Australian Government
Australian Fisheries Management Authority

Vessel Monitoring Systems

AFMA EDUCATION GUIDE

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Securing Australia's fishing future
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Contents

Introduction

The Australian Fisheries Management Authority (AFMA) is the Australian Government agency responsible for the efficient management and sustainable use of Commonwealth fish resources on behalf of the Australian community.

Vessel Monitoring Systems (VMS) are an essential part of managing fisheries and monitoring compliance with fisheries regulations. This guide is a general overview of what AFMA believes to be best practice for implementing a VMS program for fisheries compliance. It does not constitute formal advice or a recommendation. Instead, it introduces VMS to those interested, including governments, vessel operators and researchers.

For more information, please visit https://www.afma.gov.au or contact ausvms@afma.gov.au.

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1	July 2026		Tod Spencer, Senior Manager, National Compliance Operations
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1 What is a Vessel Monitoring System (VMS)?

A Vessel Monitoring System (VMS) is a system that provides information on a vessel's position, course and other vessel data to the fisheries management agency or authority.

VMS is used to:

- ensure vessels are fishing in permitted areas
- monitor fishing activity in protected areas
- detect port entry and exit events
- conduct targeted inspections of fishing vessels.

VMS tracks vessel position and movement in real time, allowing fisheries agencies to monitor vessel activity. It consists of three key components:

1. VMS Unit (also known as an Automatic Location Communicator (ALC) or Mobile Transceiver Units (MTU))
2. Communication networks
3. VMS software.

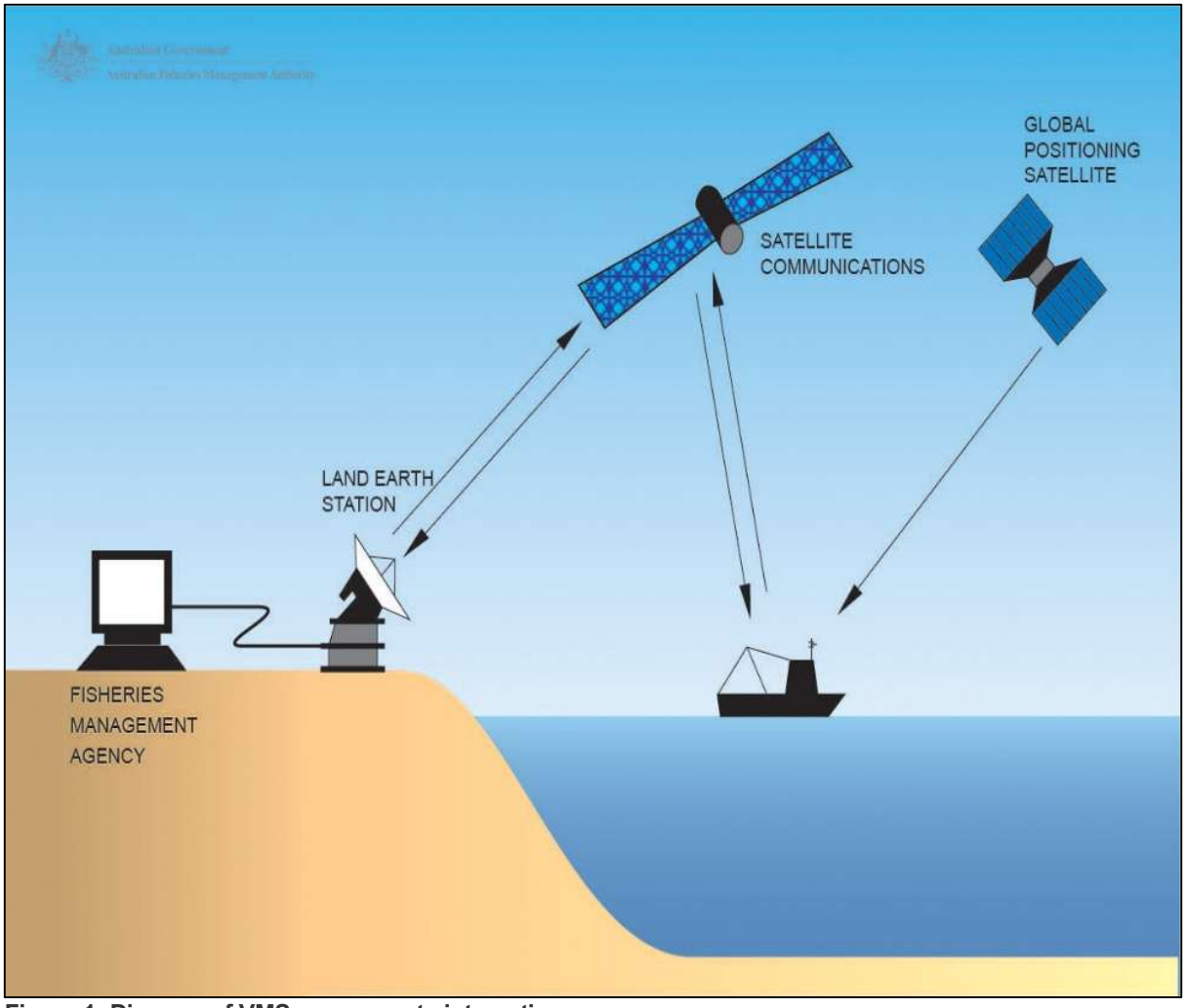


Figure 1: Diagram of VMS components interacting

1.1 VMS Units

A VMS unit is the hardware installed on a vessel that receives and sends the vessel's position to the fisheries agency. They are also known as Automatic Location Communicators (ALC) or Mobile Transceiver Units (MTU). VMS units calculate the vessel's location using the Global Positioning System (GPS). VMS units transmit the following data:

- date and time
- latitude and longitude
- speed and course.

VMS units can send status messages to the fisheries agency, including when the:

- unit is powered on or off
- signal is lost
- antenna is obstructed.

There are different types and brands of VMS units. Units vary in design, cost, features, and communication networks. Some VMS unit types are better suited to specific fisheries than others. Most countries and regional fisheries management organisations (RFMOs) restrict the types of units allowed to be used by vessels to ensure suitability, reliability, compatibility and cost effectiveness.

Fisheries agencies should test units before approving them for use. When type approving a VMS unit, the following functions need to be considered and tested:

Considerations:

- Compatibility with VMS software[1] and airtime providers.[2]
- Whether VMS data can be integrated into the software, such as by using an Application Programming Interface (API), or other method.
- If solar VMS units are used,[3] whether battery life capacity can last up to one month at desired polling rate.[4]
- Whether the VMS unit is compliant with the relevant RFMO requirements, noting that RFMO type approval can take up to one year.

Tests:

- Reliability of polling rates.
- Battery life of solar units at desired polling rate.
- Suitability for vessel types, sizes and fishing methods.
- Reliability and robustness, including weather resistance, communication and tamper resistance.

The list of approved VMS units should be available to vessel operators. This should specify which units are allowed in each fishery.

[1] For more information on VMS software, visit section 3.1.1.
[2] For more information on airtime, visit section 3.1.
[3] For more information on VMS unit types, visit section 1.1.1.
[4] For more information on polling rates, visit section 4.3.3.

Example: AFMA's type approved VMS units

AFMA publishes its list of type approved VMS units on its website. This list includes the model names and numbers of each unit, as well as the fisheries each unit can be used in.

Figure 2: AFMA type approved units

1.1.1 Types of units

VMS units can be powered or solar. Each has advantages and disadvantages.

Powered units

Powered units are hardwired into the vessel and must be installed by a technician. Powered units use the vessel's electrical system and do not rely on internal batteries.

Advantages:

- Provides constant reporting when powered, even when turned on at night.
- Can provide more features and programming over the air than solar units.
- Fixed to the vessel, therefore more difficult to remove or tamper with.
- More choices on the market.

Disadvantages:

- Usually more expensive to purchase than solar units.
- Powered units require a technician to install them, which is time-consuming and expensive.

Figure 3: Examples of powered VMS units

Solar units

Solar units use rechargeable batteries charged by solar panels and do not need to be installed by a technician. They still need to be securely attached to the vessel, such as with bolts, glue or zip ties.

Advantages:

- Cheaper to purchase than powered units.
- No installation costs because they do not have wiring.
- Generally reliable as most have sufficient battery life for standard polling intervals and/or cables for external power charging.

Disadvantages:

- Solar units can be moved between vessels, allowing for fishers to illegally place units on unauthorised vessels.
- Solar units usually have fewer features than powered units.
- Solar units can be unreliable at night.
- High reporting frequency (<15 minutes) reduces battery life.

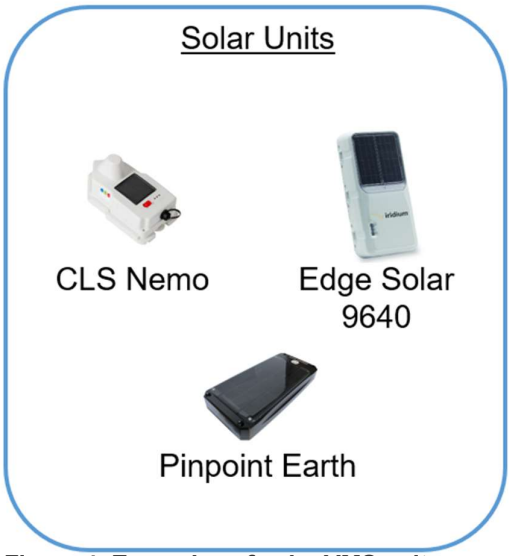


Figure 4: Examples of solar VMS units

1.2 Communication Networks

VMS units use three main communication network types:

- satellite
- cellular
- hybrid systems that switch between satellite and cellular, depending on coverage.

These networks transmit vessel position, speed, and course data to the VMS software.

Satellite Networks

Many VMS units operate on satellite networks. Units send data to the fisheries agency via satellite, instead of cellular networks.

The most common satellite networks include:

- ViaSat
- Iridium
- Argos.

Advantages:

- Satellite networks provide near-global coverage, allowing fisheries agencies to receive reports, even when vessels are out of cellular range or on the high seas.

Disadvantages:

- Satellite operational costs are much more expensive than cellular costs, especially for higher polling rates.

Cellular Networks

Some VMS units use cellular networks when operating near shore. The most common networks are the Global System for Mobile Communications (GSM), which operates on 2G, and General Packet Radio Service (GPRS), which operates on 4G and 5G networks. Cellular network range is determined by cellular towers.

Advantages:

- Cellular is cheaper than satellite.
- Cellular is a suitable option for coastal fisheries.

Disadvantages:

- Coverage is generally limited to coastal areas.

Hybrid (Satellite + Cellular) VMS Units

Many VMS units use hybrid communication. These units automatically switch between satellite and cellular networks. Hybrid units reduce airtime costs while maintaining reliable offshore coverage.[5]

Advantages:

- Hybrid units have lower operating costs than satellite-only units.
- Continuous coverage, regardless of a vessel's distance from the shore.
- More flexible reporting intervals.

Disadvantages:

- Initial purchase cost of hybrid units can be higher than satellite-only units.
- Cellular range on hybrid units is often limited, delaying the transmission of cellular data, which can affect alerts.

[5] For more information on airtime costs, visit section 3.1.

1.3 VMS Software

VMS software is the shore-based software used by fisheries agencies to receive, analyse, and display GPS reports from VMS units in real-time. VMS software is an essential tool for fisheries management, enabling fisheries officers to:

- monitor vessel movements in real-time
- detect suspicious behaviour (e.g. slowing in a closed area)
- support search and rescue when needed.[6]

VMS software typically provides the following functions:

- map-based vessel tracking
- geofencing tools for closed areas
- automated alerts (e.g. overdue notifications and geofenced entry and exit alerts)
- historical playback of vessel tracks
- reporting and analytics tools
- unit health and status monitoring for each vessel's VMS unit
- VMS unit management.

[6] VMS units are strictly NOT safety devices.

2 VMS Regulation

2.1 VMS Legislation

Effective VMS programs require supporting legislation. Legislation allows fisheries agencies to implement VMS requirements across fisheries. Legislation may include Acts, Regulations, Directions and Management Plans.

Legislation should allow fisheries agencies to:

- apply VMS requirements across fisheries
- impose VMS requirements on individual fishers and/or groups of fishers (e.g. fishers grouped by fishery, vessel size, area fished, method used)
- set the standard requirements for VMS units (type approval)
- take enforcement action in the event of non-compliance (including the ability to impose penalties).

Example: Australia's VMS Legislation

The two pieces of Australian legislation most relevant to VMS are the *Fisheries Management Act 1991* and the *Fisheries Management Regulations 2019*. The *Fisheries Management Regulations 2019* is authorised by the *Fisheries Management Act 1991*.

The *Fisheries Management Act 1991* defines the Australian Fishing Zone (AFZ) and most Commonwealth fisheries offences. It underpins AFMA's domestic and foreign compliance work and provides AFMA with enforcement powers to protect Australia's fishery resources. The Act:

- defines what a vessel monitoring system (VMS) is.
- grants the power to impose conditions on fishing rights, licenses and permits (fishing concessions).
- makes it an offence to breach a condition of a fishing concession.

Fisheries Management Regulations 2019 is an instrument under the Act. It specifies regulations outside the AFZ and Commonwealth managed fisheries to which the Act also applies. The Regulations:

- define what an "**approved**" VMS unit is
- define what an "**operating**" VMS unit is
- define the process for AFMA approving a VMS unit
- enable the imposition of standard conditions across all fishing concessions
- proscribe VMS requirements as a standard condition.

Fisheries legislation should also comply with and ratify a country's obligations under international law and RFMOs. An overview of some of the international agreements Australia is party to can be found in Appendix A.

2.2 VMS Licence Conditions and Rules

Fisheries legislation should set the VMS conditions and rules for concession holders. Failure to comply with legislation should result in fines and loss of fishing licence(s). Effective VMS legislation should include requirements that:

- licenced fishing vessels must be fitted with active, approved VMS units at all times
- VMS units can only be switched off with prior written approval[7]
- it is the operator's responsibility to fit and maintain a working VMS unit
- operators must not interfere with the VMS unit
- failure to have a working VMS unit is an offence.[8]

Example: Australia's VMS Conditions

In Australia, licence conditions and rules are mandated by the *Fisheries Management Act 1991* and the *Fisheries Management Regulations 2019.*

For example, Regulation 37 of the *Fisheries Management Regulations 2019* imposes the standard conditions for VMS requirements on Australian (Commonwealth) licensed fishing vessels:

37 Concession holder to ensure that vessel monitoring system is fitted and operating

(1) The holder of a fishing concession must ensure that each nominated boat is fitted with an approved vessel monitoring system.

(2) The holder of a fishing concession must take all reasonable steps to ensure that the approved vessel monitoring system on a nominated boat is operating at all times.

(3) If the approved vessel monitoring system stops operating, the holder of the fishing concession must ensure that AFMA is informed as soon as practicable after the holder of the concession becomes aware that the vessel monitoring system has stopped operating.

[7] For more information on Temporary Switch Off (TSO), visit section 4.1.2.
[8] For more information on monitoring VMS compliance, visit section 4.1.

2.3 Enforcement Powers

To enforce compliance effectively, legislation should establish VMS requirements for vessels. Enforcement powers may form part of a Fisheries Management Act or other specific fisheries legislation.

Legislation should allow fisheries agencies to enforce VMS requirements and to administer penalties for non-compliance.

Some important enforcement provisions include:

- financial penalties for non-compliance
- control over VMS unit types that vessel operators can use
- ability to mandate the installation of specific VMS units on vessels that have conditions
- power to suspend or cancel licences for non-compliance
- power to order a vessel to return to port for breaching VMS conditions
- power to prosecute serious instances of non-compliance.

Example: Australia's VMS Enforcement

If a vessel operator is found to be seriously non-compliant with the VMS rules, the fisheries agency may:

- order the vessel to return to, and remain in, a port
- suspend the licence for up to 30 days
- issue a fine of up to $3,756 AUD and/or
- prosecute (maximum penalty $78,250 AUD).

Failing to comply with an order to return to port has a maximum penalty of $37,560 AUD, two (2) years imprisonment, or both.

3 Vessel Monitoring System Management

3.1 Procurement of Service Providers

Establishing contracts with VMS service providers can be complex and time-consuming. Depending on the preferred arrangements, the fisheries agency may require several different contracts with several different providers to use the most suitable VMS technology, relevant to the needs of their fisheries.

Separate contracts may be required for software, airtime, and hardware (VMS units).

- **Software providers** provide the software for collection, management, use and analysis of VMS data.
- **Airtime providers** provide the communication network(s) used by VMS units to transmit the data to the VMS software.
- **Hardware providers** provide the VMS units to vessel operators.[9]

An example of AFMA's approach to VMS procurement can be found in **Annex B**.

[9] A contract with providers may be unnecessary, where the obligation to purchase VMS units rests with the fishers themselves. For more information on hardware, visit section 1.1.1

3.1.1 Approaching the market

Tender Processes

When acquiring contracts for VMS providers, it is best to approach the market with an open-source tender. Open-source tender is the best method to ensure all viable suppliers are considered. An open-source tender ensures a fair process and high-quality procurement options, aligning strongly with the principles of probity, integrity and accountability. Other strategies for approaching the market should be avoided, including limited tender.

Evaluating providers

Selection panels should define evaluation criteria before reviewing tenders. This requires a robust set of standardised criteria applied equally to all tenders. Standardised criteria facilitate easy and fair comparison and helps the panel keep track of the pre-determined requirements.

The evaluation should be conducted by a diverse selection panel. Panellists should include a combination of technical experts, government officials and external stakeholders to ensure that all aspects of the tenders are considered. A separate financial and technical assessment should be completed. These two elements should be considered separately, rather than as one.

Selection panels should always ask for a demonstration of the features promised by each tender to ensure that they perform as expected. Without a demonstration, there may be issues implementing and rolling out the VMS units on schedule as the technical issues are navigated and resolved.

3.1.2 Software and Hardware Requirements

When procuring VMS software and hardware (VMS units), the essential and desirable system functions should be identified. The essential and desirable features depend on the needs of the region, the fisheries to be monitored, and the types of analysis the fisheries agency conducts.

The software and hardware capabilities should be included in the tender evaluation criteria. It is important to differentiate between what the fisheries agency considers essential and what is considered desirable. If a provider is unable to deliver the essentials, they should not be the selected tender.

The "essentials" and "desirables" listed below are examples of potential requirements an agency may want to include within its procurement process.[10]

Example: List of essential and desirable features for VMS software and hardware

Software

Essential

Users and Security

- Secure system and data encryption
- Provide individual named user accounts with password-protected logins
- Apply user-based restrictions on viewing, accessing and downloading data, including:
  - Basic (read-only)
  - Officer (basic functions)
  - Manager (full fleet management functions)
  - Administrator (full functionality and user management).
- Allow users to save documents in their profiles

Fleet Capacity and Management

- Support use of multiple VMS unit types and airtime providers
- Add, remove, and manage VMS unit devices within vessel profiles
- Receive and display device messages (e.g. power on/off, signal loss, antenna obstruction)
- Support large fleet sizes (e.g. more than 1,000 units or unlimited)
- Support multiple units and unit types on a single vessel
- Send programming commands to VMS units

Data and Display

- Record basic vessel details
- Attach records and documents
- Record and retain all historical data for vessels, including VMS units (minimum 7 years)
- Prevent users from editing or deleting data
- Maintain audit trails for all users and data exports
- Provide data extraction for historical records and multiple vessels
- Display vessel tracks and individual positions on a geographic interface

[10] Note: This is only a guide based on those used by AFMA in its procurement processes. Fisheries agencies should develop their own essential and desirable criteria.

