Meeting an old friend after 3 decades: The 2018 New England mesoscale coccolithophore bloom, (but viewed with new glasses!)

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30 years can make for a big change in some things and not in others!

My story begins in 1988-89…

Biological and optical properties of mesoscale coccolithophore blooms in the Gulf of Maine

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Steven G. Ackleson[1]
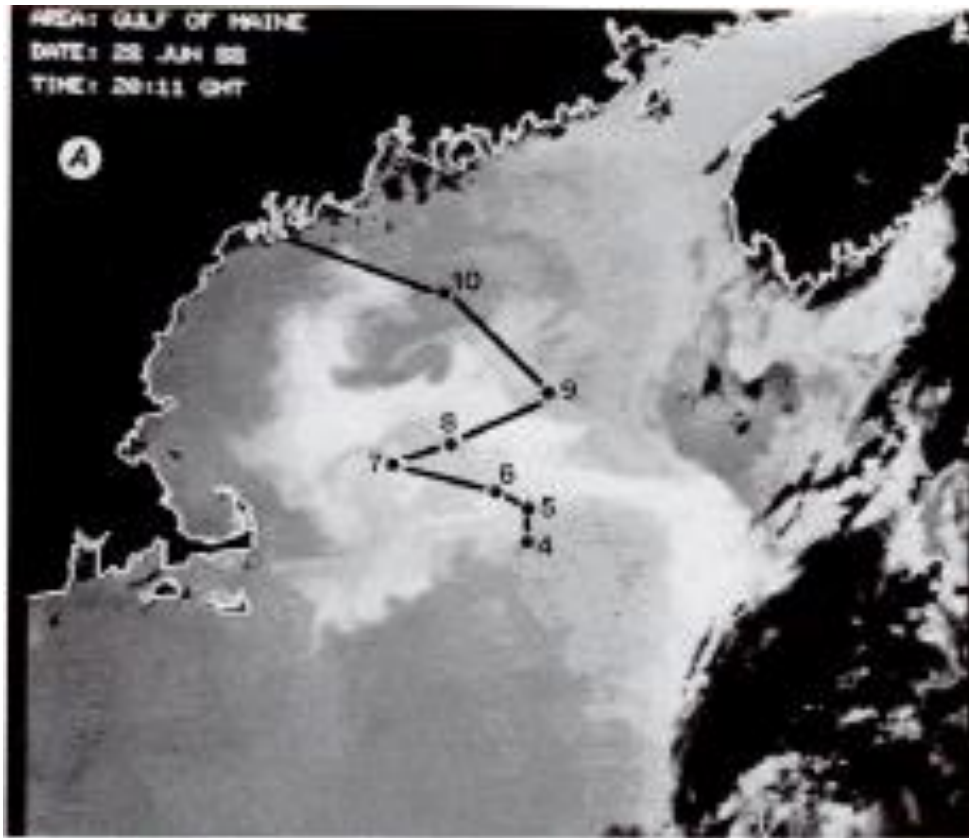Bigelow Laboratory for Ocean Sciences, McKown Point, West Boothbay Harbor, Maine 04575

Kenneth J. Voss
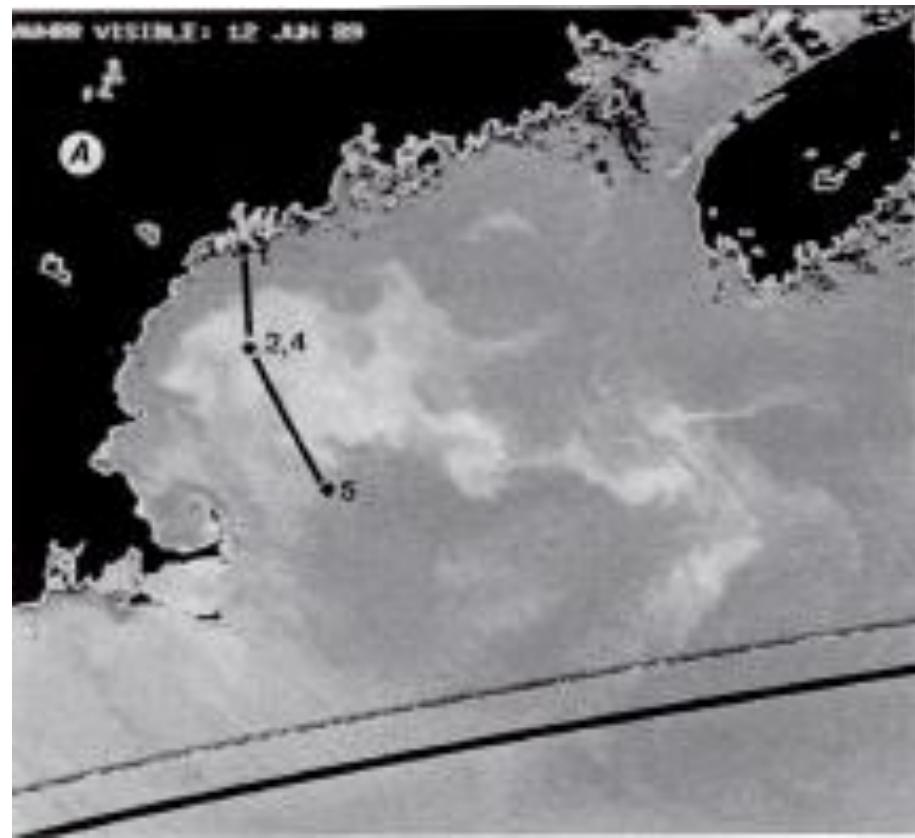Department of Physics, University of Miami, Coral Gables, Florida 33124

"Old glasses"

There was no CZCS. Our eyes in the sky were aboard NOAA-9 with a broad-band, low sensitivity visible channel and an IR channel. $R_{vis} - R_{IR}$ (Groom and Holligan,1987)
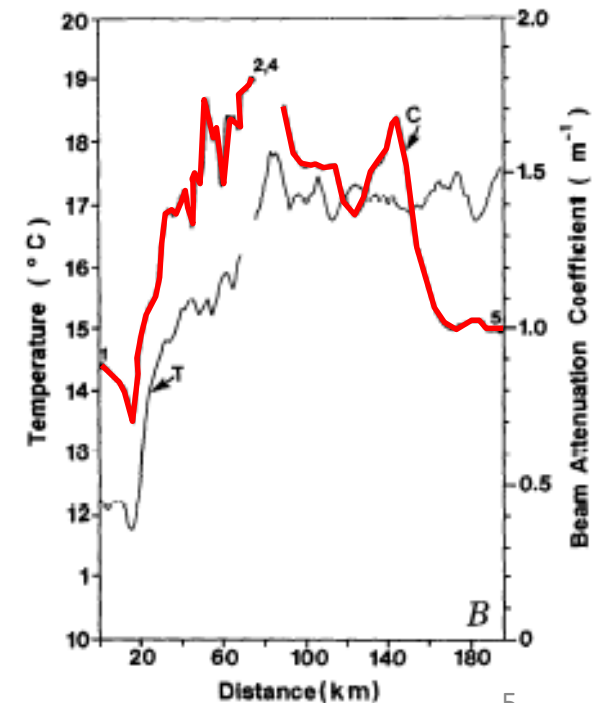
Balch et al. NASA OCRT Busan 4/8/19

June 1988

June 1989

Balch et al. NASA OCRT Busan 4/8/19

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Other defining characteristics of the 1988-89 blooms in the Gulf of Maine…

