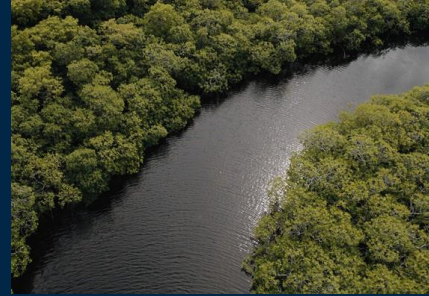




# Advancing Marine Surveillance with M2 Radar at TAMR-Caye Bokel

# Largest Marine Reserve in Belize & Largest & Most Biodiverse Coral Atoll in the Caribbean



Declared a Marine Reserve in 2012;  
TASA was formed in 2013



363,400  
Acres  
of seagrass,  
mangroves  
and coral  
reef



# Three Conservation Stations

Mauger Caye



Calabash Caye

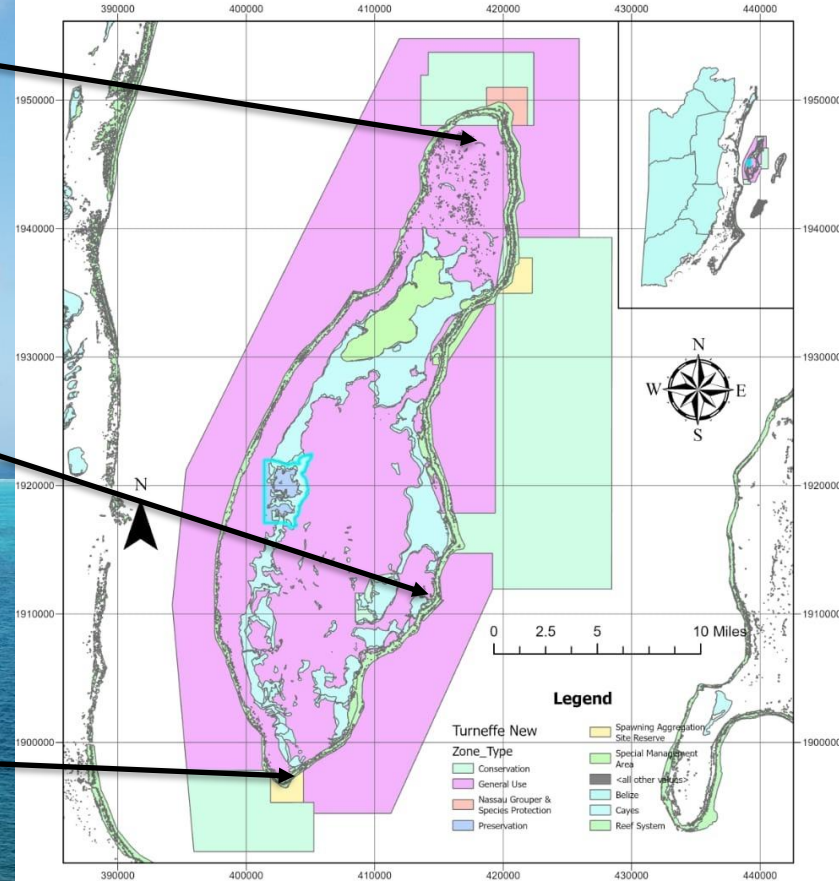


Caye Bokel



## Turneffe Atoll Marine Reserve

Updated August 2022- SI 71 of 2022



# Threats

1. Illegal Fishing
2. Fishing in Conservation Zones (no take)
3. Fishing without licenses
4. Fishing during closed season
5. Fishing undersize products
6. Coastal Development
7. Tourism Development
8. Land Speculation
9. Climate Change



# Strategies to Combat IUU Fishing

1. Integration with National Plans and Policy
2. Capacity Building and Training of Staff
3. Use of Technology to improve efficiency and reach
  - SMART
  - Drones
  - Vessel Monitoring System
  - M2 Radar



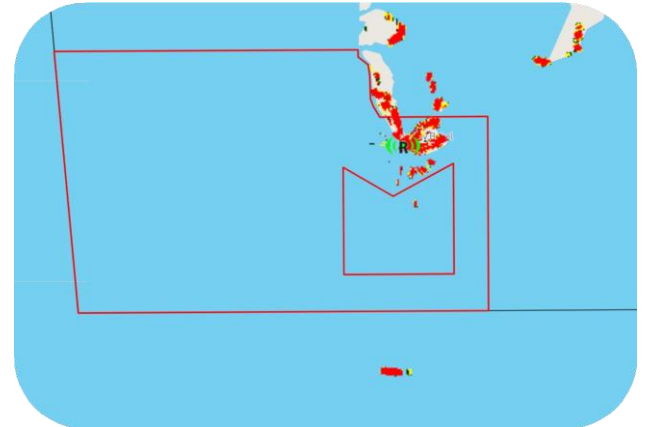
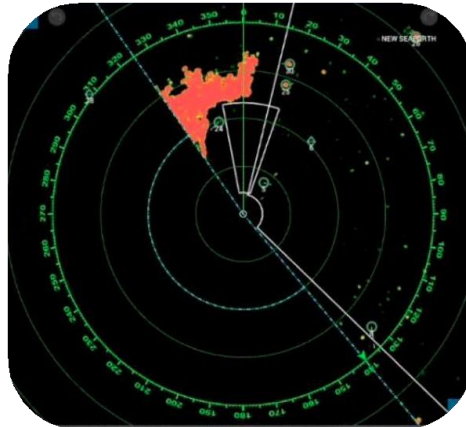
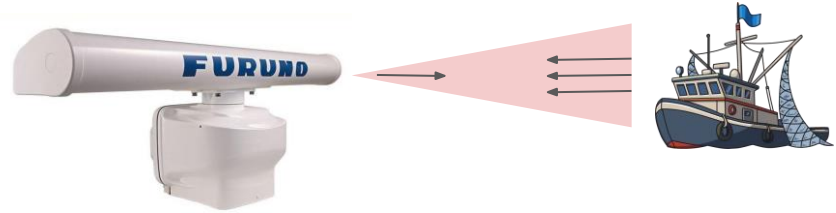
# What is Marine Monitor (M2)?

- Developed in 2015 to provide a low cost, easy-to-use tool for improved monitoring of marine managed areas
- Created specifically for marine resource managers and to increase strategic management and enforcement in protected areas
- Systems deployed in the United States, Mexico, Palau, Philippines, Ecuador, and now Belize!



