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Murua, H., Granado, I., Gee, J., Kroodsma, D., Miller, N. A., Taconet, M., Fernandes, J. A. (2019). FAO Area 51 - AIS-based fishing activity in the Western Indian Ocean. *In* **Taconet, M., Kroodsma, D., Fernandes, J.A. (eds.)** *Global Atlas of AIS-based fishing activity - Challenges and opportunities.* Rome, FAO. (also available at www.fao.org/documents/card/en/c/ca7012en)

Recommended citation for the full publication:
Taconet, M., Kroodsma, D., & Fernandes, J.A. (2019). *Global Atlas of AIS-based fishing activity - Challenges and opportunities.* Rome, FAO. (also available at www.fao.org/documents/card/en/c/ca7012en)

ACKNOWLEDGEMENTS

The editors would like to thank Alejandro Anganuzzi, James Geehan and Mark Dimech for excellent comments and feedback during the elaboration of the chapter. Graphical design was elaborated by Juan Carlos Alonso. Layouts were produced by Virginia Rodríguez. Jefferson Murua helped with the final revision of text before publication. Dr. Jose A. Fernandes research on fuel consumption and emissions reduction of tuna fleets in the Indian Ocean is partly funded through DataBio project (No 732064) within European Union's Horizon 2020 research and innovation programme. Global Fishing Watch would like to thank Marisla Foundation, The Waterloo Foundation, Bloomberg Philanthropies, Leonardo DiCaprio Foundation, and Oceans 5 for support. This publication represents the research and experience of authors and reviewers, but does not represent their employers' and collaborators' views or opinions.

FAO AREA 51

AIS-based fishing activity in Western Indian Ocean

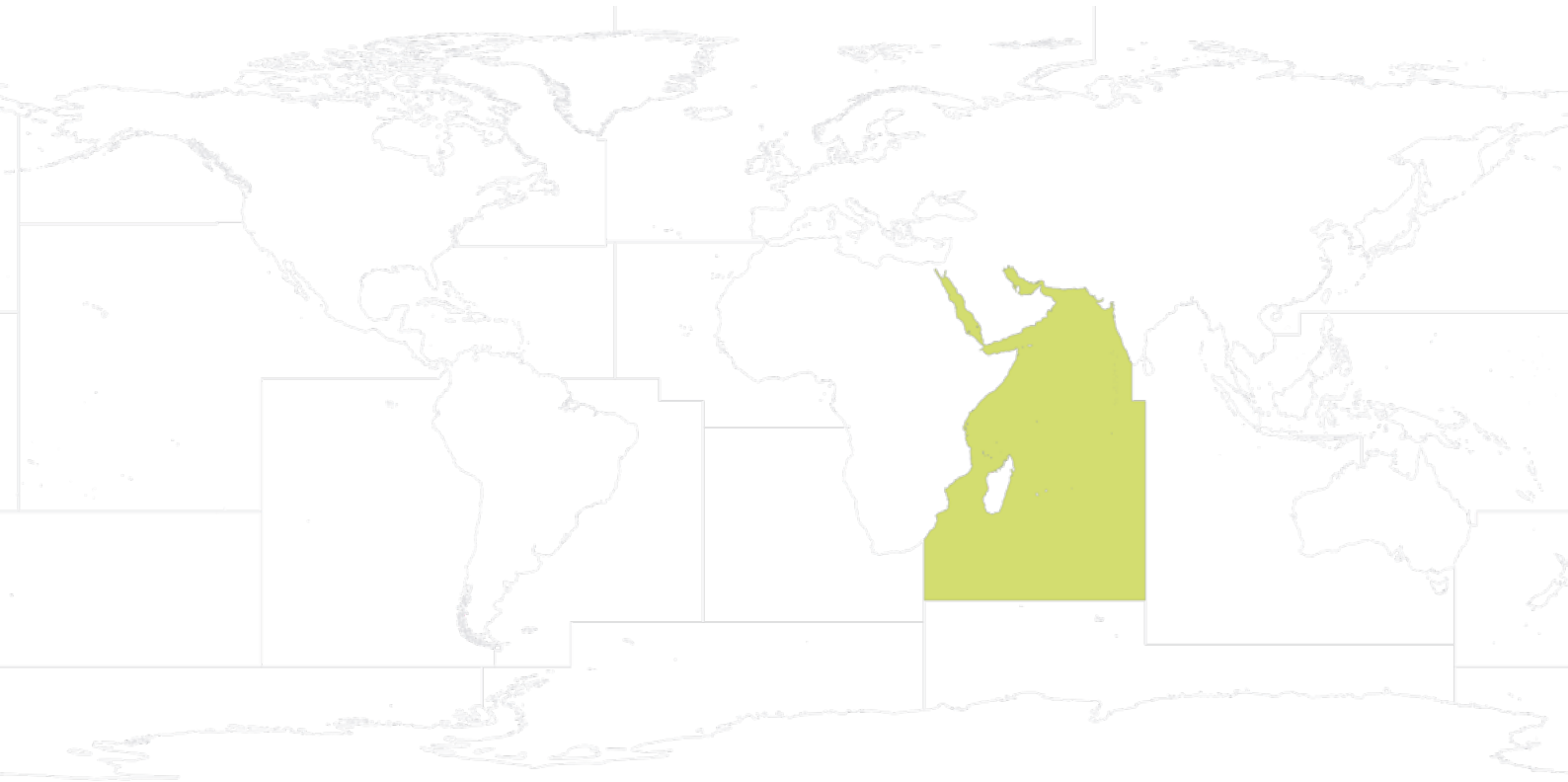


Figure 51. 1. Location of FAO Area 51.

Hilario Murua, Igor Granado, Jennifer Gee, David Kroodsma, Nathan A. Miller, Marc Taconet and Jose A. Fernandes

PREAMBLE

This chapter assesses, through a comparison with fleet statistics and public fisheries data, the capacity of Automatic Identification System (AIS) data and Global Fishing Watch (GFW) algorithms (Kroodsma *et al.*, 2018) to identify and quantify fishing vessel activity in the Western Indian Ocean. This assessment reviews fleet activity, main gear types, and spatial distribution of fishing vessel activity and fishing operations.

SUMMARY AND CONCLUSIONS FOR THE WESTERN INDIAN

In the northern portion of the Western Indian Ocean region, the ability to map fishing activity through AIS data is limited by poor AIS reception and low levels of AIS use in artisanal and semi-industrial fleets from coastal countries. Throughout the region, gillnet is one of the main fishing gears for the artisanal and semi-industrial fleets, but this activity cannot be mapped as most of these vessels are under 12 m without AIS. Larger vessels in the region, however, also show relatively low use of AIS. Less than 50 percent of coastal country/territory vessels over 24 m use AIS. The exceptions are Bahrain, Seychelles and distant water longliner fleets with higher AIS use. Therefore, longliner activity appears to be well represented by the AIS data and GFW classification, particularly in the southern part where AIS reception quality is good. In contrast, the spatial distribution of trawler and purse seiner activity is poorly captured by AIS, and noticeably the industrial pelagic purse seiner fleet makes limited use of AIS.

