

Table 1. Chronological development of the incorporation of information on connectivity into the science advice for NAFO.

Year	Benchmarks for the Use of Connectivity-Related Data in NAFO	Reference
2008	Delineation of ecoregions at three nested scales	NAFO (2008)
2010	Indices of biomass, abundance and biomass/abundance (BA) ratio were used to describe the changes in the fish community in two functional sub-units of the Newfoundland and Labrador Shelves Bioregion.	NAFO (2010)
	Elaboration of the overall EAFM framework described as a three-tiered, hierarchical one. The first tier defines fishery production potential at the EPU level, taking into account environmental conditions and ecosystem state.	NAFO (2010)
2011	“Roadmap for the development of and ecosystem approach to fisheries (EAF) for NAFO” introduced. Subsequent reports focus on developing and implementing the “Roadmap to EAF” which includes identification of VMEs.	NAFO (2011)
2012	First mention of connectivity in relation to recovery of sponge grounds from bottom-contact fishing.	NAFO (2012)
2013	Connectivity first raised in the assessment of areas closures for the protection of sea pen Vulnerable Marine Ecosystems (VMEs), for example: “the lack of protection for the entire eastern part of their distribution is of concern for the long term sustainability of these VME given the lack of knowledge of recruitment processes and connectivity “, “the areas between 13 and 14 should be linked for sustaining connectivity in this system”, “the system of sea pen VMEs on Flemish Cap”.	NAFO (2013)
	WG-ESA notes that “the closed areas should be viewed as connected systems”.	NAFO (2013)
2015	“Index of Risk of VME fragmentation”, the proportion of discrete VME without protection, introduced for the assessment of Significant Adverse Impacts (SAI) of bottom-contact fishing (sensu FAO, 2009). This risk was incorporated into “Overall SAI risk scores” for sponge, sea pen and large gorgonian VME in the NAFO Regulatory Area (NRA).	NAFO (2015b)
	ToRs for WG-ESA updated and include: Spatial Considerations. ToR 2. In support of the Roadmap, develop research and summarize new findings on the spatial structure and organization of marine ecosystems, with emphasis on connectivity, exchanges and flows among ecosystem units in the NAFO Convention Area.	NAFO (2015b)
2018	Connectivity agreed to be a part of the re-assessment of VME closures in 2020: “Consideration of the connectivity of VMEs through links between propagule/larval transportation and VME distribution/location... should be included. This will highlight the importance of certain VME closed areas in supporting larval dispersal and recruitment between other VME closed areas of the same type...”	NAFO (2018)
	First assessment of connectivity among closed areas within the fishing footprint in the NRA.	Kenchington <i>et al.</i> (2018); NAFO (2018)
	Agent-based modeling of sea pens introduced for understanding the level of connectivity and dependence among the distinct aggregations that exist on the seascape.	NAFO (2018)
2019	“Projected Connectivity Among Closures” added to the assessment of SAI to be applied to the reassessment of bottom fisheries in 2021. Connectivity is defined as the “physical links between two or more areas; an area is considered to have redundancy when two or more other areas connect to it. These properties relate to the ability of populations to persist.”.	NAFO (2019); Wang <i>et al.</i> (2019)
	Connectivity discussed as a part of the re-assessment of VME closures and included in the identification of High Priority Areas for Management Action.	NAFO (2019)
2020	VME Closure Connectivity Index developed based on enhanced model developments and connectivity characteristics for each of the areas closed to protect large gorgonian corals, sea pens and sponges in the NRA, including outputs from 3D forward- and backward-tracking biophysical models using yearly and seasonally averaged oceanographic models.	NAFO (2020); Wang <i>et al.</i> (2020)
	“Importance as a Larval Source for other Closed Areas” introduced to the review of the closed areas in addition to retention and redundancy.	NAFO (2020)
	Agent-based modeling of sea pens identified that, in the absence of fishing, recovery of an area could take place in 50 years. Also that, under current fishing scenarios, sea pen connectivity might be compromised, leading to longer recovery times. In the case of the NAFO closures, recovery time could exceed 100 years.	NAFO (2020)
	Proposed management actions prioritized based on connectivity. The lowest priority for management action is for ‘Sink’ areas that have ‘Moderate’ to ‘Strong’ Redundancy, on the basis that such areas likely receive larvae from other closed areas to retain their local populations. Other scenarios are discussed.	NAFO (2020)
	Isolation/Proximity Index as a measure of VME fragmentation introduced.	NAFO (2020)
	Work of WG-ESA on connectivity discussed in the context of Other Effective Area-Based Conservation Measures (OECMs).	NAFO (2020)
2021	Application of Isolation/Proximity Indices to Large-sized sponge VMEs	NAFO (2021a)
2022	Connectivity among VMEs evaluated using particle tracking models applied to the seven VME indicator taxa (Large-size sponges, Sea pens, Large and Small gorgonian corals, Black corals, Sea squirts and Erect bryozoans).	NAFO (2022a)
2024	Publication of simulations of VME habitat loss on connectivity networks for each of the VME indicator taxa.	Wang <i>et al.</i> (2024)
2025	When the six sponge areas in the NRA were submitted to the World Protected Area database as OECMs, they were considered to be ecologically connected based on connectivity analyses conducted in WG-ESA.	https://www.nafo.int/Fisheries/OECMs [Accessed 8/14/2025]