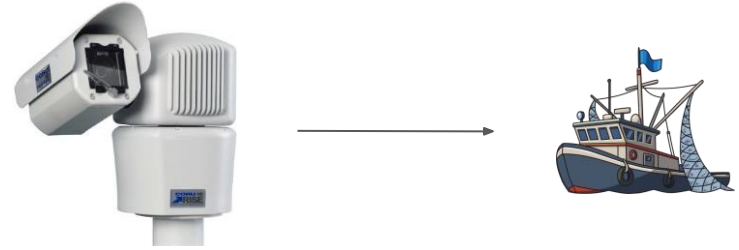
# M2 Overview - Radar

- M2 uses radar to detect objects on the water
- Pulse returns off solid objects
- Designed to track boats
- Can track false targets
  - Waves, rain, storm systems



# M2 Overview - Camera

- Directed by radar positions
- Pre-programmed zoom
- Daylight camera
- Conditions, distance may impact quality
- Lower on mast than radar
  - Tower may obstruct view





# Marine Monitor (M2) System Sensors

Automatic  
Identification  
System (AIS)

Furuno Radar Antenna



Pan-Tilt Camera



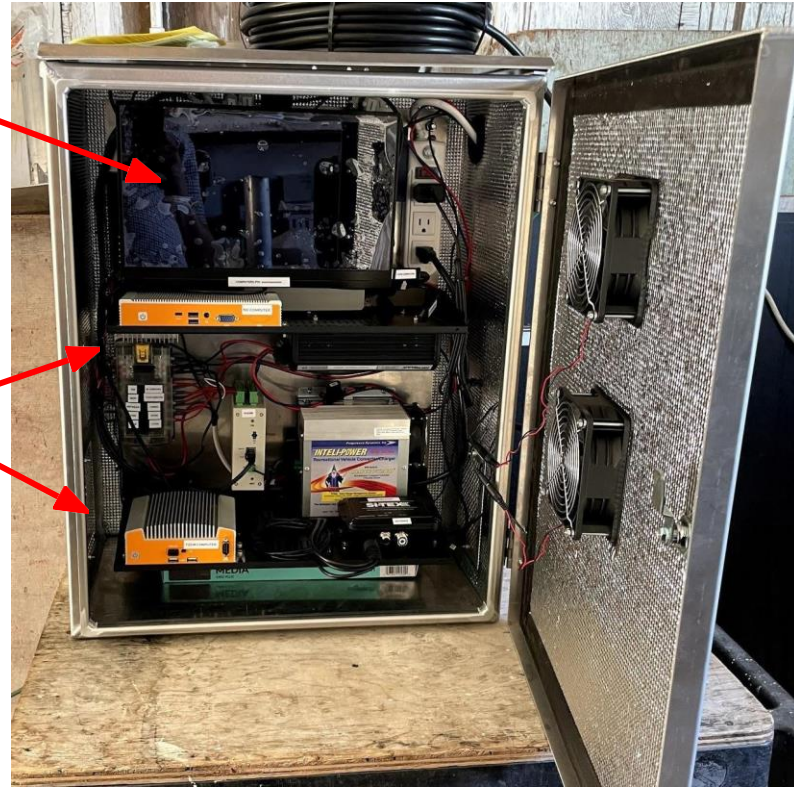
Weather station



# Marine Monitor (M2) Control Center

Monitor

Computers



# M2 Local System

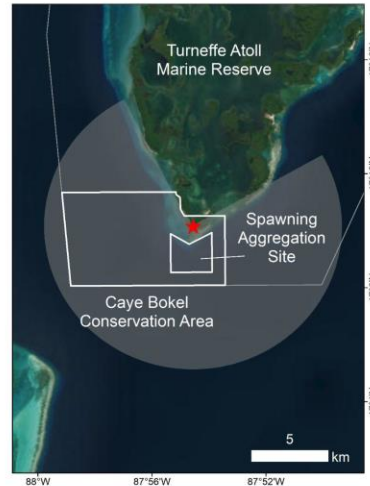
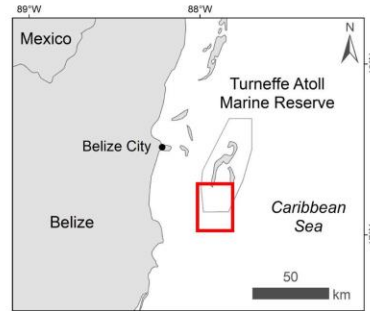
- Computer on site
- Data stored here
- Access M2 Viewer
- Change **all** settings
- Create/edit zones
- **Control camera**

vs.

# M2 Cloud Viewer

([www.m2.protectedseas.net](http://www.m2.protectedseas.net))

- Data transferred here with internet connection
- Access M2 Viewer
- Change **basic** settings
  - Notifications
  - Subscriptions
  - Email/phone preferences
  - Password change



