DEVELOPMENTS IN VESSEL TRACKING TECHNOLOGY AT SEA

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Overview

- Why track vessels?
- Challenges of tracking
- Dependence on cooperation
- What to track?
- AIS
- Small craft tracking – shrink the haystack
- Cooperative tracking:
  - Class B AIS
  - Self-reporting services
- Non-cooperative tracking:
  - Space based surveillance technologies
  - Acoustic buoys
- What's next: Kuaka: Small craft tracking trial Feb-Mar 2023
- Summary
- Discussion

Why track vessels?

There are multiple potential benefits….

Safety at Sea

- Safety of sea transport
  - anti-collision
  - SAR response: Yacht Nina lost in the Tasman June ’13 despite having beacons and a Satphone.

“Help us help you”

Health

- protecting public health at the maritime border: Yacht Anita seized Sep ‘20

Economy

- Revenue protection, biosecurity, immigration system and asset and infrastructure protection

Kaitiakitanga

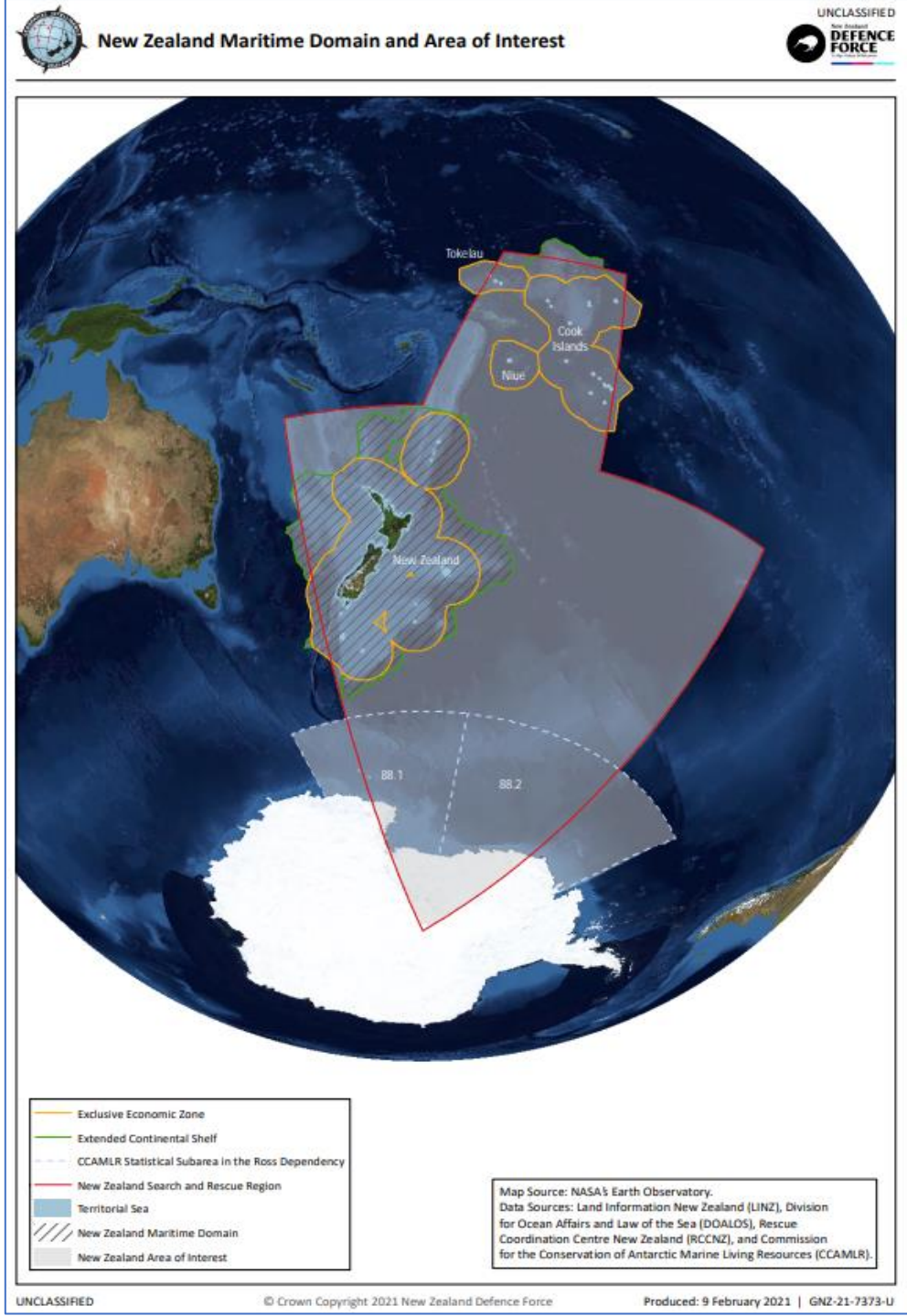
- Environmental protection including Maritime Protected Areas and Offshore Islands, tracking vessel emissions, protecting maritime cultural identity, living and non-living resources
  - Illegal pet landings and 304 marine reserve breaches (last 2 years)

Resilience & Security

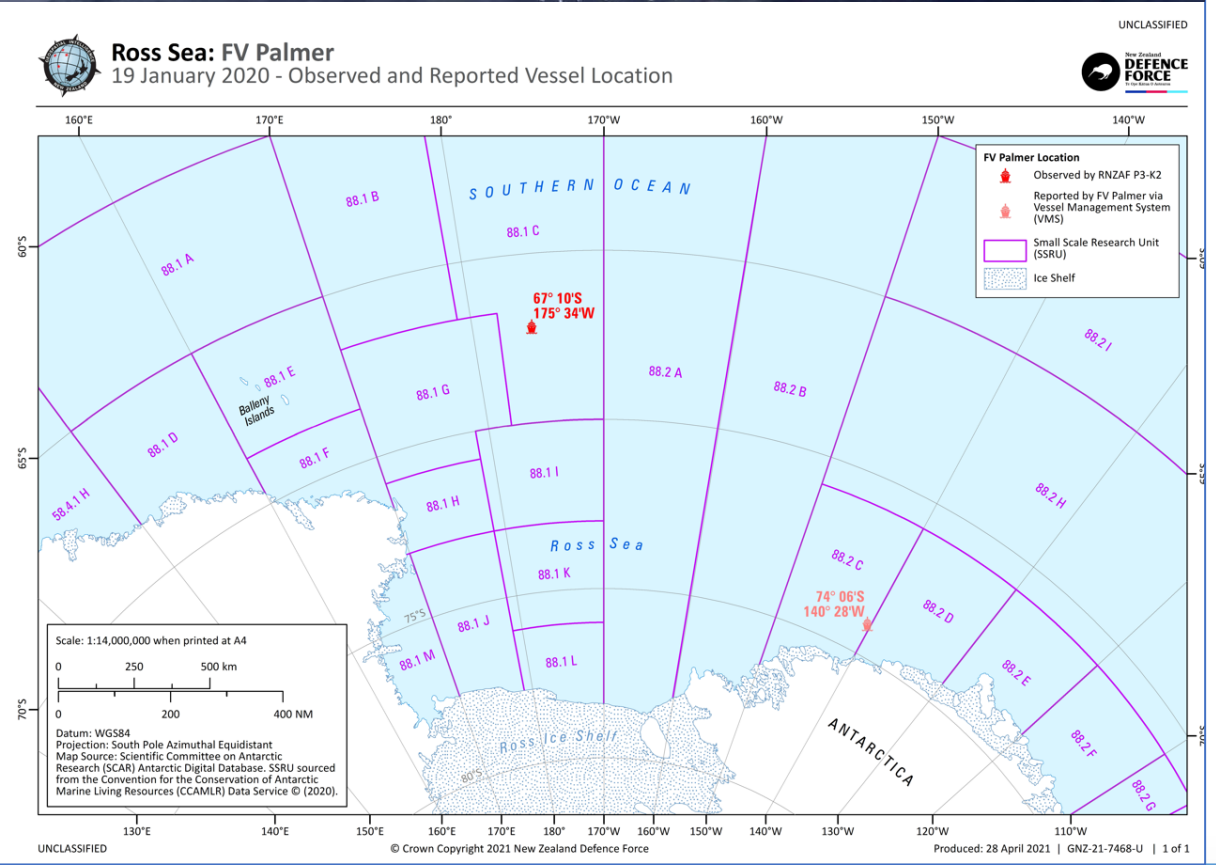
- Social and other benefits of allowing people to travel and engage with the world, while keeping out criminals, drugs, fraudulent and dangerous goods: Operation Essex Apr ‘19. Whakatāne fishing charter RV with unidentified catamaran for an at-sea 500kg methamphetamine transfer

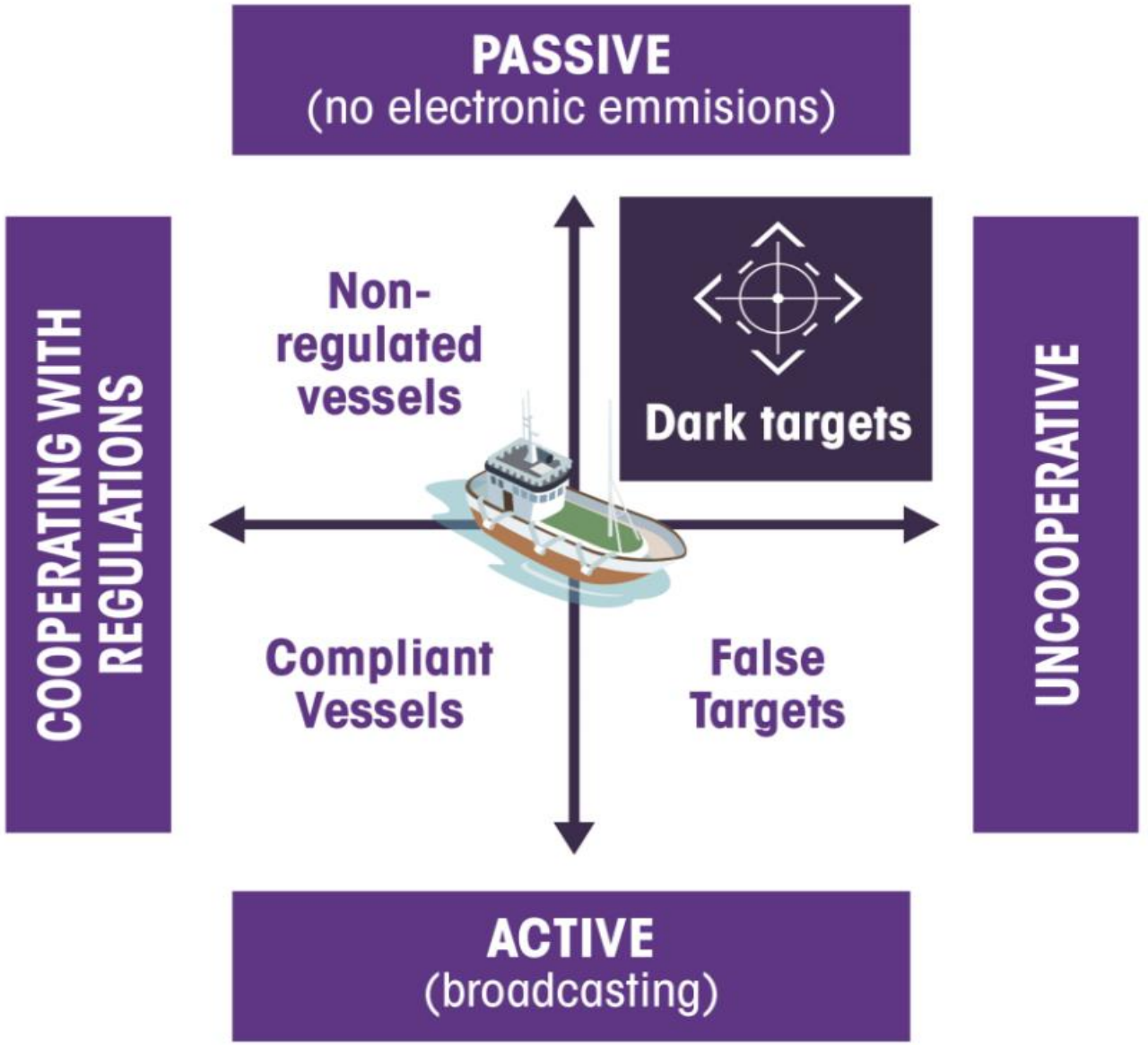
Challenges of tracking?