- Max coccolith abundance ~300,000 per mL
- Max coccolithophore abundance ~1500 cells mL^{-1}
- Max beam attenuation 1.8 m^{-1}
- Max coccoliths/plated cell = 400
- Monospecific- *E. huxleyi*
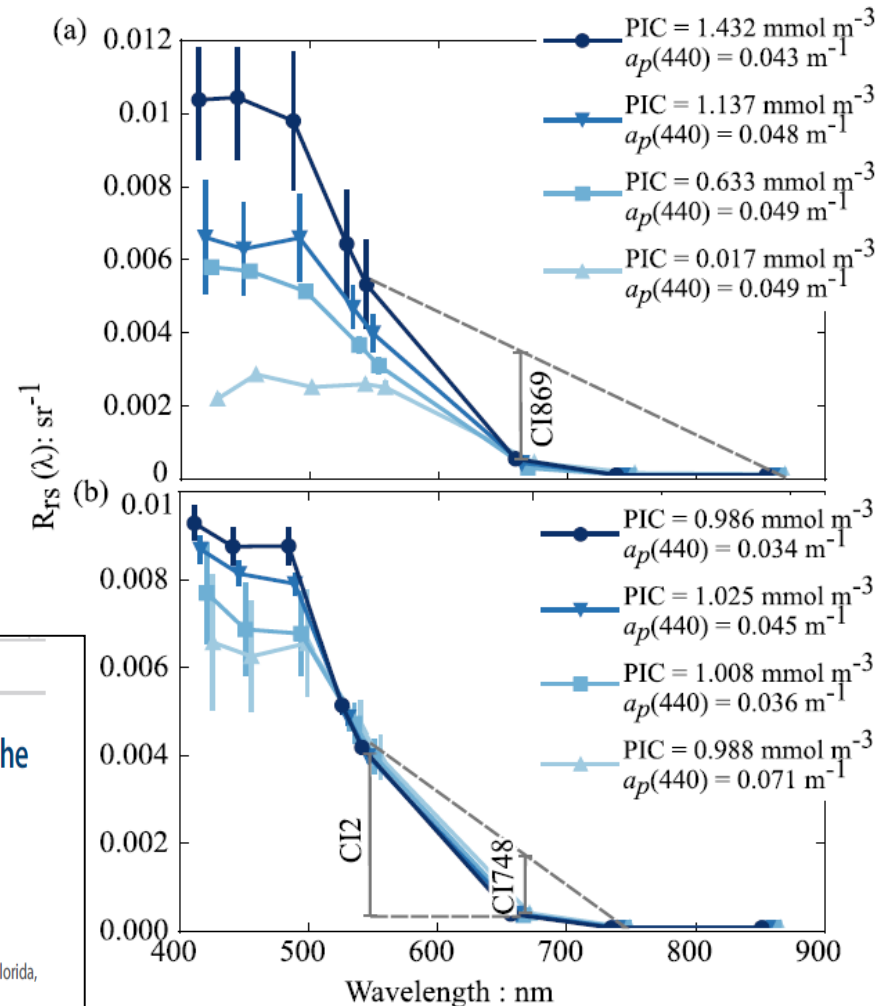
2018 Cruise R/V Endeavor EN616 "New glasses"

- 2B-3B PIC algorithm (Balch et al., 2005; Gordon et al. 2001) and PIC 2CI "difference algorithm" (Mitchell et al., 2017)

- Carried above-water SeaBird Hypersas radiometer system mounted on a SeaBird solar tracker

- In-water *Hyperpro* hyperspectral radiometer system

- LIDAR (ODU): Characteristics: Wavelength = 532nm; speed= 10hz; 100 shots at 5 different gain settings...profiles stitched together

- MODIS Aqua & NPP VIIRS imagery

Balch et al. NASA OCRT Busan 4/8/19

The basis of the PIC-CI algorithm…

3-band index vs 2-band index

- CI670 is sensitive to PIC, but not to *ap*

- *A two-band color index (547-667nm) does almost as well as a three-band color index.*
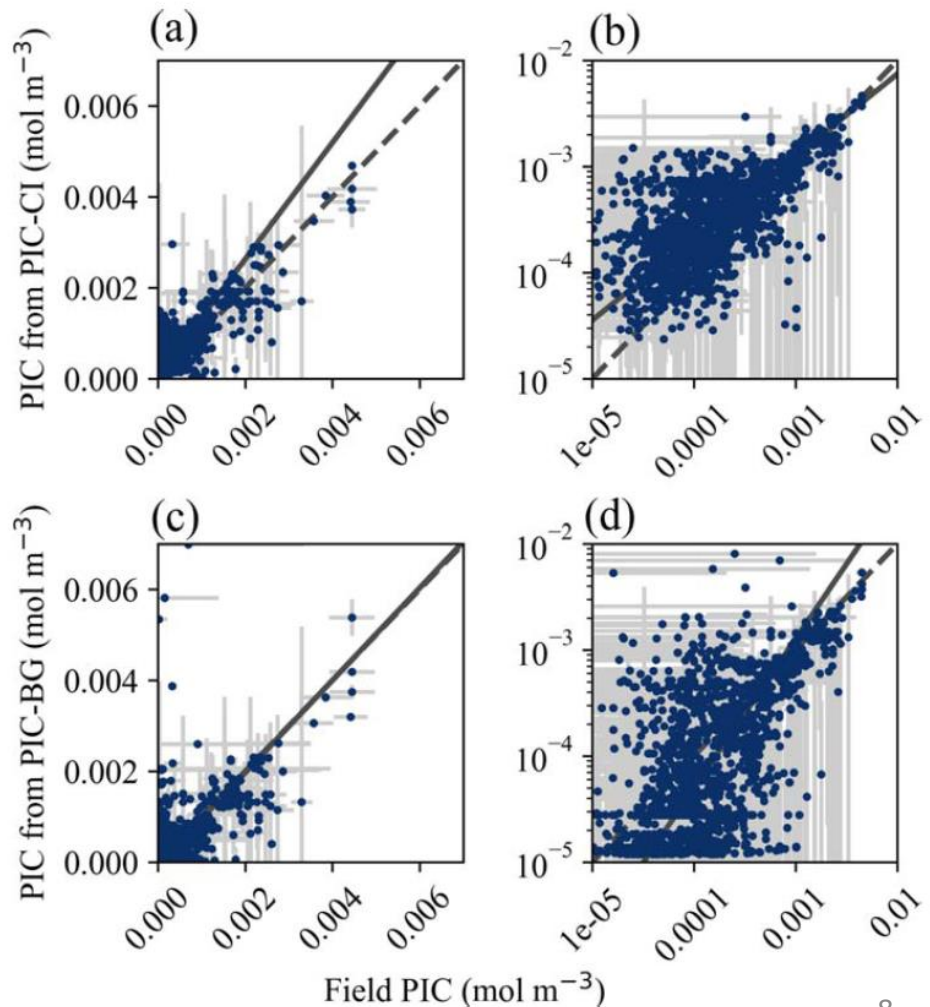
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- RMSE lower for PIC-CI

- R^2 for log-log plots higher for PIC-CI than 2B/3B

Mitchell et al., 2017

Balch et al. NASA OCRT Busan 4/8/19

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2018 Cruise *R/V Endeavor*

Remote Sensing of Environment 215 (2018) 85–96

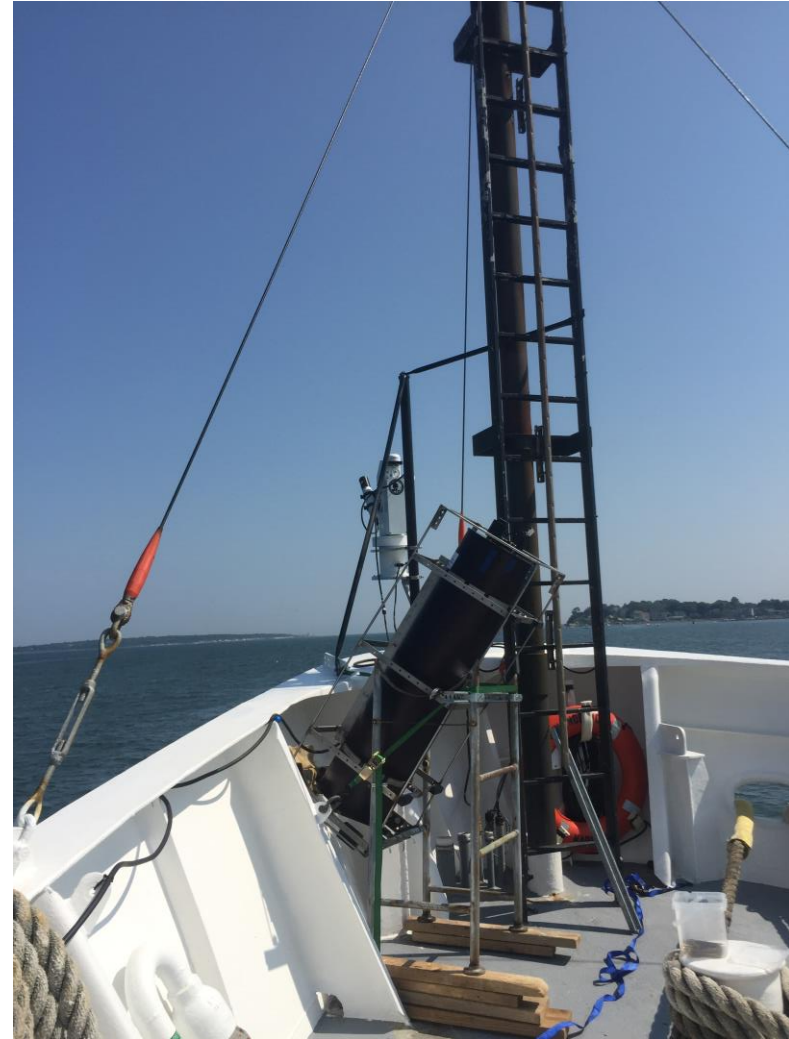Contents lists available at ScienceDirect

