

# Monitoring Water Quality Around Key West: Q2 Progress Report

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THE  
COLLEGE  
OF THE  
FLORIDA KEYS



**FIU**  
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# **3<sup>rd</sup> EPA Grant: Chemicals of Emerging Concern (CECs) in Areas of Concern (AOC)**

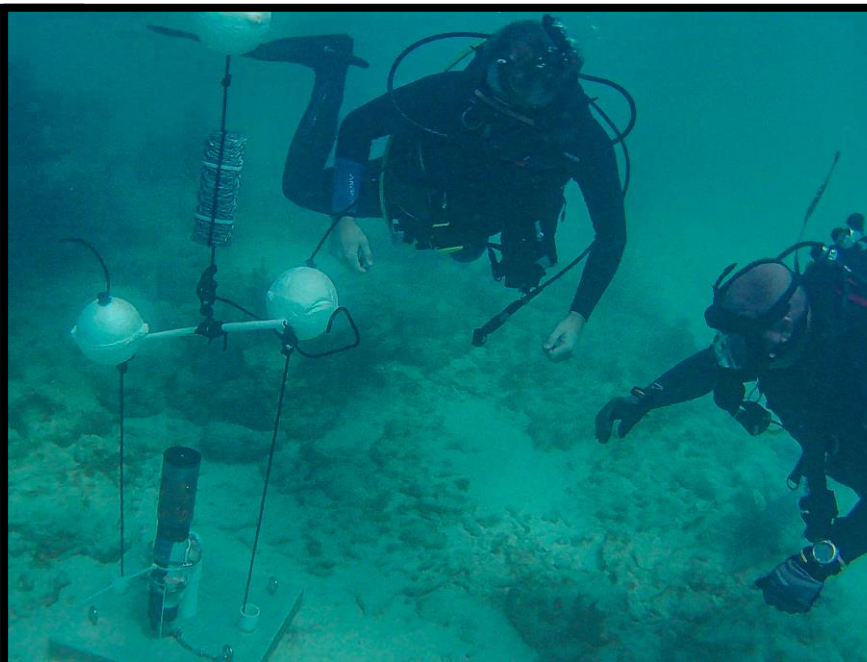
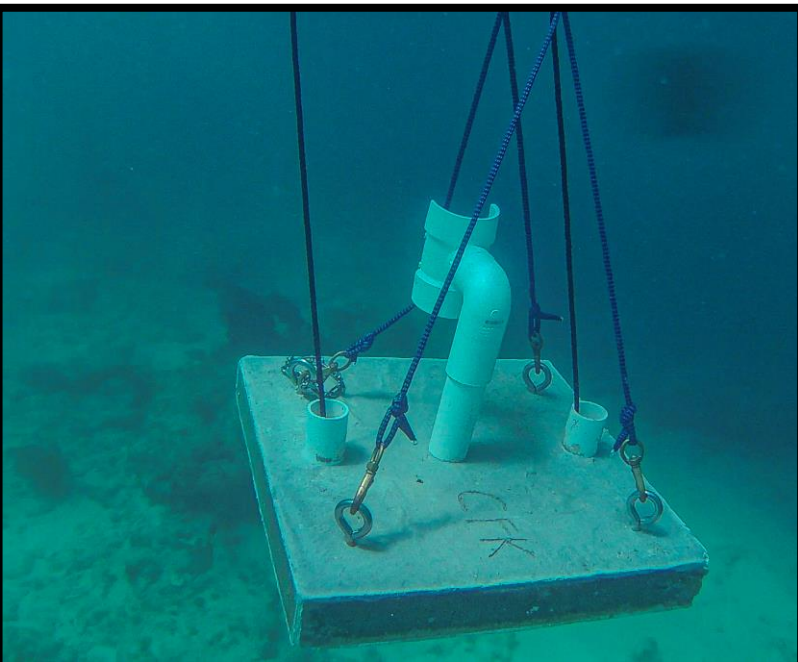
## ***Objectives***

- 1. Continue water quality monitoring in the Key West harbor and ship channel using existing technology and infrastructure.**
- 2. Expand water quality monitoring to eight AOC around the islands of Key West using an Autonomous Underwater Vehicle equipped with sensors for dissolved oxygen, temperature, salinity, turbidity, and total algae.**
- 3. Expand water quality monitoring to beach AOC around the southern section of Key West for oxybenzone in the marine food chain.**
- 4. Expand water quality monitoring to seven AOC around the islands of Key West for sewage discharge indicators (i.e. ammonia and sucralose).**
- 5. Expand water quality monitoring to marine environment near Stock Island Landfill for toxic pollutants (i.e. hydrogen sulfide).**
- 6. Provide data and input for the City of Key West's Water Quality Improvement Plan.**



# *Objective 1*

**Continue water quality monitoring in the Key West harbor and ship channel using existing technology and infrastructure.**





# Mallory Square TK System

YSI EXO Water Quality Data Sonde



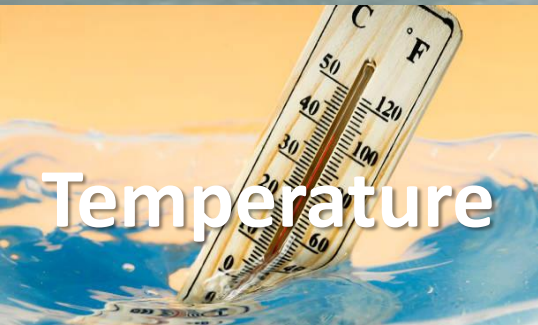
TK Data Logger System

Sea Level

Surface EXO data sonde w/ sensors

Power & Sensor cables

Temperature



Salinity



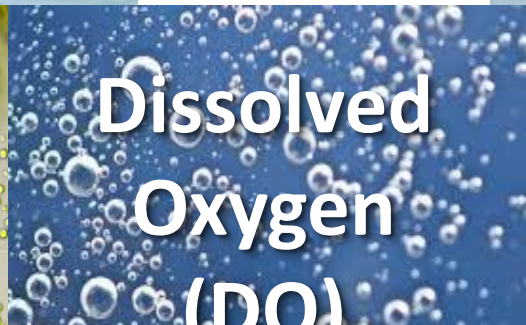
ty



Total Algae



Dissolved Oxygen (DO)