- Our area is big
  - Maritime Area of Interest at 40mkm^2 is 1/12th of the globe
- Compounded by typical vessel size in our area
  - small craft = 10m
  - Southern Ocean fishing vessels which are relatively small = 45M
- Small Craft:
  - Often fibreglass construction which gives low RADAR return
  - Emit negligible signatures (RF, light, heat)
  - Not required to report their position (more on that later….)
- Extensive year-round cloud and the roaring forties = relatively rough seas
- And dependence on co-operation…

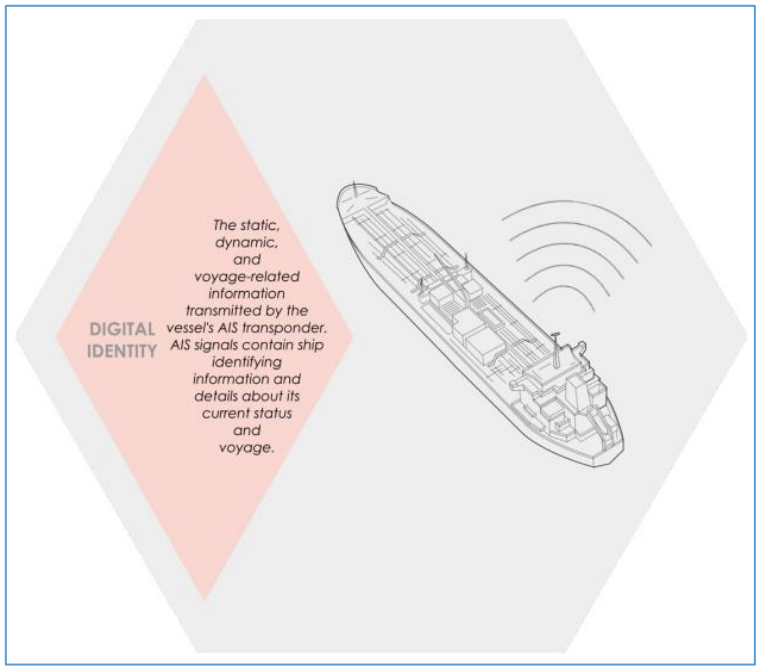


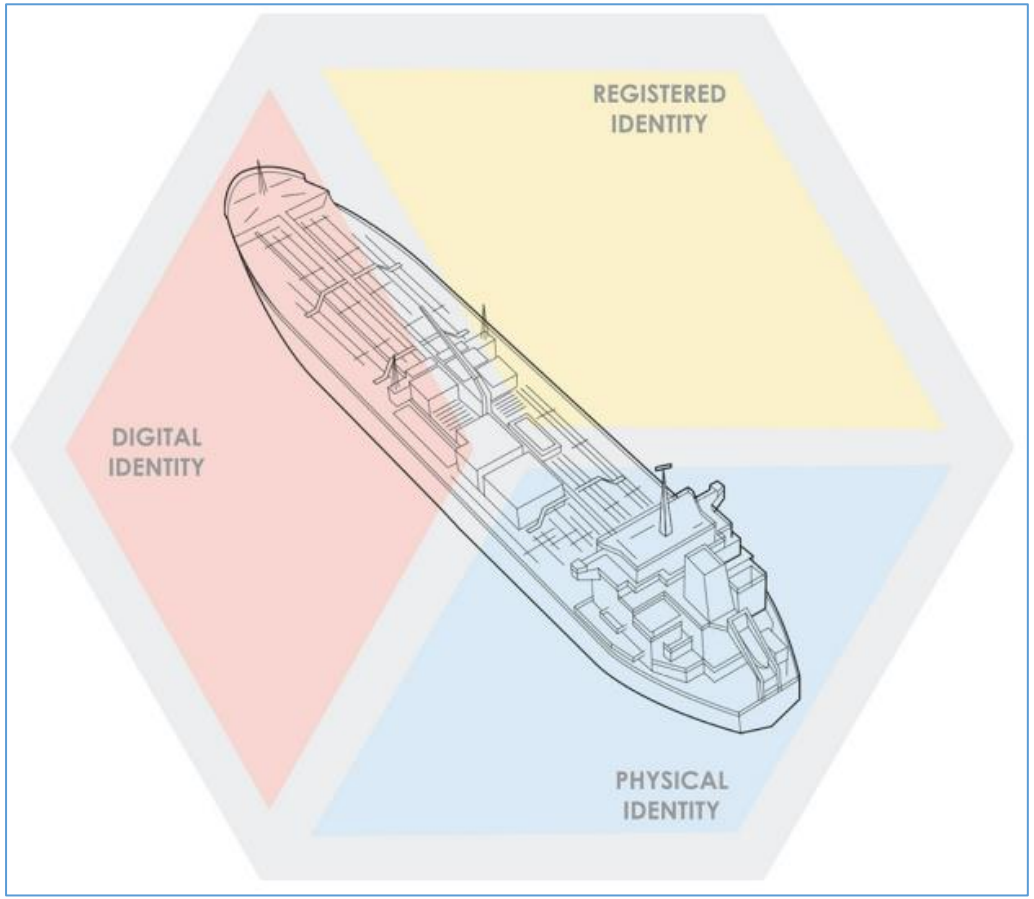
Dependence on cooperation

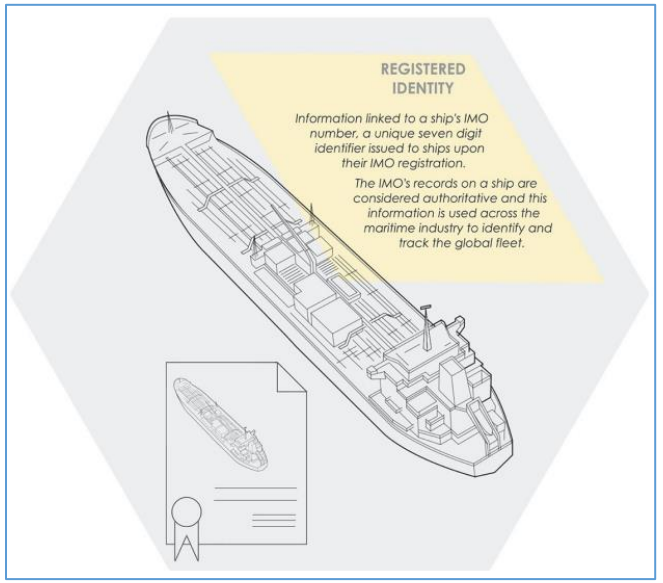


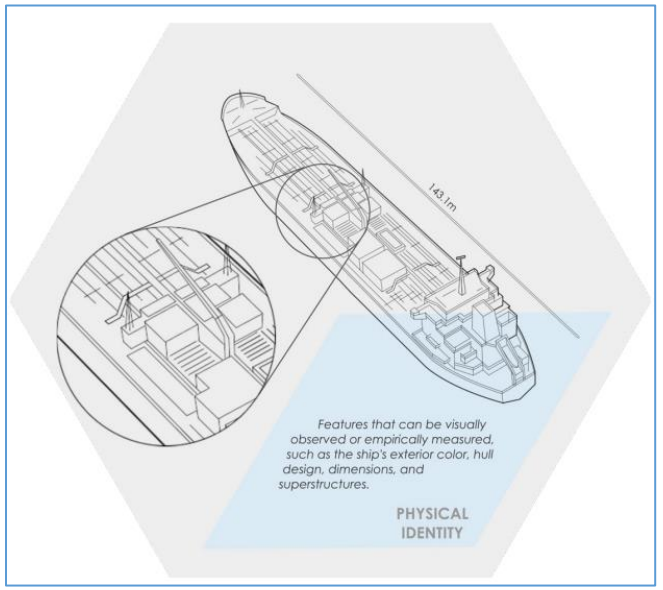


What to track?





