DALHOUSIE UNIVERSITY

October 16, 2024

The Honourable Kent Smith, E.C.N.S.
Minister of Fisheries and Aquaculture
1741 Brunswick Street, Suite 410
Halifax, NS B3J 3X8

Dear Minister Smith:

Re: Nova Scotia Aquaculture Science Advisory Committee Science Advice on the Recommended Criteria for Inclusion for Coastal Classification in Nova Scotia (NSASAC-2024-01)

On behalf of the Nova Scotia Aquaculture Science Advisory Committee (the Committee), please accept this submission of Science Advice on the recommended criteria for inclusion in the preliminary, suitability screening assessments completed as part of the coastal classification system, outlined in the July 22, 2024 report titled, Recommendations on the Criteria for Inclusion for the Regional Assessment of Aquaculture Development in Nova Scotia.

On July 16, 2024, the Committee convened for an overview presentation on the coastal classification project delivered by the Department of Fisheries and Aquaculture (the Department) and the Centre for Marine Applied Research (CMAR). The Committee received the Request for Science Advice from the Department on August 15, 2024, and began its review of the report and supporting documentation.

The Committee met on September 12, 2024, to discuss the findings of their review, request clarification where needed, and deliver its science-based recommendations in response to the issue requiring science advice. Input was provided by all committee members and the advice has been formulated by consensus. No conflict of interest was identified throughout this review process.

Please find enclosed the originating Request for Science Advice from the Department and the resulting Science Advice from the Committee for your consideration.

Yours sincerely,

S Colombo

Dr. Stefanie Colombo

Chair, Nova Scotia Aquaculture Science Advisory Committee

Enclosures

FACULTY OF AGRICULTURE | *Department Animal Science and Aquaculture*
Haley Institute | Room 100 | 58 Sipu Road | PO Box 550 | Truro NS B2N 5E3 Canada
902.893.6644 | Fax: 902.895-6734
DAL.CA

Fisheries and Aquaculture
1575A Lake Road
Sandy Point, Nova Scotia
B0T 1W0
novascotia.ca

NOVA SCOTIA AQUACULTURE SCIENCE ADVISORY COMMITTEE
REQUEST FOR SCIENCE ADVICE

☒ NEW REQUEST **REQUEST ID#:** NSASAC-2024-01

☐ PREVIOUS REQUEST (CARRY-OVER)

Title of Request:
Review and Validation of the *Recommendations on the Criteria for Inclusion* for the Regional Assessment of Aquaculture Development in Nova Scotia.

REQUEST DETAILS

Issue Requiring Science Advice (to be posed as a question):
Does the Committee feel that the process used for selecting the criteria is appropriate, and that the recommended list of criteria for inclusion is accurate and complete?

Select Committee Mandate(s) Applicable to the Request:	
☒	Advise and provide recommendations to the Minister of Fisheries and Aquaculture related to science pertaining to the aquaculture regulatory framework to ensure a sustainable, responsive, and prosperous industry.
☒	Facilitate ongoing consultation with experts on the science of aquaculture informing regulation.
☐	Address specific issues or questions identified by the Minister, through work with the Nova Scotia Aquaculture Regulatory Advisory Committee, stakeholders or Department staff, relating to the science of aquaculture on an ongoing basis.
☐	Identification and interpretation of relevant issues for discussion of science-based evidence for development of the aquaculture regulatory framework.
☐	Advise on existing and emerging science in the aquaculture industry.

Rationale and Background Information:
The 2021 Minister's Mandate Letter outlined a commitment to deliver a classification system that rates Nova Scotia's coastal waters based on their suitability for finfish aquaculture. A classification system that prescreens coastal areas for aquaculture

suitability was a core recommendation of the 2014 Doelle-Lahey Panel Report[1]. As defined in the report, a suitable site is one that has appropriate biophysical conditions while also being compatible with other economically, socially, and culturally important activities. The report suggests that the starting point for considering suitability of a coastal area should be biophysical conditions (such as water depth, current speed, oceanographic benthic circulation patterns, proximity to salmon rivers, etc.) and that social, cultural and economic considerations would feature more prominently in smaller-scale assessments (i.e., strategic assessments or individual proposals for aquaculture operations).

The Doelle-Lahey Panel Report outlined a "three-pronged approach" that included:

1. A high-level, *general assessment*, that would incorporate constraints, restrictions and / or thresholds to identify areas that are potentially suitable.
2. More targeted, *strategic assessments*, in particular coastal areas (ex. areas identified as potentially suitable).
3. Site-level assessments completed as part of the site approval process, which would take place in response to an application for license and lease.

Recent initiatives have included a similar approach, relying on low-resolution, basic data to complete a preliminary, high-level spatial assessment. The results of these preliminary assessments were then used to guide strategic development decisions and / or inform larger spatial planning exercises. Similar initiatives include:

- Regional Assessment of Offshore Wind Development in Nova Scotia process includes a large-scale, regional assessment that identified six "potential development areas". Next steps include more targeted investigation and engagement within these identified areas.
- Palau Aquaculture Suitability Assessment used key spatial considerations and thresholds to produce an online mapping tool that identifies "potential areas" for aquaculture development. The developers suggested that the potential areas could be used to identify aquaculture zones, but decision making should incorporate additional considerations, such as carrying capacity modelling.
- NOAA Aquaculture Opportunity Areas (AOAs) used spatial analysis data to select regions for more focused evaluation. The exact locations of the AOAs will be identified within the selected regions, using a more targeted, site-level analysis.

Similar to the initial stages of the initiatives outlined above, and in line with the recommendations outlined in the Doelle-Lahey Panel Report, the suitability assessments completed for this undertaking will be used to prescreen coastal waters

[1] Doelle, M. & Lahey, W. (2014). A New Regulatory Framework for Low-Impact/High-Value Aquaculture in Nova Scotia. https://novascotia.ca/fish/documents/Aquaculture_Regulatory_Framework_Final_04Dec14.pdf

for aquaculture suitability. While the mandate only includes a commitment to assess finfish suitability, the scope of the project was increased to also include shellfish suitability.

The Centre for Marine Applied Research (CMAR) has been engaged to complete the assessments and develop an online mapping tool to display the results. CMAR will be utilizing a Spatial Suitability Analysis (SSA) that couples Geographic Information System (GIS)-based process with Multi-Criteria Decision Analysis (MCDA) techniques. Further details are provided in CMAR's methods review document (see below # 1).

The first step of the GIS-MCDA process includes selecting the list criteria (i.e. types of information) that will be used for the high-level, large-scale suitability assessments. CMAR have developed a science-based process for selecting the criteria and have generated the *Recommendations on the Criteria for Inclusion* Report (see below # 2). This work was completed in collaboration with Data Committees that were established by CMAR for this project (see below # 3). An overview of the feedback received from NSDFA and the Data Committees is outlined in the Summary of feedback and response document (see below # 4).

At this time, the Department is seeking technical review and validation from the Nova Scotia Aquaculture Science Advisory Committee (NSASAC) on the proposed criteria for inclusion and the process used to select the criteria.

Following NSASAC's review, a summary report will be published on the Department's engagement website for public review and feedback via online survey. Additional information, such as fact sheets, will also be published on the website to keep people informed – promoting awareness and understanding of the project, its limitations, and potential next steps.

