

# An evaluation of Regional Fisheries Management Organization at-sea compliance monitoring and observer programs

Christopher Ewell<sup>a,b,\*</sup>, John Hocevar<sup>c</sup>, Elizabeth Mitchell<sup>d</sup>, Samantha Snowden<sup>a</sup>, Jennifer Jacquet<sup>a</sup>

<sup>a</sup> Department of Environmental Studies, New York University, 285 Mercer Street, New York, NY, 10003, United States

<sup>b</sup> Yale Law School, Yale University, 127 Wall St, New Haven, CT, 06511, United States

<sup>c</sup> Greenpeace, 702 H St. NW, Ste. 300, Washington, DC, 20001, United States

<sup>d</sup> Association for Professional Observers, PO Box 933, Eugene, OR, 97440, United States

## ARTICLE INFO

### Keywords:

High seas  
International fisheries  
Observer safety  
Remote electronic monitoring  
Transparency  
Human rights

## ABSTRACT

Independent onboard monitoring of fishing activities is important in an era of marine animal overexploitation and declining fish populations. Fisheries observers have traditionally filled this role to varying capacities. Their work is critical to fisheries managers because observers collect data on, for example, catch composition, discard and by-catch policy compliance, and transshipment activities - data that would otherwise be unreliable if collected from other sources. However, fisheries observers have been subject to human rights and safety violations, including intimidation and assault, and many observers have even disappeared from their vessel assignments. In some cases, remote electronic monitoring (REM) has been deployed to complement or substitute for human observers. This study is the first comparison of existing at-sea compliance monitoring and observer programs for 17 Regional Fisheries Management Organizations (RFMOs), the main institutions that currently exist to manage and conserve fish on the high seas or straddling high seas boundaries. Currently only three RFMOs mandate 100% observer coverage on fishing vessels, and no RFMOs mandate 100% at-sea monitoring coverage using REM. Moreover, no RFMOs mandate full transparency of either human observer or REM data. In addition, no RFMOs include regulations to sufficiently ensure the protection of fisheries observer rights and safety, and only four RFMOs mandate a specific process in the event that an observer disappears or dies. RFMOs are well positioned to mandate comprehensive, independent, and transparent monitoring coverage onboard fishing vessels by utilizing a complementary approach of human observers and REM. This would help ensure better management of fisheries as well as better protection of marine ecosystems and human rights at sea.

## 1. Introduction

The rallying cry in the era of globalization and overexploitation has been for increased transparency, including in fisheries. The ability for those outside of the fishing industry to know and understand what is happening to the wild animals exploited offshore depends largely on fisheries observers, individuals employed by fisheries management agencies or a third-party contractor [1,2]. Fishery observer duties vary but can include logging daily fishing activities such as catch and effort, location and characteristics of vessels, reporting any incidents regarding safety on board, or quota, gear and by-catch violations, and in some cases, supervising and signing off on transshipment activities [2,3]. Regional Fisheries Management Organizations (RFMOs), institutional

bodies that manage fisheries in areas beyond national jurisdiction (the high seas), rely on accurate catch and effort data to establish the status of fish stocks and associated species, as well as sustainable fishing limits. Without these data, they cannot perform properly. There are an estimated 2500 observers worldwide (an estimate that includes national and high seas fisheries) [4] and they typically work alone and live among the crew on the vessel for as little as one day up to several months at sea [5]. The data observers report may indicate a need for changes in quotas, stricter regulation on types of fishing gear, enhanced enforcement of policies, or increased conservation efforts for species impacted by by-catch [2,3] and as a result observers can be at odds with the fisheries crew [5]. Given the risks of the position (see Table 1), who watches out for these witnesses?

\* Corresponding author. Department of Environmental Studies, New York University, 285 Mercer Street, New York, NY, 10003, United States.  
E-mail address: [chris.ewell@yale.edu](mailto:chris.ewell@yale.edu) (C. Ewell).

<https://doi.org/10.1016/j.marpol.2020.103842>

Received 10 August 2019; Received in revised form 24 January 2020; Accepted 28 January 2020

Available online 17 February 2020

0308-597X/© 2020 Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

There is a plausible connection between the protection of fisheries observers and the protection of marine animals. Observers are likely to be at a greater risk when they observe illegal activities, which often compromise the regulations put in place to protect or conserve a species. On the high seas, the areas of the ocean outside of national jurisdiction, fish and invertebrates have been subject to more and more fishing effort over the past few decades [6–8], in large part due to government subsidies, especially for fuel [9]. Many fish species straddle the boundaries between national Exclusive Economic Zones (EEZs) and international waters, and as coastal waters have become increasingly exploited, fishing vessels have traveled further offshore to catch fish [7,8,10,11]. An estimated two-thirds of high seas fish populations are either depleted or being overfished [12,13], and much of the global fish catch is stable or declining despite increasing effort [14]. Discards and by-catch of non-target species, such as seabirds, turtles, sharks and rays, threaten many vulnerable species and present a major conservation concern [15–17]. Ocean pollution, particularly plastic, is also negatively impacting marine ecosystems and fish populations [18].

RFMOs, international bodies comprised of fishing countries and where too often resource exploitation considerations are prioritized over conservation concerns, are charged with coordinating and implementing fisheries management efforts of highly migratory species both within and beyond the areas of national jurisdiction, and of areas of the high seas generally under the United Nations Fish Stock Agreement of 1995 [19]. Fisheries management issues are particularly difficult to address for fisheries that straddle the boundaries between national waters and the high seas due to the remote nature of high seas fishing activity and the large areas that some fish species, such as tuna, traverse [8,9]. RFMO requirements for the use of satellite tracking technology have improved monitoring of the movement of fishing vessels and enhanced governance, including detecting the presence of unauthorized vessels in delineated management areas and illegal transshipments at-sea [20,21], but this technology does not provide direct information about what is happening onboard the fishing vessel.

Fisheries observer programs or some form of at-sea monitoring are part of the regulations for most RFMOs, as well as the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), and

for our purposes we include CCAMLR as an RFMO [22]. The mandates of these observer programs vary from being primarily focused on scientific data collection to being primarily a compliance monitoring scheme [23], although most observer program mandates include elements of both. Fishing vessel owners and captains are often resistant to observers due to logistics and costs [3,24] and also because observers are recording the vessels' activities [25]. Human observers have been subject to intimidation, harassment, assault, and have been murdered or have disappeared at sea [5,26]. According to official reports, crewmembers have requested that observers in the Western and Central Pacific Fisheries Commission not report conservation measure violations [27], illustrating pressures on observers and demonstrating why observers may collude with crewmembers on illegal activity to protect their own safety [25].

Remote Electronic Monitoring (REM) on-board fishing vessels, a system of cameras, gear sensors, video storage, and satellite positioning, has been proposed as one alternative monitoring tool, as it could lead to more comprehensive coverage and could complement some of the liabilities associated with human observation [24,28–33]. In trial studies, REM recording was able to closely match human observer accuracy in some monitoring areas, including catch volume, effort, and species composition [24,29–31,33]. Beyond fisheries regulations and conservation measures, well-regulated, transparent, and independent REM systems could be used to monitor labor and human rights conditions onboard vessels, and facilitate the adoption of specific RFMO provisions on human rights and the monitoring of their implementation, as well as compliance with existing obligations under other conventions, such as Articles 40 through 44 on compliance and enforcement in the International Labor Organization Work in Fishing Convention (No. 188) [24]. A study on Danish fisheries using a variety of on-board monitoring techniques found that the majority of fishers who had used REM responded positively to its use, signaling the potential for crew acceptance [32]. As REM systems become more cost-effective, the potential for scaling the technology to cover all fishing vessels in RFMOs becomes more realistic. A study on REM installation on UK fisheries found that the costs of installation fell by 22% per year from 2015 to 2017 [28]. Although a detailed study comparing the costs of REM and human observers has not

**Table 1**

Selected anecdotal reports of observer deaths or disappearances under suspicious circumstances in RFMO convention areas from 2010 to present.