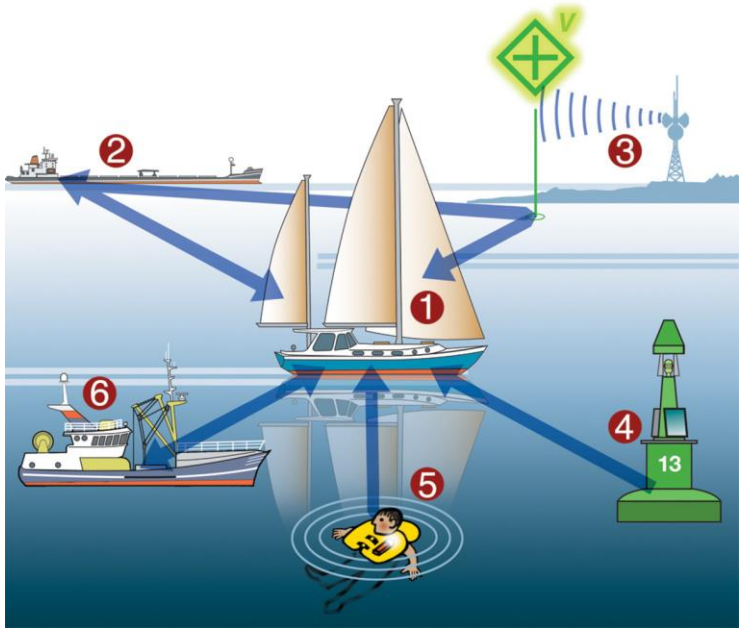




Courtesy of C4ADS: Unmasked Vessel Identity Laundering

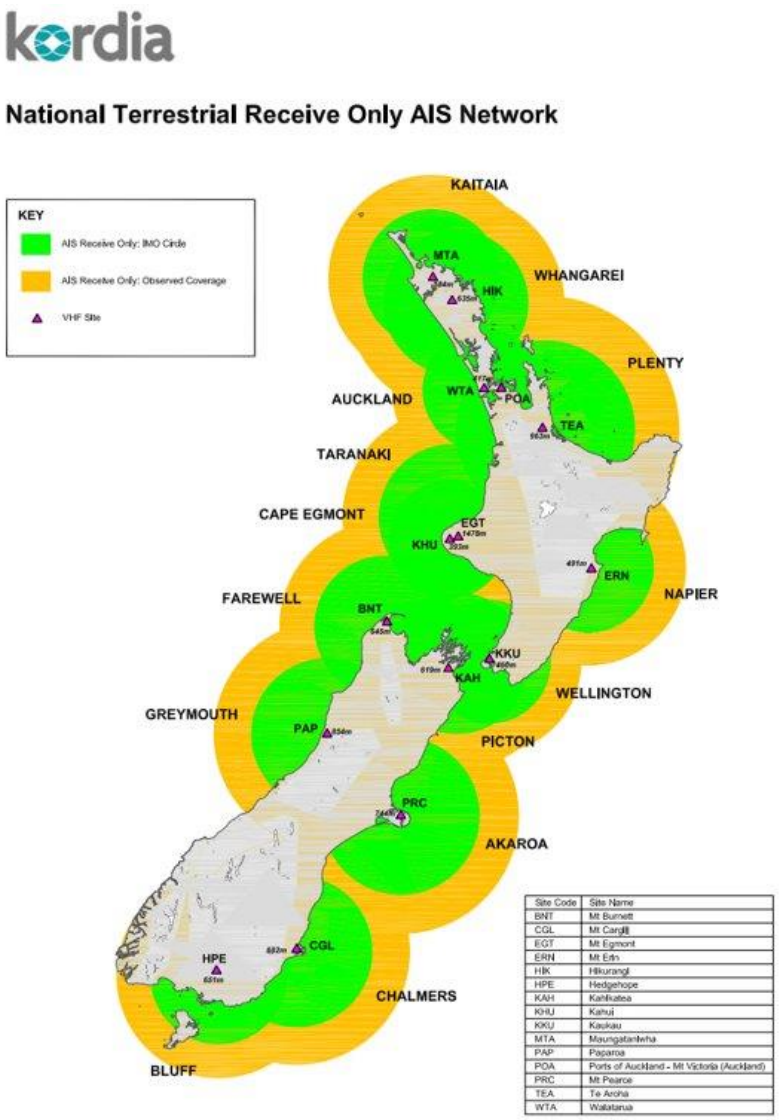
What is the Automatic Identification System (AIS)?

- **Maritime Vessel Collision Avoidance System**
  - Vessels are fitted with an AIS Transceiver which broadcasts unsolicited digital messages over VHF
  - Other AIS equipped vessels in the area receive those broadcasts and plot that vessel's position in their electronic charting system
  - And vice versa
  - Cooperative system; relies on all parties operating their AIS correctly and when required
  - Class A AIS is mandatory for SOLAS class vessels
  - **Class B AIS optional to fit, and optional to operate for all other vessels**
    - Lower transmit RF power
    - Transmits less often
    - Two standards – Class B-CS and Class B-SO (aka Class B+)
    - Skippers may have legitimate reasons to turn it off
  - AIS also used in SAR transponders, Aids to Navigation (AtoN), port Vessel Traffic Services (VTS), SAR Aircraft



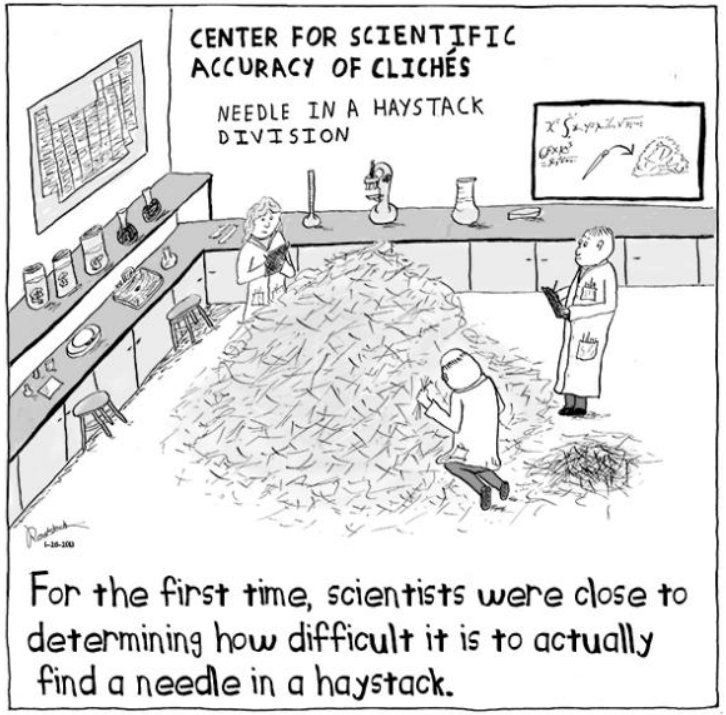
Automatic Identification System (AIS)

- **Maritime Surveillance**
  - AIS is exploited for maritime surveillance via terrestrial and space-based AIS receivers
  - NZ Govt Agencies have access to the Kordia AIS service:
    - Kordia NZ's 15 terrestrial receivers
    - ORBCOMM satellite constellation receivers
  - But its passive; receiving AIS signals is incidental and not guaranteed
  - Terrestrial receivers offer high probability-of-detection but range is limited to the RF horizon
  - Satellite receivers offer global coverage but lower probability-of-detection <20%



Small Craft Tracking – Needle in a haystack?

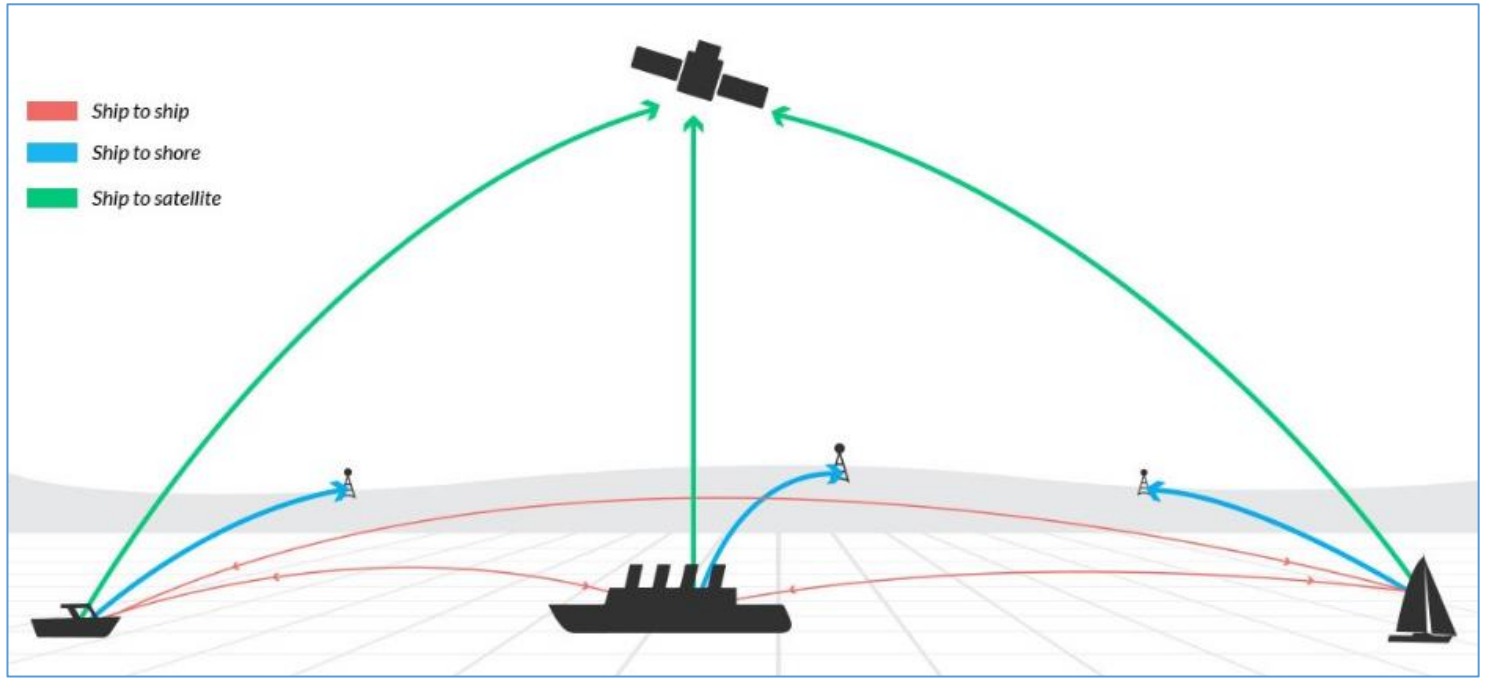
- Across NZ agencies there is no common definition of Small Craft based on physical size or use, therefore, for the purposes of this discussion....
- Small Craft are:
  - **Recreational vessels engaged in international voyages**
  - **Not** required to report their position
- Tracking is:
  - Detect, Classify, Identify, and Track Small Craft on the **High Seas**
- Our Approach:
  - First shrink the haystack using **Cooperative Surveillance**
    - Entities knowingly share their identity and position
  - Then find the needle using **Non-cooperative Surveillance**
    - Entities don't do anything to enable tracking and probably don't know they are being tracked
  - But single source data is **not acceptable** (NATO operating procedures)
    - Use secondary sources of data to validate the primary sources



