MARINE MONITOR DATA

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The geospatial data distributed here are formatted in decimal degrees and datum WGS84. They were collected via a Marine Monitor (M2) system and represent potential vessel activity in the nearshore coastal area within spatial range of the local system.

Automatic Identification System (AIS) Data

These data are received by an AIS receiver (if installed at site). Data are provided by the vessels and their onboard instruments and transmitted to the M2 AIS receiver where the data are integrated into the M2 system processes.

Radar Data

These data are processed by the marine radar sensor. Targets are tracked using the Automatic Radar Plotting Aid (ARPA) which identifies unique targets and tracks them over time. Because radar may also track those vessels broadcasting AIS data, an algorithm is applied to search for the following similarities between radar and AIS data:

-target detections were within 100 meters in geolocation,

-target detections occurred less than 15 seconds apart,

-target detections had a difference in speed less than 1.5 knots, and

-target detections had less than a 10-degree difference in heading.

If these conditions are met for at least 20 target detection points, the corresponding radar target data are not presented under default conditions in the M2 Viewer, but note that all data are included in the data download package.

CONSIDERATIONS

Because AIS data are transmitted via very high frequency (VHF) radio waves, the spatial range of AIS data received is likely different than the range of data collected via radar. The spatial range of radar data collection is dependent on local conditions and the radar antenna model specifications. See the M2 Viewer map for the most up-to-date radar ranges for each site.

Given the autonomous nature of vessel detection and tracking, false vessel tracks and missed vessels are possible. Since radar technology relies on electromagnetic pulse reflections off of solid objects, exclusion zones have been created around known buoys, land masses, etc. where the system may falsely identify these objects as vessels. When a vessel does pass nearby these objects and into the exclusion zone, the M2 system may drop the target and initiate a new one (depending on time spent in the zone) when the vessel leaves. The same result may occur if multiple vessels are in close proximity with one another as the radar cannot differentiate between multiple unique objects when they are within a certain distance (according to radar antenna model specifications). In certain conditions the M2 system can detect false targets such as standing waves, choppy waters, or rainfall which can also result in false target detection and tracking. Therefore, the total number of tracks observed can be an overestimate of total vessels observed.

The accuracy of radar target detection and tracking is dependent on the proprietary, built-in software belonging to the commercial off-the-shelf radar system. M2 applies a model developed using machine learning to assign target confidence scores (0-1) to each track detected by the system. These scores indicate the likelihood that a target is a true vessel track (scores closer to 1) and are meant to provide a tool for filtering out false targets. Tracks with low target confidence scores are hidden under default conditions in the M2 Viewer, but all tracks are accessible in the M2 Viewer and available in raw data format. While a target is live, the score is calculated every 5 minutes, so tracks with duration less than 5 minutes will not have an associated score. The model uses the following track attributes as potential inputs.

| * Speed variation * Minimum, maximum, average speed * Curviness | * Distance traveled variation * Circular mean and standard deviation of heading * Mean and standard deviation of turning |
| --- | --- |

Model accuracy was evaluated bi-monthly to start, but the frequency of evaluation was reduced to tri-annually beginning in 2022. Two days of recent data are selected from each site, the day with the highest average hourly wind speed and the day with the lowest (track count is used for those sites without available wind data). All observed tracks on these days are ground-truthed to determine if the model accurately predicted the track to be a true vessel or a false target. Model accuracy typically improves over time but can fluctuate with the incorporation of additional data from new sites and different site conditions. A new predictive model is typically trained and deployed at the time of evaluation.

Based on the local site configuration, power or internet outages may occur and lead to gaps in the data provided. In the event that the system loses internet connection only, the system will continue collecting data, and data will be available for download once connection is resumed. System updates and improvements will also occasionally occur that may impact data collection.

The polylines formed by connecting target detection points provided by the M2 system are estimates of the target path using the shortest distance between consecutive points.

FILES PROVIDED

Target Detections (csv)

These data show each individual detection point from radar data.