FAO Area 51 bathymetry

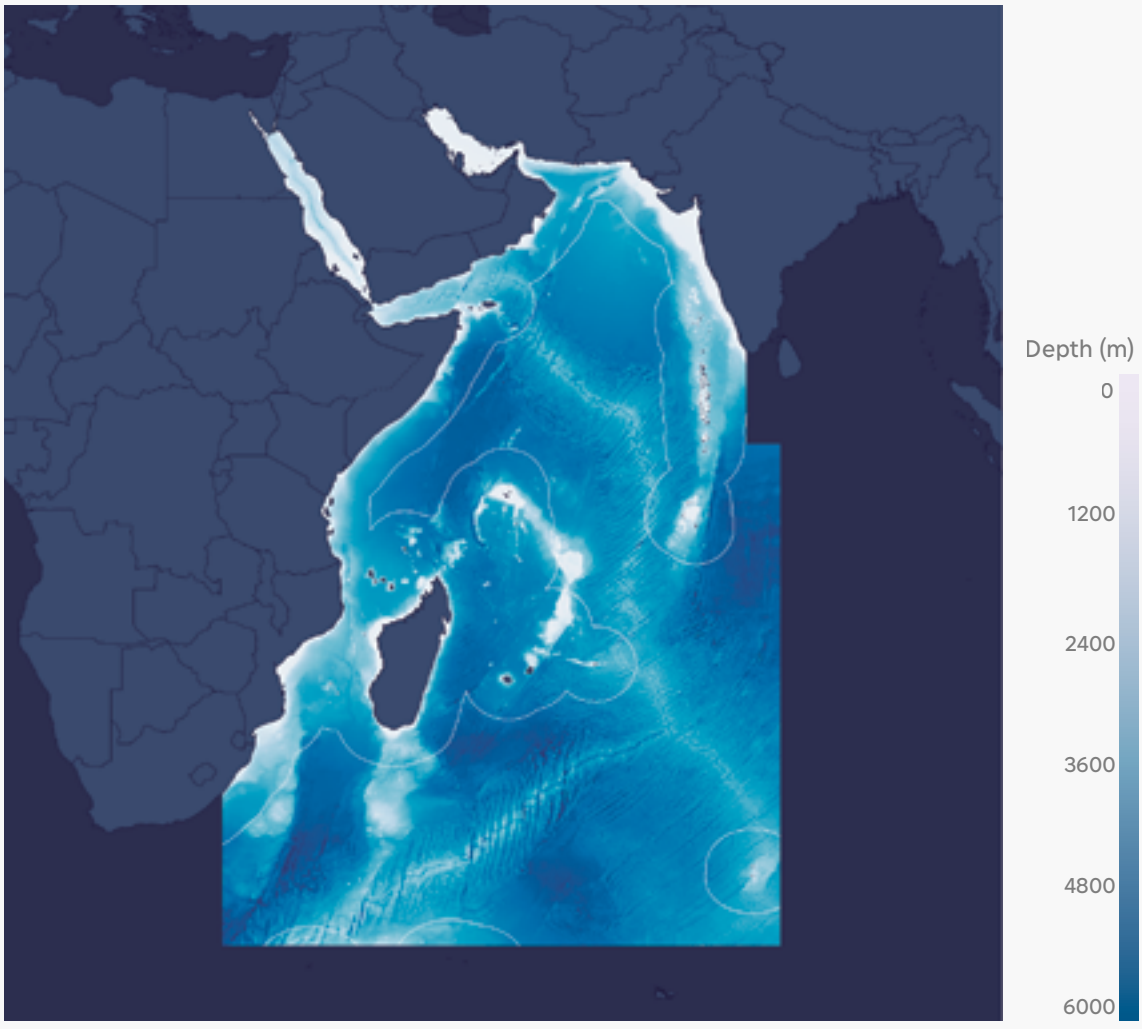


Figure 51. 2. FAO Area 51 bathymetry (depth) and 200 nautical miles arc.

INTRODUCTION FOR THE WESTERN INDIAN

The Western Indian Ocean FAO Area encompasses all marine waters of the western Indian Ocean bounded on the west and north by the coastline from southern Africa to the south of India, and extending eastwards to 80°E and southwards to 45°S. The following coastal countries/territories border FAO Area 51: Bahrain, British Indian Ocean Territories, Comoros, Djibouti, Egypt, Eritrea, Ethiopia, Ethiopia PDR, French Southern Territories, India, Iran, Iraq, Israel, Jordan, Kenya, Kuwait, Madagascar, Maldives, Mauritius, Mozambique, Oman, Pakistan, Qatar, Saudi Arabia, Seychelles, Somalia, South Africa, Sudan, United Republic of Tanzania, United Arab Emirates, Yemen and and the United Republic of Tanzania, Zanzibar. About 42 percent of the region's waters are under national jurisdiction, with the high seas accounting for 58 percent of the total marine waters (the proportion of high seas in all FAO areas ranges between 20 and 80 percent).

In this region, fisheries are managed by two Regional Fishery Management Organizations: the Indian Ocean Tuna Commission (IOTC), which is responsible for the management of tuna and tuna-like species in the Indian Ocean, and the Southern Indian Ocean Fisheries Agreement (SIOFA), which is responsible for the management of high seas deep seas non-highly migratory species. In addition, the Southwest Indian Ocean Fisheries Commission (SWIOFC) is a Regional Fishery Body providing advice on coastal resources of Eastern African States.

The continental shelf is generally narrow along east Africa, but wider along the north western coast of India, and covers the entire Gulf and Red Sea. Along mid-ocean ridges and fracture zones occur extended strips of islands and relatively shallow banks, while large seamounts occur particularly in the western part (Gershanovich and Dubinets, 1991). Seamounts contribute to the biodiversity of the Indian Ocean (Wafar *et al.*, 2011). During summer monsoon the productivity of the Indian Ocean is driven by the upwelling systems along Somalia, Oman, and the southwest coast of India and is spread across the Arabian Sea. In contrast, during winter monsoon, productivity is driven by convective mixing and is mostly limited to northern Arabian Sea (Jayaram and Kumar, 2018). FAO landings statistics (FishStatJ, 2018) show that in the period from 2010 to 2014, catches were dominated by small and large pelagic species. The largest catches have been made of Indian oil sardine, Yellowfin tuna, Skipjack tuna, Croakers, Bombay-duck, Indian mackerel *(Rastrelliger kanagurta)*, Natantian decapods, Hairtails, Longtail tuna *(Thunnus tonggol)*, Giant tiger prawn *(Penaeus monodon)*, Cephalopods, Sea catfishes, Anchovies, Narrow-barred Spanish mackerel *(Scomberomorus commerson)*, Carangids, Clupeoids, and Kawakawa *(Euthynnus affinis)*. These species and groups made up 70 percent of the reported catch in that period (FishStatJ, 2018).

REGION FLEETS AND AIS USE IN THE WESTERN INDIAN

Assessing fleets capacity in FAO Area 51 is challenging because countries in this region often lack accurate fleet reporting for FAO statistics (Fig. 51. 3), including absence of vessel length information. Many countries/territories (e.g. Bahrain, Réunion and Mozambique) did not report vessels over 24 m (Fig. 51. 4a) despite vessels of this size class being detected in the AIS data (Fig. 51. 4b).

Coastal fleets in this region have a high proportion of small vessels, both powered and unpowered, which are not tracked in the AIS data (Fig. 51. 3). According to these fleet statistics, non-motorized vessels account for 44.2 percent of the fishing vessels in this region, being higher than the global average of 39 percent (based on SOFIA, 2018). Coastal countries/territories in this region report very few vessels larger than 24 m. This number may be a reporting error, but may also reflect that many are developing countries with a low proportion of large vessels (McCauley *et al.* 2018). Also, two of the top three fleets, India and Yemen, lack reporting on the number of fishing vessels by size, explaining the high fraction of motorized vessels with unknown lengths and making it difficult to assess how many large fishing vessels should have AIS data.