Observer Name	Date	Circumstances	RFMO Area	Nationality	Source
Edison Geovanny Valencia Bravo	March 6, 2018	Disappeared from an Ecuador-flagged vessel in the Inter-American Tropical Tuna Commission (IATTC) under the Agreement for International Dolphin Conservation Programme	IATTC	Ecuador	<a href="https://www.elcomercio.com/actualidad/angustia-familiares-biologo-desaparecido-guayaquil.html">https://www.elcomercio.com/actualidad/angustia-familiares-biologo-desaparecido-guayaquil.html</a>
James Junior Numbaru	June 25, 2017	Allegedly fell overboard from Chinese-owned purse seine vessel Feng Xiang 818 and vessel did not initiate search and rescue operation as required under the Western and Central Pacific Fisheries Commission (WCPFC) observer safety measures	WCPFC	Papua New Guinea	<a href="https://www.rnz.co.nz/international/pacific-news/334953/fisheries-observer-safety-measures-not-fully-implemented">https://www.rnz.co.nz/international/pacific-news/334953/fisheries-observer-safety-measures-not-fully-implemented</a>
Usaia Masibalavu	May 21, 2016	Died onboard U.S. flagged purse seine vessel F/V Western Pacific registered in the WCPFC convention area from an unexplained "infection from injury"	WCPFC	Fiji	<a href="http://www.humanrightsatsea.org/wp-content/uploads/2019/09/FIJI-Islands_Business_Magazine_Keeping_Our_Seafarers_Safe_10-13-IB-July-2019.pdf">http://www.humanrightsatsea.org/wp-content/uploads/2019/09/FIJI-Islands_Business_Magazine_Keeping_Our_Seafarers_Safe_10-13-IB-July-2019.pdf</a>
Larry Gavin	2016	Disappeared at sea, no information known, not investigated	Unknown	Papua New Guinea	<a href="http://www.humanrightsatsea.org/wp-content/uploads/2019/09/FIJI-Islands_Business_Magazine_Keeping_Our_Seafarers_Safe_10-13-IB-July-2019.pdf">http://www.humanrightsatsea.org/wp-content/uploads/2019/09/FIJI-Islands_Business_Magazine_Keeping_Our_Seafarers_Safe_10-13-IB-July-2019.pdf</a>
Wesley Talia	2015	Disappeared at sea, no information known, not investigated	Unknown	Papua New Guinea	<a href="http://www.humanrightsatsea.org/wp-content/uploads/2019/09/FIJI-Islands_Business_Magazine_Keeping_Our_Seafarers_Safe_10-13-IB-July-2019.pdf">http://www.humanrightsatsea.org/wp-content/uploads/2019/09/FIJI-Islands_Business_Magazine_Keeping_Our_Seafarers_Safe_10-13-IB-July-2019.pdf</a>
Keith Davis	September 10, 2015	Disappeared from a vessel under the IATTC transshipment observer program after documenting witnessing illegal activity	IATTC	USA	<a href="http://www.hakaimagazine.com/features/mysterious-disappearance-keith-davis/">http://www.hakaimagazine.com/features/mysterious-disappearance-keith-davis/</a>
Charlie Lasisi	March 29, 2010	Disappeared from F/V Dolores 838 registered in the WCPFC and his body was later discovered bound with chains	WCPFC	Papua New Guinea	<a href="http://www.apo-observers.org/docs/2015_Tuna_forum_Patricia_Kailola.pdf">http://www.apo-observers.org/docs/2015_Tuna_forum_Patricia_Kailola.pdf</a>

Adapted from Association of Professional Observers (APO) reports

been conducted, estimates currently suggest that a combination of REM and human observer monitoring could be used to cover fishing vessels with 100% at-sea monitoring at a small fraction of the cost of using only human observers, including maintenance [24,28].

However, REM still has some important limitations and a move towards more extensive fishing industry monitoring using REM would require extensive regulation to ensure adherence to technical and implementation standards, as well as public accountability and oversight. Currently, REM is less accurate at recording high-volume fisheries, such as purse seines and trawls, and there are scientific data, such as sex and maturity, that REM either cannot detect at all or cannot detect as effectively as human observers [24]. Trial studies highlighted that there are still some instances of REM failing to record catch, by-catch, discards, or species interactions, due to camera angles, system handling, and other technological limitations [24,29,30]. In addition, REM systems are potentially prone to corruption and tampering, including being turned off by crewmembers and prevented from recording critical information [34]. Human observers that are onboard alongside REM systems can help to direct camera angles, ensure system functions, act as an important third-party witness, and record specific data that REM systems will miss, such as discard survival and more detailed scientific data critical to fisheries management. Most studies on REM argue that with proper handling and the complement of human observers, REM could allow fisheries to approach 100% at-sea coverage and accuracy, but that strictly applied high standards are crucial to REM success [24, 28,35]. Most important, wide-scale adoption of REM should not lead to less transparency and independent oversight and increased self-monitoring by the fishing industry.

Here we examined the mandated at-sea compliance monitoring and observer programs for 17 Regional Fisheries Management Organizations, including CCAMLR (Table 2), and how they ensure that monitoring of conservation measures takes place effectively while protecting human observer safety. Previous studies have compared certain RFMO observer programs as they relate to specific conservation goals, such as by-catch provisions, but no study has previously conducted a broad scale review of all RFMO observer and at-sea monitoring programs as they relate to coverage levels, compliance reporting, observer rights and safety regulations, and public transparency [3,23]. We developed a set of criteria questions to assess the RFMOs across these conservation concern areas. We also look specifically at trends in observer reports of violations from 2013 through 2017 in the Western and Central Pacific Fisheries Commission (WCPFC) [27]. Finally, we make policy recommendations around the complementary nature of human observers and REM systems.

**Table 2**  
The Regional Fisheries Management Organizations included in this study.

Acronym	Full Name
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCBSP	Convention on the Conservation and Management of the Pollock Resources in the Central Bering Sea
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
GFCM	General Fisheries Commission for the Mediterranean
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
IOTC	Indian Ocean Tuna Commission
IPHC	International Pacific Halibut Commission
NAFO	Northwest Atlantic Fisheries Organization
NASCO	North Atlantic Salmon Conservation Organization
NEAFC	North East Atlantic Fisheries Commission
NPAFC	North Pacific Anadromous Fish Commission
PSC	Pacific Salmon Commission
SEAFO	South East Atlantic Fisheries Organization
SIOFA	South Indian Ocean Fisheries Agreement
SPRFMO	South Pacific Regional Fisheries Management Organization
WCPFC	Western and Central Pacific Fisheries Commission

## 2. Methods

We reviewed RFMO convention texts, resolutions, mandates, conservation measures, and information available on official websites to evaluate at-sea compliance monitoring and observer programs in place as of January 2019 (See [Supplementary data](#) for a list of the most comprehensive sources on observer and electronic monitoring regulations for each RFMO in addition to the measures cited directly in the text). We developed a set of criteria questions across four categories to examine the stringency of RFMO programs. This study only reviewed observer program mandates and not the extent of their implementation. The existence of observer program mandates does not necessarily mean that all observer regulations and coverage requirements are being properly and comprehensively met or implemented.

The first category considered observer coverage generally (Table 3). Question 1 asked whether the RFMO mandates some kind of regional observer program for its contracting partners and co-operating non-members in the RFMO area. Questions 2-5 addressed public availability of observer data, whether observers are guaranteed a right to logbooks and fish stock information onboard vessels, and whether the observer is required to be from a different flag state than the fishing vessel. The remaining questions focused on the kinds of vessels that are required to carry observers and what percentage of vessels are required to carry observers.

The second category considered the kinds of compliance monitoring and reporting powers bestowed upon human observers (Table 4). The first question was whether observers are tasked with collecting scientific data on fish catch. The second asked whether monitoring compliance was the primary function of the observer. While many RFMO observer programs require observers to collect data on the implementation of conservation and management measures, not all of these RFMO programs cast the observer as the official compliance monitor, instead leaving the contracting parties to determine whether to use the data collected for compliance purposes [23]. Subsequent questions went into further detail about the kinds of conservation measures for which observers are tasked to report compliance, ranging from gear type to by-catch policies, regardless of whether compliance monitoring is the primary function of the observer program.

The third category broadly considered the RFMO policies in place to protect observer rights and safety (Table 5). These questions are based in part on the International Observer Bill of Rights (IOBR), most recently updated in 2013 by the Observer Professionalism Working Group (OPWG) and Association for Professional Observers (APO) [1]. The APO and other NGOs have been putting pressure on RFMOs to adopt the stipulations in the IOBR as official policies to protect observer rights [36]. The first six questions in this category asked whether policies and resources ensure crew and observer rights and safety. Questions 7–10 focused on what kinds of policies and processes are in place that protect observers from harassment, intimidation, and assault. Question 8 asked specifically about sexual harassment against fisheries observers, because this issue has been highlighted for observers in Alaska [37].

The fourth category considered RFMO policies on Remote Electronic Monitoring (REM) (Table 6). The first question was whether the RFMO

**Table 3**  
General at-sea monitoring and observer coverage criteria questions

1.	Is a regional observer program in place and implemented by the RFMO (as opposed to delegated to contracting parties)?
2.	Are all raw observer reports and data publicly available?
3.	Are summaries of observer reports publicly available?
4.	Does the observer have a guaranteed right to access fish stocks and logbooks onboard?
5.	Does the observer have to be from a different flag state than the vessel?
6.	Are there observer requirements for different gears types/areas/species?
7.	Are 100% of fishing vessels required to carry observers?
8.	Are 100% carrier vessels required to carry observers during transshipments with fishing vessels?

**Table 4**  
Observer compliance monitoring and reporting criteria questions.

1.	Does the observer collect scientific data?
2.	Is compliance monitoring the primary function of the observer program?
3.	Does the observer record gear type compliance?
4.	Does the observer record compliance with catch restrictions?
5.	Does the observer record compliance with by-catch/discard policies?
6.	Does the observer record interactions with marine mammals/sea-birds?
7.	Is an observer required to report compliance during transshipments at-sea?
8.	Does the observer record sightings of unauthorized vessels in the RFMO?
9.	Does the observer record compliance with pollution policies?
10.	Does the observer record witnessed human rights abuses?

**Table 5**  
Observer rights and safety criteria questions.

1.	Is there a codified observer safety mandate?
2.	Is there an observer manual that includes provisions of their rights?
3.	Is there radio equipment on board for the observer to use in case of an emergency?
4.	Is there a policy in place to protect the human rights of all crew?
5.	Is the observer guaranteed suitable living standards?
6.	Is there a policy governing observer wages/hours/leave?
7.	Is there a policy against harassment of fisheries observers?
8.	Is there a policy specifically against sexual harassment of fisheries observers?
9.	Is there a prescribed process if an observer reports harassment/intimidation?
10.	Is there a prescribed process if an observer dies/is reported missing?

