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Proposal for the Adoption of a Standardised Photographic Sampling Protocol for Benthic Invertebrate Bycatch Collected by Commercial Longline and Trawl Fisheries in the SIOFA Convention Area

Delegation of France Overseas Territories

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Abstract	<p>This paper proposes the adoption of a standardised photographic sampling protocol for benthic macro-invertebrates incidentally captured by commercial longline and trawl fisheries operating within the SIOFA Convention Area.</p> <p>The proposal is grounded in three complementary proof-of-concept developments: The Bendima image-based benthic database system, demonstrating the feasibility and scientific value of systematic image documentation linked to metadata and DNA validation (Martin et al., 2023a); A deep-learning study on automatic detection and classification of benthic macro-invertebrates, establishing the technical feasibility of AI-assisted identification workflows (Martin et al., 2023b);</p>

¹ Restricted documents may contain confidential information. Please do not distribute restricted documents in any form without the explicit permission of the SIOFA Secretariat and the data owner(s)/provider(s).

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The EAF-Nansen Programme survey leg 3.3 (2025) conducted in the SIOFA Area, which operationally implemented structured benthic documentation procedures under deep-sea survey conditions (FAO, 2025)

In addition, this proposal introduces a structured **sub-sampling and extrapolation framework** to ensure that the protocol remains operationally feasible when total benthic bycatch volumes exceed onboard processing capacity.

Recommendations

The Scientific Committee is invited to:

- **Endorse** the regional photographic protocol.
- **Recognise** laboratory-based identification as the standard approach.
- **Adopt** the structured sub-sampling framework.
- **Establish** minimum metadata standards.
- **Support** development of a regional image repository.
- **Encourage** AI pilot initiatives.

Proposal for the Adoption of a Standardised Photographic Sampling Protocol for Benthic Invertebrate Bycatch Collected by Commercial Longline and Trawl Fisheries in the SIOFA Convention Area

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1. Executive Summary

This paper proposes the adoption of a standardised photographic sampling protocol for benthic macro-invertebrates incidentally captured by commercial longline and trawl fisheries operating within the SIOFA Convention Area.

The proposal is grounded in three complementary proof-of-concept developments:

- The **Bendima image-based benthic database system**, demonstrating the feasibility and scientific value of systematic image documentation linked to metadata and DNA validation (Martin et al., 2023a);
- A **deep-learning study on automatic detection and classification of benthic macro-invertebrates**, establishing the technical feasibility of AI-assisted identification workflows (Martin et al., 2023b);
- The **EAF-Nansen Programme survey leg 3.3 (2025) conducted in the SIOFA Area**, which operationally implemented structured benthic documentation procedures under deep-sea survey conditions (FAO, 2025)

In addition, this proposal introduces a structured **sub-sampling and extrapolation framework** to ensure that the protocol remains operationally feasible when total benthic bycatch volumes exceed onboard processing capacity.

2. Background and Regulatory Context

United Nations General Assembly (UNGA) resolutions on deep-sea fisheries (UNGA, 2006; 2009; 2011) and the FAO International Guidelines for the Management of Deep-Sea Fisheries in the High Seas (FAO, 2009) require RFMOs to:

- Identify and protect Vulnerable Marine Ecosystems (VMEs);
- Monitor interactions with VME indicator taxa;

- Apply encounter protocols;
- Ensure transparency and scientific robustness in reporting.

Within SIOFA, effective implementation of these obligations depends on reliable and reproducible identification of benthic macro-invertebrates.

However, current reporting practices often rely on summary occurrence tables without systematic photographic documentation or specimen preservation, limiting reproducibility and taxonomic validation (Martin et al., 2023a).

