Food and Agriculture Organization of the United Nations

Global Atlas of AIS-based fishing activity

Challenges and opportunities

Global Fishing Watch

SEYCHELLES FISHING AUTHORITY

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Global Atlas of AIS-based fishing activity

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Preparation of this document

With advances in information technology, it is becoming possible to create a global database of fishing effort by gear type with an unprecedented spatial and temporal resolution. Such a database has the potential to assist with fisheries management and research around the globe. When initiating this publication, FAO intended to present this potential by reviewing AIS-based data in the context of global and regional knowledge on fisheries, and to communicate the main findings as well as the strengths and limitations of these data and current processing methodology.

The aim of this document, hereafter referred to as the Atlas, is to enable stakeholders to understand the opportunity and challenges of mapping and analysing fishing activity using AIS data. For each FAO Area, based on AIS data, this Atlas presents the number and percentage of vessels broadcasting AIS, the spatial patterns of presence and intensity of fishing activity, and an analysis by gear type. For these data, the Atlas includes detailed methods, case studies, and comparisons with other data. These comparisons, explanatory text, and caveats are presented with the goal of helping FAO Members understand how this new dataset can be applied.
To ensure the accuracy of the conclusions, 80 fishery experts from around the world either authored, reviewed or assessed the maps, charts, and supporting text produced by the authors and editorial team.

This Atlas has been prepared through a collaboration between Food and Agriculture Organization of the United Nations (FAO), Global Fishing Watch (GFW), and Fundación AZTI - AZTI Fundazioa. Seychelles Fishing Authority (SFA) has also contributed with a local study chapter.

FAO is a specialized agency of the United Nations (UN) that leads international efforts to defeat hunger. FAO's goal is to achieve food security for all and ensure people have regular access to enough high-quality food to lead active, healthy lives. FAO has contributed to the Atlas with 1) the initial idea, 2) project partner coordination; 3) revision of fleet data statistics for FAO area chapters led by GFW; 4) coordination of external review; 5) leading introductory chapters and the conclusions chapter; and 6) overall study material editing and reviewing.

GFW is an independent and non-profit organization originally set up through a collaboration between three partners: Oceana, an international ocean conservation organization; SkyTruth, experts in using satellite technology to protect the environment; and Google, which provides the tools for processing big data. GFW's aim is to advance ocean sustainability and stewardship through increasing transparency. GFW has contributed to the Atlas with: 1) the initial idea, together with FAO; 2) providing the processed data, graphs and maps; 3) leading the writing of chapters on AIS data processing, methods and use; 4) leading revision of fleet statistics for FAO areas chapters together with FAO; 5) providing text and revision of FAO regions chapters; and, 6) revision of the two detailed comparisons with VMS/logbook data (Bay of Biscay and Seychelles comparisons).

AZTI is an independent and non-profit research and technology organization that aims to develop sustainable products and services for the long-term healthy development of society. Its marine research division works closely with fisheries and related industries towards increasing environmental and economic sustainability. AZTI has contributed to the Atlas: 1) as an independent reviewer and editor of all Atlas materials, 2) data analysis and writing of the AIS and VMS/logbook data comparison chapter for the Bay of Biscay, and 3) leading the writing and review of FAO area chapters and the conclusions chapter.

SFA is the competent fisheries and marine resources management authority for the Seychelles. The SFA monitors its national coastal and high seas fishing fleets and the foreign fleets licensed to operate within Seychelles waters. The SFA has contributed to the Atlas with:
(1) the detailed case study comparing AIS data to VMS and logbook data in the Seychelles tuna fisheries and (2) the revision of the Bay of Biscay case study.

Contents

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Acronyms

- **AIS** – Automatic Identification System
- **AZTI** – Fundación AZTI – AZTI fundazioa
- **DWF** – Distant water fleet
- **EEZ** – Exclusive Economic Zone
- **FAO** – Food and Agriculture Organization of the United Nations
- **FFA** – Pacific Islands Forum Fisheries Agency
- **GFW** – Global Fishing Watch
- **IMO** – International Maritime Organization
- **MMSI** – Maritime Mobile Service Identity
- **RFMO** – Regional Fisheries Management Organization
- **SFA** – Seychelles Fishing Authority
- **VMS** – Vessel Monitoring System

Executive summary

The Automatic Identification System (AIS) provides detailed tracks of tens of thousands of industrial fishing vessels, and these detailed tracking data have the potential to provide estimates of fishing activity and effort in near real time. Realizing this potential, though, is not straightforward and depends on the vessel size, gear type, and the species targeted. This Atlas, using a global database of AIS data from 2017, assesses this potential and shows that AIS can start to be considered a valid technology for estimating fishery indicators. This Atlas reveals both promising findings and key limitations of inferring fishing effort from AIS data.