Supporting Documentation (attachment or link):	
1.	Methods Review for Spatial Suitability Analysis in the Context of the Coastal Classification System (CCS)
2.	Recommendations on the criteria for inclusion. A report in support of a regional suitability assessment of coastal aquaculture in Nova Scotia (including appendices)
3.	List of Coastal Classification Data Committee Members
4.	Summary of feedback and response to working drafts of Report of Recommendations on Criteria for Consideration

Timelines for Receiving Science Advice:
September 30, 2024

Fisheries and Aquaculture
1575A Lake Road
Sandy Point, Nova Scotia
B0T 1W0
novascotia.ca

REQUESTING ADVICE

Name of Director (or Delegated Authority)	**Request Date**
Hilary Steele	July 31, 2024
Name of Coordinator/NSDFA Staff	**Date Submitted to Committee**
Jennifer Feehan	August 15, 2024

CENTRE FOR MARINE APPLIED RESEARCH

2024-DRAFT.v.0.3.

Methods Review for Spatial Suitability Analysis in the Context of the Coastal Classification System (CCS)

July 3, 2024

Prepared by:

Jenny Weitzman
Gregor Reid
Leah Lewis-McCrea

27 Parker Street · Dartmouth, Nova Scotia · B2Y 4T5

CMAR.CA

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Version Control			
Status	**Version**	**Date**	**Rationale**
Draft	0.1	March 6, 2023	First draft
Draft	0.2	August 25, 2023	Addition of glossary, revisions to refine language and provide additional context based on further project clarifications
Draft	0.3	July 3, 2024	Refinement of terminology and language for consistency to other documentation

Glossary

Attribute (Criteria)	A measurable property (quality / quantity) of the real-world geographic system, or relationship between geographic elements
Boolean	A data type that is binary in nature, having only two possible values either as “true” or “false”
Constraint	A type of criterion / parameter that serves to limit the spatial scope of suitability area; element or feature that represents restrictions and / or limitations that would preclude the activity under consideration
Criteria	Attributes that are evaluated to determine how well an area meets various objectives of the project
Decision-makers	The individual(s), groups of individuals, or organizations involved in making judgements for the assessment (especially with respect to assigning scores and weights)
Factor	A type of criterion / parameter that enhances or detracts from the suitability of a specific alternative for the activity under consideration
Geographic Information System (GIS)	Computer system for capturing, storing, analyzing, and presenting geographical data
Multi-criteria Decision Analysis (MCDA)	A collection of formal approaches to explicitly account for multiple criteria in decision-making environments
Normalization	The process of transforming/converting data from many different sources to a common/consistent format or scale that will allow for meaningful comparison, analysis, and interpretation.
Objective (Criteria)	A statement about the desired state of the system under consideration, indicating the direction of improvement of one of more attributes (i.e., the less (or more) of the attribute, the better)
Parameter	Refers to specific measures agreed to be important in achieving a criteria’s objectives and goals (also see sub-criteria)
Resolution	The dimensions represented by each cell (pixel) within a GIS environment

Scoring	The process of assigning suitability scores to criteria based on the implications for aquaculture suitability, allowing for meaningful comparison, analysis, and interpretation.
Spatial Suitability Analysis (SSA)	A GIS-based process used to determine the appropriateness of a given area for a specific use
Standardization	See normalization
Sub-criteria	In criteria grouping, sub-criteria describe criteria that are clustered alongside other sub-criteria, contributing the overall objective of higher-level criteria.
Suitability Index (SI)	A composite measure that represents the overall suitability of a location, as calculated by combining the scores assigned to individual criteria into a single index value for each location.
Suitability scale	The range of suitability scores assigned to a given criterion / parameter
Suitability score	a numerical value indicating an area's suitability for a given parameter / criterion
Suitability rating	The descriptive rating associated with a specific suitability score, indicating an area's suitability
Weight	The relative importance of a given criterion / parameter compared to other criteria / parameters

1 Introduction

Spatial Suitability Analysis (SSA) is a geographic information system (GIS)-based process or strategy that seeks to designate and / or classify an area(s) with a given ranking based on the suitability of desired criteria to meet multiple objectives. SSA relies on Multi-Criteria Decision Analysis (MCDA), a process that aims to take explicit account of multiple diverse criteria in aiding structuring complex problems with multiple often varying considerations (Belton and Stewart, 2002), such as aquaculture suitability.

Coupling GIS with MCDA techniques (GIS-MCDA) provides a powerful platform for handling complex problems involving spatial data, which is becoming a well-established approach applied across a variety of planning and management situations (Malczewski and Rinner, 2015). Fundamentally, GIS-MCDA is a procedure that combines quantitative geographic data with decision-makers (experts and / or agents) preferences into a decision (output) map, and in the case of SSA, a suitability map (see **Figure 1** for a general process flow). MCDA allows for the calculation of the combined suitability of a range of criteria by standardizing criteria to a comparable scale based on suitability thresholds and characteristics, as established through scientific literature and decision-makers' judgements. Suitability can thus be calculated across multiple cells within a larger area (i.e., grid), which can effectively be mapped and analyzed using GIS software.

A common understanding of the project's context is critical for MCDA projects. This includes identifying the decision points, and considering the criteria by which decisions are made. Various methods, approaches, and techniques may be applicable across each of the four broad MCDA project phases of 1) structuring, 2) standardizing/scoring, 3) weighting, and 4) aggregating and is dependent on the broader project context and objectives (Malczewski and Rinner, 2015) (**Figure 1**). Generally, the outcome of MCDA depends on the assumptions and decisions made in the development of the process at the various phases. Effective design of a SSA process thus requires decisions across several key methodological considerations that can influence the complexity and validity of the outputs.

This report is designed as a preliminary overview and discussion of key methodological considerations relevant for the design and implementation of analysis across the four SSA phases. Some general considerations for determining the most suitable methods for SSA and preliminary recommendations for Nova Scotia Department of Fisheries and Aquaculture's Coastal Classification System (CCS) for aquaculture are presented. However, more project-specific and relevant recommendations for each distinct phase of the SSA assessment will be outlined in subsequent reports based on the ongoing discussions and project decisions, especially in consideration of the objectives and scope of the assessment.