# Mallory Square TK System: Dissolved Oxygen Deep sonde (20 m)

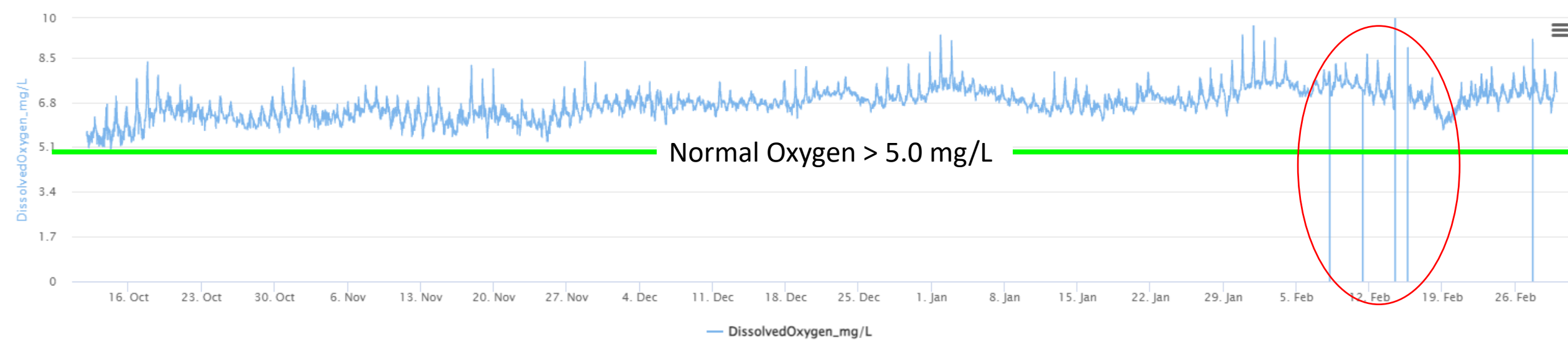
Mallory Square

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Y-axis scaling      
Min Max



# Mallory Square TK System: Temperature Deep sonde (20 m)

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10/12/2023 - 02/29/2024

Y-axis scaling

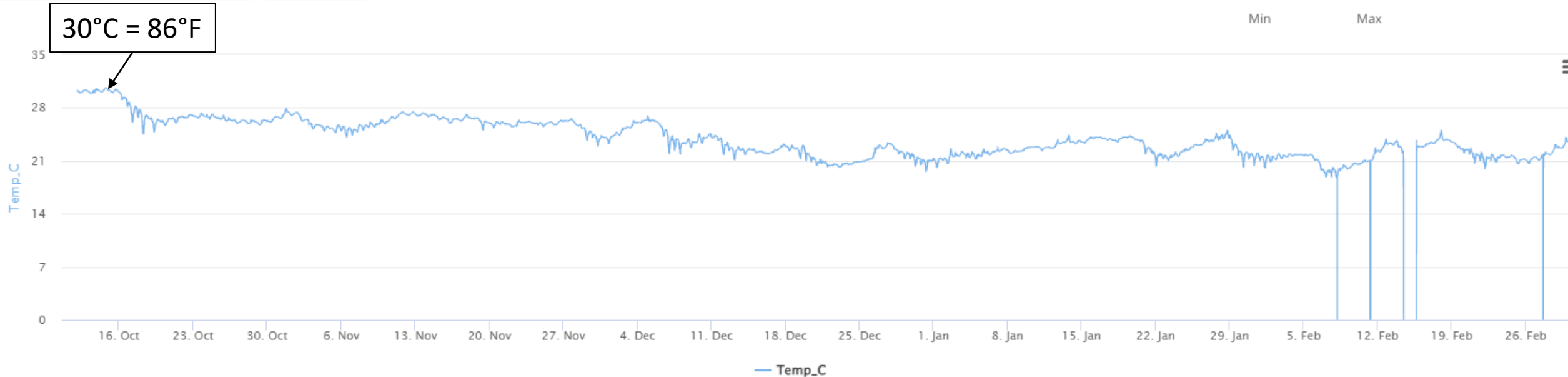
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35

Clear

Min

Max



# Mallory Square TK System: Conductivity (i.e. salinity) Deep sonde (20 m)

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Y-axis scaling

0

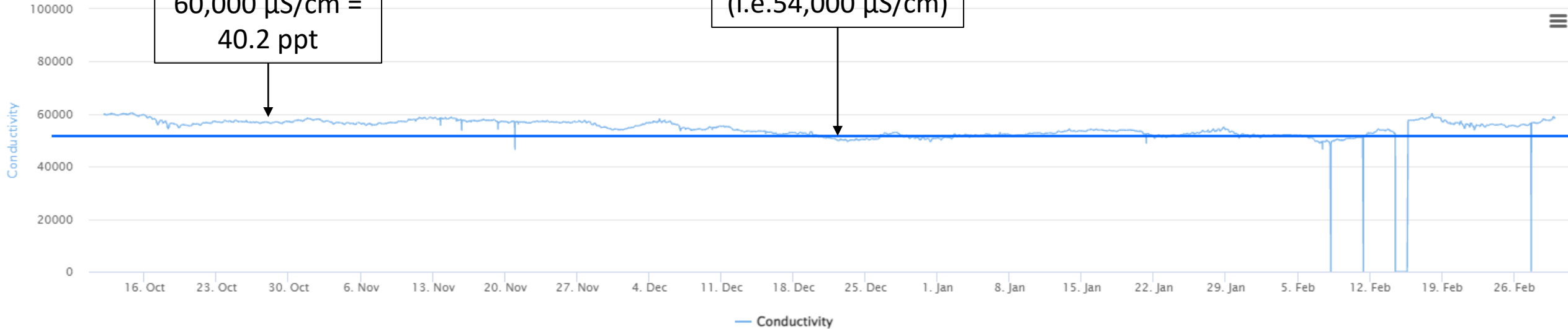
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X

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Max

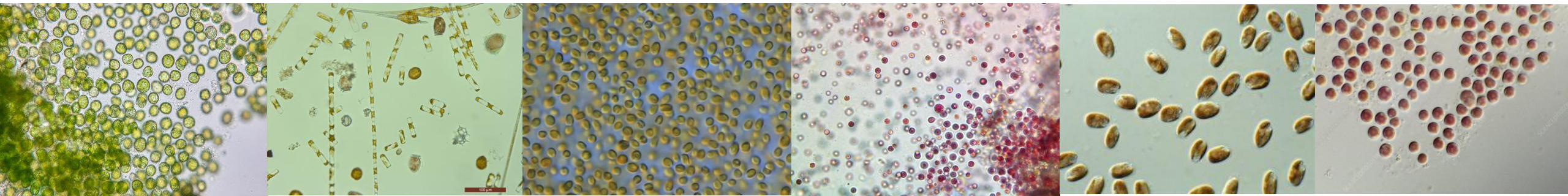




# Mallory Square TK System: Total Algae Sensor - Phycoerythrin and Chlorophyll Deep sonde (20 m)

This optical sensor uses a beam of light and measures the reflection from pigments found in marine algae.