**Table 6**  
Remote electronic monitoring criteria questions.

1.	Is there a regional policy on REM?
2.	Can REM replace human observers in order to meet observer coverage requirements?
3.	Is there any penalty for failing to comply with REM provisions?
4.	Is there a system in place to review REM footage at the RFMO level?
5.	Is there a requirement that REM footage and data must be publicly available?
6.	Are 100% of fishing vessel required to carry REM systems?

has mandated any regional policy on the use or implementation of REM. The second was whether a REM system can be used to replace human observers under certain circumstances. The third and fourth questions went into some more detail about how the RFMO ensures REM compliance monitoring can work effectively. The fifth question examined public transparency of REM data and footage. The final question asked whether any RFMO has mandated 100% REM coverage. Since REM is still a developing technology area, these criteria questions are forward-looking to establish some standards that RFMOs could use to improve REM policies.

In addition, as a case study, we examined and analyzed trends in observer reports of compliance violations in the Western and Central Pacific Fisheries Commission (WCPFC) annual reports for the regional observer program over the five-year period from 2013 through 2017 (the most recent report available). Starting with the 6th Annual Report for the Regional Observer Program released in 2014, the WCPFC has reported a uniform “Observer Trip Monitoring Summary” detailing observer compliance reporting on observer rights, national regulations, WCPFC conservation and management measures (CMMs), log sheet recording, interactions with “Species of Special Interest”, pollution, and sea safety. We used the data from these tables to assess trends in observer monitoring. The WCPFC is one of only three RFMOs that publicly report regional-level summaries of observer compliance and violation reports (although note that the most recent data is from 2017), and the only RFMO that does not restrict these regional summary reports to only transshipment-related observer reports [27,38,39]. A more detailed study of all publicly available observer violation reports in all RFMOs is necessary and desirable.

### 3. Results

Of the 17 RFMOs (Table 7 and Fig. 1), 14 have some form of regional policy on observers. None of the RFMOs make all observer reports and raw data publicly available. Three RFMOs: ICCAT, IOTC, and WCPFC publish regional-level summaries of observer compliance violation reports and safety concerns that are publicly available [27,38,39]. For both the ICCAT and the IOTC, these summary reports are only available for the transshipment observer scheme [38,39]. In addition, the IATTC makes yearly observer summary reports of all individual contracting parties publicly available, but it does not publish a regional-level summary of observer reports [40]. Japan and Indonesia have both released yearly summary reports of their national observer programs in the CCSBT convention area, but other contracting parties in the CCSBT have not, and the CCSBT does not mandate public disclosure of these individual contracting party summaries [41,42]. Nine RFMOs include specific provisions in their observer policies that state captains must guarantee the observer’s access to fisheries logbooks and fish stocks onboard fishing vessels. The GFCM and SPRFMO both have policies around observers on the regional-level but do not require observers on fishing vessels as part of their mandate [43,44]. GFCM only requires observers to be present on carrier vessels during transshipments at-sea with GFCM vessels [43], while SPRFMO’s observer program only went into place in 2019 and outlines how observers should be utilized but currently merely encourages contracting parties to use observers while the RFMO determines appropriate levels of observer coverage over the next year [44]. Five RFMOs require observers to be present on all carrier vessels that are engaged in transshipments at-sea.

Only three of the 17 RFMOs (CCBSP, NAFO, and SEAFO) officially mandate 100% observer coverage for all fishing vessels operating in their convention area as of 2019 [45–47]. However, contracting parties to the NAFO may request to reduce their observer coverage level to 25% for each calendar year, providing they can prove any vessels not carrying observers will meet other regulatory requirements and only fish in areas of low by-catch concern [46]. CCAMLR currently mandates 100% observer coverage on vessels fishing for toothfish, and has initiated an increasing scale of coverage levels for krill fisheries, which started at 50% required coverage for the 2016/2017 fishing, currently mandates 75% coverage, and will graduate to a 100% observer coverage requirement after the 2019/2020 fishing season in December 2020 [48]. The other RFMOs with observer mandates vary in their coverage level requirements. Some mandate specific coverage percentage rates, such as IOTC, which mandates that contracting parties ensure that at least 5% of fishing vessels have observers onboard [49]. ICCAT mandates 100% observer coverage for purse seine vessels fishing for bluefin tuna, 20% observer coverage for longline vessels fishing for bluefin tuna, and 5% observer coverage for longline vessels fishing for Mediterranean swordfish [50,51]. ICCAT also adopted a proposal in November 2019 to expand the coverage for tropical tunas to 100% observer coverage for purse seine vessels by 2020 and at least 10% observer coverage for longline vessels by 2022 [52]. IATTC and WCPFC both mandate that 5% of longline vessels and 100% of purse seine vessels have observers onboard [53,54]. However, some fleets are still falling well short of this requirement. A review of contracting party compliance with the scientific observer coverage mandate in the IATTC found that most contracting parties failed to meet even 5% coverage in the period from 2015 to 2018, and that many contracting parties were failing to submit observer reports at all [55]. Other RFMOs have observer program requirements only for specific types of gear, such as SIOFA’s mandate of 20% observer coverage for longline vessels engaging in bottom fishing and 100% observer coverage for trawlers engaging in bottom fishing [56].

The results of the second set of criteria questions (Table 8 and Fig. 2) about how observers are used for compliance monitoring and science showed that 13 RFMOs mandate the use of human observers to collect scientific data on fish stock, including biological sampling. Four RFMOs:

**Table 7**  
General observer coverage criteria question results.

RFMO	Regional Policy?	Data Public?	Summary reports available?	Right to access logs?	Different flag state?	Observers for some gear/ areas/species?	100% of fishing vessels?	100% of carrier vessels?	Total
CCAMLR	1	0	0	1	0	1 <sup>a</sup>	0	0	3
CCBSP	1	0	0	1	0	1	1	0	4
CCSBT	1	0	0	0	0	1 <sup>b</sup>	0	1	3
GFCM	1	0	0	0	0	0	0	1	2
IATTC	1	0	1 <sup>c</sup>	1	0	1 <sup>d</sup>	0	1	5
ICCAT	1	0	1 <sup>e</sup>	1	0	1 <sup>f</sup>	0	1	5
IOTC	1	0	1 <sup>g</sup>	1	0	1 <sup>h</sup>	0	1	5
IPHC	1	0	0	0	0	1 <sup>i</sup>	0	0	2
NAFO	1	0	0	1	0	1	1	0	4
NASCO	0	0	0	0	0	0	0	0	0
NEAFC	1	0	0	0	0	1 <sup>j</sup>	0	0	2
NPAFC	0	0	0	0	0	0	0	0	0
PSC	0	0	0	0	0	0	0	0	0
SEAFO	1	0	0	1	0	1	1	na	4
SIOFA	1	0	0	0	0	1 <sup>k</sup>	0	0	2
SPRFMO	1	0	0	1	0	0	0	0	2
WCPFC	1	0	1	1	0	1 <sup>l</sup>	0	0	4

<sup>a</sup> (100% toothfish, 75% krill)

<sup>b</sup> (10% of all fishing vessels)

<sup>c</sup> (contracting parties)

<sup>d</sup> (5% for longline vessels, 100% for purse seines and in Antigua area)

<sup>e</sup> (only transshipments)

<sup>f</sup> (20% bluefin tuna longlines, 100% bluefin tuna purse seines, 5% Mediterranean swordfish longlines)

<sup>g</sup> (only transshipments)

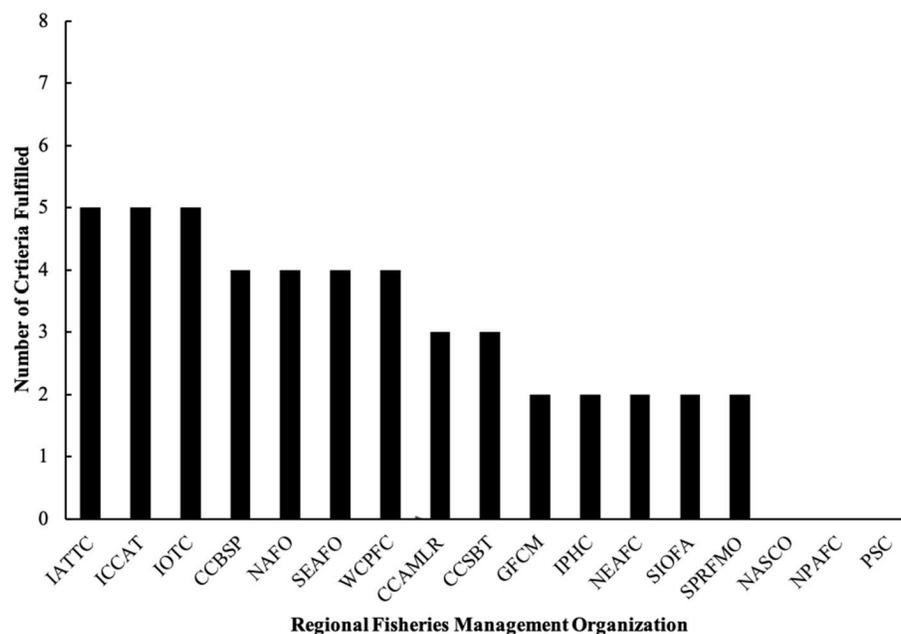
<sup>h</sup> (5% of all fishing vessels)

<sup>i</sup> (~20 vessels)

<sup>j</sup> (exploratory bottom fishing)

<sup>k</sup> (100% bottom trawls, 20% other bottom fishing gear)

<sup>l</sup> (5% for longline vessels, 100% for purse seine vessels)