- Retrieve at least 12 months of data for a single vessel
- Display 6 months of data on the map interface
- Provide web-based access on mobile devices (e.g. phones and tablets)
- Allow authorised users to plot locations on the geographic interface
- Allow authorised users to enter manual vessel positions
- Generate automated alerts for geofence entry and exit
- Generate automated overdue alerts
- Display base layers within the geographic interface (e.g. sea charts, satellite imagery)
- Support multiple geofences and allow users to create, modify and manage them
- Display multiple vessel tracks simultaneously

Desirable

- Send alert messages via email or SMS
- Search across all vessel details
- Differentiate unit types within track displays
- Display environmental data (e.g. sea surface temperature, wind speed)
- Integrate licence details automatically
- Display vessel images
- Support multiple fishing methods and licence types
- Provide trail playback through the geospatial interface
- Generate automated overdue alerts for variable time intervals (e.g. 2, 4, or 6 hours)
- Integrate data feeds from electronic monitoring (EM) systems, including sensor data

Hardware

Essential

- Comply with relevant RFMO requirements for areas of operation
- Be approved by the regulatory body (fisheries agency)
- Transmit data securely (non-public) via satellite or GSM
- Support remote configuration of polling intervals
- Be tamper-resistant and tamper-evident
- Automatically send device status messages (e.g. power on/off, antenna obstruction)

Desirable

- Include solar power capability
- Support batch polling
- Transmit via both satellite and GSM
- Provide in-unit programmable geofencing
- Include internal tamper alarms

3.2 Data Security

Fisheries agencies have legal obligations to ensure that data gathered from VMS is secure, in line with their country's security legislation.

Example: Australia's data security policy

AFMA follows the Commonwealth Attorney-General's Protective Security Policy Framework and the Australian Signals Directorate's Australian Government Information Security Manual. AFMA also has contractual obligations with its partner agencies that include extensive security clauses that protect both AFMA and other agencies.

Recommended VMS Access Provisions

Registration forms

Each VMS software user signs a form acknowledging their security obligations. Administrators of the system should undergo annual mandatory training that covers security obligations and penalties if breached.

Regular auditing of users and data

It should be mandatory that all user profiles are audited to ensure that their registration forms match their level of access. This ensures that their profile is disabled if they have left the agency.

Security training

Extensive and regular security training helps maintain a highly secure system. Training should be tailored to users at all levels.

3.3 User Management and Training

Fisheries agencies should ensure that all VMS users undertake training to ensure that they know how to effectively, securely and safely use VMS technology. Below are some examples of elements that should be incorporated into VMS training.

Mandatory Administrator Training Program

VMS Administrators are system users that have full access to the VMS with no system restrictions. VMS Administrators should complete training every year and have their accounts and access audited regularly.

Online Training

Online training platforms can effectively develop and deliver training for all user levels. These platforms also track and monitor each participant's completion status to ensure that their training is up to date. Having a variety of training resources available ensures users know how to use the software relevant to them, their access level and their needs. It also reduces the workload for VMS Administrators to perform tasks for other users and provide support.

Other Training Suggestions

VMS Administrators should be qualified and skilled in multiple aspects of VMS training. This allows them to train high level analysis of VMS data, beyond just using the relevant software. VMS users should have access to training in:

- geographic information systems (GIS)
- investigation techniques (fisheries officer training)
- monitoring, control and surveillance (MCS) techniques.

4 Monitoring and Enforcement of Vessel Activity with VMS

4.1 Monitoring VMS Compliance

4.1.1 Principles for Compliance Management

Two best-practice principles apply for managing VMS compliance.

1. All relevant fishing vessels must have an approved VMS unit that is fitted and operating, and
2. The VMS unit must remain switched on at all times.

The following section explains these principles and how they are defined, implemented and enforced.

Approved Units

VMS units should be trialled and tested to assess their suitability before they are approved.

Once deemed suitable, VMS units should be published on a “type approved list”. Vessel operators should be required to use one of these approved units to meet their VMS obligations.

Fitted and Operating

A unit is “operating” when the fisheries agency receives data that:

- is in a format that has been approved by the fisheries agency, and
- accurately identifies the location of the vessel to which the VMS is fitted.

A unit is “fitted” when vessel operators:

- physically attach (e.g. screw, bolt, or glue) the VMS unit to the relevant licenced vessel
- provide the unit details to the fisheries agency. Details should include:
    - operators’ details (name, email and phone number)
    - vessel details (name, distinguishing symbol(s), International Maritime Organisation (IMO)/ Maritime Mobile Service Identity (MMSI) number)
    - VMS unit details (type, manufacture, model, Automatic Location Communicator Identity (ALCI), serial number).

Once the fisheries agency receives the unit details, it should:

- upload the unit details into the VMS software
- activate the unit on the relevant satellite networks
- confirm that the unit is reporting correctly
- notify the operator that the unit is “fitted and operating”.

After the operator has been notified that their VMS unit is fitted and operating, their vessel may commence fishing in accordance with their licence conditions.

Switched on at all Times

Operators must ensure the VMS unit remains switched on at all times. This requires the fisheries agency to receive regular position reports. This includes the vessel is:

- fishing
- in port
- in the dry dock or on the slip
- in another jurisdiction.

4.1.2 Temporary Switch Off

Fisheries agencies may allow a vessel to temporarily switch off their VMS unit. This should only be allowed in limited circumstances and must require approval of the fisheries agency. A vessel operator may request a temporary switch off (TSO) when the vessel is:

- undergoing maintenance or repair-type activity and the electrical equipment on board this vessel is required to be shut down, or
- not undertaking any fishing activity, and the vessel will be in an extended berth at a single port.

Under these circumstances, vessel operators can complete an application for a VMS Temporary Switch Off. The fisheries agency should assess this application and, if appropriate, grant a written TSO approval. Approval must:

- be granted for a defined period, and
- specify the vessel's required location.

Example: Australia's TSO application form

Australia's VMS TSO form can be completed online, on the AFMA website. The webpage outlines the terms and conditions of a TSO, and contact details for AFMA's VMS team

4.1.3 Other Monitoring Requirements

Manual reporting

VMS units may fail while a vessel is at sea, such as due to mechanical failure or flat batteries. In the event of VMS failure, fisheries agencies may allow vessel operators to manually report their vessel's positions until the end of the fishing trip. If manual reporting is approved, the fisheries agency should require that the vessel operator must:

- Provide the vessel name, distinguishing symbol, time and date of position, and the vessel's latitude and longitude (in degrees, minutes, seconds), and
- Record the vessel's position at least every 4 hours and report these positions to the fisheries agency at the end of each day.

If the operator does not comply with these requirements, the vessel should be ordered to return to port and/or further action may be taken. Once a vessel returns from a fishing trip, they should not be allowed to fish again until the VMS unit is operating.

When assessing a request for manual reporting in the event of VMS failure, fisheries officers should consider the operator's past compliance. Vessels with a strong history of compliance should be trusted to manually report more than a vessel with a history of repeated non-compliance.

4.1.4 VMS Alerts

VMS software tools can be programmed to automatically alert fisheries officers of a VMS event.[11] Alerts enable fisheries officers to quickly identify and respond to non-compliance.

Alerts can be configured to display on the VMS software, and some software systems can also send notifications via SMS or email. Fisheries officers should monitor alerts daily to ensure that instances of non-compliance are actioned quickly and effectively. When an alert is received, it should be reviewed and actioned according to standard operating procedures (SOPs).

Notifications should be reviewed daily. Frequently reviewing VMS notifications ensures that a vessel that has:

- stopped reporting is not undetected
- entered a no-fishing zone is actioned appropriately
- switched their VMS unit off is investigated.[12]

Fisheries agencies should have at least one dedicated officer responsible for managing VMS notifications as a part of standard daily compliance checks. This officer should review each notification, then investigate and action accordingly.

Geofence Alerts

VMS software can be programmed to send automated alerts to the fisheries agency when a vessel enters or exits particular areas. This can be done by creating geofences. Geofences are digital boundaries around a particular area or group of areas. They can be defined for any location and in any shape or size. Geofences can be created either within the VMS software or within the VMS unit, depending on the specifications.

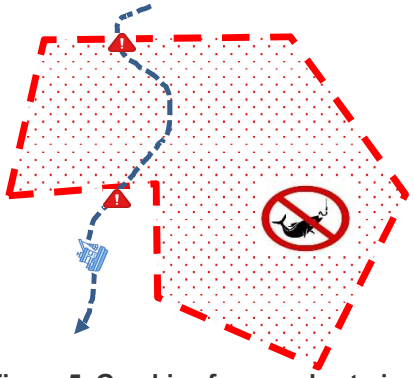


Figure 5: Graphic of a vessel entering a closed area

Geofences can be used to define:

- port boundaries
- areas closed to fishing[13] and particular types of fishing[14]
- environmentally sensitive areas, including marine protected areas
- specific fisheries
- exclusive economic zones (EEZs), national fishing zones, and inshore or coastal waters.

Once a geofence is established, it can be used to trigger:

[11] For more information on VMS software, visit section 1.1 and 3.1.2.
[12] For more information on switched off VMS units, visit section 4.1.2 and 4.1.3.
[13] For more information on monitoring closed areas, visit section 4.4.
[14] For more information on identifying different types of fishing, visit section 4.2.2.

- alerts to fisheries officers when vessels enter or exit geofenced areas
- alerts to fisheries officers when vessels travel at particular speeds in particular areas, e.g. less than 5 knots in closed areas
- messages to vessel operators.

Device Alerts

Most VMS units can be programmed to alert the fisheries agency about the device's health and status. This can include when the VMS unit is powered on, powered off, the antenna obstructed and suspected tampering.

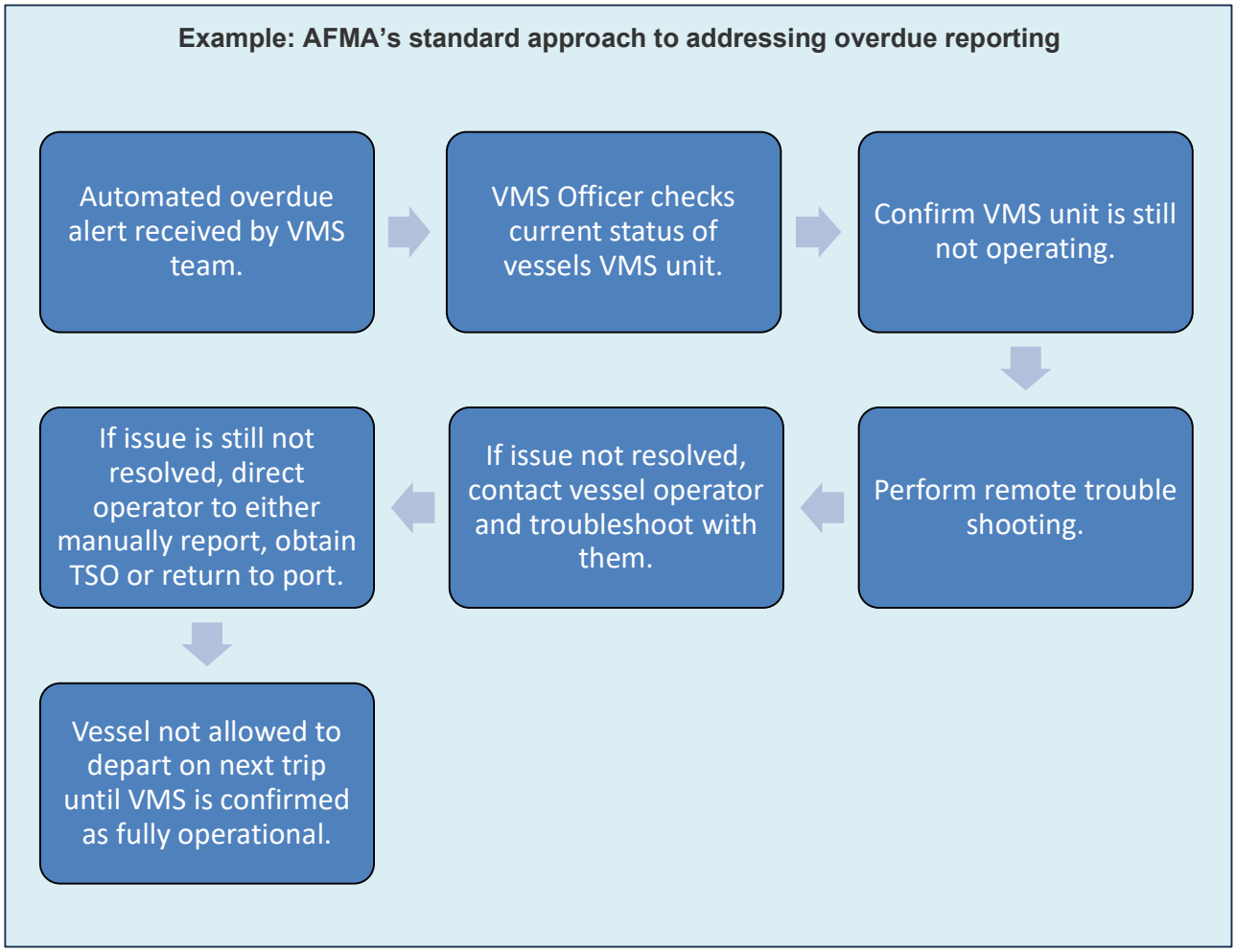
Device alerts can be very helpful in detecting VMS unit faults, as well as identifying deliberate attempts by the operator to disable the units, especially when analysing vessel tracks.[15]

Overdue Alerts

Overdue alerts help identify VMS units that are not reporting. These alerts trigger when the VMS has not received a position from the unit for a specific period (e.g. 2, 5, 12 or 24 hours).

Overdue alerts quickly bring non-reporting VMS units to the attention of fisheries officers so that it can be investigated and promptly actioned.

Example: AFMA's standard approach to addressing overdue reporting



[15] For more information on vessel track analysis, visit section 4.2.1.

Email Messaging and SMS (Text)

Many VMS software systems can be set to send alerts by email or SMS. Email and SMS alerts assist fisheries officers who might not have constant access to a computer.

Email and SMS alerts can be used to communicate with both fisheries officers and vessel operators. For example, automated SMS and email messaging can be used to notify:

- vessel operators when their vessel has entered an area closed to fishing, or
- fisheries officers when a vessel is entering (or leaving) port.

Example: Automated email sent to AFMA from its VMS regarding a vessel whose VMS report was overdue by two hours.

Figure 6: Example of email alert for overdue reporting

Adjustable Alerts

Some VMS software can also allow for setting up of specific, targeted alerts. These can be changed depending on the fisheries agency needs. Adjustable alerts help fisheries officers respond to the needs of their jurisdiction.

Alerts can be created to trigger depending on the:

- type of vessel
- type of fishery
- geographic area
- vessel speed
- VMS device type
- overdue period (length of time since last report)
- device message (e.g. if a vessel has sent a “power on” or “power off” report).

4.1.5 Other Tools

Most VMS tools are not built for complex analysis of data or geospatial imagery. Employing multiple tools allows for more complex analysis of VMS data to ensure vessels are complying with fisheries legislation, and to take action as necessary.

Geographic Information System (GIS) Tools

VMS software is not designed for detailed spatial analysis of VMS data. Geographic information system (GIS) tools can be used for detailed spatial analysis. GIS tools can be used for:

- preparing evidence maps for court proceedings
- detailed spatial analysis of VMS data, including heat mapping and trend analysis
- preparing more “user friendly” maps for public use.

Database Tools

Most VMS software does not have built-in data analysis tools that can perform complex data analysis or create readable graphs and charts.[16] Suitable spreadsheets and database tools can be used when detail analysis is needed. Spreadsheet and database tools can be used for:

- daily checks and compliance rate monitoring
- data extraction, preparation and analysis, such as for GIS analysis.

[16] For more information on VMS data analysis, visit section 4.3.

4.2 VMS Vessel Track Analysis

VMS track analysis is the process of using VMS data to determine the speed and location of vessels to help identify different types of fishing behaviours.

4.2.1 Poll Position and VMS Track

Most VMS software systems use dots to represent a vessel's polled (reported) locations. These polls (dots) are usually joined by a straight line between two polls. This line is known as the VMS track. The VMS track is only indicative of the vessel's movement and does not necessarily show the vessels actual track, especially at low polling rates.[17]

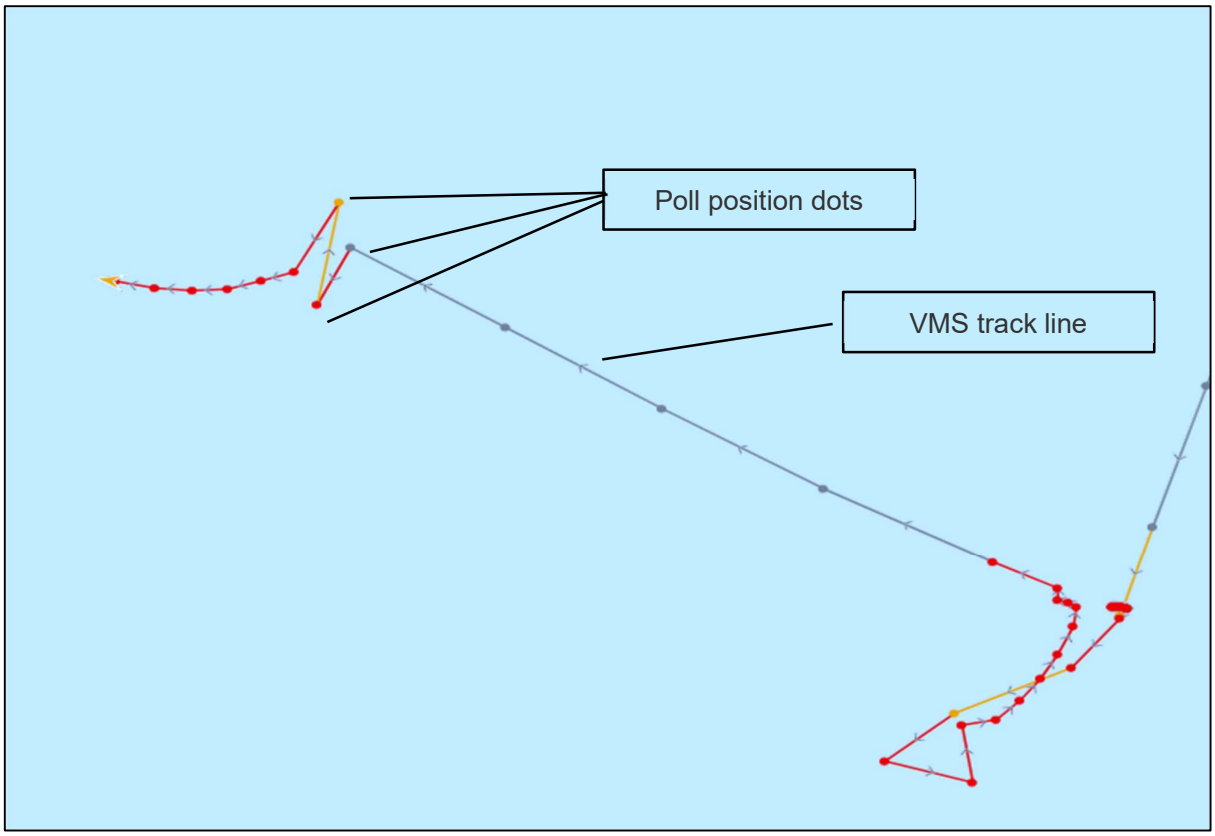


Figure 7: Example of poll positions and VMS track

4.2.2 Vessel Speed

Colour Display

VMS software can use colour to represent the vessels speed. Speed is a good indicator of fishing activity, as vessels have defined speeds when operating fishing gear. Generally, vessels travelling at speeds of 7 knots or higher are unlikely to be fishing, whereas vessels travelling slower than 5 knots are more likely to be fishing. The VMS track line and/or poll position (dot) colour represents the speed travelled.

[17] For more information on polling rates, visit section 4.3.3.

Example: AFMA's vessel speed colour display

AFMA's VMS software uses three colours to represent vessel speed. Speeds less than 5 knots (<5) are shown in red, speeds between 5-7 knots are shown in orange and speeds greater than 7 knots (>7) are shown in grey.

