PRELIMINARY EVALUATION OF IOTC FORM 3DA IMPLEMENTATION AND PROPOSED IMPROVED DATAFLOW

Author: IOTC Secretariat

Abstract

This paper presents an initial assessment of Form 3DA submissions under the IOTC Drifting Fish Aggregating Device (DFAD) reporting framework. The analysis focuses on reporting coverage, data completeness, internal consistency, and the extent to which submitted information can support the monitoring and management of DFAD activities in the Indian Ocean purse seine fishery. Rather than providing a general overview of the fishery itself, the paper evaluates the reporting system as an operational monitoring tool: what was submitted, how usable the data are, what patterns can already be described, and what practical improvements could strengthen future reporting.

The assessment covered submissions from eight CPCs, representing 44 purse seine vessels and 10 supply vessels, comprising 86,261 reported records. The submission of one additional CPC could not be included in the validation and analysis, as the required reporting format was not used. Reported activities included 8,797 fishing events, of which 8,147 contained associated catch information. Reported catches were dominated by skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), and bigeye tuna (*Thunnus obesus*), with additional reporting of associated and dependent species.

Initial assessment indicates that Form 3DA already provides a substantial volume of operational information with clear potential to support DFAD monitoring and management. However, recurring reporting issues were identified, including missing mandatory information, invalid controlled vocabulary entries, and incorrectly formatted fields, which reduced analytical usability and limited interpretation in some areas.

The findings suggest that relatively practical improvements could substantially increase the value of future submissions, including clearer reporting guidance, refinement of controlled vocabularies and field definitions, automated pre-submission validation, and targeted adjustments to the reporting form to reduce ambiguity and improve analytical usability.

Background

The increasing use of Drifting Fish Aggregating Devices (DFADs) has raised a range of management concerns, including the concentration of fishing effort, juvenile tuna mortality, bycatch of associated and dependent species, abandoned or lost fishing gear, marine debris, and the ecological implications of increasingly sophisticated DFAD technologies.

In response to these concerns, the IOTC Working Group on FADs was established to assess the consequences of increasing DFAD use and technological development, and to inform future management measures (Resolution 15/09). Its mandate includes compiling information on DFAD and buoy numbers, reviewing data collection requirements, assessing ecological and fishery impacts, considering technological developments, and identifying management options.

Resolutions 19/02 and 24/02 translated several of these information needs into mandatory reporting requirements for DFAD-related activities. CPCs are required to ensure that purse seine and associated supply vessels record activities involving floating objects and/or instrumented buoys, from deployment through end of use, using the reporting template provided by the Secretariat.

Form 3DA therefore serves as an operational monitoring tool rather than merely an administrative reporting mechanism mechanism (see details in IOTC-2023-WPDCS19-14). The template is available for download on the IOTC reporting form webpage, together with a description of its fields: https://data.iotc.org/reference/latest/forms/#Form_3DA.

This paper presents an initial assessment of Form 3DA implementation and addresses four practical questions: what was submitted, to what extent do the submitted data meet validation requirements, what initial patterns emerge from the usable data, and what practical improvements could strengthen future reporting.

Submitted Data Overview

Reporting Scope and Participation

This analysis covers Form 3DA submissions for the 2024 reporting period. Reporting obligations apply to CPC purse seine and associated supply vessels operating with DFADs in the IOTC Area of Competence.

The assessment included submissions from nine CPCs (with one submission omitted), representing 44 purse seine vessels and 10 supply vessels, comprising a total of 86,261 reported records. One additional submission could not be included in the validation and analysis, as the required reporting format was not used.

The submitted records included 8,797 reported fishing events, of which 8,147 contained associated catch information.

Table 1: Dataset overview and comparison of catch values with IOTB data.

Metric	Value
Reporting period	2024
CPCs reported	9
Purse seine vessels	44
Supply vessels	10
Submitted records	83,875
Number of catch events	8,499
Total catch of SKJ (t) (3DA)	144,185.4
Total catch of YFT (t) (3DA)	59,352.5
Total catch of BET (t) (3DA)	12,272.3
Total catch of all species (t) (3DA)	219,145.2
Reported catch of SKJ (t) (IOTDB)	174,257
Reported catch of YFT (t) (IOTDB)	74,569
Reported catch of BET (t) (IOTDB)	19,263
Reported catch of all species (t) (IOTDB)	268,090

Catch overview

Reported DFAD-associated catches were recorded throughout the reporting year, with clear temporal variation in reported volumes. Higher reported catches were observed during the first and fourth quarters, while lower volumes were reported during the middle of the year (**Fig. 1**).

Reported catches were dominated by skipjack tuna (*Katsuwonus pelamis*), followed by yellowfin tuna (*Thunnus albacares*) and, to a lesser extent, bigeye tuna (*Thunnus obesus*). Other reported species contributed comparatively smaller volumes. Records reported in numbers rather than weight were excluded from these summaries as incorporating them was not appropriate, due to a lack of conversion factors.

These summaries provide an initial descriptive overview of the catch information currently available through Form 3DA reporting, while acknowledging that interpretation remains dependent on reporting completeness and consistency.

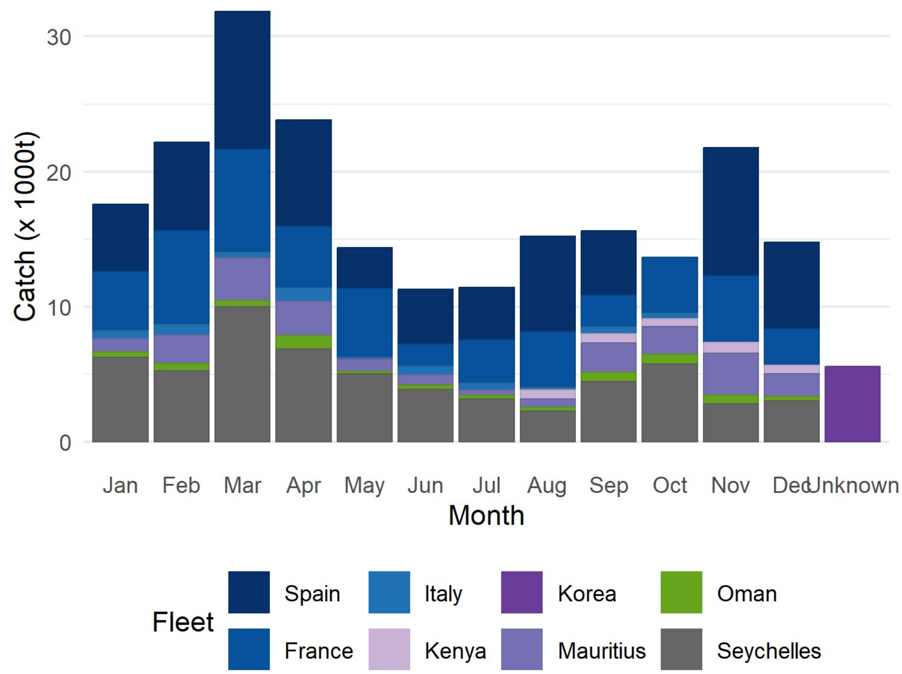

Fig. 1. Monthly reported DFAD-associated catch composition by fleet for 2024. Records reported in numbers were excluded, and raised and non-raised catches were aggregated.

