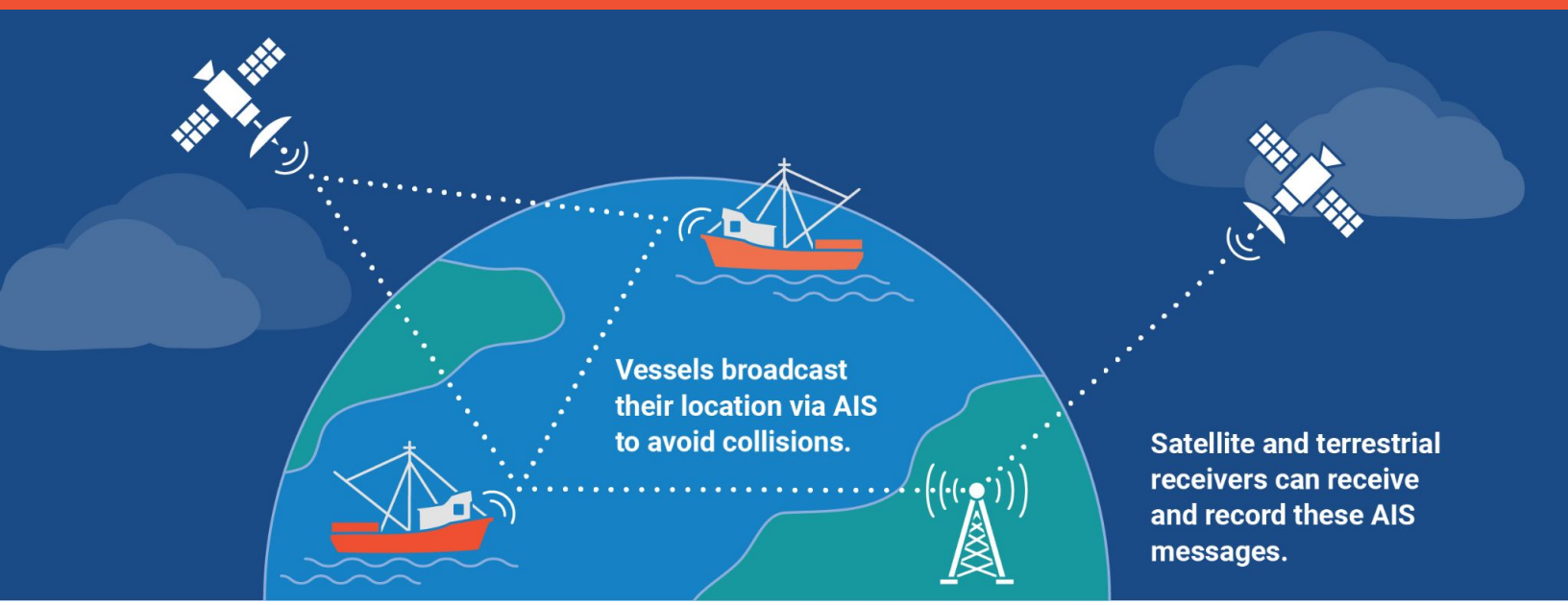
Global Fishing Watch

AIS Explainer
November 2023



Automatic Identification System (AIS)

What is AIS?

Automatic Identification System (AIS) is an automatic tracking system originally developed to complement shipboard marine radars for preventing collisions between vessels at sea. Vessels fitted with AIS transceivers[1] broadcast short-range signals alerting other vessels to their presence. These AIS signals can be received not only by nearby vessels, but also by terrestrial receivers, which allows authorities such as maritime safety and ports to monitor vessel movements.

AIS was developed in the 1990s, initially designed to communicate with vessels in line of sight. However, it was soon found that low earth orbit satellites could also receive AIS signals. Over the past decade, as governments and private companies have launched more low-earth orbit satellites, AIS data has become increasingly accessible and has broader global coverage. As such, AIS is now used for various purposes including monitoring and control of fishing fleets, enhancing maritime security, and aiding navigation.