Fleets of coastal countries/territories in FAO Area 51

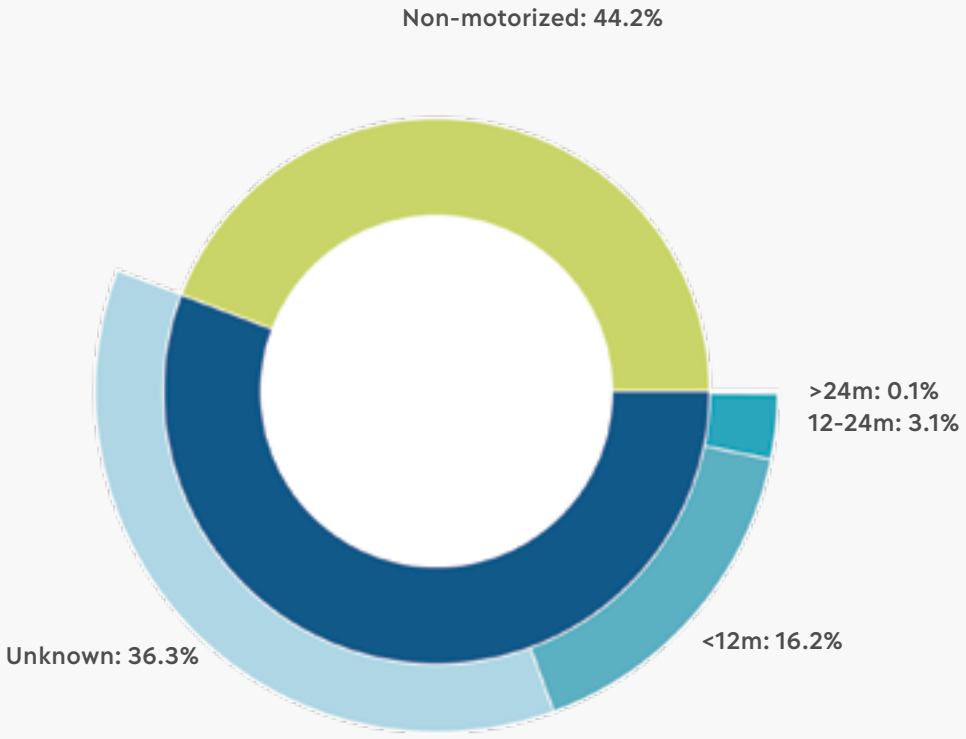


Figure 51. 3. Structural composition of fleets of coastal countries/territories in FAO Area 51. In dark blue motorized fishing vessels and in green non-motorized vessels. Distant water fleets active in FAO Area 51 are not included (see next Figure). Notice that India and South Africa border more than one FAO area, yet their entire fleet size is included here. Source: FAO statistics for 2017. Statistics were not available for the following coastal countries/territories within FAO Area 51: British Indian Ocean Territories, Ethiopia and Somalia.

Figure 51. 4.a shows that the coastal country with the largest number of reported motorized vessels was India, followed by Pakistan, Yemen and Oman. Correspondingly, India accounts for 50 percent of total captures across all species in the FAO Area 51 (FishStatJ, 2018). The AIS data for FAO Area 51 provided a very different picture of fishing activity, largely because it was dominated by the distant water fleets which have a relatively high adoption of AIS compared to coastal territories. Figure 51. 4.b shows the number of fishing vessels, by fleet, operating in the region and broadcasting AIS. About half the vessels broadcasting AIS are from distant water fleets, where Taiwan Province of China had the largest number of vessels using AIS in the region. China, Japan, Republic of Korea, Malaysia and Spain also had sizeable fleets, mostly operating in the high seas. Despite this higher use of AIS by distant fleets in the region, Sala *et al.* (2018) estimated that in the IOTC, less than half of Chinese longliners and only just over half of the Taiwanese Province of China ones broadcast AIS, and that these fractions were lower than in the Pacific or Atlantic Ocean high seas. For regional fleets, AIS data severely underrepresent the number of vessels.

Within coastal territories, Bahrain had the highest vessel number represented in the AIS data. This high representation is a result of Bahrain's national regulations requiring AIS use for its entire fleet including small vessels. India was the second largest regional fleet from the AIS data, even though it likely has by far the most vessels operating in the region and accounts for around 1.8 million tonnes of catch per year (FishStatJ, 2018). Other coastal fleets with some vessels broadcasting AIS were the Islamic Republic of Iran, Seychelles, Mauritius, Qatar, Réunion and other Indian Ocean Tuna Commission (IOTC) members that operate tuna fisheries in the region. In most countries the fraction of large vessels that broadcast AIS was well below 50 percent, and negligible in relation to total vessels. There were many semi-industrial vessels in the 12-24 m length class which did not appear to be using AIS. These would include thousands of gillnetters from Pakistan, Iran, Sri Lanka and possibly India; thousands of longliners from Indonesia; or, baitboats from Maldives, India and Indonesia. Finally, as shown by Figure 51. 3, the region has a high number of small, non-powered vessels from the coastal fleets.

Fishing gears identified by AIS data showed that foreign fleets are dominated by longliners, while coastal fleets are a mix of gear types with trawlers and purse seiners being the most common. China also had over 15 squid jiggers, which operated mostly in international waters near the Arabian Peninsula. These AIS results were based on 968 identified likely fishing vessels active in the region, from all fleets, 387 of which could be matched to registries with gear type information, thus confirming their identity. Meanwhile the other vessels' gear types were identified through the neural net classifier and flag states were assigned based on their AIS broadcast. Almost all vessels matched to public vessel registries were from distant water fleets and not regional fleets.