3. The Global Taxonomic Impediment and Its Implications for SIOFA

A structural constraint affecting benthic monitoring globally is the well-documented **taxonomic impediment** — the shortage of trained taxonomists relative to biodiversity assessment needs (Giangrande, 2003; Costello et al., 2010). This issue has been widely acknowledged in the scientific literature and is particularly acute for deep-sea taxa, including Porifera, Cnidaria (e.g., cold-water corals), Bryozoa, Brachiopoda, and various echinoderm groups. Marine macro-invertebrates comprise over 90,000 recognised species across more than 30 phyla (Costello et al., 2013). Many deep-sea taxa remain poorly studied, and systematics capacity has declined in several regions (Costello et al., 2010).

This shortage has direct implications for fisheries monitoring:

- Commercial vessels cannot embark benthic taxonomic specialists;
- Observers are required to implement multiple monitoring protocols simultaneously (catch, effort, compliance, biological sampling);
- Time constraints during gear retrieval limit the possibility of detailed morphological examination;
- Laboratory equipment, reference collections, and specialised identification keys are unavailable onboard;
- Many benthic taxa require microscopic examination or comparison with curated reference material;
- Species-level identification frequently requires post hoc verification, sometimes including molecular analysis.

In practice, this results in three major limitations when photographic documentation and specimen preservation are not systematically implemented:

1. **Low taxonomic resolution** – Under current observer-only reporting systems, benthic records are frequently limited to high-level taxa (e.g., “coral”, “sponge”), and without primary documentation, identifications cannot be reviewed or corrected, limiting ecological interpretation and VME assessment precision.
2. **Irreversible loss of primary evidence** – Without images or preserved material, identifications cannot be reviewed, validated, or corrected.
3. **Inconsistent reporting across fleets and observers** – Variability in training and experience leads to heterogeneous datasets.

Under current practices, observers who record benthic bycatch without photographic documentation or specimen preservation are effectively producing non-verifiable occurrence tables. This severely constrains reproducibility and long-term dataset reliability.

As noted by Giangrande (2003), the lack of taxonomic expertise limits ecological inference and biodiversity monitoring. Costello et al. (2010) further highlight that marine biodiversity knowledge gaps remain substantial due to insufficient taxonomic capacity.

Without image and specimen archiving, species-level benthic data in deep-sea fisheries remain effectively unattainable.

4. Strategic Shift: Relocating Identification from Vessel to Laboratory

The proposed protocol addresses the taxonomic impediment by structurally separating documentation and identification (Martin et al., 2023a).

4.1 Field Phase: Standardised Documentation

Under the proposed system, onboard observers are not required to produce precise taxonomic identifications. Instead, they:

- Sort by morphotype;
- Photograph systematically with scale and haul identification;
- Weigh morphotype lots;
- Preserve representative specimens where feasible;
- Record standardised metadata.

This reduces dependence on onboard taxonomic expertise and standardises data collection across fleets.

4.2 Laboratory Phase: Expert-Based Identification

Identification is conducted under controlled laboratory conditions, where:

- Specialists have access to taxonomic literature and reference collections;
- Images can be examined in detail;
- Cropped organism images can be reviewed iteratively;
- Independent experts may cross-validate determinations;
- Molecular barcoding can confirm or refine identifications.

This approach allows:

- Species-level identification when feasible;
- Retrospective correction of identifications;
- Progressive improvement of taxonomic resolution over time;
- Development of curated regional reference image collections.

As demonstrated in the Bendima system, this model allows thousands of observations to be re-examined and refined over time, significantly improving data quality relative to traditional observer-based reporting (Martin et al., 2023a).

5. Proof of Concept I: The Bendima Image-Based Database System

The Bendima database (Martin et al., 2023a) demonstrated model directly addresses reproducibility challenges in benthic ecology:

- Feasibility of systematic photographic documentation (Fig.1);
- Linkage of images to metadata and sampling effort;
- Retrospective correction of identifications (Fig. 2);
- Integration of DNA barcoding (Fig. 2).