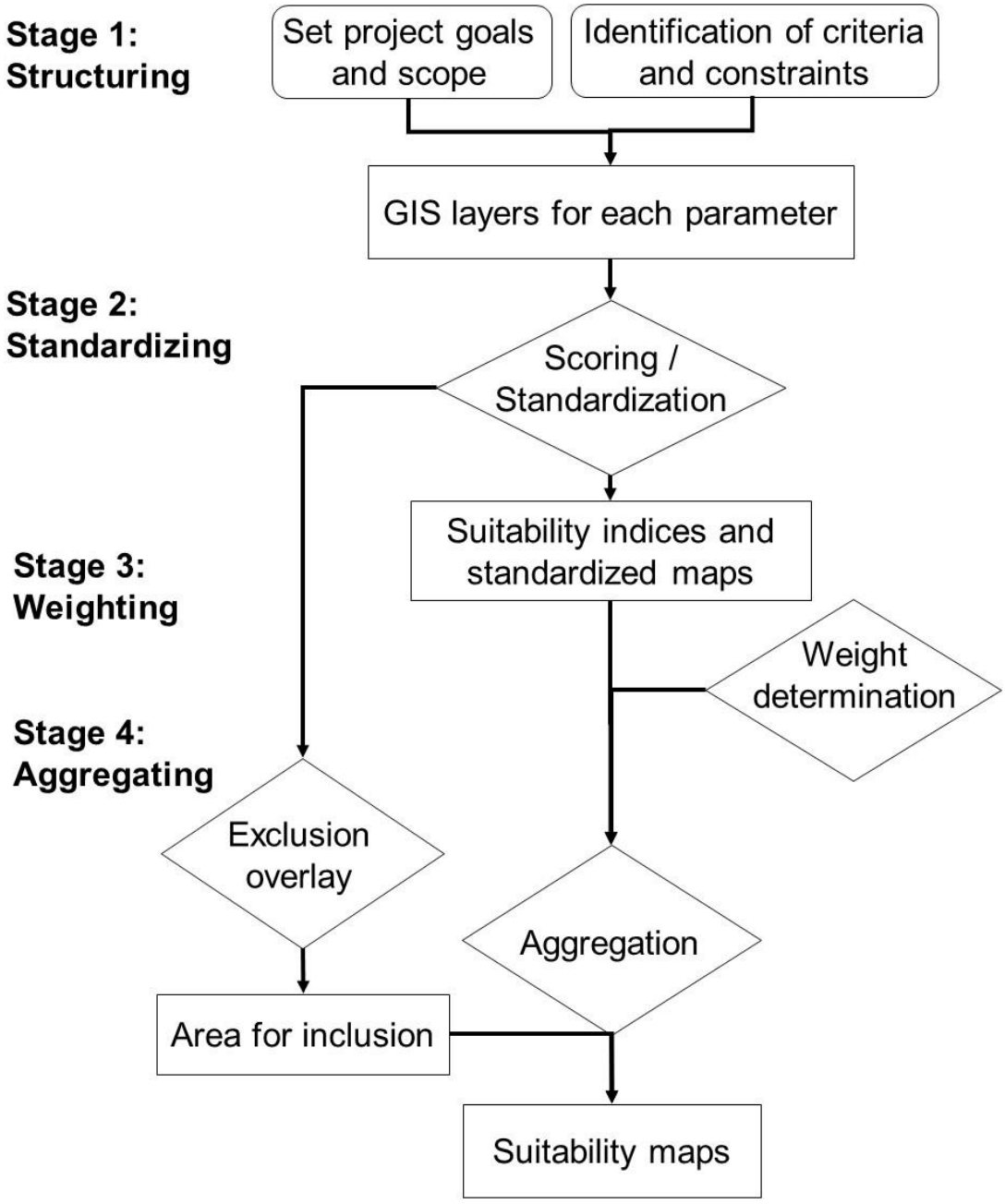

Figure 1. A representative flowchart of the four general phases of Spatial Suitability Analysis (SSA) using GIS and Multi-Criteria Decision Analysis (MCDA) based methods. ⬭ = goals ▭ = GIS layer ◇ = methods.

2 Spatial Suitability Analysis Phases

2.1 Phase 1 – Structuring

In the project structuring phase, the broad project goals and objectives are outlined. This has important consequences for the types of methods available and sources of uncertainties in subsequent phases. Generally, the goals of project structuring in the context of MCDA is to design a defined and logical analysis structure that incorporates criteria which best reflects the objectives of the project (Belton and Stewart, 2002), in this case the assessment of suitability for aquaculture. Key to this is consideration for the decision-makers involved, the spatial extent (scope) of the analysis, and careful criteria selection.

2.1.1 Decision-makers

Central to MCDA analysis is the involvement of decision-makers[1], that is individuals, groups of individuals, or organizations, with a role in making judgements related to the project, specifically how the assessment is conducted. MCDA processes require judgements across potentially numerous diverse interests and priorities[2]. Key jugdements in an SSA include assigning suitability scores (**Phase 2 –Scoring**) and assigning weights (**Phase 3 – Weight determination)** to criteria. Both scoring and weighting effectively build in judgements about whose preferences the scores and weights represent and thus the process by which these decisions are made influence the methods and approaches for scoring and weighting.

Often, those involved in the assessment include more than one individual, and thus selection of scoring schemes and weights ultimately involves some form of group judgement, reflecting the judgements of multiple participants (or 'decision-makers'). Group-judgement can broadly be divided into either shared or aggregated (Belton and Pictet, 1997). Shared (or univocal) judgments involve the group coming together to propose a single value (s) for scores and weights assigned. This can require techniques that seek consensus among a group of individuals. Shared judgements is often appropriate when the goals, priorities, and preferences are relatively consistent within the group, such as the case within an government organization. If there are conflicting goals and priorities among participants, the process of determining the scoring and weighting can impose substantial cognitive burden on participants and require considerable time commitment, with participants needing to remain invested and engaged throughout the SSA. In contrast, in aggregated judgements, several individuals or groups assign their preferred scores or weights, and the final judgement is based on an average across all participants. This process often employs survey techniques to combine and analyze preferences across various individuals, which can often be computationally demanding and complex. The choice of process thus depends on

[1] In this context, 'decision-makers' does not refer to government or policy making officials, but rather a wider range of individuals whose judgements will be captured in scoring and weighting criteria for suitability analysis.

[2] In the context of MCDA projects in policy contexts, these often include experts, analysts and representatives from government, research, or industry, where appropriate.

the actors involved in the process and the underlying goals of the SSA. As this assessment is being produced through an evidence-based and collaborative effort involving the Centre for Marine Applied Research, NSDFA, and other experts and network partners (e.g., Fisheries and Oceans Canada) brought together through advisory committees established under the CCS project[3], a process that elicits shared judgements is most appropriate.

2.1.2 Spatial scope

The project *scope* can be defined as the total spatial area upon which the SSA will be applied. Results of GIS-MCDA are ultimately spatially scale-dependent (Malczewski and Rinner, 2015). The scope on which the analysis will be calculated can influence the computational needs of the SSA methods. Larger spatial scopes require data across a larger area. Spatial scopes are largely determined by overarching project goals. In the context of aquaculture, a small spatial scope may be applied for local site selection within a bay but cannot inform regional planning. A province wide SSA thus requires a large spatial extent.

Spatial extent is closely linked to spatial resolution, having important consequences on SSA analysis and outputs. In GIS-MCDA applications, suitability is calculated for each 'cell' (or 'pixel' within the larger study area (i.e., grid), with each 'cell' being the spatial unit of analysis which will display a single suitability value. The size of individual 'cells' (otherwise known as resolution) ultimately affects the level of detail represented within the spatial scope (see **Figure 2** as an example). The choice of cell size can reflect trade-offs in data availability and project objectives which ultimately affect the output of suitability. Ideally, full spatial coverage is required across the scope, so the selection of the cell size needs to reflect data availability and be theoretically justified given the criteria selected. While smaller cell sizes would enable greater spatial accuracy, the smallest possible cell size for the final suitability will be limited by the lowest resolution data across all parameters. The cell size should also be appropriate for the phenomena under consideration, and thus reflect broader project objectives. For example, Norway's Traffic Light System for the management of finfish aquaculture assigns a single suitability score for each of Norway's 13 production areas (i.e., 13 large 'cells') reflecting legislative boundaries (Ministry of Industry and Fisheries, 2017).

[3] Which include a Technical Oversight Committee (TOC) and three Data Committees (DCs).