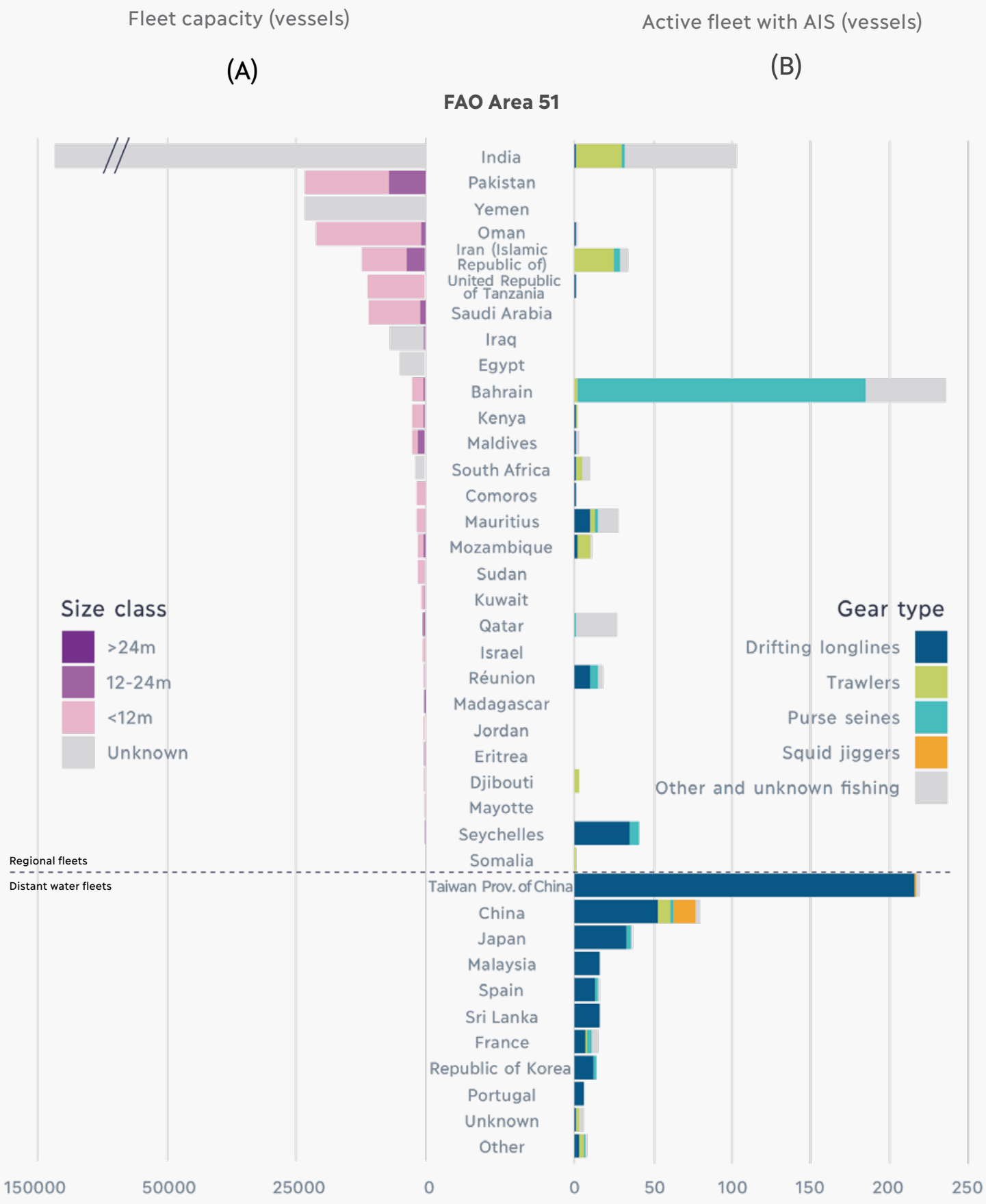


Figure 51. 4. Coastal and distant fleets summary based on FAO statistics and AIS data classification by GFW in FAO Area 51 for 2017. A) Number of motorized vessels as reported to FAO (left panel). The entire national Indian and South African fleets are shown, even though both countries border more than one FAO area. Source: FAO statistics. Statistics were not available for the following coastal countries/territories border FAO Area 51: British Indian Ocean Territories, Ethiopia, Somalia. B) AIS-identified number of fishing vessels broadcasting AIS during their operations in FAO Area 51 by gear type and flag state (right panel). Dashed lines separate regional fleets (top) from distant fleets (bottom). Only vessels that fished for at least 24 hours in the area are included. Source: GFW.

AIS RECEPTION AND FISHING VESSEL ACTIVITY IN THE WESTERN INDIAN

Figures 51. 5a,b show all fishing vessel activity captured by AIS in FAO Area 51 (Class A and Class B AIS devices). About three quarters of AIS operating fishing vessels in the region used the lower quality Class B devices. It appears that India's entire fleet uses Class B, as does most of the Iran and Bahrein fleets. The squid fleet, which is mostly Chinese, operating in the high seas near the Arabian Peninsula generally used Class A. The reception of high-quality Class A devices is good across the region, except in the Arabian Sea and near Pakistan and India (Fig. 51. 5c). The reception of Class B devices was poor in the northern half of the region, which is a productive fishing zone, and relatively good in the southern half of the region (Fig. 51. 5d).