**Fig. 1.** General observer coverage criteria results.

ICCAT, NAFO, SEAFO, and WCPFC, mandate that compliance monitoring is the primary function of their observer program. IATTC only includes a compliance monitoring mandate specifically for observers on vessels in the Agreement on the International Dolphin Conservation Program [57]. IOTC similarly only includes a compliance monitoring mandate for observers present during transshipments at-sea [58]. Regardless of whether compliance monitoring is the primary function of the observer, 11 RFMOs mandate that human observers report

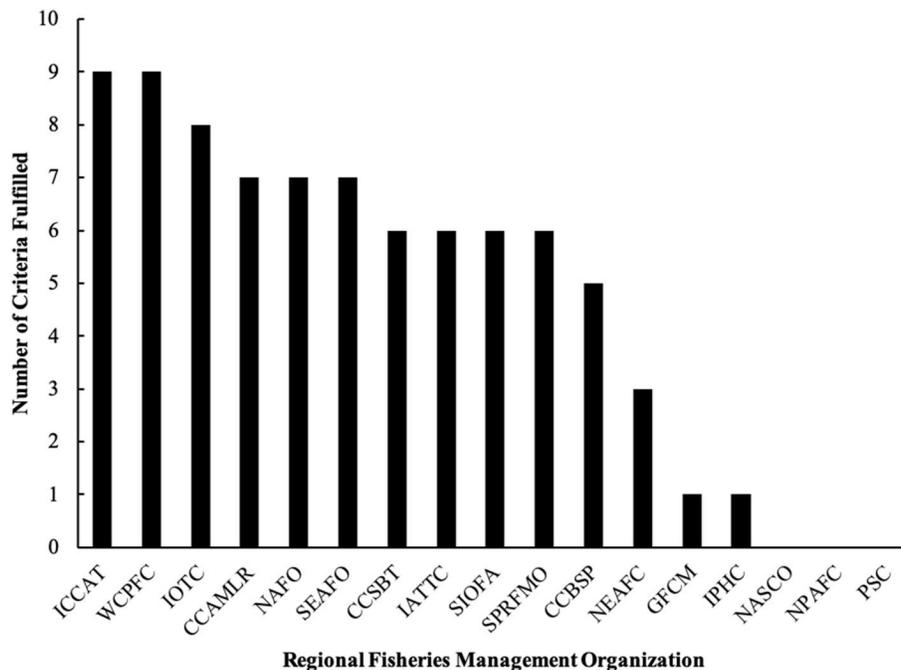
compliance with species catch restrictions, gear restrictions, by-catch and discard policies, and interactions with marine mammal or seabird interactions; and nine RFMOs mandate that human observers report compliance during transshipments at-sea, from either the fishing vessel or the carrier vessel. It is notable that SEAFO officially bans all transshipments at-sea so was not included in the compliance question, although transshipments do happen in the SEAFO jurisdiction [59]. Only five RFMOs mandate that human observers report sightings of

**Table 8**  
Observer compliance reporting criteria question results.

RFMO	Scientific data?	Compliance Primary Mandate?	Gear type compliance?	Species catch restrictions?	By-catch/discard policies?	Marine mammals/sea-birds?	Transshipments at-sea?	Unauthorized vessels?	Pollution policies?	Human Rights Abuses?	Total
CCAMLR	1	0	1	1	1	1	0	1	1	0	7
CCBSP	1	0	1	1	1	1	0	0	0	0	5
CCSBT	1	0	1	1	1	1	1	0	0	0	6
GFCM	0	0	0	0	0	0	1	0	0	0	1
IATTC	1	0 <sup>a</sup>	1	1	1	1	1	0	0	0	6
ICCAT	1	1	1	1	1	1	1	1	1	0	9
IOTC	1	0 <sup>b</sup>	1	1	1	1	1	1	1	0	8
IPHC	1	0	0	0	0	0	0	0	0	0	1
NAFO	1	1	1	1	1	1	1	0	0	0	7
NASCO	0	0	0	0	0	0	0	0	0	0	0
NEAFC	1	0	0	0	1	1	0	0	0	0	3
NPAFC	0	0	0	0	0	0	0	0	0	0	0
PSC	0	0	0	0	0	0	0	0	0	0	0
SEAFO	1	1	1	1	1	1	na	1	0	0	7
SIOFA	1	0	1	1	1	1	1	0	0	0	6
SPRFMO	1	0	1	1	1	1	1	0	0	0	6
WCPFC	1	1	1	1	1	1	1	1	1	0	9

<sup>a</sup> (except for observers in the Agreement on the International Dolphin Conservation Program)

<sup>b</sup> (except for observers present during transshipments at-sea)



**Fig. 2.** Observer compliance monitoring criteria results.

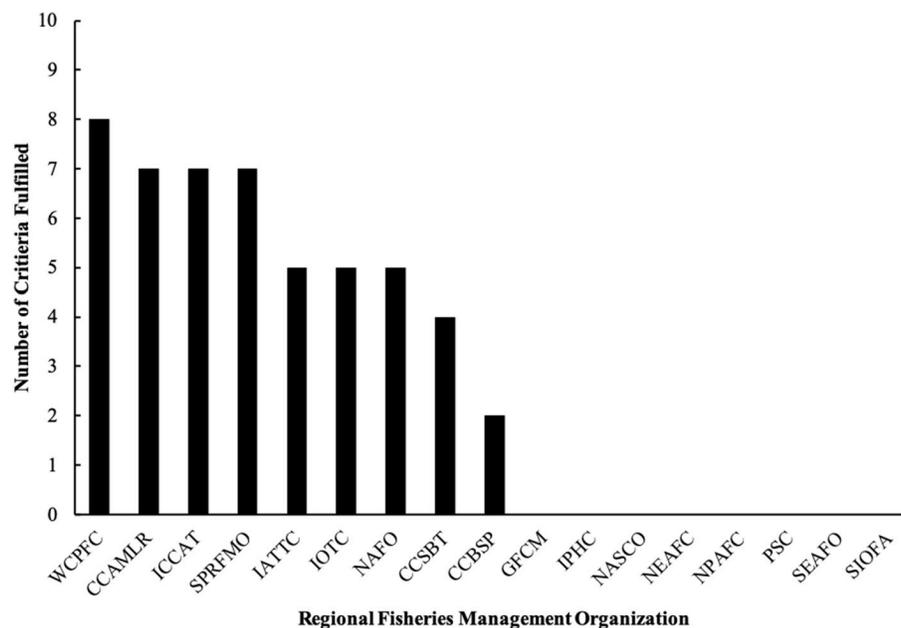
unauthorized vessels in RFMO waters, and only four RFMOs mandate that human observers report compliance with pollution and garbage disposal policies. In addition, none of the RFMOs currently mandate that observers report witnessed human rights violations of crewmembers onboard fishing vessels. Although the WCPFC included observer reports of mistreatments of crewmembers up until 2015, this category was removed from observer reports without explanation in the following years [27].

Table 9 and Fig. 3 show the results of observer safety and observer rights provisions and documents on the RFMO-level. Different contracting parties of RFMOs may have their own observer safety and observer rights guarantees or bilateral agreements without such guarantees being in place on the RFMO-level. Only eight RFMOs have some form of publicly available regional-level observer safety mandate and all

eight of these RFMOs mandate that observers should be guaranteed the right to carry out their duties without harassment or intimidation, while only the ICCAT specifically includes sexual harassment under this mandate [60]. The IPHC, not included in these eight, conducts trainings on observer safety for its “sea samplers” program, the alternative to observers used in the IPHC, but information on these trainings or any specific regulations is not transparent. However, only five RFMOs have a regional observer manual or document that outlines the specific rights and safety policies for observers. Nine RFMOs mandate that observers have access to emergency communication equipment and eight RFMOs mandate that observers be provided with suitable accommodation and living conditions at least akin to the rest of the crew. Only the WCPFC, however, includes any provisions on human rights conditions for crewmembers in general [61]. Also, none of the RFMOs mandate

**Table 9**  
Observer rights and safety criteria question results (listed as n/a if not transparent).

RFMO	Observer safety regulation?	Observer manual?	Radio equipment?	Human Rights of crew?	Living conditions?	Wages/ hours?	Harassment policy?	Sexual harassment policy?	Process for harassment/ intimidation?	Process for disappearance/ death?	Total
CCAMLR	1	1	1	0	1	0	1	0	1	1	7
CCBSP	0	0	1	0	1	0	0	0	0	0	2
CCSBT	1	0	1	0	1	0	1	0	0	0	4
GFCM	0	0	0	0	0	0	0	0	0	0	0
IATTC	1	0	1	0	0	0	1	0	1	1	5
ICCAT	1	1	1	0	1	0	1	1	1	0	7
IOTC	1	1	1	0	1	0	1	0	0	0	5
IPHC	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0
NAFO	1	0	1	0	1	0	1	0	1	0	5
NASCO	0	0	0	0	0	0	0	0	0	0	0
NEAFC	0	0	0	0	0	0	0	0	0	0	0
NPAFC	0	0	0	0	0	0	0	0	0	0	0
PSC	0	0	0	0	0	0	0	0	0	0	0
SEAFO	0	0	0	0	0	0	0	0	0	0	0
SIOFA	0	0	0	0	0	0	0	0	0	0	0
SPRFMO	1	1	1	0	1	0	1	0	1	1	7
WCPFC	1	1	1	1	1	0	1	0	1	1	8



**Fig. 3.** Observer rights and safety criteria results.

specific policies around wages, hours, or leave for fisheries observers, although they could set minimum standards in their observer program schemes. Six RFMOs specifically outline the processes that need to be undertaken if an observer faces harassment or intimidation, while only four RFMOs mandate specific processes in the case of an observer disappearance or death.