What vessels report on AIS?

AIS is not mandated internationally for use by all vessels. The International Maritime Organization (IMO) requires AIS to be fitted and used on international voyaging vessels which are 300 gross tons (GT) in size or larger, and all passenger ships regardless of size. However, some states may require AIS reporting on smaller vessels, and the requirements can vary depending on the regulations in each jurisdiction.

[1] Transceivers are devices that allow for two-way communication: they can both send and receive messages. They differ from transponders, which lack the capability to initiate any communication on their own. Instead, transponders only receive incoming signals and have the capacity to transmit these received signals.

AIS data therefore tends to be biased in favor of larger vessels, countries/territories with stronger regulations, and distant water fleets. AIS effectively captures up to about 85% of the commercial fishing activity on fishing vessels larger than 24 meters. However, this drops down to less than 20% for fishing vessels between 12 and 24 m in length. For vessels under 12 m, which include most small-scale fisheries, AIS data is available for less than 0.4%.[2]

What data does AIS provide and how is it collected?

AIS Data types

AIS transceivers broadcast information of three types:

- Fixed messages on identity features of the vessel, such as ship name, call sign, International Maritime Organisation (IMO) number, vessel dimensions, and an identifier known as its Maritime Mobile Service Identity (MMSI).
- Dynamic vessel positional data on location, speed, and course and
- Voyage-specific information, such as vessel draught, and destination.

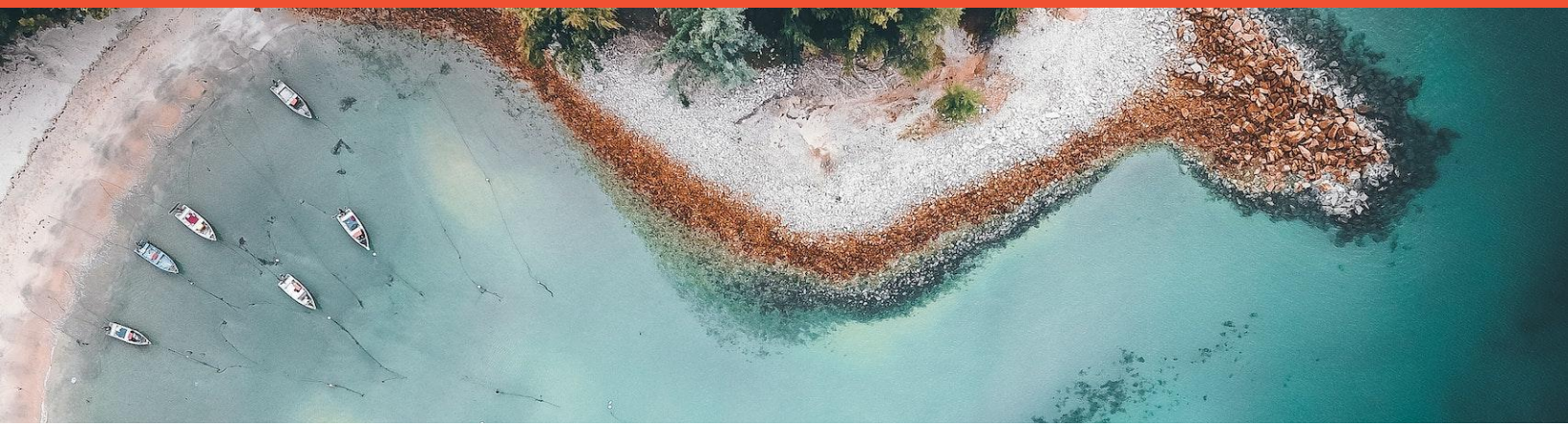
MMSIs are unique nine-digit numbers used by AIS devices and other equipment to identify vessels. The first three digits of an MMSI are known as the Maritime Identification Digits (MIDs). The MID indicates the flag state of the vessel, with the first digit denoting the geographic region. Whenever a vessel is re-flagged, a new MMSI must be assigned to the vessel with the MID of the new flag state. MMSIs differ from the IMO Number, which remains with that vessel for its entire lifetime, irrespective of changes in flag state, vessel name, or ownership. Monitoring, Control and Surveillance (MCS) personnel must take this into account and endeavor to confirm a vessel's identity using multiple different data sources, rather than relying solely on the information provided by an MMSI.