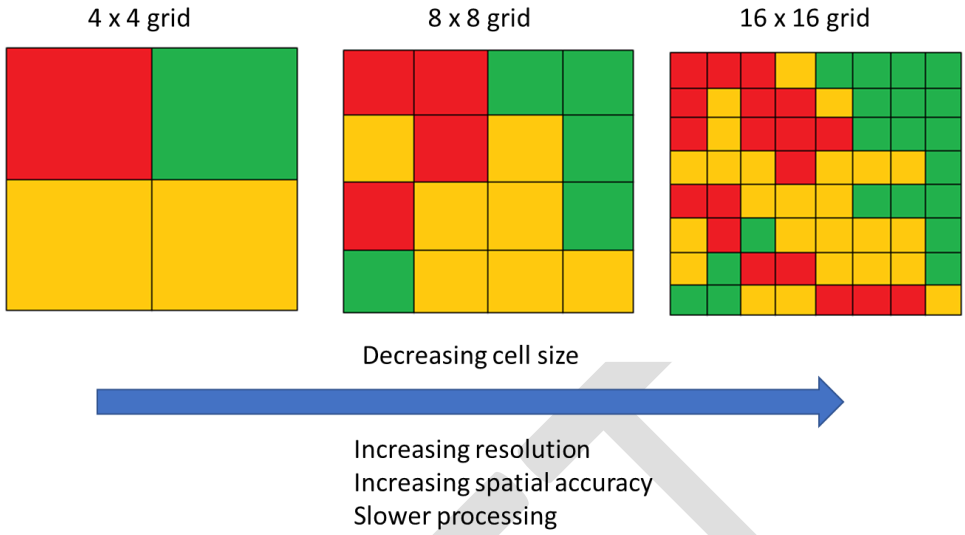

Figure 2. Hypothetical suitability maps at different cell sizes and implication for processing and interpretation.

Another important consideration is over how weights and scores are applied across each cell within the larger scope (grid). The judgements (e.g., weights and scoring classifications) can either be consistently applied across the entire scope (i.e., a "global" approach), or applied differently across different areas (i.e., a "local" approach) (Malczewski and Rinner, 2015). To that end, a global approach assumes that the standardization categories and weights assigned to parameters remain constant; in other words, each 'cell' of analysis is subject to the same rules for scoring and weighting. In the example of a suitability classification, this would assume that what determines a low versus high suitability value is universal across the scope. For example, if a temperature value of 16 °C is considered suitable in one area, then that same temperature value (16 °C) must also be considered suitable (e.g., given the same suitability rating) in another area. To ensure the validity of suitability scores, the selection of criteria, standardization, and weighting process should reflect universally applied thresholds and objectives.

While the "global" approach is the most straightforward and common in MCDA applications, a few weighting procedures (e.g., see **Ordered Weighted Average**) and standardization functions can apply the "local approach" and integrate spatial heterogeneity of weights and scoring systems (Malczewski and Rinner, 2015). The "local" approach enables variability in scores and weights across different areas and can account for contextual differences. It is also more computationally complex and requires a more localized understanding of how parameter values vary across the project scope. While acknowledging these limitations, a "global" approach is recommended for projects with large spatial scopes and multiple criteria.

2.1.3 Criteria and parameter selection

An essential feature of MCDA is the ability to integrate multiple considerations or criteria relevant to suitability in the case of SSA. Broadly, criteria in the context of MCDA can be defined as attributes that are evaluated to determine how well an area meets the objectives of the

assessment. In this way, criteria include both the concept of attributes, that is a measurable property of a geographic environment, and objectives, which is the statement about the desired state of the attribute (Malczewski and Rinner, 2015). In MCDA, considerations can be grouped into a hierarchy of criteria based on underlying objectives and theoretical relevance (Belton and Stewart, 2002). Grouping together criteria into sets that relate to separate and distinguishable components relative to the overall objective can help ease the process of weighting (see **Phase 3 – Weight determination**) and is especially useful when a large number of criteria are considered. In the context of the CCS, suitability could be grouped based on overarching goals, such as "Biophysical", "Conservation" or "Ocean Use" criteria, which may also each encompass multiple parameters (i.e., often also called sub-criteria).

Careful consideration for the selection of criteria (and parameters) is a critical step in MCDA project structuring. When selecting criteria for MCDA, several desirable properties can be considered (**Table 1**), including value relevance, measurability, non-redundancy, judgmental independence, completeness, and operationality (Belton and Stewart, 2002).

Table 1. Relevant principles to consider when deciding on criteria for inclusion in MCDA applications (Belton and Stewart, 2002).

Principle	Description
Relevance	Criteria need to be linked to conceptual objectives
Measurability	Ability to measure / characterize criteria in a consistent manner
Non-redundancy	Criteria should be mutually exclusive (no double-counting) to avoid inflating or over exaggerating the influence of individual criteria
Judgmental independence	Criteria can be assessed independently of each other
Completeness and operationality	All important aspects of the decision-context should be captured, parsimoniously

Ultimately, parsimony is an important consideration in criteria selection, as the final list of criteria should be as simple as possible yet capture the process' complexity to meet objectives and goals (Belton and Stewart, 2002). The total number of criteria and parameters selected can have important consequences for the final output and influence the computational needs of the analysis and the resulting uncertainty of outputs. The inclusion of additional criteria increases both the number of decisions on scoring and weighting and the data and analysis required. Selecting the number of parameters will also partly depend on the process of standardization, weighting, and aggregation selected (further described in Phases 2, 3, and 4 below).

Practical considerations like data availability are also significant in determining the inclusion of parameters. Ideally, parameters should be selected based on having access to data for all locations across the spatial scope of the project. If data is not available for a parameter, precluding that parameter from analysis will ultimately increase the relative influence of others on the final suitability. This can provide a misleading representation of suitability when comparing between

areas if different areas are based on different criteria. Therefore, the cell size and project scope are also important factors in considering which parameters to include.

2.2 Phase 2 –Scoring / Normalization

During the second phase of an MCDA, data are transformed through a scoring process into a normalized scale. The normalization (also sometimes called standardization) process allows the assignment of a dimensionless score to different units of measurement so they can be easily compared and aggregated. These normalized criterion scores, otherwise known as suitability scores, capture the priorities or preferences of the values within a criterion in relation to finfish aquaculture suitability. Scoring systems may calculate suitability across a continuous scale (0 to 1) or can divide scores into discrete scales that separating datasets into hard boundaries / categories, with higher scores representing higher suitability (for example, 1 = less suitable, 2 = sub-optimal, 3 = optimal).

For scoring, criteria must first be categorized as either 'factors' or 'constraints', since each has implications for how they are scored and incorporated into the analysis. Factors are recognized as criteria that must undergo normalization through the assignment of suitability scales. Normalized factors then become aggregated to produce a single final suitability rating. While constraints, or restrictions, are defined as binary parameters that when normalized become Boolean, in that they are either assigned a score of "0" or "1". While some MCDA applications only use constraint criteria, when combined with factors, constraints are generally overlaid with suitability maps in a separate, compensatory process to remove areas eligible for suitability (**Figure 1**).

Several normalization methods are available for MCDA (**Table 2**), and can have different advantages and disadvantages depending on the underlying datasets and the desired outcomes and communication objectives (Cinelli et al., 2020).

Table 2. The effect of different normalization methods on suitability scores, with examples of different scoring at three different areas (cells). See original table from Cinelli et al. (2020) for more description on each method. Colour scheme demonstrates the highest suitability in green, and the least suitability in red, with yellow in the middle.