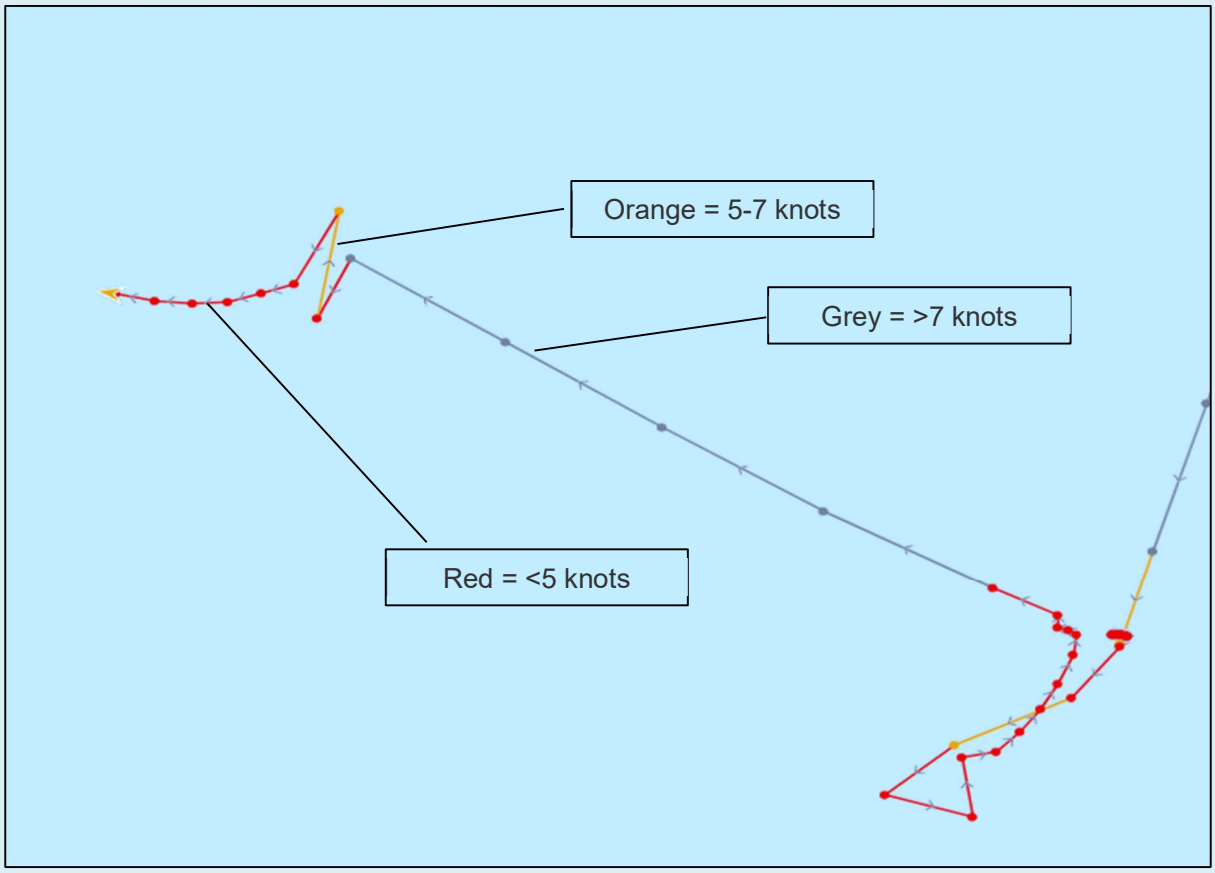


Figure 8: Example of VMS track speed colours

Reported Vs Calculated Speed

VMS can measure vessel speed in two ways: reported speed and calculated speed.

- **Reported Speed** is the speed the vessel is traveling at the time it records a position (polls), recorded by the VMS unit.
- **Calculated Speed** is the speed calculated by the VMS software over a period. Calculated speed is the distance travelled divided by the time (Distance ÷ Time)

Calculated speed is generally more useful than reported speed. Calculated speed more accurately reflects the vessel's activity, as it represents the maximum distance the vessel could have travelled. Reported speed is less useful, because a vessel's speed at the time of polling can be affected by variables including wind, waves, steering or fishing activity. Using calculated speed can help create a better understanding of the vessel's actual activity.

Example: Reported Speed vs Calculated Speed

A vessel travels 10 nautical miles over a period of 2 hours, reporting every 30 minutes, generating 5 reported speeds. The reported speed shows that the vessel was traveling at speeds above 7 knots the whole time, indicating that it was transiting. However, the calculated speed shows that the vessel was travelling below 7 knots for most of the trip, suggesting that it could have been fishing.

Table 1: Example speed calculations

Polling point	Distance travelled (nautical miles)	Time (hours)	Calculated speed (distance ÷ speed)	Reported speed (knots)
A	2nm	0.5	4kn	7.2kn
B	3nm	0.5	6kn	7kn
C	1.7nm	0.5	3.4kn	7.4kn
D	4.3nm	0.5	8.7kn	7.1kn

Using the reported speed, the track would look like this (not to scale):

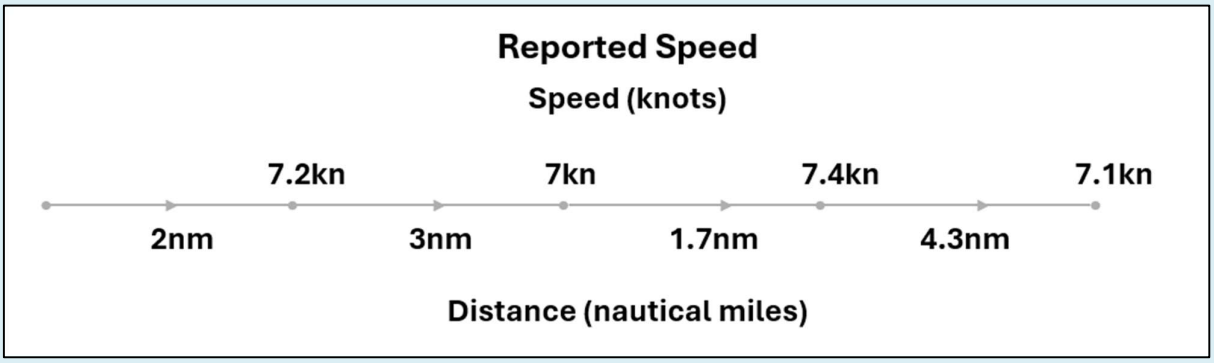


Figure 9: Example reported speed vessel track

Using the calculated speed, the vessel track would look like this (not to scale):

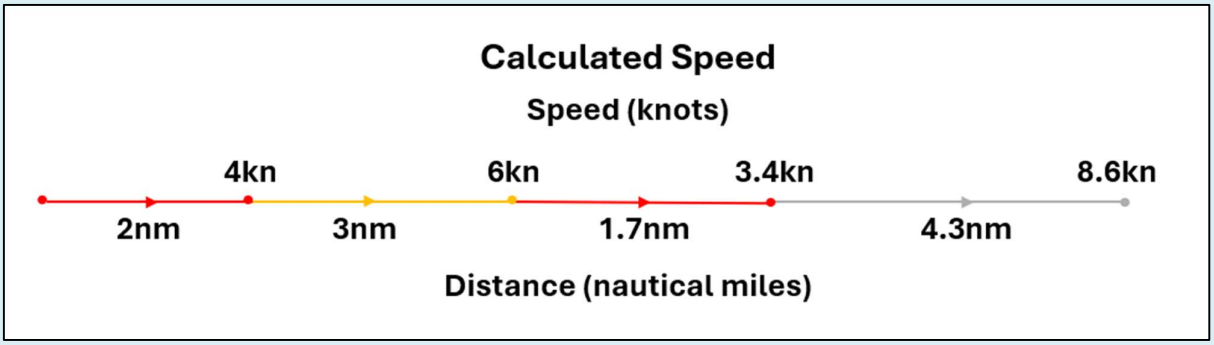


Figure 10: Example calculated speed vessel track

The below diagram is a visual representation of the difference between calculated and reported speed. The vessel has travelled 14 nautical miles in 2 hours, with reported speeds of 12 knots, 4 knots and 10 knots. Using calculated, the vessel is travelling at 7 knots.

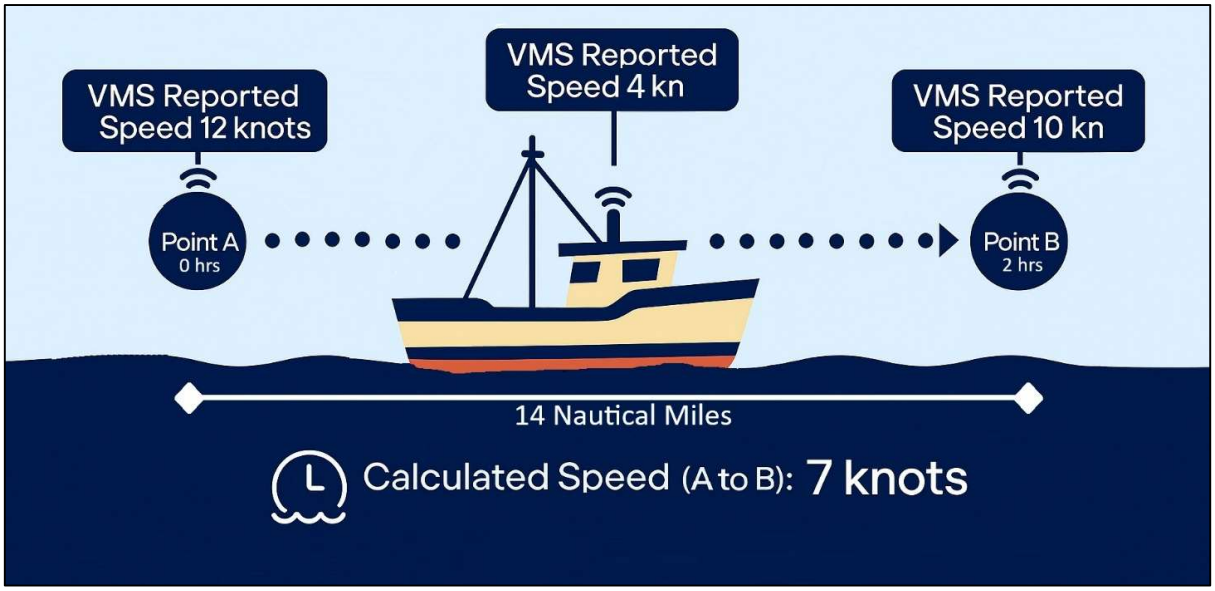


Figure 11: Reported Vs Calculated Speed

4.2.3 Polling rates

Polling rates (the frequency of VMS position reports) affect the accuracy of the VMS track. When vessels have high polling rates, the VMS track better reflects the vessel's actual activity. The best polling rate to use is determined by the mobility and fishing methods of the vessel and polling rate costs.

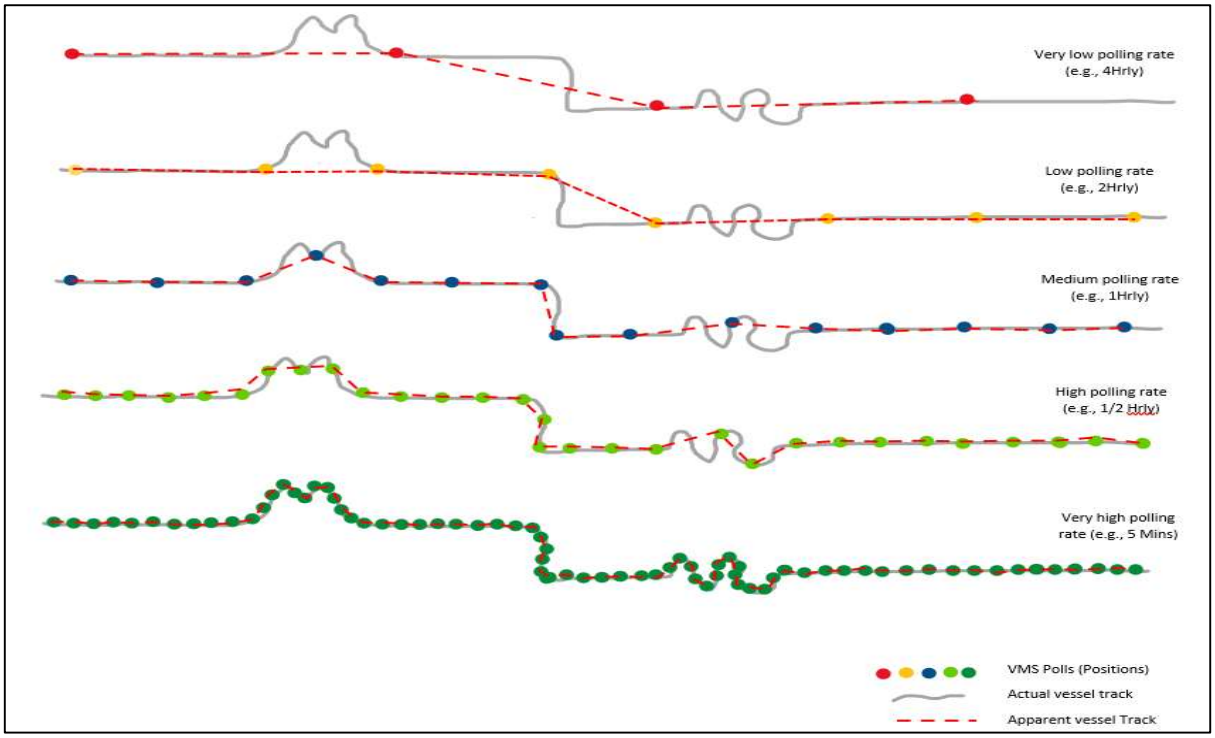


Figure 12: Polling rates diagram

Example: 1 hour vs 2-minute polling

Below is a diagram of a vessel that is sending their location once per hour. The track shows that the vessel is just below the closed area but does not go inside.

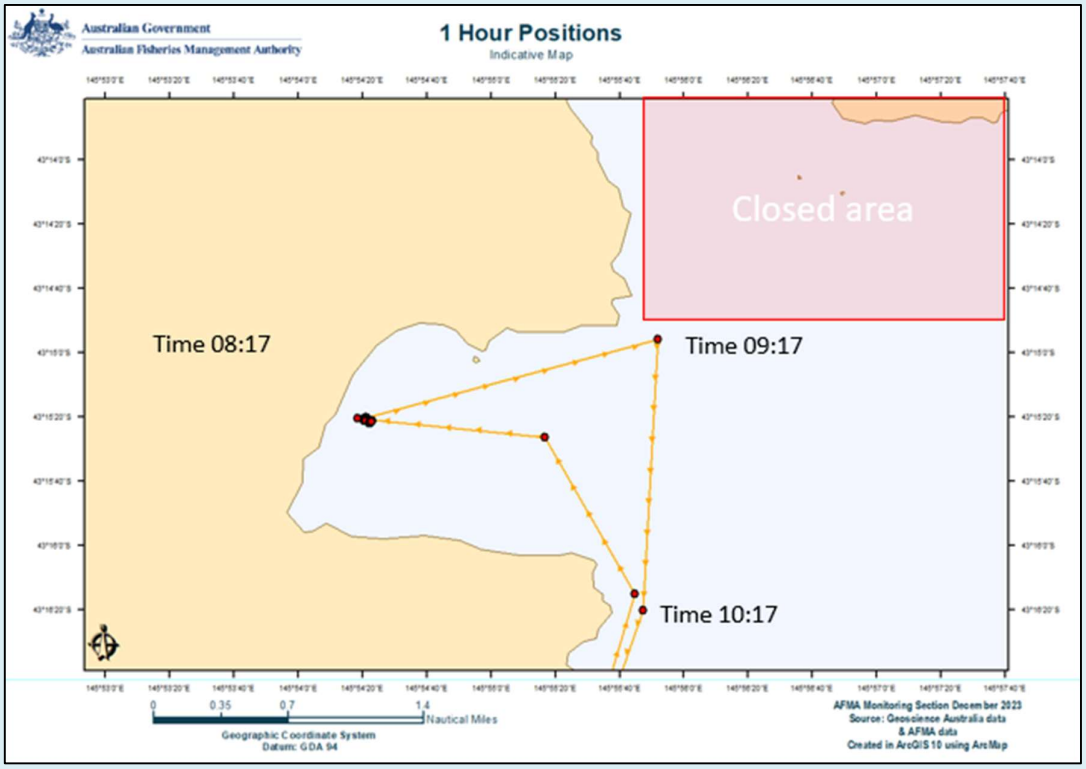


Figure 13: Vessel map with 1-hour polling

However, when the same vessel polls every two minutes, instead of once per hour, the track shows that the vessel entered the closed area.

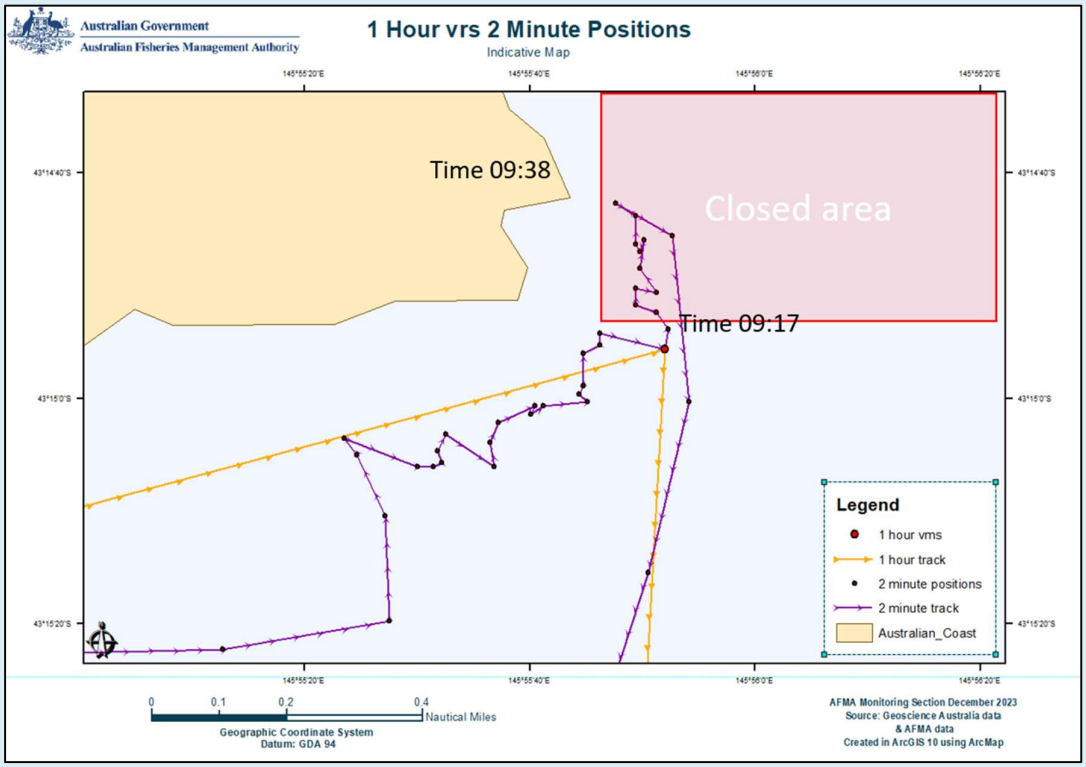


Figure 14: Vessel map with 2-minute polling

Trail Playback

Sometimes viewing the trail of a vessel as a static line can make it difficult to interpret what a vessel, or group of vessels, was doing. The ability to “play back” a trail (or trails) can help in understanding what was occurring.

When multiple vessels travel close together, the vessel tracks can be hard to analyse. By playing back the vessel tracks, fisheries officers can see how the vessels were moving in relation to each other, over time. This can help identify when vessels are working together to pair trawl or tranship.

Example: tracks of multiple vessels

Below is an example of when trail playback helped AFMA identify suspicious fishing behaviour. The static image made it difficult to identify the individual vessels’ movements. By playing back the trails, it was easier to see how the vessels interacted.