AIS Data latency

An AIS transmission does not contain a timestamp. A timestamp is applied when the transmission is detected by a receiver. While this is not an issue for direct vessel-to-vessel AIS communication that occurs in near real-time, there can be a significant delay when AIS transmissions are delivered to end users via satellite transceivers. This delay, known as data latency, can vary from minutes to hours, and must be considered when using AIS data. In some cases, data latency may mean that an MCS officer is not viewing a vessel's geographic position in near real-time. This can significantly influence decision-making, particularly for enforcement operations that rely on current vessel locations. However, latency may not be a critical issue in other enforcement responses, such as evidence to support an investigation into potential IUU activities that have already occured or analyzing a vessel's movements prior to port entry.

It is important to note that the AIS data that Global Fishing Watch provides via its online platform includes an additional delay, an analytical latency of 72 hours. This latency is built in to allow for processing and quality assurance to identify anomalies of the raw data, and subsequent analysis to identify potential fishing activity along the vessel tracks.

[2] Kroodsma, D., Miller, N. A., Gee, J., Hochberg, T., Park, J., Clavelle, T. 2019. Use of AIS by the world's fishing fleet. In Taconet, M., Kroodsma, Fernandes, J. A. (eds.) Global Atlas of AIS-based fishing activity - Challenges and opportunities. Rome, FAO.



AIS Data collection and transmission

Shore-based terrestrial receivers and infrastructure such as Land Earth Station (LES) networks are designed to collect AIS transmissions captured by satellites. This infrastructure is commonly deployed by commercial AIS data collection companies like ORBCOMM, exactEarth and Spire, as well as governments and intergovernmental agencies (such as the European Space Agency). The network of satellite, terrestrial receivers and LES are used to provide for a global footprint of AIS activity for those vessels transmitting on AIS no matter where they are operating on the globe.

AIS devices fitted on vessels fall into three categories: Class A, Class B and Class B+. Class A devices have the strongest signal, broadcast most often, and are primarily used by large vessels operating at sea, most of which are large commercial vessels. AIS broadcasts on only two frequencies, and if two messages are broadcast on the same frequency simultaneously the transmissions will often interfere with each other. This is a greater issue for Class B device types, which only transmit a signal if there is a free slot available within the frequency being used by the AIS transceiver. The frequency of AIS transmissions (ping rates) depends on the vessel speed and rate of turn. The AIS device will ping faster when the vessel is moving quickly, and at a much lower rate if the vessel is stationary.

AIS Device	Class A	Class B+	Class B
Application	Mandatory on all vessels greater than 300GT on international voyages and all passenger vessels	Relatively recent and is not as widely deployed as Class A or Class B.	A lower cost transceiver used by smaller fishing and leisure vessels
Broadcast power	12.5 watts	5 watts	2 watts
Broadcast frequency	**Anchored or moving less than 3 Knots**: Every 3 min **Moving faster than 3 knots**: Every 2-10 seconds	**Anchored or moving less than 2 Knots**: Every 3 min **Moving faster than 2 knots**: Every 5-30 seconds	**Anchored or moving less than 2 Knots**: Every 3 min **Moving faster than 2 knots**: Every 30 seconds
Transmission type	Signals are coordinated with devices on nearby vessels so that they do not broadcast at the same time. This has the advantage of minimizing data corruption but does introduce a coverage limitation.		Looks for unused slots in the communication channel to broadcast the signal. If no unused slots are available, Class B devices cannot broadcast. This results in slower or less frequent transmissions.