Alternative (e.g., cell)	**Raw values**	**Rank** Ranked from best to worst	**Percentile rank** Ranked based on percentage of values equal or lower than itself	**Categorical (1,2,3)** Data transformed according to predefined rules	**Min-Max** Linear transformation driven by minimum and maximum values	**Logistic** Normalizes the data with a sigmoid curve
A	10	1	0.75	3	1	0.74
B	5	2	0.5	2	0.44	0.48
C	1	3	0.25	1	0	0.25

Noramlization methods can also be categorized as being data-generated or user-generated. Data-generated ones are based on the statistical properties of the data, such as the minimum, maximum, and standard deviation values. Data-driven methods commonly apply mathematical

functions to normalize data through linear, exponential, or multi-modal models appropriate to the data. Data-generated methods generally produce a continuous scale, most often represented from 0 to 1 (or 0-10, or 0-100), but can also produce discrete categories by dividing data into statistical quartiles. Data-generated scales are advantageous since they reflect the underlying properties of the original datasets. However, the final interpretation of continuous scales can be complex and may require careful explanation to interest holders and end-users (Cinelli et al., 2020). Alternatively, continuous scales can be converted to discrete categories following suitability analysis to enable easy interpretation. For example, Porporato et al. (2020) developed a suitability index for aquaculture ranging from 0 to 1, which was then equally partitioned into five discrete suitability classes following existing European directives (European Communities, 2000).

In comparison, user-generated methods rely on direct or indirect inputs from decision-makers to assign scores to criterion values. User-generated methods are often time-consuming and can be difficult to reach agreement on categories given knowledge gaps or variable interests of the individuals generating the scale classifications. Generating discrete scales can also be challenging since categories must be justifiable and supported by strong evidence. However, discrete categorization is advantageous since aggregation is computationally simpler. In addition, the outputs of both partial and final suitability maps can be more easily communicated to interest holders and end-users.

Other normalization processes may use a combination of scale types for different data. While this approach can better align the scale to the relevant data and reflect a diversity of data types, applying different scales may not be possible with all methods of aggregation (see **Phase 4 - Aggregation**). In addition, inconsistency of scales reduces the clarity during interpretation of outputs, resulting in the need for careful explanation to end-users. For example, in 2019, England calculated suitability for aquaculture using various types of normalized scales across parameters but represented the final scale as continuous from 0 to 1 (MMO, 2019).

In conclusion, discrete user-generated normalization is most suitable for CCS. However, the number of discrete categories is an important consideration for SSA. Fewer categories are generally considered to improve comprehension and communication of findings. This is typically applied across existing aquaculture SSAs, exemplified by classification systems in Norway, which categorises production areas as red, yellow, or green (Ministry of Trade Industry and Fisheries, 2015) and in Scotland, which classifies each sea loch based on three-category system of suitability (The Scottish Government, 2014). Nevertheless, parameters may not easily be divided into few categories for suitability. It can become difficult to justify the distinction between categories, since there can often be variability in the data in relation to its suitability, meaning that fewer categories can give insensitive results. Therefore, categorization needs to be well-justified based on strong scientific evidence or expert insights. This may be possible for some criteria (for example, temperature where mortality thresholds are well-established) but not for others. Alternatively, higher number of categories (for example 9-point) can reflect the variability and nuance of parameters and has been applied in previous aquaculture suitability exercises (Perez et al., 2003; Vaz et al., 2021). However, scoring systems with large number of categories can be complicated

to use, and results not as easily interpreted. Larger number of categories are also challenging, since the implications for regulatory or policy decisions is not as clear.

2.3 Phase 3 – Weight determination

Before normalized criteria can be aggregated, considerations for criterion weights must be applied. A weight is a value assigned to a criterion / parameter that indicates its relative importance (Malczewski and Rinner, 2015). The greater the weight, the more important the criteria / parameter is to overall suitability. Weights must be ratio-scaled; that is if parameter A is twice as important as parameter B (weight = 0.25), the weight value must also be twice (e.g., parameter A weight = 0.5).

Another consideration for weighting is that when more than a few criteria are involved, it becomes difficult to make weight assignments on the set as a whole, especially if a variety of individuals are involved in contributing to the judgements. Comparing and ranking parameters across different qualitative objectives can be challenging and often is not practical. To reduce decision complexity, criteria can be grouped, and weights assigned in a nested, hierarchical weighting process that provides separate weights for broad criteria and for individual parameters nested within the criteria (**Figure 4Figure 4**). In a hierarchical weighting, broad criteria groupings would first be based on their relative importance. Then, within each criterion, a subset of parameters would be rated in the context of each criterion objectives. In this way, partial suitability maps for each criterion can be generated, and a final suitability map can be generated based on normalized weights of all parameters. Hierarchical decomposition of criteria involving several heterogenous criteria (e.g., "Biophysical", "Conservation", and "Ocean Use") is cognitively easier on those involved in weighting. This approach also allows SSA to develop criteria suitability maps based on

parameter weighting and a final aggregated suitability map based on criteria weighting, which are useful in visualizing the suitability implications of each criterion both individually and together.

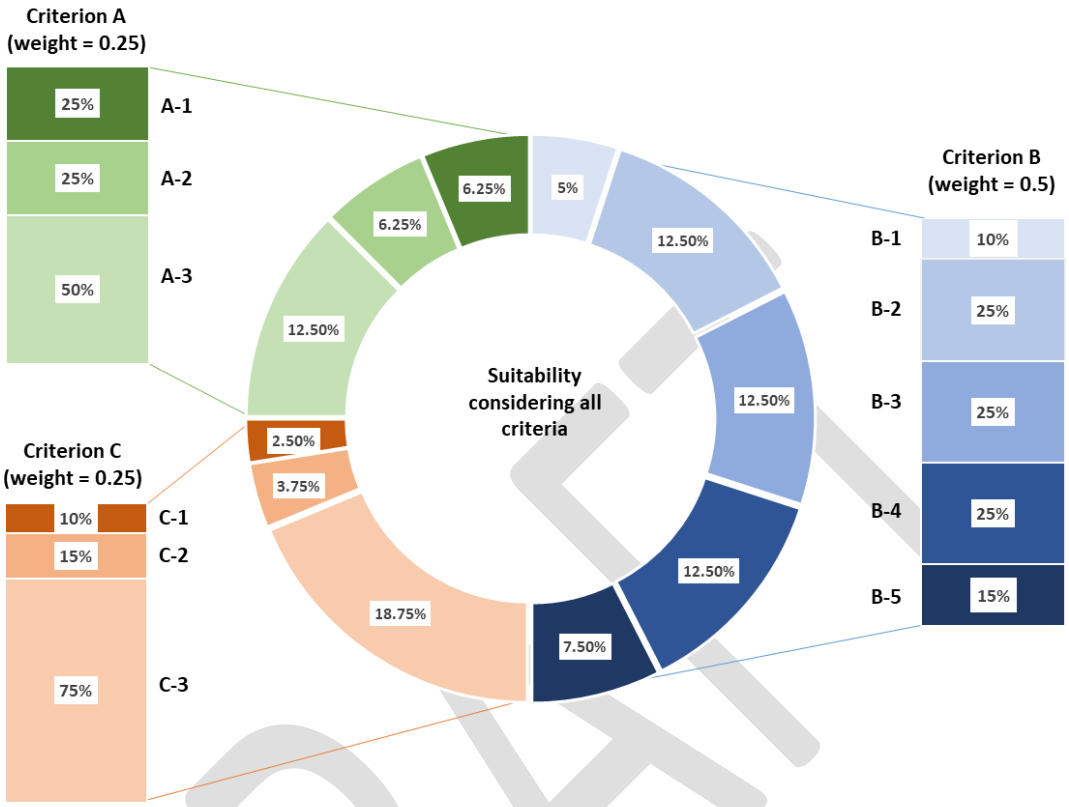

Figure 4. Graphical representation showing example of hierarchical weighting, with three criteria (A, B, and C), and variably weighted parameters within each criterion. Final suitability maps would be based on normalized weights (donut graph) which include multiplying parameter weights (bar charts) by criterion weights.