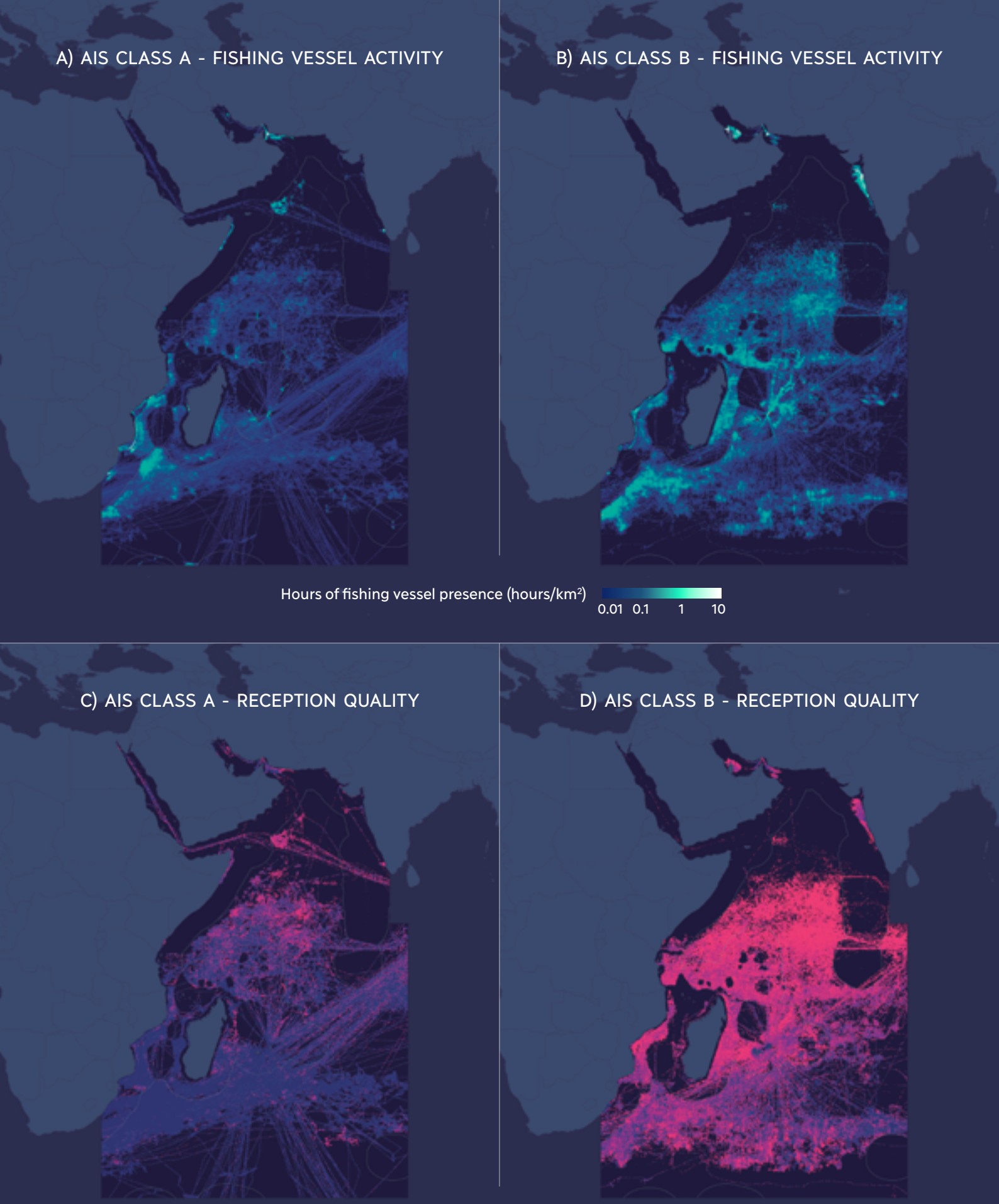
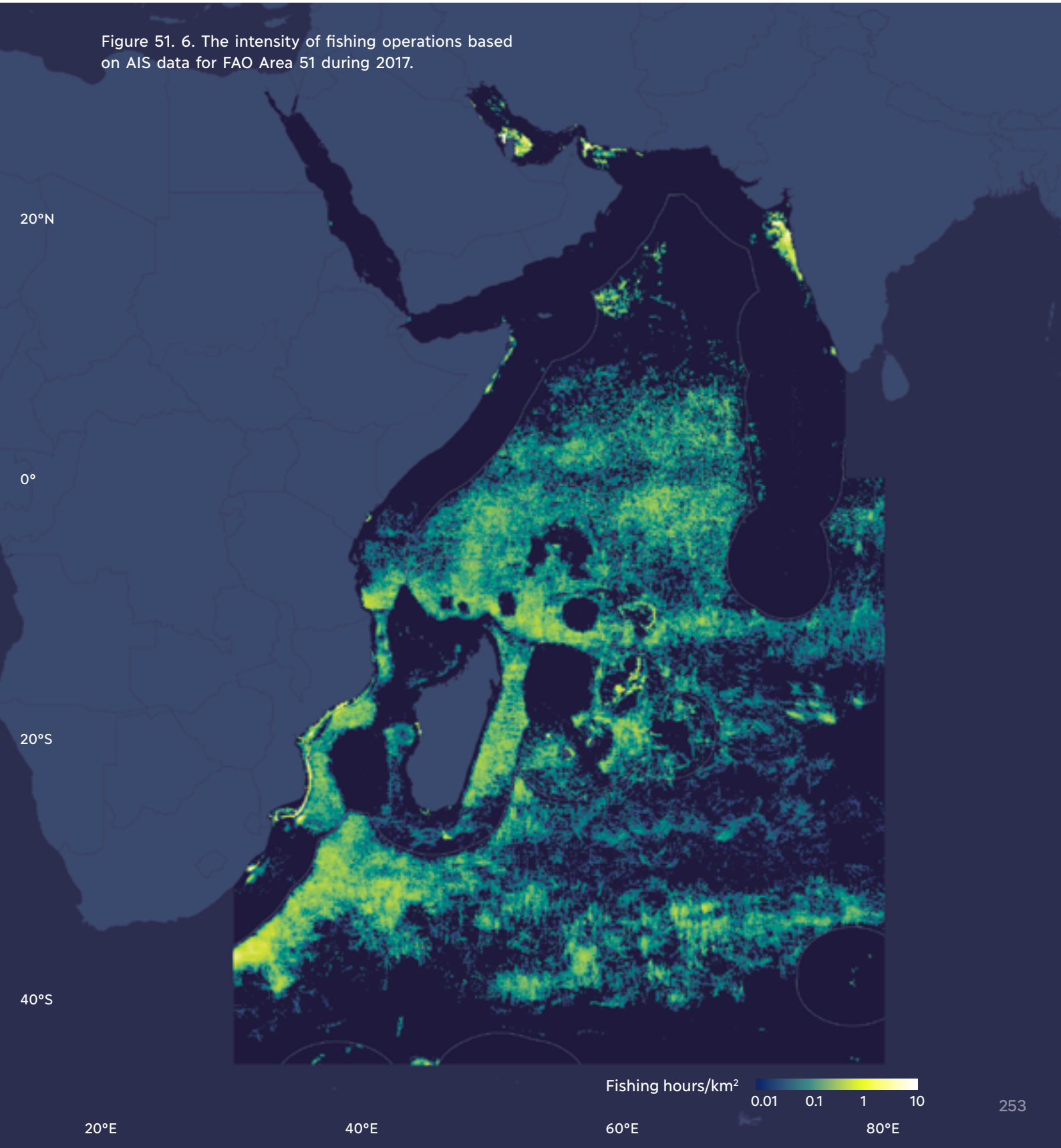


Figure 51. 5. Fishing vessel activity and quality of AIS reception for FAO Area 51 during 2017. Top row shows activity of vessels broadcasting using Class A devices (left panel) and Class B devices (right panel). The bottom row shows reception quality maps for devices Class A (left panel) and B (right panel). About two thirds of the fishing vessels in this region broadcast Class B. Blank spaces on the map (i.e. dark blue ocean background) mean that no signals from fishing vessels in this area were received, which is due to either no vessel activity or poor reception.

The spatial pattern of vessel fishing operations depicted by AIS showed that most fishing concentrates in the south western part and is mostly exerted by distant nation fishing fleets (Fig. 51. 6). This is because the AIS data is biased toward longliner distant water fleets, and because AIS reception is better in the southern half of the basin. The northern area, in contrast, shows little AIS-monitored fishing activity. Despite weak reception, northern India's coastal fishing activity was high in some located spots. The Red Sea showed, incorrectly, almost no activity.

Figure 51. 6. The intensity of fishing operations based on AIS data for FAO Area 51 during 2017.



FISHING VESSEL ACTIVITY AND OPERATIONS BY GEAR IN THE WESTERN INDIAN

This section reviews the spatial distribution patterns of the main fishing gears in FAO Area 51 as estimated by Global Fishing Watch (GFW) based on 2017 AIS data. The most recent datasets available as of mid-2018 were used to assess GFW capacity to provide an AIS based characterization of fishing activity by fishing gear in terms of presence/absence, intensity and hotspots. The Introduction chapter describes the rationale and challenges for use of contrasting data sources (e.g. Global Fisheries Landings database (GFLD; Watson, 2017)) for benchmarking AIS data classification.

GEAR TYPES	Catches (GFLD) 2010-2014 average		Total fishing vessel activity (GFW-AIS) 2017	
	Tonnes of catch in 1000s	% of catch	Active days in 1000s	% of active days
Trawls	1 601	38%	8.3	7%
Other	923	22%	16.9	13%
Set gillnets	925	22%		
Purse seines	606	14%	18.2	15%
Longlines	154	4%	83.8	66%
Total	4 211	100%	123.0	100%

Table 51. I. Summary table comparing average catch from GFLD during 2010-2014 with fishing vessel activity from GFW in FAO Area 51. Only vessels that fished for at least 24 hours in FAO Area 51 are included.

AIS-based fishing activity estimated by GFW suggests that the main fishing gear in the region are longliners (Table 51. I). In contrast, some of the highest catches in GFLD are associated with the gillnet fleets. AIS could not detect most of their activity because almost no gillnetters broadcast AIS. According to Williams *et al.* (2018) (Fig. 51. 7), these gillnetters are active mostly in the northern part of the region, where AIS use and reception are poor.