Remote Sensing of Environment
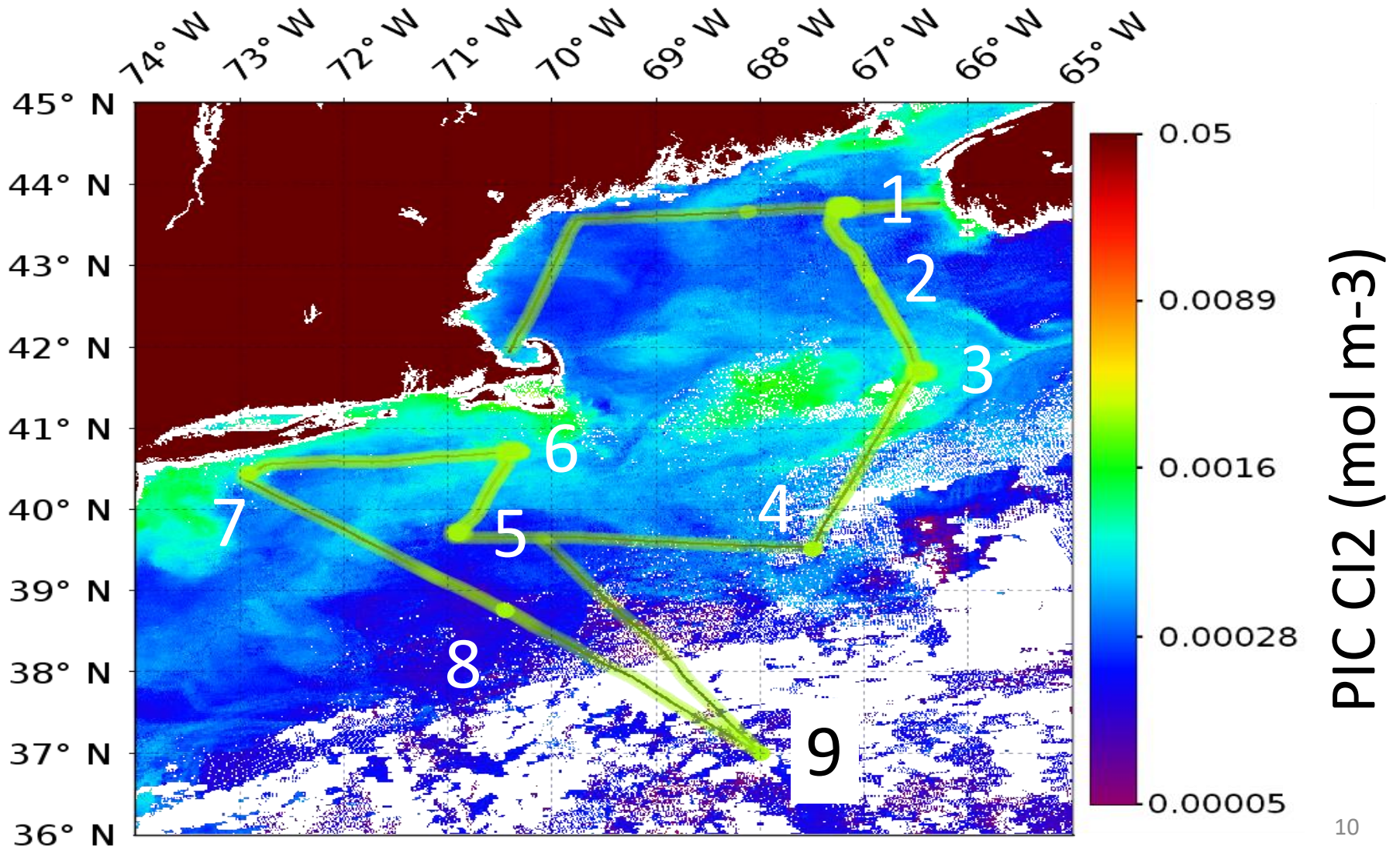
journal homepage: www.elsevier.com/locate/rse

Remote sensing of optical characteristics and particle distributions of the upper ocean using shipboard lidar
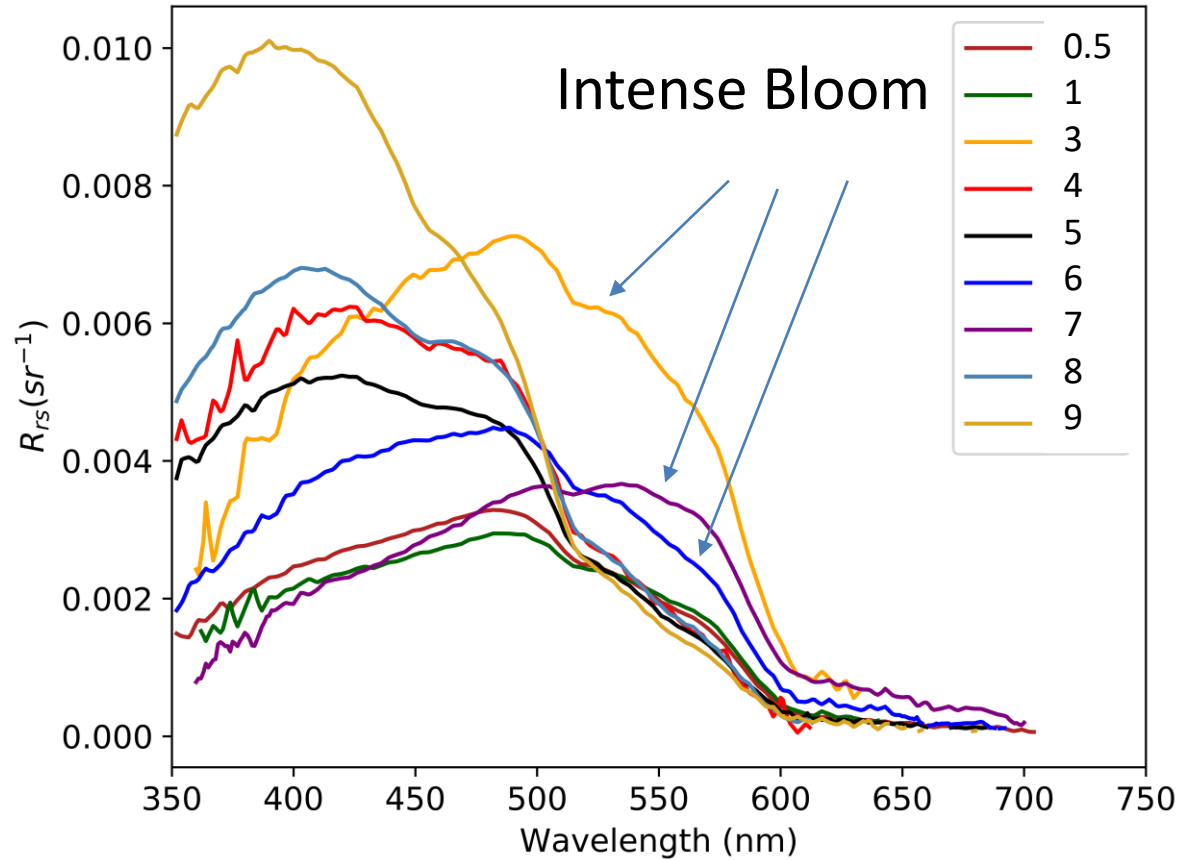
Brian L. Collister[a,*], Richard C. Zimmerman[a], Charles I. Sukenik[b], Victoria J. Hill[a], William M. Balch[c]

