



Naval Oceanographic Office Airborne Coastal Surveys Update

19 July 2016
Silver Springs MD

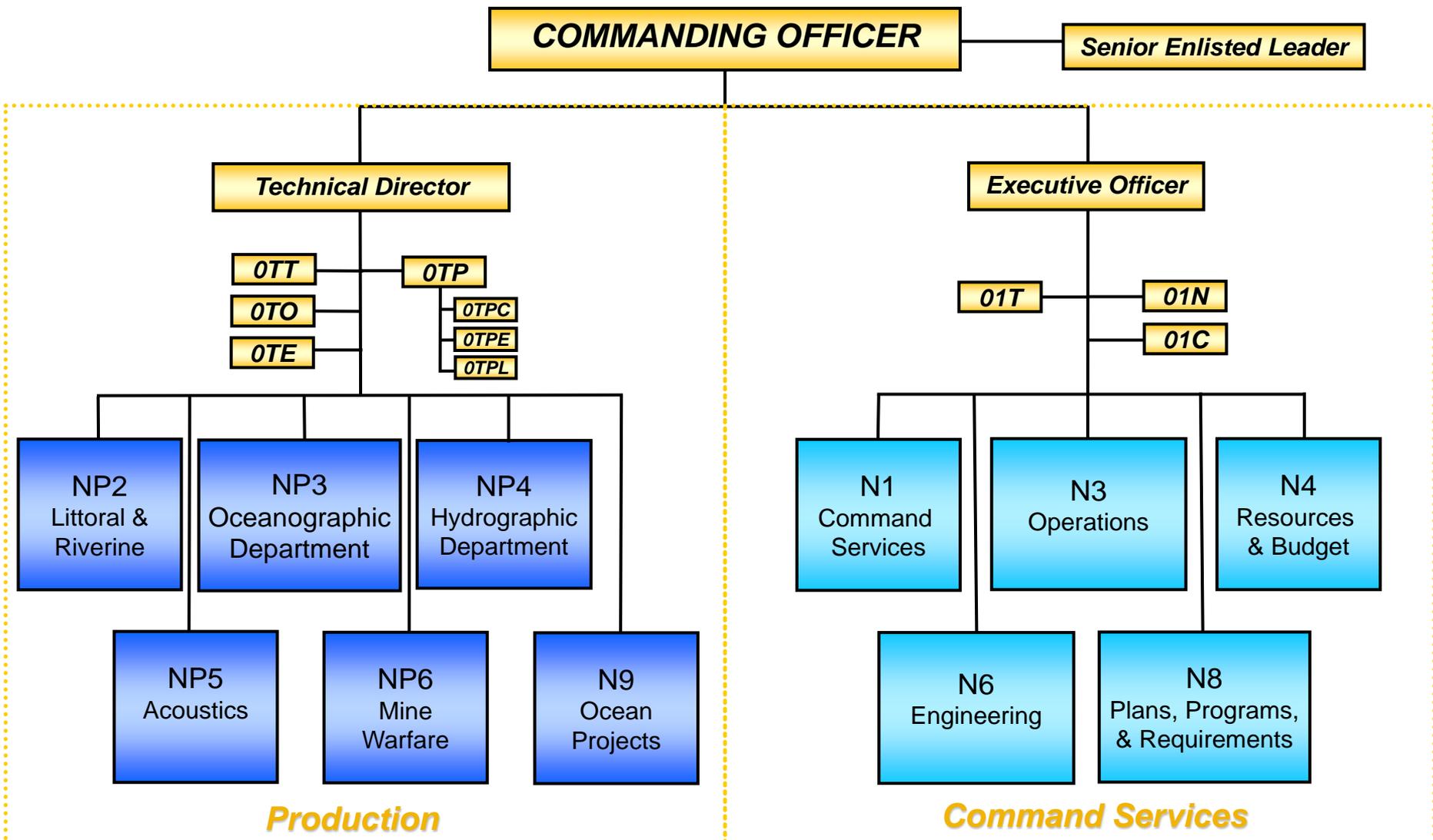
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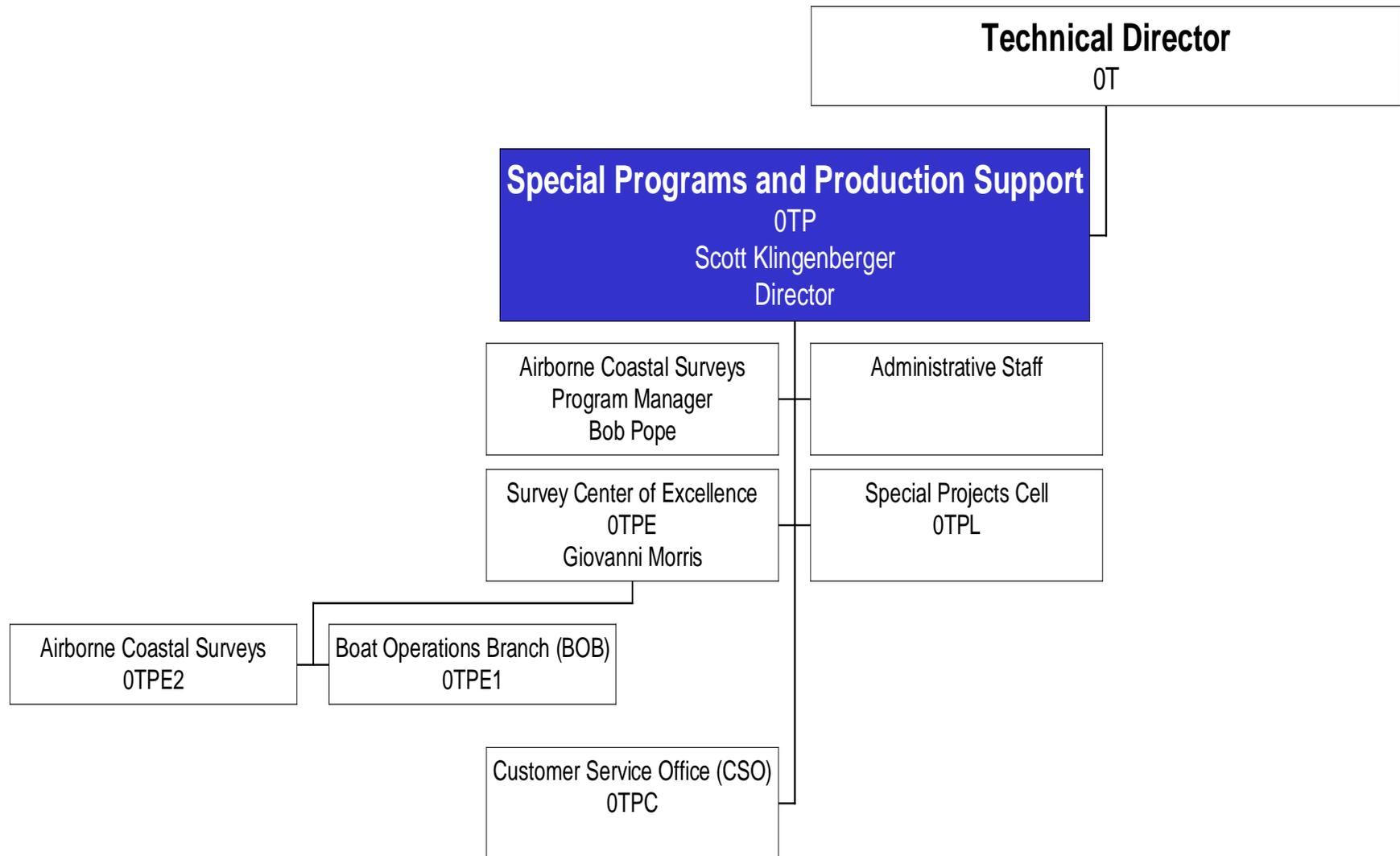


NAVOCEANO Organization





OTP Organization

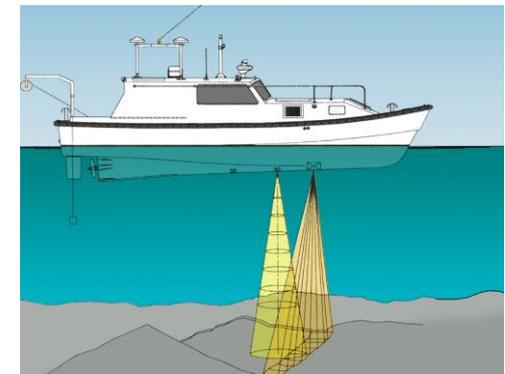




Survey Center of Excellence (OTPE)



- **Mission:**
 - Integrates **new survey technology** into existing CONOPS and production flows
 - Operates the CZMIL LIDAR system & pursues advancement in LIDAR technology w/ Joint Airborne LIDAR Bathymetry Technical COE
 - Facilitates training of surveyors
 - Survey Manning & Survey Technical Specifications
- **Products & Services:**
 - **LIDAR** Surveys using the Coastal Zone Mapping and Imaging (CZMIL) system
 - Operates the **Boat Operations Branch** to provide a platform for testing, training, and data collection on the Gulf Coast
 - Survey manning and planning coordination





Honduras 2015 Mission Timeline

- **17 Oct: Survey personnel arrived**
- **20 Oct: C-FBKB, field equipment arrive**
- **22 Oct – 24 Nov: 36 survey flights**
- **25-30 Nov: Northrop Grumman / Woolpert contractor turnover**
- **01 Dec - 16 Dec : 16 survey flights**
- **21 Dec: C-FBKB, field equipment, personnel depart SOUTHCOM**