Figure 1: Images and samples collection; sorting of the caught organisms (a), full photographing (b), taxa identification/counting/measurement and storage in the Bendima database in the form of cropped images (c), conservation of partial representative samples for taxonomy and DNA barcoding (d) (from Martin et al., 2023a)



Figure 2: Preserved specimen sorting and tissue sampling for DNA barcoding

6. Proof of Concept II: AI-Assisted Detection and Classification

The deep-learning study (Martin et al., 2023b) demonstrated that:

- Neural networks can detect organisms within heterogeneous bycatch images;
- Preliminary taxonomic grouping is feasible (Fig. 3 to 6);
- Performance improves with dataset size.

This establishes a technological foundation for AI-assisted workflows in SIOFA monitoring.



Figure 3: Example of detection and classification obtained with an image of sea stars with deep learning (from Martin et al., 2023b)



Figure 4: Example of detection and classification obtained with an image including ascidians and a sea star with deep learning (from Martin et al., 2023b)



Figure 5: Example of detection and classification obtained with an image including an ophiuroid, a piece of coral and a sea star with deep learning (from Martin et al., 2023b)



Figure 6: Example of detection and classification obtained with an image including crinoids, a gastropod and pieces of sea weed with deep learning (from Martin et al., 2023b)

7. Proof of Concept III: Implementation in the EAF-Nansen Survey in the SIOFA Area

The EAF-Nansen Programme survey leg 3.3 (FAO, 2025) implemented structured benthic documentation procedures within the SIOFA Convention Area (see survey report). This confirmed:

- Operational feasibility under deep-sea conditions;
- Compatibility with RFMO data standards;
- Institutional scalability.



Figure 7: Example of photographic benthos sampling implemented for trawling operations during the EAF-Nansen Programme survey leg 3.3 (FAO, 2025)

8. Proposed Standardised Photographic Sampling Protocol

8.1 Full-Coverage Scenario

When operationally feasible, the following procedure applies:

1. Full sorting of benthic bycatch by morphotype.
2. Photographic documentation of each morphotype lot:
 - Overhead view;
 - Uniform background;
 - Visible metric scale;
 - Station/haul identifier in frame.
3. Weighing of each morphotype lot.
4. Individual photography where feasible.
5. Preservation of representative specimens.
6. Recording of full metadata:
 - Date, coordinates;
 - Depth;
 - Gear type;

- Fishing effort;
- Total benthic bycatch weight.

9. Sub-Sampling and Extrapolation Framework

9.1 Rationale

In some trawl hauls or longline sets, benthic bycatch volumes may be too large to allow exhaustive sorting and photography within operational time constraints.

To maintain scientific integrity while ensuring feasibility, a structured sub-sampling design is proposed.

9.2 Sub-Sampling Design Options

Depending on operational constraints, one of the following statistically defensible methods may be applied:

A. Proportional Mass-Based Sub-Sampling

1. Weigh total benthic bycatch (W_{total}).
2. Randomly select a known proportion (e.g., 25%, 50%) of the total mass.
3. Fully sort and photograph the sub-sample (W_{sample}).
4. Record taxon-specific abundance and biomass within the sub-sample.
5. Extrapolate to total catch:

$$\text{Estimated total abundance}_i = \text{Abundance}_{i, \text{sample}} \times (W_{total} / W_{sample})$$

This method assumes proportional distribution of taxa within the catch mass.

B. Volumetric Sub-Sampling

Where weighing is impractical:

- Use standardized containers of known volume;
- Randomly select a predefined number of containers;
- Fully process selected units;
- Extrapolate proportionally to total container count.

C. Systematic Fraction of Gear Retrieval (Longline Context)

- Sample a fixed proportion of hooks (e.g., 25%);
- Apply sampling systematically along the line to avoid spatial bias;
- Extrapolate results to full gear length.

This approach is consistent with established longline observer sampling methodologies.

9.3 Statistical Considerations

- Sampling fraction must be recorded.
- Sub-sampling method must be declared in metadata.

- Confidence intervals can be calculated when replicate sub-samples are taken.
- Extrapolation uncertainty should be reported when data are used for VME threshold evaluation.

9.4 Safeguard for VME Indicators

Regardless of sub-sampling strategy:

- Any clearly identifiable VME indicator taxon encountered outside the sub-sample must be recorded and photographed.
- If VME taxa exceed encounter thresholds within the processed sub-sample, precautionary protocols (e.g., move-on rules) must apply.