## M2 Computer

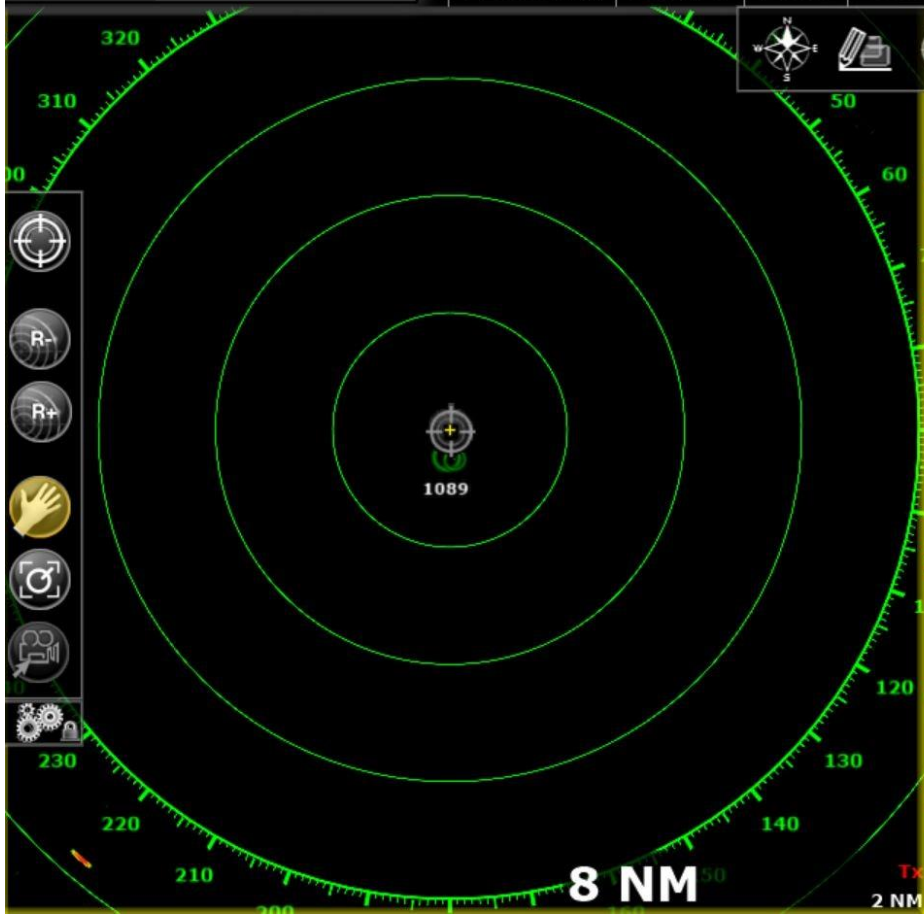
Used to control camera



## TimeZero Coastal Monitoring (TZCM) Computer

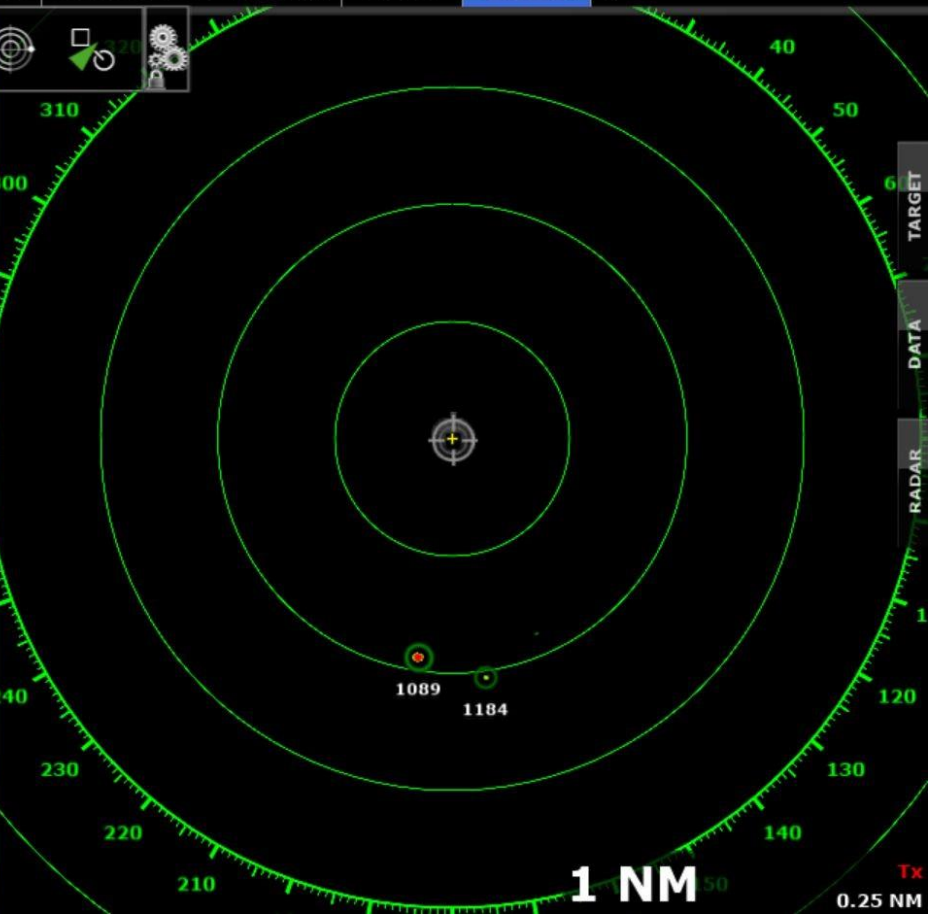
Used to control radar





8 NM

Tx  
2 NM



1 NM

Tx  
0.25 NM

TARGET  
DATA  
RADAR

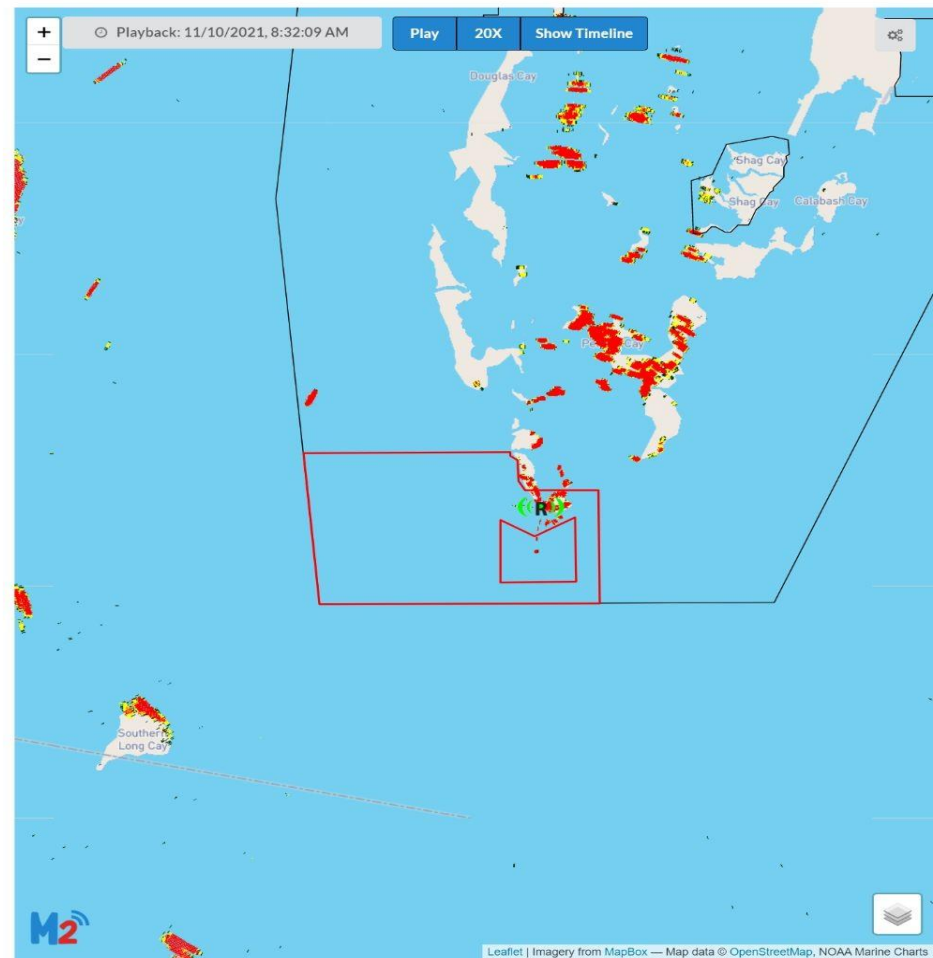
# M2 Viewer Demo

Radar: ● Belize-Turneffe Atoll View Options Clear Map

Tracks: [48]