LiDAR on bow

Cruise Track EN616; July 2018

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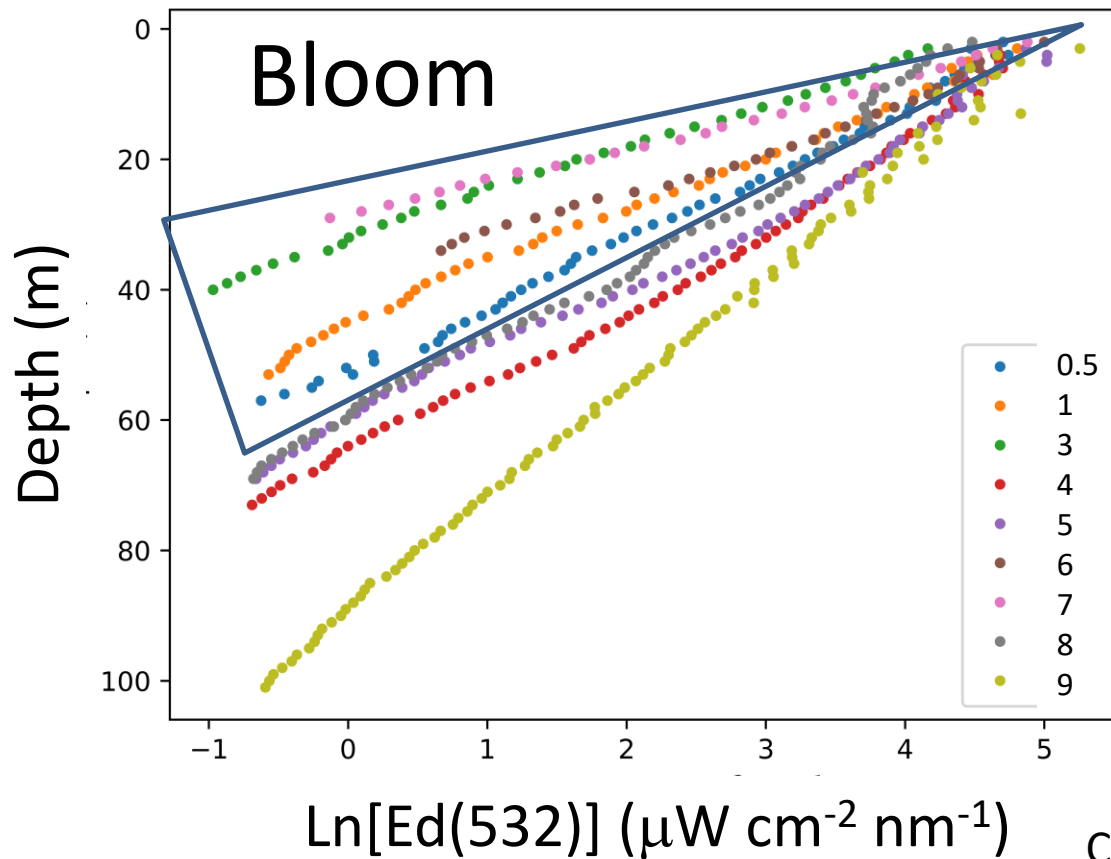# $R_{rs}(\lambda)$ a just below surface...

Collister et al., in prep

Hyperpro profiles…

Bloom

Depth (m)

Ln[Ed(532)] (μW cm^{-2} nm^{-1})

Legend:
- 0.5
- 1
- 3
- 4
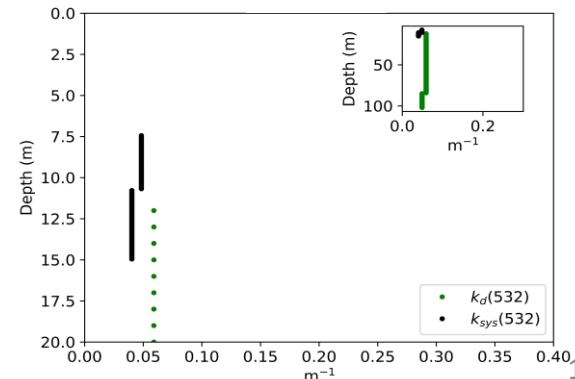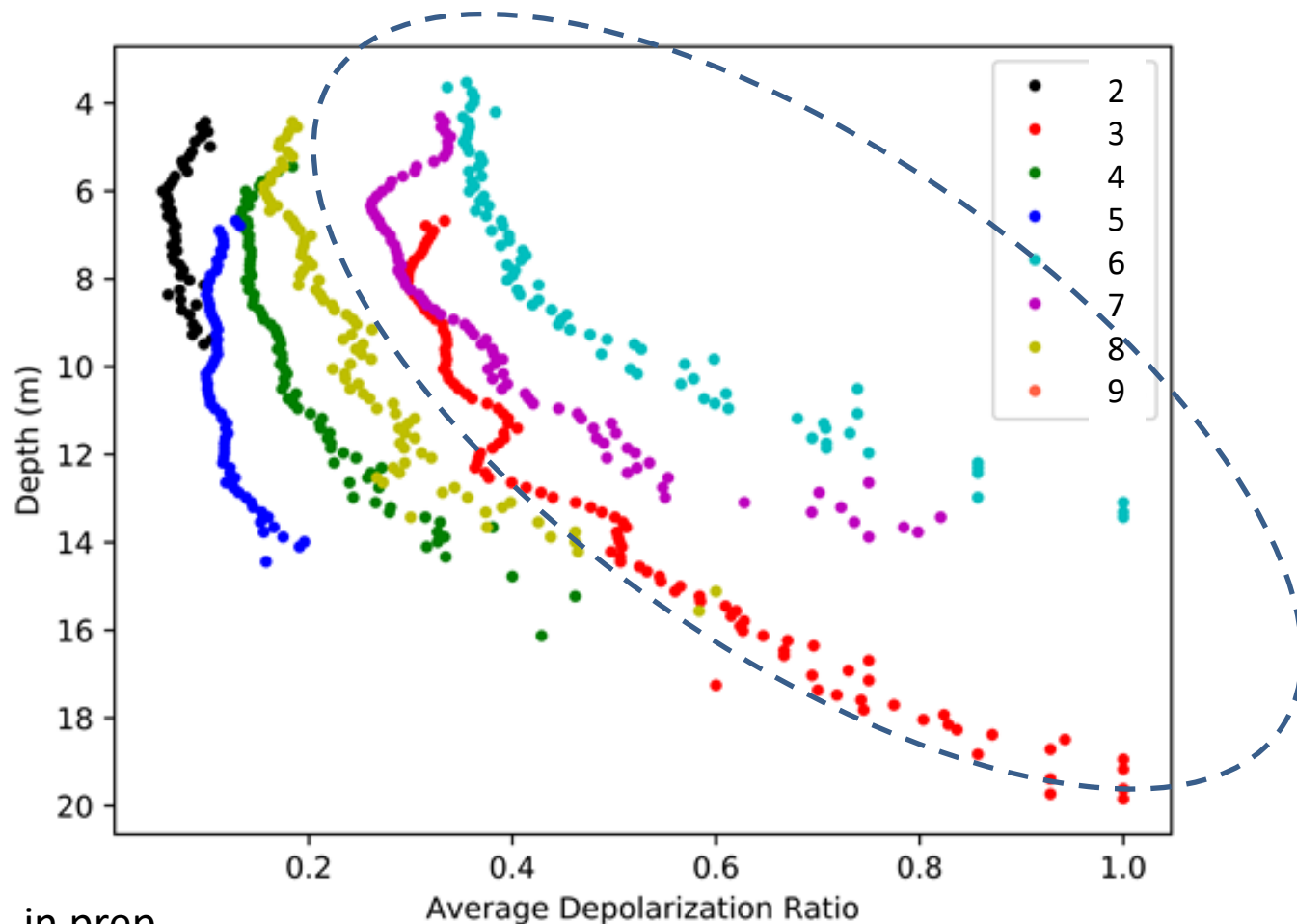- 5
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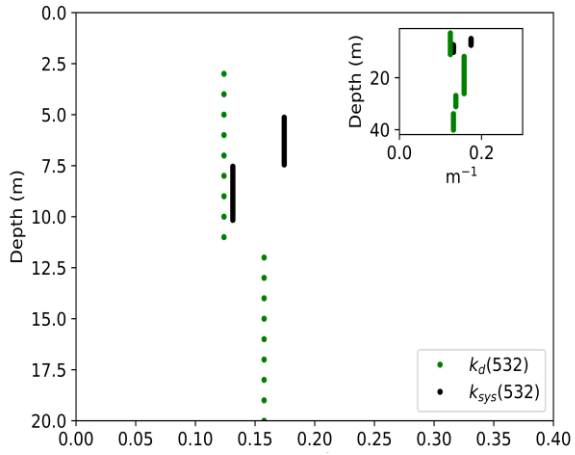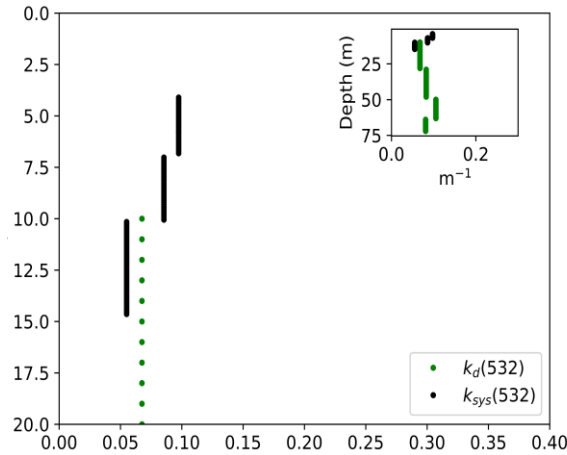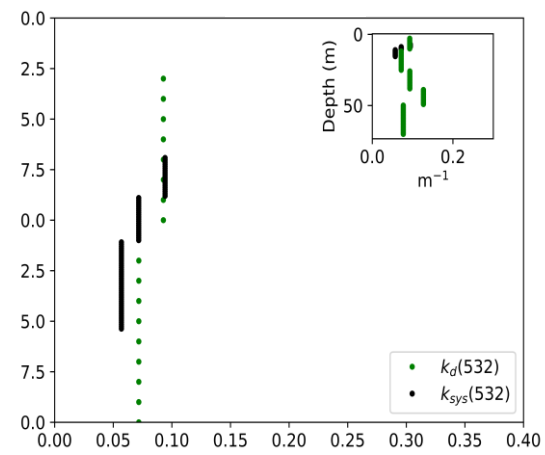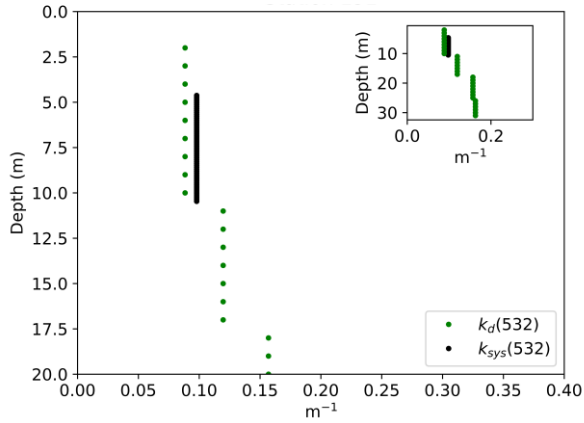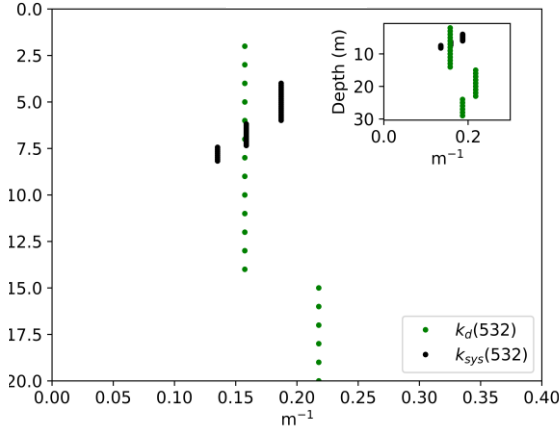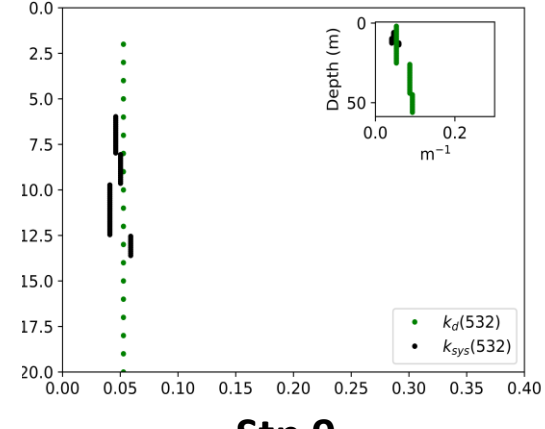
Collister et al., in prep