AIS use is steadily increasing and its utility in tracking fishing vessel activity is growing. In 2017, AIS was broadcast by approximately 60 000 fishing vessels of which just over 22 000 could be matched to publicly available vessel registries. This number is steadily increasing, and between 2014 and 2017, the number of vessels broadcasting increased by 10 to 30 percent each year. Moreover, AIS can be used to track the majority of the world's large fishing vessels (above 24 m), especially those from upper and middle-income countries and territories, distant water fleets and vessels operating on the high seas. AIS tracking performs less well on smaller vessels: only a small fraction of vessels under 24 m, which account for the vast majority of fishing vessels globally, use AIS.

The current algorithms perform well at classifying the most common gear types among larger vessels: longlines, trawls and pelagic purse seines. The classification algorithms do less well at differentiating gear types that are more common in smaller coastal vessels, such as set gillnets, trollers and pots and traps. Also, the current AIS algorithms can assign only one gear type, limiting the ability to classify the type of fishing when vessels change gears on a voyage or between voyages.

Poor AIS reception limits the ability to monitor fleets in some regions. In particular, satellite AIS reception is weakest in Southeast Asia, followed by East Asia, the northern Indian Ocean, the Gulf of Mexico and Europe, although terrestrial receivers along coastlines can, in some of these regions, compensate for poor satellite reception. The reception quality also depends on the specific type of AIS device in use (Class A or B).

Comparing AIS-based fishing vessel activity with catch reconstructions and literature reveals varying use of AIS by region and gear and possible biases in the relative importance of different gears. Catch reconstructions mostly show that areas with high catch have high activity by vessels with AIS, although some areas with high catch have little AIS activity, such as in Southeast Asia (Area 71), as a result of few vessels having AIS. Catch reconstructions agree on

the most important gears worldwide (trawlers, followed by purse seiners), although AIS data shows a higher importance of longliners because a higher fraction of these broadcast AIS. The recent increasing importance of squid jiggers in the high seas was not captured in the slightly lagged catch reconstruction work.

In optimal conditions where AIS use and reception are good, and where vessel registries with gear type exist AIS algorithm can perform well for gears such as longline or trawl and provide good estimates of fishing effort.

This work has contributed to improving the quality of FAO fleet statistics, revealed some errors in classifications of gear types in the European Union (EU) registry, and pinpointed limitations of catch reconstructions. With regard to the AIS data, in addition to showing limitations of AIS, this project has helped improve methods for analysing AIS data and align AIS-based metrics with fishery statistical standards, and this work can provide a basis for further improvement of these methods and algorithms.

Introduction of Global Atlas of AIS-based fishing activity

Marc Taconet, David Kroodsma, Jennifer Gee and Jose A. Fernandes

PREFACE

The spatial impact of fishing can be measured in several ways. It can be measured through the inputs required, such as the fuel used or time expended (Basurko *et al.*, 2013), or by analyzing outputs such as catch, where catch is measured in tonnes of fish or total primary production indirectly consumed through the food web (Swartz *et al.*, 2010). Another measure is the impact various fishing gears have on ecosystems, such as the catch of non-target species (bycatch), the disturbance of benthic habitats by trawlers (Sciberras *et al.* 2018; van Denderen *et al.* 2014; Puig *et al.* 2012; Venetoulis and Talberth, 2008) or the wider effects on fish community structure (Queirós *et al.*, 2018). Because different fishing methods have different impacts, fishing environmental footprints often need to be calculated and estimated differently depending on the gear type (Puig *et al.*, 2012; Sciberras *et al.*, 2018; van Denderen *et al.*, 2014; Victorero *et al.*, 2018). For instance, baitboats may have a relatively small impact on ecosystems due to their higher selectivity (Suuronen *et al.*, 2012), but this benefit might come at the cost of more fuel use and higher greenhouse gas emissions. Indeed, greenhouse gas emissions from the fishing industry are gaining increased attention (Basurko *et al.*, 2013; Tyedmers *et al.*, 2004; Tyedmers *et al.*, 2005) and, as such, the new FAO report on climate change has an entire chapter with recommendations on how to reduce fishing vessels' fuel consumption and derived emissions (Barange *et al.*, 2018). These various costs, or environmental footprints, must of course also be weighed against the benefits or socio-economic footprint that fishing brings to society, including food security and income for coastal communities and national economies (Fernández-Macho *et al.*, 2015; Fernandes *et al.*, 2017).