Satellite receivers

- Are Low Earth Orbit (LEO) satellites that orbit the earth in 90 to 110 minutes
- Can “see” a swath ~5,000km across
  - For class A devices, reception is limited to the horizon
  - For class B and B+ devices, limited by distance, so the effective radius is smaller
- Are overhead only 10 to 20 minutes at a time
- Do not receive transmissions well in regions of high vessel traffic as the slots to receive signals onboard a satellite are limited

Terrestrial receivers

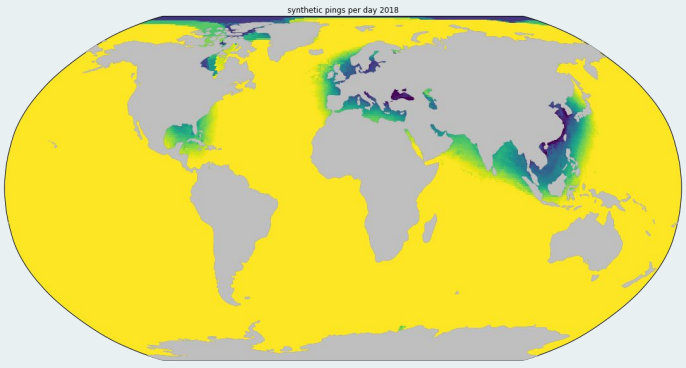
- Are limited by line of sight, and can only collect AIS transmissions from no more than 10 to 100 nautical miles
- Are essentially antennas deployed along the coastline, collectively these receivers comprise networks
- Are less affected by vessel traffic, because they don’t “see” as many vessels at once

Dynamic receivers

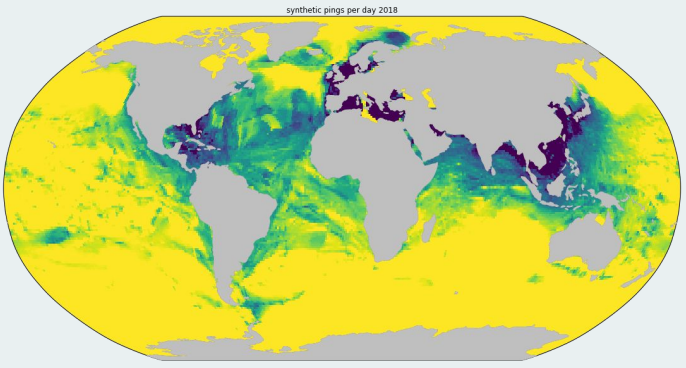
- Are AIS receivers deployed onboard vessels and buoys at sea
- Are helping to fill the gaps that exist in AIS coverage due to limited terrestrial receiver coverage (e.g. the South China Sea), or AIS transmissions getting obscured by high vessel traffic in specific areas, which overwhelms satellite receivers