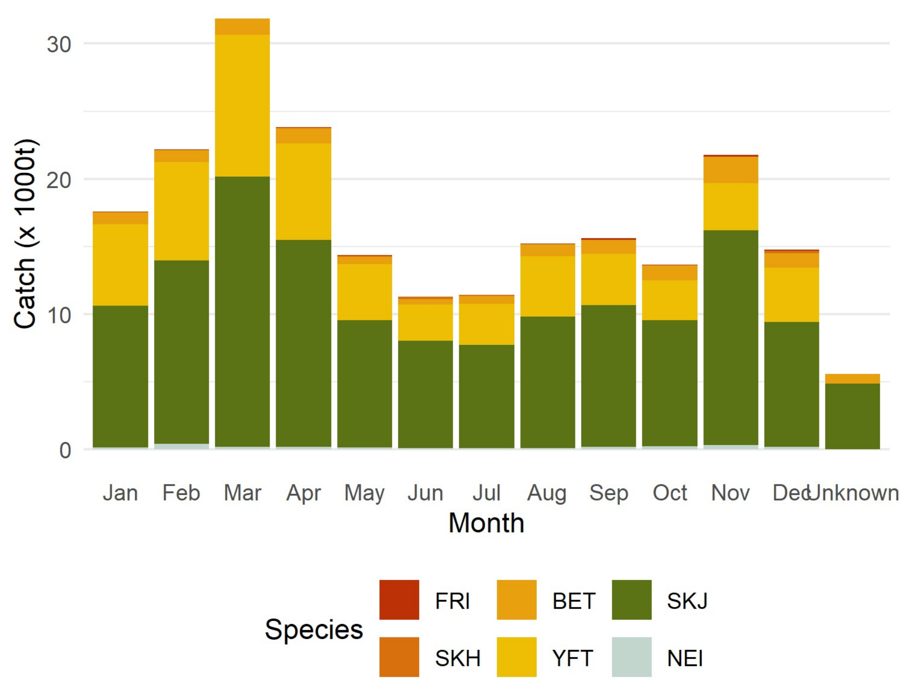

Fig. 2. Monthly reported catch composition for the five species with the highest reported catch volumes. Records reported in numbers were excluded, and catches from raised and non-raised sets were aggregated.

Submission composition

Submitted records were summarised by reported activity type to provide a high-level overview of the operational profile captured by Form 3DA reporting.

Form 3DA supports reporting of a range of DFAD-related operational activities involving both floating objects and associated instrumented buoys. Across the submitted records, activity reporting was dominated by fishing-associated visits and deployment events, with retrievals also representing a substantial proportion of reported activity (**Figs. 3-4**). Losses, transfers, strandings, and other less frequent operational events were reported in smaller numbers.

Differences between floating object and buoy activity summaries reflect the distinct operational roles captured by the reporting framework and provide useful initial insight into how the form is currently being used in practice

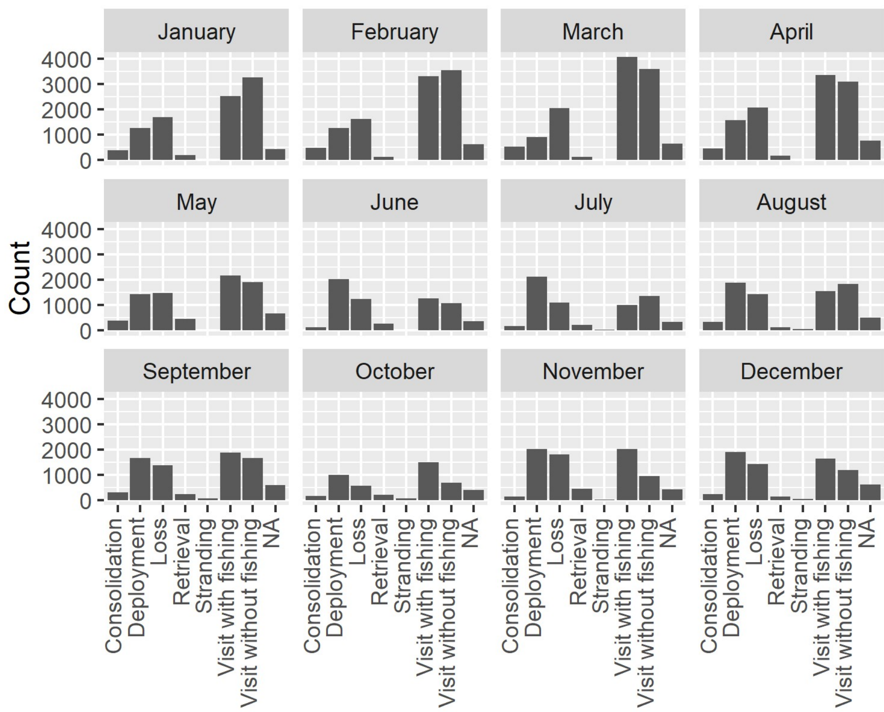

Fig. 3. Monthly distribution of submitted Form 3DA records by activities on DFADs for 2024.

