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IDENTIFICATION AND PROTECTION OF SPECIAL AREAS, ECAs AND PSSAs

Considerations regarding the integration of dynamic biological hazard data into the S-100 ECDIS environment

Submitted by RINA

SUMMARY

Executive summary:	This document provides technical information on using the International Hydrographic Organization's S-124 navigational warnings product specification within the S-100 electronic chart display and information system (ECDIS) environment to support operational mitigation of ship strike risk to marine megafauna. A global overlay analysis identifies 585 high-risk hexagons where high shipping density intersects with repeated megafauna occurrence; 482 of these (82.4%) fall outside the strict Marine Protected Areas (IUCN Ia–IV) and IMO-designated Particularly Sensitive Sea Areas included in this assessment, indicating that static area-based measures alone leave many risks unseen on the bridge. This document sets out how SOLAS Chapter V/4 (Navigational warnings) provides a basis for Administrations to promulgate time-bounded, geo-referenced warning areas when quality-assured intelligence is available from reliable sources. S-124 offers a practical digital mechanism to encode such warnings as polygons with defined validity for display as an ECDIS overlay, complementing (not replacing) static routeing and protected-area tools. The result is a pathway towards time-limited dynamic biological warnings that fit established workflows.
Strategic direction, if applicable:	4
Output:	4.1
Action to be taken:	Paragraph 13
Related documents:	None

Introduction

1 Current SOLAS navigational frameworks rely heavily on static definitions (e.g. traffic separation schemes). However, biological collision risks are inherently mobile. This document explores the discrepancy between static regulatory boundaries and dynamic biological reality.

Gap analysis

2 To understand the existing regulatory regime, the Sustainability Mission at The Alan Turing Institute analysed the interaction between industrial shipping and vulnerable marine life, producing this global map. The analysis identifies 585 high-conflict zones between shipping and marine megafauna. Notably, 82.4% of these zones fall outside existing strong protections. This suggests that, without a mechanism to display dynamic zones, the majority of collision risk remains invisible to the bridge team.