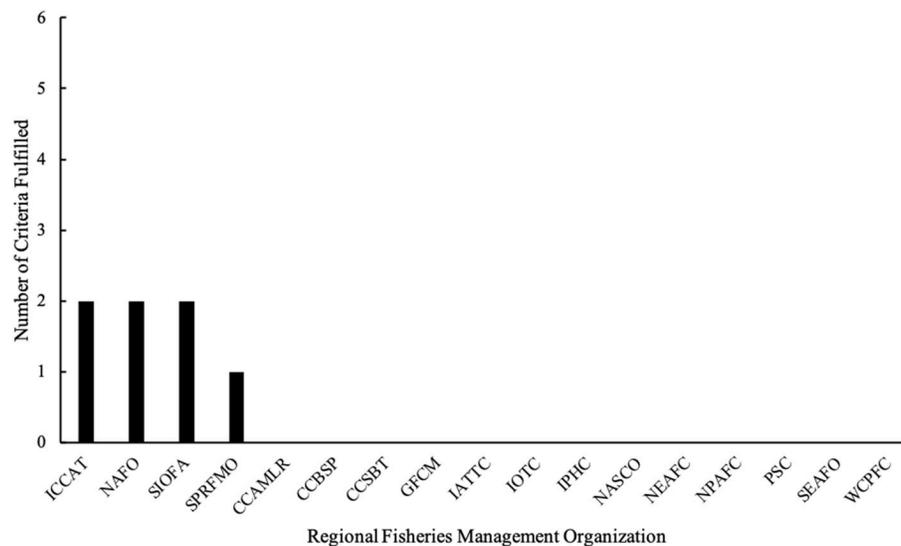
Three RFMOs have a regional level policy for the use and implementation of REM systems across contracting parties (Table 10 and Fig. 4). In four RFMOs, official policy states REM systems can be used to fulfill some of the compliance monitoring tasks of human observers, including in SPRFMO, which does not officially have a regional electronic monitoring policy but states that some contracting parties may have capabilities to use REM [44]. None of these RFMOs, however, currently have stipulations around penalties for disrupting REM coverage or a RFMO level process for reviewing REM footage. In addition, none of these RFMOs currently mandate that REM footage and data be publicly available for transparency and oversight. None of the RFMOs currently require REM systems to be used on all fishing vessels.

An analysis of trends in the observer summary reports of the WCPFC

from 2013 to 2017 shows that generally the number of observer reports of rights violations was on a downward trend from 2013 to 2017 (see Supplementary data for details of all observer reports over this period). Observer reports of intimidation or obstruction have fallen from 35 (5.5% of total trip reports) in 2013 to 18 (1.5% of total trip reports) in 2017 and observer reports of lacking living conditions have fallen from 31 (4.8% of reports) in 2013 to 2 (0.2% of reports) in 2017. Observer reports of vessel non-compliance with commission conservation and management measures (CCMs) were more sporadic, jumping from 64 (10% of reports) in 2013 up to 183 (14.8% of reports) in 2015 and back down to 77 (6.4% of reports) in 2017. The violations cited in the highest number of observer reports were logbook-recording violations, for example observers reported inaccurate recording of discarded “Target Species” 262 times (40.1% of reports) in 2013 and 236 times (19.7% of reports) in 2017, and inaccurate recording of discarded by-catch species 134 times (20.9% of reports) in 2013 and 251 times (21% of reports) in 2017. Observer reports of vessels disposing garbage in the ocean has also fallen from 281 reports (48.8% of reports) in 2013 and 402 reports (51.9% of reports) in 2014 to 110 reports (9.2% of reports) in 2017.

**Table 10**  
Remote electronic monitoring criteria question results.

RFMO	REM Policy?	Can electronic monitoring be used to replace human observer compliance monitoring policies?	Is there any penalty for disrupting REM coverage?	Is there a system in place to review REM footage?	Requirement that REM data and footage is publicly available?	100% REM?	Total
CCAMLR	0	0	0	0	0	0	0
CCBSP	0	0	0	0	0	0	0
CCSBT	0	0	0	0	0	0	0
GFCM	0	0	0	0	0	0	0
IATTC	0	0	0	0	0	0	0
ICCAT	1	1	0	0	0	0	2
IOTC	0	0	0	0	0	0	0
IPHC	0	0	0	0	0	0	0
NAFO	1	1	0	0	0	0	2
NASCO	0	0	0	0	0	0	0
NEAFC	0	0	0	0	0	0	0
NPAFC	0	0	0	0	0	0	0
PSC	0	0	0	0	0	0	0
SEAFO	0	0	0	0	0	0	0
SIOFA	1	1	0	0	0	0	2
SPRFMO	0	1	0	0	0	0	1
WCPFC	0	0	0	0	0	0	0



**Fig. 4.** Remote electronic monitoring criteria results.

#### 4. Discussion

The heterogeneity among RFMO rules about fisheries observers is notable and shows that improvements are necessary (Fig. 5). Only four RFMOs (CCAMLR, IATTC, SPRFMO, and WCPFC) currently mandate a specific process in the event that an observer disappears or dies. The Association for Professional Observers (APO) has identified several known observer deaths or disappearances that occurred under suspicious circumstances (Table 1). Many of the known observer disappearances occurred in RFMOs that have since mandated processes and reporting of disappearances, such as the WCPFC in 2017 and the IATTC in 2018 [62,63]. The APO states that the reported disappearances and deaths are likely only a small anecdotal subset of observer disappearances, many of which may go unreported [26], leaving an open question about observer disappearances in RFMOs that do not mandate reporting of observer injuries, deaths, or disappearances. All RFMOs are failing in some way to establish comprehensive observer programs or adequately ensure the safety of human observers. The WCPFC has taken some steps to address the safety of fisheries observers, and observer reports of obstruction and intimidation have fallen from 5.5% of reports in 2013 to 1.5% of reports in 2017. Without explanation, the WCPFC halted observer reports of crew mistreatment after 2015 [27].

To adequately address observer safety, RFMOs could start by integrating the International Observer Bill of Rights (IOBR) into official RFMO regulations. Crucially, beyond safety measures, the IOBR outlines the rights that observers should hold while working onboard fishing vessels [1]. Currently, none of the RFMOs have a uniform policy governing labor rights for observers, such as their wages, working hours, or right to work leave. The results of the observer rights and safety criteria questions outlined in this study are only a rudimentary review of the observer protections that can and should be mandated by RFMOs. To properly align with the IOBR, RFMOs need to ensure that all observers receive written contracts defining employment terms, ensure systems for fair and equitable employment and deployment of observers, ensure competitive wage packages commensurate with similar positions, include policies about break time between vessel assignments to afford observers proper rest and rejuvenation, and protect observer rights to regular mental and physical health check-ups [1]. To help prevent blackmailing and threats to force collusion with illegal activities, RFMOs also need to mandate that all observer pay, travel, and lodging benefits are independent of the vessel on which they are assigned to prevent captains from holding these benefits over observers' heads [1].

In addition, although eight RFMOs mandate that observers be guaranteed suitable living conditions, only the WCPFC has any

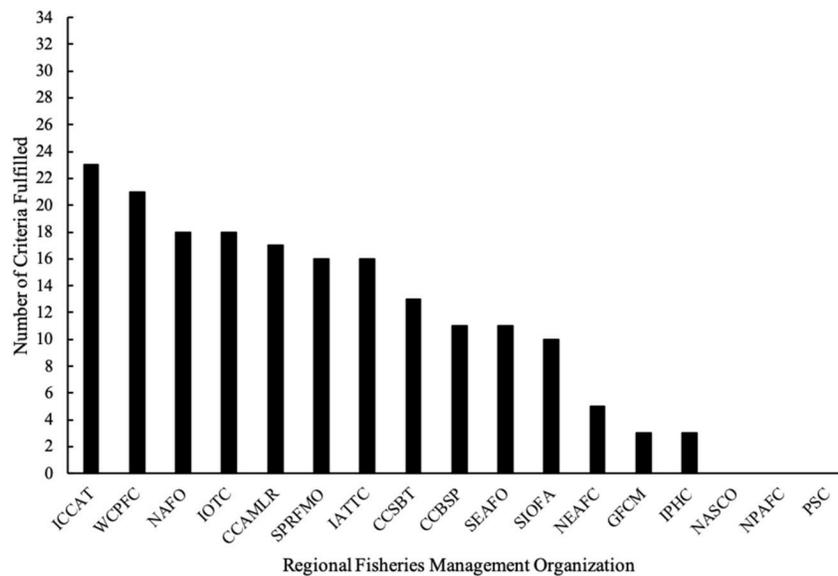


Fig. 5. RFMO performance on at-sea compliance monitoring and observer policies aggregated across all 34 questions in the four categories.

regulations governing the protection of human rights and the guarantee of adequate living conditions of crewmembers in general [61]. Human rights abuses, including cases of labor trafficking, onboard fishing vessels on the high seas are widely documented and have not received adequate legislative attention from RFMOs [5,21,64]. RFMOs are well placed to adopt measures to protect the rights and safety of fisheries observers and crewmembers. Such measures may require the amendment of RFMO conventions to include a broader mandate that specifically covers human rights protections at sea, but given the increasing human rights issues on the high seas, this is a necessary step to ensure that the rights of individuals working under RFMO governance schemes are protected.