Cooperative Surveillance

1) Class B AIS

2) Self-reporting Services

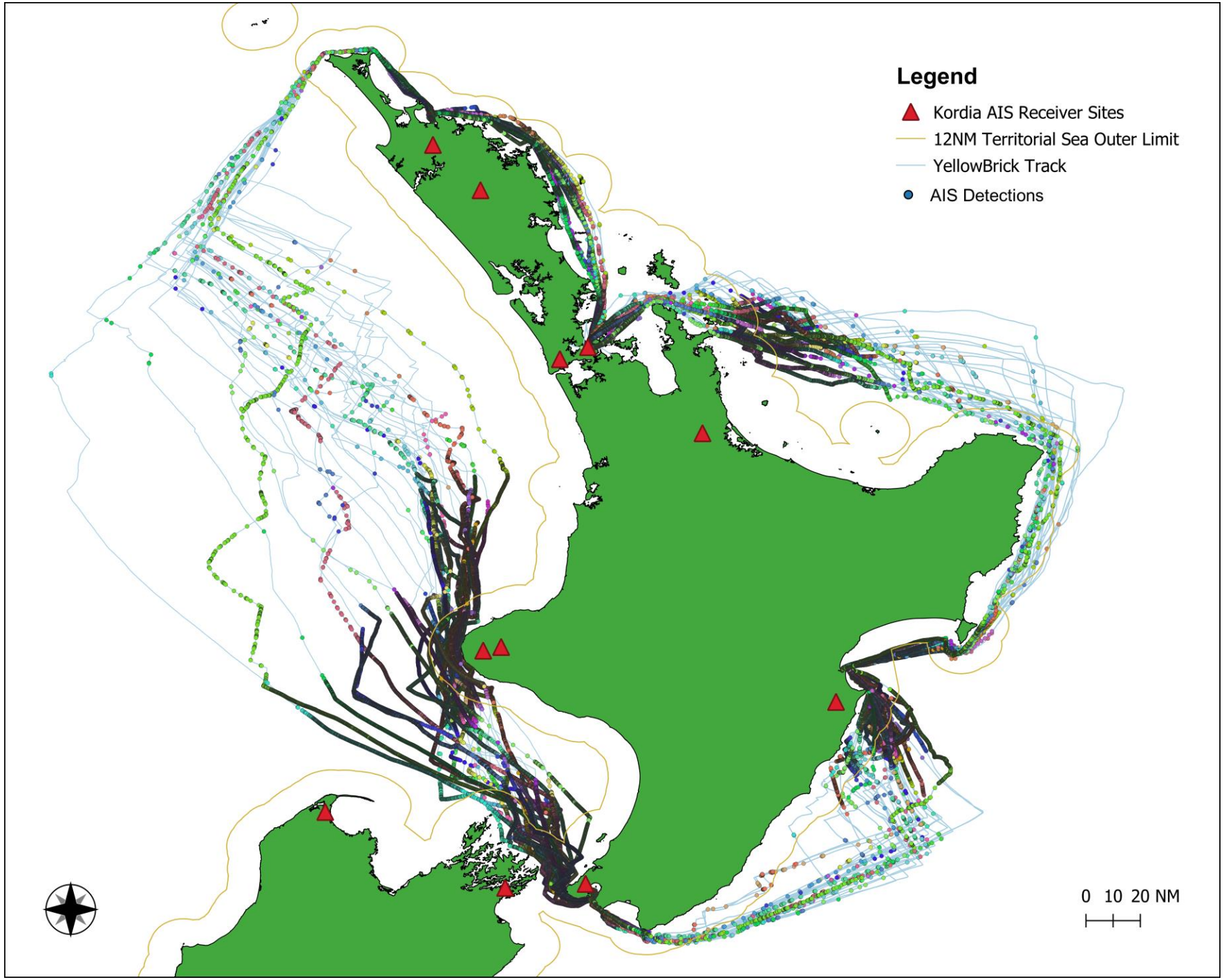


Cooperative Surveillance 1 - Class B AIS & RNI2020

- 2020 Two-handed Around the North Island yacht race (RNI2020)
- All yachts required to **fit and operate** Class B AIS and an Iridium based Yellowbrick Tracker
- This offered us a chance to analysis AIS detections of 30+ small craft when we knew they had AIS on
- We obtained terrestrial and satellite AIS detections from NZ Kordia AIS Service
  - Plotted AIS detections and YellowBrick tracks in a GIS
  - Surveyed yacht owners about their AIS installation

RNI2020 AIS Detections All sources

Race Rules required Class B AIS to be operated



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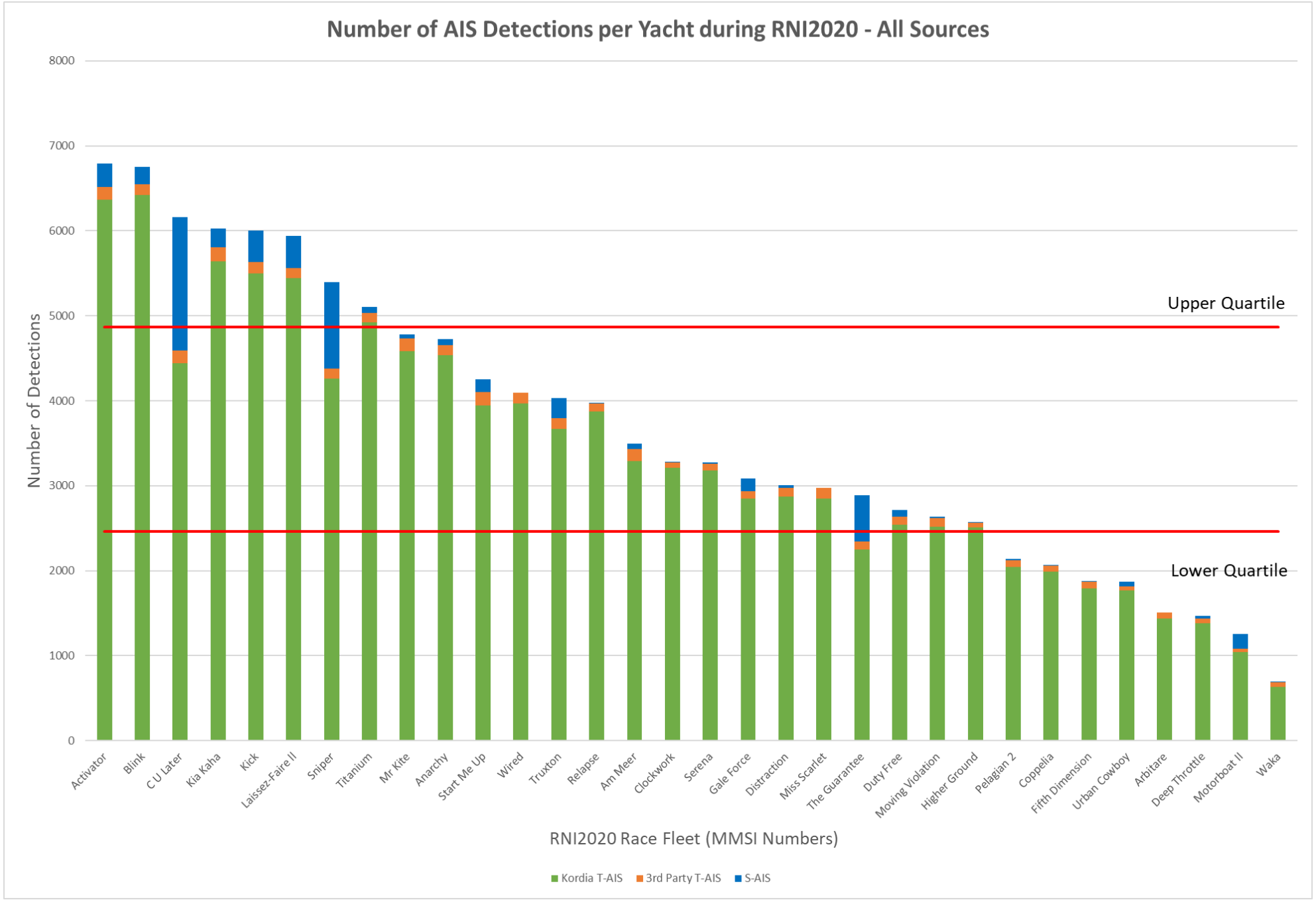
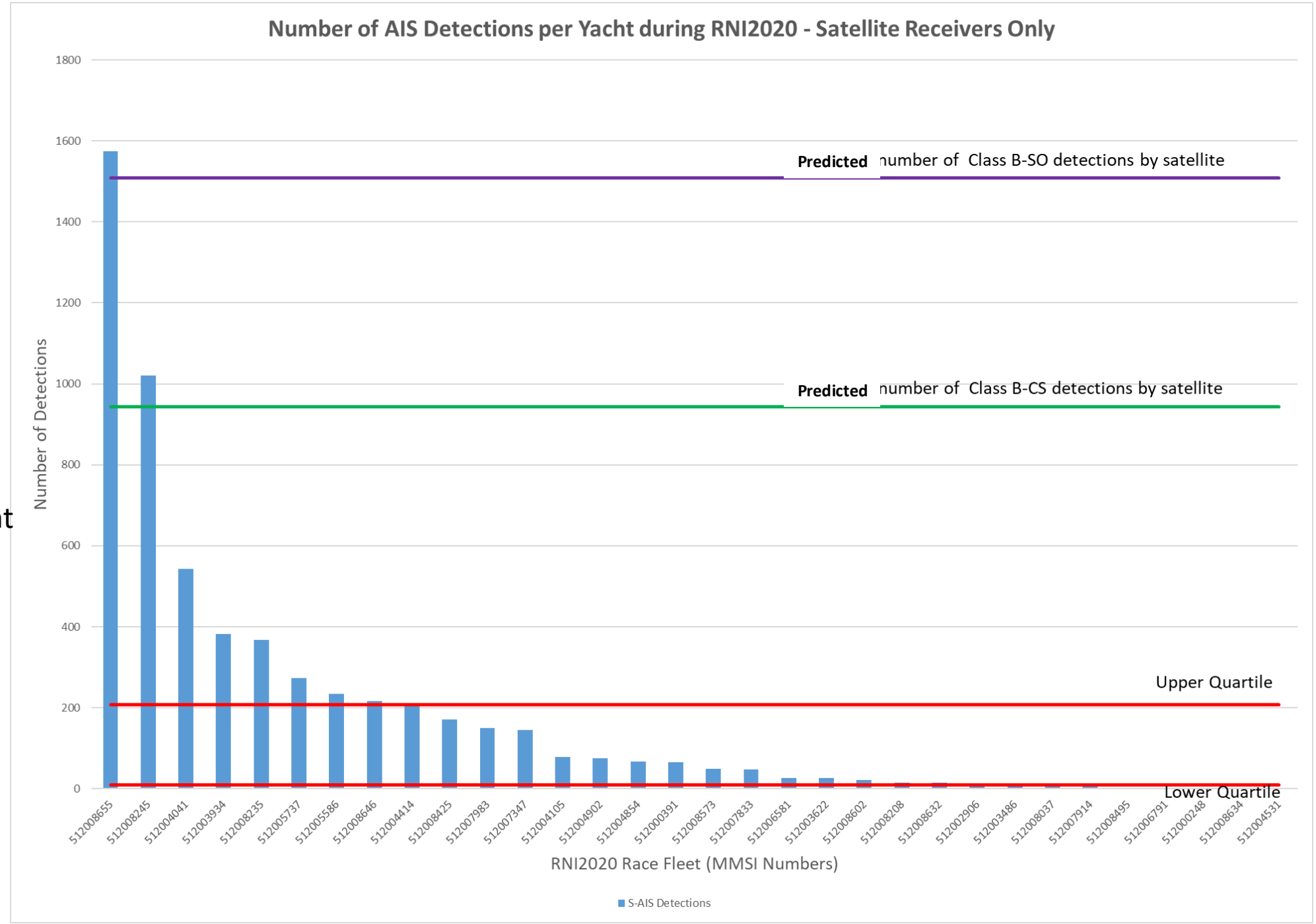
Data normalised to finish time of first yacht