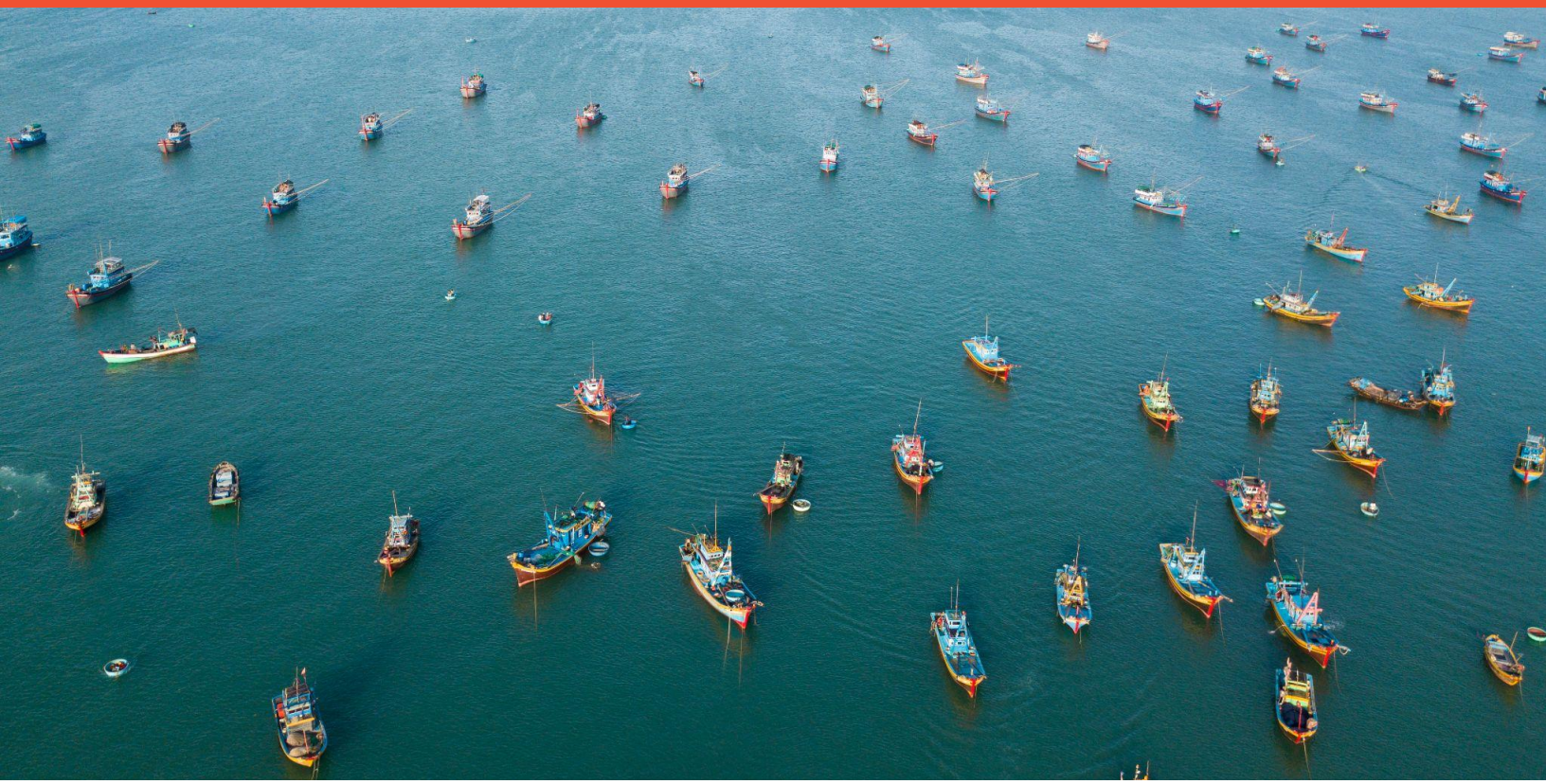
Satellite positions per day

Class A



Class B





How does AIS differ from VMS?

The fundamental difference between AIS and vessel monitoring systems (VMS) lies in their accessibility. AIS is an “open” system accessible to a wide range of end users, while VMS is a “closed” system with its data encrypted and typically only available for access and use by government authorities.

VMS uses end-to-end (e2e) transmissions, where the transponder sends an encrypted information package to the receiver and continues to do so until the receiver acknowledges it has been received. In contrast, AIS uses a different model, where position data is transmitted “openly” between a pair of transceivers, one on a vessel and another on a second vessel, or shore- or satellite-based receiver. A vessel transmitting on AIS will broadcast its positional data at set intervals and AIS receivers will collect the transmissions, regardless of whether they are the intended recipient. AIS reception is governed by line of sight, signal power, the number of Class A and Class B transceivers broadcasting within the receiver’s line of sight, and the availability of satellites capable of receiving the transmissions.