*File name:* detections\_radar

*Attributes*

*-id\_detect:* Unique identification number for each detection

*-id\_track:* Unique identification number for each track

-*id\_site:* Unique M2 system identifier

-*id\_m2:* Unique track identifier used on M2 Viewer

-*source:* Identifies if detected by AIS or radar

-*speed:* Observed speed over ground of target (knots)

-*course:* Observed course over ground of target (degrees clockwise from north)

-*assoc\_str:* Association strength - numeric count of similar detection points with afcnother track

-*assoc\_id:* The id of the track (id\_track) with the most associated detection points

-*confidence:* Target confidence score (0-1) reflecting the likelihood that a target is a true vessel and not a false target (all AIS tracks will automatically receive a score of 1)

-*cdate:* Local date when detection point was created in M2 system

-*ctime:* Local time when detection point was created in M2 system

-*longitude:* X coordinate (WGS 1984)

-*latitude:* Y coordinate (WGS 1984)

AIS Tracks (csv)

These data are formed from connecting individual detection points from AIS data. Data received from Class A transceivers onboard vessels typically include both vessel and voyage information, but data from Class B transceivers typically only provide voyage information. Vessel-specific data may be missing from track records of those vessels using Class B. Class B vessels do not report dimensions in AIS data. The U.S. Coast Guard only requires Class A AIS for vessels 65 feet (roughly 20m) and greater in length. Therefore, Class B vessels are typically less than 20m in length.

*File name:* tracks\_ais

*Attributes*

*-id\_track:* Unique identification number for each track

-*id\_site:* Unique M2 system identifier

-*id\_m2:* Unique track identifier used on M2 Viewer

-*source:* Identifies if track was detected by AIS or radar

-*duration:* Duration of track time (seconds)

-*alarm:* Track triggered local system alarm (0=no, 1=yes)

-*min\_speed:* Minimum observed speed over ground detected along track (knots)

-*max\_speed:* Maximum observed speed over ground detected along track (knots)

-*avg\_speed:* Average speed over ground of all detections along track (knots)

-*curviness:* Total distance along track / distance between first and last detection

-*heading\_mean:* Circular mean of all heading values along track

-*heading\_std:* Standard deviation of all heading values along track

-*turning\_mean:* Mean value of the absolute value of change in heading between consecutive detections

-*turning\_std:* Standard deviation of the absolute value of change in heading between consecutive detections

-*duration\_z:* Time spent in designated zone of interest (seconds)

-*distance:* Total distance target traveled along track (kilometers)

-*distance\_o:* Maximum distance the target was from its origin (kilometers)

-*assoc\_str:* Association strength - numeric count of similar detection points with a radar track

-*assoc\_id:* The id of the radar track (id\_track) with the most associated detection points

-*tagged:* Whether user has tagged the track in some way on M2 Viewer (0=no, 1=yes)

-*has\_photos:* Track has associated photos (0=no, 1=yes)

*-detections:* Total number of target detections along the track

-*mmsi:* Vessel’s unique Maritime Mobile Service Identity reported in AIS data

-*imo:* Vessel’s unique International Maritime Organization number reported in AIS data

-*name:* Vessel name reported in AIS data

-*type:* Vessel type code classification number reported in AIS data (see definitions below)

-*dim\_a:* Distance on vessel from AIS antenna fore reported in AIS data (meters)

-*dim\_b:* Distance on vessel from AIS antenna aft reported in AIS data (meters)

-*dim\_c:* Distance on vessel from AIS antenna to port reported in AIS data (meters)

-*dim\_d:* Distance on vessel from AIS antenna to starboard reported in AIS data (meters)

-*draft:* Distance between water surface and lowest point on vessel reported in AIS data (meters)

-*dest:* Vessel’s destination reported in AIS data

-*eta\_month:* Estimated month of arrival at destination reported in AIS data

-*eta\_day:* Estimated day of arrival at destination reported in AIS data

-*eta\_hour:* Estimated hour of arrival at destination reported in AIS data

-*eta\_minute:* Estimated minute of arrival at destination reported in AIS data

-*type\_m2:* Internal classification of vessel type (see definitions below)