1. Chlorophyll - pigments found in green algae (Chlorophyll a and b), diatoms (Chlorophyll a and c), golden brown algae (Chlorophyll a and c)
2. Phycoerythrin (PE) - pigment-protein complex predominantly found in rhodophytes (red algae), cryptophytes, and cyanobacteria



Chlorophyta  
(Green algae)

Diatoms

Chrysophyta  
(Golden-brown algae)

Rhodophytes  
(Red algae)

Cryptophytes

Cyanobacteria



# Mallory Square TK System: Total Algae Deep sonde (20 m)

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**Chart View**

Table View

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10/12/2023 - 04/04/2024

Y-axis scaling

0

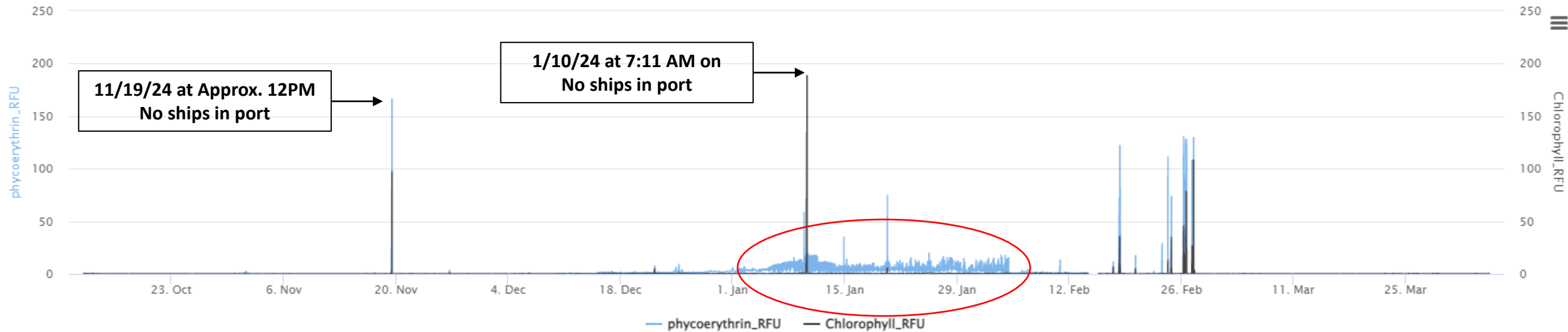
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Clear

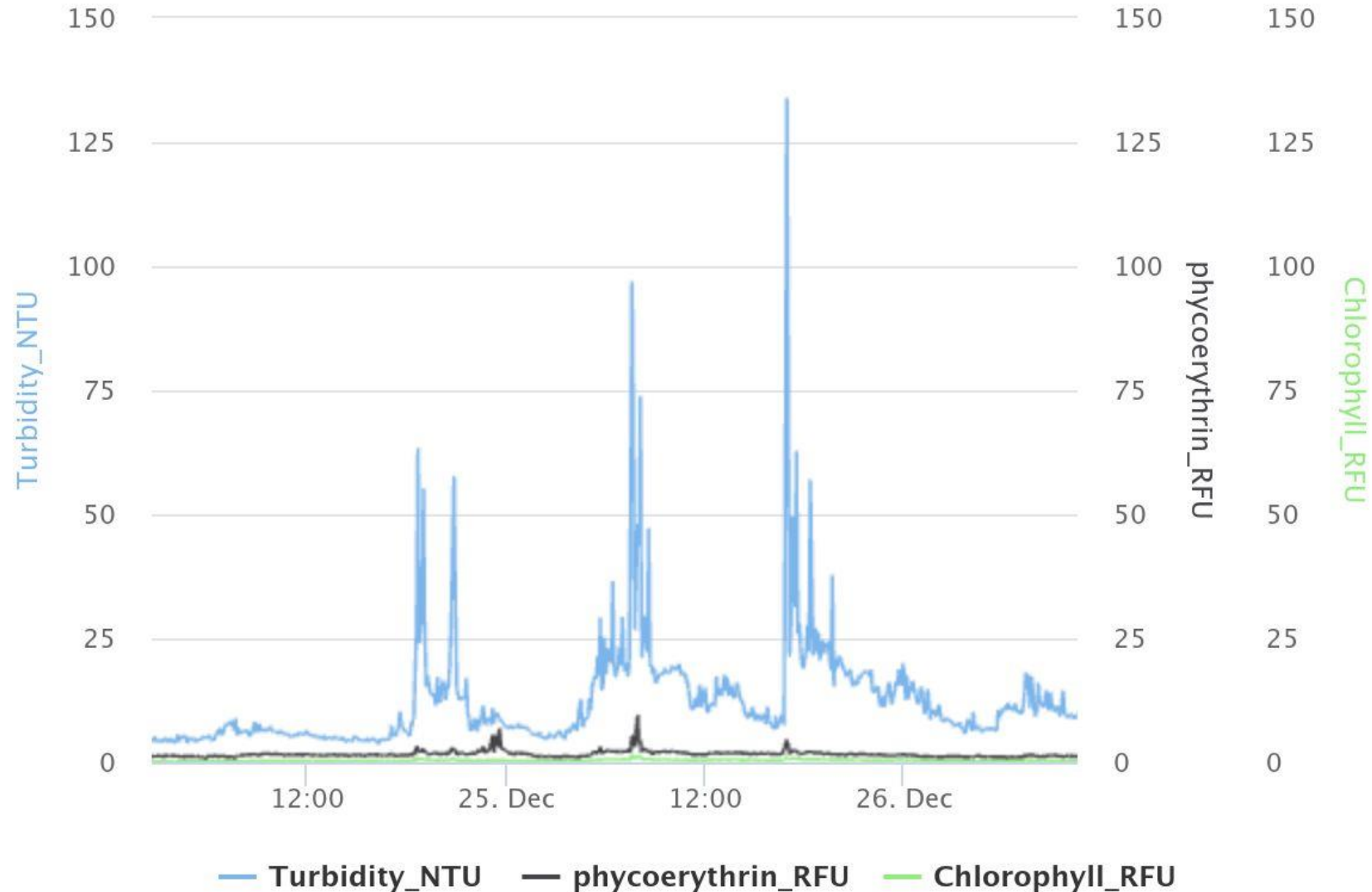
✕

Min

Max



# Mallory Square TK System: Total Algae Deep sonde (20 m)



# Cruise ship data in the Key West Harbor

- ❑ 132 ships have visited KW Harbor since Oct. 12, 2023
- ❑ Cruise ships range in size (i.e. capacity) from:
  - Smallest - American Glory (Capacity = 49 Passengers)
  - Largest - Carnival Dream (Capacity = 3,646)
- ❑ Data collected on:
  - Capacity
  - Arrival/Departure time
  - Ambient water quality at arrival/departure
  - Wind direction
  - Wind speed

- ❑ Turbidity events associated with cruise ships exceeded EPA standards 19.4% of the time (EPA Chapter 62-302: Water Quality Standards)
- ❑ The most substantial turbidity event was 430% beyond the EPA standards (i.e. 133.94 NTU)



**Carnival Dream in Key West Harbor**



# 2023 (Oct. - Dec.)

Table 2. Cruise ship data for Key West Harbor (2023)

