	 Depth (m): 2.0 – 4.9
5	 Depth (m): 4.3 – 5.5	 Depth (m): 3.8 – 6.3	 Depth (m): 2.0 – 8.7

AVIRIS Imagery: Coconut Island & Patch Reef

08 Feb 2017 | 22 Feb 2017 | 03 Mar 2017

Reference = Coral, Depth = 3.5 - 4.5 m

SNR	$R_{rs,noise}$
1000	0.00016
500	0.00032
100	0.00159

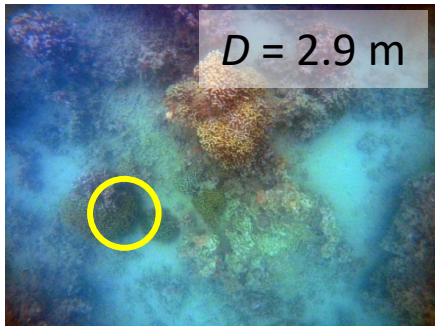
Image	$\Delta R_{rs\ (Sand)}$	$\Delta R_{rs\ (Bay)}$
02/08	.00076	.00075
02/22	.00202	.00049
03/03	.00236	.00048

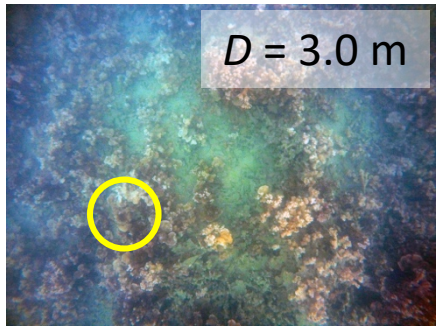
Autonomous Kayak Data: Coconut Patch Reef
Reference: Coral-dominated, *D* = 3 m.

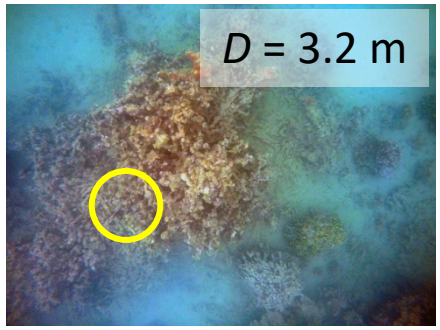
SNR

Example Benthic Cover

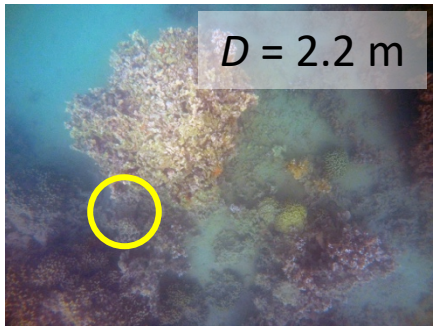
1000
ΔD: 2.4 – 3.5 m

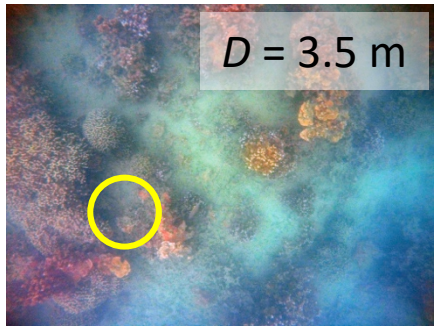


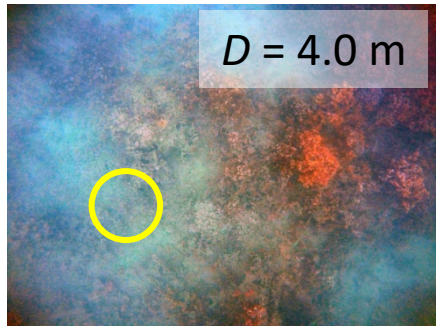




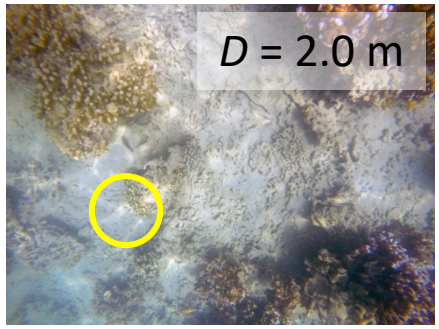
500
ΔD: 2.1 – 4.0 m

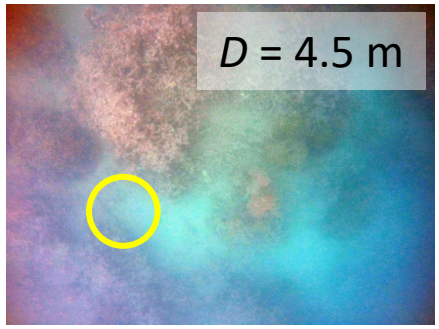


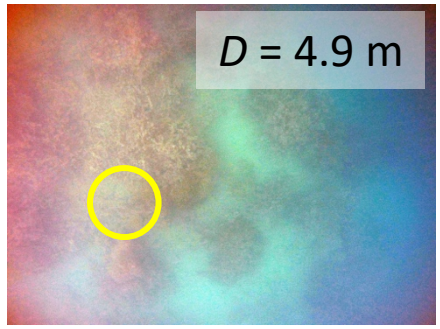




100
ΔD: 1.8 – 14.9 m







What SNR can we reasonably expect for HyspIRI?