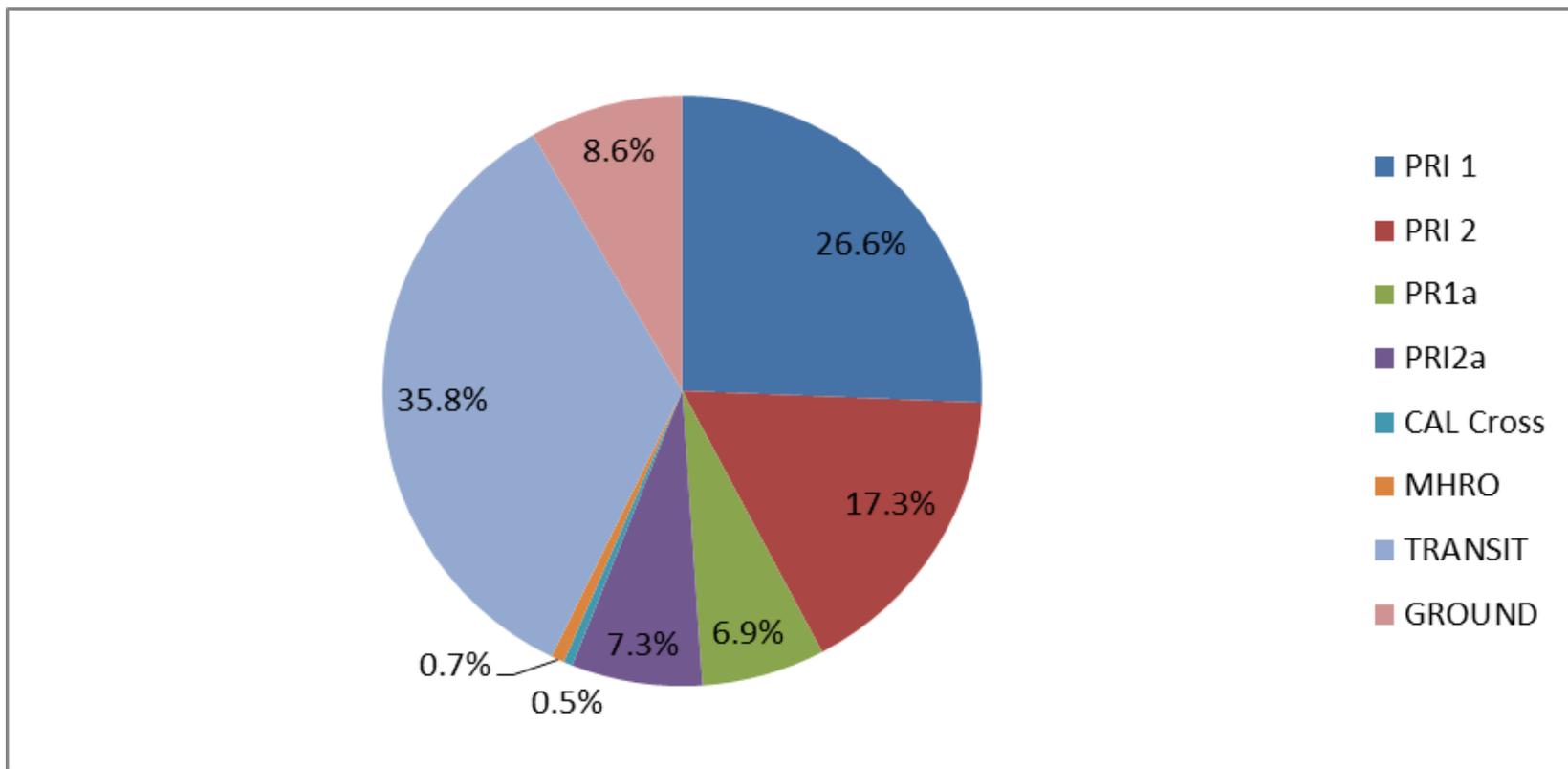
Planned survey flights: 44
Planned non-survey days: 19
Actual non-survey days: 21
Actual survey days: 42



Honduras Aircraft Engine Time



Total flight hours (including transits): 307





Honduras Data Collection



- **~23 TB raw data:**
 - 17 TB lidar**
 - 4 TB Optech T4800 camera**
 - 2 TB Itres CASI 1500**

- **Buoys: 4 AN/SSQ-57XN9**
 - 6 AN/SSQ-36B**

Area surveyed / % coverage:

Priority 1 / 200%: 845 km² / 250 Nm²

Priority 1a / 200%: 544 km² / 159 Nm²

Priority 2 / 200%: 655 km² / 192 Nm²

Priority 2a / 100%: 179 km² / 53 Nm²

Total: 2223 km² / 654 Nm²



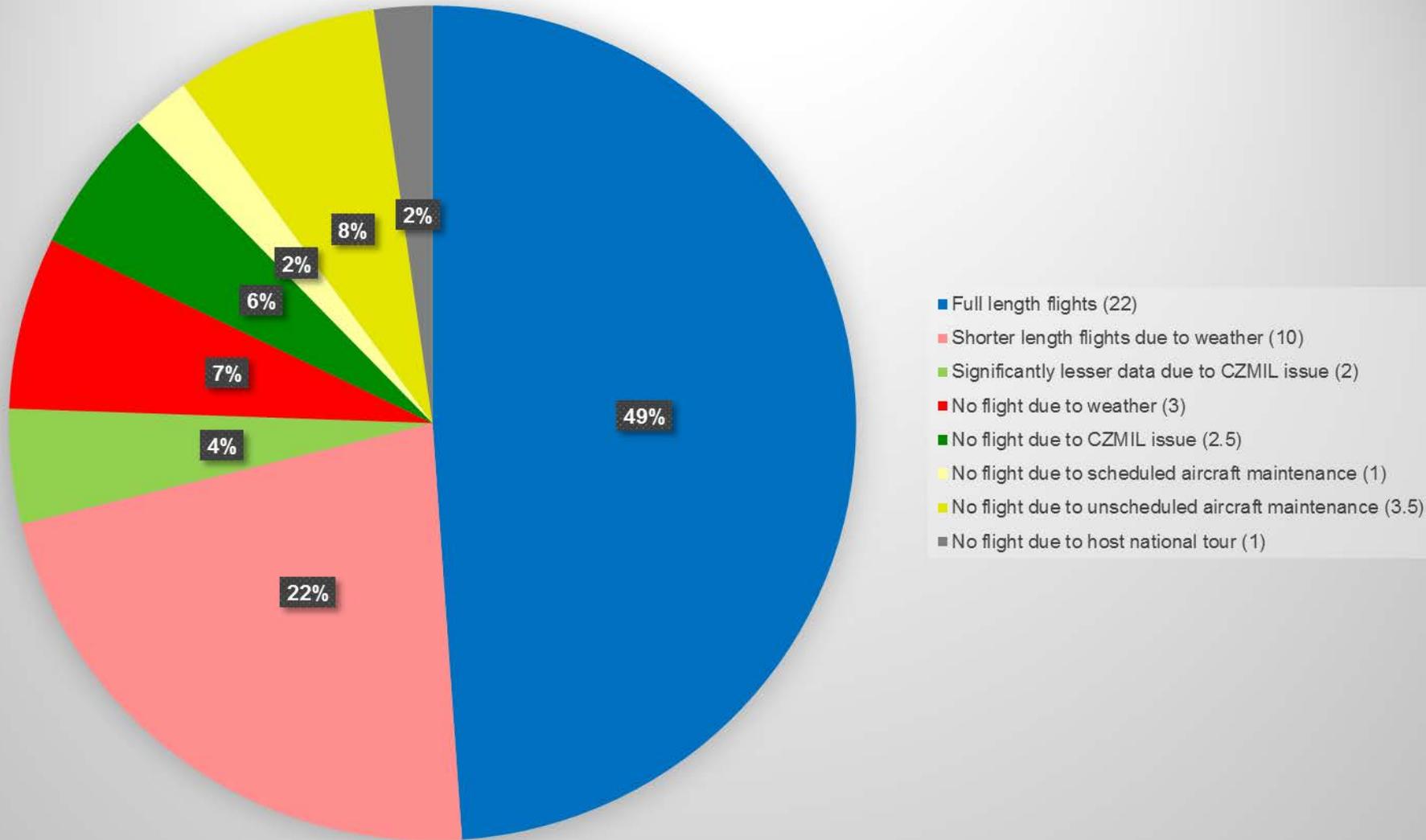
Mission Timeline



- **25-26 Jan: surveyors arrived in Muharraq, Bahrain**
- **27-31 Jan: C-FBKB transit from Stennis to Bahrain across North Atlantic and Europe**
- **28 Jan: NSA Bahrain meeting with 5th Fleet and CTF-57 to discuss operation and force protection**
- **31 Jan: Meeting w/ Bahrain ATC to discuss airspace complications**
- **31 Jan: Meeting w/ Bahrain SLRB/BDF**
- **02 Feb: Host national tour at airfield**
- **04 Feb: First survey day**
- **25 Feb: Mid survey review with 5th Fleet, Bahrain BDF, SLRB, CAA, ATC**
- **17 March: Last survey day**
- **20 March: C-FBKB exited Bahrain**
- **20-21 March: All surveyors departed Bahrain**



45 Flight Opportunities 2/2-3/17





Bahrain 2016 Data Collection



- **~31 TB raw data:**
 - 19.3 TB lidar**
 - 5.6 TB Optech T4800 camera**
 - 6.3 TB Itres CASI 1500**
- **~15 TB processed lidar and camera**
- **16,555 Nm (30660 km) linear on-line logged data**
- **2592 Nm² non-unique coverage**
- **OVERALL of ~940 Nm² total area:**
 - 98% (~921 Nm²) one overflight**
 - 56% (~526 Nm²) 2+ overflights**
 - Area 1: 86% and 0%**
 - Area 2: 100% and 15%**
 - Area 3: 100% and 99%**
 - Area 4: 100% and 84%**