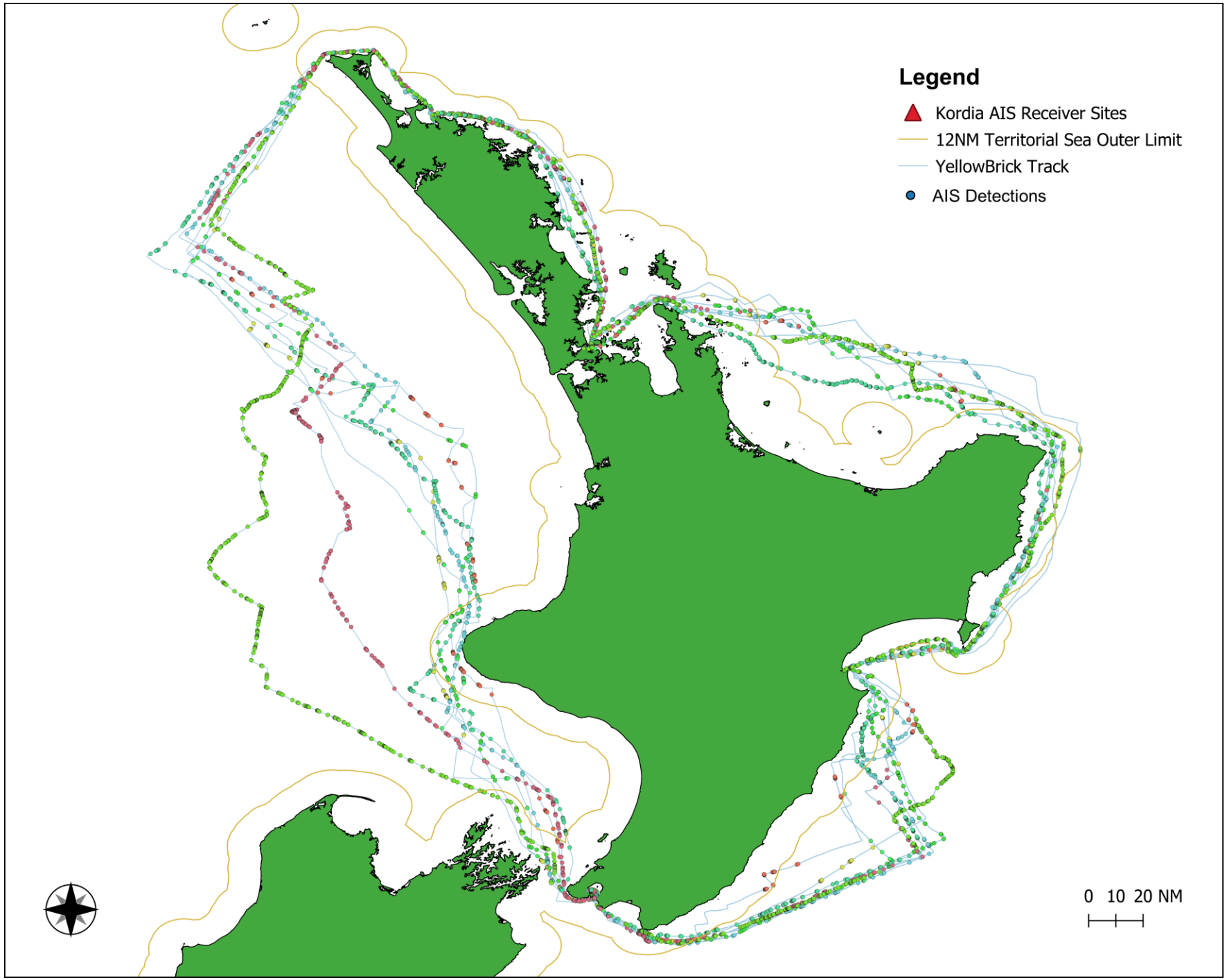
RNI2020 AIS Detections Satellite only

Race Rules required
Class B AIS to be operated
Data normalised to finish time of first yacht



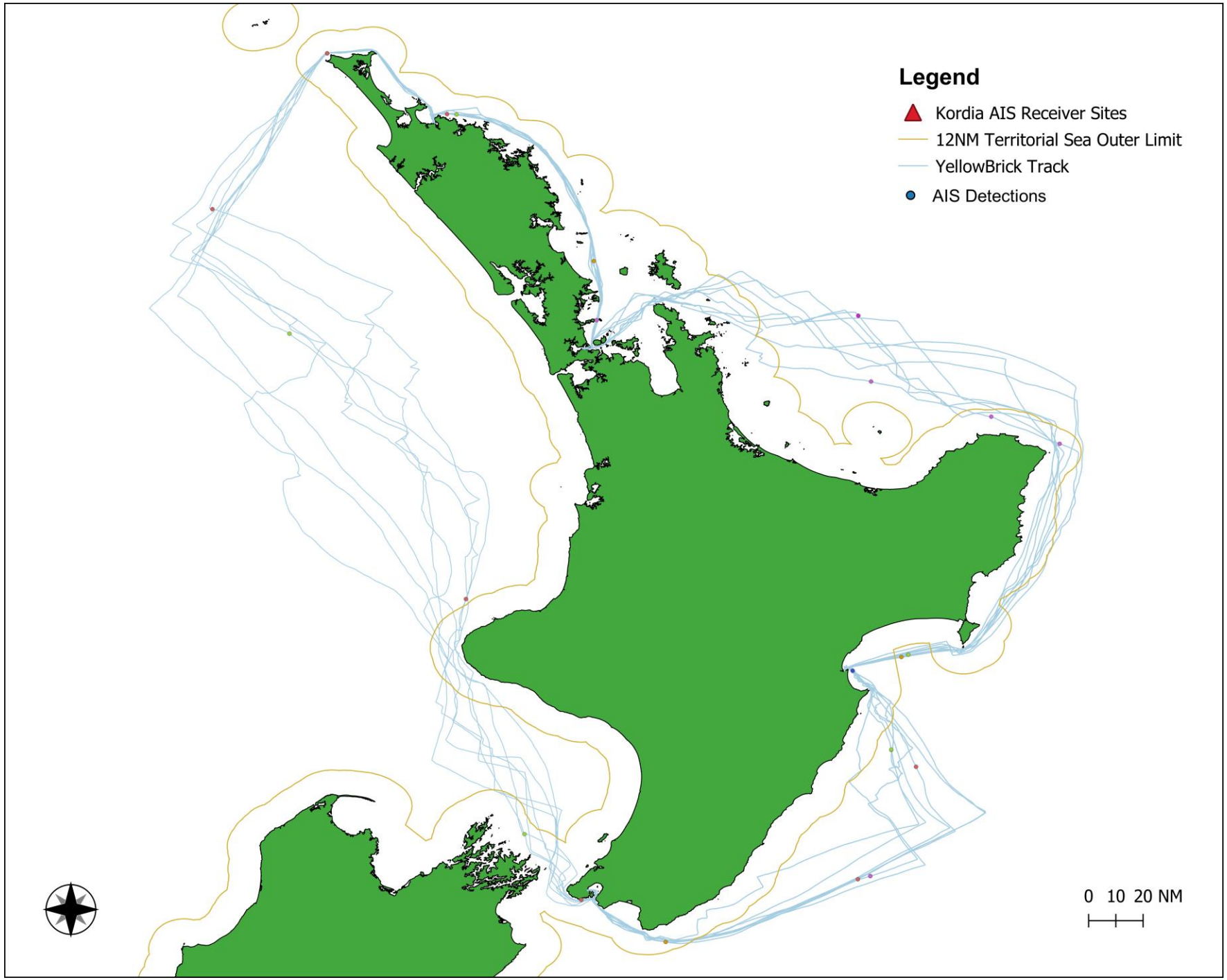
RNI2020
AIS Detections
Satellite only
upper quartile

Race Rules required Class B AIS to be operated



RNI2020
AIS Detections
Satellite only
lower quartile

Race Rules required Class B AIS to be operated

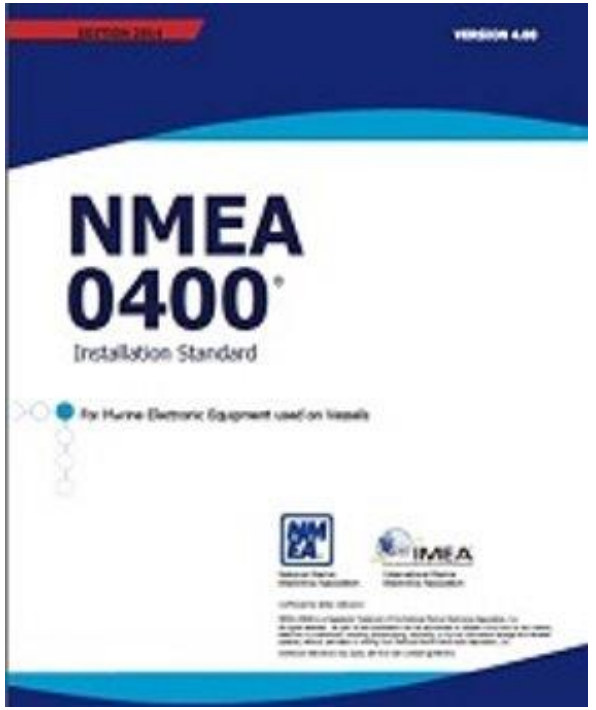


Class B AIS – RNI2020 Results

- Significant variance in the number of observed detections between vessels
- This was unexpected given 30+ similar yachts were in about the same place at about the same time
- A number of vessels had **0%** probability of detection by satellite
- Of the skippers who responded to survey, differences in the AIS installation configuration
  - Manufacture of AIS transceiver
  - Class B standard – SO or CS
  - Location of antenna - mast head or rail height
  - Type of antenna – fibreglass or 1M SS whip
  - Dedicated AIS antenna or shared with VHF marine radio antenna via RF splitter