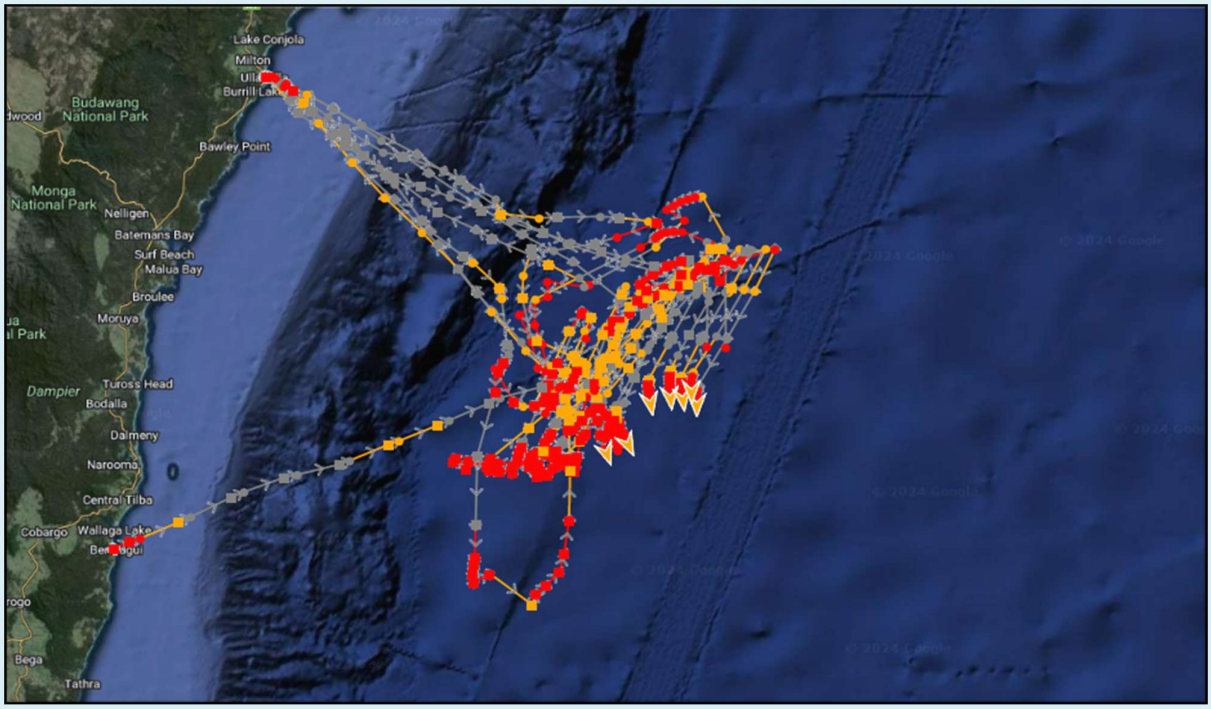


Figure 15: Trail playback image

4.3.1 Identifying fishing activities and different fishing methods

VMS track data can be used to identify the different fishing techniques and gear used by vessels. Understanding how vessels use, set up and retrieve fishing gear will assist VMS track data interpretation.

To understand a vessel's track pattern, it is important to know:

- how different fishing gear operates and how that can change depending on vessel size and sea conditions
- what the vessel is licenced to catch and the gear they are permitted to use
- seasonal variations that affect fishing.

The following are examples of common fishing techniques and how this is presented in VMS track data.

Demersal (Bottom) Longline

Bottom (demersal) longlines are set horizontally along the ocean floor and are held in place using anchors. This differs from auto longline fishing, because the hooks are baited by hand rather than a machine. When set, the longline can be many kilometres in length and have several thousand hooks. Bottom longlines are used to catch shark species that live on or near the sea floor in shelf waters generally less than 100m deep.

The lines are set at 4-6 knots. Hauling speeds are generally less than 2 knots, following the setting tracks to collect the anchored lines. There is usually no drifting between setting and hauling, as vessels often set multiple lines before hauling.

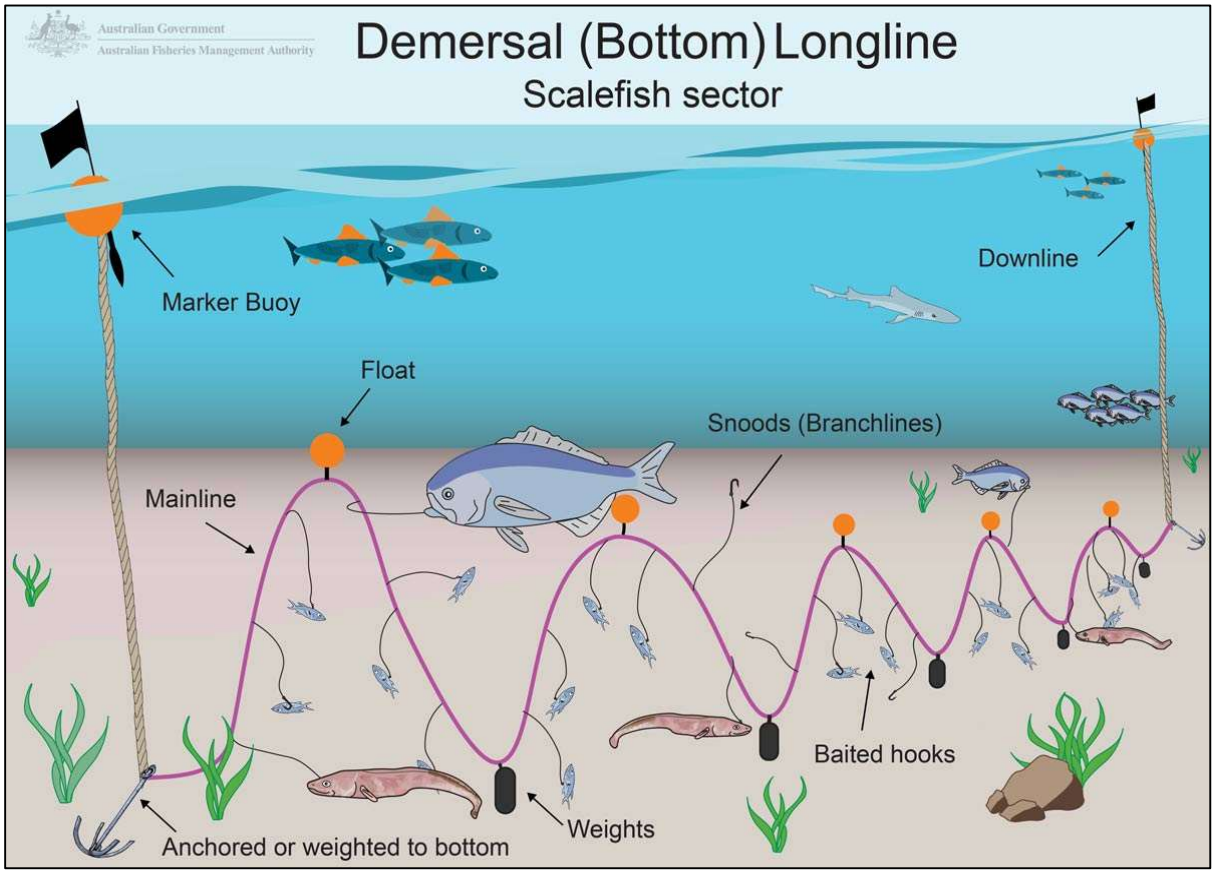


Figure 16: Demersal longline fishing diagram

Figure 17: Demersal longline fishing vessel tracks

Pelagic Longline Fishing

Pelagic longline fishing involves baited hooks that are attached to the longline by short lines that hang off the mainline, called snoods. The longline can be many kilometres long and can carry thousands of hooks.

Pelagic longlines are not anchored and are set to drift near the surface of the ocean with a radio beacon attached, so that the vessel can track them to haul in the catch. Vessels set lines at 5-8 knots, then drift to allow the lines to soak. The lines are then be hauled at less than 5 knots.

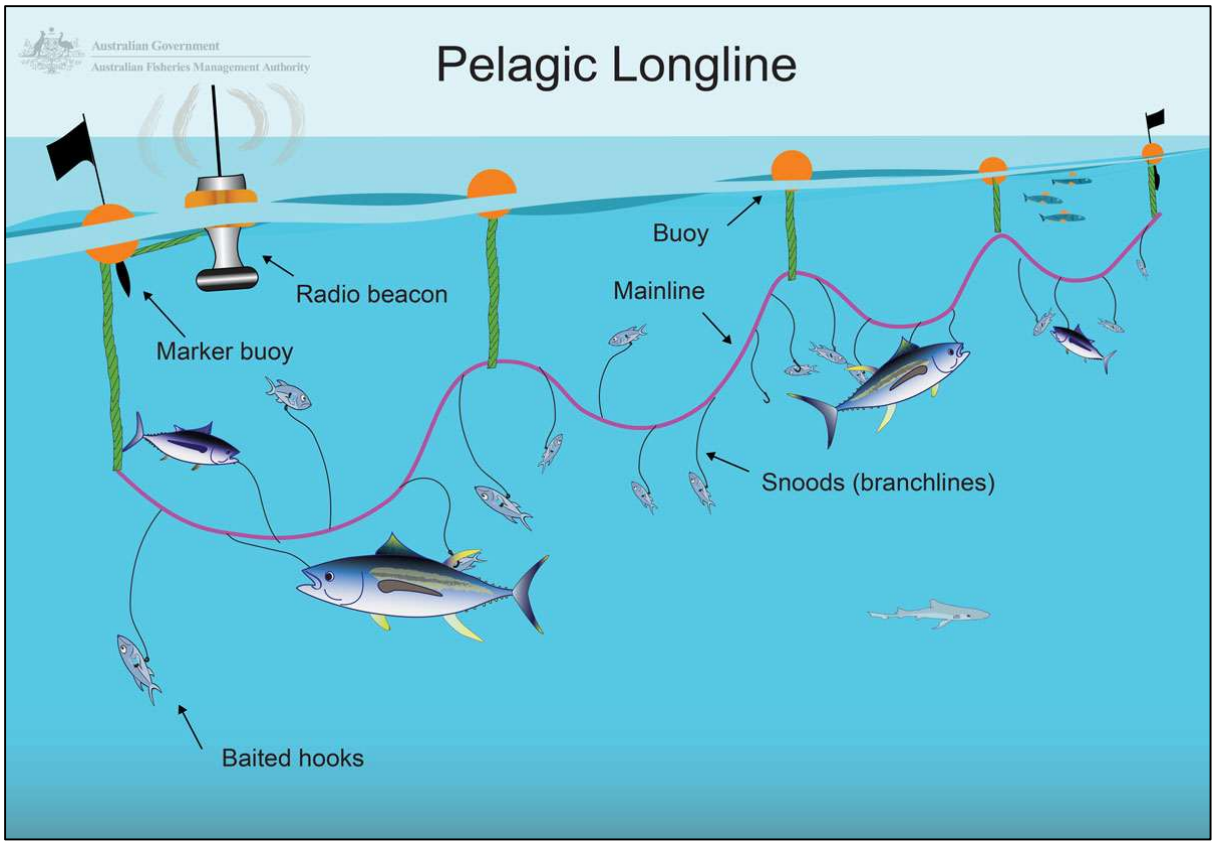


Figure 18: Pelagic longline fishing diagram

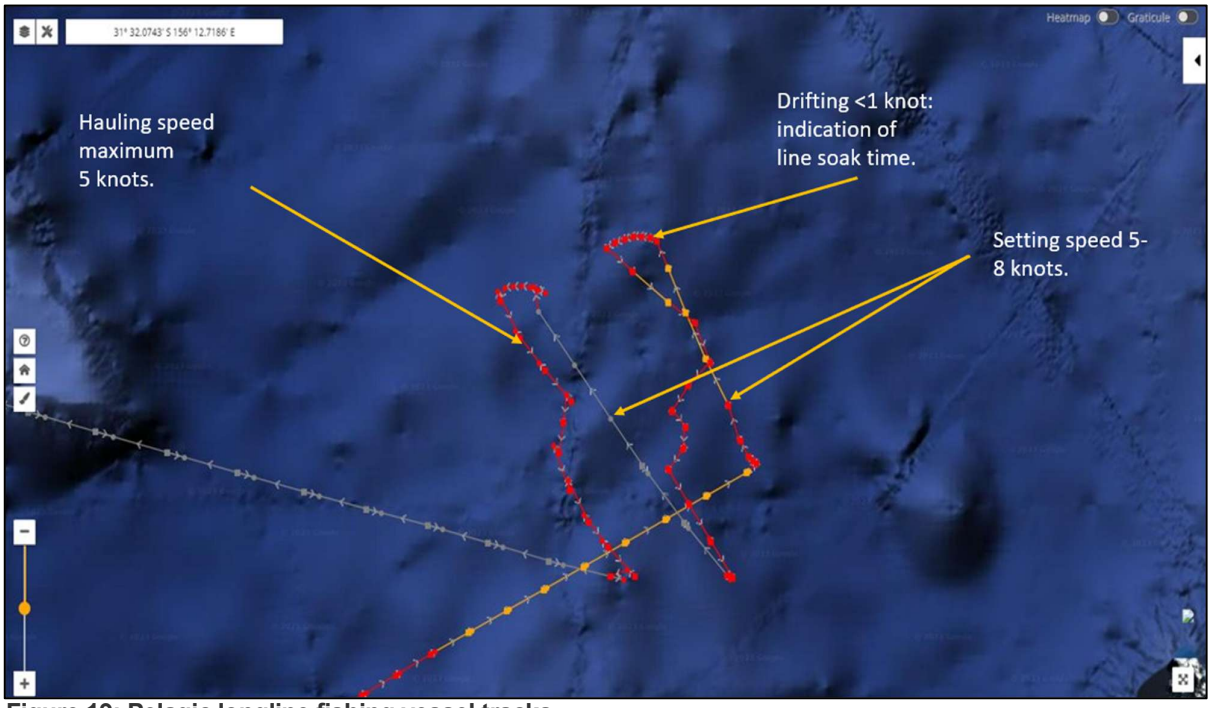


Figure 19: Pelagic longline fishing vessel tracks

Demersal (Bottom) Set Gillnet

Gillnets are long rectangular panels of netting with diamond-shaped mesh that are held vertically in the water column and anchored to the ocean floor at either end. They are generally used to target sharks.

Fish swim into the net and are entangled by the gills, fins and spines. The nets are kept vertical by floats along the top and weights along the bottom. Gillnets are normally used in shelf waters, less than 100m deep.

Nets are set at 2-4 knots and left to soak. These nets are fixed to the seabed by an anchor and do not move very much from their setting position. The haul speed is usually less than 2 knots.

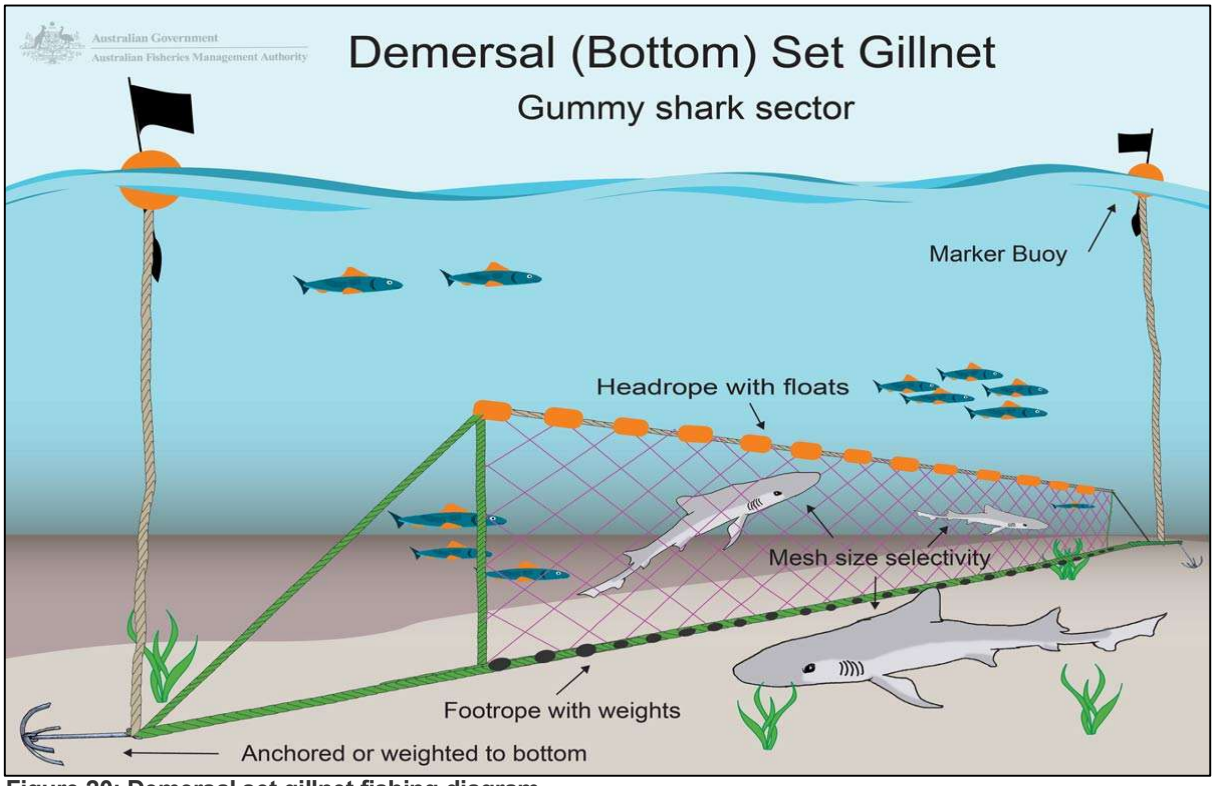


Figure 20: Demersal set gillnet fishing diagram

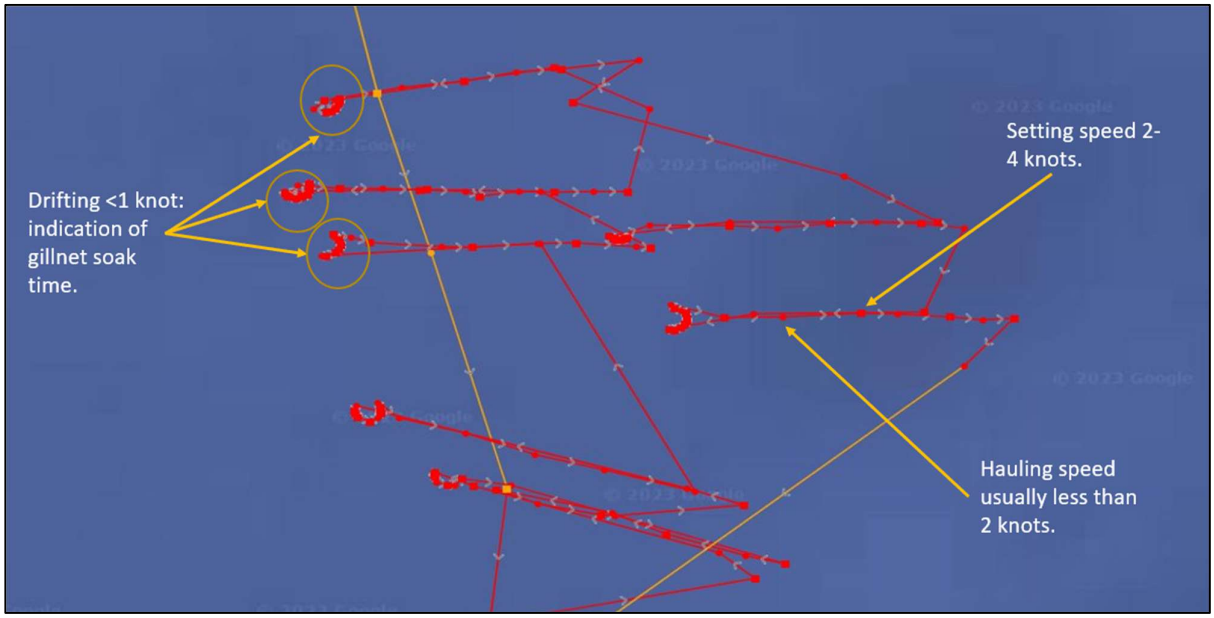


Figure 21: Demersal set gillnet vessel track

Trawling

Trawling is one of the most common methods of fishing. Trawl nets are designed to be towed by a vessel through the water column (midwater trawl) or along the sea floor (bottom trawl).