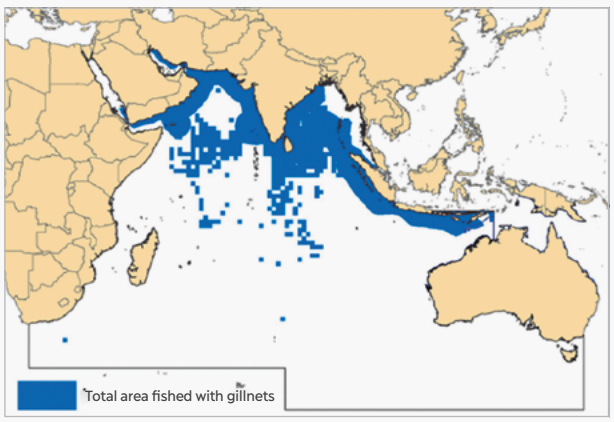


Figure 51. 7. Figure reproduced from report by Williams *et al.* (2018). Distribution of gillnet fishing activity in the IOTC area the years 2012-2016. Note that reported gillnet fishing is grossly underestimated in the IOTC area and in this map gillnet fishing was assumed to occur within the entire Exclusive Economic Zones (EEZs) of the main gillnet countries (Islamic Republic of Iran, Oman, Pakistan, Yemen, India, Sri Lanka and Indonesia).

AIS depicts drifting longliners as mostly operating in international waters, although some activity was observed within EEZs, including those of Kenya, Mozambique, United Republic of Tanzania, Seychelles, Madagascar and Réunion, where the activity was conducted either by local vessels or by foreign vessels licensed through fishing agreements. These longliners were mostly large deep-freezing vessels from Taiwan Province of China, China, Japan and the Seychelles targeting tuna and tuna-like species. The spatial distribution of fishing activity and number of vessels captured by AIS for these longline fleets seemed to correspond with the data of larger deep-freezing vessels for these countries and territories as provided by the IOTC (2017). However, there were also many fresh tuna longliners under 24 m which were not identified in the AIS characterization (IOTC, 2017). The Global Fisheries Landings database (GFLD; Watson, 2017) suggests that fishing activity from longliners cover a broader geographic coverage than depicted by the AIS characterization (Fig. 51. 8). This wider characterization is especially marked in the northwestern Indian Ocean, where the vessels may turn off the AIS signal for security reasons or may not be detected because of poor AIS reception quality (Fig. 51. 5).

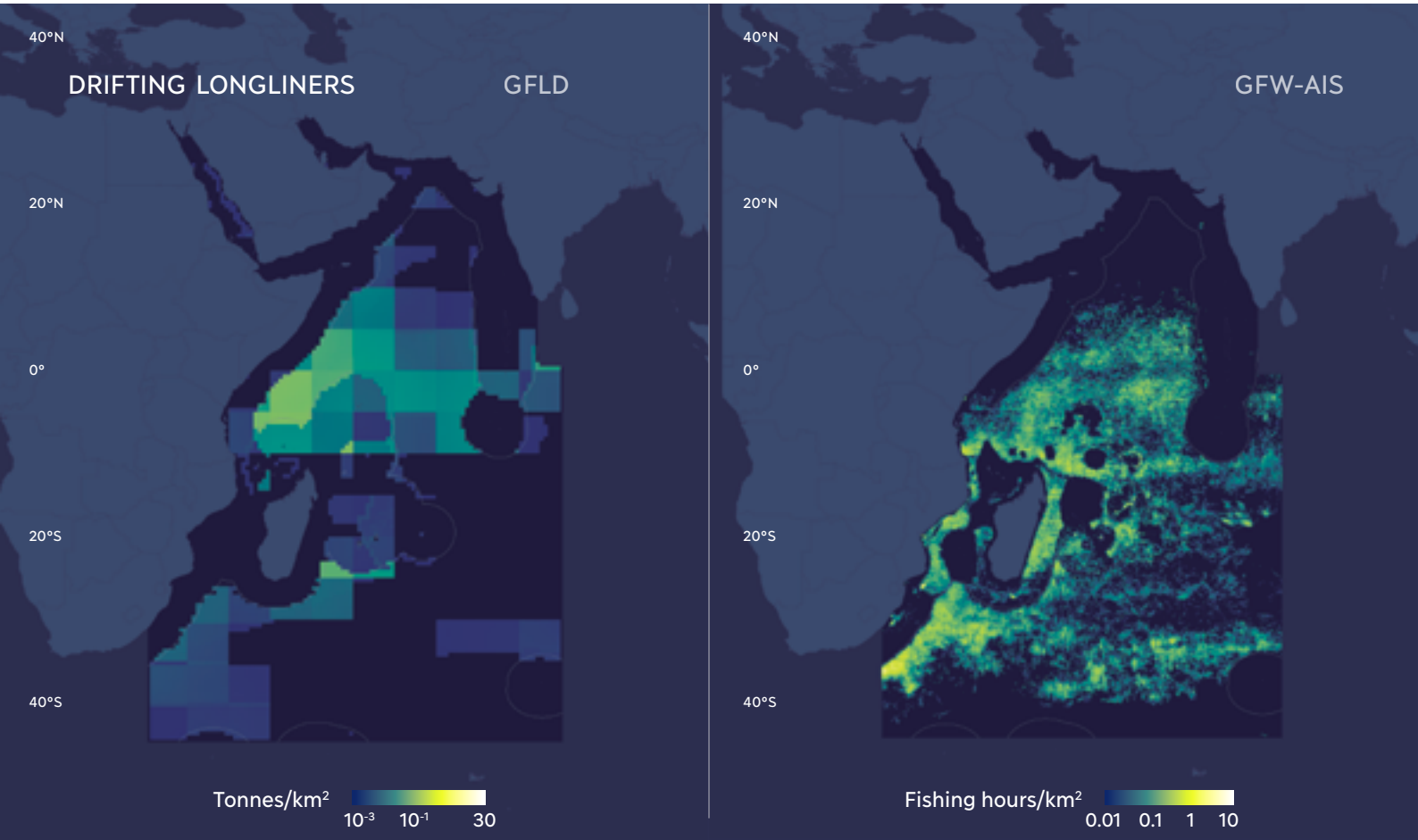


Figure 51. 8. Catch and activity of drifting longliners in FAO Area 51. Maps comparing average catch during 2010-2014 from GFLD (left panel) with drifting longliners fishing operations in 2017 from GFW (right panel). GFLD maps are catches in tonnes/km² and GFW maps are AIS-based fishing operations in hours/km².

For drifting longliners, AIS data identified a small seasonal pattern of fishing activity (Fig. 51. 9), which could be related to longliner seasonal spatial movements and spatial differential reception of the AIS system between the northern and southern parts of the area.