	Date	Vessel Name	Capacity	Arrival	Deep Turbidity (NTU)	Shallow Turbidity (NTU)	Wind Direction (Arrival)	Wind Speed (mph)	Departure	Deep Turbidity (NTU)	Shallow Turbidity (NTU)	Wind Direction (Departure)	Wind Speed (mph)	Departure Direction	Comments
October 2023	10/17/2023	Manilla Discover	1,576	9:00 AM					6:00 PM						(1) Scheduled arrival and depart times; (2) no video clip
	10/17/2023	Carnival Glory	3,581	9:00 AM					5:00 PM						(1) Scheduled arrival and depart times; (2) no video clip
	10/19/2023	Scarlet Lady	2,860	9:00 AM					5:00 PM						(1) Scheduled arrival and depart times; (2) no video clip
	10/21/2023	Carnival Dream	3,646	11:00 AM					7:00 PM						(1) Scheduled arrival and depart times; (2) no video clip
	10/24/2023	Carnival Conquest	3,581	7:30 AM	4.34	2.28	NE	10	1:30 PM	2.15	3.15	E	13	Forward	(1) Departs late ~ 2:30 PM; (2) haze turbidity plume (see video clip); (3) Arrival guests up to 21 mph, Departure guests up to 23 mph; (4) Shallow Sonde records -99.9 at 1:11 pm
	10/26/2023	Norwegian Sky	2,004	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	(1) No show; (2) video clip with comments
	10/27/2023	MS Eurova	408	9:31 AM	4.76	4.76	NE	10	4:31 PM	3.77	3.12	NE	10	NA	(1) Actual departure times from video clip with comments; (2) Arrival guests up to 23 mph, Departure guests up to 25 mph; (3) Shallow Sonde records -99.9 at 4:11 am
	10/29/2023	Wakarusa	930	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	(1) No video clip
	10/30/2023	Radiance of the Sea	2,946	7:16 AM	1.56	2.46	VAR	7	8:52 PM	19.23	13.85	N	7	Reverse	(1) Actual arrival and departure times from video clips with comments; (2) No Arrival guests, No Departure guests; (3) Shallow Sonde records -99.9 at 12:06 am, 9:36 am, and 9:31 pm
	10/31/2023	Carnival Paradise	2,668	11:21 AM	0.99	0.98	VAR	6	5:55 PM	1.26	2.00	N	9	NA	(1) Arrival based on observation; (2) departure based on video clip; (3) No Arrival guests, No Departure guests
November 2023	11/2/2023	Scarlet Lady	2,860	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	(1) No show due to gulf force winds
	11/3/2023	Main Staff 6	2,700	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	(1) No show due to gulf force winds
	11/4/2023	MSC Explora 1	1,473	7:39 AM	1.95	2.65	NNE	14	5:38 PM	4.48	4.43	SNE	9	-	(1) Arrival based on observation; (2) departure based on video clip; (3) Arrival guests up to 24 mph, No Departure guests; (4) Shallow Sonde records -99.9 at 7:26 am
	11/5/2023	Hamburg	450	8:49 AM	1.20	2.31	N	10	5:58 PM	1.68	2.20	N	8	Forward	(1) Actual arrival and departure times from video clips with comments; (2) No Arrival guests, No Departure guests; (3) Shallow Sonde records -99.9 at 1:01 am and 12:21 am
	11/6/2023	Carnival Dream	3,646	10:31 AM	1.22	2.05	NNE	13	6:49 PM	1.19	1.80	N	7	-	(1) Actual arrival and departure times from video clips with comments; (2) Arrival guests up to 22 mph, No Departure guests; (3) Shallow Sonde records -99.9 at 5:51 am
	11/7/2023	Carnival Conquest	3,581	7:19 AM	7.78	1.83	NNE	7	1:37 PM	3.28	2.32	SNE	12	Reverse	(1) Reverse departure; (2) Arrival/Departure based on video clips w/comments; (3) No Arrival guests, No Departure guests; (4) Shallow Sonde records -99.9 at 12:46 am, 9:46 am, 10:11 am, 11:11 am
	11/9/2023	Arctura	1,260	7:36 AM	0.80	1.92	ESE	8	5:43 PM	2.03	4.39	E	13	Reverse	(1) Reverse departure; (2) Arrival/Departure based on video clips w/comments; (3) No Arrival guests, No Departure guests; (4) Shallow Sonde records -99.9 at 11:21 am
	11/13/2023	MS Eurova	516	9:20 AM	3.21	3.84	NE	12	4:20 PM	1.61	2.53	NE	12	-	(1) Actual arrival and departure times from video clips with comments; (2) No Arrival guests, No Departure guests; (3) Shallow Sonde records -99.9 at 12:46 am, 9:46 am, 10:11 am, 11:11 am
	11/16/2023	Scarlet Lady	2,860	7:40 AM	11.03	11.59	NNE	5	5:00 PM	19.87	3.38	N	5	NA	(1) Arrival based on video clip; (2) departure based on schedule; (3) No Arrival guests, No Departure guests
	11/17/2023	Calabria Sibonarte	3,463	8:00 AM	11.58	20.21	CALM	0	5:00 PM	14.33	10.43	W	8	NA	(1) Scheduled arrival and depart times; (2) no video clip due to power outage; (3) No Arrival guests, No Departure guests; (4) Shallow Sonde records -99.9 at 12:01 pm, 3:40 pm, and 6:31 pm; (5) 7:40 am time used for arrival
	11/18/2023	MSC Explora 1	1,473	7:33 AM	1.76	3.34	NNW	15	5:00 PM	2.92	4.18	NNW	16	NA	(1) Arrival based on video clip; (2) departure based on schedule; (3) Arrival guests up to 28 mph, Departure guests up to 23 mph; (4) Shallow Sonde records -99.9 at 12:31 am, 4:21 pm, 5:48 pm, and 7:51 pm
	11/20/2023	Carnival Dream	3,646	7:31 AM	1.63	2.63	NE	5	6:44 PM	2.06	2.99	E	8	NA	(1) Actual arrival and departure times from video clips with comments; (2) No Arrival guests, No Departure guests
	11/21/2023	Carnival Glory	3,581	8:49 AM	1.63	3.93	ESE	17	4:47 PM	18.30	14.92	E	16	-	(1) Actual arrival and departure times from video clips with comments; (2) Arrival guests up to 28 mph, No Departure guests; (3) Shallow Sonde records -99.9 at 10:01 pm and 10:21 pm
	11/23/2023	MS Rotterdam	3,230	11:00 AM	NA	NA	NA	NA	6:00 PM	NA	NA	NA	NA	NA	Cancelled
	11/24/2023	Carnival Sunrise	2,984	7:16 AM	2.11	2.56	NNE	8	1:47 PM	2.14	4.03	NNE	6	Forward	(1) Actual arrival and departure times from video clips with comments; (2) No Arrival guests, No Departure guests; (3) Shallow Sonde records -99.9 at 2:06 pm
	11/25/2023	MSC Maestica	3,017	7:50 AM	1.64	3.07	NE	10	5:47 PM	1.80	3.74	E	8	Reverse	(1) Reverse departure; (2) Actual arrival and departure times from video clips; (3) Arrival guests up to 22 mph, No Departure guests; (4) Shallow Sonde records -99.9 at 6:11 am
	11/26/2023	Calabria Apex	3,173	7:15 AM	10.75	10.17	SE	8	5:00 PM	13.07	16.34	SW	8	Reverse	(1) Reverse departure; (2) 13:07 NTU @ 5:11 PM; (3) Arrival/departure times from video; (4) No Arrival guests, No Departure guests; (5) Shallow Sonde records -99.9 at 8:21 am
	11/27/2023	Norwegian Jade	2,882	10:25 AM	1.00	2.34	N	13	5:39 PM	2.63	2.79	N	9	Reverse	(1) Turbidity at arrival; (2) Reverse departure; (3) Arrival/departure times from video; (4) Arrival guests up to 24 mph, No Departure guests; (5) Shallow Sonde records -99.9 at 11:11 pm
	11/28/2023	Calabria Sunrise	2,990	7:39 AM	6.93	7.60	N	10	4:58 PM	1.46	2.69	N	15	Reverse	(1) Reverse departure; (2) Actual arrival and departure times from video clips; (3) Arrival guests up to 23 mph, Departure guests up to 22 mph; (4) Shallow Sonde records -99.9 at 9:51 pm