Collister et al., in prep

K_d hyperpro vs K_{sys} lidar

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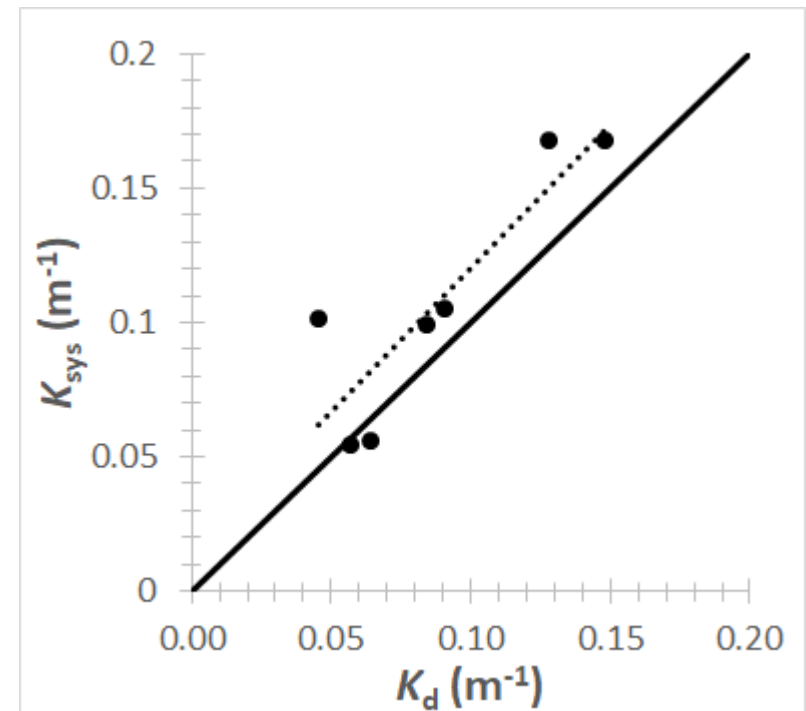
Highest depolarization associated with bloom stations...

Collister et al., in prep

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Low (but significant) correlation of depolarization ratio to PIC concentration. Higher correlation of Kd and Ksys.

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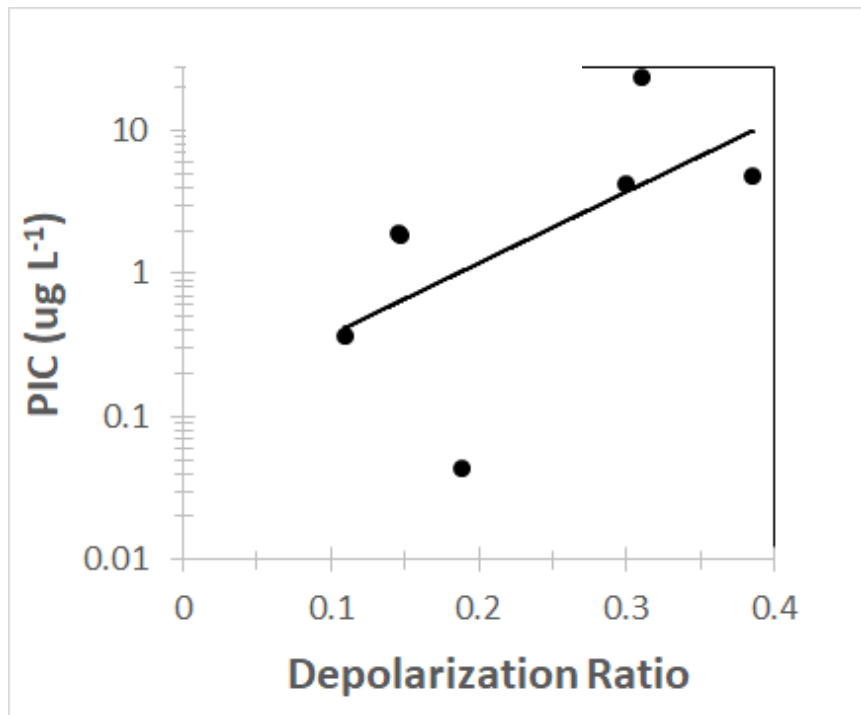
Alleged cocco bloom: What was in the water?