Drifting longlines fishing in FAO Area 51

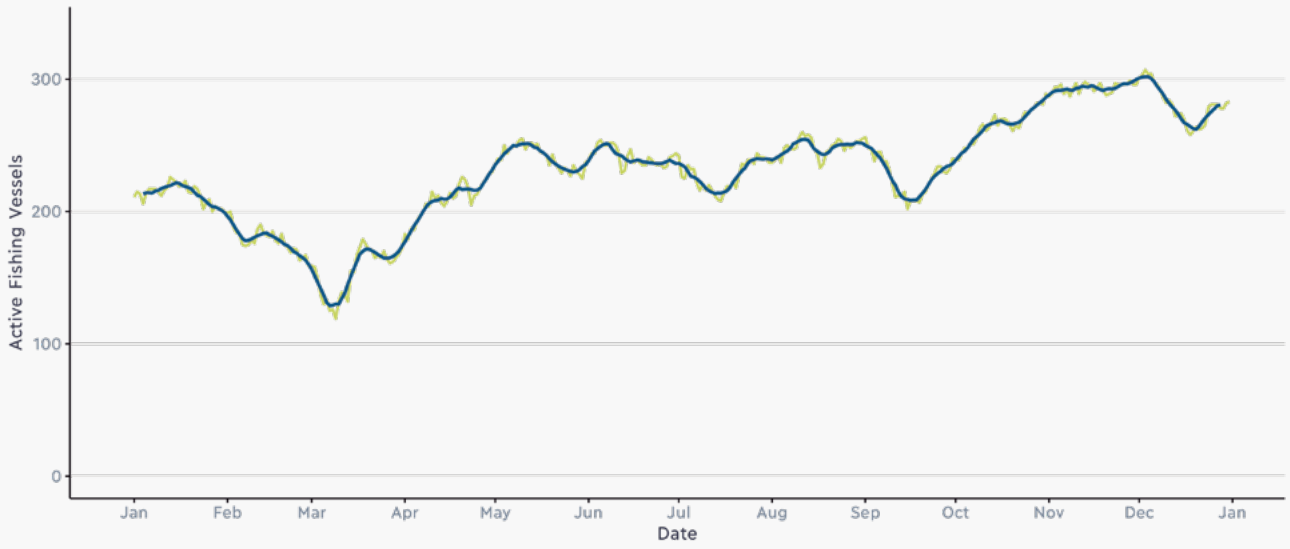


Figure 51. 9. Number of AIS-identified active drifting longliners per day in FAO Area 51 during 2017. Only vessels that fished at least 24 hours in the area over the course of the year are included. Dark blue line shows a 7-day rolling average.

For trawlers, low activity and few vessels were identified by AIS, and the vessels that were identified were restricted to a few coastal regions (Fig. 51. 10). A few deep-sea trawlers from the Cook Islands which operated in the region under the management of the Southern Indian Ocean Fisheries Agreement (SIOFA) targeted alfonsino and orange roughy near seamounts. The catch reconstruction (GFLD) found that the most prevalent fishing gear in the region was trawling (Table 51. I), whereas AIS ranked it as being only 7 percent of the fishing activity. The extremely low use of AIS by coastal fleets explains why AIS poorly reflects trawler activity in coastal areas, in contrast to the information from GFLD. On the contrary in the high seas, where the AIS data performs better, GFLD represented trawlers operating across the entire Indian Ocean; this wide characterization is however unlikely, and the AIS data is probably more accurate in depicting a general lack of deep water trawling.

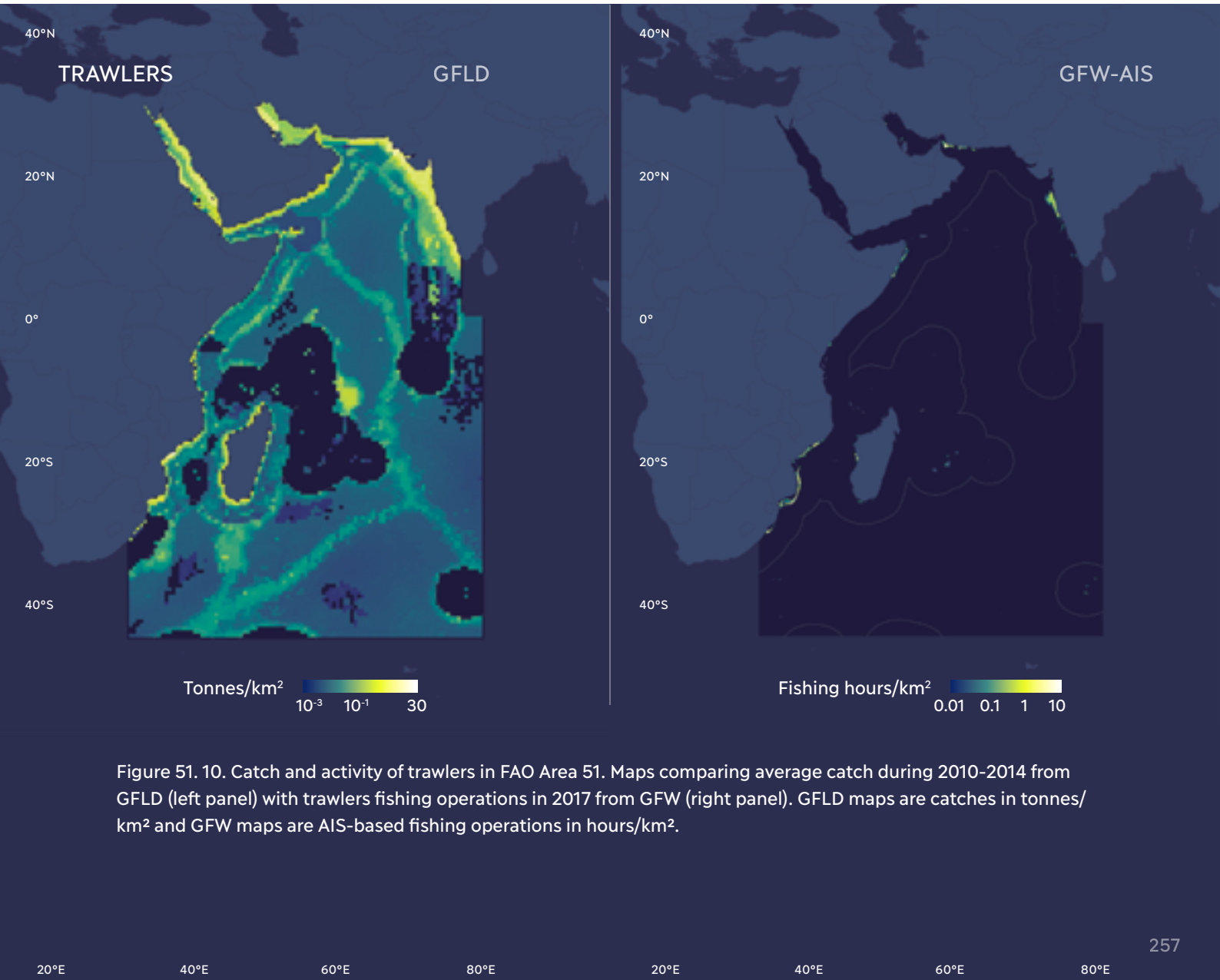


Figure 51. 10. Catch and activity of trawlers in FAO Area 51. Maps comparing average catch during 2010-2014 from GFLD (left panel) with trawlers fishing operations in 2017 from GFW (right panel). GFLD maps are catches in tonnes/km² and GFW maps are AIS-based fishing operations in hours/km².

Regarding purse seiners, AIS did not identify most of the industrial tuna purse seiner fishing activity in the Western Indian Ocean (Fig. 51. 11). This underrepresentation is largely because many of these vessels in the region disable their AIS systems during fishing operations for several reasons, including security. Also, for the few purse seiners broadcasting, the AIS algorithm for identifying fishing activity only accounts for setting and hauling time, and does not include searching time, which is the main fishing activity. The Seychelles case study chapter in this report shows that AIS detects properly the number of industrial purse seiners from the Seychelles (13) and European Union (19), but that almost all these vessels turn off their AIS after leaving port. In summary, the AIS system does not capture well the characterization of purse seiners in this region. The comparison with GFLD (2017) confirms this discrepancy by showing that catches from purse seiners occur over much broader geographic areas in FAO Area 51 than currently shown by the AIS characterization (Fig. 51. 11). Notice that some vessels from India which were classified as using unknown fishing gears (Fig. 51. 4) because the GFW neural net algorithm was not confident of the exact gear type, may be purse seiners.