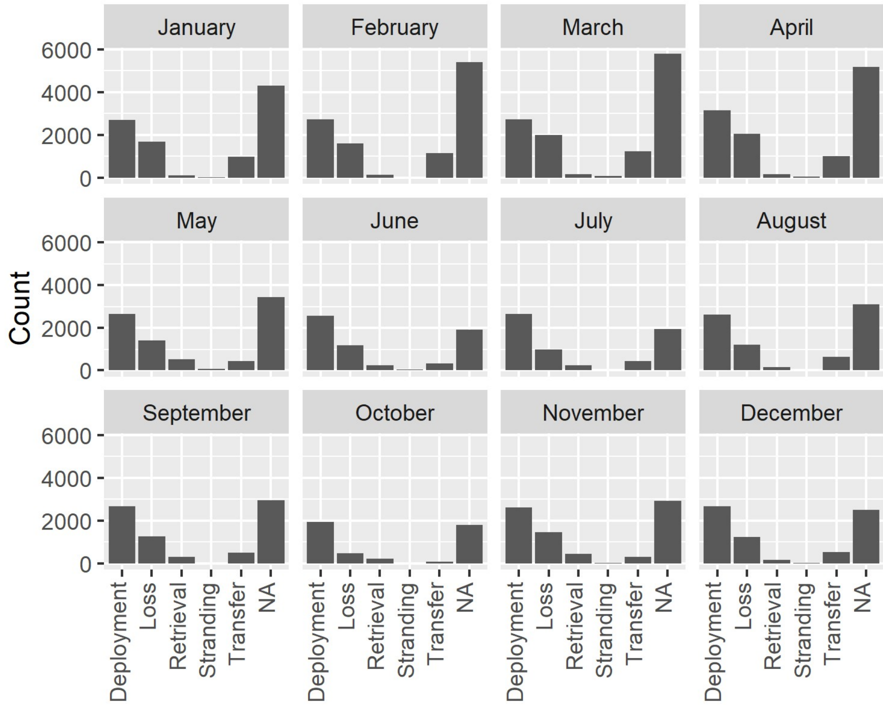

Fig. 4. Monthly distribution of submitted Form 3DA records by activities on buoys for 2024.

Overview of Submitted Data Quality

Validation framework

Submitted data were processed through an automated rule-based validation framework prior to analysis with the `R` package `vrule`. The objective of the validation process was to assess whether submitted records were structurally valid, internally consistent, and suitable for descriptive analysis.

The validation framework was implemented using a modular rule-based architecture in which expected field structures, mandatory requirements, and validation logic were defined in an external JavaScript Object Notation (JSON) specification rather than being hard-coded within the analytical workflow. This design improves transparency, reproducibility, and maintainability, while allowing validation logic to be adapted as reporting requirements evolve.

For each field, the JSON specification defines expected properties such as field name, whether the field is mandatory, whether it forms part of the structural event definition, and the validation rules to be applied. An illustrative example of a field-level validation rule is shown in **Figure 5**.

In the example shown, the latitude field is defined as a mandatory structural field and validated using a coordinate-specific rule. Similar rule definitions were used to implement checks against controlled vocabularies, logical field validation, reference data comparisons, numeric range constraints, and consistency checks between related variables.

Validation included checks for mandatory fields, expected data formats, controlled vocabulary compliance, coordinate validity, duplicate records, plausible numerical values, and logical consistency between related fields. Examples of logical consistency checks included verifying that buoy identifiers were only reported where a buoy was present, mesh dimensions were only reported where mesh presence was indicated, and structural measurements were consistent with reported DFAD configurations.

Validation coverage reflected both technical feasibility and the current maturity of reporting specifications. Fields for which controlled vocabularies, acceptable formats, or business rules remain under discussion were intentionally excluded from full automated validation at this stage. This avoids imposing arbitrary assumptions where reporting definitions are still evolving, while maintaining transparency regarding the current scope of validation.

This rule-based design provides a transparent and extensible validation framework for current and future reporting cycles, while ensuring that the analytical workflow remains reproducible and adaptable as reporting requirements develop.

```json
{
  "name": "latitude",
  "required": true,
  "dimension": true,
  "rules": [
    {
      "vrule": "coordinates",
      "args": {
        "coordinate_type": "latitude"
      }
    }
  ]
}
```

Fig. 5. Illustrative example of a JSON-defined field validation rule used in the automated Form 3DA validation framework. External rule definitions support transparency, reproducibility, and adaptation as reporting specifications evolve.

Completeness

Completeness was assessed for variables central to the reporting objectives of Form 3DA. These included event metadata, floating object identifiers, reported activity types, DFAD characteristics, biodegradability-related descriptors, buoy information, structural design fields, and catch reporting variables.

Particular attention was given to fields required for management interpretation, including identifiers necessary for tracking DFAD lifecycles, descriptors relevant to structural compliance, and catch reporting fields required to interpret fishing interactions.

Missing or inconsistently completed fields reduce the ability to reconstruct DFAD trajectories, assess compliance with design-related measures, and interpret operational or ecological patterns from the reported data.

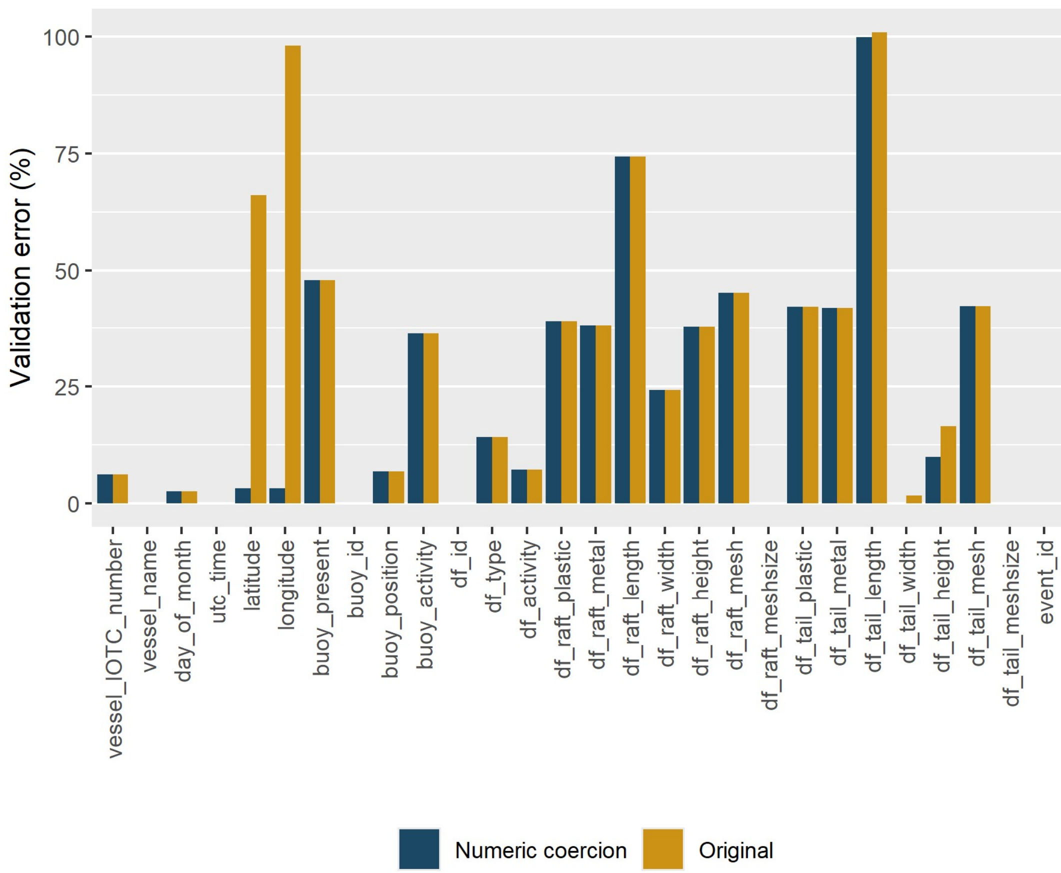

Fig. 6. Field-level validation error rates before and after numeric coercion.