Class B AIS - Installation Standards

- Vessel owners are investing in AIS equipment in the belief it makes their vessel more visible – but is it?
- No Class B AIS installation standards in NZ
- In collaboration with the MoT and MNZ we developed draft standards based on a literature review – mainly the NMEA 0400 Installation Standard
- However, the standards can be difficult to achieve practically
- Anecdotal observations - poor compliance is widespread
- Fundamentally, the quality and configuration of the installation influences the **RF power radiated by the antenna**
- Therefore we can assume that ship-to-ship AIS performance is impacted as well
- Will be conducting at sea testing of 3 different installations early 2023
- Exploring ways to remotely monitor the AIS RF performance of passing vessels
- Emphasis on AIS Collison Avoidance and Safety aspects



Cooperative Surveillance 2 - Self-reporting Services

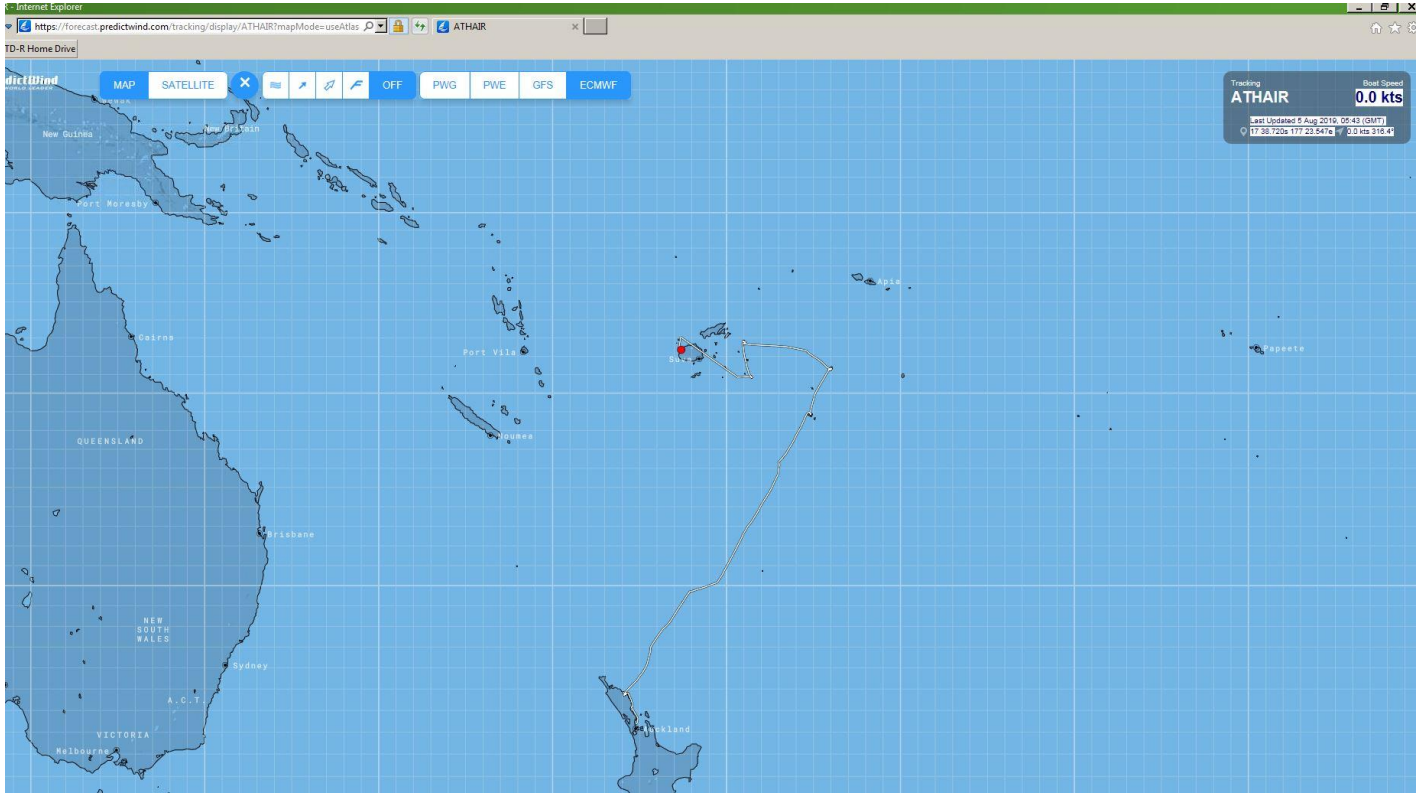
- Many vessel owners/skippers choose to self-report their vessel's position to public websites
- Keeps friends, family, sponsors informed
- Some sites allow blogs and photos to be posted
- Sites include Sailblogs, PacSeaNet, PredictWind, YIT, Yellowbrick, some even have YouTube channels, maybe other sites?
- Active reporting – 100% probability-of-detection (if everything is working as it should)

https://www.yit.nz/
https://pacseanet.blogspot.com/
https://www.sailblogs.com/
https://www.ybtracking.com/

PredictWind.com

- NZ company that provides optimised weather data to customers
- Popular with blue water yachties and has a good international reputation

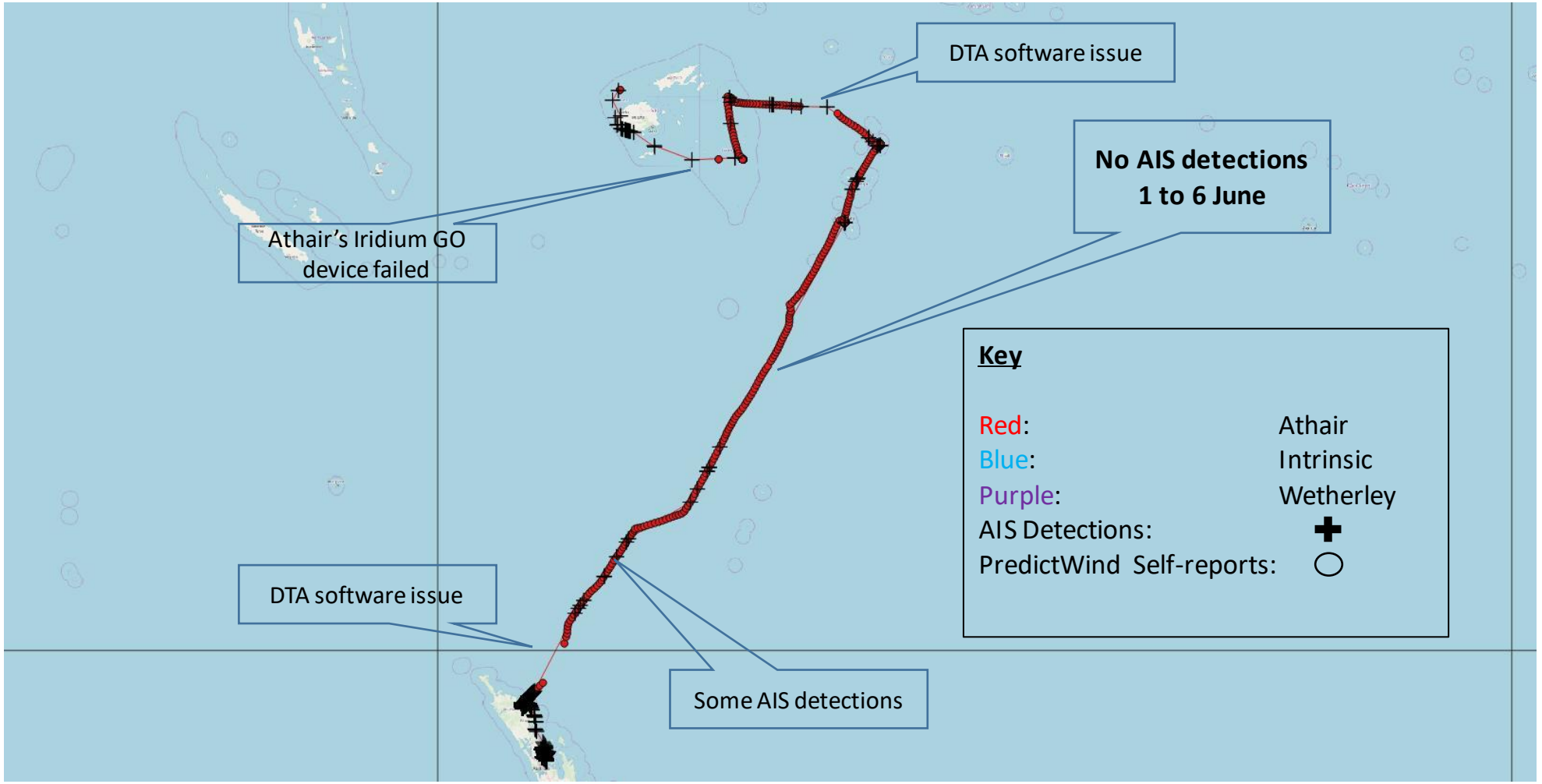
- Also offers a self-reporting vessel tracking service
- If you know the URL, anyone can view a dedicated webpage to see the position of the vessel concerned; https://forecast.predictwind.com/tracking/display/athair