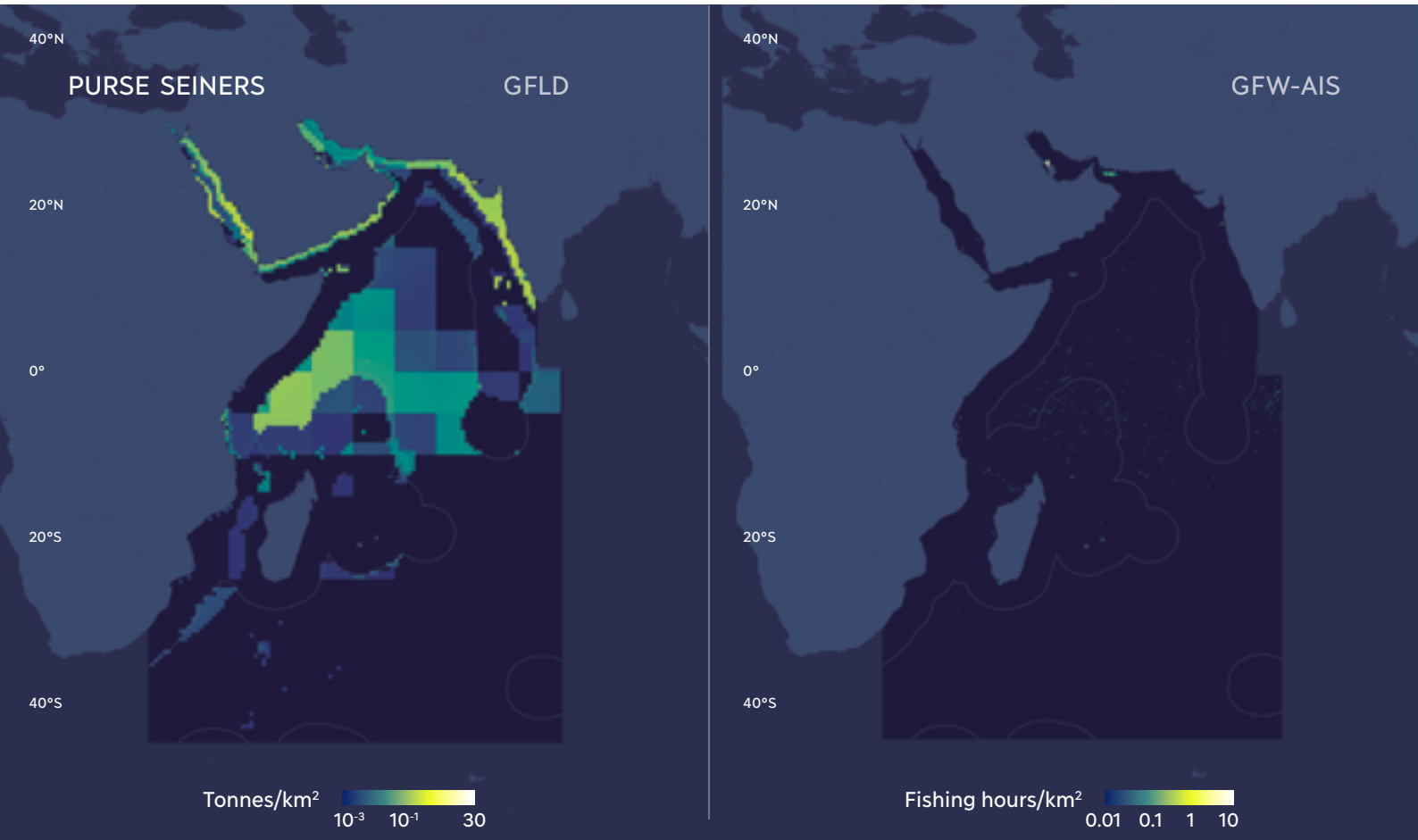


Figure 51. 11. Catch and activity of purse seiners in FAO Area 51. Maps comparing average catch during 2010-2014 from GFLD (left panel) with purse seiners fishing operations in 2017 from GFW (right panel). GFLD maps are catches in tonnes/km² and GFW maps are AIS-based fishing operations in hours/km².

Interestingly, the purse seiner activity best identified by AIS data corresponded to the seasonal fishing activity of the Bahrain fleet, as most of the purse seiners broadcasting AIS all year around in the region are from this nation. The entire Bahraini fleet is covered by AIS and restricted to fishing within national waters. The purse seiners identified, though, were either relatively inactive, or operating with their AIS off or in poor reception regions. Although over 200 purse seines were identified in the region, fewer than 20 were active most days of the year.

Purse seiners fishing in FAO Area 51

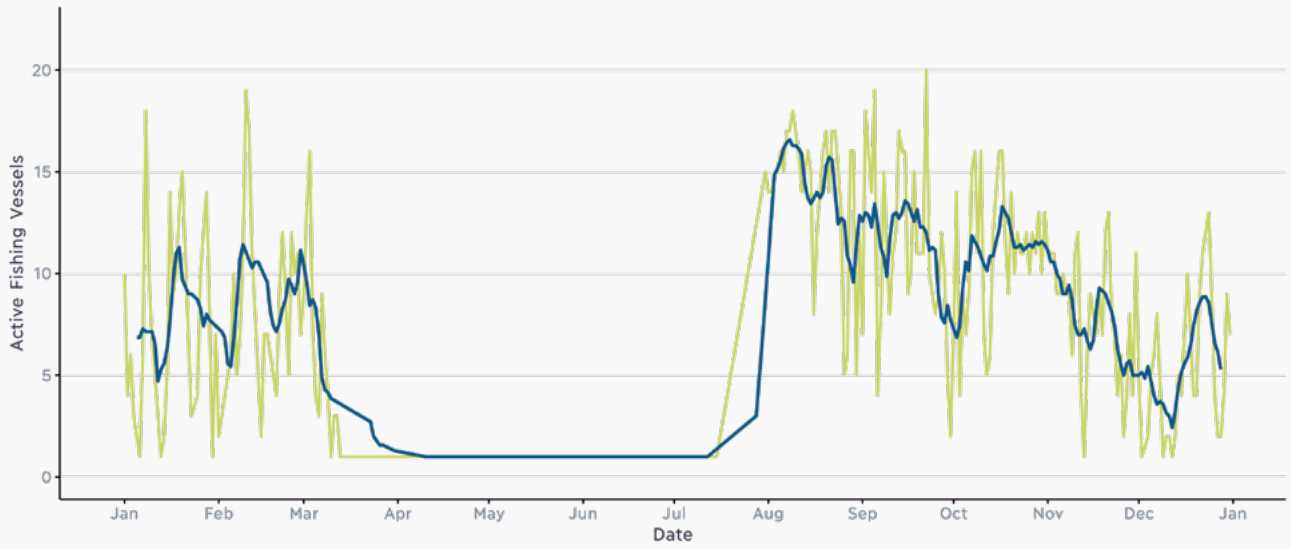


Figure 51. 12. Number of AIS-identified active purse seiners per day in FAO Area 51 during 2017. Only vessels that fished at least 24 hours in the area over the course of the year are included. Dark blue line shows a 7-day rolling average.

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