10μm
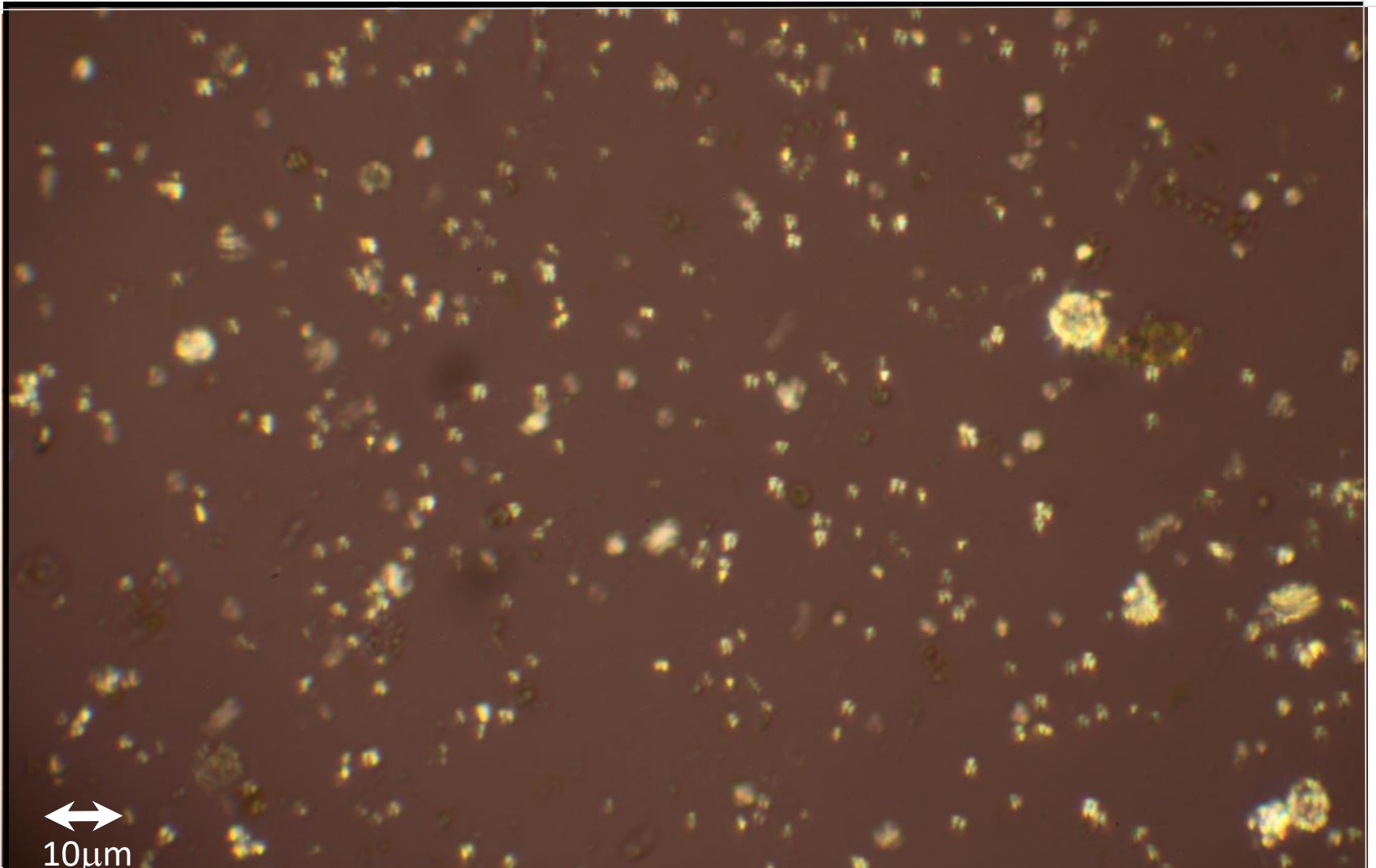
At the bloom center, was it all E. huxleyi?

Ophiaster formosus
(with body coccoliths & osteoliths)

1μm   **Bigelow Laboratory for Ocean Sciences**   Date :28 Aug 2018
File Name = EN616-3-17-002.tif   Mag = 15.53 K X WD = 6 mm   Aperture Size = 30.00 μm   EHT = 10.00 kV

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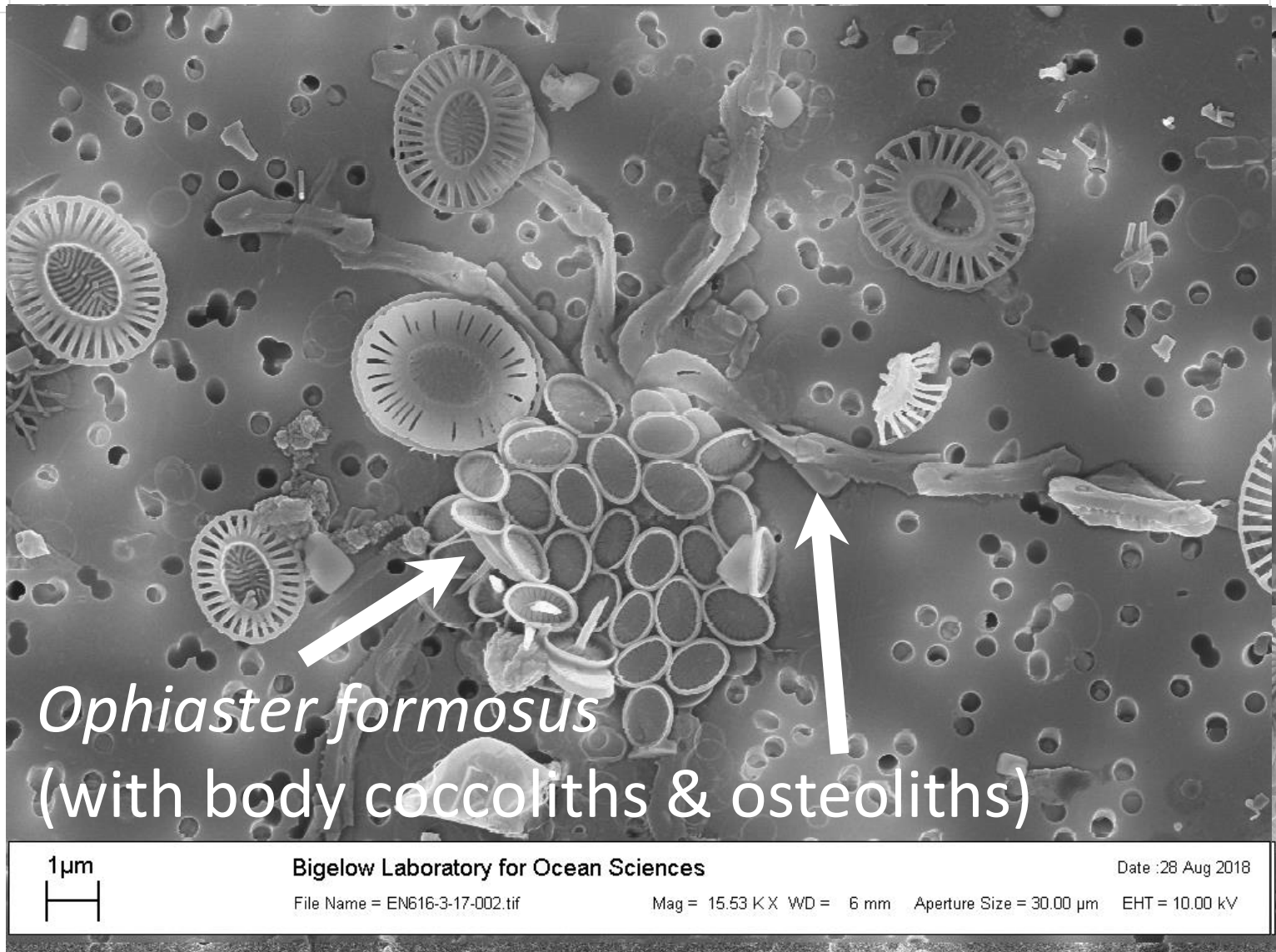
Other important characteristics of the 2018 coccolithophore bloom:

- Peak coccolith abundance = 85,000 coccoliths mL^{-1}
- Peak coccosphere abundance = 380 cells mL^{-1}
- 275 Coccoliths per plated cell
- coccolith PIC = 0.2-1.5 pg PIC per coccolith…E. huxleyi is usually 0.2-0.4 pg/coccolith
- # spp and diversity of coccolithphores > coccoliths
- E. huxleyi never exceeded 50% of total species, in and out of bloom
- In and out of bloom saw typically 15 species

Allowing b_b* to vary according to analytical measurements of PIC and bb'.
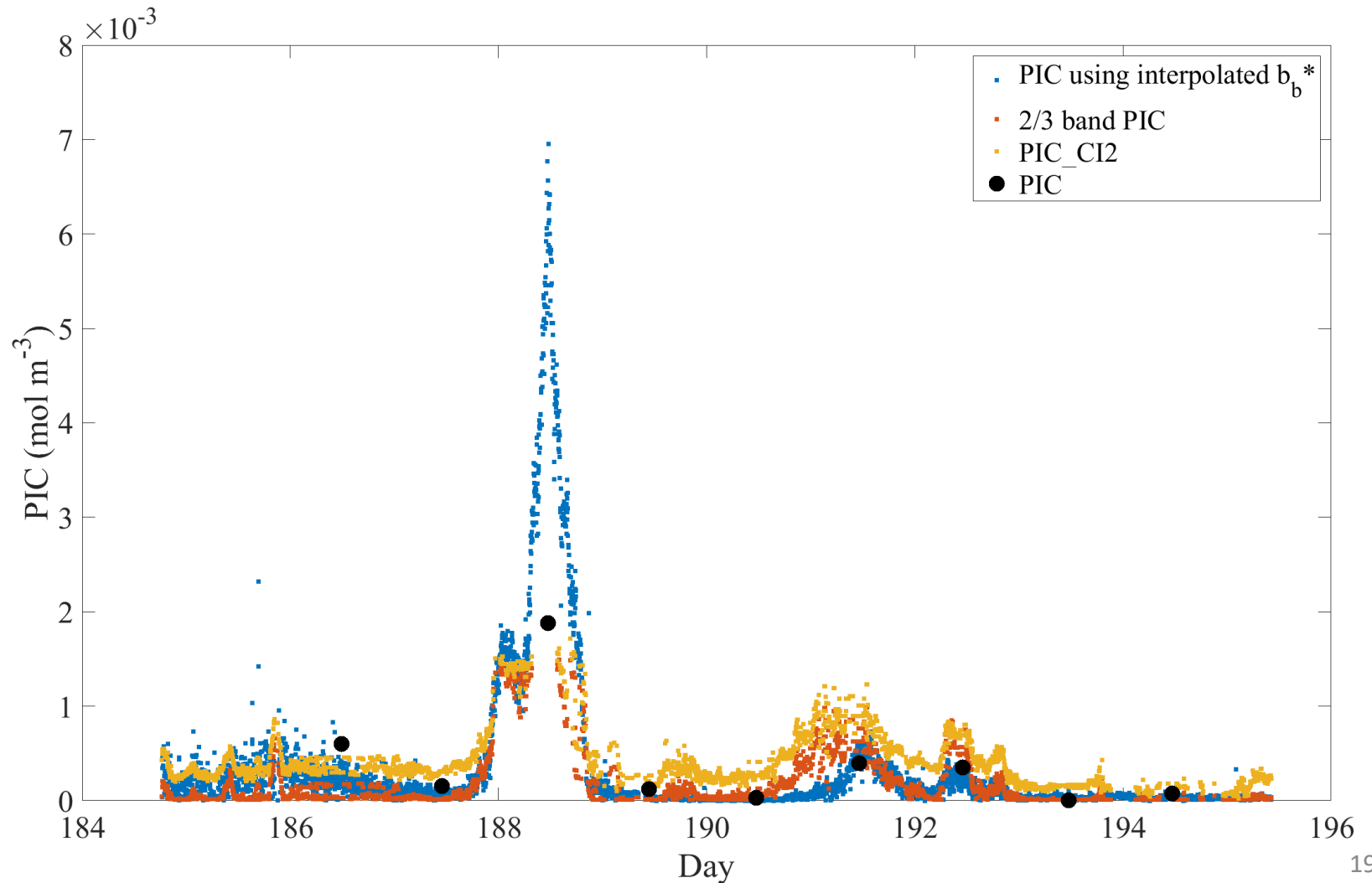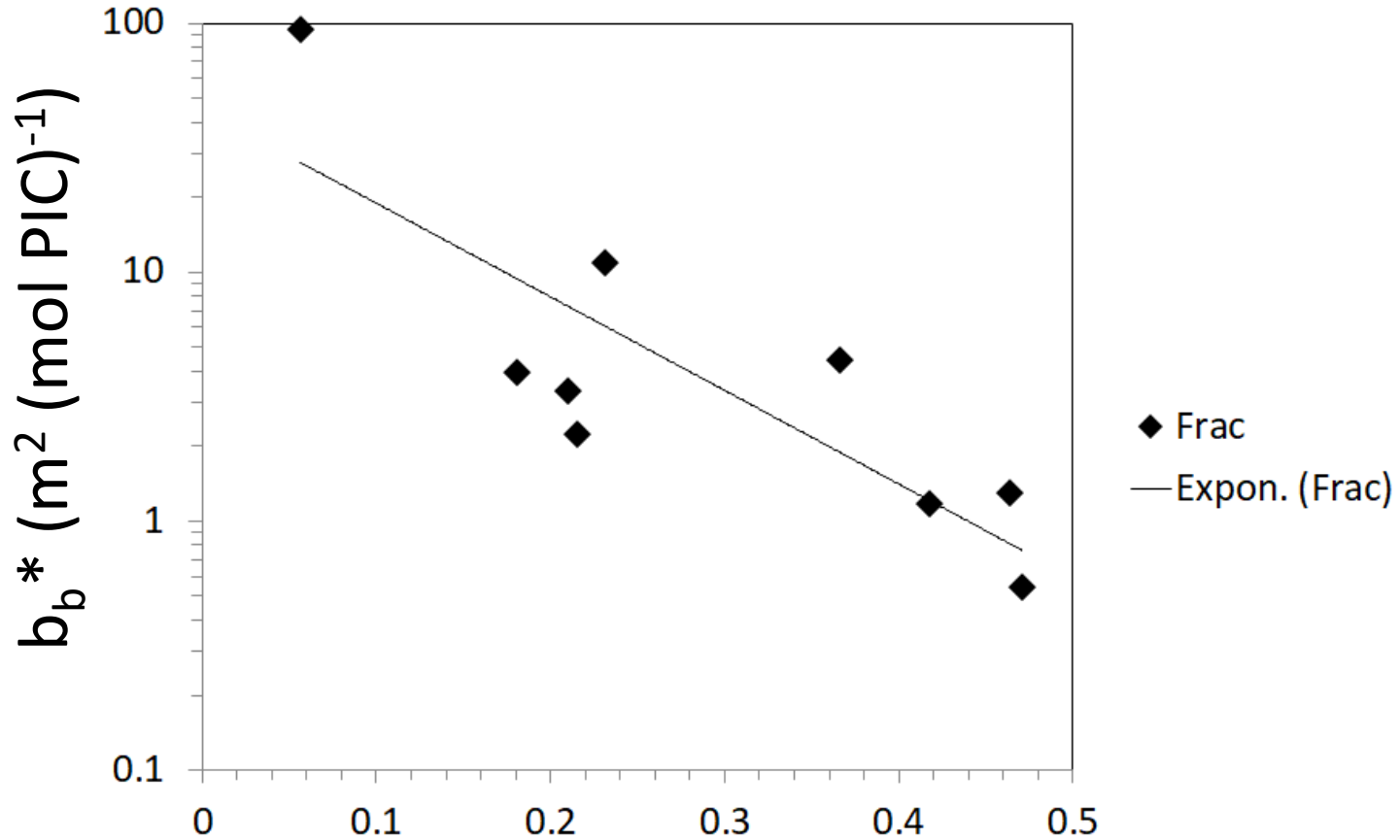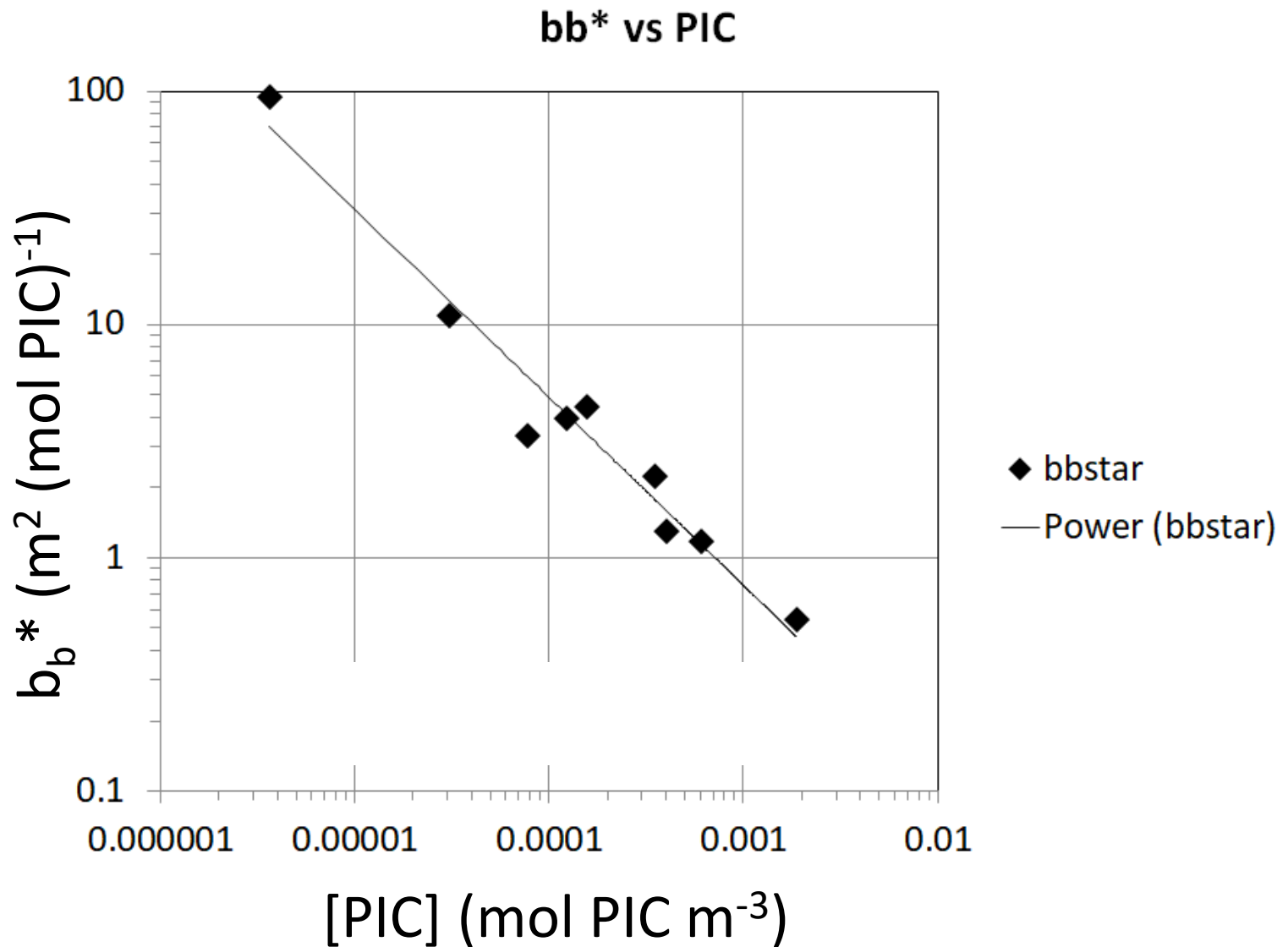
How would b_b* (=b_b'/PIC) vary?