Common reporting issues

Validation identified recurring issues affecting the analytical usability of the submitted data.

The most common problems included missing mandatory information, invalid controlled vocabulary entries, incorrectly formatted fields, and logical inconsistencies between related variables. Additional recurring issues included contradictory buoy reporting states, identifiers reported in incompatible contexts, structural measurements recorded as zero or implausible values, and mesh dimensions reported where no mesh presence was indicated.

These issues are important because the reporting framework depends not only on fields being populated, but on them being internally coherent and consistently interpretable across CPCs and fleets.

The validation results therefore provide an important context for interpreting subsequent descriptive analyses, distinguishing between patterns that reflect reported operational activity and limitations arising from reporting quality.

What do the submissions reveal?

Activity patterns

One of the first practical outputs of Form 3DA reporting is a description of reported DFAD-related operational activity. Submitted records were summarised by activity type to provide an overview of the relative importance of deployments, fishing-associated visits, retrievals, losses, transfers, strandings, and other reported operational interactions.

Reported activity occurred throughout the reporting period, with clear temporal variation in the number of submitted events. Fishing-associated visits and deployment events accounted for the largest share of reported activity, while retrievals also represented a substantial component of submissions. Losses, transfers, strandings, and other less frequently reported event types were recorded in smaller numbers.

Taken together, these summaries provide an initial indication of the operational activity currently captured through Form 3DA reporting and demonstrate that the reporting framework can already support broad descriptions of DFAD-related operational patterns.

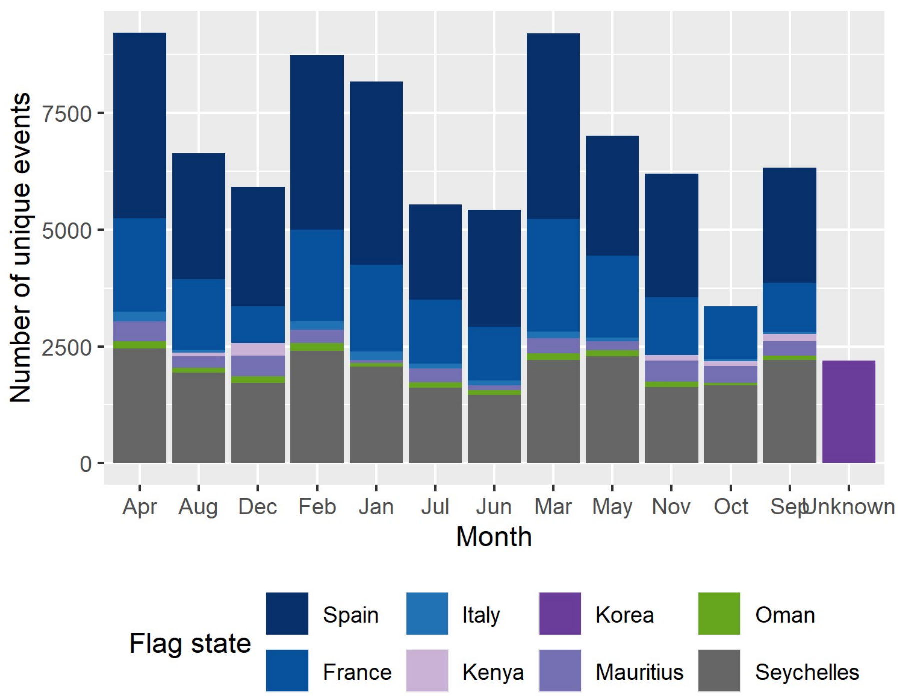

Fig. 7. Distribution of reported DFAD-related activities by CPC by month for 2024.

Spatial distribution of reported interactions

Reported event locations were used to describe the spatial distribution of DFAD-related interactions across the IOTC area of competence. To improve interpretability and avoid overplotting, spatial summaries were presented as aggregated density surfaces rather than raw point distributions.

Reported activity was distributed broadly across the western and central Indian Ocean, with clear concentrations in areas associated with purse seine fishing activity (**Figs 8 - 11**). Monthly summaries indicate that this general spatial footprint remained relatively consistent throughout the reporting period, although variation in intensity is evident between months.

The spatial outputs should be interpreted as descriptive summaries of reported activity rather than complete representations of DFAD operations, as their resolution and reliability remain dependent on reporting completeness and consistency.