Trawl nets are shaped like a cone or funnel with a wide opening and a narrow, closed “cod-end”. Trawls can be performed at various depths and nets differ by their mesh size. Both bottom and midwater trawls use “otter boards” or “trawl doors” to keep the mouth of the net open.

Trawling patterns differ between vessels, making this technique hard to identify.

Demersal (Bottom) Trawl

Bottom trawls (also known as demersal trawl) are used to catch fish and prawns that live on or near the sea floor. Bottom trawls use trawl boards/doors made of timber or steel to keep the mouth of the net open and on the bottom. These nets are heavy and are trawled at slower speeds compared to midwater trawls.

Fish trawls have long metal cables, called sweeps, connecting the trawl boards with the net which allow the boards to spread much further than the overall width of the net. The sweeps “herd” fish until they tire and drop back into the net where they are finally caught. Trawl nets have bobbins or rollers on the ground gear to allow the net to move over the sea floor without snagging and to minimise bottom contact. Trawl nets are designed differently depending on whether the target species is fish or prawns.

Vessels transit at speeds of >7 knots, then trawl at speeds of 1.5-3.5 knots.

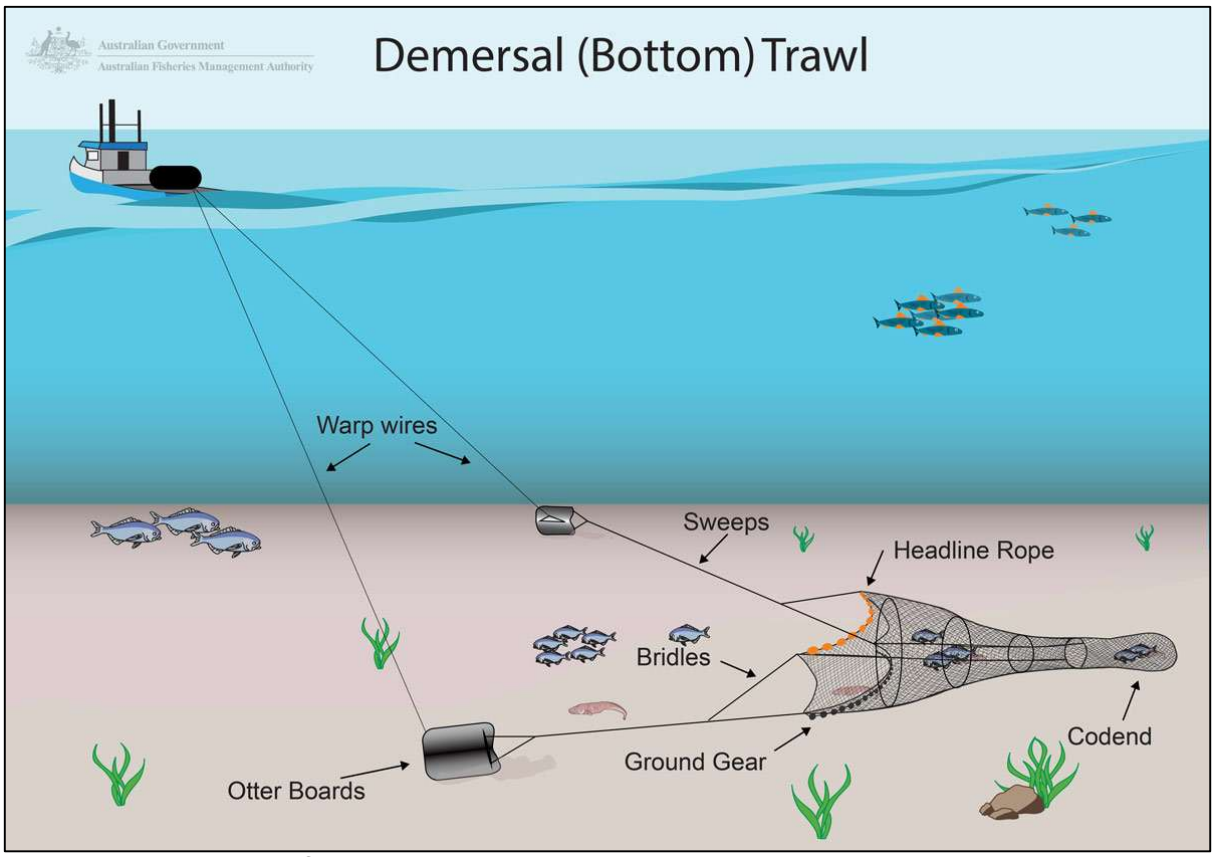


Figure 22: Demersal trawl fishing diagram

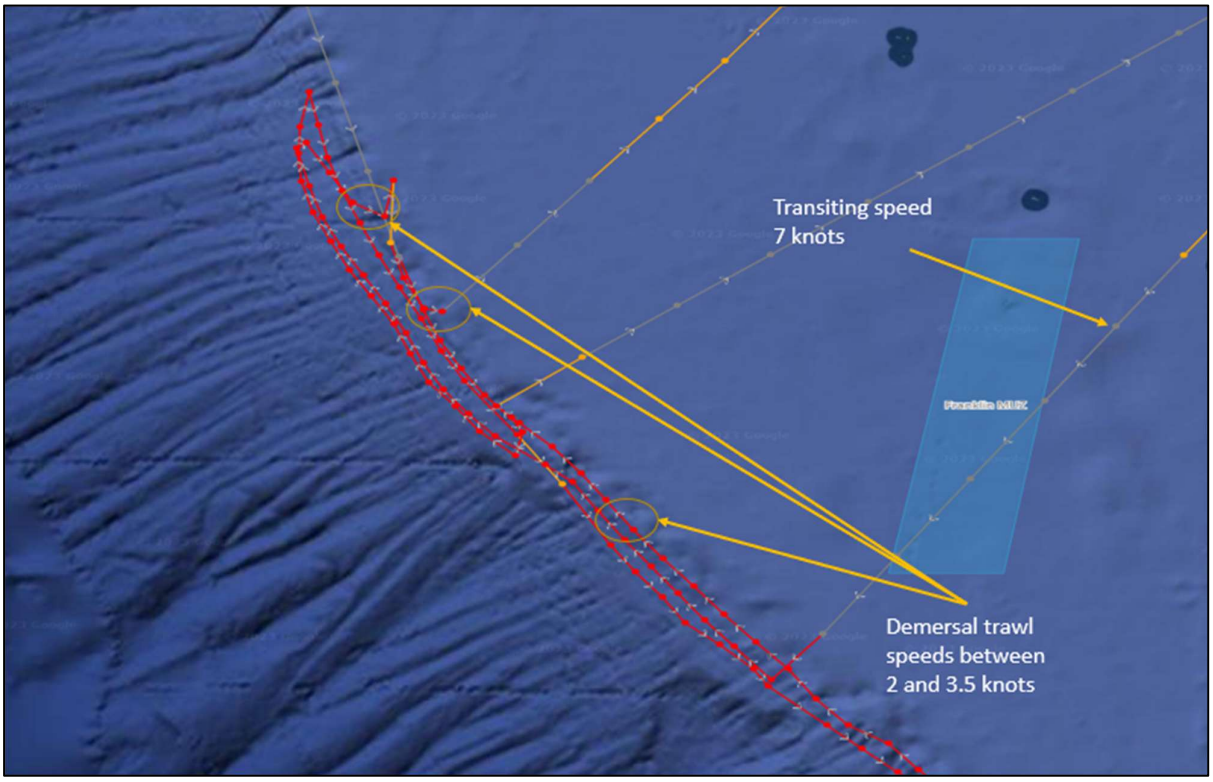


Figure 23: Demersal trawl vessel track

Midwater Trawl

Midwater trawls fish in the water column and are used to catch a variety of pelagic fish species. Midwater trawl nets may incorporate acoustic technology to tell the skipper the position of the net in the water column, the opening/spread of the net and the volume of fish entering the net.

Midwater trawling involves towing a net behind a vessel to catch fish species. The net is connected to the vessel by the warp wires and the opening to the net is spread using two large boards known as otter boards. The net is towed off the bottom in depths from just off the bottom to near the surface. Midwater trawl nets are generally shaped like a cone or a funnel with a wide opening to catch fish and a narrow end called a cod-end where fish are collected.

Vessels usually transit before trawls at speeds of more than 5 knots and trawl at speeds of 1.5-3.5 knots.

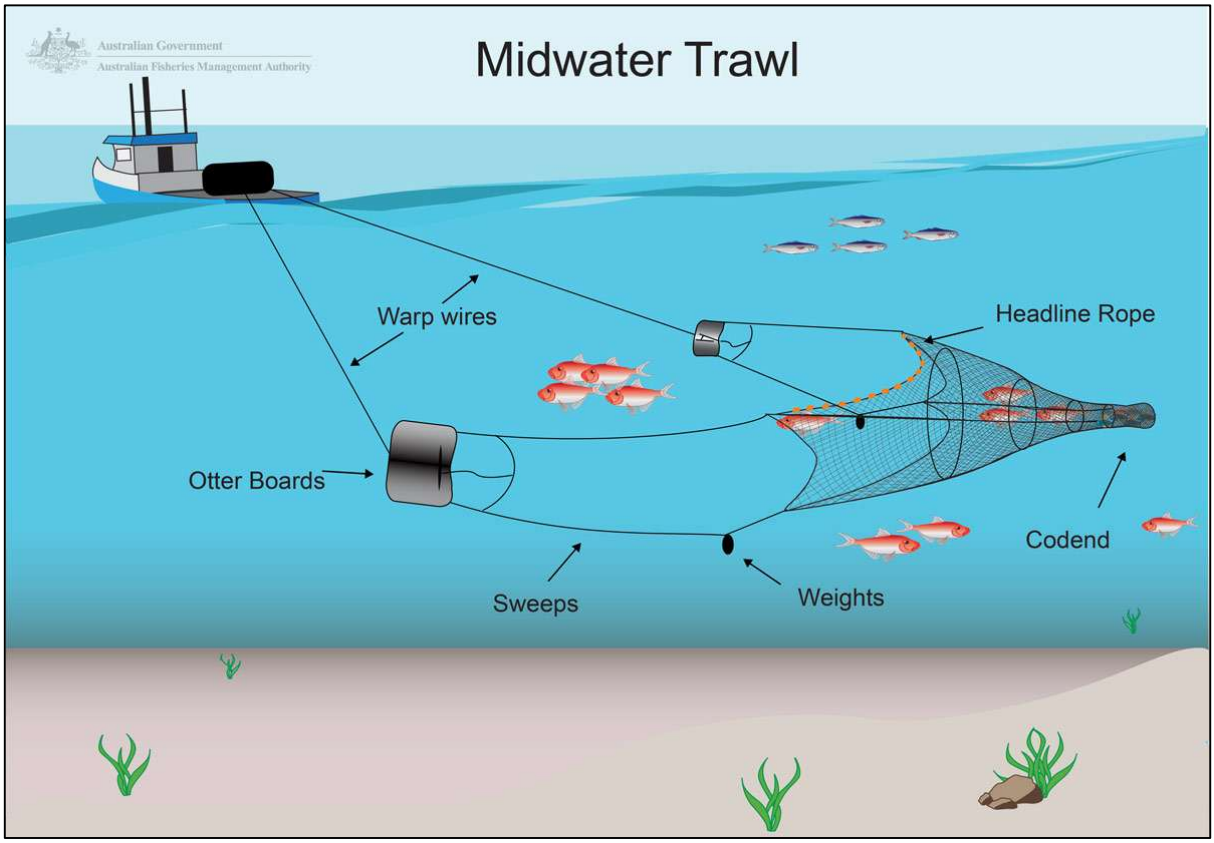


Figure 24: Midwater trawl fishing diagram

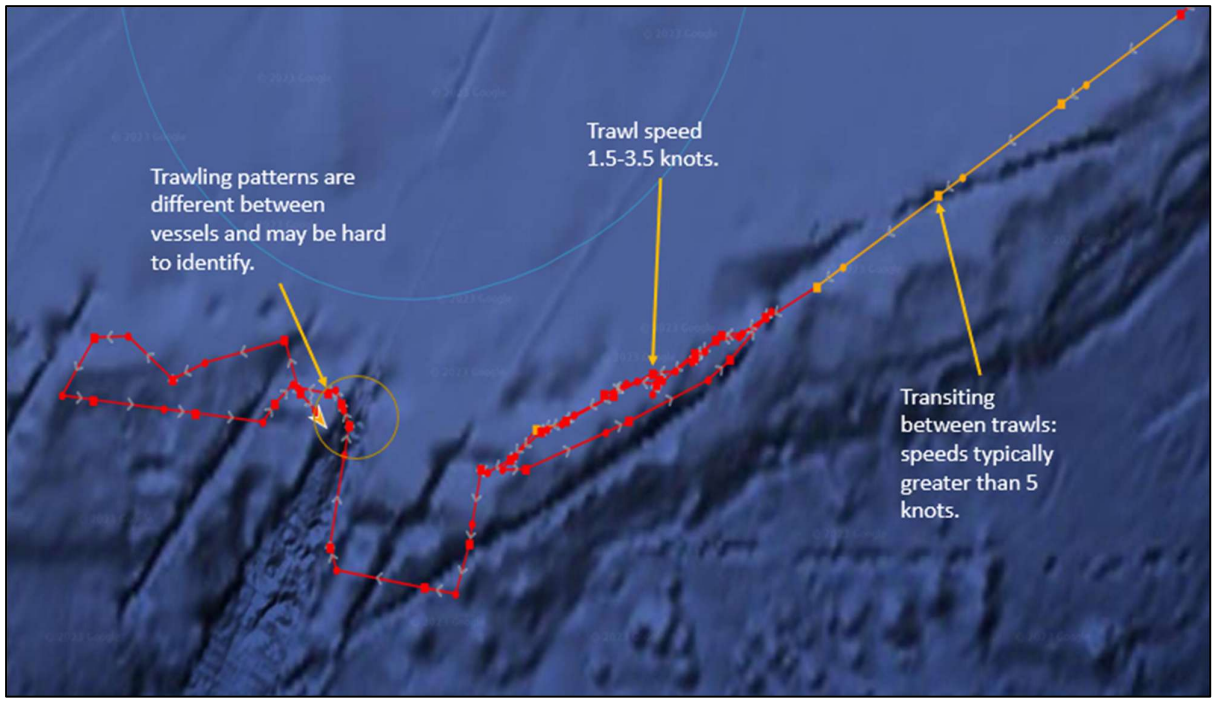


Figure 25: Midwater trawl vessel track

Danish Seine

Danish seine fishing is mainly used to catch fish species found on the ocean floor, also known as bottom species. The gear is deployed with one end of a weighted rope attached to an anchor buoy. The vessel sweeps in a large circle as the rope is deployed, sinking to the bottom, followed by the Danish seine net, and another weighted rope, until the vessel returns to the anchor buoy. Once a full circle has been made the gear is towed for approximately 30 minutes until the ropes come together.

The towing operation then ceases, and the net is winched back onto the vessel scooping up fish that have been herded into its path by the ropes coming together on the bottom. The operation takes approximately 1⅓ hours.

Vessels transit between trawls at speeds greater than 5 knots and trawl below 2 knots.

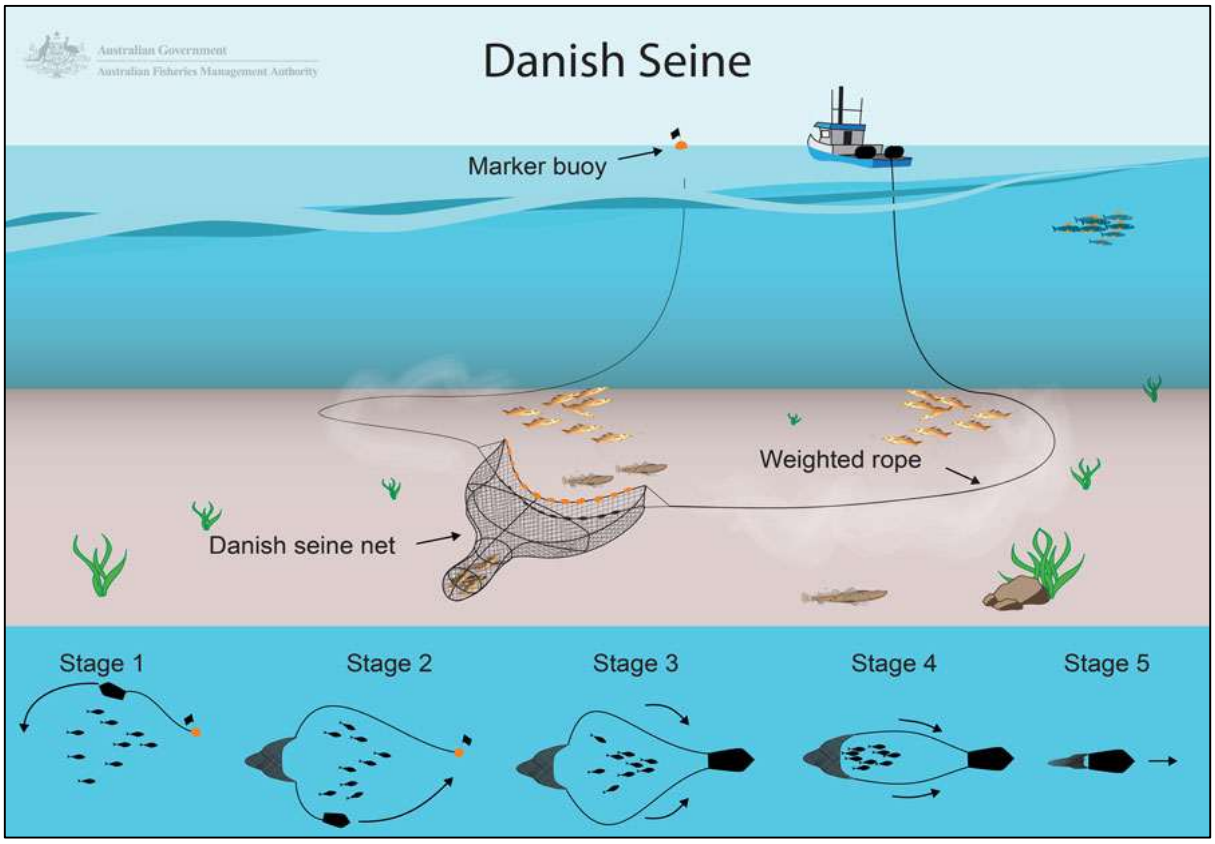


Figure 26: Danish seine fishing diagram

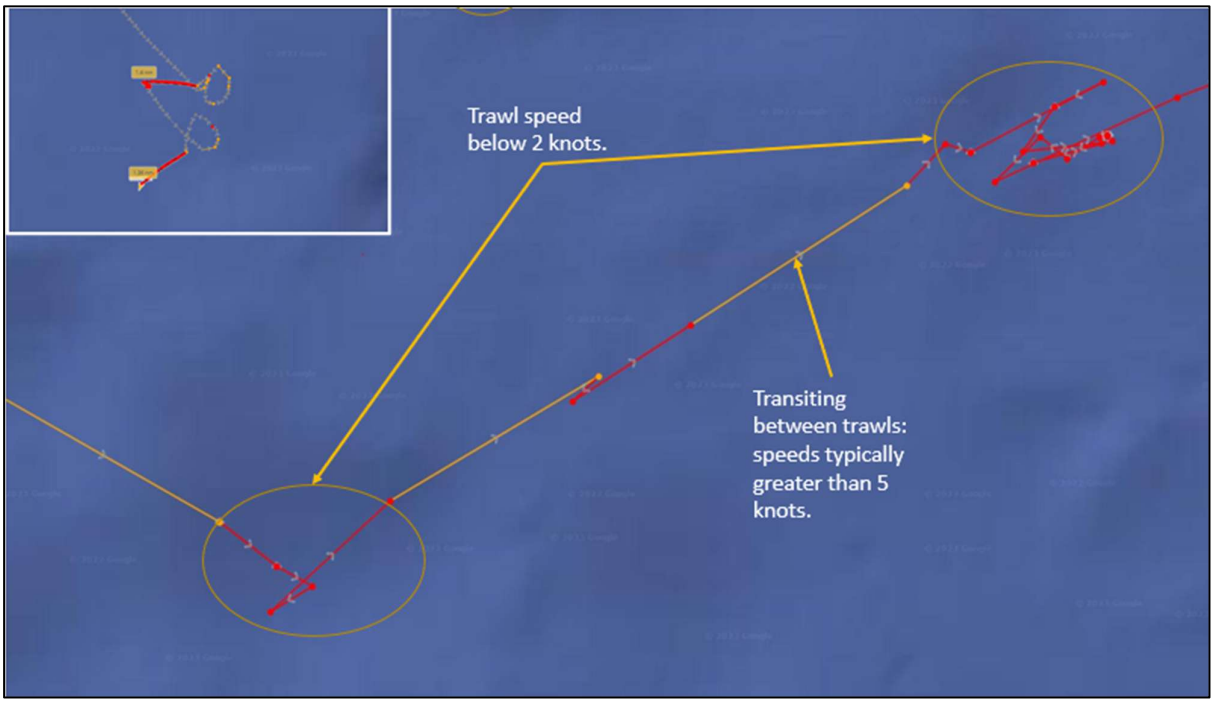


Figure 27: Danish seine vessel track

Purse Seine

Purse seine fishing is mainly used to catch fish species that swim in large schools near the ocean surface. In a purse seine, the top of the net is floated at the ocean's surface, and the bottom of the net has weights attached that pull the walls of the net downward.