Survey Summary

- **34 survey flights from 04 February to 17 March**
- **240 hours of engine time / 212 hours flight / 118 hours online**
- **Aircraft maintenance: 6 planned down days and 4 unplanned down days (10 total)**
-- Better track record than planning expectation of one day per week on average
- **ZERO CZMIL CASREPS during mission following 2 week delay in January**
- **31 TB raw and ~9.5 TB field processed (unedited) data delivered to Bahrain SLRB:**
largest on scene data transfer to host nation to date for ACS
- **First CENTCOM deployment for ACS since 2010: Overcame many challenges including ground and field office logistics, IT issues, and complicated airspace**
- **Coordination with 5th Fleet OPCON, CTF-57 Flight Following, CTF-53 ground logistics**
- **Coordination with Bahrain Survey Land Registration Bureau (data recipients), Bahrain Defense Forces (flight and field office observation), Bahrain Civil Aviation Affairs (field office and airfield access), Bahrain Air Traffic Control (airspace deconfliction)**



Mission Timeline

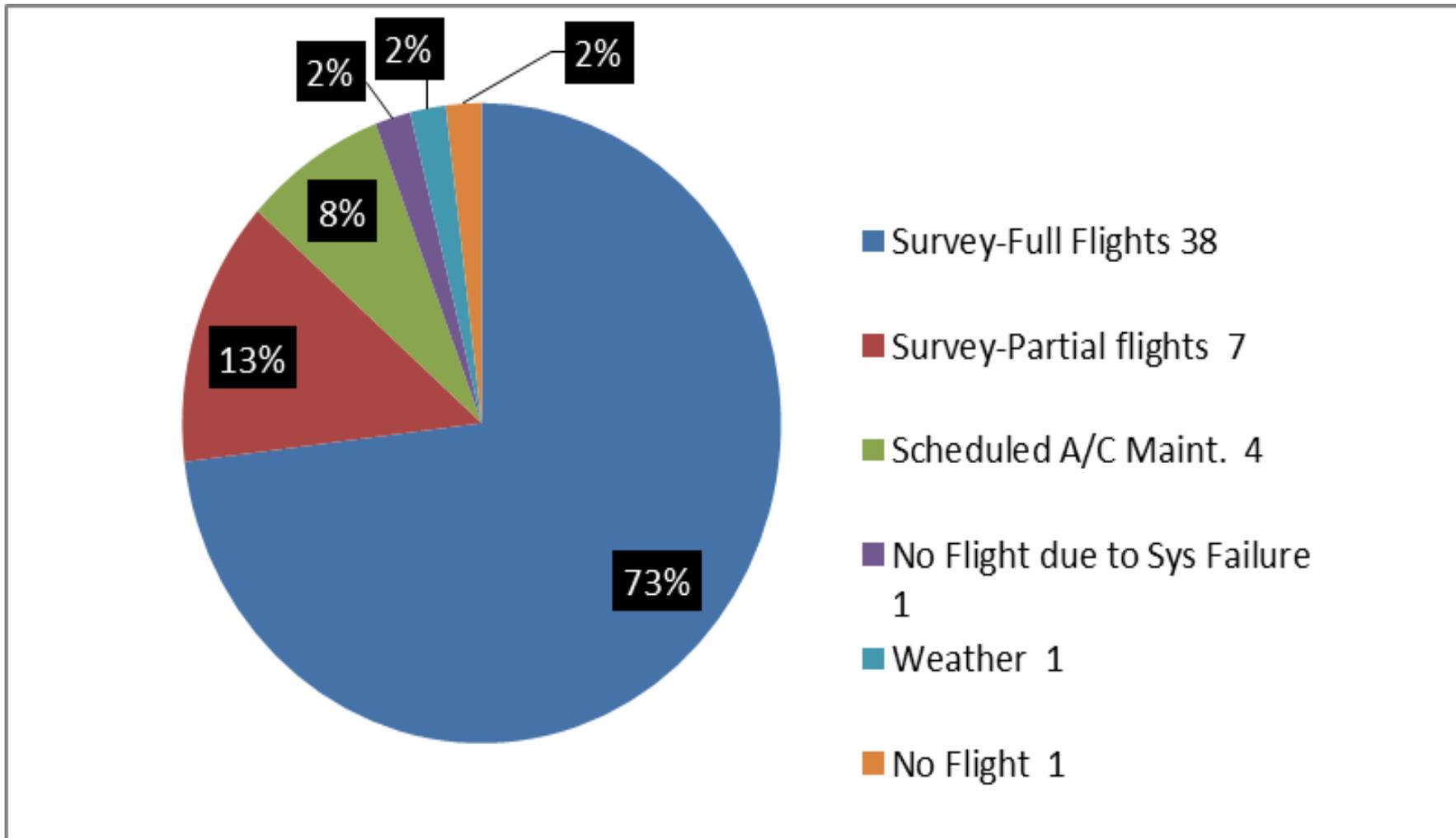


- **21 - 23 Mar: surveyors arrived in Puerto Princesa**
- **23 Mar: C-FBKB arrived in Puerto Princesa**
- **25 Mar: First survey day**
- **13 - 14 Mar: C-FBKB Maintenance**
- **6 - 7 May: C-FBKB Maintenance**
- **6 - 8 May: C-4 CASREP**
- **15 May: Last survey day**
- **17-19 May: surveyors departed Puerto Princesa**
- **18 May: C-FBKB transit (departure delayed 24 hours due to no accommodation in Japan)**
- **22 - 23 May: CZMIL offload, Calgary, Canada**





52 Planned Flights: 25 Mar – 15 May





Philippines Summary



- **45 survey flights**
- **1926 Nm² non unique coverage**
 - **Pri1: 100% and 100% 200%=300 Nm²**
 - **Pri2: 100% and 45% 200%=317 Nm²**
 - **Pri3: 33% and 0% 100%= 24 Nm²**
 - **Pri4: 2% and 0% 100%= 2 Nm²**
- **18 terabytes raw lidar data**
- **2 terabytes raw CASI 1500H**
- **5 terabytes raw T-4800 RGB camera**
- **17 SSQ-36B AXBTs**
- **17 SSQ-53F ambient noise sonobuoys (16/1 G/B)**



Panama City FL Target Detection



IHO Order 1A requires detection of "...cubic features greater than 2 meters in depths up to 40 meters; 10% of the water depth beyond 40 meters."

Deliverables

- ***Probability of detection (POD) of an "IHO-sized" object for each waveform with valid bottom detection***
- ***Include POD as a field within CZMIL .cpf file***
- ***Graphical display of POD (e.g. "color by probability of detection")***

Additional benefits:

- ***Better understanding of the CZMIL waveform (volume scattering, bottom and object signals)***



Panama City 2015 Schedule



- ***Sept.: two additional cubes fabricated***
- ***07 Oct. Four cubes painted/textured***
- ***08 Oct. Cubes shipped to vessel contractor CSI***
- ***08 Oct. Optical sensor calibration complete***
- ***11 Oct. Cubes deployed***
 - ***Bertram begins transit***
- ***12-13 Oct. NAVOCEANO MB/SSS collection***
- ***14 Oct. NOAA NRT-2 MB/SSS collection***
- ***14-16 Oct. CZMIL collection***
 - ***Optical profile collection***
 - ***Bottom and cube reflectance measured***
- ***16 Oct. target cubes recovered***



New NAVOCEANO 8 m³ cubes





Primed and Painted at NAVO



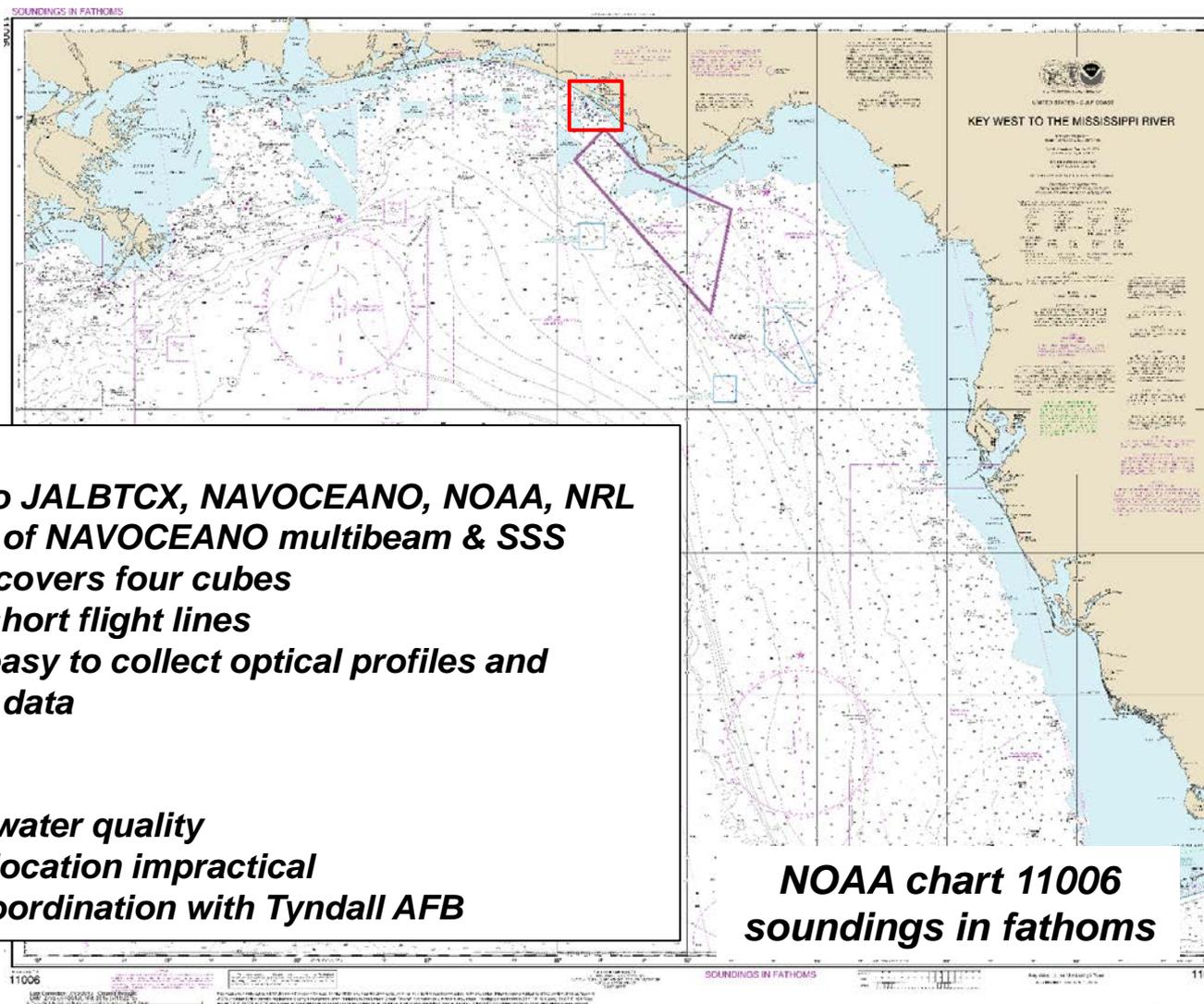


Existing NAVOCEANO 8 m³ Cubes





Location: Panama City, FL



Pros:

- Proximity to JALBTCX, NAVOCEANO, NOAA, NRL
- Availability of NAVOCEANO multibeam & SSS
- Single line covers four cubes
- Relatively short flight lines
- Relatively easy to collect optical profiles and reflectance data

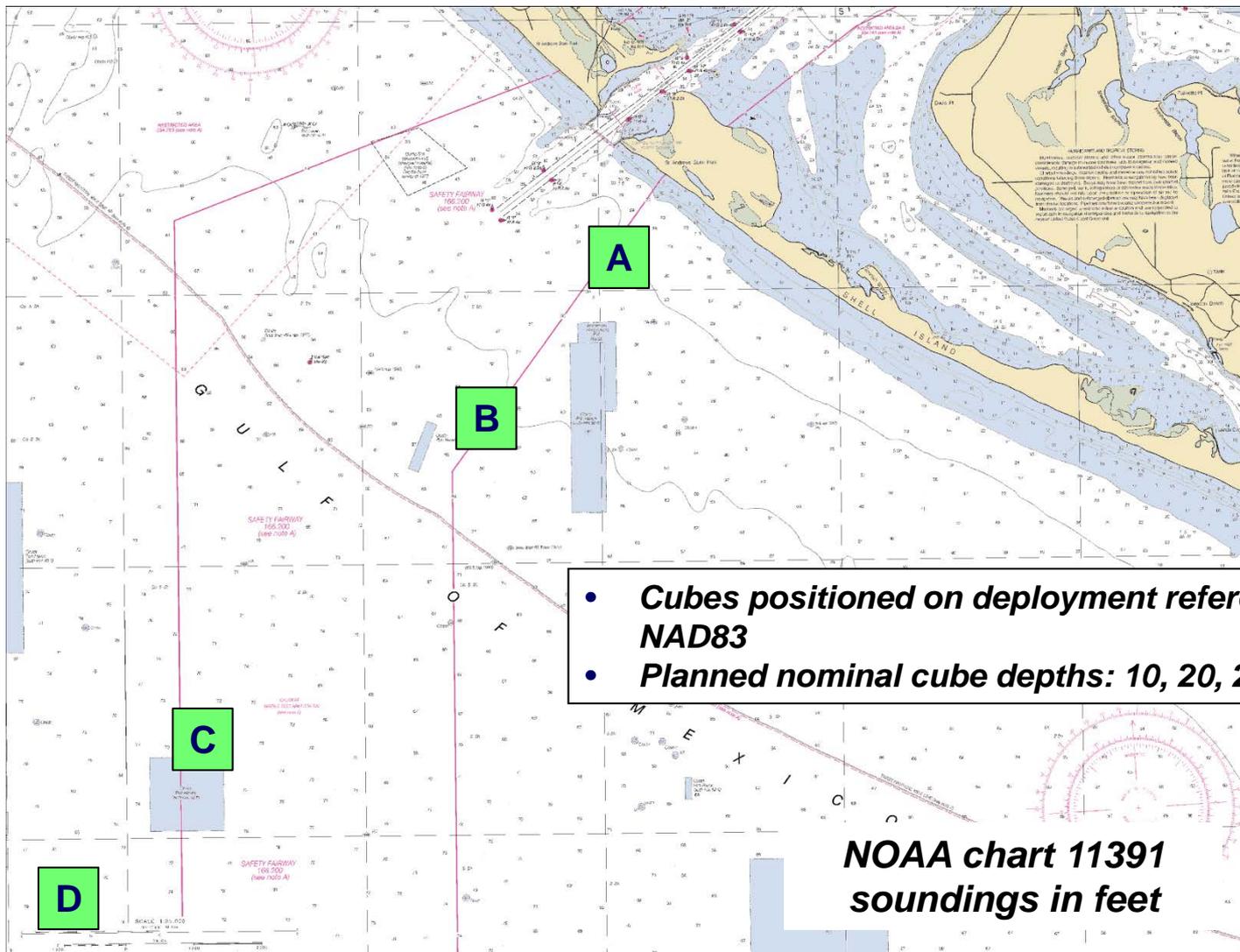
Cons:

- "Average" water quality
- 40 m cube location impractical
- Airspace coordination with Tyndall AFB

**NOAA chart 11006
soundings in fathoms**



Location: Panama City, FL





CZMIL Survey Plan: 5 flight lines

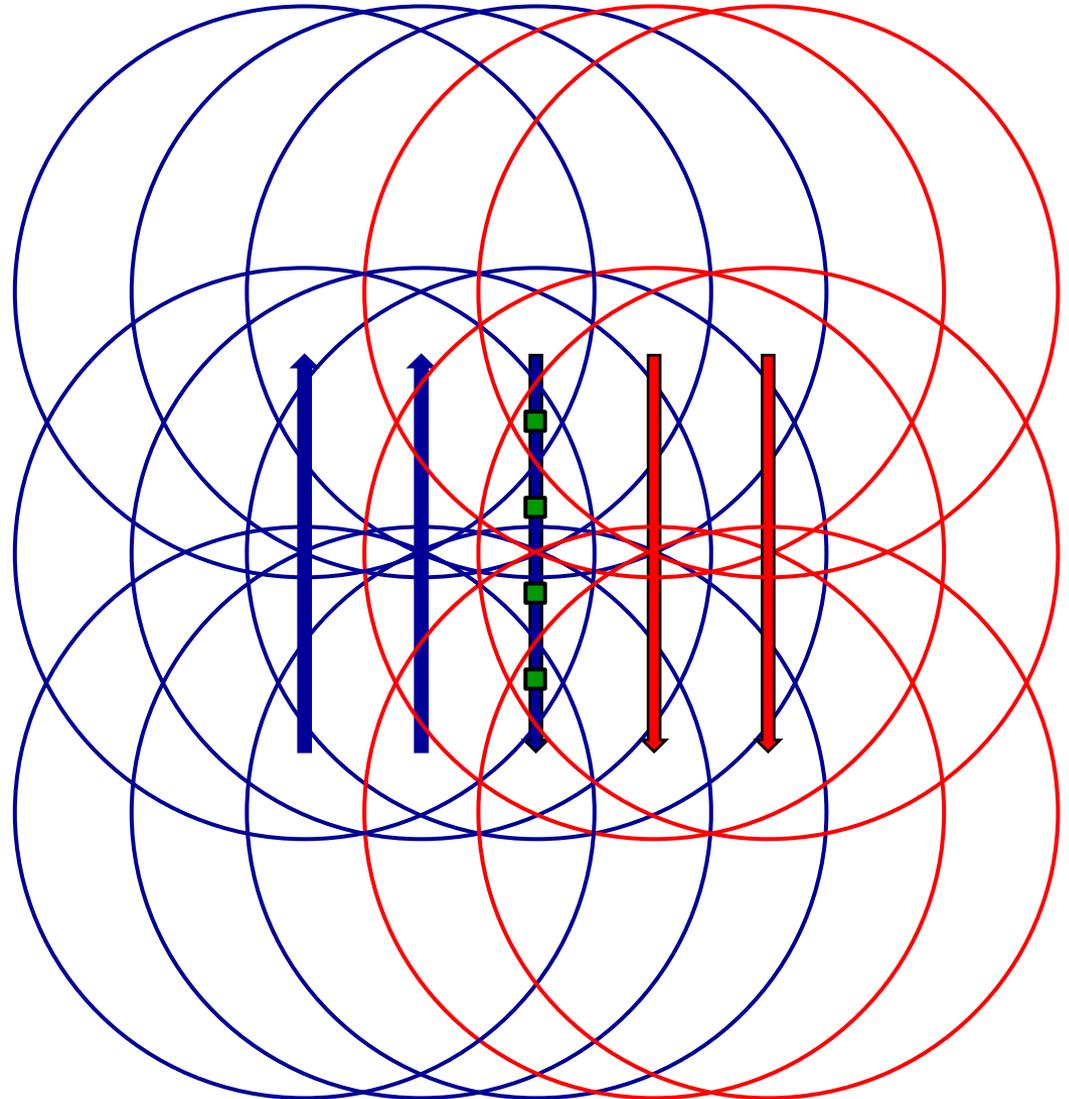


Optimal plan for each day:

- ***60 total lines***
- ***140 kts, 400 m / 1300 ft AGL***
- ***540 min / 9 hrs collection / day***

Planned collection

- ***~24 hrs / 3 survey days***
- ***increases number of detection attempts***
- ***varies environmental conditions***
- ***mitigates risk of inclement weather (for aircraft, dive and boat ops)***