-*sdate:* Local date of first detection along track

-*stime:* Local time of first detection along track

-*ldate:* Local date of last detection along track

-*ltime:* Local time of last detection along track

AIS Vessel Type Definitions (see [MarineCadastre.gov](https://hub.marinecadastre.gov/) for details)

| Type Code | AIS Vessel Type | M2 Vessel Type Class |
| --- | --- | --- |
| 0 | - | other |
| 1-19 | Reserved | other |
| 20-29 | Wing in ground\* | wing\_in\_ground\_effect |
| 30 | Fishing | fishing\_boat |
| 31-32 | Towing | towing\_ship |
| 33 | Dredging or underwater operations | other |
| 34 | Diving operations | other |
| 35 | Military operations | military\_ship |
| 36 | Sailing | sailboat |
| 37 | Pleasure craft | pleasure\_craft |
| 38-39 | Reserved | other |
| 40-49 | High speed craft\* | high\_speed\_craft |
| 50 | Pilot vessel | pilot\_boat |
| 51 | Search and rescue vessel | search\_and\_rescue\_boat |
| 52 | Tug | tug |
| 53 | Port tender | port\_tender |
| 54 | Anti-pollution equipment | other |
| 55 | Law enforcement | law\_enforcement\_boat |
| 56-57 | Spare - local vessel | other |
| 58 | Medical transport | other |
| 59 | Noncombatant ship | other |
| 60-69 | Passenger\* | passenger\_ship |
| 70-79 | Cargo\* | cargo\_ship |
| 80-89 | Tanker\* | tanker\_ship |
| 90-99 | Other type | other |
| \*\* | - | class\_b |

\*Type codes in range may further define subcategories

\*\*Since Class B AIS data do not typically provide voyage information (including a vessel type code), these vessels cannot be classified with further detail.

Radar Tracks (csv)

These data are formed from connecting individual detection points from all radar data.

*File name:* tracks\_radar

*Attributes*

*-id\_track:* Unique identification number for each track

-*id\_site:* Unique M2 system identifier

-*id\_m2:* Unique track identifier used on M2 Viewer

-*source:* Identifies if track was detected by AIS or radar

-*duration:* Duration of track time (seconds)

-*alarm:* Track triggered local system alarm (0=no, 1=yes)

-*min\_speed:* Minimum observed speed detected along track (knots)

-*max\_speed:* Maximum observed speed detected along track (knots)

-*avg\_speed:* Average speed of all detections along track (knots)

-*curviness:* Total distance along track / distance between first and last detection

-*heading\_mean:* Circular mean of all heading values along track

-*heading\_std:* Standard deviation of all heading values along track

-*turning\_mean:* Mean value of the absolute value of change in heading between consecutive detections

-*turning\_std:* Standard deviation of the absolute value of change in heading between consecutive detections

-*duration\_z:* Time spent in designated zone of interest (seconds)

-*distance:* Total distance target traveled along track (kilometers)

-*distance\_o:* Maximum distance the target traveled from its origin (kilometers)

-*assoc\_str:* Association strength - numeric count of similar detection points with an AIS track

-*assoc\_id:* The id of the AIS track with the most associated detection points

-*tagged:* Whether user has tagged the track in some way on M2 Viewer (0=no, 1=yes)

-*has\_photos:* Track has associated photos (0=no, 1=yes)

-*confidence:* Target confidence score (0-1) reflecting the likelihood that a target is a true vessel and not a false target

*-detections:* Total number of target detections along the track

-*sdate:* Local date of first detection along track

-*stime:* Local time of first detection along track

-*ldate:* Local date of last detection along track

-*ltime:* Local time of last detection along track

Tagged Tracks (csv)

These data are formed from connecting individual detection points from radar or AIS track data that have been tagged by a user in the M2 Viewer.