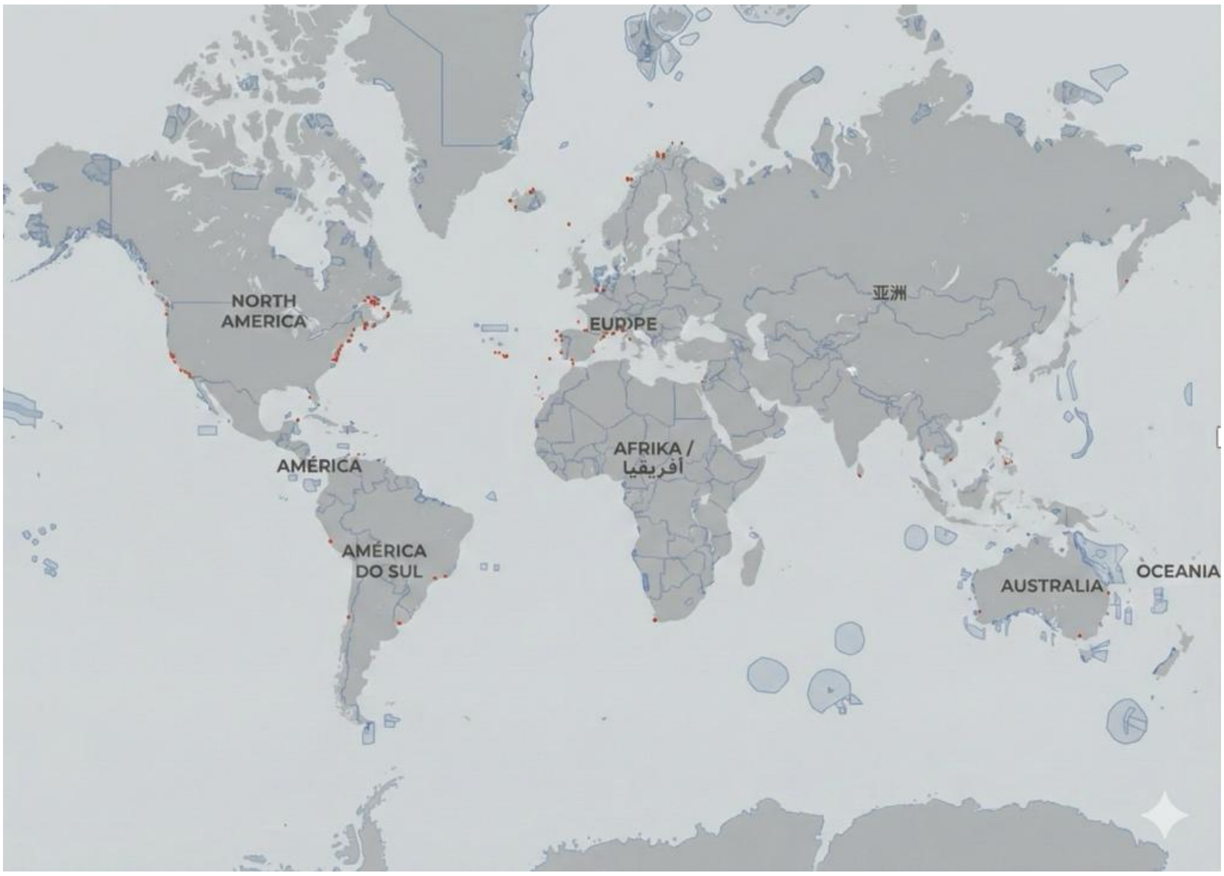

Figure: 1 High conflict zones between shipping and megafauna

3 The analysis uses three distinct layers:

.1 megafauna congregations (the biological layer):

.1 RINA aggregated raw occurrence data from the Global Biodiversity Information Facility (GBIF), identifying almost 60,000 verified sightings/location records from 2018–2025;

.2 the analysis targets four species of the 75 species documented to be susceptible to ship strikes: blue whales (*B. musculus*), fin whales (*B. physalus*), humpback whales (*M. novaeangliae*), and whale sharks (*R. typus*)[1]; and

[1] Renée P. Schoeman et al., *A Global Review of Vessel Collisions With Marine Animals*, Frontiers in Marine Science 7 (May 2020), https://doi.org/10.3389/fmars.2020.00292

.3 RINA defines "congregation zones", hexagons (approximately 20km radius) containing more than one confirmed sighting of the species in the 7-year time frame.

.2 high shipping intensity (the threat layer):

.1 data source: World Bank "Global Shipping Traffic Density", using AIS data (Class-A vessels >300GT, for 2015-2021), calculating the mean shipping density for every biological hexagon; and

.2 isolated the top 20th percentile to highlight marine highways.

.3 protected areas (the regulation layer):

.1 RINA mapped current strict Marine Protected Areas (IUCN Ia-IV) and IMO-designated Particularly Sensitive Sea Areas (PSSA), excluding designated areas that allow unrestricted commercial use, from the WDPA (World database on protected areas)

4 This analysis takes a conservative and concrete approach, focusing on sightings of four species from the GBIF database. An analysis that incorporates wider animal tracking and satellite data, along with modelling on the basis of this, would show yet higher risk, not least because the analysis would take into account the expected skew towards coastal sightings. Further, regions with low historical reporting (e.g. parts of the Indian Ocean) may exhibit artificially low risk scores in this approach. Nonetheless, RINA can identify a large number of definite high-risk areas by overlaying the layers described. These divide into two types:

.1 managed risk (grey hexagons): (megafauna congregation + high traffic) inside (protected zone). These areas are theoretically regulated. However, the data shows that high shipping density (top 20% globally) persists inside these zones. This shows how static designation can fail to reduce physical traffic; and

.2 unmanaged risk (red hexagons, the gap): (megafauna congregation + high traffic) outside (protected zone). These are high-intensity conflict zones that fall outside the regulatory map. Because establishing new zones is cumbersome in regulatory terms, these areas represent an immediate opportunity for dynamic rerouteing or speed restrictions, using live data to change ships' behaviour.

5 The total high-risk zones (megafauna + shipping) amounts to 585 hexagons. The total managed risk zones (grey) amounts to 103 hexagons. The total unmanaged risk (red) amounts to 482 hexagons (no strong regulatory overlap). 82.4% of the identified high-risk zones fall outside strict protections.

6 The analysis is in accord with broader modelling in this area, noting analyses on shifting populations as habitats change,[2] and the overlap of megafauna space use with large ship traffic.[3]

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2 Freya C. Womersley et al., *Climate-Driven Global Redistribution of an Ocean Giant Predicts Increased Threat from Shipping*, Nature Climate Change 14, no. 12 (2024): 1282–91, https://doi.org/10.1038/s41558-024-02129-5.

3 Freya Wormsley, *Global Collision-Risk Hotspots of Marine Traffic and the World's Largest Fish, the Whale Shark*, https://doi.org/10.1073/pnas.2117440119 ; Ana M. M. Sequeira *et al*., *Global Tracking of Marine Megafauna Space Use Reveals How to Achieve Conservation Targets*, n.d.