11/30/2023	Scarlet Lady	2,860	7:49 AM	6.26	6.32	NE	9	5:34 PM	2.23	3.10	E	14	Forward	(1) Actual arrival/departure times from video; (2) forward departure; (3) low turbidity; (4) Arrival guests up to 23 mph, No Departure guests; (5) Shallow Sonde records -99.9 at 2:16 am and 9:01 pm	
December 2023	12/1/2023	Seven Seas	908	11:54 AM	2.34	3.93	ESE	12	6:41 PM	1.99	3.23	E	8	Forward	(1) Actual arrival/departure times from video; (2) forward departure; (3) low turbidity; (4) No Arrival guests, No Departure guests; (5) Shallow Sonde records -99.9 at 7:26 am and 11:26 pm
	12/2/2023	Calabria Sibonarte	3,463	8:46 AM	2.00	3.48	ESE	8	4:36 PM	2.32	5.30	ESE	7	Forward	(1) Actual arrival/departure times from video; (2) forward departure; (3) 18 NTU turbidity; (4) No Arrival guests, No Departure guests; (5) Shallow Sonde records -99.9 at 8:36 am
	12/4/2023	Carnival Dream	3,646	10:31 AM	3.60	5.27	VAR	5	6:40 PM	2.12	5.83	N	5	Forward	(1) Turbidity at arrival (see video); (2) Arrival/departure times from video; (3) No Arrival guests, No Departure guests; (4) Shallow Sonde records -99.9 at 10:11 am
	12/5/2023	Carnival Conquest	3,581	7:29 AM	1.68	4.84	NNE	12	1:36 PM	13.03	4.43	N	10	Reverse	(1) Reverse departure; (2) Actual arrival/departure times from video; (3) Turbidity cloud; (4) Arrival guests up to 23 mph, Departure guests up to 21 mph
	12/8/2023	Calabria Sunrise	2,990	7:49 AM	1.80	3.87	ESE	15	4:59 PM	1.89	6.78	NE	7	Reverse	(1) Reverse departure; (2) Arrival/Departure based on video clips w/comments; (3) No Arrival guests, No Departure guests; (4) Shallow Sonde records -99.9 at 12:31 pm, 2:51 pm, and 3:36 pm
	12/9/2023	MSC Maestica	3,017	8:28 AM	1.83	3.76	ESE	10	5:48 PM	2.64	6.47	ESE	8	Reverse	(1) Reverse departure; (2) Arrival/Departure based on video clips w/comments; (3) No Arrival guests, No Departure guests; (4) Shallow Sonde records -99.9 at 6:11 am; (5) Shallow Sonde spikes to 243.35 NTU at 7:41 am
	12/10/2023	Calabria Apex	3,173	7:29 AM	4.26	4.73	SE	15	4:52 PM	6.62	4.93	SE	7	Reverse	(1) Reverse departure; (2) Arrival/Departure based on video clips w/comments; (3) No Arrival guests, No Departure guests; (4) Shallow Sonde records -99.9 at 11:06 am and 2:26 pm
	12/11/2023	Norwegian Jade	2,882	10:34 AM	3.23	4.62	N	21	5:30 PM	4.26	8.96	N	12	NA	(1) Arrival from video; (2) No departure video webcam malfunction; (3) 19 NTU - depart times; (4) Arrival guests up to 29 mph, No Departure guests; (5) Shallow Sonde records -99.9 at 4:11 pm
	12/12/2023	Calabria Sunrise	2,990	7:36 AM	6.30	6.77	NNE	17	5:06 PM	3.58	4.03	NNE	13	Reverse	(1) Reverse departure; (2) Arrival/Departure based on video clips w/comments; (3) Arrival guests up to 25 mph, No Departure guests; (4) Shallow Sonde records -99.9 at 11:46 am
	12/12/2023	American Glory	49	8:15 AM	7.25	5.00	NNE	16	4:41 PM	2.33	4.02	NNE	13	NA	(1) Small ship at Mallory dock; (2) Arrival/Departure based on video clip w/comments; (3) Arrival guests up to 26 mph, No Departure guests; (4) Shallow Sonde records -99.9 at 11:46 am
	12/13-13/2023	American Glory	49	8:52 PM	3.99	4.67	NE	10	3:43 PM	2.20	4.26	ESE	14	NA	(1) Small ship at Mallory dock; (2) Arrival guests up to 20 mph, Departure guests up to 28 mph; (3) Shallow Sonde records -99.9 at 9:36 am and 6:21 pm
	12/16-19/2023	Rico Carbone	298	7:10 AM	12.03	9.55	NW	7	5:00 PM	10.37	11.55	N	14	NA	(1) Small ship at Pier B; (2) no effect on turbidity; (3) no arrival video; (4) arrival guests up to 21 mph; (5) Shallow Sonde records -99.9 at 9:01 am; (6) Shallow Sonde spikes at 2004 after arrival
	12/20/2023	MSC Maestica	3,017	9:29 AM	6.32	8.13	NNE	12	5:02 PM	6.79	22.99	NE	15	Reverse	(1) Reverse departure; (2) Arrival/Departure based on video clips; (3) 19.63 NTU at departure; (4) No Arrival guests, No Departure guests; (5) Shallow Sonde records -99.9 at 10:26 am and 6:26 pm
	12/21/2023	Visage Amsterdam	2,306	7:43 AM	8.83	8.63	NNE	13	4:44 PM	7.22	10.61	NE	9	Reverse	(1) Reverse departure; (2) Arrival/Departure based on video clips; (3) Arrival guests up to 23 mph, Departure guests up to 22 mph; (4) Shallow Sonde records -99.9 at 9:56 am
	12/22/2023	Calabria Sunrise	2,990	7:43 AM	13.54	13.29	NE	12	5:00 PM	24.23	17.01	ESE	9	NA	(1) Arrival based on video clip; (2) departure based on schedule; (3) Arrival guests up to 23 mph, No Departure guests
	12/22/2023	American Glory	49	8:14 PM	6.57	10.12	NE	6	-	NA	NA	NA	NA	NA	(1) Arrival based on video clip; (2) no camera or schedule for departure, No Arrival guests
	12/23/2023	MSC Explora 1	1,473	7:30 AM	8.32	12.17	NNE	9	3:48 PM	5.58	8.85	NE	9	Reverse	(1) Reverse departure; (2) Arrival/Departure based on video; (3) No Arrival guests, No Departure guests; (4) Shallow Sonde records -99.9 at 6:11 am; (5) Shallow Sonde spikes at 311 pm above 95 NTU
12/24/2023	Carnival Dream	3,646	10:25 AM	6.79	8.77	NE	8	6:35 PM	10.21	10.54	SE	20	Reverse	(1) Reverse departure; (2) Arrival/Departure based on video; (3) 14.85 NTU at 6:41 PM; (4) No Arrival guests, No Departure guests; (5) Shallow Sonde records -99.9 at 6:56 am	
12/25/2023	Calabria Equinox	3,420	7:28 AM	20.75	19.21	SE	17	4:53 PM	13.04	16.77	ESE	13	Reverse	(1) Reverse departure; (2) Arrival/Departure based on video; (3) 13.04 NTU at 4:56 PM; (4) Arrival guests up to 28 mph, No Departure guests; (5) Shallow Sonde records -99.9 at 7:56 am	
12/26/2023	Rico Carbone	298	8:59 AM	10.04	10.60	CALM	0	4:45 PM	6.12	7.57	NW	9	Reverse	(1) Small ship at Pier B; (2) no effect on turbidity; (3) No Arrival guests, No Departure guests; (4) Shallow Sonde spikes to 58.9 NTU at 6:11 am	
12/27/2023	Calabria Sunrise	2,990	7:29 AM	5.20	No Data	NE	5	4:44 PM	5.05	7.25	N	7	Forward	(1) Turbidity spikes to 19.47 at 7:40 AM; (2) forward departure w/ no impact on turbidity; (3) No Arrival guests, No Departure guests; (4) Shallow Sonde records -99.9 at 9:16 am and at 9:31 am	
12/29/2023	Visage Amsterdam	2,306	7:15 AM	6.02	18.20	NNW	12	3:43 PM	3.33	6.93	NW	12	Forward	(1) Turbidity spikes to 15.77 at 7:50 AM; Deep Sonde; (2) Turbidity spikes to 182.16 at 1:46 pm (Shallow Sonde); (3) forward departure w/ no impact on turbidity; (4) No Arrival guests, No Departure guests	
12/30/2023	American Glory	49	8:00 AM	3.96	7.41	NNW	10	PM	NA	NA	NA	NA	NA	(1) Arrival and departure times based on video; (2) Missing departure video, No Arrival guests, Departure time N/A	
12/30/2023	Carnival Conquest	3,581	7:15 AM	4.34	17.94	NNW	9	1:34 PM	3.92	7.18	NW	9	Forward	(1) Arrival and departure times based on video; (2) forward departure w/ no impact on turbidity; (3) No Arrival guests, No Departure guests	