Attribute	AIS	VMS
System scope	Worldwide (satellite) Typically 40 nautical miles from the coast (for terrestrial receivers)	Worldwide (using satellite and terrestrial receivers)
Signal reception frequency	Every 2 to 180 seconds	Varies by regulation, but usually every hour to every 4 hours
Data availability	Publicly-accessible Visible to other vessels.	Usually confidential and restricted access with regulations that limit the use and sharing of the data. Other vessels and groups do not have ready / direct access
Vessel identity	Vessel identity can be altered. Need to verify with other sources.	Assumed accurate, based on registry of fishing vessels (best practice includes hard link from registry to tracking data)
Tamper resistance	Requires crew to accurately input identity data manually and keep the device switched on which makes the system open to tampering. Vessels can use multiple transceivers and more sophisticated users can manipulate their positional (global navigation satellite system) data.	Additional security features make it harder to tamper / disable. VMS units often are required to include visible security measures that make efforts to tamper easier to identify.
Device installation	Regulations, if they exist, typically require device installation. In some jurisdictions only certified installers can programme and change the MMSI in an AIS transceiver, but this is not a requirement for all vessels in all jurisdictions.	Regulations typically require “certified” installations that restrict the ability for tampering and VMS units that are “type approved” by the regulating authority.
Positive points	• Very high transmission rates (real-time tracking), allows for differentiating activity at a granular level and not just vessel tracking • Accessible by control units at sea • Relatively low cost	• Reliable system with limited risk of manipulation • Designed specifically for fishing vessels • Can be customized with other features (e.g., electronic catch reporting, geofencing, etc.) • Generally supported by mandatory manual reporting provisions in the case of unit problems and/or failure.
Negative points	• Easy to manipulate vessel identity information • Easy to turn on and off by vessel crew • High volume but noisy data (i.e., raw data typically contains a lot of random or irrelevant information and inconsistencies that need to be cleaned up before analysis) • Not optimized for fishing vessels • Variable reception and device quality limits relevance in some places and for some fisheries	• Can have long periods between transmissions which may limit analysis of vessel movement and activity. But in some cases transmission frequency can be manually changed by the management authority to assist in more granular monitoring. • High cost and proprietary software by provider

Due to their relative strengths and weaknesses, VMS and AIS data can most effectively support MCS when they are used together.

Based on the EFCA Course for EU fisheries monitoring centres’ operators on vessel tracking systems: non-E countries, 2022. https://data.europa.eu/doi/10.2835/726865

How can AIS data address fishery information needs?

By tracking vessel location, AIS data can provide valuable insights on fishing activity and effort. This includes:

1. **Vessel Monitoring**: AIS data allows for near real-time tracking of fishing vessels, enabling authorities to monitor the movement of boats on the water. This provides useful information on where fishing vessel positions and movements are consistent with fishing effort and for how long, and helps to monitor protected areas and compliance with other management measures such as depth or temporal restrictions on fishing effort, and the management of transshipment activities.
   Some examples include:
   - Use of AIS data to approximate the global footprint of fishing effort, both spatially and temporally
   - Monitoring changes in Peruvian fishing activity

2. **Illegal, Unreported, and Unregulated (IUU) Fishing**: AIS data assists in combating IUU fishing by identifying suspicious vessel movement behaviour and potential violations associated with spatial or temporal closures or vessel encounters. AIS data can be used to detect vessel movement patterns such as vessel loitering, suspicious vessel activity such as unauthorised transshipments, or fishing vessel movement patterns consistent with fishing activity based on gear type for vessels not authorized to fish within certain areas. This can help authorities to investigate further and take necessary enforcement action if required. Some examples where AIS data has been used to support the detection of potential IUU fishing activity include:
   - Fisheries patrol planning
   - Independent verification of at-sea transshipments
   - Identification of an illegal fishing hotspot in the Northwest Indian Ocean consistent with potential illegal fishing vessel activity.