Start Time	Duration	Avg Speed	Dist (km)	Triggered	Show on Map	
1-1110-0828 📹 🟡 🟢 [0.990]	11/10/2021, 8:28:39 AM	01:04:53	2.4	5.0	Yes	<input type="checkbox"/>
6-1110-0800 📹 🟡 🟢 [0.990]	11/10/2021, 8:00:10 AM	00:44:32	2.7	4.2	Yes	<input type="checkbox"/>
157-1110-0750 📹 🟡 🟢 [0.999]	11/10/2021, 7:50:07 AM	00:09:32	11.6	3.4	No	<input type="checkbox"/>
6-1110-0724 📹 🟡 🟢 [0.999]	11/10/2021, 7:24:53 AM	00:34:46	1.2	1.4	Yes	<input type="checkbox"/>
83-1109-1618 📹 🟡 🟢 [0.979]	11/09/2021, 4:18:02 PM	02:19:13	0.3	2.5	Yes	<input type="checkbox"/>
9-1109-1410 📹 🟡 🟠 [0.718]	11/09/2021, 2:10:39 PM	00:18:34	10.3	6.0	Yes	<input type="checkbox"/>
166-1109-1151 📹 🟡 🟢 [0.982]	11/09/2021, 11:51:17 AM	11:01:56	0.1	2.3	Yes	<input type="checkbox"/>
102-1109-1146 📹 🟡 🟢 [0.990]	11/09/2021, 11:46:30 AM	03:57:08	0.6	9.4	Yes	<input type="checkbox"/>
58-1109-0800 📹 🟡 🟢 [0.992]	11/09/2021, 8:00:10 AM	00:40:50	0.8	1.7	Yes	<input type="checkbox"/>
58-1109-0625 📹 🟡 🟢 [0.969]	11/09/2021, 6:25:24 AM	01:33:55	0.3	1.4	Yes	<input type="checkbox"/>
177-1108-1656 📹 🟡 🟢 [0.935]	11/08/2021, 4:56:25 PM	00:16:18	3.5	2.0	Yes	<input type="checkbox"/>
91-1108-1547 📹 🟡 🟢 [0.994]	11/08/2021, 3:47:56 PM	03:18:38	0.5	5.6	Yes	<input type="checkbox"/>
141-1108-1502 📹 🟡 🟠 [0.510]	11/08/2021, 3:02:27 PM	00:20:54	1.3	1.5	Yes	<input type="checkbox"/>
177-1108-1226 📹 🟡 🟢 [1.000]	11/08/2021, 12:26:52 PM	00:21:13	17.8	11.6	No	<input type="checkbox"/>
122-1108-1217 📹 🟡 🟢 [0.973]	11/08/2021, 12:17:06 PM	08:54:28	0.5	12.0	Yes	<input type="checkbox"/>


[Generate Report](#) Page 1 of 4 Next >



# M2 Viewer Live Tracks with Camera

Radar: ● Belize-Turneffe Atoll View Options Clear Map

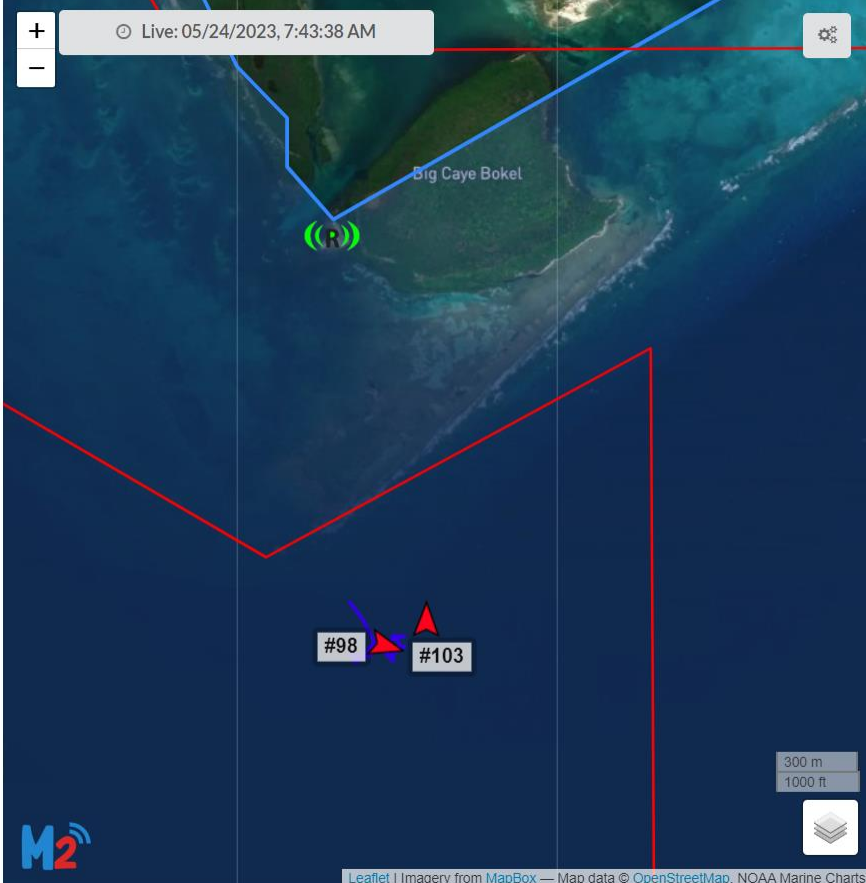
Click to Close



Track: 98-0524-0717 (0nm) Size: undefinedm At: 07:42:32 Photo: 1 of 12

Tracks: <span>[6]</span>	Started	Speed (Knts)	Triggered	Last Update	Show on Map
636022765-0524-0739 <span style="color: blue;">SEABOARD BLUE</span>	05/24/2023, 7:39:03 AM	0.0	No	05/24/2023, 7:43:24 AM	<input type="checkbox"/>
98-0524-0717 <span style="color: green;">●</span> [0.935]	05/24/2023, 7:17:45 AM	0.7	Yes	05/24/2023, 7:43:20 AM	<input checked="" type="checkbox"/>
103-0524-0723 <span style="color: green;">●</span> [0.927]	05/24/2023, 7:23:27 AM	0.4	Yes	05/24/2023, 7:43:20 AM	<input type="checkbox"/>
109-0524-0732 <span style="color: green;">●</span> [0.927]	05/24/2023, 7:23:27 AM	0.4	Yes	05/24/2023, 7:43:20 AM	<input type="checkbox"/>