The bottom of the net has a wire threaded through it. The wire is pulled, tightening the net and trapping fish inside. The net is then pulled in toward the vessel, and the catch is either pumped or lifted out with small nets, or the whole net is brought aboard. The size of purse seine nets varies, usually depending on the species targeted.

Vessels using this method trawl at 1.5-3 knots. The VMS tracks generally appear as clusters, as the nets are set in a circular pattern. However, different VMS polling rates may mean that the tracks do not appear to be circular.[18] However, they should still appear as a tight concentration around the fishing area.

[18] For more information on polling rates, visit section 4.2.1.

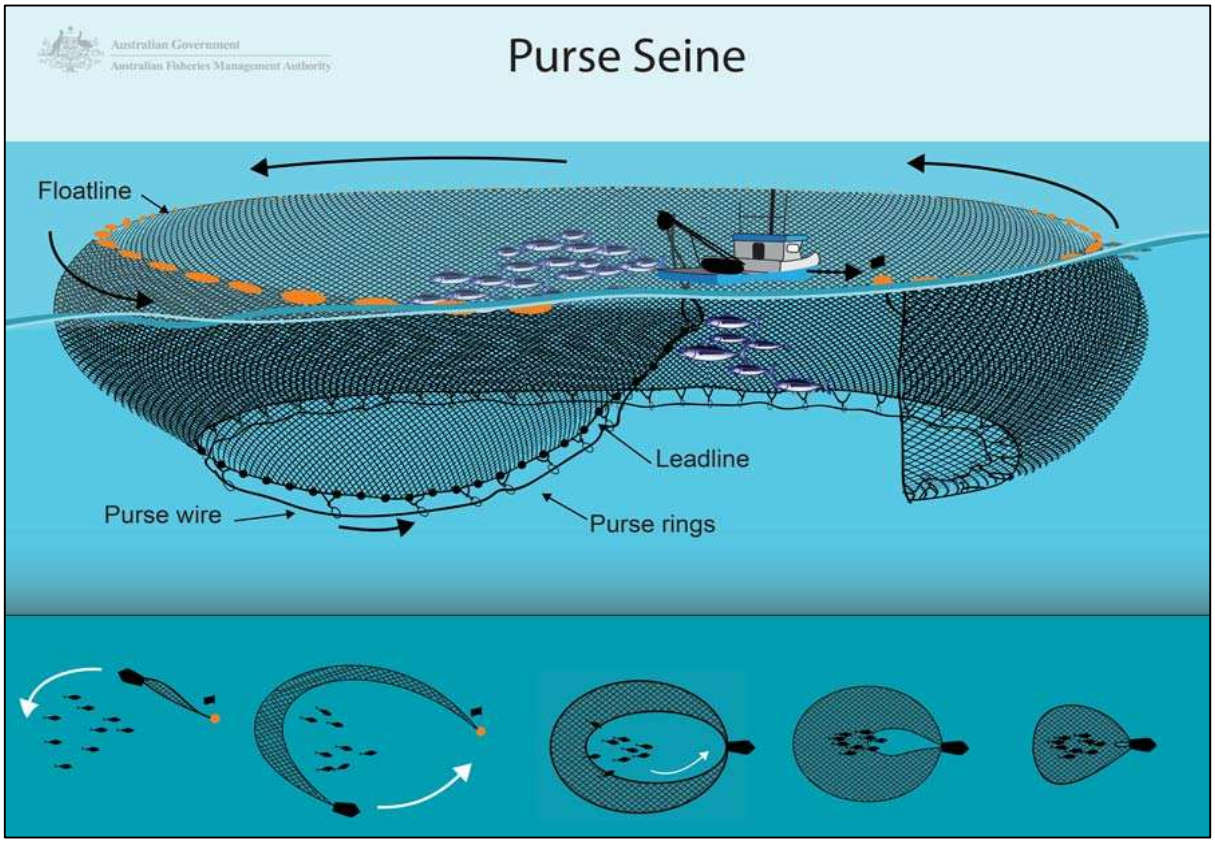


Figure 28: Purse seine fishing diagram

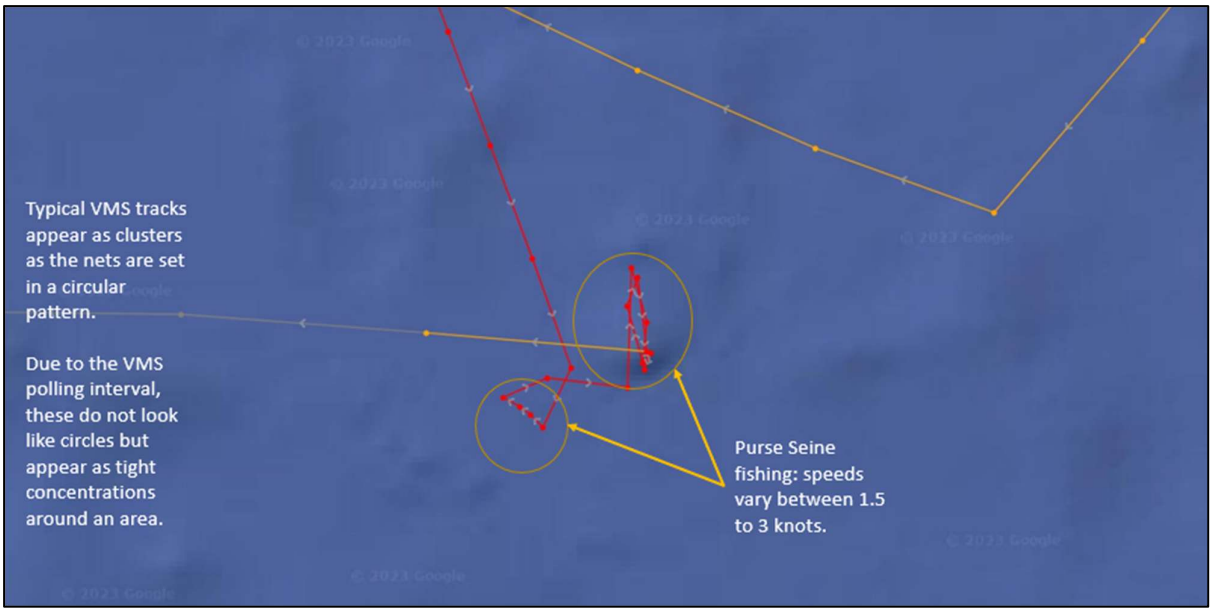


Figure 29: Purse seine vessel track

4.3 VMS Data Analysis

VMS data analysis is essential to interpreting fishing activity and identifying illegal fishing. Data analysis is also essential to detecting missing polls, interpreting device events (including VMS units being turned off), and aligning the VMS data with fishing logbooks.

Spreadsheets are one of the most effective tools to analyse VMS data. Spreadsheet analysis requires having a VMS that enables fisheries officers to extract data for a single vessel or fleet of vessels for a specified period. Extracting data into spreadsheets and CSV formats is essential for preparing data for mapping tools, such as ARC PRO. Once data is available, it can be analysed many ways.

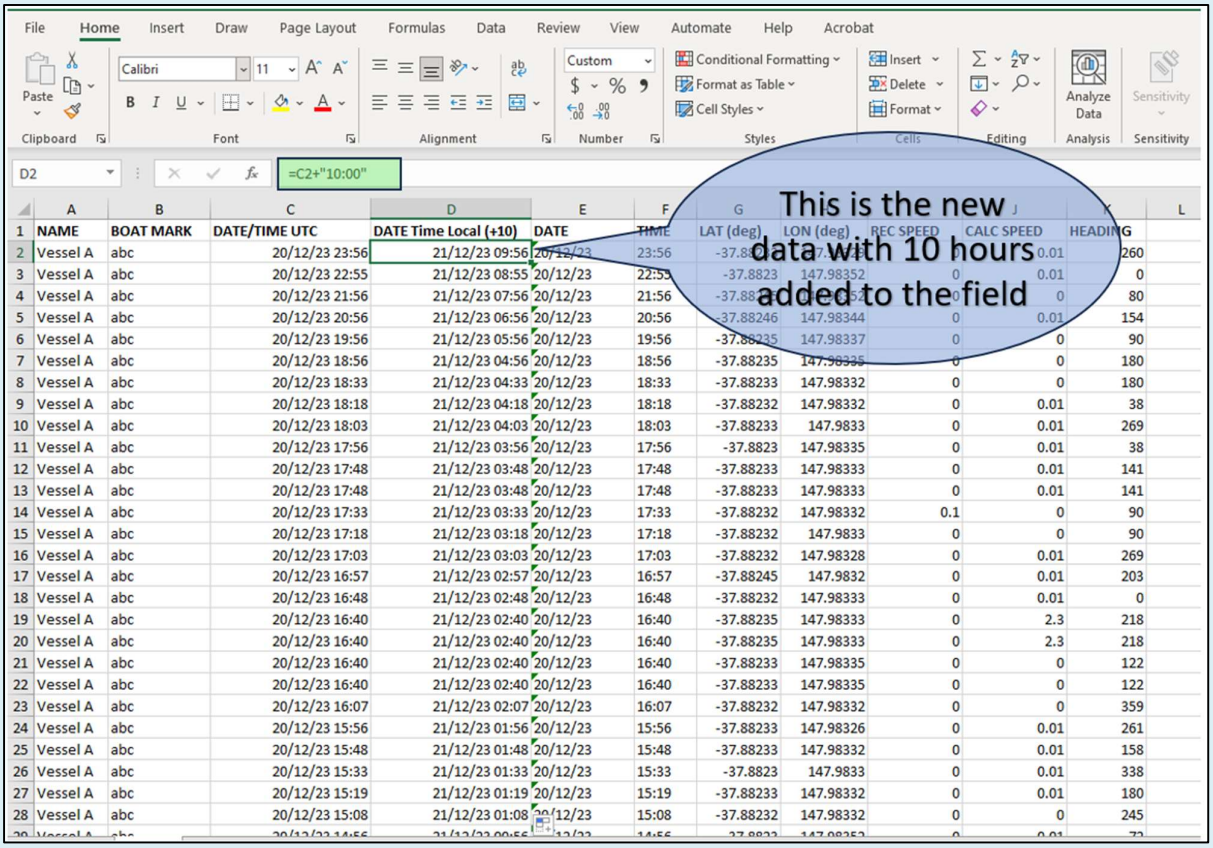
Changing VMS Data to Local Time Zone

The first step for any VMS data analysis is to change the raw data to the local time zone. This is useful for comparing logbook data and local sighting information, as well as analysing VMS outages to identify reporting issues.

Most VMS units default to Coordinated Universal Time (UTC). To change the time in a spreadsheet, add the UTC time zone to the UTC time.

Example: Changing VMS data from UTC to AEST

Australian Eastern Standard Time (AEST) time is UTC+10, so 10:00 is added to the UTC time in a new column.



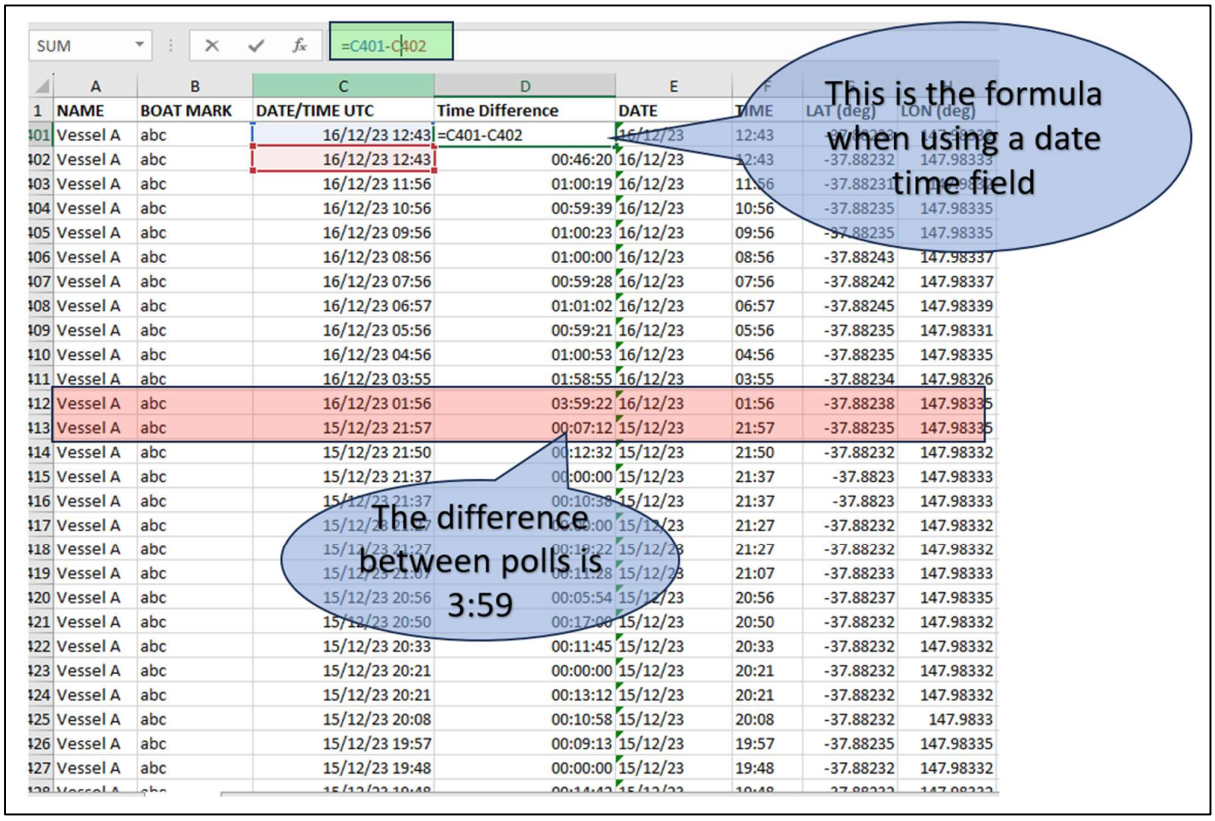
	A	B	C	D	E	F	G	H	I	J	K	L
1	NAME	BOAT MARK	DATE/TIME UTC	DATE Time Local (+10)	DATE	TIME	LAT (deg)	LON (deg)	REC SPEED	CALC SPEED	HEADING	
2	Vessel A	abc	20/12/23 23:56	21/12/23 09:56	20/12/23	23:56	-37.88	147.9		0.01	260	
3	Vessel A	abc	20/12/23 22:55	21/12/23 08:55	20/12/23	22:55	-37.8823	147.98352	0	0.01	0	
4	Vessel A	abc	20/12/23 21:56	21/12/23 07:56	20/12/23	21:56	-37.88	147.9	0	0	80	
5	Vessel A	abc	20/12/23 20:56	21/12/23 06:56	20/12/23	20:56	-37.88246	147.98344	0	0.01	154	
6	Vessel A	abc	20/12/23 19:56	21/12/23 05:56	20/12/23	19:56	-37.88235	147.98337	0	0	90	
7	Vessel A	abc	20/12/23 18:56	21/12/23 04:56	20/12/23	18:56	-37.88235	147.98335	0	0	180	
8	Vessel A	abc	20/12/23 18:33	21/12/23 04:33	20/12/23	18:33	-37.88233	147.98332	0	0	180	
9	Vessel A	abc	20/12/23 18:18	21/12/23 04:18	20/12/23	18:18	-37.88232	147.98332	0	0.01	38	
10	Vessel A	abc	20/12/23 18:03	21/12/23 04:03	20/12/23	18:03	-37.88233	147.9833	0	0.01	269	
11	Vessel A	abc	20/12/23 17:56	21/12/23 03:56	20/12/23	17:56	-37.8823	147.98335	0	0.01	38	
12	Vessel A	abc	20/12/23 17:48	21/12/23 03:48	20/12/23	17:48	-37.88233	147.98333	0	0.01	141	
13	Vessel A	abc	20/12/23 17:48	21/12/23 03:48	20/12/23	17:48	-37.88233	147.98333	0	0.01	141	
14	Vessel A	abc	20/12/23 17:33	21/12/23 03:33	20/12/23	17:33	-37.88232	147.98332	0.1	0	90	
15	Vessel A	abc	20/12/23 17:18	21/12/23 03:18	20/12/23	17:18	-37.88232	147.9833	0	0	90	
16	Vessel A	abc	20/12/23 17:03	21/12/23 03:03	20/12/23	17:03	-37.88232	147.98328	0	0.01	269	
17	Vessel A	abc	20/12/23 16:57	21/12/23 02:57	20/12/23	16:57	-37.88245	147.9832	0	0.01	203	
18	Vessel A	abc	20/12/23 16:48	21/12/23 02:48	20/12/23	16:48	-37.88232	147.98333	0	0.01	0	
19	Vessel A	abc	20/12/23 16:40	21/12/23 02:40	20/12/23	16:40	-37.88235	147.98333	0	2.3	218	
20	Vessel A	abc	20/12/23 16:40	21/12/23 02:40	20/12/23	16:40	-37.88235	147.98333	0	2.3	218	
21	Vessel A	abc	20/12/23 16:40	21/12/23 02:40	20/12/23	16:40	-37.88233	147.98335	0	0	122	
22	Vessel A	abc	20/12/23 16:40	21/12/23 02:40	20/12/23	16:40	-37.88233	147.98335	0	0	122	
23	Vessel A	abc	20/12/23 16:07	21/12/23 02:07	20/12/23	16:07	-37.88232	147.98332	0	0	359	
24	Vessel A	abc	20/12/23 15:56	21/12/23 01:56	20/12/23	15:56	-37.88233	147.98326	0	0.01	261	
25	Vessel A	abc	20/12/23 15:48	21/12/23 01:48	20/12/23	15:48	-37.88233	147.98332	0	0.01	158	
26	Vessel A	abc	20/12/23 15:33	21/12/23 01:33	20/12/23	15:33	-37.8823	147.9833	0	0.01	338	
27	Vessel A	abc	20/12/23 15:19	21/12/23 01:19	20/12/23	15:19	-37.88233	147.98332	0	0.01	180	
28	Vessel A	abc	20/12/23 15:08	21/12/23 01:08	20/12/23	15:08	-37.88232	147.98332	0	0	245	

Figure 30: VMS data converted from UTC to AEST

Identifying Time Between Polls

Spreadsheets can be used to identify the amount of time between polls. Analysing the time between polls can reveal polling abnormalities, including non-reporting or VMS malfunction.

To generate times between polls, subtract two consecutive poll times.