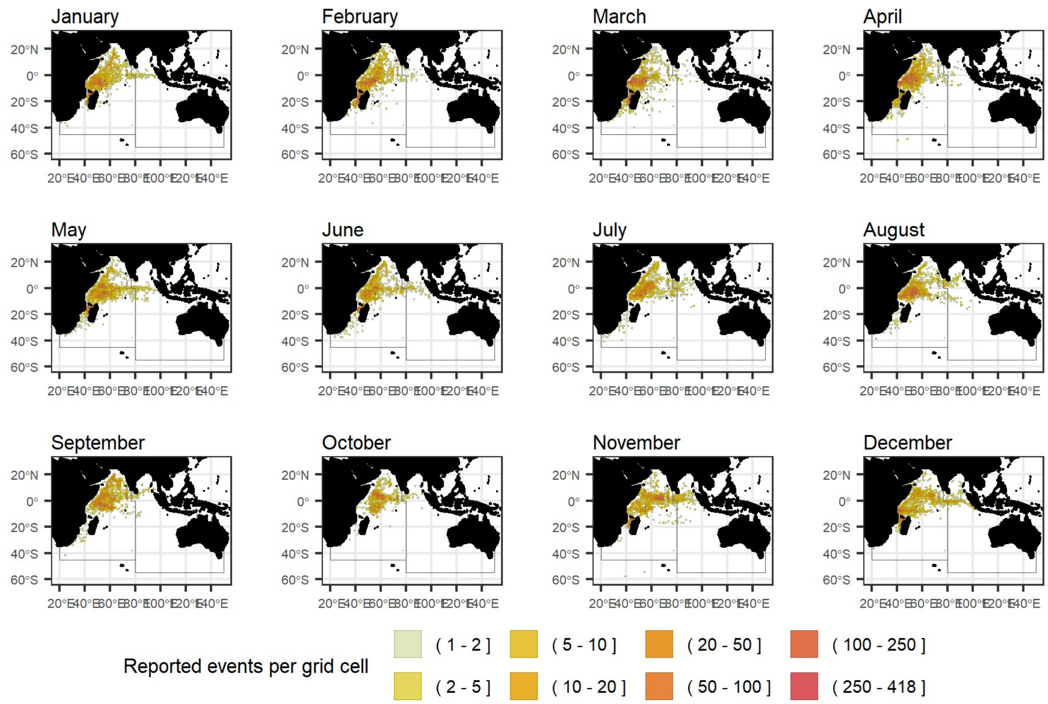

Fig. 8. Spatial distribution of reported DFAD-related interactions by reporting month in 2024. Records with missing month information were excluded.

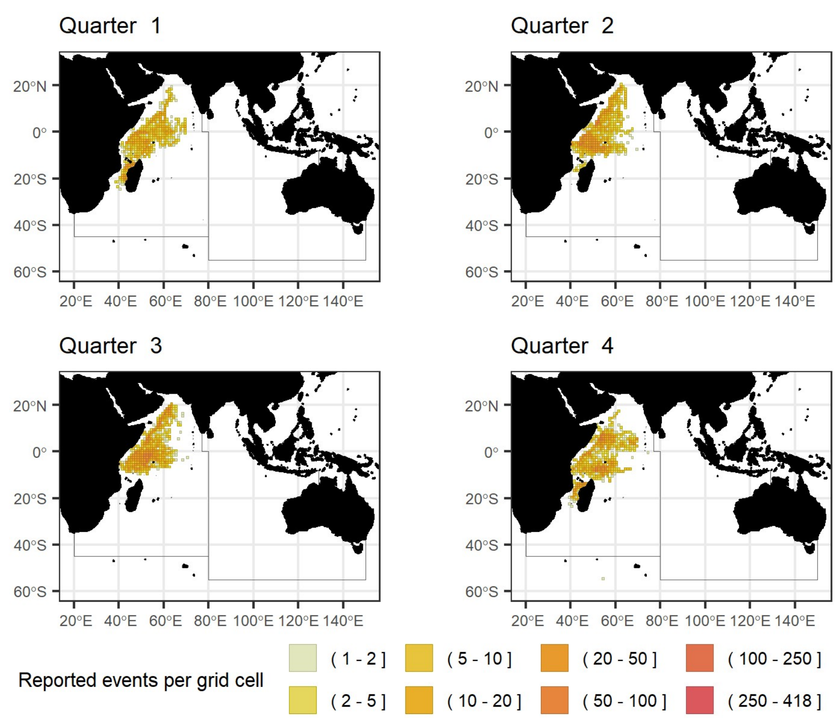

Fig. 9. Distribution of reported DFAD deployments for 2024.

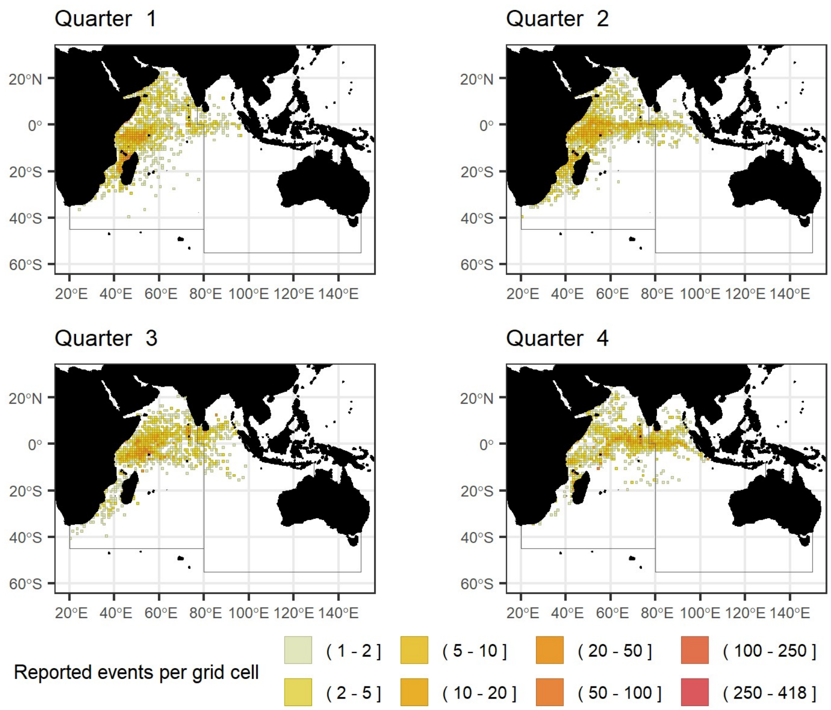

Fig. 10. Distribution of reported DFAD losses for 2024. Loss is understood to mean: "Unvoluntary end of use of the floating object (end of transmission of the buoy)"

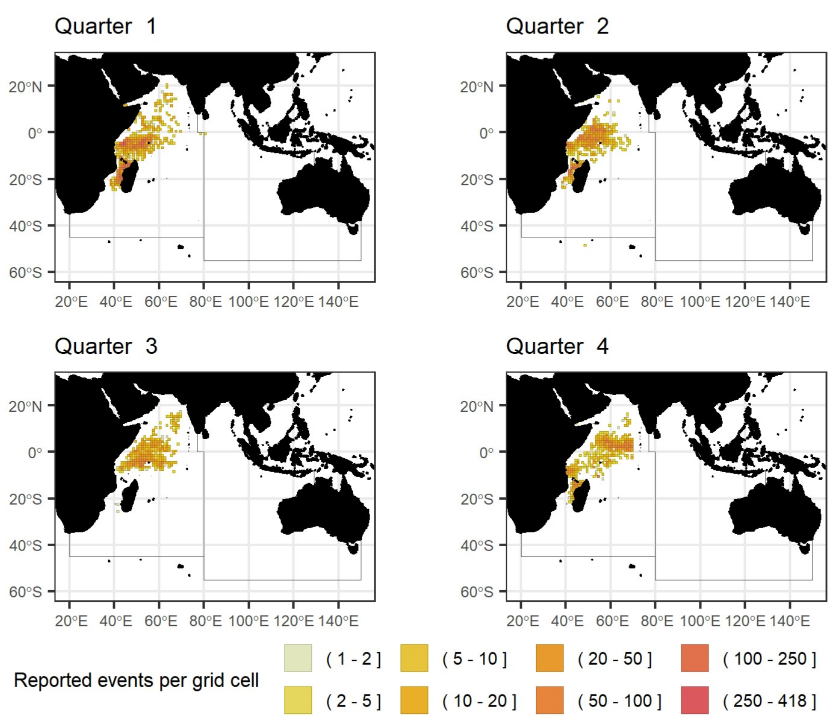

Fig. 11. Distribution of reported DFAD-related fishing sets by quarter in 2024.