A variety of techniques can be used for the development of weights (Malczewski and Rinner, 2015). Three main groups of techniques for weight determination are most relevant for the CCS assessment including rating, ranking, and pairwise comparison. Rating and ranking methods can be done through both shared judgements (i.e., providing a single value for each criterion) or through aggregated judgements, with multiple weights across multiple decision-makers. Methods for pair-wise comparison are only possible through aggregated approaches and can help reduce the complexity and cognitive effort on participants.

2.3.1 Rating methods

Rating methods generally require the participants to estimate weights based on a predetermined scale. In the point allocation technique, a certain number of points is allocated across all criteria, often to total 100 or 1. The point allocation technique is one of the simplest methods to determine criteria weights and is easy to aggregate across multiple participants and combine scores across criteria.

Another form of weight rating includes direct rating, performed by asking decision-makers to assign numerical weight values to each criterion, with higher numbers relating to relative preference or importance of the criteria. This method is generally non-comparative and does not involve any trade-offs between criteria. In this method, two criteria might have the same rating, and they do not add up to a total, making it more challenging to incorporate during aggregation.

2.3.2 Ranking methods

In ranking methods, all criteria are ranked from lowest to highest importance. Aggregated rank weights can then be determined through mathematical calculations include rank sum, rank exponent, or rank reciprocal. Ranking methods are simple and have been demonstrated to be empirically useful in many decision contexts, especially when aggregating weights across multiple individuals. However, this method is often not appropriate with large numbers of criteria, or across different underlying objectives. Decision-makers may find it challenging to rank one criterion above another, especially across diverse objectives. Furthermore, it is not always theoretically appropriate to do so, for example when comparing biophysical and socio-economic objectives.

Assigning equal weights to parameters is considered a type of ranking approach and is often applied in many existing MCDA applications due to its inherent simplicity. Equal weighting often assumes that no information is known about the relative importance of preference, functioning rather on the argument of uniform distribution of weights across all criteria (Ezell et al., 2021). However, assigning equal weights is not theoretically justifiable (Malczewski and Rinner, 2015), especially if information exists to distinguish criteria on the basis of importance (Ezell et al., 2021). Equal weighting is also a challenge if applying a hierarchical criteria structure, since decisions about where to apply equal weights on the hierarchy have automatic implications for the contribution of each criterion to the total score (for example, see **Figure 4**). While it may be possible to justify equal importance of few criteria, equal importance across larger number of criteria becomes theoretically inappropriate.

2.3.3 Pairwise comparison methods

Pairwise comparison methods such as the Analytical Hierarchy Process (AHP) (Saaty, 1980) is a common procedure for weight determination in many GIS-MCDA applications (Malczewski and Rinner, 2015). AHP generates all criteria weighting by eliciting preferences through a series of pairwise comparisons, as opposed to utilizing numerical values directly. This process helps reduce the complexity of judgements across multiple parameters by cutting the decisions made into a series of choices between pairs of parameters. AHP provides a systematic analysis of factors and allows for the incorporation of both qualitative and quantitative inputs. However, this process also requires the rating approach across multiple parameters to be consistent, which becomes difficult in cases of large number of parameters, and subsequent pairwise comparisons. AHP can thus be operationally complex and demanding. The pairwise comparison method has further been criticized for its ambiguity in rankings, in part because weighting is done without consideration for criteria scoring, leading to different and potentially erroneous weighting (Munier and Hontoria, 2021).

2.4 Phase 4 - Aggregation

In the final phase of SSA, suitability scores across multiple criteria must be combined to calculate the final Suitability Index (SI) scores, which is the composite measure that represents the overall suitability of an area. In this way, normalized maps and constraint maps are also aggregated to produce final suitability maps. Multiple potential processes exist for aggregating such data, which include the choice of simple overlay, weighted linear combination (WLC), or ordered weighting average (OWA). Often, the choice will depend on the decisions related to the normalization methods and spatial heterogeneity across the project scope.

2.4.1 Simple overlay

In simple overlay, suitability maps are overlaid with the final suitability score representing a simple additive or averaged function. In this process, all parameters are considered equally relevant / important in determining suitability. This is the common approach when aggregated constraint or Boolean data, as it is relatively easy to distinguish between suitable and unsuitable areas. This approach is computationally simple, yet not always appropriate for complex decision problems involving multiple heterogeneous criteria.

2.4.2 Weighted Linear Combination

The weighted linear combination (WLC) is one of the most often used aggregation method in MCDA (Malczewski and Rinner, 2015). Known otherwise as additive weighting, weighted linear average, and weighted overlay, WLC involves a process whereby the suitability scores on each criterion are multiplied by their weights and summed. WLC is attractive since it is an intuitive approach that is easily incorporated into the GIS environment. The weighted-sum function also allows for aggregation of variable suitability scales, which may be desirable (see **Appendix Table A1**). However, WLC processes have some important assumptions and considerations. First, WLC is often considered a *compensatory technique,* since it assumes that low scores in one parameter may be compensated by high scores in another (**Table 3**). WLC also infers independence of parameters, such that criteria are assumed not to interact. In addition, WLC assumes linearity, meaning the desirability of an additional unit of the parameter is constant for any level of the attribute.

Table 3. Simplified example of WLC aggregation (e.g., weighted average) to highlight how interpretation of final suitability can be influenced by compensation (scenario 1).

	Weight	Scenario 1 score	Scenario 2 score
Parameter A	0.75	2 (Poorly suitable)	3 (Moderately suitable)
Parameter B	0.25	5 (Very highly suitable)	3 (Moderately suitable)
Suitability Index (SI) score		2.75 (Moderately suitable)	3 (Moderately suitable)

Other mathematical functions may be appropriate for aggregation depending largely on objectives and decision-makers preferences (see **Appendix Table A2**). For example, if the assumption of full compensation is not required and it is desired to penalize areas that perform poorly on even one parameter, a geometric or harmonic function may be appropriate. In cases where there may be a desire for suitability to be based on the least performing criterion, selecting the minimum score across criteria may be appropriate. Alternatively, selecting the median score across parameters may be used to identify overall trends. However, applying minimum or median functions would not allow the incorporation of weights, and so are generally less suitable for MCDA applications.

2.4.3 Ordered Weighted Average

One alternative to WLC is the ordered weighted average (OWA) method (Drobne and Lisec, 2009). The OWA is procedurally similar to WLC but calculates two sets of weights: criterion weights and order weights. OWA addresses the limitation of WLC by including a trade-off measure indicating the degree of compensation to be allowed between criteria. Ordered weights differ from criterion weights used in WLC methods, as they are not applied to a whole criterion, but determined on a pixel-by-pixel basis. Therefore, OWA method accounts for spatial heterogeneity of data and is suitable if using a "local" evaluation approach. The OWA increases the complexity of the decision-problem and requires an additional step to traditional WLC since additional decisions are required to account for spatial heterogeneity.

3 Conclusions and recommendations

This review has highlighted several key factors that distinguish the techniques and methods relevant to the SSA process. This includes:

1. The level of validity and uncertainty acceptable by decision makers;
2. The cognitive burden that methods pose on experts / decision makers:
3. Interpreting and communicating the results of SSA; and
4. Practical constraints (i.e., expertise, time, and resources).