# Mallory Square

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Alarms

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Last Day

Y-axis scaling

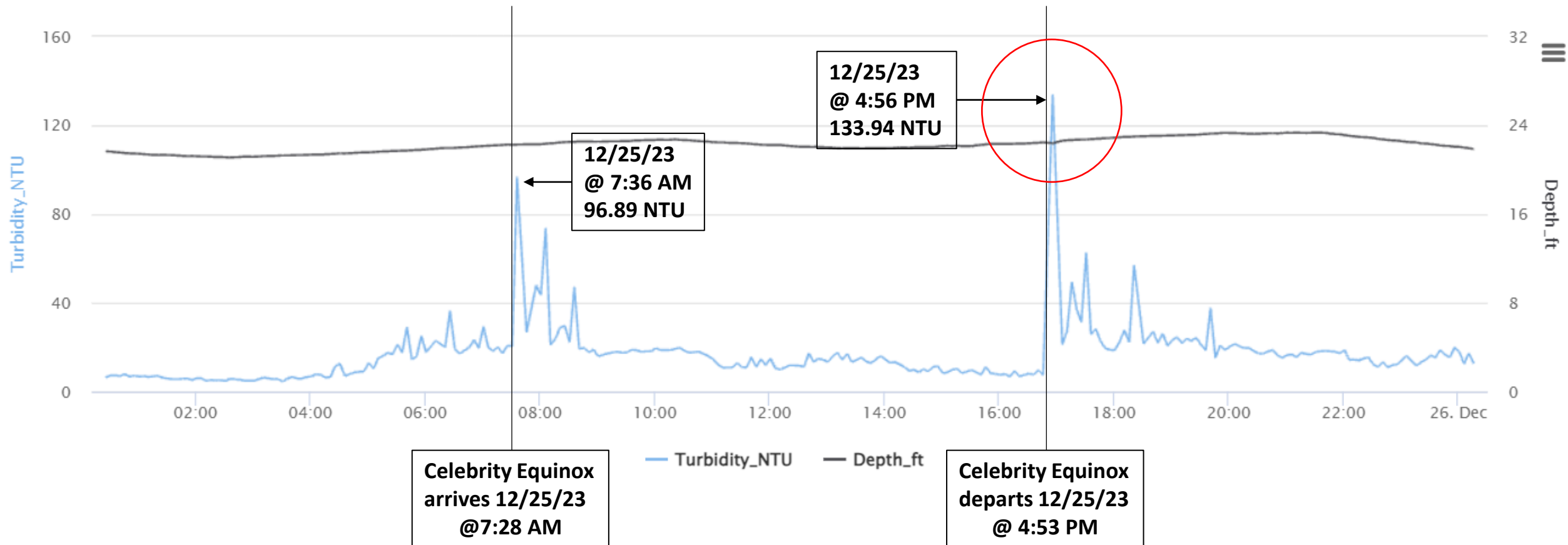
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Min