+ 📍 Live: 05/24/2023, 7:43:38 AM 🗨️



#98      #103

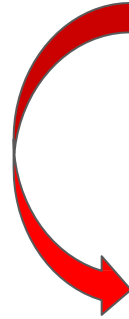
300 m  
1000 ft

M2

Leaflet | Imagery from MapBox — Map data © OpenStreetMap, NOAA Marine Charts

# AIS targets

- M2 receives AIS data from commercial vessels
- To find out more information on an AIS vessel, click the vessel name in the track table



Tracks: [3]	Started	Speed (Knts)	Triggered	Last Update	Show on Map
367090830-0408-1632 DOUGC	04/08/2019, 4:32:53 PM	0.1	No	04/09/2019, 11:08:22 AM	<input type="checkbox"/>
249666000-0409-0908 <b>CELEBRITY ECLIPSE</b>	04/09/2019, 9:08:46 AM	11.4	Yes	04/09/2019, 11:07:26 AM	<input checked="" type="checkbox"/>
477738600-0409-1049 OOCL LUXEMBOURG	04/09/2019, 10:49:41 AM	11.4	No	04/09/2019, 10:59:30 AM	<input type="checkbox"/>

MarineTraffic

CELEBRITY ECLIPSE

Passenger Ship

IMO: 9404314 | MMSI: 249666000 | Call Sign: 9HXC9 | Flag: Malta [MT] | AIS Vessel Type: Passenger

Gross Tonnage: 121878 | Deadweight: 9500 t | Length Overall x Breadth Extreme: 317.14m x 36.8m | Year Built: 2010 | Status: Active

Voyage Info

US SAN ATD: 2019-04-08 17:55 LT (UTC-7) | US MY3 ETA: 2019-04-10 07:00 LT (UTC-7)

Distance Travelled: \*\*\*\*\*

© Pat Davis, MarineTraffic.com



Playback Tracks shown in Viewer can be filtered

# Filtering tracks

Go back to default settings

View Mode: Playback Tracks

Playback Date / Time Range

Start Date: 11/09/2018

End Date: 11/16/2018

Active After: 00:00

Active Before: 23:59

Restore Defaults Update Tracks

Playback Track Filters

Limit to Trigger Zone: All

Triggered Only

Radar Tracks Only

AIS Tracks Only

Only Tracks w/ Photos

Delink AIS & Radar Tracks

Un-Tagged Only

Soft Exclusion Only

Use toggles

Duration: 1

Average Speed Range: 0 - 50 knots

Maximum Speed Range: 0 - 50 knots

Minimum Speed Range: 0 - 50 knots

Minimum Track Distance: 1

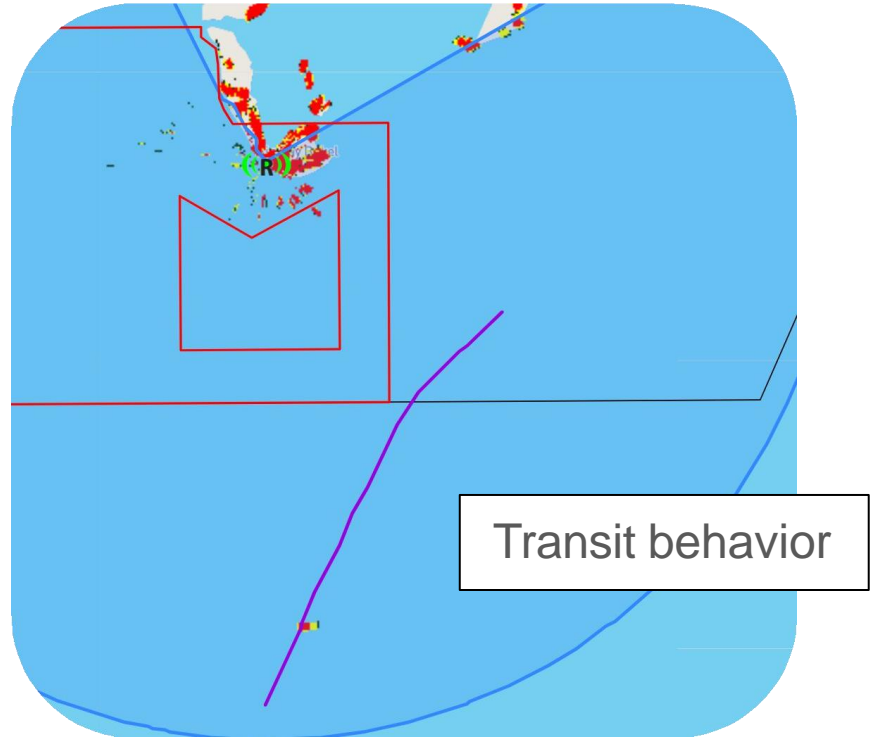
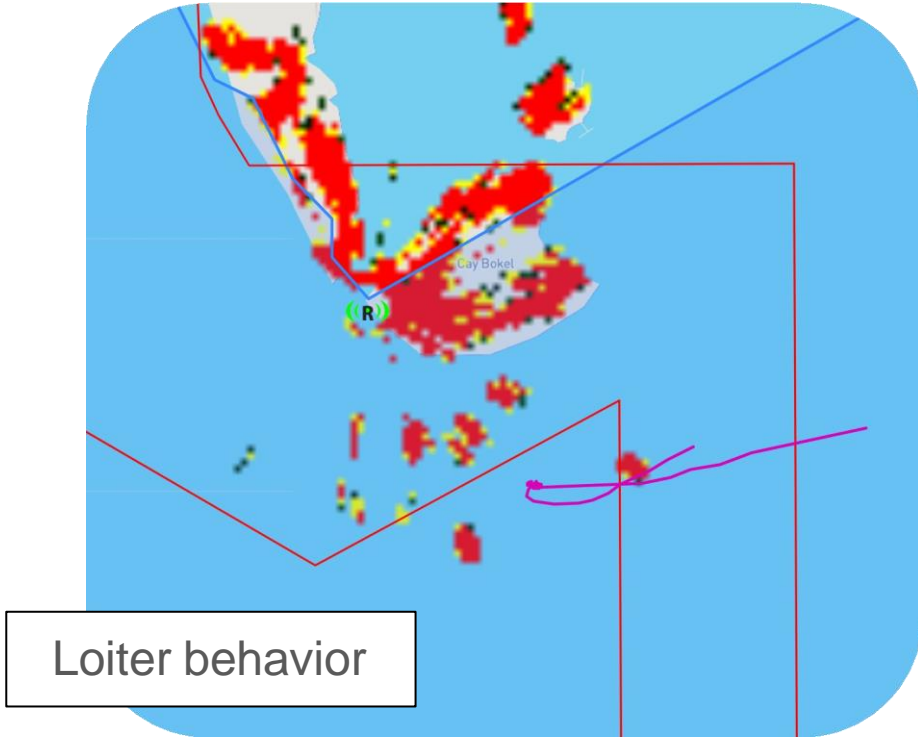
Minimum Distance from Origin: 0.5