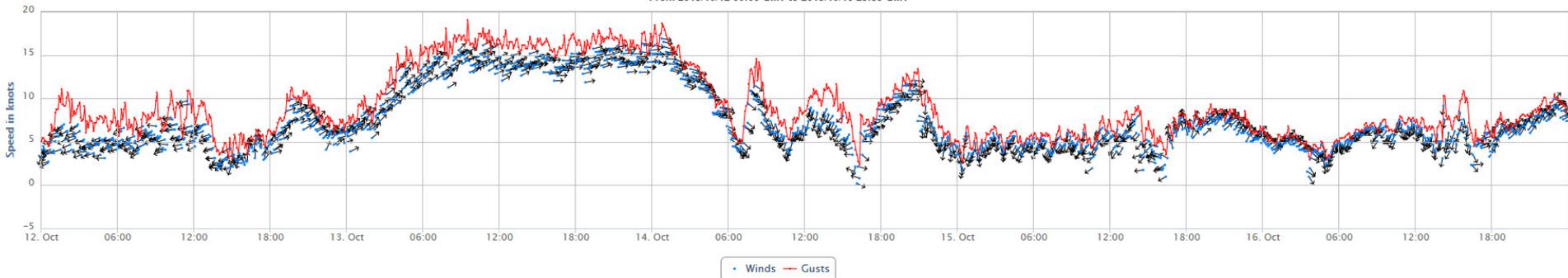




Weather and Water Levels

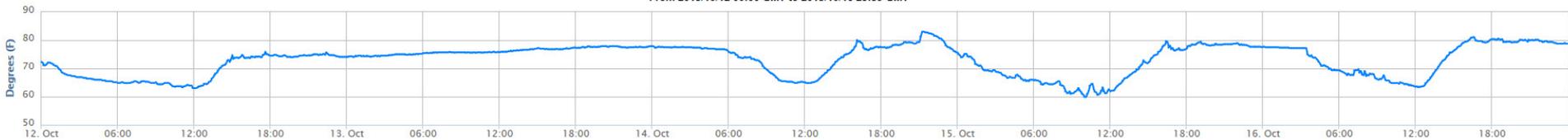


NOAA/NOS/CO-OPS
Winds at 8729210, Panama City Beach FL
From 2015/10/12 00:00 GMT to 2015/10/16 23:59 GMT

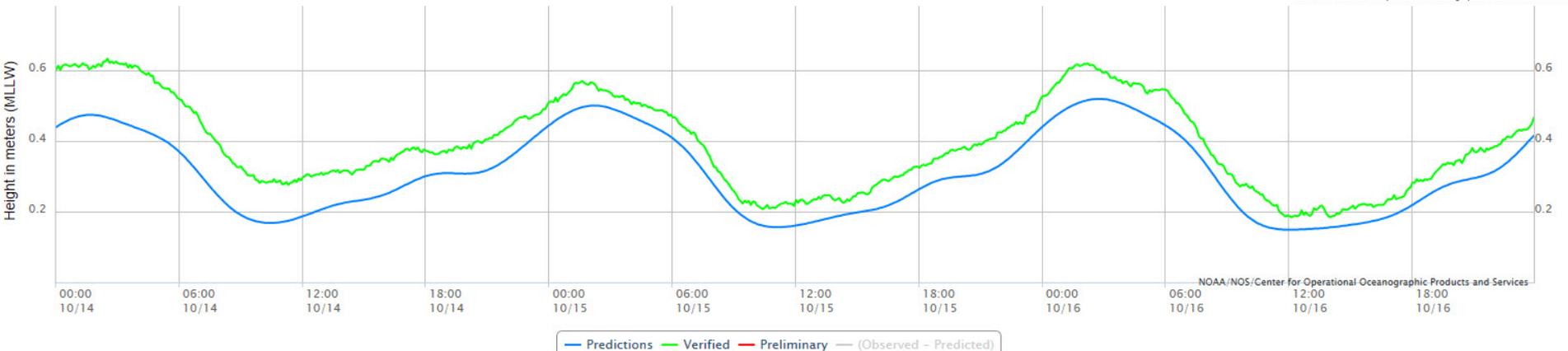


NOAA/NOS/Center for Operational Oceanographic Products and Services

NOAA/NOS/CO-OPS
Air Temperature at 8729210, Panama City Beach FL
From 2015/10/12 00:00 GMT to 2015/10/16 23:59 GMT



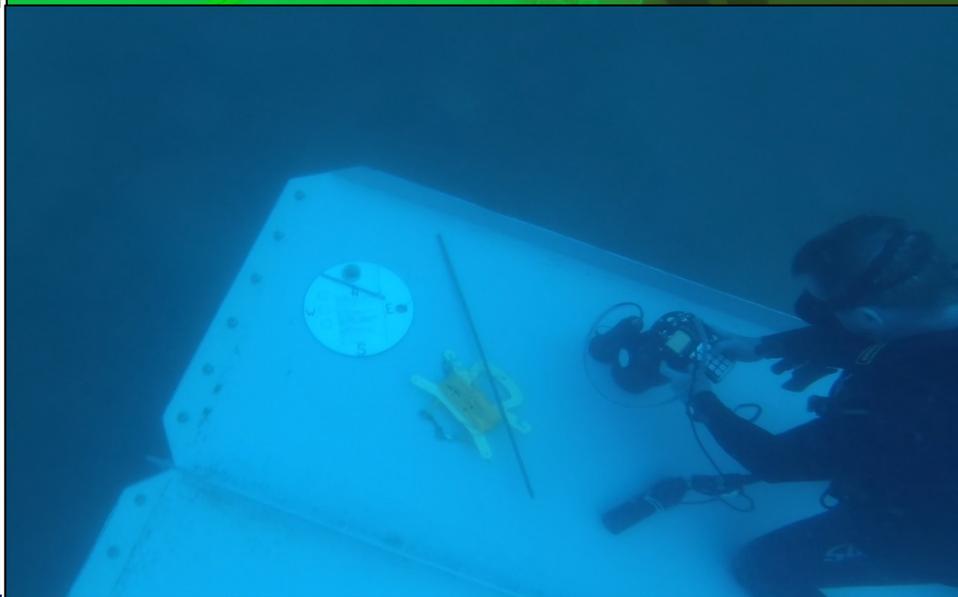
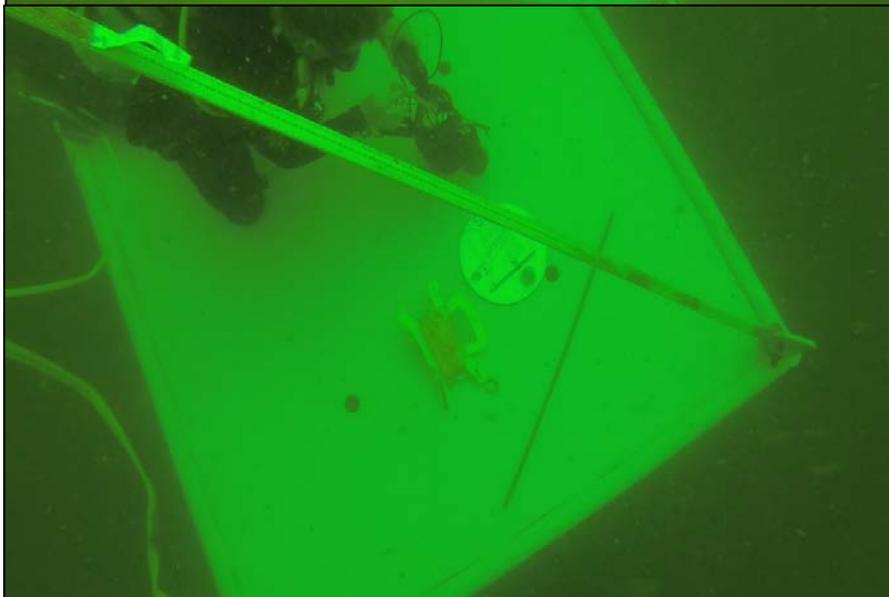
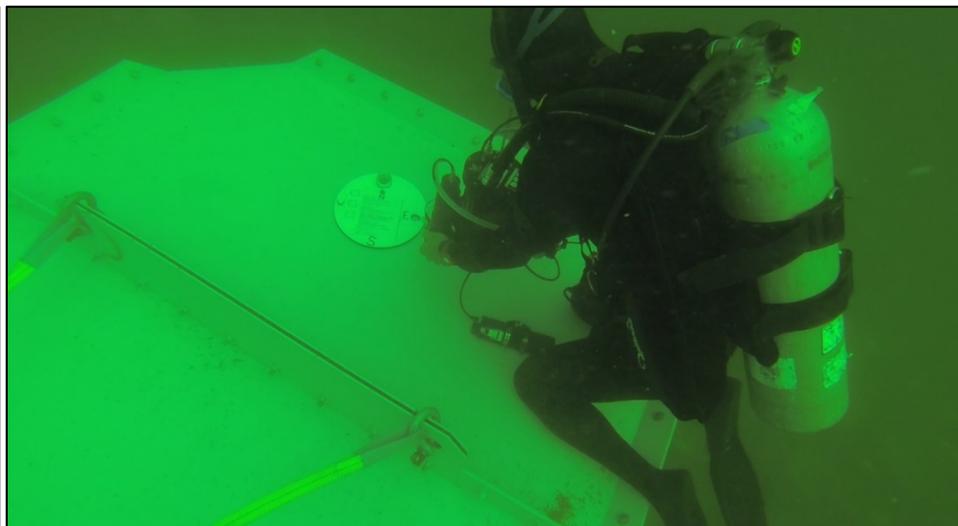
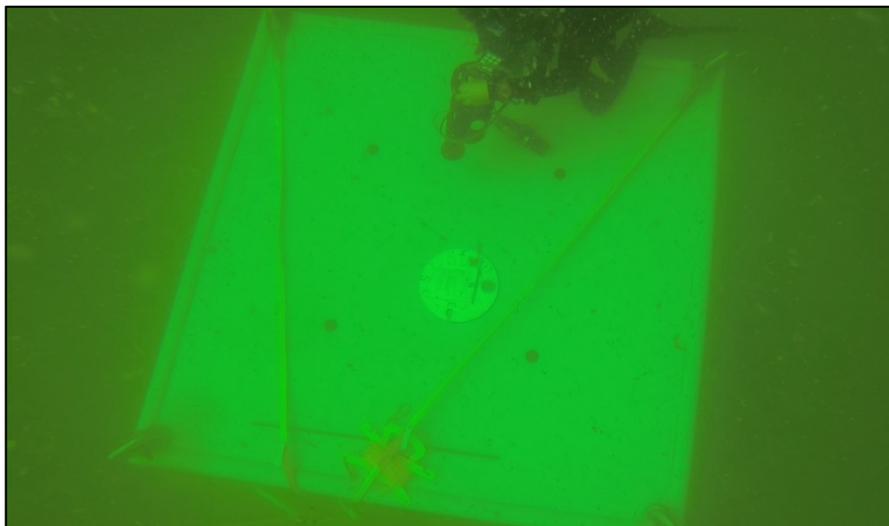
NOAA/NOS/Center for Operational Oceanographic Products and Services