Max

Clear

✕





# Turbidity Anomaly (5337.38 NTU)

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Y-axis scaling

0

Min

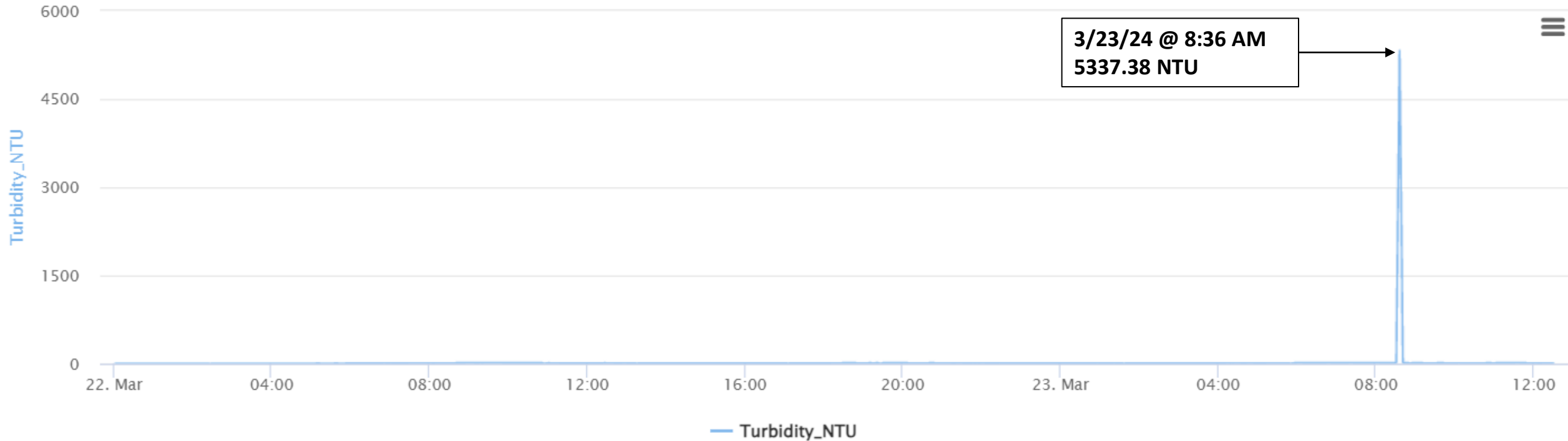
6000

Max

Clear

X

Deep sensor



# Shallow (1 m) Turbidity Sensor

: Mallory Square

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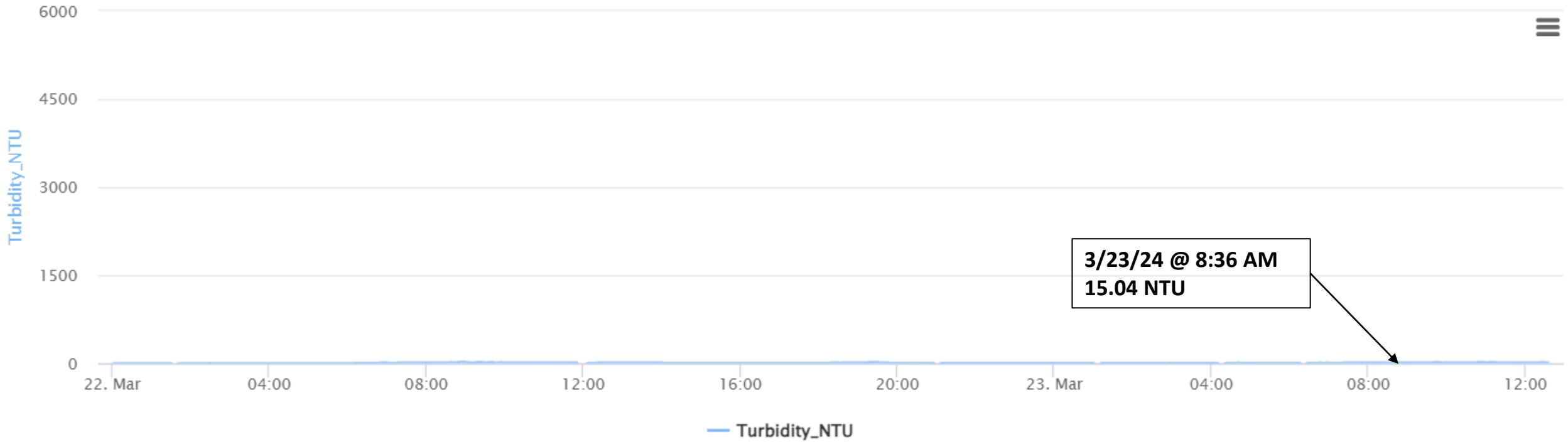
Parameters ▾

Studies ▾

 Last Day

Y-axis scaling      
Min Max

Shallow sensor



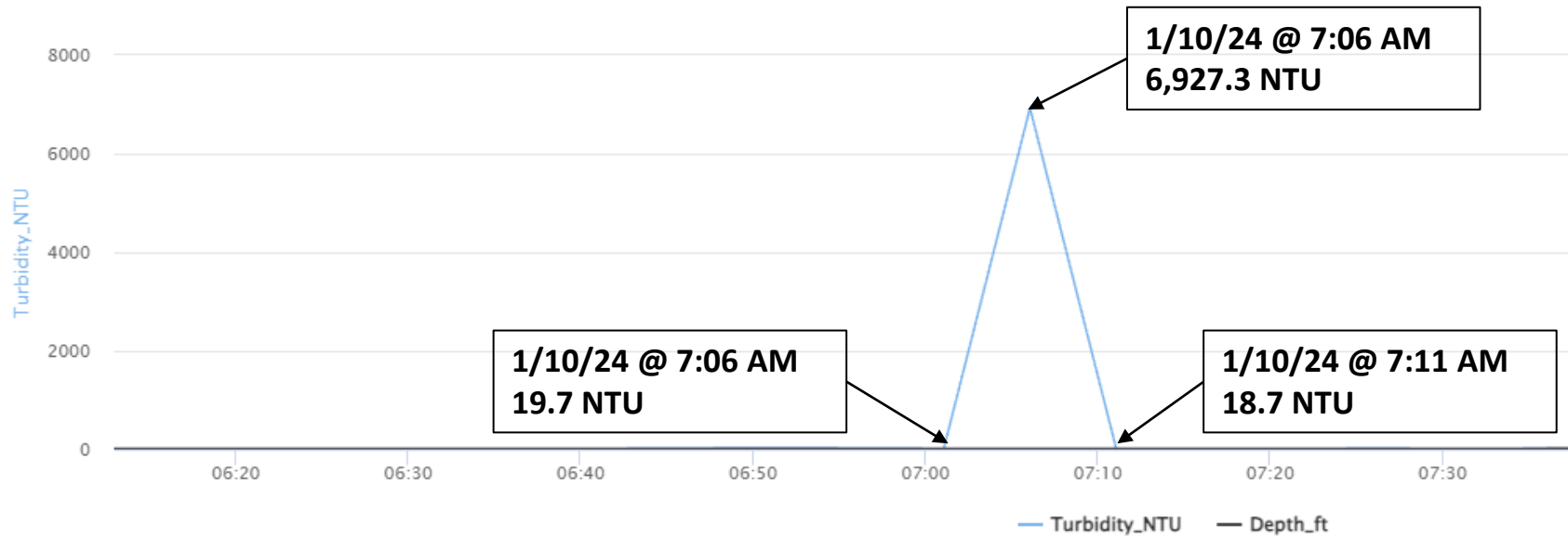
# Turbidity Anomalies

Mallory Square

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**Chart View** Table View Site Information Alarms

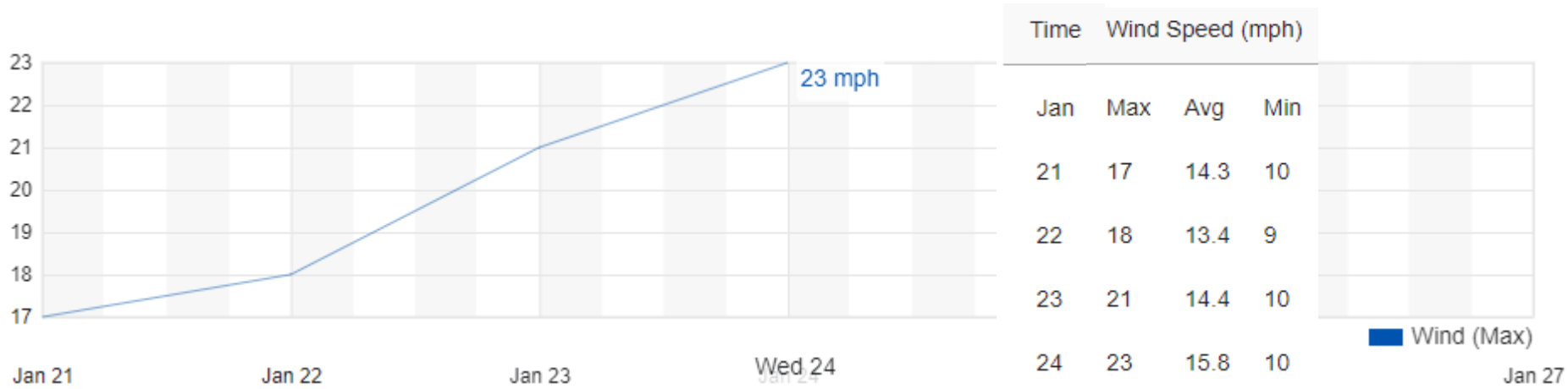
Exo1Data ▾ Parameters ▾ Studies ▾ Jan 1, 2024 - Jan 29, 2024