The majority of RFMOs, but not all, include some form of regional observer program, in line with United Nations recommendations on effectively monitoring fisheries management programs [65,66]. However, three (NASCO, NPAFC, and PSC), which all focus on anadromous species fisheries, mainly salmon, do not have any form of regional policy related to observers or REM. Yet important infractions that might be caught by observers, including by-catch of unwanted fish and other species, illegal gear-use, unreported fishing, and plastic pollution have all been documented in salmon fisheries [18,67–70]. The anadromous fish RFMOs would be well placed to coordinate and harmonize observer or electronic monitoring policies across contracting parties to enhance fisheries management efforts and conservation compliance.

The 14 RFMOs that do have a regional observer program differ widely in the extent, breadth, and specificity of their policies, including around compliance monitoring and observer rights. Such a disparity in RFMO policies has been criticized for allowing illegal activity and overfishing to congregate in areas of the ocean with looser compliance monitoring and poorer governance [71]. International coordination and consistency of regional observer programs across RFMOs could prevent the exploitation of areas with weaker policies by illegal fishers, enhance the effectiveness, and reduce the costs of observer coverage by allowing for cross-endorsement of approved observers between RFMOs since observers could receive the same training on data and compliance monitoring requirements. This kind of cross-endorsement of observers through a memorandum of agreement is already occurring between some RFMOs, including the Inter-American Tropical Tuna Commission (IATTC) and the Western and Central Pacific Fisheries Commission (WCPFC) [72], and a stronger harmonization between RFMO observer policies would only improve such collaboration.

The required extent of observer coverage is another inconsistent

policy across RFMOs. Babcock et al., 2003 [73] found that to accurately estimate by-catch of common species, unbiased and proportionally distributed observer coverage would need to be in place in 20% of a fishery, and that coverage levels would need to be 50% for accurate estimates of rare species by-catch. However, randomized and statistically representative partial observer placement is highly unlikely to be present in any of the RFMOs without a 100% observer coverage requirement. Observers are most often placed on vessels that volunteer to have observers onboard and/or have the logistical capacity to house observers, and these vessels are not necessarily representative of the fishery or fishing effort as a whole [73,74]. In addition, vessels with observers onboard may be under an “observer effect”, where they change their behavior as the result of the observer [73,74]. In the face of global fisheries declines and the necessity of holistic fisheries data [12, 14], it would be prudent for all RFMOs to mandate 100% at-sea monitoring coverage for all fishing vessels using a combination of human observers and REM.

Beyond coverage levels, the observer programs of many RFMOs are lacking in key areas that could improve the effectiveness of observer programs as a whole. None of the RFMOs require that all observers be from a different flag state than the vessel on which they are assigned in all cases. Corruption at all levels of the seafood supply chain has been highlighted as an issue facing fisheries management [25,75–77], and RFMOs can develop international observer programs to help ensure impartiality on the part of the observers and combat corruption. CCAMLR includes an international observer scheme that seeks to train and assign observers from different flag states to fishing vessels in the convention area. However, it is not mandated for all fishing vessels in the CCAMLR convention area - some krill fisheries and vessels in EEZ waters are permitted to use national observers, and it has failed to be implemented in its entirety due to contracting party objections [78–80]. However, such international observer schemes can only be effective if they are complemented with strong observer rights protections, and observers do not fear threats or physical intimidation that may force them to falsify or misreport data and collude with illegal fishers [25].

None of the RFMOs make all observer reports and raw data publicly available, only four RFMOs make summaries of violations reported by observers publicly available, and only three at the regional level. Moreover, currently none of the RFMOs mandate that REM data be made completely publicly available for oversight and transparency. This lack of transparency across the observer programs of almost all RFMOs hampers accountability and the potential for analysis and investigation

into the effectiveness of observer programs, which could enhance RFMO fisheries sustainability goals. Currently raw data is only made available selectively to NGOs or regulators for implementation assessment or review [54], but in the face of increasing fisheries declines and reports of human rights abuses [5,12,14], this selective transparency is not sufficient to pressure RFMO member states to act. The member states of each RFMO create the legal mandates and measures that govern fisheries in the convention area, although often enforcement is dependent on the flag state – or the country of registry – of each fishing vessel [81]. Currently, reports of observer safety abuses in many RFMOs are only unofficially and anecdotally reported and limited to the worst instances, including disappearances and death [5,26]. We propose that full transparency of observer safety records would pressure RFMOs to follow up on safety concerns before observers are subject to serious dangers. Since fisheries observers only have, at most, a compliance monitoring mandate and cannot themselves enforce the RFMO mandated consequences of violations, data transparency is crucial to ensuring that RFMOs are pressuring flag states to follow up on observer compliance reports. The public release of all observer reports is likely to be controversial and to be met with significant resistance from some RFMO members. However, the current state of affairs is dangerous to both observer safety and the sustainable management of fisheries. Increased discussion of full public transparency needs to be an active point of debate at RFMO committee meetings.

The extent of the compliance reporting requirements of observers also differs between RFMOs, and many RFMOs are not utilizing observers to record compliance in important areas. A study showed that fisheries observers in Alaska with a mandate to record fisheries regulation violations at-sea were more effective at detecting violations than randomized at-sea inspections [2]. However, only four RFMOs: ICCAT, NAFO, SEAFO, and WCPFC, have observer programs where compliance monitoring is the primary mandate of the observer, rather than leaving contracting parties to decide whether to use observer reports for compliance purposes. The WCPFC observer reports on vessel compliance with conservation, fisheries management, and reporting measures indicate that an observer mandate to report wide ranging compliance violations could help deter illegal activity. Since the broadening of the observer-reporting mandate to its current form in 2013, WCPFC observer reports show decreases in inaccurate logbook recordings, fishing effort in non-permitted areas, and fishing with non-licensed gear, among other violation decreases. However, since the WCPFC only mandates 5% observer coverage for some fishing vessels, and given the potential for unrepresentative sampling at any observer coverage level below 100%, it is uncertain whether these data accurately reflect fishing vessel activity and compliance in the WCPFC convention area. It is possible that these declines are the result of the “observer effect.” The WCPFC would need to increase its at-sea monitoring coverage levels, ideally to 100% coverage for longline vessels and non-purse seine vessels, to accurately determine compliance with conservation and management measures within its convention area. In addition, the WCPFC needs to ensure that observers can accurately and confidently report violations without fear of intimidation and violence. Nonetheless, adapting the broad mandate of observer compliance reporting in the WCPFC across all RFMOs could help ensure the collection of critical data for monitoring the effectiveness of conservation measures and more effective follow-up on such reports.

Only four RFMOs mandate that observers report compliance with waste and pollution policies, despite the increasingly serious risks to marine life and fish populations from ocean plastics and debris [18,82]. Discarded fishing nets and gear make up a large percentage of ocean plastics, including a large portion of the Great Pacific Garbage Patch [82], and observers are well placed to monitor fishing net discards onboard vessels. Between 2013 and 2017 observer reports in the WCPFC of waste disposal, including fishing nets, fell from 48.8% of reports in 2013 to 9.2% of reports in 2017 on vessels monitored by observers, indicating a potential for reducing waste disposal on observer-monitored vessels.

Only five RFMOs mandate that observers record sightings of unauthorized vessels in convention areas. Illegal, unreported and unregulated (IUU) fishing is preventing effective fisheries management efforts and stripping the ocean of fish, with losses estimated up to \$23.5 billion annually [75,83]. Observers that are already onboard fishing vessels can help to record and track sightings of unauthorized vessels at no extra cost to the RFMO.

RFMOs have also not effectively implemented REM systems – only three RFMOs have a regional policy on the use of REM. RFMOs are uniquely positioned to mandate and help ensure consistent, effective, independent, and transparent use of REM systems to improve fisheries management, marine conservation, and crew conditions in high seas and EEZ border areas across contracting parties. While human observer reporting is an important tool in fisheries management and compliance reporting, there are some key shortcomings in relying solely on human observers. In addition to the previously mentioned issue of physical intimidation and threats forcing observers to misreport data and falsify documents [75,77], some observers are prone to human error and studies have shown that observers sometimes inadvertently misidentify landed species, discards, and by-catch [84–86]. Moreover, the cost of 100% human observer coverage is often cited as a hindrance to comprehensive at-sea monitoring [73,74], and onboard vessels that do have human observers, the risk to the safety of the observer is believed to increase as their compliance monitoring mandate becomes stronger [75,77]. Given, the difficulty in implementing a truly representative at-sea monitoring program at below than 100% coverage and the decreasing costs of electronic observation, RFMOs could benefit from mandating REM as a complementary tool with human observers to achieve 100% at-sea compliance monitoring [24,28,35]. This will require strong, well-tested minimum standards, and provisions to ensure the compliance regime evolves to adapt to the introduction of REM. Most importantly, the adoption of REM systems must be accompanied with a strong mandate for transparency and public oversight. REM systems are promising tools for better fisheries management and marine animal exploitation, but cannot be viewed as a quick or easy solution to the complicated issue of improving fisheries oversight. REM footage and data cannot be exclusively owned by fishing industries or become a tool for industry self-monitoring. Removing human observers from fishing vessels, often the only third-party witness to activities that occur in far-reaching areas of the high seas, and replacing them with industry-controlled and potentially algorithm-driven electronic monitoring systems would be harmful and counterproductive to sustainability and conservation goals if RFMOs do not mandate strict REM regulations [35].