NOAA/NOS/Center for Operational Oceanographic Products and Services



Navy Divers w/ DiveSpec





DiveSpec Data

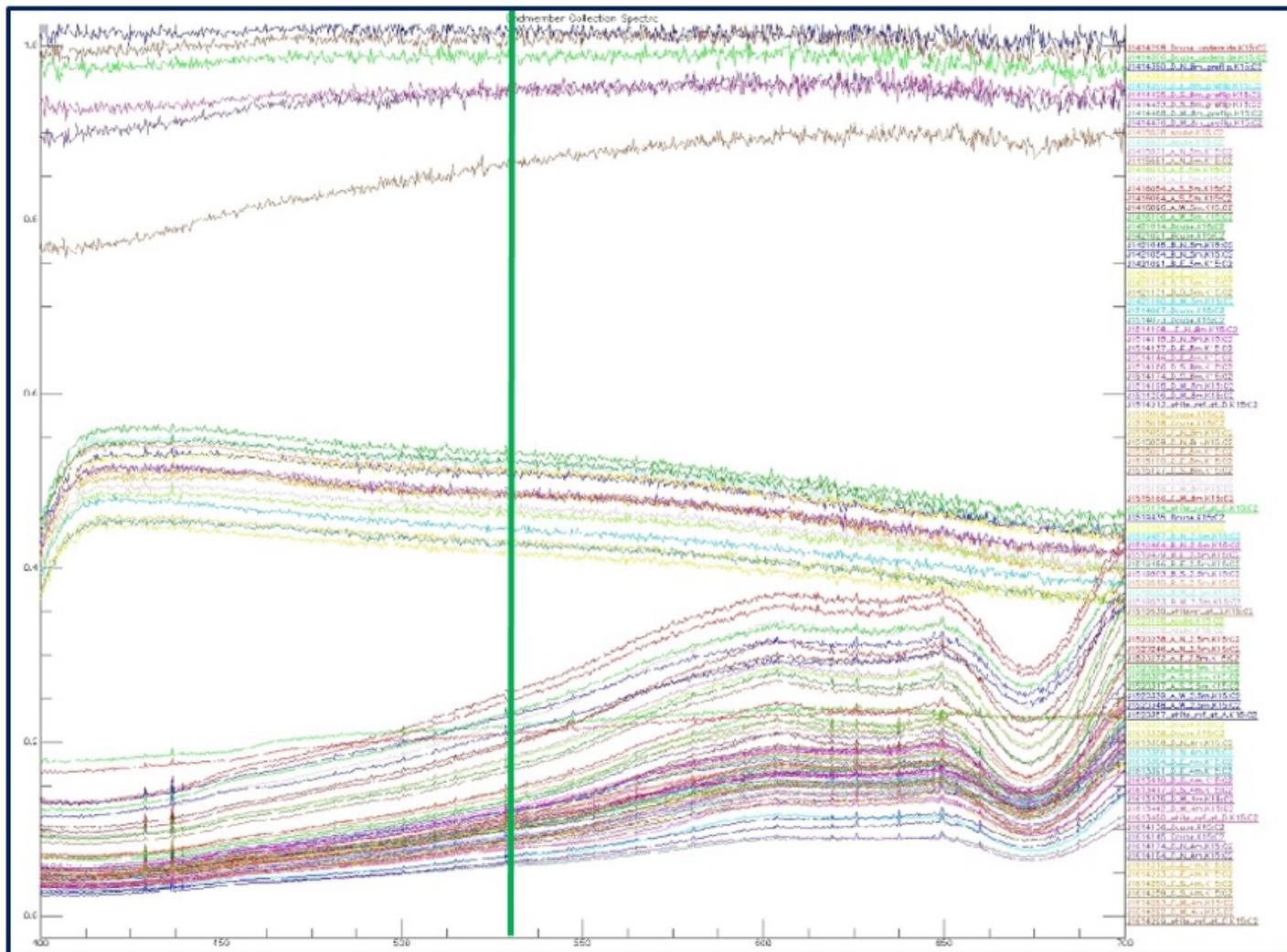


White References
Ideally ~1.0

Cube Spectra

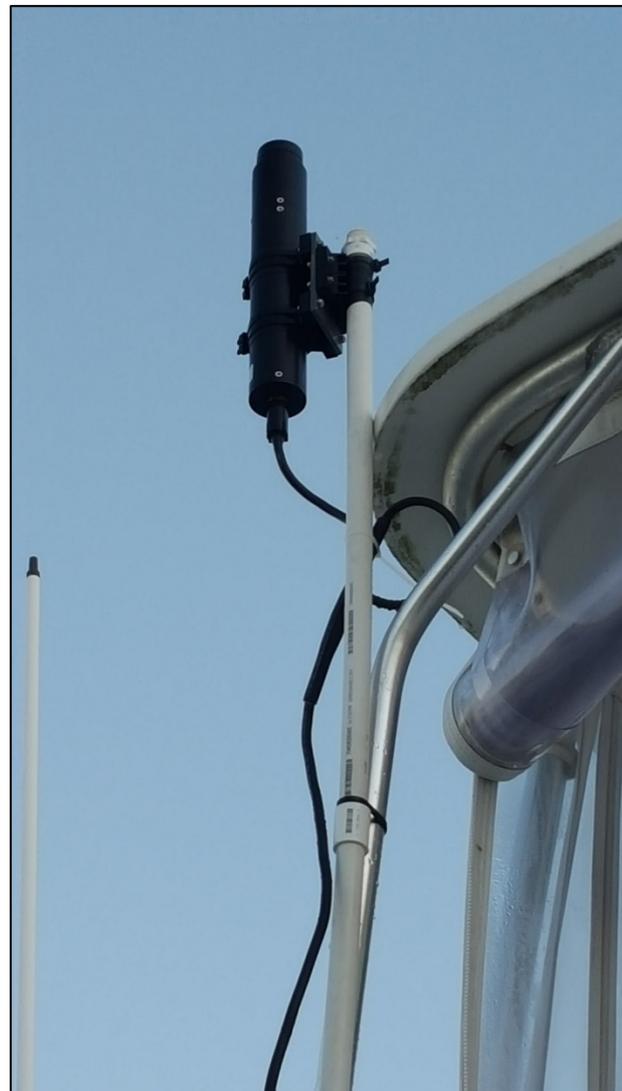
Underside of Cube D

Seafloor Spectra





HyperPro from NAVO Bertram



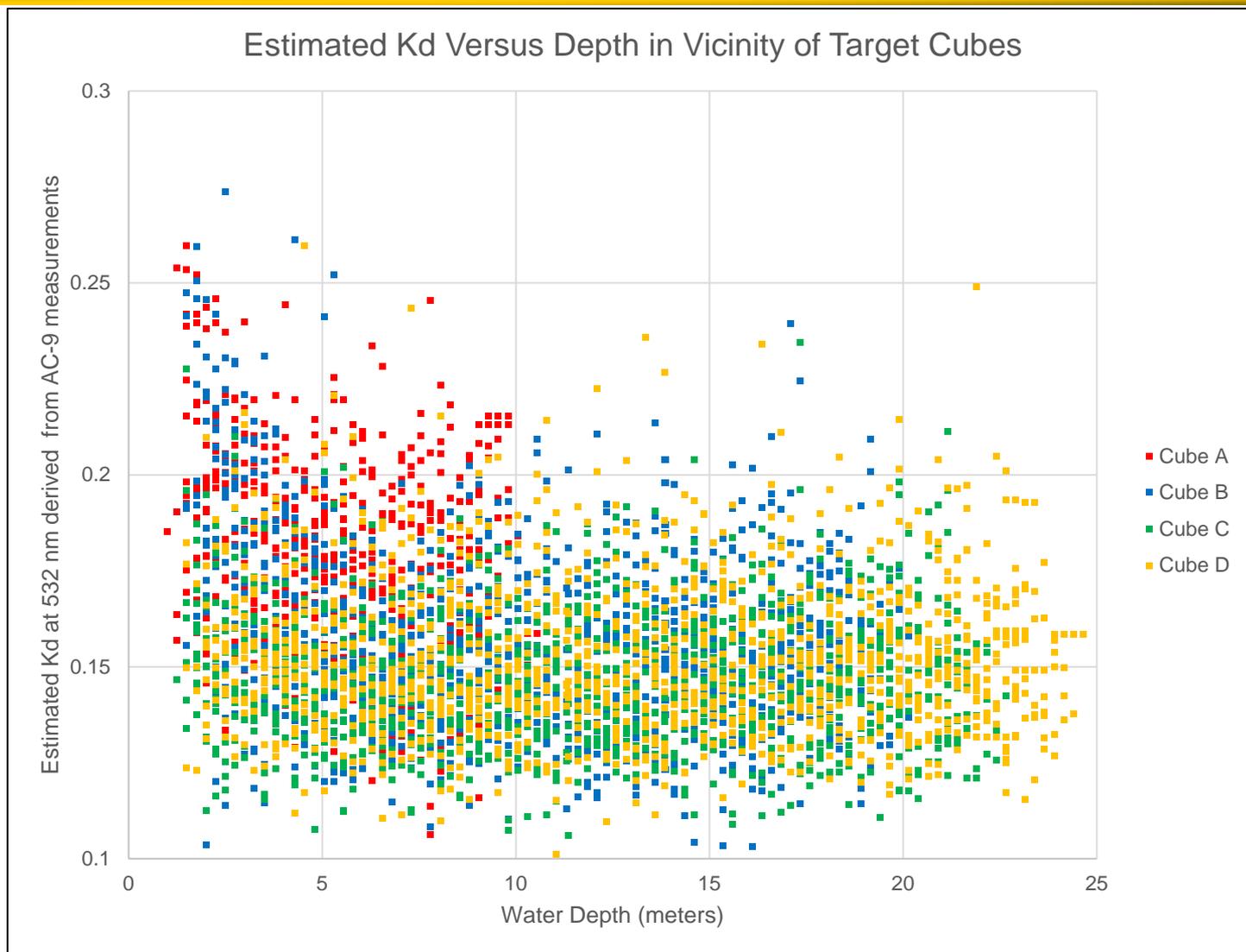


AC-9 from NAVO Bertram



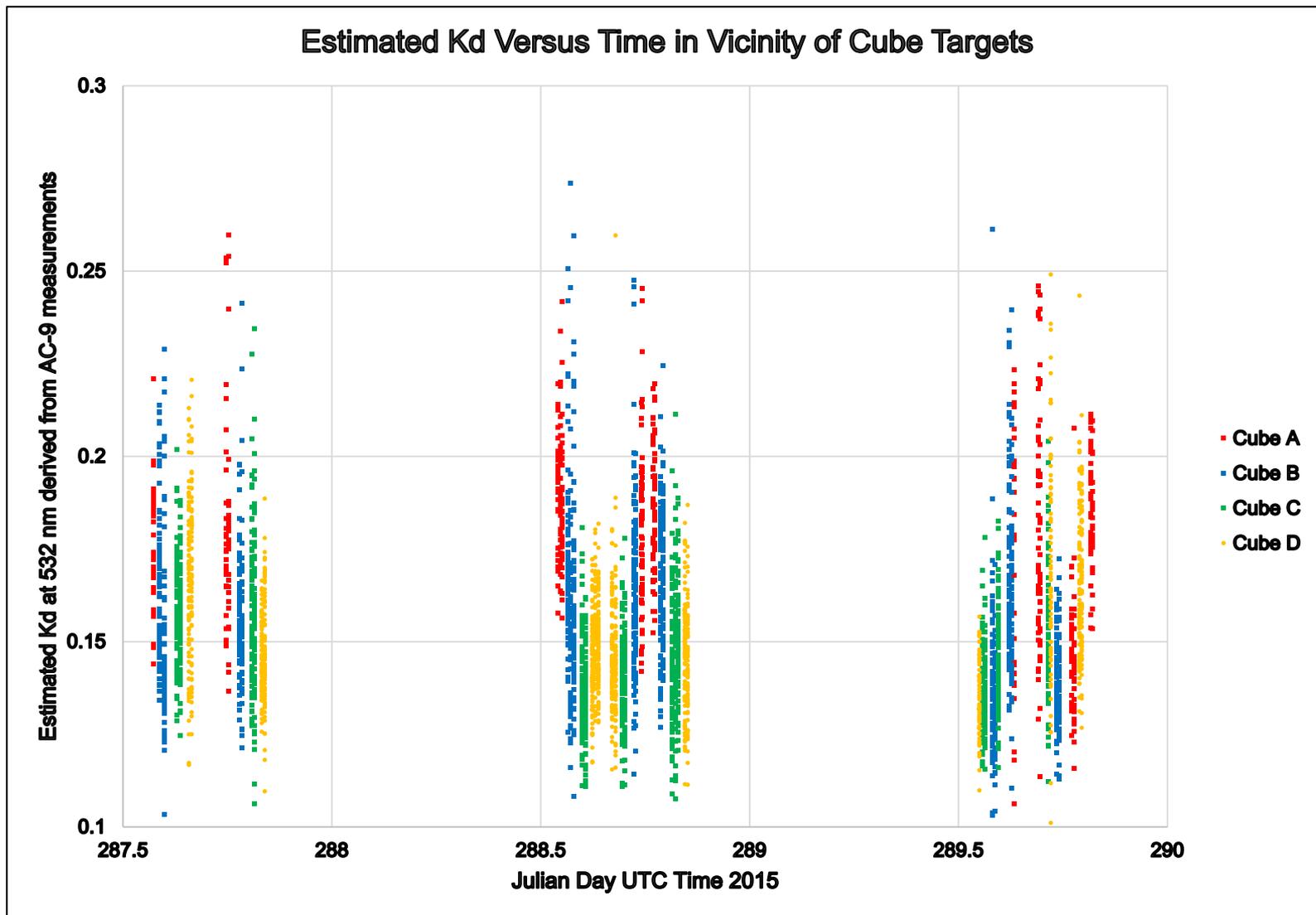


Approximate K_d 532



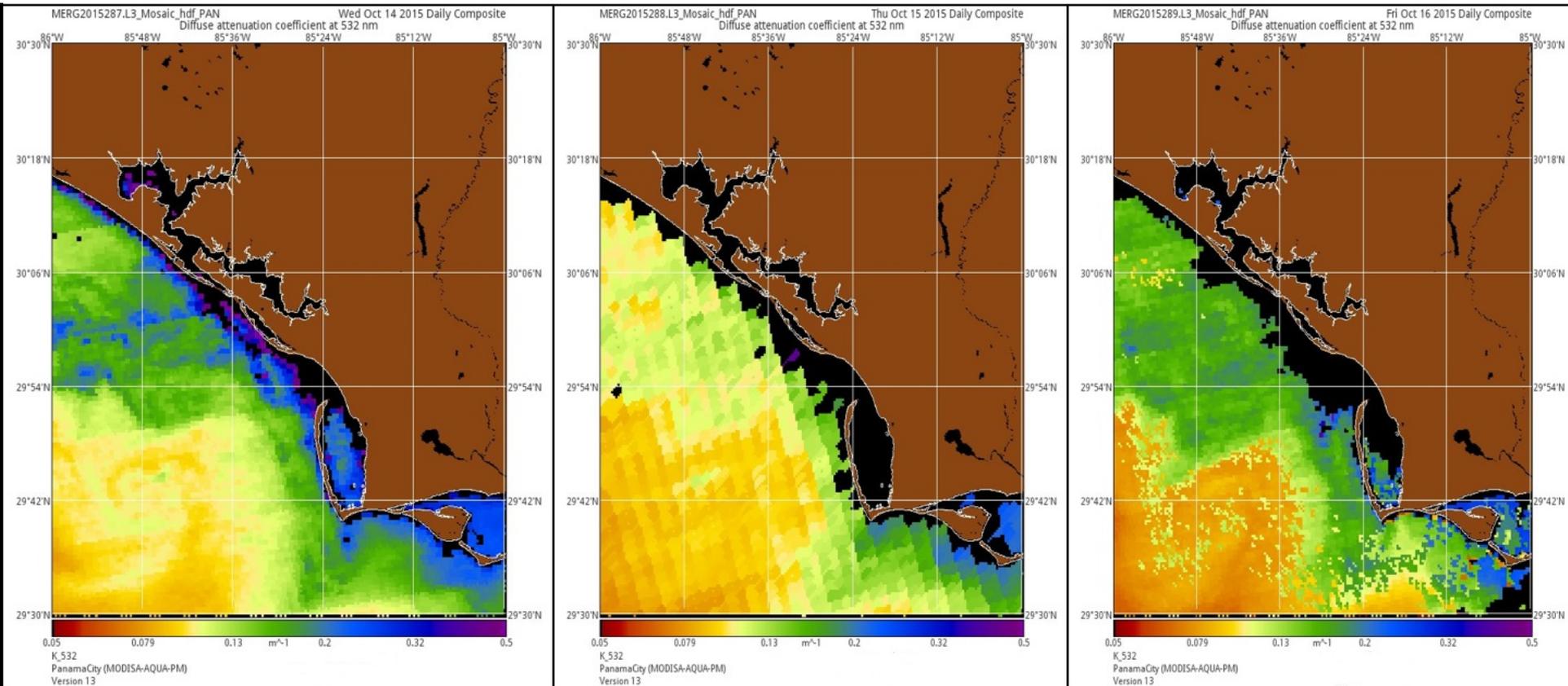


Approximate Kd 532





MODIS derived $K_d 532$





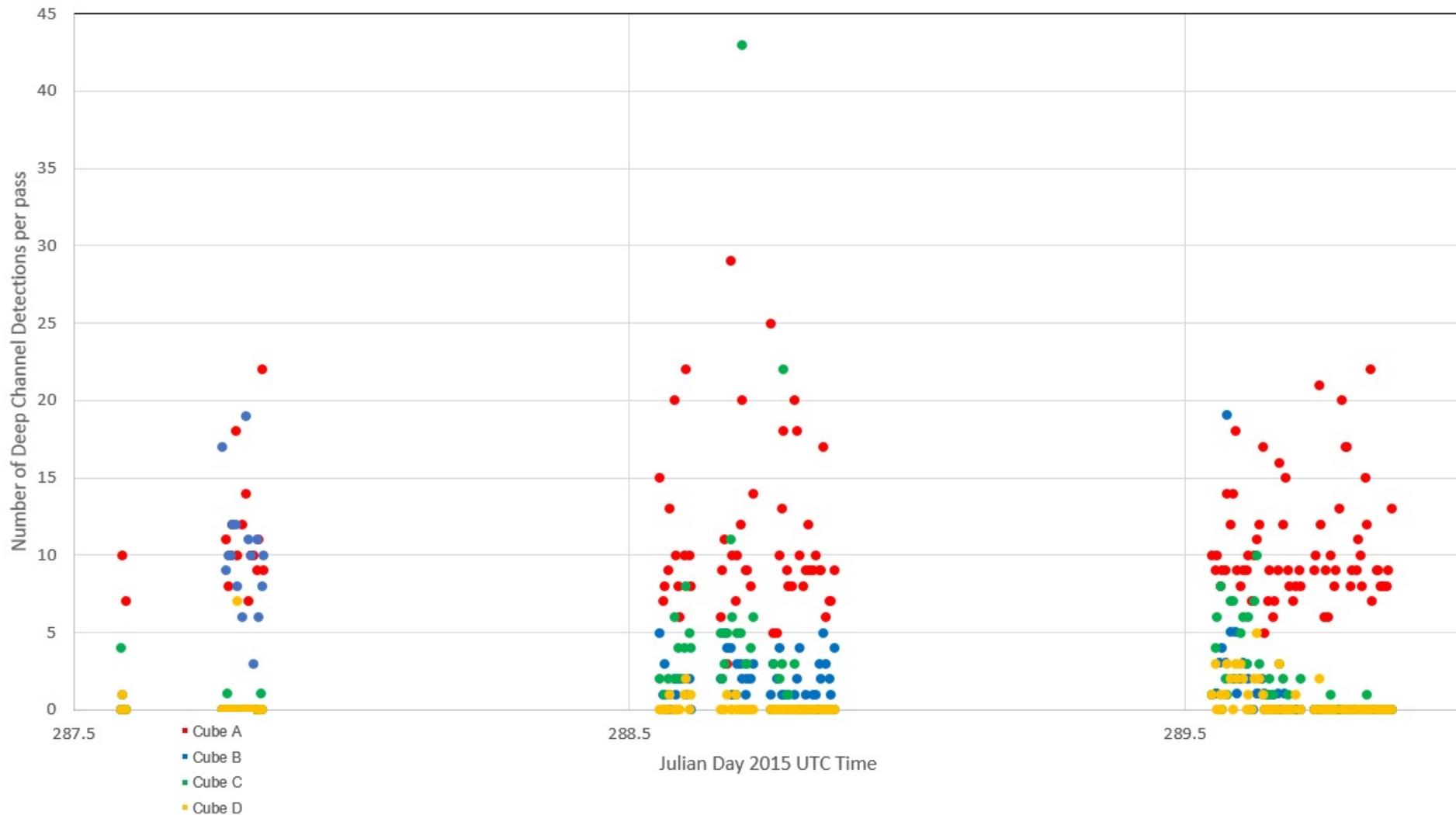
Observed Results- Shallow Channels

	14-Oct	15-Oct	16-Oct	Combined Avg
CUBE A	100.00%	100.00%	100.00%	100.00%
CUBE B	0.00%	0.00%	0.00%	0.00%
CUBE C	0.00%	0.00%	0.00%	0.00%
CUBE D	0.00%	0.00%	0.00%	0.00%

avg # of shallow channel points/overflight when detected				
	14-Oct	15-Oct	16-Oct	Combined Avg