To understand many of the impacts of fishing, one needs to know the presence and measure the intensity of fishing activity, operations, and effort, ideally at a spatial and temporal resolution sufficient to assess the impacts and benefits outlined above. One way to estimate the presence and intensity of fishing is to use detailed tracking data from logbooks and Vessel Monitoring Systems (VMS). Logbook and VMS systems are usually established by national governmental authorities or Regional Fisheries Management Organizations (RFMOs) for monitoring, control, and surveillance. VMS monitor vessel movements with GPS and then broadcast the positions, usually encrypted, to satellites. The information is then shared with the authorities that monitor a given fishery. Commonly, VMS is a mandatory system for vessels above a given size, but the regulations vary by jurisdiction. Detailed VMS data, however, are usually not shared publicly by authorities or are only provided as aggregated values and with a time lag of several months to safeguard confidentiality. Further, confidentiality requirements often ressult in a lack of VMS data sharing between states and RFMOs, even among those with overlapping jurisdictions. This confidentiality further limits the full potential of using VMS. Similarly, logbooks are often treated as highly confidential, limiting their use for assessing fisheries in some regions and at a global scale.

Whether logbook and/or VMS data are available or not, some fishing activity can be assessed with the Automatic Identification System (AIS). AIS devices contain a GPS unit and broadcast, via VHF radio, a vessel's position, course, and other information every few seconds (ITU, 2014). AIS was initially intended to improve ship safety by broadcasting and receiving AIS signals to avoid collisions between vessels, and is used by large, oceanic vessels. While the purpose of these signals is to alert nearby marine traffic of a vessel's presence, the messages can be received by a wide array of satellites and terrestrial receivers that operate worldwide. In addition, every three minutes, AIS devices broadcast the vessel's identity, including callsign, name, IMO number, activity, and size, allowing one to identify and distinguish fishing vessels. During 2017, more than 300 000 unique AIS devices broadcasted the location of a vessel in the world's oceans and this large quantity of available AIS data is increasingly being viewed as a tool to monitor and provide historical analysis of vessel activity. Many recent applications of AIS data aim to understand the distribution of and changes in human activity. Some examples include estimating fishing activities (Natale *et al.*, 2015; McCauley *et al.*, 2016; Merten *et al.*, 2016; Russo *et al.*, 2016; Souza *et al.*, 2016; Vespe *et al.*, 2016; Wang and Wang, 2016; Guyader *et al.*, 2017), vessel behavior (Eguiluz *et al.*, 2016), and shipping emissions (Smith *et al.*, 2014; Coello *et al.*, 2015).

For monitoring fishing, AIS has some notable limitations. AIS is carried by only a small fraction of the world's roughly 2.8 million fishing vessels (FAO, 2018), and this fraction of vessels is not evenly distributed between regions, making it difficult to compare activity in different areas of the ocean. Compared with most VMS units, vessels can more easily turn off their AIS or broadcast incorrect identity information. In some parts of the ocean with high vessel traffic, AIS messages can interfere with one another, limiting the ability of satellites to receive these messages. Also, inferred fishing activity from AIS data is based on machine learning models that analyze how vessels move, and these models are inherently less accurate than most VMS or well-collected logbook data. Moreover, models are only as good as the data used to train them (Fernandes *et al.*, 2009), and errors and bias in training data sets can lead to misclassification of gear types.

The aim of this document, henceforth referred to as the Atlas, is to use AIS data to provide an initial footprint of fishing activity and highlight the strengths and weaknesses of using this new dataset. Specifically, the Atlas seeks to quantify, for each FAO Area, the number and percentage of vessels broadcasting AIS and the presence of fishing activity, including by gear. The number of gear types that can be accurately identified is limited, but the general overview is an important first step in mapping global fishing activity. Although the Atlas also provides case studies that compare fishing effort measured with AIS to official measurements from VMS and logbooks, the key focus of the Atlas is to identify fishing vessel activity and its intensity in FAO areas based on AIS.