In sum, it is important we all know and understand what is happening on the high seas, a collective commons, where fishing, as well as human rights abuses (including human trafficking), by-catch of marine life, illegal fishing, and the discarding of fishing gear occurs. At-sea compliance monitoring and observer programs differ widely across RFMOs and are overall insufficient. International harmonization of at-sea monitoring policies across RFMOs, with 100% coverage achieved through a complementary approach of remote electronic monitoring and human observers, would help ensure the safety and rights of human observers and lead to stronger environmental and animal protection on the high seas.

#### Declaration of competing interest

All of the authors declare no conflict of interest.

#### CRediT authorship contribution statement

**Christopher Ewell:** Conceptualization, Methodology, Writing - original draft, Writing - review & editing. **John Hocevar:** Conceptualization, Resources, Writing - review & editing. **Elizabeth Mitchell:** Conceptualization, Resources, Writing - review & editing. **Samantha**

**Snowden:** Conceptualization, Writing - review & editing. **Jennifer Jacquet:** Conceptualization, Methodology, Writing - review & editing, Supervision, Funding acquisition.

## Acknowledgments

We wish to thank the Pew Marine Conservation Fellowship to J.J. in 2016 that supported J.J. and C.E. The authors also thank two anonymous reviewers, as well as James Gibbon, Chris Jones, Sebastian Losada, Andy Shen, Robin Teets, and members of the Association for Professional Observers for their helpful comments on the manuscript.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.marpol.2020.103842>.

## References

- Association for Professional Observers, International observer Bill of rights and codes of conduct for responsible observer programmes. <http://www.apo-observers.org/billofrights>. (Accessed 23 July 2019).
- R.D. Porter, Fisheries observers as enforcement assets: lessons from the north pacific, *Mar. Pol.* 34 (3) (2010) 583–589.
- E. Gilman, K. Passfield, K. Nakamura, Performance assessment of by-catch and discards governance by regional fisheries management organizations, IUCN, Gland, Switzerland (2012).
- T. Knudson. "He was supposed to protect the sea. Then he vanished from his ship." Reveal. February 15, 2017.
- Human Rights at Sea. "Investigate report and case study: fisheries abuses and related deaths at sea in the pacific region." December 1, 2017.
- D.A. Kroodsma, J. Mayorga, T. Hochberg, N.A. Miller, K. Boerder, F. Ferretti, A. Wilson, et al., Tracking the global footprint of fisheries, *Science* 359 (6378) (2018) 904–908.
- W. Swartz, E. Sala, S. Tracey, R. Watson, D. Pauly, The spatial expansion and ecological footprint of fisheries (1950 to present), *PLoS One* 5 (2010) 12, e15143.
- D. Tickler, J.J. Meeuwig, M.L. Palomares, D. Pauly, D. Zeller, Far from home: distance patterns of global fishing fleets, *Science Advances* 4 (8) (2018) eaar3279.
- E. Sala, J. Mayorga, C. Costello, D. Kroodsma, M.L. Palomares, D. Pauly, U. R. Sumaila, D. Zeller, The economics of fishing the high seas, *Science Advances* 4 (6) (2018) eaat2504.
- J.J. Maguire, The state of the world highly migratory, straddling and other high seas fishery resources and associated species, *FAO Fish. Tech. Pap.* 495 (2006). Food & Agriculture Org.
- U.R. Sumaila, V.W.Y. Lam, D.D. Miller, L. Teh, R.A. Watson, D. Zeller, W.W. L. Cheung, et al., Winners and losers in a world where the high seas is closed to fishing, *Sci. Rep.* 5 (2015) 8481.
- D. Pauly, Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts, Island Press, 2016.
- S. Cullis-Suzuki, D. Pauly, Failing the high seas: a global evaluation of regional fisheries management organizations, *Mar. Pol.* 34 (5) (2010) 1036–1042.
- D. Pauly, D. Zeller, Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining, *Nat. Commun.* 7 (2016) 10244.
- D. Zeller, T. Cashion, M.L. Palomares, D. Pauly, Global marine fisheries discards: a synthesis of reconstructed data, *Fish. Fish.* 19 (1) (2018) 30–39.
- S. Oliver, M. Braccini, S.J. Newman, E.S. Harvey, Global patterns in the by-catch of sharks and rays, *Mar. Pol.* 54 (2015) 86–97.
- K. Willsher, Mutilated dolphins wash up on French coast in record numbers, *The Guardian*, March 31, 2019.
- N.J. Beaumont, M. Aanesen, M.C. Austen, T. Börger, J.R. Clark, M. Cole, T. Hooper, P.K. Lindeque, C. Pascoe, K.J. Wyles, Global ecological, social and economic impacts of marine plastic, *Mar. Pollut. Bull.* 142 (2019) 189–195.
- United Nations, Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. 1542 A/CONF.164/37, 34 International Legal Materials 1542, United Nations, New York, 1995.
- D.C. Dunn, C. Jablonicky, G.O. Crespo, D.J. McCauley, D.A. Kroodsma, K. Boerder, K.M. Gjerde, P.N. Halpin, Empowering high seas governance with satellite vessel tracking data, *Fish. Fish.* 19 (4) (2018) 729–739.
- C. Ewell, S. Cullis-Suzuki, M. Ediger, J. Hocesvar, D. Miller, J. Jacquet, Potential ecological and social benefits of a moratorium on transshipment on the high seas, *Mar. Pol.* 81 (2017) 293–300.
- J. Jacquet, E. Blood-Patterson, C. Brooks, D. Ainley, 'Rational use' in Antarctic waters, *Mar. Pol.* 63 (2016) 28–34.
- SPRFMO, COMM-4-INF-04: Observer Programmes of RFMOs. 4th Meeting of the Commission. Valdivia, Chile, Secretariat of the South Pacific Regional Fisheries Management Organization, January, 2016.
- M. Michelin, M. Elliott, M. Buchner, M. Zimring, M. Sweeney, Catalyzing the Growth of Electronic Monitoring in Fisheries, California Environmental Associates and the Nature Conservancy, San Francisco, CA, 2018.
- WCPFC, Observers and Corruption, *West. Cent. Pac. Fish. Comm. WCPFC-TCC10-2014-14*, September 12, 2014.
- Association for Professional Observers. "Catalogue of Observer Casualties, Injuries, and Near Misses." Association for Professional Observers. May 15, 2018. Retrieved from: <http://www.apo-observers.org/misses>.
- WCPFC, 10th annual report for the regional observer programme, *West. Cent. Pac. Fish. Comm. WCPFC15-2018-IP10*, September 2, 2018.
- WWF, Remote electronic monitoring, in: *SeaScope Fisheries Research, Worldwide Fund for Nature*, September, 2017.
- J. Ruiz, A. Batty, P. Chavance, H. McDerry, V. Restrepo, P. Sharples, J. Santos, A. Urtizberea, Electronic monitoring trials on in the tropical tuna purse-seine fishery, *ICES (Int. Coun. Explor. Sea) J. Mar. Sci.* 72 (4) (2014) 1201–1213.
- R. Evans, B. Molony, Pilot Evaluation of the Efficacy of Electronic Monitoring on a Demersal Gillnet Vessel as an Alternative to Human Observers, Perth, Australia, Fisheries Research Division, Western Australian Fisheries and Marine Research Laboratories, 2011.
- D.C. Bartholomew, J.C. Mangel, J. Alfaro-Shigueto, S. Pingo, A. Jimenez, B. J. Godley, Remote electronic monitoring as a potential alternative to on-board observers in small-scale fisheries, *Biol. Conserv.* 219 (2018) 35–45.
- K.S. Plet-Hansen, S.Q. Eliassen, L.O. Mortensen, H. Bergsson, H.J. Olesen, C. Ulrich, Remote electronic monitoring and the landing obligation—some insights into Fishers' and fishery inspectors' opinions, *Mar. Pol.* 76 (2017) 98–106.
- J.P. Monteagudo, G. Legorburu, A. Justel-Rubio, V. Restrepo, Preliminary study about the suitability of an electronic monitoring system to record scientific and other information from the tropical tuna purse seine fishery, *Collect. Vol. Sci. Pap. ICCAT* 71 (1) (2015) 440–459.
- Association for Professional Observers, Implications and trends of electronic monitoring, Available at: <http://www.apo-observers.org/electronicMonitoring>. (Accessed 23 July 2019).
- The Pew Charitable Trusts, *Electronic Monitoring: A Key Tool for Global Fisheries*, September 2019.
- Fish Wise, *Policies and Recommendations to Improve the Safety of Fisheries Observers Deployed in Tuna Fisheries*, June, 2018.
- D. Eaton. "NOAA law enforcement researches sexual harassment, assault among fisheries observers." Alaska Public Media. June 12, 2018.
- IOTC. "Summary report on possible infractions observed under the regional observer programme." Indian Ocean Tuna Comm.. IOTC-2019-CoC16-08b. May 16, 2019.
- ICCAT, "ICCAT regional observer programme for at-sea transshipments." International Commission for the Conservation of Atlantic Tunas, Available at: [http://www.iccat.int/Documents/Comply/transshipmentreports\\_current.pdf](http://www.iccat.int/Documents/Comply/transshipmentreports_current.pdf). (Accessed 23 July 2019).
- IATTC, "IATTC and Inter-American Tropical Tuna Commission – informational reports (INF)." Inter-Atlantic Tropical Tuna Commission, Available at: <http://www.iattc.org/InformationalReportsENG.htm>. (Accessed 23 July 2019).
- T. Itoh, T. Yuichi, I. Yukiko, Y. Semba, K. Oshima. "Report of Japanese scientific observer activities for southern bluefin tuna fishery in 2016." *Comm. Conserv. South. Bluefin Tuna. CCSBT-ESC/1708/19*.
- L. Sadiyah, Z. Fahmi, B. Setyadi, P.A.R.P. Tampubolon, F. Satria. "Indonesian scientific observer program activities for Indian ocean in 2015 and 2016." *Comm. Conserv. South. Bluefin Tuna. CCSBT-ESC/1708/Info 04*.
- GFCM. "Recommendation by ICCAT establishing a programme for transhipment by large-scale longline fishing vessels." *Gen. Fish. Comm. Mediterr.. GFCM/2006/08*.
- SPRFMO. "Conservation and management measure establishing the SPRFMO observer programme." *South Pac. Reg. Fish. Manag. Org.. CMM 16-2019*.
- CCBSP, Convention on the conservation and management of pollock resources in the central bering sea, in Washington D.C. Available at: <https://www.afsc.noaa.gov/REFM/CBS/Docs/Convention%20on%20Conservation%20of%20Pollock%20in%20Central%20Bering%20Sea.pdf>. (Accessed 16 June 1994).
- NAFO. "Chapter V: observer scheme." conservation and enforcement measures 2019. Northwest Atl. Fish. Organ.. NAFO/COM Doc. 19–01.
- SEAFO. "System of observation, inspection, compliance and enforcement (2018)." *South East Atl. Fish. Org.. December 5, 2018*.
- CCAMLR, General measure for scientific observation in fisheries for euphasia superba, *Comm. Cons. Atl. Mar. Liv. Res. Conserv. Meas.* 51–6 (2016).
- IOTC. "Resolution 11/04: on a regional observer scheme." *Comp. Act. Conserv. Manag. Meas. Indian Ocean Tuna Comm.. December 1, 2017*.
- ICCAT, Recommendation by ICCAT establishing a multi-annual management plan for bluefin tuna in the eastern atlantic and the mediterranean sea [rec. 18-02], *Int. Comm. Conserv. Atl. Tunas* (2018).
- ICCAT, Recommendation by ICCAT replacing the recommendation [13-04] and establishing a multi-annual recovery plan for mediterranean swordfish [rec. 16-05], *Int. Comm. Conserv. Atl. Tunas* (2016).
- ICCAT, Fifth draft proposal for a recommendation by ICCAT to replace recommendation 16-01 By ICCAT on multi-annual conservation and management programme for tropical tunas, *Int. Comm. Conserv. Atl. Tunas* (November 2019).
- IATTC, Resolution on scientific observers for longline vessels, *Int. Am. Trop. Tuna Comm. (July, 2011). Resolution C-11-08*.
- WCPFC, "Implementation Programme for the Regional Observer Programme." Annex C. Conservation and Management Measure for the Regional Observer Programme, Western and Central Pacific Fisheries Commission, December 2018. *Conserv. Manag. Meas.* 2018-05.