Results: 1000

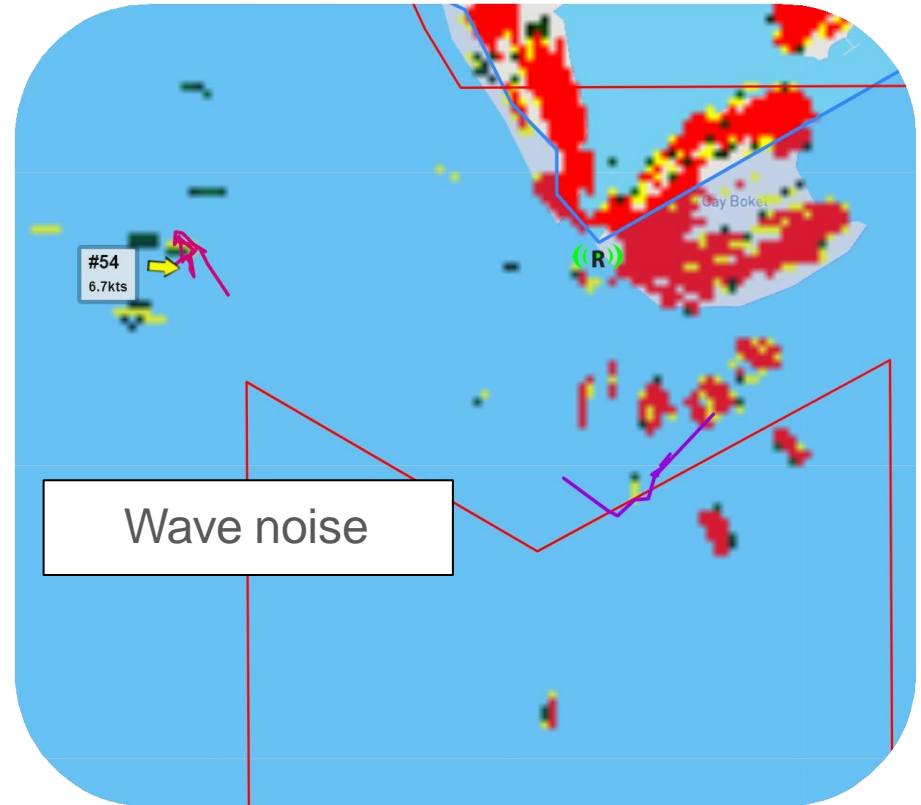
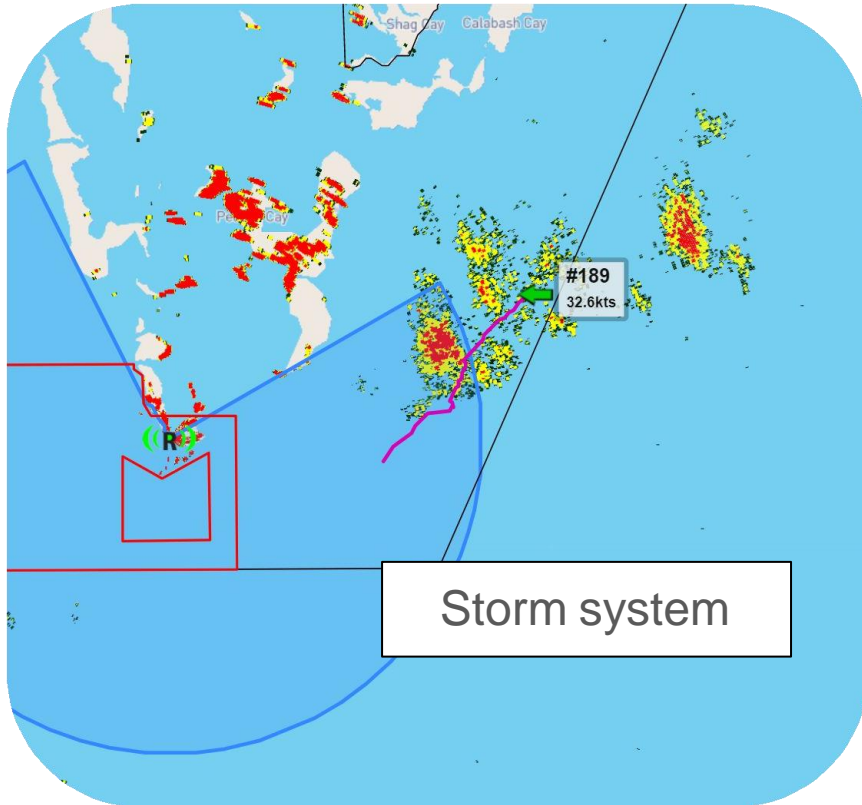
Use sliders