3. **Fisheries Research and Planning**: AIS data can be used to map fishing vessel activity, or effort such as identifying high- density fishing areas (fishing grounds) and understanding both spatial and temporal fishing patterns and trends. This data can be used to contribute in part to the development of effective fisheries management or MCS strategies, and support assessments of the impact of fishing or vessel activity on marine ecosystems.
   AIS data has been used to support the analysis of the:
   - Interaction of whale sharks with shipping vessels
   - Interaction of seabirds with fishing fleets
   - Relative risk that fishing activity poses to seamount ecosystems

How does Global Fishing Watch use AIS data to create information on fishing activities?

Global Fishing Watch runs AIS data through a set of mathematical steps (machine learning methods) to create modelled estimates of what fishing vessels broadcasting AIS are doing. This information is different from observed or reported fishing records, because it is a model and our best estimate of what is happening in reality. Before we can map fishing activity, we first identify fishing vessels in the AIS data using a vessel characterization model. The model identifies all likely fishing vessels by considering the known (e.g., registered) and inferred vessel class of each MMSI. Our fishing detection model then predicts where and when the vessel is likely setting or hauling its gear and engaging in fishing operations, based on its movement patterns. Every AIS position point receives a classification of either fishing or non-fishing. Because this fishing activity is modelled and not observed, we qualify all designations of vessel fishing activity, as "apparent," rather than certain.[3]

Global Fishing Watch AIS data does not:

Provide real time positions of a fishing vessel

The processed AIS data that Global Fishing Watch provides via its online platform is delayed by 72 hours. This latency does not make this AIS data as useful for "live" aerial or surface fisheries patrol support or emergent enforcement responses to observed and ongoing potential non-compliance, nor for safety at sea or live rescue situations.

Provide a hard link between a fisheries registry and the tracked vessel's identity

The vessel identity information broadcast on AIS is dependent on the voluntary and accurate input by the operator. As such, vessel identity should be confirmed through use of multiple datasets or sources.

Provide a tamper proof "closed" system similar to VMS

An AIS transceiver can be turned on or off at will by the vessel master. Alternatively, the device's power can be reduced, which makes the signal weaker and less likely to be picked up.

Provide estimates of effort or catch

No effort or catch data is broadcast by AIS.

Provide estimates of the 70% of fishing vessels that do not broadcast on AIS!

An estimated 10-30% of fishing vessels globally use AIS, but the uptake varies by country and geography, depending on the rules and regulations in place.