	Δλ nm	GSD (m)	SNR
HyspIRI (Benchmark)*:	10	60	400

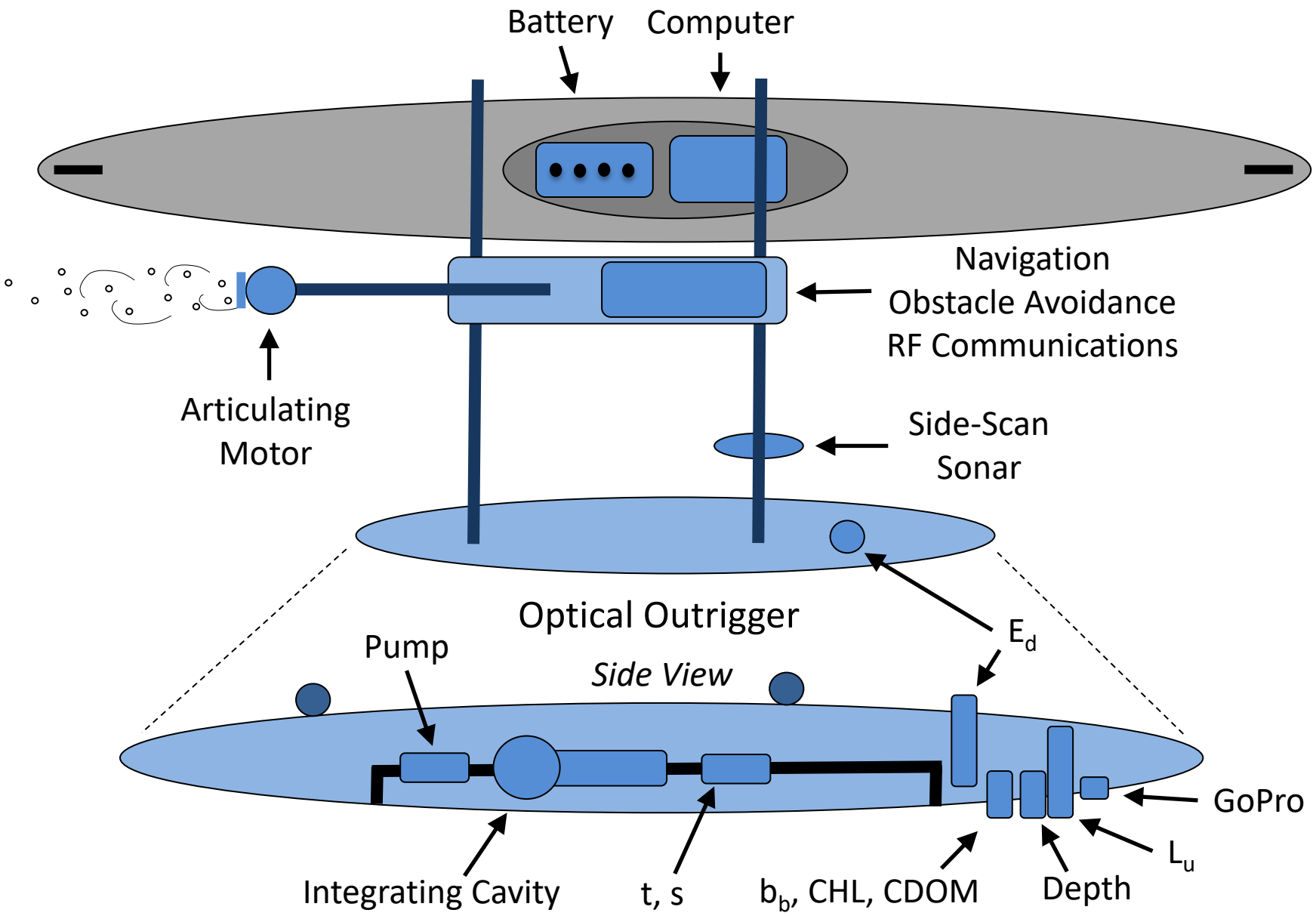
* *Gao, 2010, NRL Tech Report*

HICO:	10	100	200
	10	60	120

Summary

- Model, in situ, and AVIRIS data indicate that ecologically useful ocean color imagery for a coral reef environment would require an SNR (clear atmosphere over a 5% target) of ≈ 500 or better.
- The HyspIRI benchmark requirement (SNR = 400) is compatible with this conclusion.
- The ecological value of imagery degrades rapidly with depth and optimum utility would likely be confined to < 3 m.
- Addition studies assessing the impacts of water quality, GSD and spectral resolution would be helpful.
- Future investments in autonomous approaches to surveying shallow coastal environments in support of remote sensing *will* greatly enhance shallow-water ecological research and permit more quantitative assessments of future remote sensing systems.

Autonomous Kayak – The Next Generation



Shallow Water Reflectance Model

$$R_{rs} = R_{rs,\infty} + (\rho_b/\pi - R_{rs,\infty})\, e^{[-(K_d+K_u)D]}$$

Maritorena et al., 1994

$$R_{rs,\infty} = \frac{0.52\, r_{rs}}{1 - 1.7\, r_{rs}}$$

Lee et al., 1999

$$r_{rs} = 0.084\, X + 0.125\, X^2;\ X = b_b\,(a + b_b)^{-1}$$

Gordon et al., 1988

$$K = \frac{a}{\mu}\left[1 + (0.425\,\mu - 0.19)\frac{b}{a}\right]^{0.5}$$

Kirk, 1984