- [55] The Pew Charitable Trusts, A Review of Longline Observer Coverage Reporting within the Inter-American Tropical Tuna Commission, July 2019.
- [56] SIOFA, "Conservation and Management Measure for the Interim Management of Bottom Fishing in the Agreement Area (Interim Management of Bottom Fishing)." Scientific Observer Coverage: No. 31, 32. Conservation and Management Measures, Southern Indian Ocean Fisheries Agreement, 2018.
- [57] IATTC, "Resolution to support the on-board observer program and establish a working Group to develop captain incentives." Agreement on the International Dolphin Conservation Program, Int. Am. Trop. Tuna Comm. (11 October 1999).
- [58] IOTC, "Resolution 14/06: on establishing a programme for transshipment by large-scale fishing vessels", Indian Ocean Tuna Comm. (October 8, 2014).
- [59] K. Boerder, N.A. Miller, B. Worm, Global hot spots of transshipment of fish catch at sea, *Science Advances* 4 (7) (2018) eaat7159.
- [60] ICCAT. "ICCAT scheme of joint international inspection." annex 7. Recommendation by ICCAT establishing a multi-annual management plan for bluefin tuna in the eastern atlantic and mediterranean sea. 18-02. Int. Comm. Conserv. Atl. Tunas.
- [61] WCPFC, Resolution on Labour Standards for Crew on Fishing Vessels, Western and Central Pacific Fisheries Commission, December 2018. Resolution 2018-01.
- [62] WCPFC, "Conservation and Management Measure for the Protection of WCPFC Regional Observer Programme Observers.", Western and Central Pacific Fisheries Commission, December 2017. Conserv. Manag. Meas. 2017-03.
- [63] IATTC, Resolution on Improving Observer Safety at Sea: Emergency Action Plan, Inter-American Tropical Tuna Commission, August 2018, 18-07.
- [64] B.D. Ratner, B. Åsgård, E.H. Allison, Fishing for justice: human rights, development, and fisheries sector reform, *Global Environ. Change* 27 (2014) 120–130.
- [65] United Nations General Assembly. 63/112. Sustainable fisheries, including through the 1995 agreement for the implementation of the provisions of the united Nations convention on the law of the sea of 10 december 1982 relating to the conservation and management of straddling fish stocks and highly migratory fish stocks, and related instruments. Resolut. Adopt. December 5, 2008.
- [66] United Nations General Assembly. 71/123. Sustainable fisheries, including through the 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and related instruments. Resolution adopted December 7, 2016.
- [67] S.A. Otto, S. Simons, J.S. Stoll, P. Lawson, Making progress on by-catch avoidance in the ocean salmon fishery using a transdisciplinary approach, *ICES (Int. Council. Explor. Sea) J. Mar. Sci.* 73 (9) (2016) 2380–2394.
- [68] G.D. Raby, A.H. Colotelo, G. Blouin-Demers, S.J. Cooke, Freshwater commercial by-catch: an understated conservation problem, *Bioscience* 61 (4) (2011) 271–280.
- [69] E.F.C. Melvin, Seabird by-catch: trends, roadblocks, and solutions. Proceedings of the Symposium vol. 1999, 1999. Blaine, Washington, February 26-27. 206.
- [70] G. Pramod, K. Nakamura, T.J. Pitcher, L. Delagran, Estimates of illegal and unreported fish in seafood imports to the USA, *Mar. Pol.* 48 (2014) 102–113.
- [71] J.S. Barkin, E.R. DeSombre, Do we need a global fisheries management organization? *J. Environ. Soc. Sci.* 3 (2) (2013) 232–242.
- [72] IATTC, Document IATTC-81-10a REV. Cooperation with WCPFC observer program, Inter-American Tropical Tuna Commission, Antigua, Guatemala, 1 October, 2010.
- [73] E. Babcock, E. Pikitch, C. Hudson, How much observer coverage is enough to adequately estimate by-catch? *Pew Ins. Ocean Sci.* (2003).
- [74] M.A. Hall, Estimating the ecological impacts of fisheries: what data are needed to estimate by-catches. Proceedings of the International Conference on Integrated Fisheries Monitoring, 1999, pp. 175–184.
- [75] M.L. Stiles, A. Kagan, E. Shaftel, B. Lowell, Stolen seafood: the impact of pirate fishing on our oceans, *Ocean* (2013) 1–25.
- [76] J. Putt, K.M. Anderson, A National Study of Crime in the Australian Fishing Industry, vol. 21, Australian Institute of Criminology, 2007.
- [77] U.R. Sumaila, J. Jacquet, A. Witter, When bad gets worse: corruption and fisheries, in: *Corruption, Natural Resources and Development: from Resource Curse to Political Ecology*, vol. 93, 2017.
- [78] CCAMLR. "Review of the CCAMLR scheme of international scientific observation". SC-CAMLR-XXXII/07 rev. 1. CCAMLR SISO Review Panel. 19 September 2013.
- [79] CCAMLR, Convener's Report of the Workshop on the CCAMLR Scheme of International Scientific Observation (WS-SISO), SC-CAMLR-XXXVI/08, 31 August 2017.
- [80] CCAMLR. "Implementation Consideration for the CCAMLR Observation Training Program Accreditation Scheme". SC-CAMLR-XXX/8. 9 September 2011.
- [81] J. Swan, Fishing Vessels operating under open registers and the exercise of flag State responsibilities. Information and Options, FAO Fisheries Circular. No. 980 FAO, Rome, 2002.
- [82] L. Lebreton, B. Slat, F. Ferrari, B. Sainte-Rose, J. Aitken, R. Marthouse, S. Hajbane, et al., Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic, *Sci. Rep.* 8 (1) (2018) 4666.
- [83] D.J. Agnew, J. Pearce, G. Pramod, T. Peatman, R. Watson, J.R. Beddington, T. J. Pitcher, Estimating the worldwide extent of illegal fishing, *PLoS One* 4 (2) (2009), e4570.
- [84] S.M. Williams, J.G. Pepperell, M. Bennett, J.R. Ovenden, Misidentification of istiophorid billfishes by fisheries observers raises uncertainty over stock status, *J. Fish. Biol.* 93 (2) (2018) 415–419.
- [85] H.P. Benoît, J. Allard, Can the data from at-sea observer surveys be used to make general inferences about catch composition and discards? *Can. J. Fish. Aquat. Sci.* 66 (12) (2009) 2025–2039.
- [86] C.H. Faunce, J. Cahalan, J. Bonney, R. Swanson, Can observer sampling validate industry catch reports from trawl fisheries? *Fish. Res.* 172 (2015) 34–43.