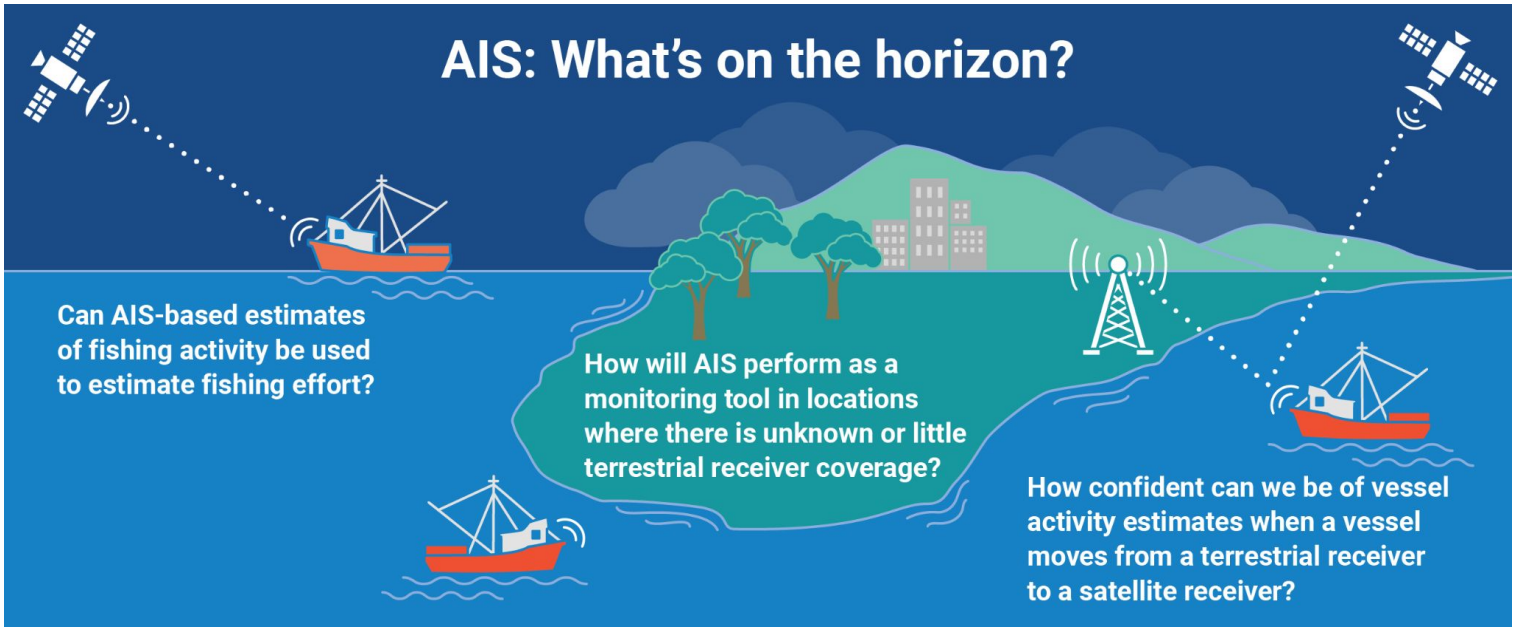
Where else can AIS data be freely accessed?

- Marine Traffic
- My Ship Tracking
- Vessel Finder: Live and raw AIS data streaming
- AISHub: Raw AIS data sharing

[3] Any/all Global Fishing Watch information about "apparent fishing activity" should be considered an estimate and must be relied upon solely at your own risk. Global Fishing Watch is taking steps to make sure fishing activity designations are as accurate as possible.

What lies ahead for AIS?

There are still many open questions about the quality of AIS-derived estimates of vessel activity when operating at a single vessel level. A fisheries compliance officer working at this level might ask:



Where can I find out more?

- **Spire**: Introduction to Automatic Identification Systems
- **MarineTraffic Guide**: Understanding AIS - Terrestrial vs Satellite AIS Tracking
- **FAO:** Global Atlas of AIS-based fishing activity
- **All About AIS**: AIS transmission types
- Table of Maritime Identification Digits
- AIS reporting intervals

References

Kroodsma, D.A., Mayorga, J., Hochberg, T., Miller, N.A., Boerder, K., Ferretti, F., Wilson, A., Bergman, B., White, T.D., Block, B.A., Woods, P., Sullivan, B., Costello, C. & Worm, B. 2018a. Tracking the global footprint of fisheries. Science, 359(6378): 904–908. https://doi.org/10.1126/science.aao5646

Kroodsma, D., Miller, N. A., Hochberg, T., Park, J., Clavelle, T. 2019. AIS-based methods for estimating fishing vessel activity and operations. In Taconet, M., Kroodsma, Fernandes, J. A. (eds.) Global Atlas of AIS-based fishing activity - Challenges and opportunities. Rome, FAO

Kroodsma, D., Miller, N. A., Gee, J., Hochberg, T., Park, J., Clavelle, T. 2019. Use of AIS by the world's fishing fleet. In Taconet, M., Kroodsma, Fernandes, J. A. (eds.) Global Atlas of AIS-based fishing activity - Challenges and opportunities. Rome, FAO. (also available at www.fao.org/3/ca7012en/ca7012en.pdf)

Global Fishing Watch

ima INTERNATIONAL

INTERNATIONAL MCS NETWORK

WILDAID MARINE PROGRAM