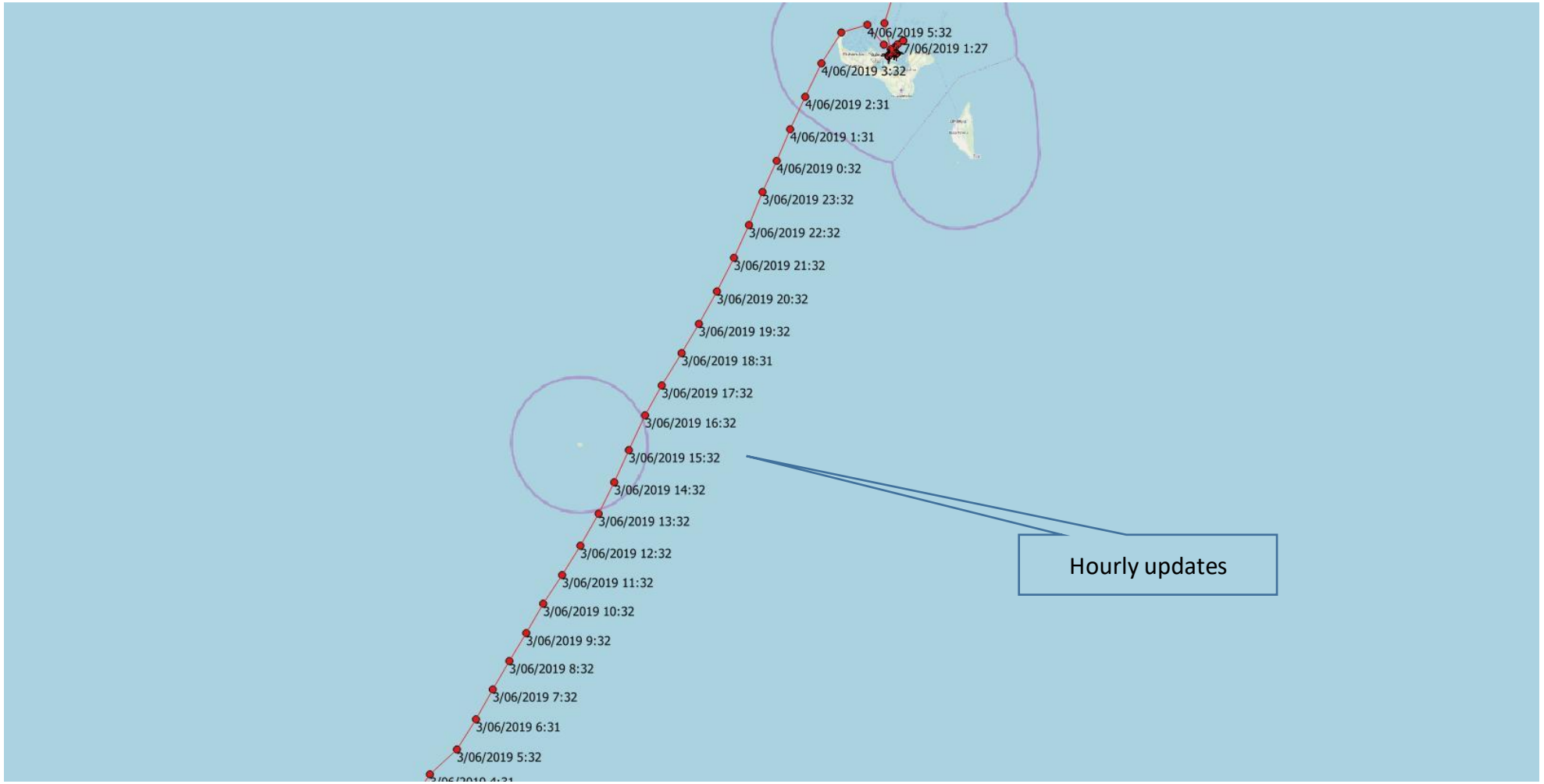
Self-reporting Trial - 2019

- DTA obtained permission from three vessel owners to track them heading north for the winter cruising season
  - Athiar
  - Intrinsic
  - Whetherly
- All three were PredictWind subscribers and fitted with Class B AIS
- Vessel owners asked not to do anything different
- We logged their self-reports
- Retrieved AIS data for the same three vessels from the Kordia AIS archive
- Plotted both datasets in a GIS