Sub-sampling must never override precautionary management obligations (FAO, 2009; UNGA, 2006).

10. Laboratory Processing and Data Integration

Sub-sampled data shall be processed identically to full-coverage data:

- Cropping and identification of each organism;
- Database entry linked to sampling fraction;
- Explicit tagging of extrapolated versus observed values;
- Integration with preserved voucher specimens.

This structure is consistent with the Bendima model.

11. Integration with AI-Assisted Identification

The deep-learning proof of concept

demonstrated that detection algorithms perform best when trained on large, well-annotated datasets.

Sub-sampling does not undermine AI development provided:

- Sampling fractions are documented;
- Images remain representative;
- Taxonomic diversity is preserved.

Over time, AI tools may assist in:

- Rapid counting within sub-samples;
- Automated detection of VME indicator taxa;
- Quality control across fleets.

12. Benefits for VME Management and SIOFA Governance

Adoption of this protocol, including its sub-sampling framework, would:

- **Ensure operational feasibility** across fleets
- **Improved reliability of VME indicator identification**
Many VME indicator taxa (e.g., certain corals or sponge taxa) require morphological expertise not available onboard. Laboratory review reduces misclassification risk
- **Transparent documentation for encounter thresholds** (FAO, 2009)
Images provide auditable evidence in cases where move-on rules are triggered.
- **Retrospective harmonisation of historical datasets**
Previously recorded morphotypes can be reclassified using archived images.
- **Capacity building through regional expertise pooling**
Instead of requiring each fleet to carry a benthic taxonomist, identification capacity can be centralised and shared
- **Facilitate Secretariat-level data auditing**

13. Recommendations to the Scientific Committee

The Scientific Committee is invited to:

1. Endorse the regional photographic protocol.
2. Recognise laboratory-based identification as the standard approach.
3. Adopt the structured sub-sampling framework.
4. Establish minimum metadata standards.
5. Support development of a regional image repository.
6. Encourage AI pilot initiatives.

14. Conclusion

The global taxonomic impediment (Giangrande, 2003; Costello et al., 2010) makes species-level onboard identification structurally unrealistic in deep-sea fisheries.

The proposed protocol provides a scientifically robust solution by:

- Decoupling documentation from identification;
- Relocating taxonomic work to laboratory environments;
- Enabling expert validation and molecular confirmation;
- Producing precise, reproducible, and auditable datasets.

Supported by:

- the Bendima system (Martin et al., 2023a),
- the deep-learning feasibility study (Martin et al., 2023b),
- and operational implementation during the EAF-Nansen survey (FAO, 2025),

this proposal provides strong technical and institutional proof of concept for regional adoption within SIOFA.

15. References

Costello, M.J., Coll, M., Danovaro, R., Halpin, P., Ojaveer, H. and Miloslavich, P. 2010. A census of marine biodiversity knowledge, resources, and future challenges. *PLoS ONE*, 5(8): e12110. <https://doi.org/10.1371/journal.pone.0012110>

Costello, M.J., Bouchet, P., Boxshall, G., Fauchald, K., Gordon, D., Hoeksema, B.W., Poore, G.C.B., van Soest, R.W.M., Stöhr, S., Walter, T.C., Vanhove, B., Decock, W. and Appeltans, W. 2013. Global coordination and standardisation in marine biodiversity through the World Register of Marine Species (WoRMS) and related databases. *PLoS ONE*, 8(1): e51629. <https://doi.org/10.1371/journal.pone.0051629>

FAO. 2009. International Guidelines for the Management of Deep-sea Fisheries in the High Seas. FAO, Rome. 73 pp.

FAO. 2025. Survey Leg 3.3: Deep-sea fisheries resources in the SIOFA Convention Area. EAF-Nansen Programme documentation. FAO, Rome.

Giangrande, A. 2003. Biodiversity, conservation, and the 'taxonomic impediment'. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 13: 451–459.