Selecting the most suitable methods for SSA involves a variety of considerations based on both the problem context and objectives, preferences, and information types and structures. While the methods should be guided by a thorough assessment of the considerations, the following recommendations can guide the approach for the Coastal Classification System's suitability assessment.

Phase 1 – Project structuring

- Project goals and objectives must be outlined and clearly articulated, including provisions for the types of considerations included in suitability analysis;
- A shared judgement approach representing group consensus on the appropriate scales, criteria selection, and weight determination will be least operationally complex;
- Applying scoring schemes and weights consistently across the entire study area;
- Organizing criteria and factors into a hierarchical structure can help clarify objectives and considerations into distinct suitabilities; and
- Criteria selected should be limited to the fewest, most important factors relevant to the respective goals and objectives, while also considering data robustness and availability.

Phase 2 – Scoring / Normalization

- Discrete categorization of criteria is appropriate for computing suitability of different areas across criteria and clearly articulating outputs to interest holders and end users;
- Suitability classifications for each parameter need to be strongly justified by appropriate science-based evidence and through consultation with diverse experts; and
- Criteria should ideally be divided into three to five discrete categories from less to more suitable, depending on the underlying data and end-user requirements.

Phase 3 – Weight determination

- Equally weighting criteria would be the most straightforward approach, but may not be theoretically appropriate and thus carefully justified;
- The most practical weight elicitation is the rating approach due to the clarity of its outputs, ease of application, and simplicity in normalizing across multiple criteria; and
- Hierarchical decomposition of weights can minimize the cognitive burden of decision-makers during weighting.

Phase 4 - Aggregation

- Weighted linear combination is a common and widely applied intuitive approach for aggregating multiple criteria considering the scores and weights of various factors.

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5 Appendix

Table A1. Example of use of weighted-sum model.

Parameter	Parameter weight	Suitability classification	Suitability score
Parameter A	0.75	Poor	0
		Moderate	50
		Good	100
Parameter B	0.25	Poor	0
		Good	100

Scenario A:

Parameter A = Moderate

Parameter B = Good

(0.75x50)+(0.25x100) = 62.5

Scenario B:

Parameter A = Good

Parameter B = Poor

(0.75x100)+(0.25x0) = 75

Table A2. Possible aggregation functions with different degrees of compensation given decision-maker preferences and objectives. Taken from Cinelli et al. (2020).

Aggregation function	Formula	Level of compensation	Comments
Additive	$\text{score}_c = \sum_{i=1}^{n} I_{ic} \text{ x } w_i$	Full	Suitable if the decision-makers' preference values are linear, meaning that the decision-makers accept that the performance of indicators can compensate each other. For example, low-performing indicators can be fully compensated by high-performing indicators
Geometric	$\text{score}_c = \prod_{i=1}^{n} I_{ic}^{w_i}$	Partial	Suitable for decision-makers' who do not accept full compensation between indicators and want to penalize the alternatives that do perform poorly even on only one This use of this function is not possible if normalized indicators' values are negative or 0 (lowest performing indicator), as the function cannot be applied. Hence, it is only usable with normalized data sets containing strictly positive numbers
Harmonic	$\text{score}_c = \frac{n}{\sum_{i=1}^{n} \frac{w_i}{I_{ic}}}$	Partial (less than geometric)	Same considerations apply as to the geometric. It is even better for more "demanding" decision-makers who desire even less compensation. It is only usable with normalized data sets containing strictly positive numbers
Minimum	$\text{score}_c = \min(I_{1c}, I_{2c}, .., I_{nc})$	None	Particularly suitable if stakeholders want the assessment to be driven by the worst performing indicator
Median	$\text{score}_c = \tilde{I}(I_{1c}, I_{2c}, \ldots, I_{nc})$	Depends on the distribution of the indicators' values	It allows to identify overall trends as one half of an alternative's indicators are above and the other half below the median Low-performing indicators can be overcompensated by well-performing indicators
	score_c: composite score for alternative c I_{ic}: the normalized value of indicator i for alternative c w_i : weight of indicator i		n: the number of indicators min(): minimum value of all the indicators $\tilde{I}$: median of the indicators' values

CENTRE FOR MARINE APPLIED RESEARCH

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Recommendations on the criteria for inclusion

A report in support of a regional suitability assessment of coastal aquaculture in Nova Scotia

July 22, 2024

Prepared by:

Jenny Weitzman
Therese Wilson
James Cunningham
Laila Nargis
Leah Lewis-McCrea
Gregor Reid

27 Parker Street · Dartmouth, Nova Scotia · B2Y 4T5

CMAR.CA

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Version Control			
Status	**Version**	**Date**	**Rationale**
Draft	0.1	March 5, 2024	First draft
Final	1.0	July 22, 2024	Adjustments made to reflect ongoing explorations of data and to incorporate feedback from advisory committee review

Glossary

Area of analysis (AOA)	The geographic extent within which suitability for aquaculture will be assessed
Classification	The designation of an area based on a defined suitability score
Constraint	A type of criterion that serves to limit the spatial scope of suitability area; element or feature that represents restrictions and / or limitations that would preclude aquaculture
Criteria	Considerations that are evaluated to determine how well an area meets various suitability objectives.
Bay-level assessment	Type of assessment that encompasses considerations relevant to a specific bay (or waterbody) or cluster of farms
Geographic Information System (GIS)	Computer system for capturing, storing, analyzing, and presenting geographical data
Multi-criteria Decision Analysis (MCDA)	A collection of formal approaches to explicitly account for multiple criteria in decision-making environments
Regional-level assessment	Type of assessment that encompasses considerations relevant to a broader geographic area surrounding an aquaculture site, typically within the same waterbody to understand how potential aquaculture fits in with broader context of surrounding ecosystem and other marine uses
Resolution	The dimensions represented by each cell (pixel) within a GIS environment
Site-level assessment	Type of assessment that encompasses considerations relevant to a specific farm site and its immediate surroundings to explore optimal conditions for successful aquaculture production
Scoring	The process of assigning ratings to criteria based on the implications for aquaculture suitability, allowing for meaningful comparison, analysis, and interpretation.
Sub-criteria	The specific factors or constraints that make up criteria
Suitability	For this assessment, refers to the potential of an area to support aquaculture production and/development
Suitability score	A numerical value indicating an area's suitability for a given criterion

1 Introduction

In supporting the objectives of the Coastal Classification System (CCS) for aquaculture in Nova Scotia, the Centre for Marine Applied Research (CMAR) is completing an assessment to classify coastal areas based on their potential for finfish and shellfish[1] aquaculture. To assess the potential of areas for aquaculture development, multiple evaluation criteria will be assessed and rated within a Geographic Information System (GIS) tool, applying techniques from Multicriteria Decision Analysis (MCDA)[2].

For this assessment, the GIS-MCDA process focuses on defining, rating, and combining multiple evaluation criteria relevant to assessing the potential of an area for aquaculture production. GIS-MCDA has been widely used to explore the potential of aquaculture (Chentouf et al., 2023) in what can be generally referred to as a "suitability assessment". These techniques have been used in similar initiatives globally to assess suitability for aquaculture (Falconer et al., 2013; Porporato et al., 2020) and develop mapping tools[3] to help identify where opportunities for aquaculture could exist (Aguilar-Manjarrez et al., 2008).

In the first step of this process, we must identify the initiative's objectives and what types of information (i.e., criteria) we are able to include in the assessment. This suitability assessment will spatially rate areas based on the potential for aquaculture in waters up to 3 kilometres off the coast of Nova Scotia (**Figure 1**). This assessment is designed to produce results at a regional level of analysis, helping to understand potential opportunities for aquaculture development across the province. Areas will be assessed separately for each cultured finfish and shellfish species, and results will be displayed within a web-based mapping platform[4].