*File name:* tracks\_tagged

*Attributes*

*-id\_track:* Unique identification number for each track

-*id\_site:* Unique M2 system identifier

-*id\_m2:* Unique track identifier used on M2 Viewer

-*source:* Identifies if track was detected by AIS or radar

-*duration:* Duration of track time (seconds)

-*alarm:* Track triggered local system alarm (0=no, 1=yes)

-*min\_speed:* Minimum observed speed detected along track (knots)

-*max\_speed:* Maximum observed speed detected along track (knots)

-*avg\_speed:* Average speed of all detections along track (knots)

-*curviness:* Total distance along track / distance between first and last detection

-*heading\_mean:* Circular mean of all heading values along track

-*heading\_std:* Standard deviation of all heading values along track

-*turning\_mean:* Mean value of the absolute value of change in heading between consecutive detections

-*turning\_std:* Standard deviation of the absolute value of change in heading between consecutive detections

-*duration\_z:* Time spent in designated zone of interest (seconds)

-*distance:* Total distance target traveled along track (kilometers)

-*distance\_o:* Maximum distance the target traveled from its origin (kilometers)

-*assoc\_str:* Association strength - numeric count of similar detection points with an AIS track

-*assoc\_id:* The id of the AIS track with the most associated detection points

-*tagged:* Whether user has tagged the track in some way on M2 Viewer (0=no, 1=yes)

-*has\_photos:* Track has associated photos (0=no, 1=yes)

-*confidence:* Target confidence score (0-1) reflecting the likelihood that a target is a true vessel and not a false target

*-detections:* Total number of target detections along the track

-*sdate:* Local date of first detection along track

-*stime:* Local time of first detection along track

-*ldate:* Local date of last detection along track

-*ltime:* Local time of last detection along track

-*user\_id:* Last user to tag the track

-*valid:* If track was successfully tracking a vessel (0=no, 1=yes (default))

-*type:* Vessel type of the target the user has identified (default is “unknown”)

-*notes:* Text notes that the user may have included about the target

-*transit:* User tagged track as a vessel engaged in transit (0=no (default), 1=yes)

-*overnight:* User tagged track as a vessel loitering overnight (0=no (default), 1=yes)

-*loiter:* User tagged track as a vessel loitering for sightseeing (0=no (default), 1=yes)

*-cleanup:* User tagged track as a vessel engaged in cleanup (0=no (default), 1=yes)

-*fishing\_c:* User tagged track as a vessel engaged in commercial fishing (0=no (default), 1=yes)

-*fishing\_r:* User tagged track as a vessel engaged in recreational fishing (0=no (default), 1=yes)

-*research:* User tagged track as a vessel engaged in science/research (0=no (default), 1=yes)

-*diving:* User tagged track as a dive boat (0=no (default), 1=yes)

-*repairs:* User tagged track as a vessel engaged in repairs (0=no (default), 1=yes)

-*distress:* User tagged track as a vessel in distress (0=no (default), 1=yes)

-*other:* User tagged track as a vessel engaged in an unlisted activity (0=no (default), 1=yes)

-*miss\_ai:* User tagged track as a radar track duplicating an AIS track (0=no (default), 1=yes)

-*violation:* User tagged track as a vessel potentially violating regulations (0=no (default), 1=yes)

-*le\_contact:* User tagged track as vessel that was potentially violating regulations, and law enforcement was contacted (0=no (default), 1=yes)

-*tdate:* Local date when most recent tag information was entered

-*ttime:* Local time when most recent tag information was entered

TARGET CONFIDENCE SCORE ACCURACY

Prediction accuracy is evaluated using a target confidence score threshold (*p* = 0.5). Accuracy is reported using the true positive rate (TPR), which is the percentage of true vessel tracks classified correctly, and the true negative rate (TNR), which is the percentage of false targets classified correctly. Contact [M2@protectedseas.net](mailto:M2@protectedseas.net) for all site-specific historic evaluation results at sites for which you have access. Some sites may have been offline during certain evaluation periods or were decommissioned.