Catch and bycatch reporting

For fishing-associated events, Form 3DA provides catch and bycatch reporting by species, fate, and reporting unit, allowing an initial descriptive assessment of catch composition associated with reported DFAD interactions.

Reported retained catches were dominated by skipjack tuna, followed by yellowfin tuna and, to a lesser extent, bigeye tuna, consistent with the expected composition of DFAD-associated purse seine fisheries in the region (**Fig. 12**). Additional reported catches included smaller quantities of other tuna and associated species.

Discarded catches and records reported in numbers rather than weight provide additional evidence that the reporting framework can capture associated and dependent species interactions, including sharks, rays, marine turtles, and other taxa (**Fig. 13**). However, interpretation at finer taxonomic resolution remains constrained by reporting completeness, aggregation choices, and inconsistencies in reporting units.

Taken together, these results suggest that Form 3DA already provides a useful basis for broad descriptive summaries of catch and bycatch, while highlighting areas where improved reporting consistency would substantially increase analytical value.

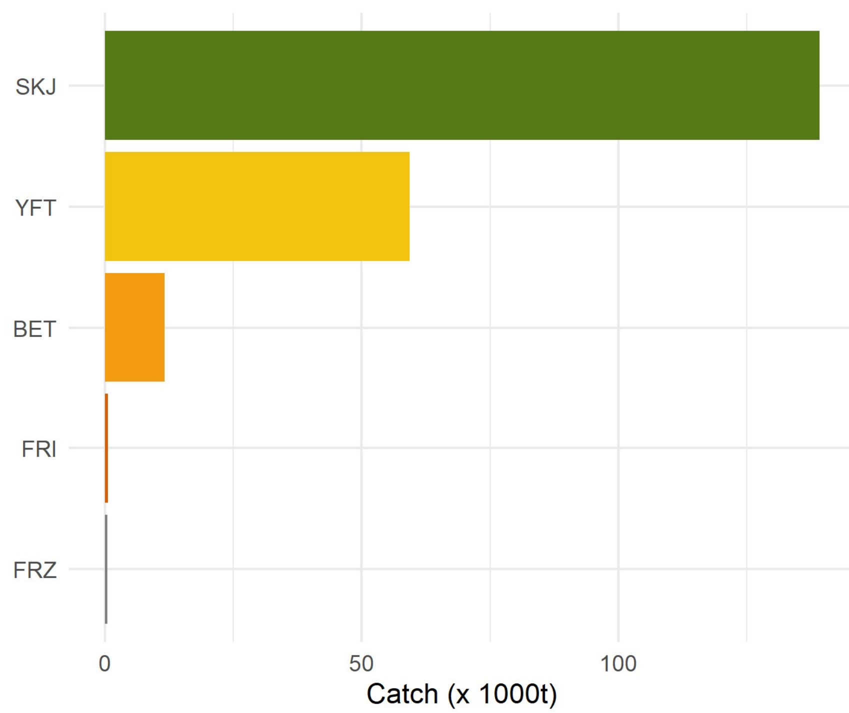

Fig. 12. Retained catches (metric tonnes; t) of the five species with the highest reportedcatch volumes. Records reported in numbers were excluded as information for the conversion from numbersto tonnes is unavailable. Both, raised and non-raised catches, were aggregated without any conversion/raisingas it is assumed 100% of the catches are reported by the CPCs.

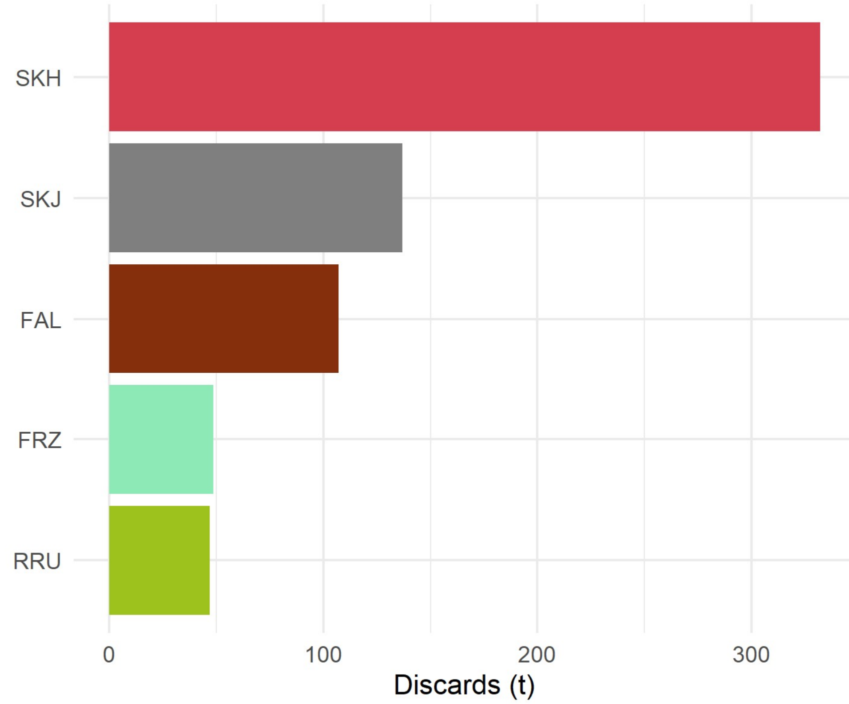

Fig. 13. Discarded catches (metric tonnes; t) of the five species with the highest reported catch volumes. Records reported in numbers were excluded as information for the conversion from numbers to tonnes is unavailable. Raised and non-raised catches were aggregated without any conversion/raising, as it is assumed that 100% of catches are reported by the CPCs. The species codes and corresponding names are: SKH - Sharks; FAL - silky shark; RRU - rainbow runner; FRZ - frigate and bullet tunas; FRI - frigate tuna.