Regulatory pathways

7 Current management of marine megafauna relies on static instruments such as PSSAs or SOLAS regulation V/10 (Ships' routeing). While effective for fixed habitats, analysis indicates that the majority of concrete high-risk zones are not under restrictions, suggesting that a full mitigation strategy will include shifting warnings as well as instruments like Marine Protected Areas. For example, feeding grounds may be active for a period of weeks. The mitigation of the risk requires a shift from static avoidance to dynamic hazard identification.[4]

8 The introduction of the S-124 (navigational warnings) product specification provides the necessary technical architecture to treat verified models of megafauna aggregations as dynamic navigational hazards. The technical challenge is to standardize the data structure within S-124 in order to ensure that these biological danger messages can be displayed on ECDIS alongside meteorological and hydrographic warnings.

9 SOLAS regulation V/4 (Navigational warnings) places an explicit obligation on Governments to ensure that "when intelligence of any dangers is received from whatever reliable source, it shall be promptly brought to the knowledge of those concerned". In practice, this regulation has been executed to report dynamic hazards such as drifting mines, unlit derelicts and naval exercises.

10 As near-real-time detection and spatial risk products mature (including passive-acoustic monitoring used to generate operational alerts), Administrations can, where the information is judged to indicate a danger, disseminate time-bounded warning areas via S-124 navigational warning overlays, avoiding the amendment latency associated with static routeing measures under SOLAS V/10. Used this way, model- or sensor-derived warnings can complement static area-based protection measures by supporting operational, time-limited risk management within bridge-team workflows. Existing precedents currently demonstrate the components of this workflow, including United States Dynamic Management Areas (establishing the regulatory mechanism for temporary zones),[5] whale seeker (AI-based detection and mapping),[6] and whale guardians (route planning).[7]

11 The concept of 'danger to navigation' includes the danger associated with evasive action taken by vessels and should be understood in the context of the increasing deployment of MASS. Sensors may interpret surfacing megafauna as unidentified semi-submerged obstacles, potentially triggering collision-avoidance manoeuvres. In this context, a biological navigational warning serves a critical safety function.

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[4] Guillermo Ortuño Crespo *et al*., *Beyond Static Spatial Management: Scientific and Legal Considerations for Dynamic Management in the High Seas*, Marine Policy 122 (December 2020): 104102, https://doi.org/10.1016/j.marpol.2020.104102; Sara M. Maxwell *et al.*, *Mobile Protected Areas for Biodiversity on the High Seas*, Science (New York, N.Y.) 367, no. 6475 (2020): 252–54, https://doi.org/10.1126/science.aaz9327.

[5] National Oceanic and Atmospheric Administration (NOAA) Fisheries, *Reducing Vessel Strikes to North Atlantic Right Whales* | NOAA Fisheries, NOAA, 26 January 2026, New England/Mid-Atlantic, Southeast, https://www.fisheries.noaa.gov/national/endangered-species-conservation/reducing-vessel-strikes-north-atlantic-right-whales.

[6] Justine Boulent *et al*., *Scaling Whale Monitoring Using Deep Learning: A Human-in-the-Loop Solution for Analyzing Aerial Datasets*, Frontiers in Marine Science 10 (March 2023), https://doi.org/10.3389/fmars.2023.1099479; '*Home* | *Whale Seeker - Marine Mammal and Bird Detection*', Whale Seeker, accessed 30 January 2026, https://www.whaleseeker.com .

[7] *Whale Conservation | Whale Guardians™ | Preventing Ship Strikes*, Whale Guardians, accessed 30 January 2026, https://www.whaleguardians.org.

Operational implications

12 The provision of an S-124 biological hazard layer allows for two distinct mitigation strategies based on the vessel's location: [8]

.1 open ocean (routeing): in deep water, early detection of a dynamic zone allows for minor course alterations. RINA's modelling indicates that avoiding these zones often results in negligible fuel penalties (<1%) for long-distance voyages; and

.2 constrained waters (speed): where routeing is constrained (e.g. port approaches or on shorter journeys), the presence of a verified hazard warning allows the bridge team to exercise heightened situational awareness or speed reduction, consistent with safe navigation, without requiring permanent regulatory speed limits.

Action requested of the Committee

13 The Committee is invited to note the information provided in this document, specifically regarding the potential of utilizing the S-124 data structure to identify dynamic biological hazards.

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[8] Ryan R. Reisinger *et al., Optimising Voyages for Biodiversity: Rerouting Vessels around Ocean Giants Can Have Minimal Impact on Shipping*, preprint, bioRxiv, 29 September 2025, 2025.09.26.678754, https://doi.org/10.1101/2025.09.26.678754.