The Atlas includes 1) definitions of fishery indicators and their mapping to AIS metrics; 2) a lengthy discussion of the methods used to assemble the Atlas, which build on the methods used in Kroodsma *et al.* (2018); 3) an analysis of the use of AIS by the world fishing fleet over time and in various jurisdictional contexts; 4) detailed comparisons of AIS information with logbook and VMS data for two regions of the world -- the Spanish fleet operating in the Bay of Biscay and the Seychelles tuna fleet operating in the Indian ocean; and 4) an analysis, by each FAO Area, of the completeness and accuracy of AIS data. The Atlas concludes with key findings on strengths and weaknesses of the AIS dataset and GFW algorithms to estimate fishing activity, provides summaries by gear type and FAO areas and suggests future possible work and likely developments.

APPROACH AND METHODOLOGY FOR THE REGIONAL COMPARISONS

Some specific methodological notes are here provided regarding the set of regional chapters, a major work of this Atlas, which aim to present a comprehensive evaluation of GFW-AIS's ability to estimate fishing vessel activity. This proceeds by reviewing for each FAO area the fleets and fishing gears for which the AIS-based metrics might be good or not. The challenge is double since it implies revising the fishing activity detected by AIS against other sources of data, but also identifying what important activity is not being seen by AIS data. This second challenge is particularly important, since it aims at correcting possible bias and misleading picture of the fishing activity of an area which can be inferred from using a convenient data source such as AIS. A typical case of such bias lies with longliners given that their activity is widespread and the use of AIS devices is very common in these fleets, which can result in the false impression that longliners dominate fishing activity in many regions; the regional chapters in this Atlas illustrate that this is often not true. For this purpose, we have used several approaches to compare 2017 AIS data (as available in mid-2018) with data from other sources as described in the following paragraphs.

For an estimation of AIS use among fleet segments, comparison was done between vessels that AIS can identify and vessels contained in FAO fleet statistics, and/or other sources of fleet statistics (e.g. GFCM fleet statistics, European Union Registry). This comparison highlights the existence in many regions of a large activity by smaller vessels and artisanal fisheries that is not tracked by AIS. It also shows some potential of AIS to improve FAO statistics given that FAO statistics are not very detailed and are based on country reports that sometimes are not accurate or outdated. Some FAO statistics have been corrected using outside sources when the only available statistics were clearly inaccurate, outdated or based on estimates. In some other cases the FAO statistics contained accurate total figures but without a breakdown in size and/or vessel type distribution, and in these cases more accurate distribution data were taken from other sources and applied to the reported statistics.

For an estimation of the spatial distribution patterns of fishing vessel activity by fleet segment and fishing gear, comparison was done with the catches reconstruction of the Global Fisheries Landings database (GFLD; Watson, 2017). GFLD allows one to identify the likely main fishing gears in each region, though GFLD has its own bias and catches cannot be used to accurately estimate fishing activity. However, GFLD does provide a systematic approach to consistently review all regional estimates based on AIS data. In some regions, however, where it was easy to obtain more accurate data sources, the comparison has been performed with these other sources of data (e.g. official regional databases such as ICES or CCAMLR, or the use of BlueBridge tuna atlas data reconstructed from RFMOs data). Also, RFMOs reports and scientific publications have also been used to contrast the maps and graphs based on AIS data. One challenge overall is that we were constrained to use the 2017 AIS datasets (i.e. the best available when work started at mid-2018) to assess GFW capacity to provide a close to real time AIS estimate of fishing vessel activity, while the most recent available public data has a several year time lag. The Global Fisheries Landings database (GFLD; Watson, 2017) reconstruction of catches by fishing gear provides information only until 2014, and RFMOs data often have at least a one- or two-year delay before becoming available to the public. These differences in years need to be kept in mind and might in certain cases of very dynamic fisheries induce some bias in the analysis.

Finally, we asked different regional fisheries experts with a long history of expertise in each area to review the text, and assess the maps produced against their knowledge of fisheries, and to give additional insights. A minimum of two reviews per area have been received with some areas receiving comments and suggestions from up to five reviewers. Altogether, over 40 external reviewers have provided their feedback. Some of these reviewers' comments have identified some significant issues that have led to corrections in some maps and graphs.

Despite all these efforts, this Atlas provides only an overview of the potential of AIS to improve our knowledge about fishing activity. Maps and conclusions should therefore be used carefully and contrasted with local sources of data and knowledge.

FISHERIES INDICATORS IN THIS ATLAS

This Atlas work is a unique opportunity to evaluate AIS in a context of fisheries and aquaculture knowledge, and to promote alignment and standardization of new AIS-based metrics with existing fishery statistics and data standards. In this respect, several concepts related to fisheries management and monitoring are referenced throughout the Atlas and are explained in this section.