Table 2: Catches in numbers of the ten bycatch species with the highest reported catch numbers. Records reported in tonnes or kilograms were excluded. Raised and non-raised catches were aggregated. MAR and SHK are not allowed as species codes in the IOTC catch reporting framework, but were included for completeness sake in this summary. Further investigations are needed to determine the cause of the reporting errors.

Species	Species code	Retained	Discarded	Total
	SHK	0	6,520	6,520
Various sharks nei	SKH	6,520	0	6,520
Requiem sharks nei	RSK	0	658	658
Rays and skates nei	RAJ	18	18	36
	MAR	11	11	22
Silky shark	FAL	10	10	20
Marlins,sailfishes,etc. nei	BIL	4	4	8
Marine turtles nei	TTX	7	0	7
Mobula nei	RMV	0	1	1

Species-specific examples

To explore the analytical potential of the submitted data beyond aggregate summaries, species-specific spatial distributions were examined for skipjack and yellowfin tuna, the two dominant reported target species.

These results demonstrate that Form 3DA can already support broad descriptive summaries of reported catch and bycatch, while also highlighting the importance of improving reporting consistency for more detailed interpretation.

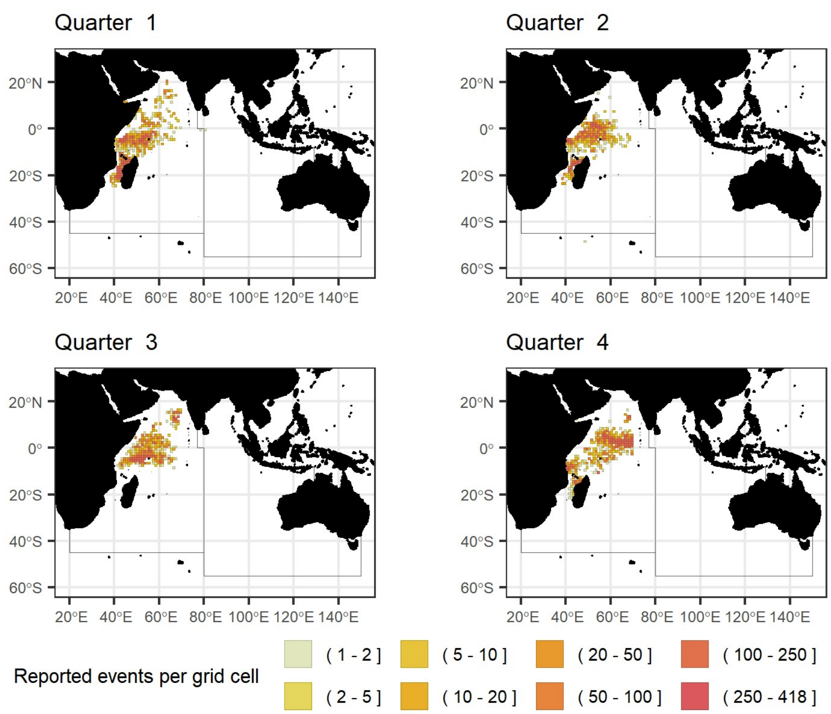

Fig. 14. Distribution by quarter of reported DFAD-related fishing activities for skipjack tuna for 2024.

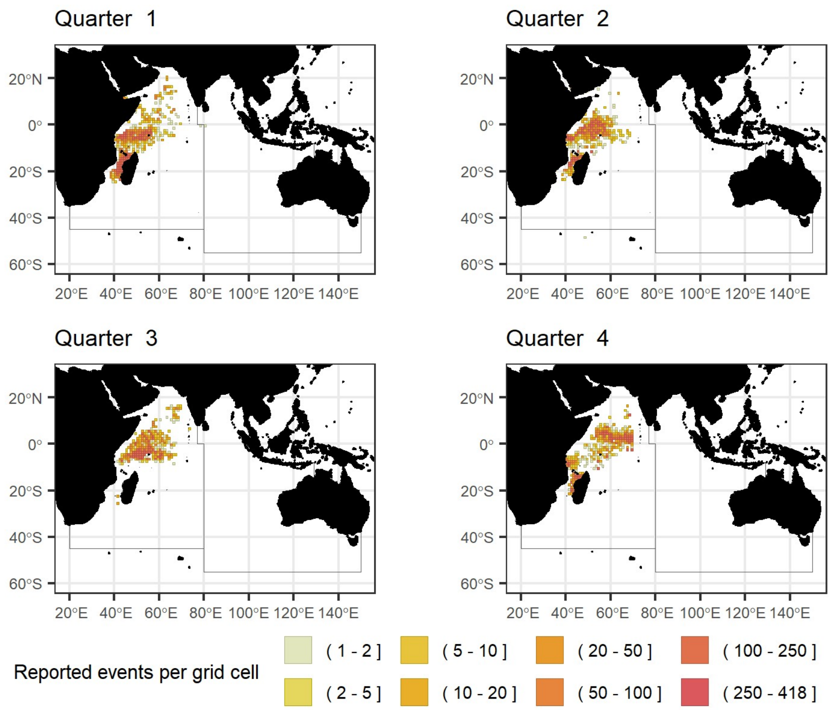

Fig. 15. Distribution by quarter of reported DFAD-related fishing activities for yellowfin tuna for 2024.

Improving the analytical utility of Form 3DA

Reporting guidance

Several of the issues identified during validation appear to reflect inconsistent interpretation of reporting requirements rather than purely technical reporting errors. Clearer guidance would improve consistency across CPC submissions, particularly for fields that were frequently incomplete or inconsistently populated.

Particular attention should be given to identifier fields, buoy status reporting, structural measurements and associated units, mesh-related fields, biodegradability descriptors, and catch reporting conventions. Greater clarity is also needed regarding logical field combinations, such as records reporting buoy-related information without an associated floating object, or vice versa. Similarly, clearer guidance on how to represent missing values would improve consistency, including explicit distinction between genuinely absent information and zero values in catch reporting.

Validation before submission

Many of the reporting issues identified in this assessment could be addressed prior to submission through automated validation. To support this, the validation framework developed for this analysis will be adapted into a user-facing Shiny application to allow CPCs to assess submissions before formal reporting. One of the tools that this shiny app will make use of is the `vrule` package, which provides a flexible framework for defining and applying rule-based validation logic to fisheries data.