	A	B	C	D	E	F	G	H
1	NAME	BOAT MARK	DATE/TIME UTC	Time Difference	DATE	TIME	LAT (deg)	LON (deg)
401	Vessel A	abc	16/12/23 12:43	=C401-C402	16/12/23	12:43		
402	Vessel A	abc	16/12/23 12:43	00:46:20	16/12/23	12:43	-37.88232	147.98334
403	Vessel A	abc	16/12/23 11:56	01:00:19	16/12/23	11:56	-37.88231	147.98334
404	Vessel A	abc	16/12/23 10:56	00:59:39	16/12/23	10:56	-37.88235	147.98335
405	Vessel A	abc	16/12/23 09:56	01:00:23	16/12/23	09:56	-37.88235	147.98335
406	Vessel A	abc	16/12/23 08:56	01:00:00	16/12/23	08:56	-37.88243	147.98337
407	Vessel A	abc	16/12/23 07:56	00:59:28	16/12/23	07:56	-37.88242	147.98337
408	Vessel A	abc	16/12/23 06:57	01:01:02	16/12/23	06:57	-37.88245	147.98339
409	Vessel A	abc	16/12/23 05:56	00:59:21	16/12/23	05:56	-37.88235	147.98331
410	Vessel A	abc	16/12/23 04:56	01:00:53	16/12/23	04:56	-37.88235	147.98335
411	Vessel A	abc	16/12/23 03:55	01:58:55	16/12/23	03:55	-37.88234	147.98326
412	Vessel A	abc	16/12/23 01:56	03:59:22	16/12/23	01:56	-37.88238	147.98335
413	Vessel A	abc	15/12/23 21:57	00:07:12	15/12/23	21:57	-37.88235	147.98335
414	Vessel A	abc	15/12/23 21:50	00:12:32	15/12/23	21:50	-37.88232	147.98332
415	Vessel A	abc	15/12/23 21:37	00:00:00	15/12/23	21:37	-37.8823	147.98333
416	Vessel A	abc	15/12/23 21:37	00:10:38	15/12/23	21:37	-37.8823	147.98333
417	Vessel A	abc	15/12/23 21:27	00:00:00	15/12/23	21:27	-37.88232	147.98332
418	Vessel A	abc	15/12/23 21:27	00:10:22	15/12/23	21:27	-37.88232	147.98332
419	Vessel A	abc	15/12/23 21:07	00:11:28	15/12/23	21:07	-37.88233	147.98333
420	Vessel A	abc	15/12/23 20:56	00:05:54	15/12/23	20:56	-37.88237	147.98335
421	Vessel A	abc	15/12/23 20:50	00:17:00	15/12/23	20:50	-37.88232	147.98332
422	Vessel A	abc	15/12/23 20:33	00:11:45	15/12/23	20:33	-37.88232	147.98332
423	Vessel A	abc	15/12/23 20:21	00:00:00	15/12/23	20:21	-37.88232	147.98332
424	Vessel A	abc	15/12/23 20:21	00:13:12	15/12/23	20:21	-37.88232	147.98332
425	Vessel A	abc	15/12/23 20:08	00:10:58	15/12/23	20:08	-37.88232	147.9833
426	Vessel A	abc	15/12/23 19:57	00:09:13	15/12/23	19:57	-37.88235	147.98335
427	Vessel A	abc	15/12/23 19:48	00:00:00	15/12/23	19:48	-37.88232	147.98332

Figure 31: Example VMS data with time between polls shown

4.4 Monitoring "Closed" Areas

Sometimes, areas or fisheries need to be "closed", meaning that entering and/or fishing in certain areas is prohibited. VMS can be effectively used to identify when vessels have entered or potentially fished in closed areas. VMS software and hardware can be used to create geofences. Geofences can automatically alert fisheries officers when a vessel enters or exits geofenced areas or travels certain speeds within these areas.[19]

Fisheries agencies should have standard operating procedures (SOPs) in place to action "closure alerts". Below is an example of a flowchart for investigating a closure alert.

Example: AFMA's approach to responding to closure alerts

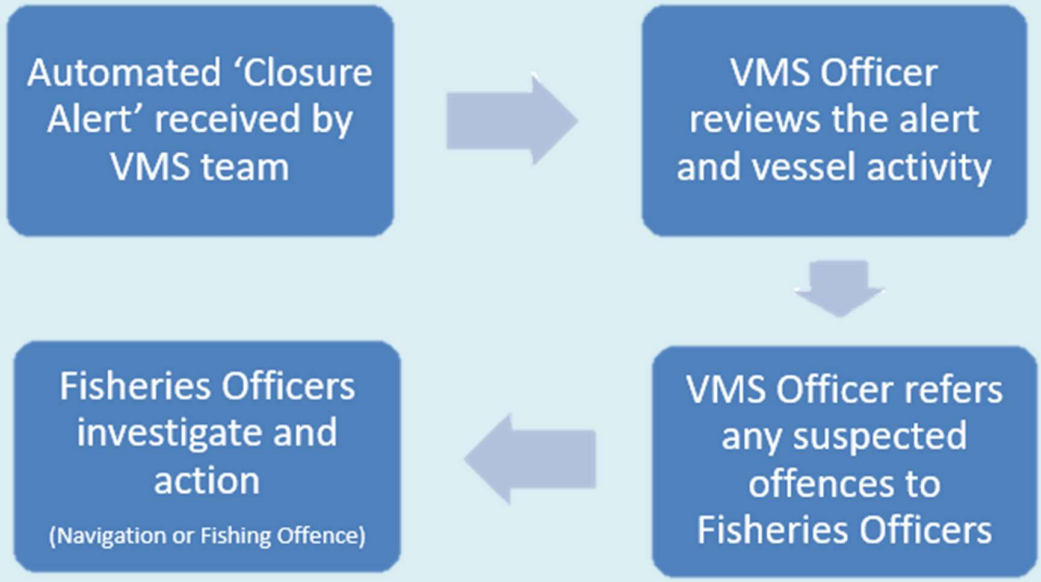


Figure 32: Flowchart for monitoring closure alerts

Navigation Regulations

Navigation Regulations are rules mandating where fishing vessels are not allowed to enter. When areas are closed to fishing vessels, the fisheries agency could implement a Navigation Regulation. A Navigation Regulation should:

- prohibit a licensed vessel from travelling at a speed of less than 5 knots in a closed area, and
- specify that the vessel's speed is the speed calculated through the vessel's VMS positions.

When a Navigation Regulation is in place, the VMS should be updated to produce an automated report when a fishing vessel is detected inside a closed area and travelling at a speed of less than 5 knots. Vessels travelling at less than 5 knots in these areas are likely to be illegally fishing.

Most VMS software can be programmed to automatically notify fisheries officers if a vessel is detected inside a closed area and travelling at a speed of less than 5 knots (fishing speed). VMS polling can be used to calculate a vessel's speed based on its position.[20]

[19] For more information on geofence alerts, visit section 4.1.3.
[20] For more information on calculating vessel speed, visit section 4.2.

5 Other Monitoring Technologies

5.1 Automatic Identification System (AIS)

Automatic Identification System (AIS) is primarily designed to operate as a collision avoidance tool but can be used to monitor vessels' locations in place of VMS. AIS transmits data via Very High Frequency (VHF) radio. Some units can also be linked to satellite systems.

AIS can be used in place of VMS because all AIS users must upload their Maritime Mobile Service Identity (MMSI), which is linked to the vessel's name, type and size. AIS tracks the vessel's position, course and speed. This information is sent to other AIS units in the vicinity and appears on nearby vessels' radar. Some AIS units have alarms that warn of potential collisions.

Advantages:

- AIS is often an existing requirement on vessels for safety purposes.
- Data is publicly available and accessible, therefore easy for the fisheries agency to access.
- Free data transmission.

Disadvantages:

- Data is publicly available and accessible, creating a privacy risk.
- Limited range offshore.
- Can be easily "spoofed" or faked.
- Less reliable communication due to the possibility of VHF saturation.

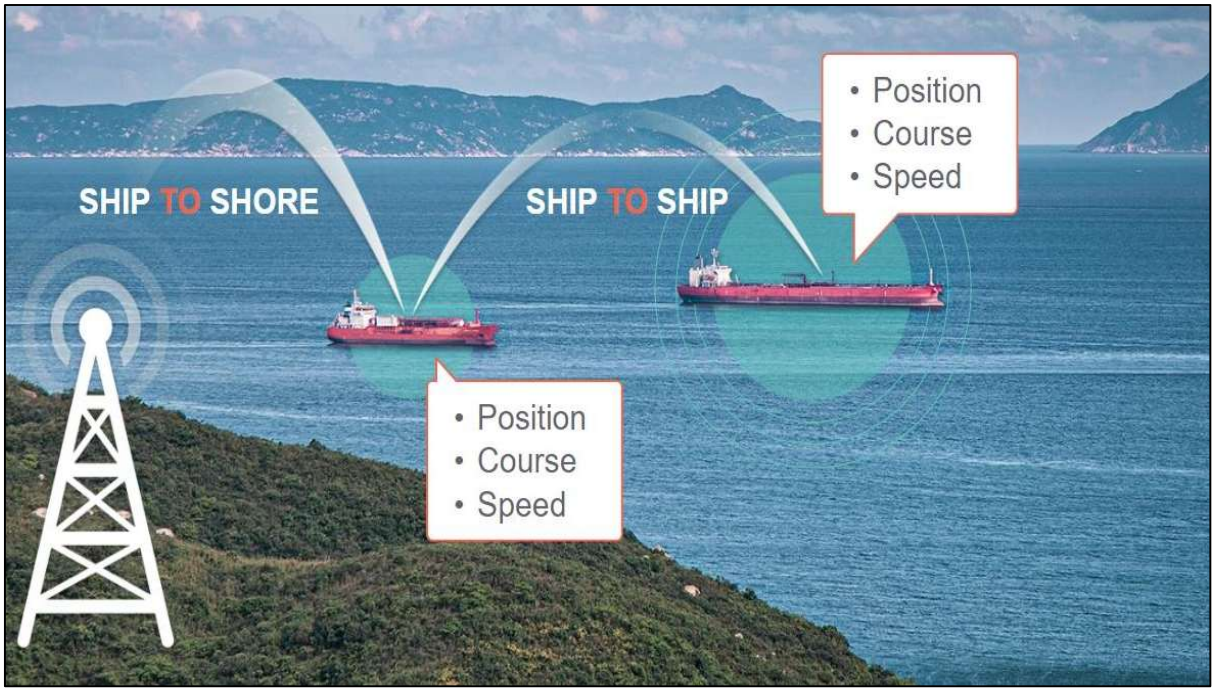


Figure 33: Diagram of AIS communication between radio towers and vessels

5.2 Electronic Monitoring (EM)

Electronic Monitoring (EM or e-monitoring) is a system of sensors and video cameras capable of monitoring and recording fishing activities which can be reviewed to verify logbook data. EM tracks vessel position and movement in real-time, recording sensor data and video footage of fishing activity, enabling the monitoring of compliance with on-board requirements. An EM system typically includes several key components: three or more video cameras, a hydraulic gear sensor, a drum sensor, a GPS receiver, and a control centre.

Data collection software monitors the EM system and stores relevant fishing activity data on a removable hard drive for later review. VMS and EM can be used together to enforce fisheries legislation.

Figure 34: Examples of electonic monitoring systems

5.3 Satellite Technologies (Dark Vessel Detection)

Satellite technologies can be utilised for Dark Vessel Detection (DVD). Dark Vessels are vessels that take deliberate actions to not be detected. Even if it is mandatory for vessels be fitted with Automatic Identification Systems (AIS), they may turn their AIS unit off when they do not want to be seen. Several remote satellite-based sensing options can be used to identify dark vessels, including Synthetic Aperture Radar, Electro Optical and Radio Frequency Detection.

Satellite-based systems can cover large areas of ocean. However, they are relatively expensive and identification is not certain.

5.3.1 Synthetic Aperture Radar (SAR)

Synthetic Aperture Radar (SAR) uses radio wave pulses directed onto the earth's surface to create images. It uses the motion of a satellite radar antenna over a target region to create an image.

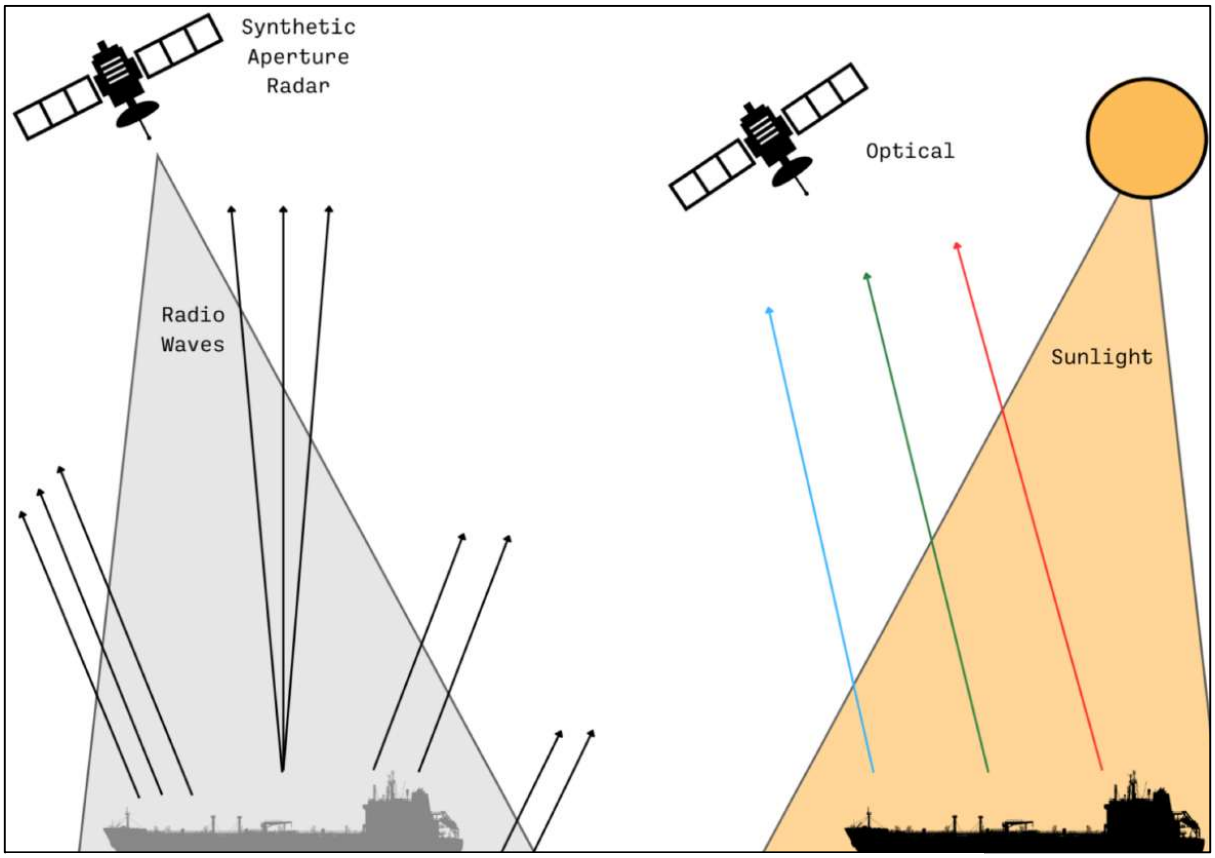


Figure 35: Diagram of SAR components

Figure 36: Example of imaged generated by SAR

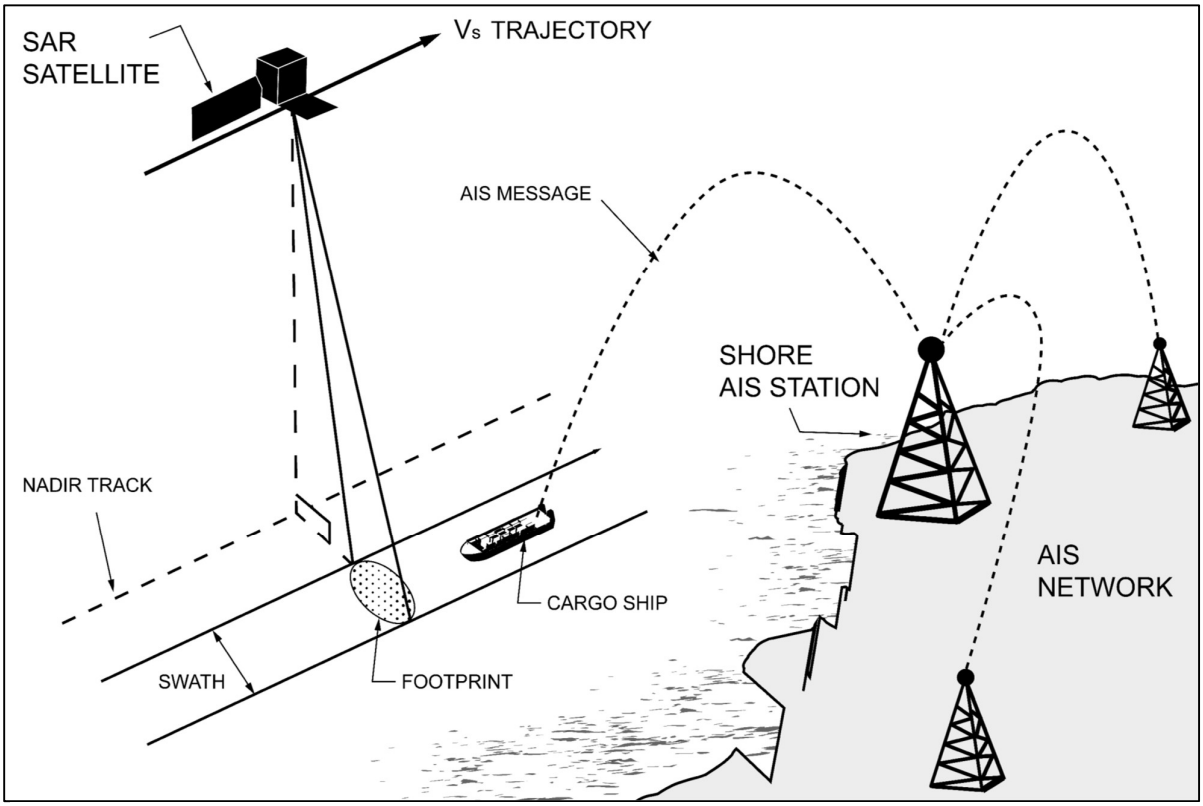


Figure 37: Diagram of SAR with AIS components

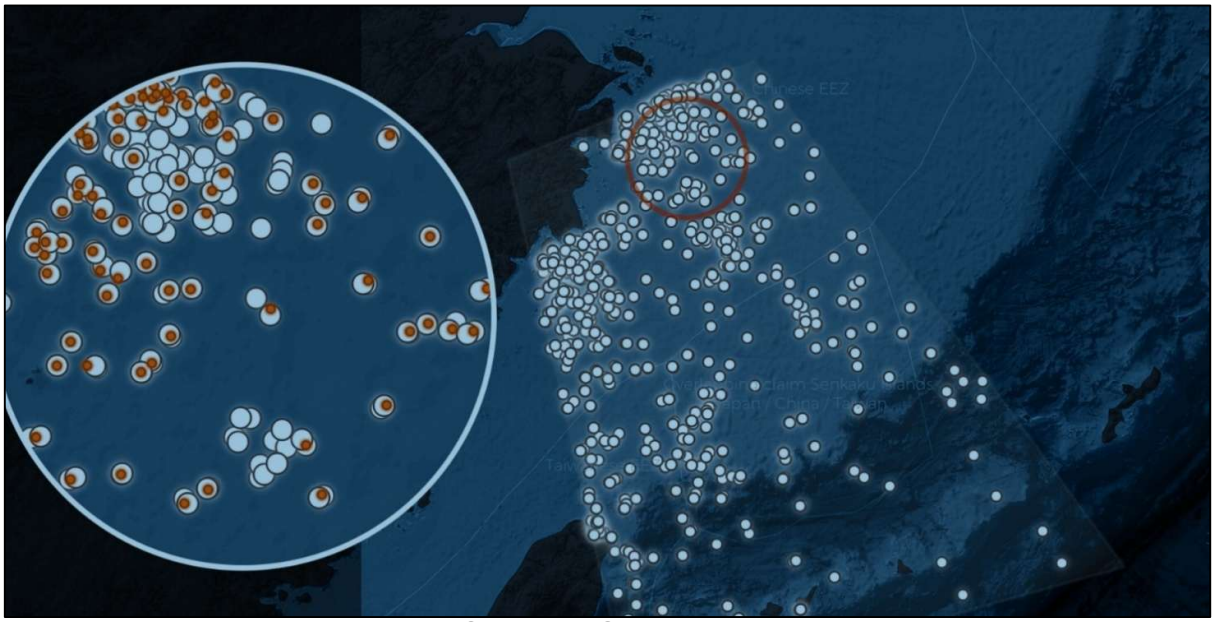


Figure 38: Example image generated by SAR with AIS detection

Advantages of SAR:

- SAR, unlike Electro Optical (EO),[21] can be used in low visibility conditions. It can be used at night and see through clouds or weather events.