# Vessel track examples



# False track examples



# Target confidence

- Score between 0 and 1 indicates likelihood that track is a vessel

Likely  
false  
target



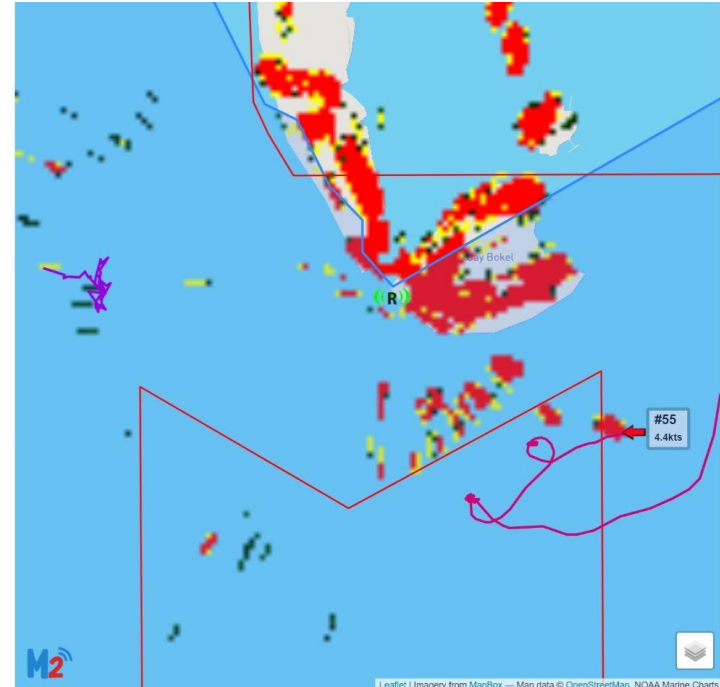
Likely  
true  
vessel



ID	Time	Speed	Altitude	Confidence	Classification	Toggle
87-1108-1105	11/08/2021, 11:05:28 AM	00:14:43	2.2	1.5	Yes	<input type="checkbox"/>
121-1108-1038	11/08/2021, 10:38:57 AM	00:03:26	12.9	1.5	No	<input type="checkbox"/>
23-1108-1035	11/08/2021, 10:35:49 AM	00:03:33	7.9	1.1	No	<input type="checkbox"/>
174-1108-1025	11/08/2021, 10:25:16 AM	00:05:31	9.1	1.5	No	<input type="checkbox"/>
178-1108-1023	11/08/2021, 10:23:11 AM	00:15:46	2.5	2.0	Yes	<input type="checkbox"/>
38-1108-1012	11/08/2021, 10:12:34 AM	00:03:33	7.8	1.1	No	<input type="checkbox"/>
133-1108-0954	11/08/2021, 9:54:15 AM	00:06:38	5.1	1.8	No	<input checked="" type="checkbox"/>
147-1108-0951	11/08/2021, 9:51:54 AM	00:16:13	4.6	3.3	Yes	<input type="checkbox"/>
7-1108-0951	11/08/2021, 9:51:54 AM	00:58:56	0.8	2.0	Yes	<input type="checkbox"/>
61-1108-0951	11/08/2021, 9:51:54 AM	00:04:03	7.1	1.1	No	<input type="checkbox"/>
55-1108-0951	11/08/2021, 9:51:54 AM	10:59:04	0.5	14.0	Yes	<input checked="" type="checkbox"/>
61-1108-0944	11/08/2021, 9:44:41 AM	00:06:39	4.0	1.5	No	<input type="checkbox"/>
86-1108-0936	11/08/2021, 9:36:28 AM	00:14:52	3.5	2.6	Yes	<input type="checkbox"/>

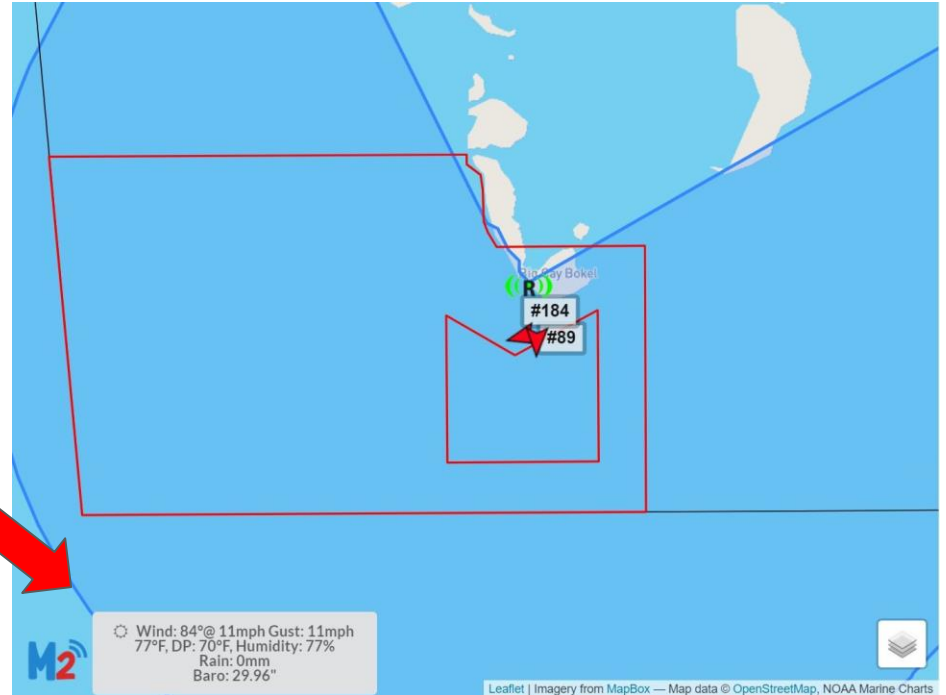
Generate Report

Previous Page 3 of 34 Next



# Weather

- Received from weather sensor
- Available in Live View
- Historical weather data are available in data download package



# Generating site report

- To create a high level report for the Playback Tracks currently in the track table, click 'Generate Report'
- Includes track statistics, figures, and map

12-0403-0321  	04/03/2019, 3:21:00 AM	01:23:15	6.4	30.1	No	<input type="checkbox"/>
13-0403-0656  	04/03/2019, 6:56:36 AM	00:30:01	12.8	12.4	No	<input type="checkbox"/>
14-0403-0721  	04/03/2019, 7:21:59 AM	00:27:58	8.8	8.0	No	<input type="checkbox"/>