Fleet capacity: Fleet capacity is a measure of the number of fishing vessels of a country/territory. Beyond a count of the number of vessels, it might include an estimate of their size, power, or type but does not contain information on time spent on the water (e.g. days at sea or hours of fishing). Fleet capacity is best measured with fleet registries or censuses, and here it is measured as the count of vessels from the FAO fleet statistics.

Active fleet: Whereas fleet capacity measures the size of the fishing fleet, active fleet measures the size of the fleet that is active in a given water area over a given time period. In this Atlas, a fishing vessel is deemed an "active fishing vessel" if it undertook more than 24 hours of fishing operations in the calendar year in a given area. Note that because inactive vessels generally do not broadcast AIS, AIS can only be used to measure the active fleet and not fleet capacity. This Atlas compares fleet capacity as measured by the FAO against the active fleet as measured either at a global scale, or at a regional scale, by AIS. This comparison is limited by the fact that fleet capacity from FAO cannot distinguish components of a fleet fishing in different regions.

Fishing vessel activity: Fishing vessel activity includes all activity of a fishing vessel when it is away from port, including transiting, searching for fish, fishing operations, and transshipments. In this Atlas, fishing vessel activity is measured in the number of hours or days that fishing vessels are at sea ("hours at sea" or "days at sea").

Fishing operation: A fishing operation is a routine sequence of actions to catch fish and which lasts until fish is removed from the fishing gear; it may involve, among other things, searching for fish, deployment, hauling and retrieval of fishing gear, and removal of catch from the gear. The AIS algorithms used for this Atlas measure the number of hours that gear is being deployed or hauled, hereafter "fishing hours." This measure of fishing operations omits searching time, and sometimes omits removal of catch from the gear. Searching time can be important for some gears, such as purse seines.

Fishing presence: Fishing presence measures the presence or absence of fishing vessel activity or fishing operations in a giving area and given time frame (e.g. calendar year). The presence can be measured as a Boolean value—is fishing present (true) or not (false) in a given area or grid cell. Not utilized in maps or tables of this publication.

Fishing intensity: Fishing intensity measures the amount of fishing vessel activity or fishing operations in each grid cell within given time frame (here a calendar year). In this Atlas, the intensity of fishing vessel activity is mapped by "hours at sea" of fishing vessels, which corresponds to the amount of time a vessel spent in each cell without differentiating between when gear is deployed or not. The intensity of fishing operations is measured in "fishing hours," which is the number of hours fishing vessels spent operating gear in each grid cell (i.e. 0.1 x 0.1 degree in this Atlas).

Fishing effort: Fishing effort is a measure of anthropogenic work inputs used to catch fish. In fisheries science, it is defined in the context of stock assessment science where fishing effort intends to provide a measure proportional to the amount of fish captured for a given fish stock (i.e. fishing mortality). FAO and the Coordinating Working Party on Fishery Statistics (CWP) set standards for different measures of fishing effort. It can be the sum of the time spent searching for fish (search duration, including fishing operations), or it can be the amount of fishing gear of a specific type used on the fishing grounds over a given unit of time, e.g. hours trawled per day, number of hooks set per day, or number of hauls of a beach seine per day.

Although gear-specific metrics are usually better for estimating fish mortality, these cannot be summed across gears to give a single value. As a result, using total time searching for or catching fish (essentially all time at sea except transiting) is the best effort metric that can be summed across gears. Given this definition, the measure of fishing activity in this Atlas, which is in days at sea, is the closest to a traditional measure of effort that can be used as common denominator across gears.

Because there is no global dataset of fishing effort and because fishing effort should be proportional to fishing mortality, in this Atlas, total catch by gear type by region is compared to fishing effort in AIS days at sea in summary tables for each FAO Area. However, to compare catch spatially with AIS data, the intensity of fishing operations, measured in fishing hours, is used instead of total fishing effort (which would be better measured as total time at sea). The reason to measure fishing hours is that it can better localize where fish was likely caught, thus allowing better spatial comparisons between catch and effort distributions. Mapping total fishing effort would include the searching time which, while contributing to the effort, extends beyond where the fish catches were taken.

A synoptic view of the concepts and measures presented and used in this Atlas is presented in Table Int.I.