Disadvantages of SAR:

- SAR images are lower resolution than EO.
- There can be granular “noise” in SAR images, especially if they are taken during rough wave conditions, as they pick up waves as “noise”.

[21] For more information on EO, visit section 5.3.2.

5.3.2 Electro Optical

Electro Optical (EO) sensors require reflected light to form an image. The visible range for EO is from ultraviolet through to infrared.

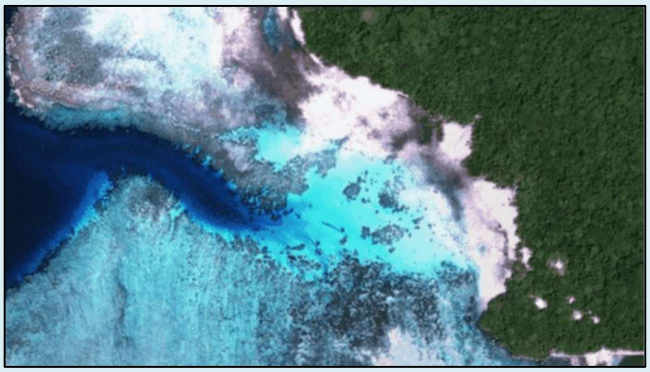
Advantages:

- EO image outputs are easy to interpret, as they resemble photographic images in the visible light spectrum.

Disadvantages:

- EO, unlike SAR, is not effective at night and in cloudy conditions.
- EO images are relatively expensive to produce.
- EO requires a smaller area of focus then SAR or Radio Frequency (RF),[22] limited to up to 50km^2.

Examples of images produced by Electro Optical sensors.



[22] For more information on SAR, visit section 5.31. For more information on RF, visit section 5.3.3.

5.3.3 Radio Frequency (RF) Detection

Radio Frequency (RF) detection uses radio frequency transmissions to detect vessels at sea. All vessels have some form of radio equipment, including marine radars, radios, mobile satellite devices or phones. All of these emit radio frequency energy that can be detected by RF satellite detectors. The RF signal can be located, and its position mapped and tracked over time. Below is an image created by RF.

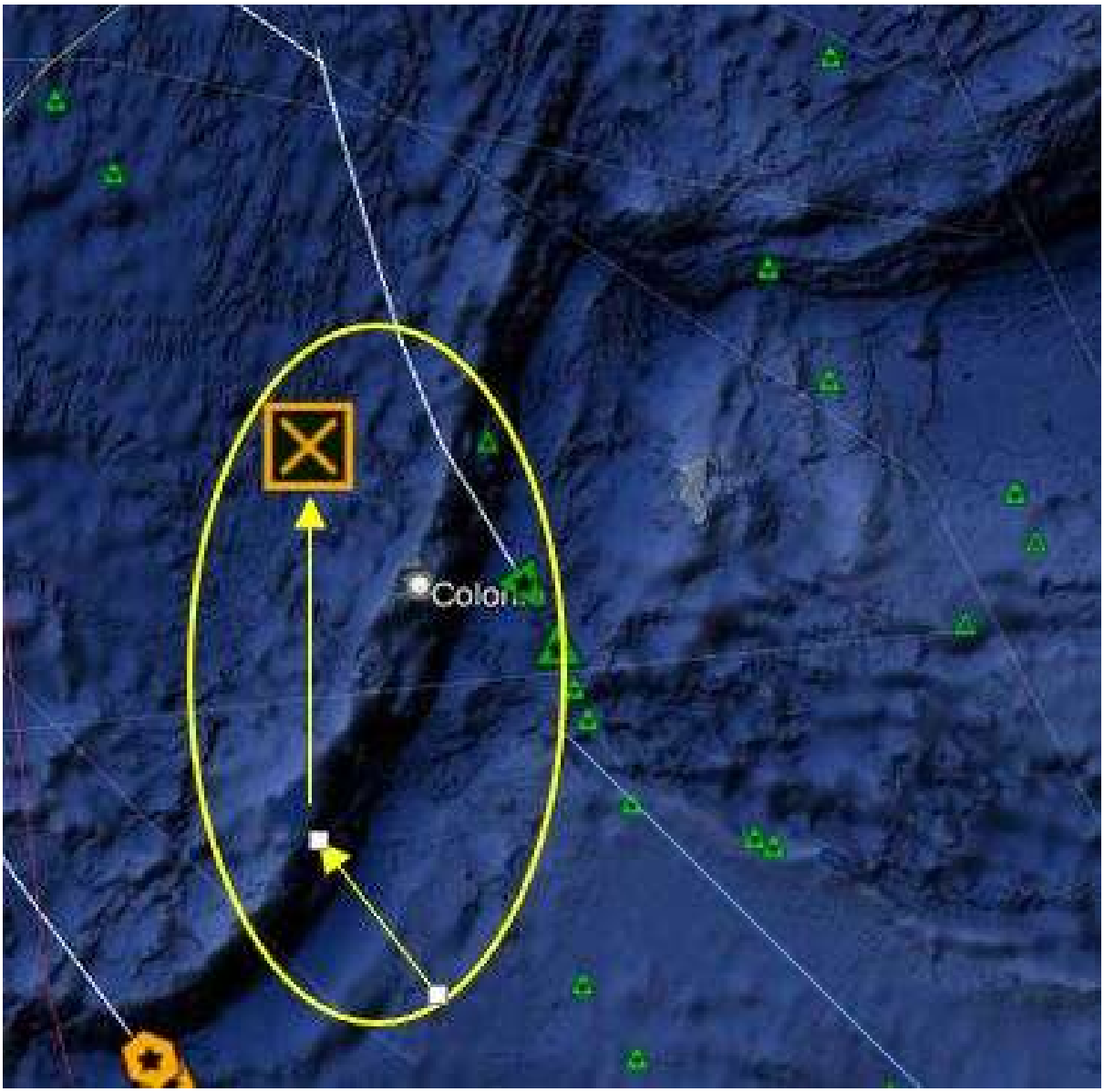


Figure 39: Example of image created by RF

Appendix A: Regional Fisheries Management Organisations

Regional fisheries management organisations (RFMOs) are international agreements between countries about how to manage fishery resources that migrate between jurisdictional waters. The mandates of RFMOs include:

- provision of scientific advice
- establishment of catch limits and harvest control processes
- establishment, and assessment of compliance with rules and obligations, and
- coordination of monitoring, control and surveillance (MCS) activities.

Australia's engagement in RFMOs is underpinned by its need to balance its commercial and environmental interests. The principles of the agreements inform Australia's fishery legislation. AFMA's VMS legislation is informed by Australia's fishery management obligations under RFMOs.

Below outlines some of the RFMOs Australia is party to.

Pacific Islands Forum Fisheries Agency

The Pacific Islands Forum Fisheries Agency (FFA) is an advisory body for countries in the Pacific Ocean to cooperate and coordinate on fisheries policies to achieve maximum long term social and economic benefit from the sustainable use of shared and migratory fishery resources. The FFA was established in 1979, and the headquarters are in Honiara, Solomon Islands. Tuna is the main species of interest.

To maximise the economic and social benefits of fisheries, the FFA mandates that parties must:

- Manage fisheries to ensure their use is sustainable and will provide tuna now and in the future.
- Monitor, control and surveillance to stop illegal fishing and make sure fishing benefits go towards fishers who follow the rules of development and management set by governments.
- Develop fisheries that harvest, process and market tuna to create jobs, income and a thriving industry.

Commission for the Conservation of Antarctic Marine Living Resources

The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) is the international body responsibility for the conservation of Southern Ocean marine life and ecosystems. The members meet annually to discuss the opening and closure of fisheries in Antarctica, the total allowable catches, and the designation of marine protected areas.

CCAMLR mandates that:

- use of fisheries is to occur on a sustainable basis
- depleted fish stocks are to be restored to sustainable levels, and
- the ecological relationship between harvested, dependent and related populations of Antarctic marine living resources maintained.

CCAMLR came into force in 1982 and is part of the Antarctic Treaty system. Its headquarters are in Hobart, Tasmania.

South Pacific Regional Fisheries Management Organisation

The South Pacific Regional Fisheries Management Organisation (SPRFMO) is an intergovernmental organisation committed to long-term conservation and sustainable use of non-highly migratory fishery resources in the South Pacific Ocean. It aims to safeguard the marine ecosystem through a precautionary approach to fisheries management.

SPRFMO was established in 2012, and the headquarters are in Wellington, New Zealand.

Indian Ocean Tuna Commission

The Indian Ocean Tuna Commission (IOTC) is an intergovernmental organisation mandated to sustainably manage highly migratory tuna and tuna-like fisheries resources in the Indian Ocean. The IOTC sits under the Council of the Food and Agriculture Organization of the United Nations.

The IOTC came into force in 1996, and its headquarters are in Victoria, Seychelles.

Commission for the Conservation of Southern Bluefin Tuna

The Commission for the Conservation of Southern Bluefin Tuna (CCSBT) is an intergovernmental organisation responsible for the conservation and sustainable use of the global southern bluefin tuna (SBT) stock. The CCSBT management target is to recover SBT stock to 30% of its unfished levels by 2035.

The Commission came into effect in 1994, and its headquarters are in Canberra, Australia.

Western and Central Pacific Fisheries Commission

The Western and Central Pacific Fisheries Commission (WCPFC) is an international organisation with the objective to ensure the long-term conservation and sustainable use of highly migratory fish stocks in the Western and Central Pacific Ocean. WCPFC manages the largest tuna fishery in the world. The total annual catch of tuna in the Western and Central Pacific Ocean represents around 55 per cent of global tuna production. Approximately half of this catch is from the exclusive economic zones (EEZs) of Pacific Island countries.

WCPFC commenced operations in 2005, and its headquarters are in Pohnpei, Federated States of Micronesia.

Appendix B: Australia's Procurement Process

Below is a diagram of AFMA's VMS procurement model. AFMA does not procure VMS units on behalf of vessel operators. AFMA approves VMS units, and vessel operators must purchase a unit off the approved list. The vessel operators and hardware provider have a separate contract, independent of AFMA.

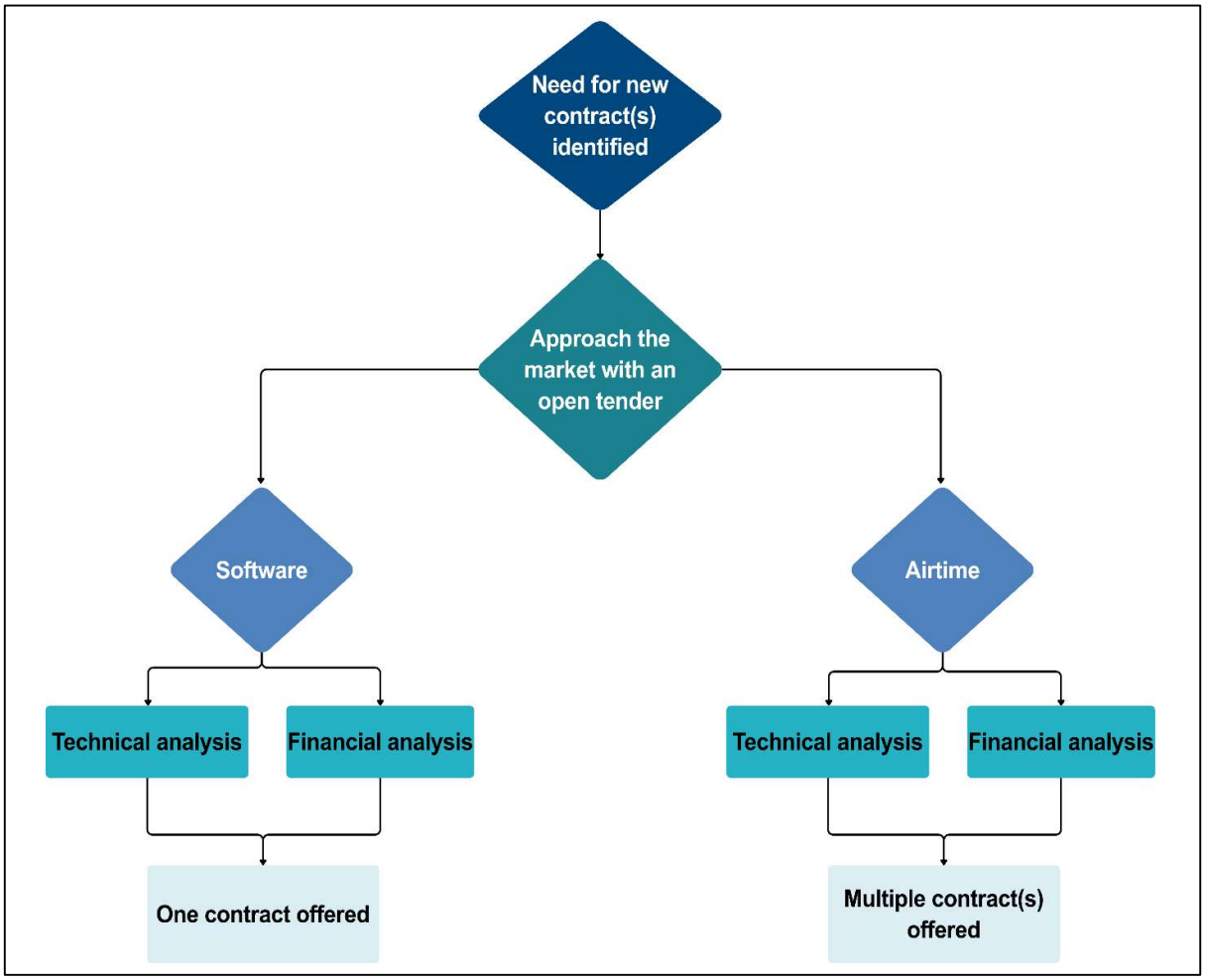


Figure 40: Flowchart of AFMA's VMS procurement process

And below is an alternative guide, where VMS hardware is procured by the fisheries agency:

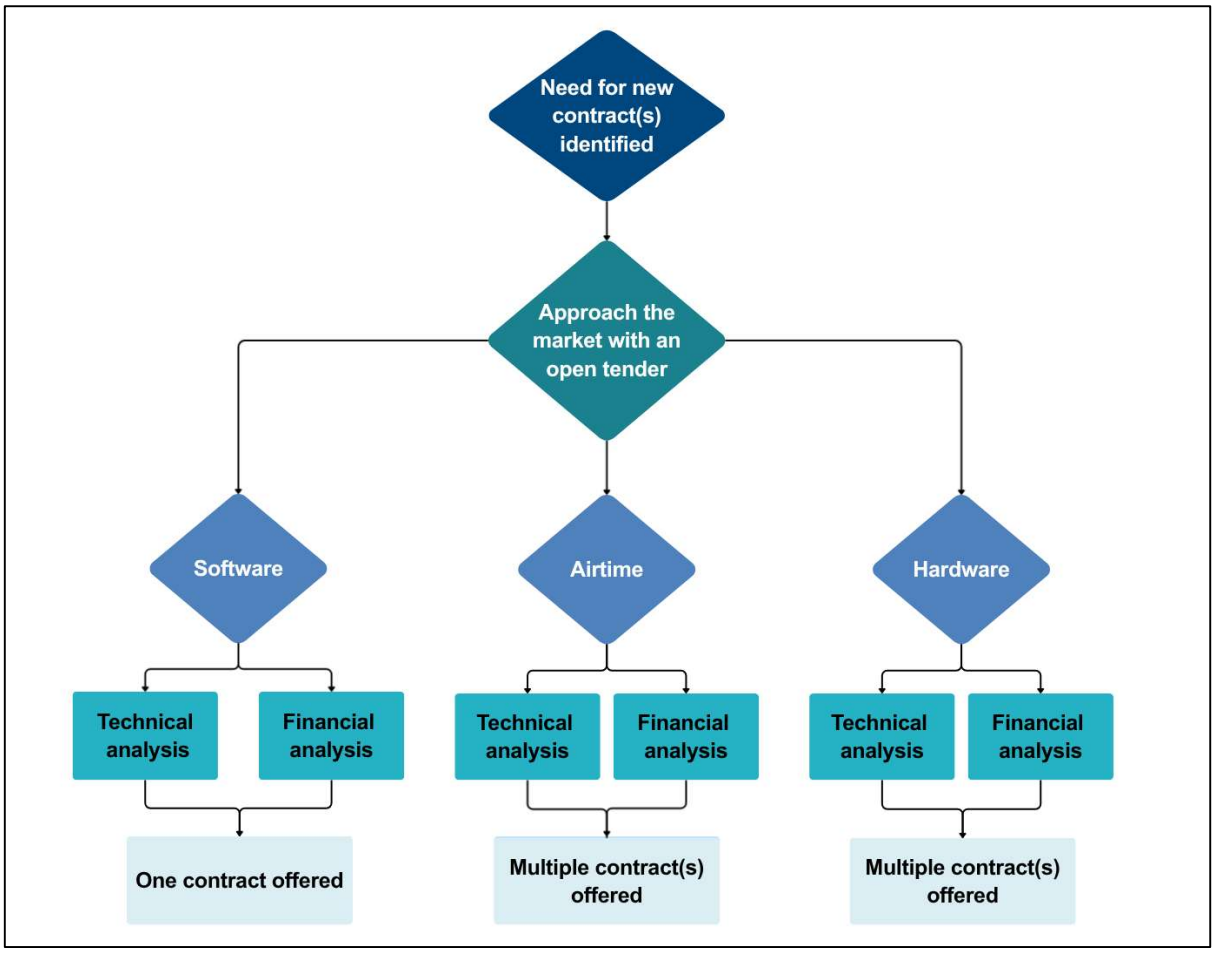


Figure 41: Flowchart of an alternate VMS procurement process

6 Glossary

AFMA – Australian Fisheries Management Authority

AFZ – Australian Fishing Zone

AIS – Automatic Identification System

ALC – Automatic Location Communicator

ALCI – Automatic Location Communicator Identity

API – Application Programming Interface

CCAMLR – Commission for the Conservation of Antarctic Marine Living Resources

CCSBT – Commission for the Conservation of Southern Bluefin Tuna

DVD – Dark Vessel Detection

EEZ – Exclusive Economic Zone

EM – Electronic Monitoring

EO – Electro Optical

FFA – Pacific Islands Forum Fisheries Agency

GIS – Geographic Information System

GPS – Global Positioning System

GPRS – General Packet Radio Service

GSM – Global System for Mobile Communications

IMO – International Maritime Organisation

IOTC – Indian Ocean Tuna Commission

MCS – Mobile Communications Service

MCS – Monitoring, Control and Surveillance

MMSI – Maritime Mobile Service Identity

MTU – Mobile Transceiver Units

RF – Radio Frequency

RFMO - Regional Fisheries Management Organisations

SAR – Synthetic Aperture Radar

SOP – Standard Operating Procedure

SPRFMO – South Pacific Regional Fisheries Management Organisation

WCPFC – Western and Central Pacific Fisheries Commission

VHF – Very High Frequency (radio)

VMS - Vessel Monitoring System