Martin, A., Blettery, J., Dettai, A., Rosset, N. and Gousseau, Y. 2023a. Bendima: a database for marine macro-invertebrate bycatch data designed to improve reproducibility in benthic ecology. *Cybium*, 47(3): 325–334.

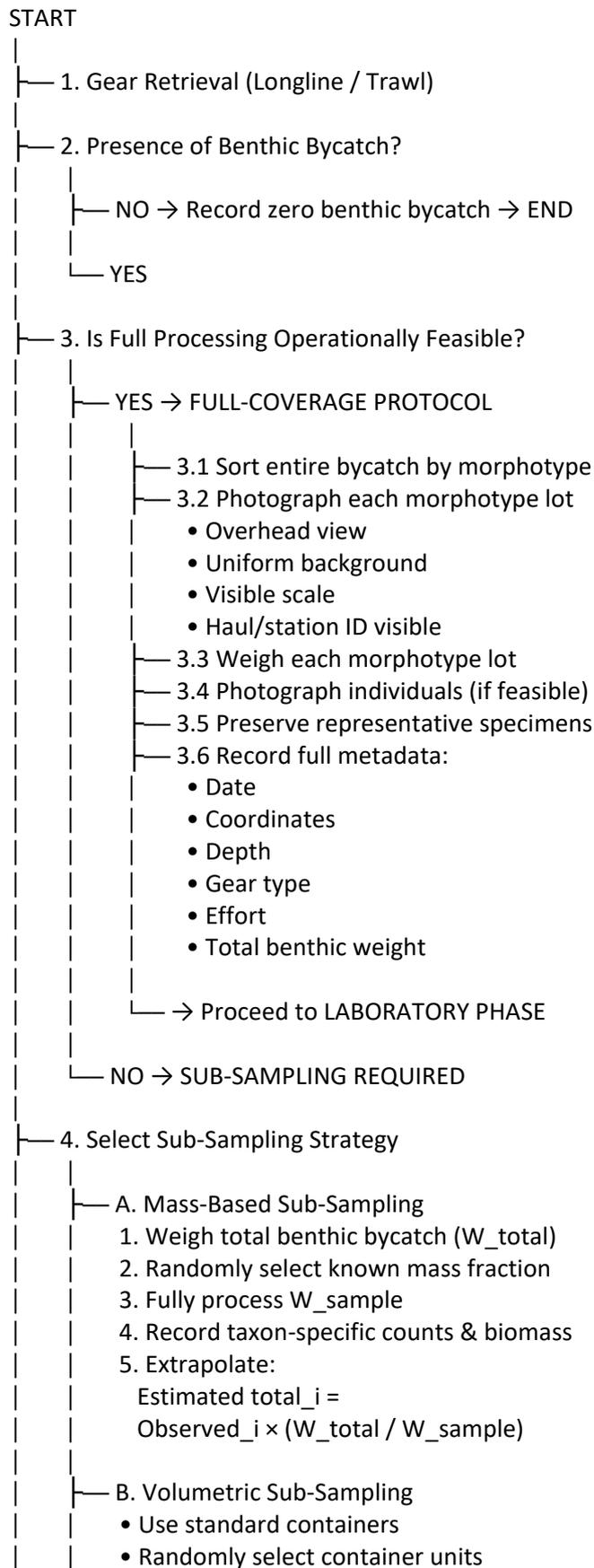
Martin, A., Rosset, N., Blettery, J. and Gousseau, Y. 2023b. Using deep-learning for automatic identification of images of marine benthic macro-invertebrate bycatch: a proof of concept. *Cybium*, 47(3): 335–341.