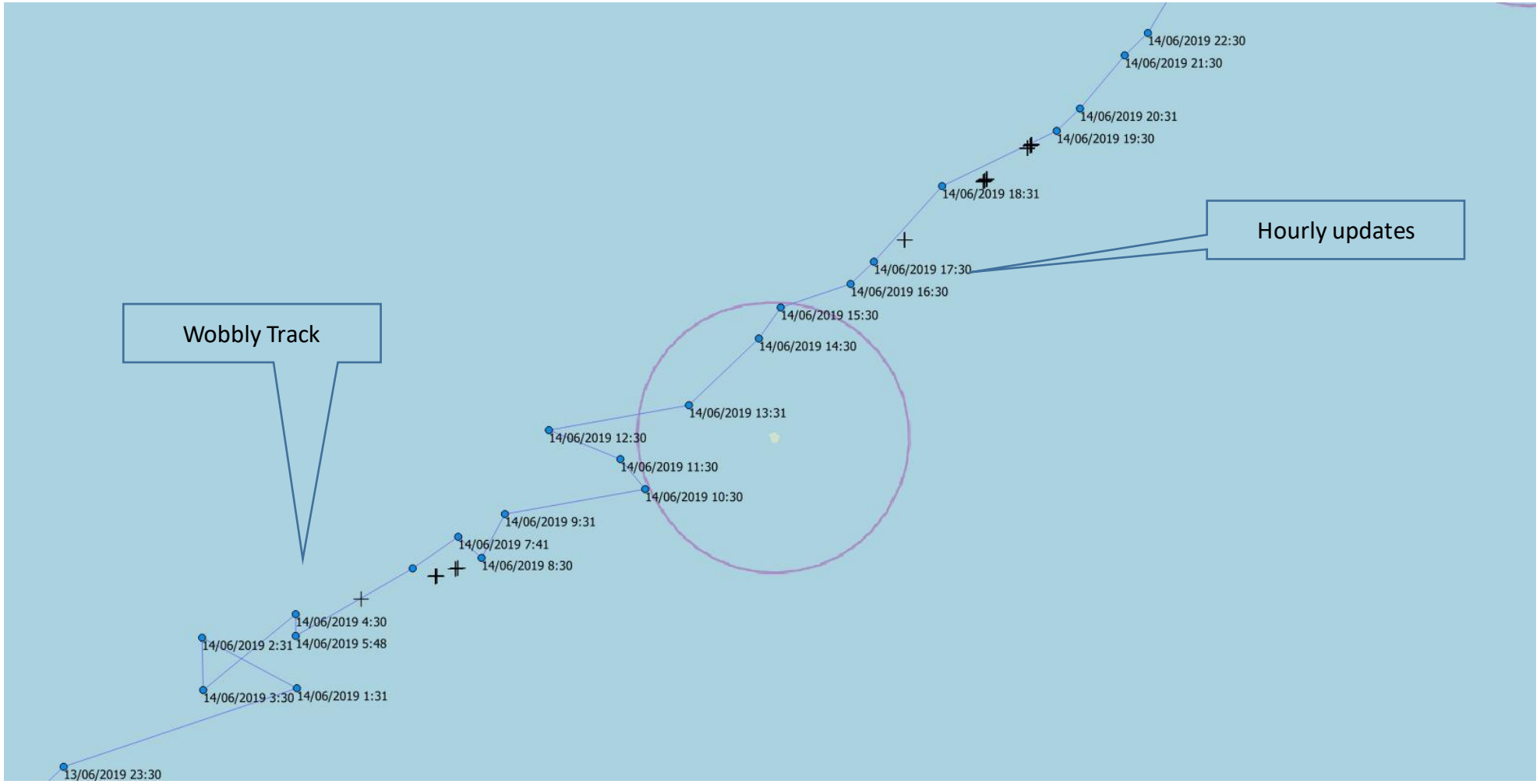
Results - Athair



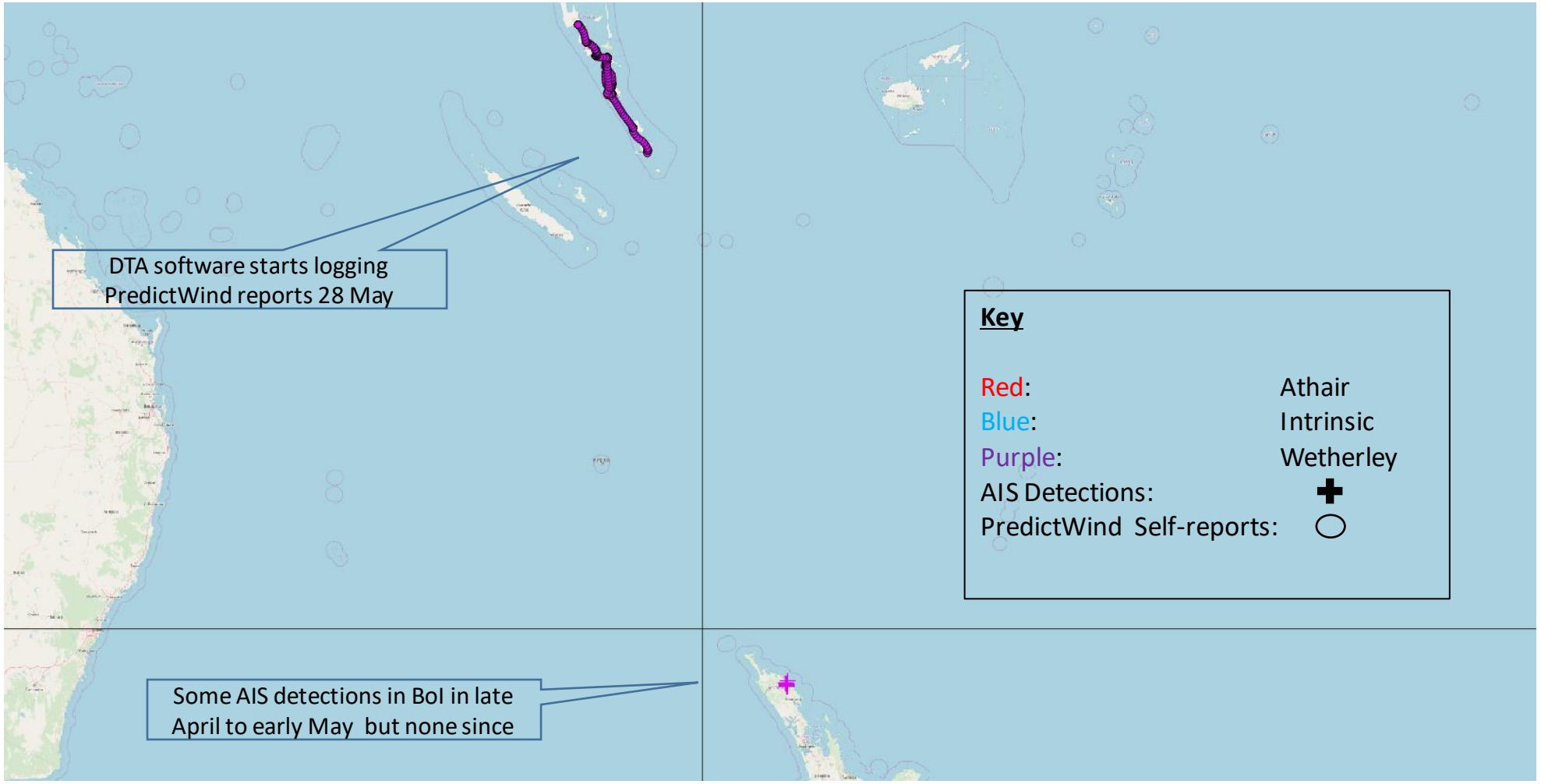
Results - Athair



Results - Intrinsic



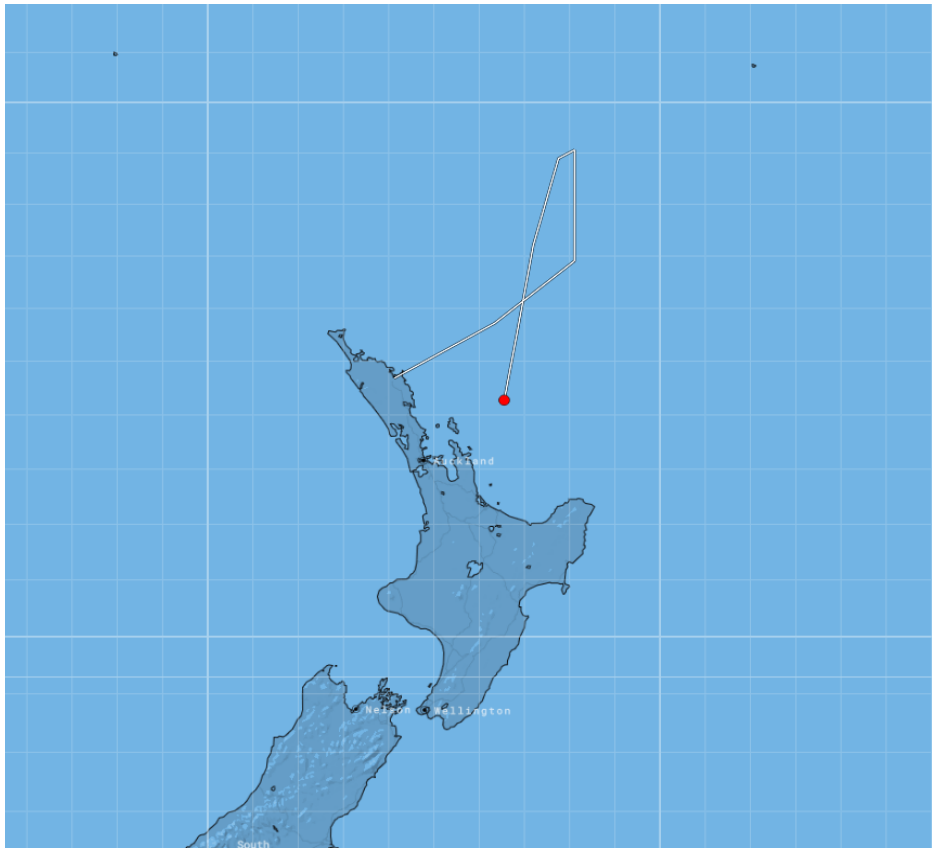
Results - Whetherley

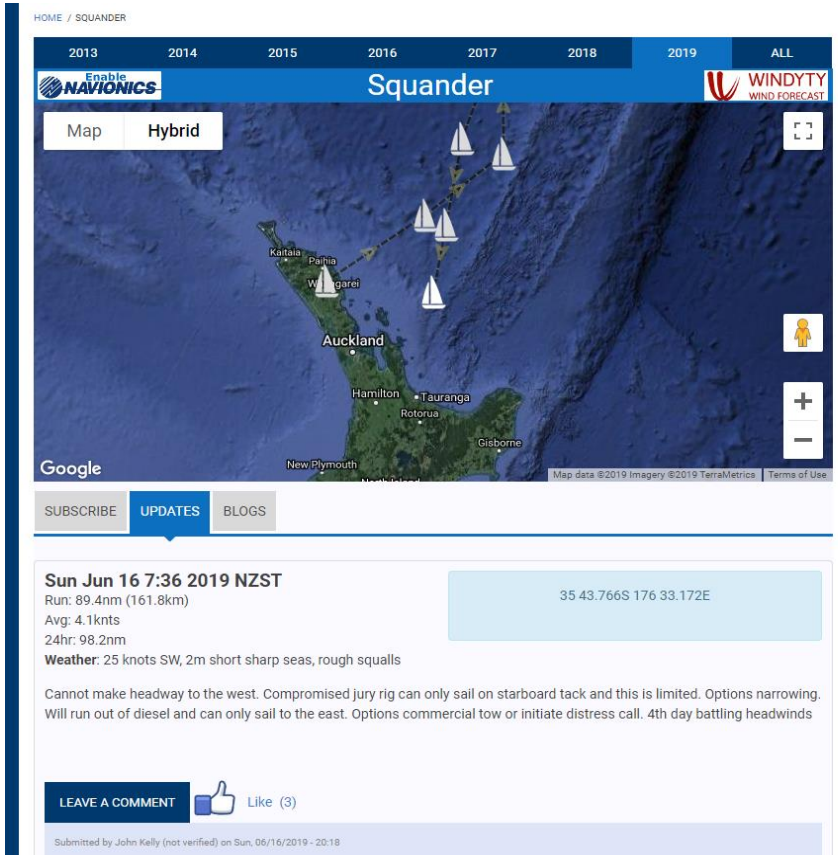


Other Observations - Self-reporting Services

- All three vessels occasionally blogged
- Provided useful information on their current status and intentions:
  - INTRINSIC - June 9 - “*Now heading north to Minerva Reef where we plan to stay a couple of days*”
  - ATHAIR - July 16 – *“…. the Iridium GO broke….”*
- Owners tend to subscribe to self-reporting services just before an overseas trip
- Vessel Identifiers used to self-report can be ad hoc and sometimes it's difficult to establish the vessel’s actual identity e.g. "This is the life"

SAR of SV SQUANDER – June 2019





Squander

DESCRIPTION

14.15m Jeanneau, Sun Odyssey, masthead cutter rigged sloop. White with blue trim. Manufactured in France 2003. She has had 2 previous live aboard owners who have sailed her extensively in English, French, Mediterranean, North African, Atlantic, and Pacific waters. Purchased in 2012 by us she has sailed the east coast of Australia from Sydney north to Darwin and returned. Our current intention is to sail the Down Under Go East rally to New Caledonia.

June 16 - "Cannot make headway to the west. Compromised jury rig can only sail starboard tack…. Options commercial tow or distress call…"

Exploiting Self-reporting Services – Options?

- Three potential options:
    - Web scraping existing sites
    - Buy the data as a service from existing service providers
    - Build a government owned self-reporting service
- Have proposed a survey of the blue water cruising community to understand:
    - Which self-reporting services do they use now and why?
    - How comfortable would they be sharing information with NZ Govt agencies?
- Regardless of option, we recommend a transparent approach where vessel owners opt in to sharing information with NZ Govt agencies

Cooperative Surveillance - Takeaways

- Detection of small craft while on the **high seas** via AIS is **not** assured
- The **quality and configuration** of the AIS installations is likely to be a contributing factor
- Self-reporting services could **compliment and validate** AIS for tracking small craft on the high seas
- Self-reporting services can also provide indications of **vessel status** and **skippers intentions**
- However, the **accuracy and frequency** of self-reports is **dependent** on the reporting vessel

Non-Cooperative Surveillance

1) Commercial Space-based Surveillance

2) Acoustics Buoys

Non-cooperative Surveillance 1 – Commerical Space

- Commercial companies now offering surveillance capabilities once the preserve of the military
  - Radio Frequency (RF) - Passive detection of RF emissions to geo-locate their source e.g. marine navigation RADAR
  - Synthetic Aperture RADAR (SAR) - a sequence of active RADAR returns received by a smaller antenna combined in a way to simulate a larger "synthetic" antenna
  - Electro Optical/Infra-Red (EO/IR) - imaging an area of the ocean in the visible and near-infrared spectrum.
- Each technology has pros and cons
- Irrespective of technology, detection of small craft is challenging
  - Emit little
  - Size and construction
  - Sea and weather conditions
- Probability of detection is also reliant of their being a satellite overhead at the right time
- And a significant cost; $5k to $10k per scene/collect

Non-cooperative Surveillance 2 – Acoustic Buoys

- University of Auckland (UoA) has been exploring the concept of buoys fitted with underwater acoustic sensors to monitor sensitive marine areas e.g. Goat Is
- See https://liveocean.com/project/buoys-that-listen/
- UoA have demonstrated using the buoy to cue a shore based camera once a vessel is detected
- A buoy offers some advantages for maritime surveillance
  - Self contained (sensor, power, comms)
  - Persistent
  - Sensors could be changed to suit the application; under water acoustics, RF, AIS, and/or cameras
  - Relatively low cost

Non-cooperative Surveillance - Takeaways

- Probability-of-detection of small craft from space can be **low**
- Commerical services can be **expensive**
- These constrain their ability to offer **reliable wide area persistent surveillance** for the detection of small craft
- Future work could explore using low-cost sensor systems, such as buoys, **to cue** high-cost space-based sensor systems to the monitor areas of high interest/risk
- But the commercial space market is **evolving**, and capabilities and constellations continue to grow...

DTA "Kuaka" Small Craft Tracking Trial

Feb-Mar 2023

Kuaka – Eastern Bar Tailed Godwit

Migratory birds that arrive in the Hauraki Gulf every summer

which is akin to the mass arrival of international cruising vessels in New Zealand waters

for the summer cruising season

Small Craft: *"Recreational vessels engaged in international voyages"*

Kuaka Trial 2023

- DTA lead trial
- Three identical yachts operating together each fitted with a different AIS installation configurations
- Supported by Navy and Customs
- Hauraki Gulf
- 21 Feb – 3 March 2023
- Will trial many of the things discussed today
  - Class B AIS installation standards
  - Remote monitoring of AIS RF performance
  - AIS Search and Rescue transponders
  - Self-reporting services
  - Acoustic Buoys
  - Commercial space-based surveillance

Summary

- Working towards recommendations for practical Class B AIS installation standards
- Also exploring how to remotely monitor the RF performance of installations
- Exploring other forms of cooperative and non-cooperative surveillance
- At sea trial planned for Feb-Mar 2023

Discussion topic…..?

Balancing freedom and privacy vs surveillance

- Extending the current international regulatory regime (SOLAS) to all vessels on international journeys would bring multiple benefits but at what price?
  - Impact on freedom and privacy
- But doesn't use of that commons come with responsibilities?
  - Cost of delivering SAR service in remote areas with relatively small tax-bases
    - Responsibility for users to provide the best locational information to aid the pinpointing of scarce rescue assets?
  - Katiakitanga: ensuring our natural environment remains intact without imposing an onerous resourcing burden on taxpayers.
    - Users help through provision of positional information?

Discussion & Questions?