**YSI EXO Water Quality Data Sonde**



# Wind event Jan. 21-24



Time	Max	Avg	Min
Jan 21	17	14.3	10
Jan 22	18	13.4	9
Jan 23	21	14.4	10
Jan 24	23	15.8	10

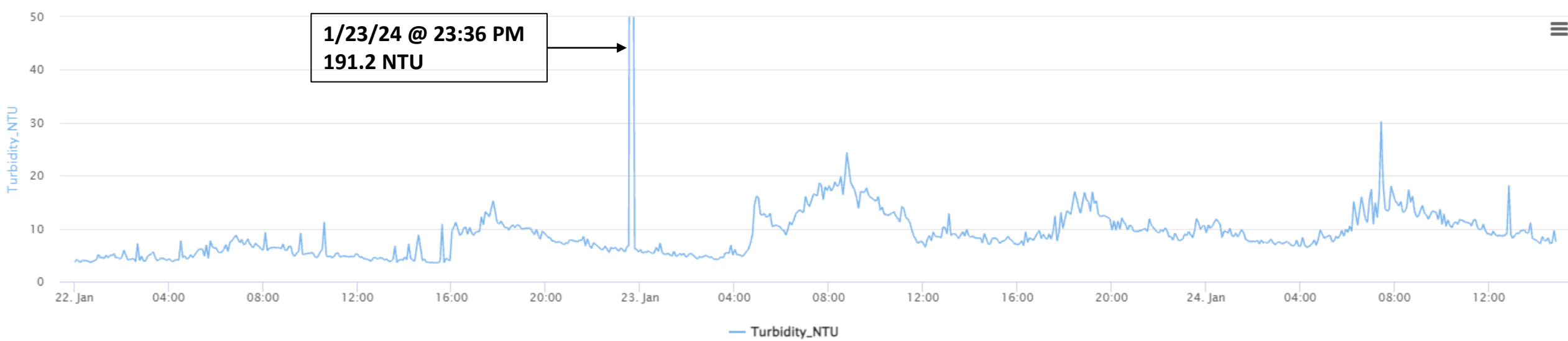
## Mallory Square

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Exo1Data ▾ Parameters ▾ Studies ▾ Jan 22, 2024 - Jan 24, 2024

Y-axis scaling  [Clear](#) Min Max



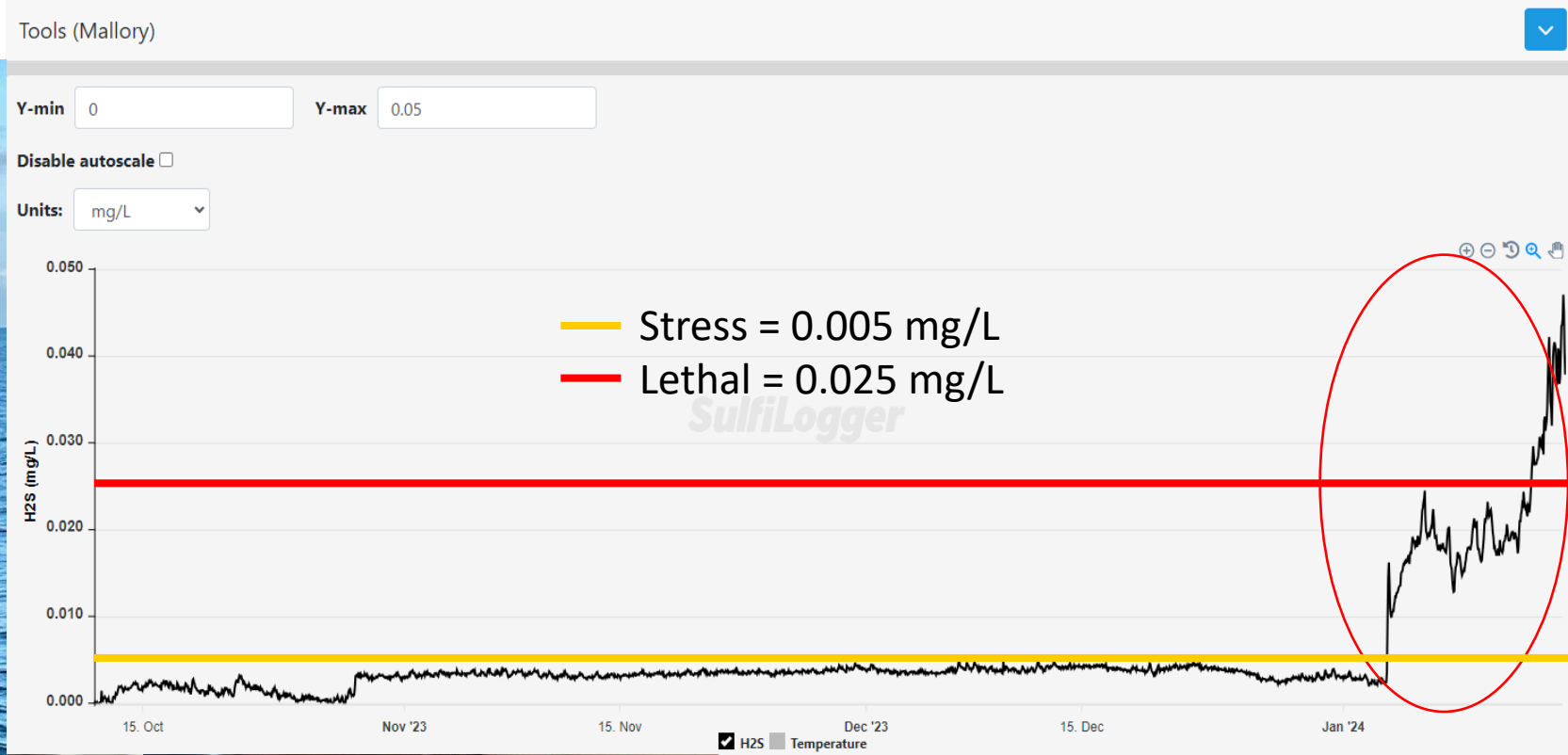
# Objective 2

Expand water quality monitoring to eight AOC around the islands of Key West using an Autonomous Underwater Vehicle equipped with sensors for dissolved oxygen, temperature, salinity, turbidity, and total algae.





# Objectives 5 - Expand water quality monitoring to marine environment near Stock Island Landfill for toxic pollutants (i.e. hydrogen sulfide).







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# Questions?



## Special thanks to:

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- Florida Department of Environmental Protection (FDEP)
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- Environmental Protection Agency (EPA)