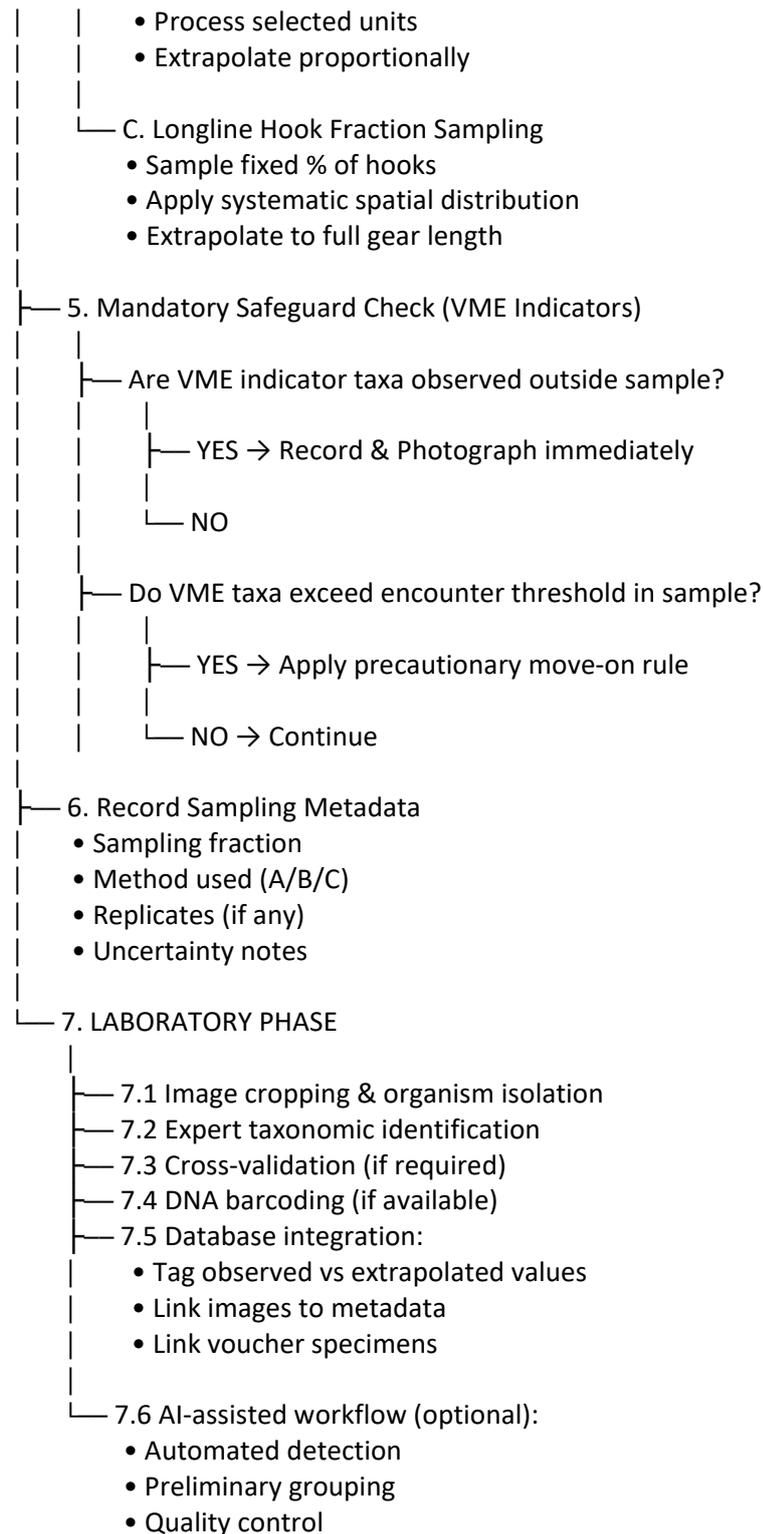
United Nations General Assembly (UNGA). 2006. Resolution 61/105. Sustainable fisheries. A/RES/61/105.

United Nations General Assembly (UNGA). 2009. Resolution 64/72. Sustainable fisheries. A/RES/64/72.

United Nations General Assembly (UNGA). 2011. Resolution 66/68. Sustainable fisheries. A/RES/66/68.

Annex I. General Diagram of the Standardised Photographic Sampling Protocol for Benthic Invertebrate Bycatch





END