CUBE A	13.88235	15.98077	18.0303	16.71851852



Observed Results- Deep Channel





Observed Results- Deep Channel



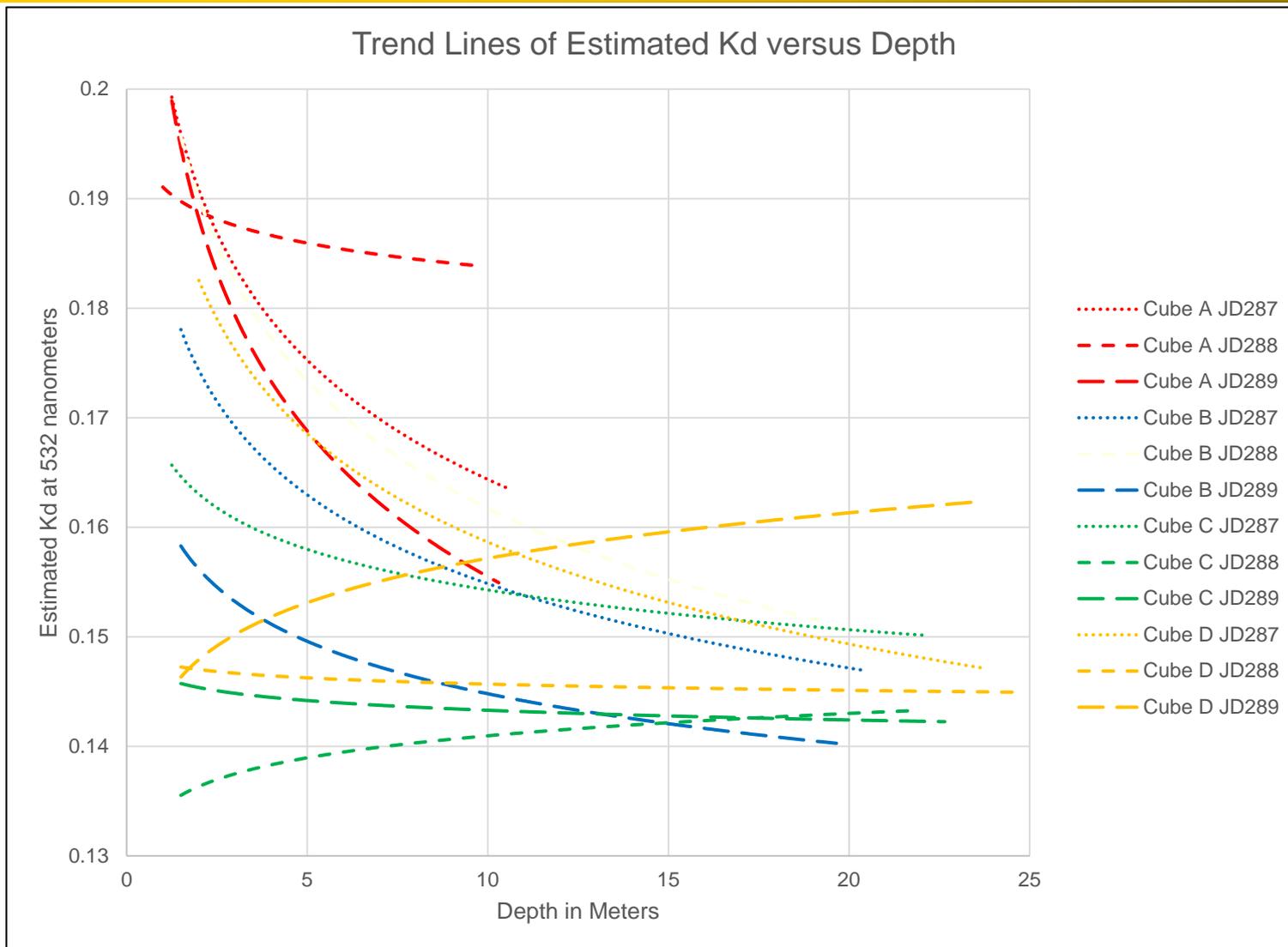
	14-Oct	15-Oct	16-Oct	Combined Avg
CUBE A	100.00%	100.00%	100.00%	100.00%
CUBE B	94.44%	86.54%	37.10%	64.39%
CUBE C	15.79%	62.26%	40.91%	45.65%
CUBE D	11.76%	11.32%	27.69%	19.26%

avg # of deep channel points per overflight- only when detected				
	14-Oct	15-Oct	16-Oct	Combined Average
CUBE A	11.2	11.0	10.5	10.8
CUBE B	9.6	2.2	2.8	3.8
CUBE C	2.0	5.5	3.5	4.5
CUBE D	4.0	1.2	2.1	2.0

Surrounding seafloor was often not imaged to Order 1 density standards, let alone Order 1a target detection! Recall that target cubes were brighter than seafloor.



Kd Trend lines in space/time

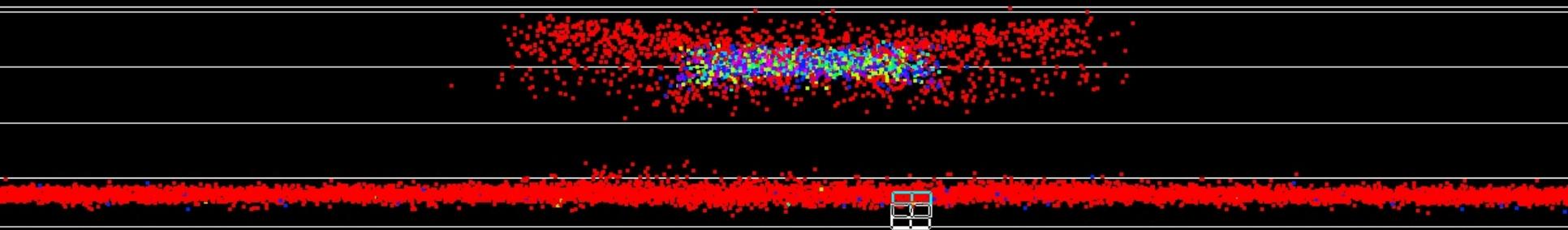




Potential Future Work



- ***Further explore vertical/horizontal uncertainty and/or CZMIL calibration refinement from deep and shallow channel responses on cube targets***



Slice view of CZMIL points through shallowest cube, multiple passes

Red points are deep channel and other colors are shallow channels

White lines represent 1 meter vertical separation. VE=1.0



Potential Future Work



- ***Test model and outputs against results once POD is implemented in HydroFusion!***
- ***Attempt to better correlate responses with variables other than depth and water clarity (e.g. model position of cube in beam footprint, sea state, sun glint, etc.)***
- ***Low false alarm rate: experiment with detection thresholds in processing algorithms?***
- ***Repeat similar test in clearer waters to at least 40 m deep with targets having lower reflectance more similar to surrounding seafloor (NAVO diver measurements not likely at 40m though)***
- ***Add 1m³ targets to future experiment?***
- ***Test with different laser, and/or improved optical filter coatings***