·98 ??
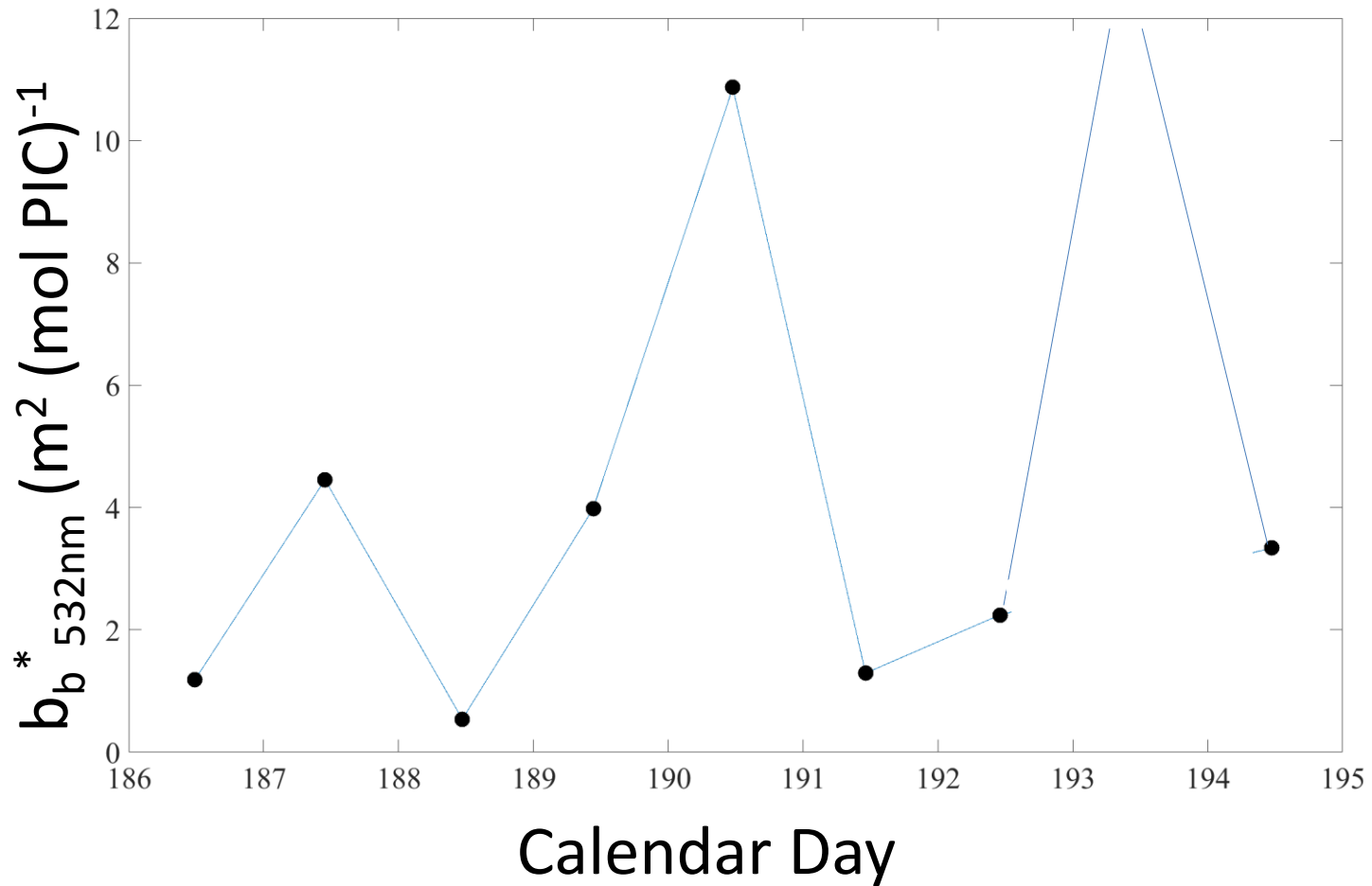
The b_b* of PIC is an inverse function of the fraction of E.hux in the sample…

Avg. Fraction of coccolithophores and coccoliths as E. hux

Balch et al., in prep

Lowest b_b*PIC at highest [PIC]

bb* vs PIC

Summary

- New PIC-CI algorithm shows reduced RMSE, higher r^2 than the 2band/3band algorithm

- View of coccolithophore bloom with lidar showed: enhanced polarization, and ~1:1 relation of K_d and K_{sys} in upper 20m

- 1988-1989 bloom monospecific; 2018 bloom contained ~15 spp, higher diversity of coccos

- b_b* was highly variable in 2018 bloom

- b_b* well correlated to % of E. huxleyi and [PIC]; important for algorithm development!

- *Thank you!* 고맙습니다

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Acknowledgements

- NASA

- NSF

- Atlantic Meridional Transect Program-10 cruises

- Captain, crew and support engineering personnel of the *R/V Endeavor*