[Generate Report](#) Page 1 of 33 [Next](#) >

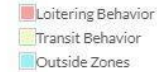
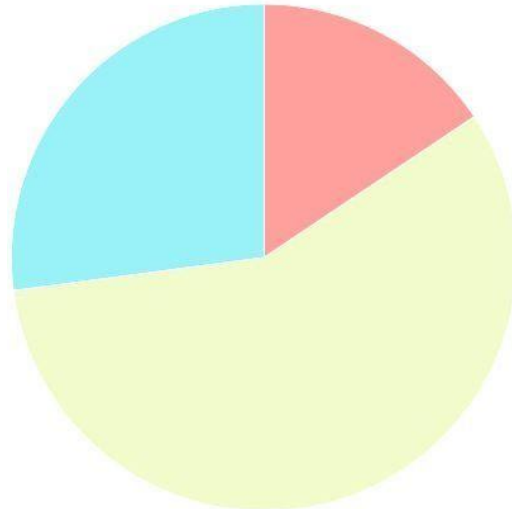


protectedseas

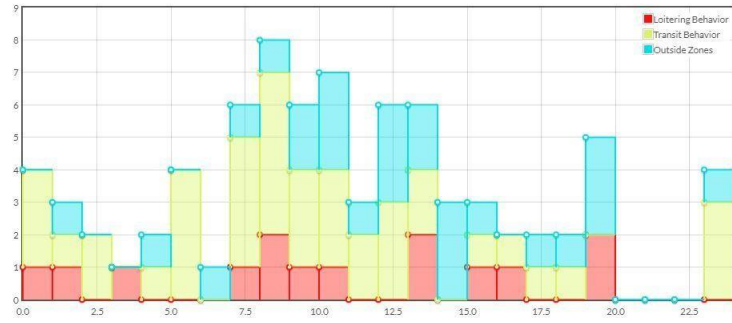


# Marine Monitor Report

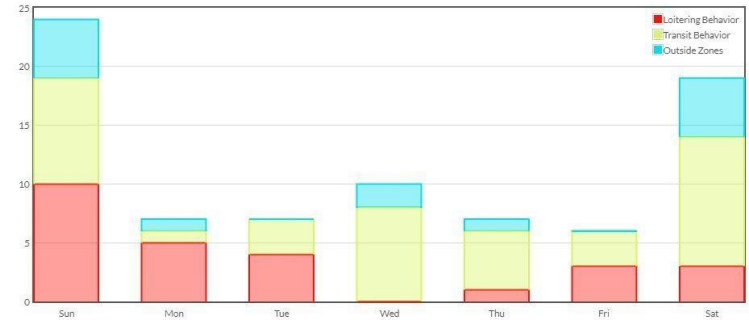
- Tracks classified by 3 behaviors
  - Loiter: Entered zone of interest and did trigger alarm
  - Transit: Entered zone of interest but did not trigger alarm
  - Outside zones: Did not enter a zone of interest



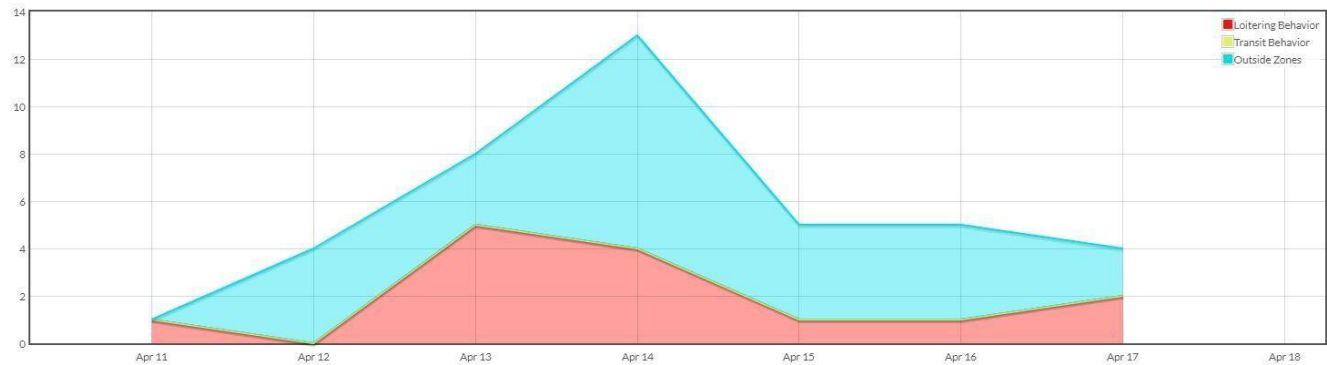
Tracks By Hour of Day



Tracks By Day of Week



Tracks Over Date Range





# Emailed report

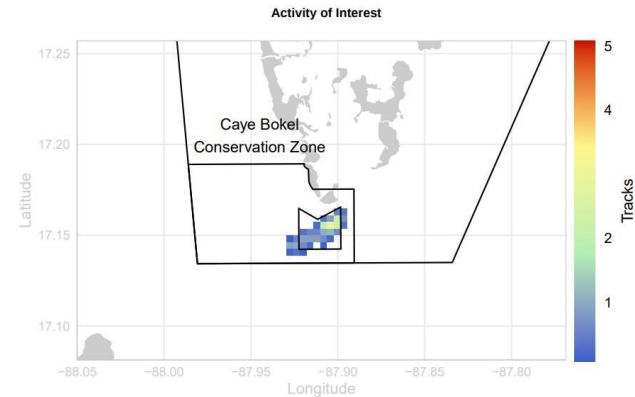
- Scientific-style overview reports
- PDF download
- Information on:
  - System functioning
  - Weather
  - Tracks of interest
  - Track counts
  - Heat maps
  - Tracks over time
  - Day and night tracks

## Marine Monitor (M2) Daily Report — Turneffe Atoll, Belize

for Tuesday November 09, 2021

M2 uses off-the-shelf marine radar to automatically detect and track targets. This report is a summary of target tracks observed at the Turneffe Atoll, Belize site. Tracks may occur outside map boundaries shown. See the M2 Viewer for an interactive view of all tracks detected.

Total	Tracks		Peak activity	
	Alarm	Date	Time	
2	1	Tue Nov 09	12pm to 3pm	



**Image:** Map shows tracks detected by radar and the Automatic Identification System (AIS), if applicable, that had an average speed less than 6 knots or triggered a preset zone alarm.



website: [M2.protectedseas.net](http://M2.protectedseas.net) | email: [M2@protectedseas.net](mailto:M2@protectedseas.net)

# M2 Mobile Viewer

**\*When Cell Reception is Available**

- Mobile-friendly Viewer
- Additional functionality that supports Live Situational Awareness
- Available anywhere with cell reception
- Identify Live Vessel Positions
- Easily share location and heading via text or email



# M2 at Turneffe Atoll

- What are the activities of interest?
  - SPAG site
  - Caye Bokel Conservation Zone
  - Tourism Visitations
- Will the system be used for live monitoring?
  - Alarm definitions
- Battery and solar functioning

Questions?

# THANK YOU FOR YOUR TIME!