		MEASURES				
		Fishing presence			Fishing intensity	
		Aggregated worldwide	Aggregated by FAO Area	Over a grid cell	Aggregated by FAO Area	Over a grid cell
		(Low spatial resolution)		(High spatial resolution)	(Low spatial resolution)	(High spatial resolution)
FISHERY INDICATORS	Fleet capacity	**Number of vessels[0]**				
	Active Fleet (by country/ territory and by gear type)	**Number of vessels with AIS present[1]**	**Number of vessels with AIS present[2]**			
	Fishing vessel activity			*	**Number of days at sea in FAO Area[3]**	**Intensity of fishing activity[4]** Hours of fishing vessels presence ($hours/km^2$)
	Fishing operations (by gear type)			*		**Intensity of fishing operations[5]** Hours of fishing operations ($hours/km^2$)

Table Int.I. Synoptic view of the concepts and measures used in this Atlas. The metric in reference is utilized in the Atlas chapters as follows: [0]from FAO fleet statistics used in 'Use of AIS by world's fishing fleet' (Fig. Use.1) and in regional chapters in section "Region fleets and AIS use" (e.g. Figs. 18.3 and 18.4); [1]in chapter 'Use of AIS by world's fishing fleet' (Fig. Use.1 to Fig. Use.4); [2]in regional chapters section 'Regions fleet and AIS use' (e.g. Fig.18.4); [3]in tables of regional chapters (e.g. Table 18.I) and in the comparisons with catch data in conclusions chapter (Fig. Conc.7); [4]in regional chapters section 'AIS reception and fishing vessel activity' (e.g. Fig. 18.5a,b) and in conclusion chapter (Fig. Conc.1); [5]in regional chapters section 'Fishing vessel activity and operations by gears' (e.g. Fig. 18.7 and following maps) and in conclusion chapter (Figs. Conc.2-5).
*Not utilized in maps or tables of this publication. Note that for the AIS-based indicators used for the world and for FAO areas, only vessels that had fishing operations for more than 24 hours in the year are included.

LIMITATIONS AND CHALLENGES OF AIS DATA

The key factors that affect the completeness and accuracy of footprints derived from AIS are **AIS use**, **AIS reception**, and **AIS algorithm performance**. Throughout this Atlas, these terms are used to describe the reliability of the AIS fishing maps globally and regionally.

AIS use is a measure of the number of vessels that have an AIS device installed and that broadcast. For analyses in this Atlas, we included only likely fishing vessels with at least 24 hours of fishing operations, measured in "fishing hours," in 2017.

AIS reception is a measure of how likely it is for a vessel's AIS message to be received correctly by the existing network of satellites and terrestrial antennas along the world's coastlines. In regions of the world with high maritime traffic, AIS signals can interfere with each other, which reduces reliable satellite reception. Terrestrial receivers, for various reasons, do not have as many challenges with signal interference, but they are not present along all coastlines.

AIS algorithm performance is a measure of how well algorithms can identify the type of vessels (whether the vessel is a fishing vessel or not and what type of gear it uses) and identify fishing operations.

AIS use, reception, and algorithm performance have varying importance to measuring the different fisheries indicators (Table Int.II). To estimate fleet capacity, AIS is of limited usefulness because many vessels do not have AIS devices, and even if they have AIS devices, they might be inactive or they may not broadcast. AIS use, though, can help identify the active fleet; if AIS use is high, then it should be possible to identify the number of active vessels. To identify the active fleet, though, AIS Reception and algorithm performance are less important; even in areas of poor reception, it is generally possible to receive some AIS messages from vessels and estimate the number of fishing vessels broadcasting. To measure the spatial extent of vessel activity, though, it is important to have both good AIS use and good reception. Finally, to estimate the intensity of fishing vessel activity and fishing operations, and to provide estimates of fishing effort by gear type for use in stock assessment, one needs good AIS use, reception, and algorithm performance.

		Quality of AIS estimates		
		AIS Use	AIS reception	AIS algorithm performance
Fisheries indicators	**Nominal data**			
	Fleet capacity			
	Active fleet			
	Fishing characterization			
	Fishing presence			
	Fishing vessel activity			
	Fishing operations			
	Fishing effort			

Table Int.II. Mapping between AIS and fishery indicators concepts. The color intensity in the cell represents the level of importance of the AIS data factors (use, reception, and algorithm performance) for providing a good estimate of the concerned fisheries indicator.

In addition to limitations due to AIS reception and use, there are several challenges to working with AIS data associated with data quality that must be addressed when identifying fishing activity. These are reviewed in the following chapter “AIS-Based Methods for Estimating Fishing Vessel Activity and Operations”.

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