The application will provide automated checks for mandatory fields, controlled vocabulary compliance, formatting consistency, duplicate identifiers, logical inconsistencies between related fields, and implausible or invalid values. This includes, for example, detection of negative catch values, contradictory field combinations, and coordinate validation, including checks that reported positions fall within the IOTC area of competence where appropriate. In order to strengthen the transparency and reproducibility of the validation process, the code for the Shiny application will be made publicly available, along with the underlying validation rules and specifications (eg the package `vrule` and the JSON rule definitions). Further checks are being developed to create a more comprehensive validation framework, including checks that are based on logical consistency between related fields and external cross-checks between other available data sources. These checks will not only be added to the Shiny application as they are developed, but their code will also be made publicly available to support transparency and reproducibility.

By providing immediate feedback through clear error messages, summary reports, and guidance for correction, pre-submission validation should reduce avoidable reporting errors, improve consistency across CPCs, and reduce the need for downstream data cleaning and interpretation.

Controlled vocabularies and field definitions

Some of the reporting issues identified during validation suggest that ambiguity in field definitions and allowed values remains an important source of inconsistency. In some cases, variation between submissions may reflect differing interpretations of reporting requirements rather than simple reporting errors.

Several fields would benefit from clearer controlled vocabularies or more explicit formatting rules. For example, fields such as UTC_time currently require clearer specification of acceptable formats to support consistent reporting and robust automated validation. Similarly, paired fields such as mesh_presence and mesh_size require clearer logical definitions to ensure that associated values are reported consistently and only where appropriate.

Buoy-related fields represent another area where tighter specification could improve consistency. Clearer controlled vocabularies for buoy_activity and buoy_type would reduce interpretation drift across CPCs, while validation against external reference sources, such as the buoy registry, may provide an additional mechanism for strengthening consistency and quality assurance.

Logical indicator fields would also benefit from tighter standardisation. Free interpretation of logical entries such as yes/no style responses introduces avoidable variability and complexity in downstream validation. Restricting such fields to a small set of explicitly defined allowed values would improve harmonisation across submissions and simplify automated quality control.

Refining these controlled vocabularies and field definitions would improve consistency across fleets, strengthen the robustness of automated validation, and increase the analytical usability of future submissions.

Fields identified so far in need clearer specifications are mentioned in **Table 3**.

Table 3: Fields identified for further refinement in the Form 3DA validation framework.

Field	Reason for improvements	Potential solutions
UTC_time	Too many upload errors; too many different formats	Make three fields: HH, MM, TZ
buoy_present	Too many interpretations; missing options	yes, no, true, false, ukn
buoy_position	Too many interpretations; missing options	yes, no, true, false, ukn
buoy_activity	Logbook activities do not map to code list	Extend code list or allow 'other'
df_raft_metal	Too many interpretations; missing options	yes, no, true, false, ukn
df_raft_plastic	Too many interpretations; missing options	yes, no, true, false, ukn
df_raft_mesh	Too many interpretations; missing options	yes, no, true, false, ukn
df_raft_meshsize	Inconsistent reporting; maybe not present	ukn, <7, >7
df_tail_metal	Too many interpretations; missing options	yes, no, true, false, ukn
df_tail_plastic	Too many interpretations; missing options	yes, no, true, false, ukn
df_tail_mesh	Too many interpretations; missing options	yes, no, true, false, ukn
df_tail_meshsize	Inconsistent reporting; maybe not present	ukn, <7, >7
all measurements	Inconsistent reporting; maybe not observable	Numbers

Additions to the form

This initial assessment identified several relatively modest additions to Form 3DA that could materially improve the usability of future submissions.

Inclusion of explicit month and year fields would simplify temporal aggregation and reduce reliance on reconstruction from other date components during downstream processing. While such information can be derived, direct reporting would reduce unnecessary processing complexity and minimise opportunities for ambiguity or error.

As noted above, inclusion of a dedicated vessel_type field would provide immediate analytical benefits by allowing clear differentiation between purse seine and associated supply vessel operations without requiring external cross-referencing against vessel registries.

Inclusion of an explicit biodegradability_category field would similarly strengthen the form's ability to support emerging management and monitoring requirements related to DFAD design characteristics. Direct reporting of this information would improve consistency, simplify interpretation, and reduce dependence on inference from multiple structural fields.

Taken together, these additions represent relatively small structural modifications that could substantially improve the analytical utility, interpretability, and efficiency of future Form 3DA reporting.

The UTC time field has proven difficult to validate consistently, as the currently observed inconsistencies may reflect either genuine differences in reporting format or artefacts introduced during data preparation and upload. As these causes cannot presently be distinguished with confidence, the field may benefit from further discussion. One possible approach would be to replace the current free-format entry with separate structured fields (e.g. hours, minutes, and time zone) to reduce ambiguity and minimise formatting-related submission errors.

The current workflow requires external cross-referencing to determine vessel type, creating unnecessary processing complexity and potential ambiguity. Inclusion of a dedicated vessel type field in Form 3DA would provide a simple structural improvement with immediate analytical benefits.

Validation analysis automation and information flow

Key takeaways

- Form 3DA represents a significant advance in DFAD operational reporting in the IOTC area of competence.
- Early implementation shows clear potential for monitoring DFAD-related activities and describing submitted catch information.
- Reporting completeness and internal consistency remain uneven across variable groups.
- Reliable identifiers and structural descriptors are essential for lifecycle tracking and design-related management evaluation.
- Automated validation and clearer guidance would substantially improve the future utility of submitted data.

Appendices

Appendix 1:Column names

Title	Element	Field	Requirement
Main elements	Vessel name	vessel_name	M
	Vessel IOTC number	vessel_IOTC_number	M
	Day of the month	day_of_month	M
	UTC time	utc_time	M
	Latitude	latitude	M
	Longitude	longitude	M
Buoy	Present	buoy_present	M
	Identifier	buoy_id	M
	Position	buoy_position	M
	Activity	buoy_activity	M
DFOB	Identifier	df_id	M
	Type	df_type	M
	Activity	df_activity	M
Surface (raft)	Plastic	df_raft_plastic	M
	Metal	df_raft_metal	M
	Length	df_raft_length	M
	Width	df_raft_width	O
	Height	df_raft_height	O
	Mesh	df_raft_mesh	M
	Mesh size	df_raft_meshsize	O
Subsurface (tail)	Plastic	df_tail_plastic	M
	Metal	df_tail_metal	M
	Length	df_tail_length	M
	Width	df_tail_width	O
	Height	df_tail_height	O
	Mesh	df_tail_mesh	M
	Mesh size	df_tail_meshsize	O