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[1] Considering key species cultured in Nova Scotia: Atlantic salmon (*Salmo salar*), Rainbow trout (*Oncorhynchus mykiss*), Eastern blue mussel (*Mytilus edulis*), and American oyster (*Crassostrea virginica*).

[2] See "Methods Review for Spatial Suitability Analysis in the context of the Coastal Classification System (CCS)" for more information about general approach and methodology.

[3] For example, see Palau Aquaculture Suitability Tool and AquaVIS (Gangnery et al., 2021).

[4] Developed and designed using ESRI ArcGIS Experience Builder.

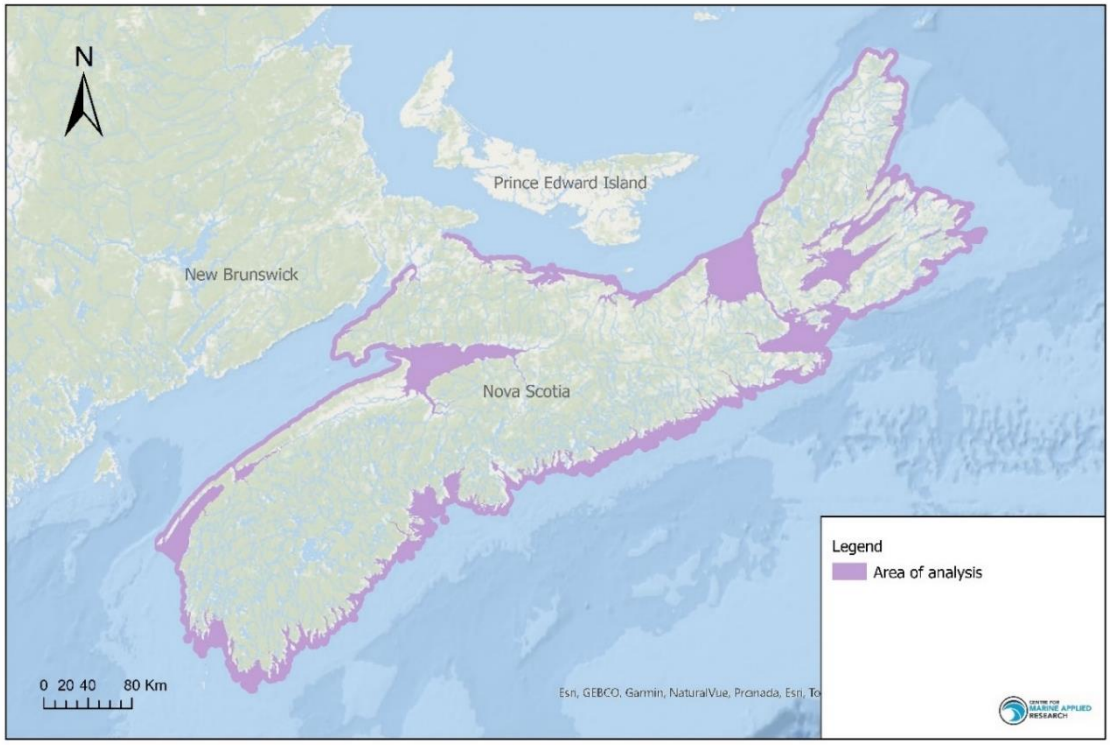

Figure 1. Area of analysis (AOA) for coastal classification of aquaculture suitability assessment.

1.1 Scope of the assessment

The overall goal of this assessment is to evaluate the potential of areas for coastal aquaculture development (hereafter referred to as "suitability") in Nova Scotia for each of the four major species cultured in the province. This assessment will include coastal waters within an Area of Analysis (AOA) encompassing up to 3 kilometres from shore, including the major jaws of land (**Figure 1**). This AOA is designed to include the area currently occupied by aquaculture in the province and is not intended to represent the needs or considerations required by offshore aquaculture[5].

When assessing geographic data for aquaculture, it is important to select the spatial scale at which data will be assessed. For aquaculture, spatial assessments may occur at various spatial scales (**Table 1**) which each involve different considerations in the information included and the resolution of that data. As the AOA encompasses coastal waters across the province, this assessment is designed at a regional level spatial scale. At the regional level, most assessments employ forms of suitability assessments to evaluate and explore potential areas of opportunity for aquaculture. At this level, assessments often reflect considerations on the scale of tens of metres to kilometres, to explore opportunities across a large geographic region, often consisting multiple bays or areas. Regional level considerations of relevance are wide-ranging and often consider broad environmental conditions or human use areas, relying on information that is available at resolutions generally in the hundreds of metres, although specific desired resolutions are highly specific on the project.

[5] Which describes aquaculture that occurs in waters beyond 3km from shore (Howarth et al., 2022).

Table 1. Spatial assessments to provide information for selection of aquaculture sites at different spatial scales and the different considerations, contexts, and needs of the assessment.

	Regional level	Bay level	Farm level
Spatial scope	Large geographic region consisting multiple bays	Area contained within a bay system or farm clusters	Area surrounding a specific site
Example regulatory processes	Scoping and zoning	Establishing aquaculture management areas	Licensing and leasing
Examples	Suitability assessments: (Falconer et al., 2013; Dapueto et al., 2015; Gimpel et al., 2015; Porporato et al., 2020; Petrosillo et al., 2023)	Suitability assessments: (Perez et al., 2005; Silva et al., 2011; Vianna and Filho, 2018) Conflict mapping: (Coccoli et al., 2018; Bergh et al., 2023) Integrated spatial models: (Sutherland et al., 2007; Filgueira et al., 2015)	Spatial models: (Corner et al., 2006; Ferreira et al., 2007; Bricker et al., 2016)
Example considerations (biophysical)	• Broad environmental conditions • Area restrictions and constraints	• Optimal conditions • Cumulative impacts • Carrying capacity	• Production needs • Carrying capacity
Spatial resolution of data	10s – 1000s of metres	10s – 100s of metres	10s of meters

This assessment at the regional level can be distinguished from other spatial assessments for aquaculture which have smaller spatial scope and are more targeted to specific areas at the bay or farm-level. At these bay or farm level, assessments are more interested in evaluating aquaculture in the context of specific ecosystems (e.g., waterbodies) or farm practices. These spatial scales are also best suited to assessing optimal conditions and production needs for specific development initiatives, as they can address aspects such as cumulative impacts, carrying capacity or other high-resolution data and models. Criteria related to specific industry operational or economic requirements, such as need for support infrastructure and services can be very broad and require an understanding of operators needs relative to site-specific proposals. Suitability as it applies to specific farm operations and layouts, industry practices, technologies, or management measures are best evaluated at the site-level.

At the regional level of analysis, this assessment aims to capture the key considerations that would either constrain/limit the culture of species, or considerations of factors that producers would need to address or account for in placing or planning their aquaculture operations[6]. While not all criteria may apply to all producers, this assessment is meant to reflect the general needs and considerations of the aquaculture sector to be applicable to the broadest range of operators.

[6] Such as the eight factors to be considered in decisions related to marine aquaculture sites set forth by the Nova Scotia Aquaculture License and Lease Regulations.

At a regional level, the potential of aquaculture is a function of appropriate ranges of physical and environmental conditions, minimizing the potential for overlap with other marine uses and supporting environmental protection and sustainability. The evaluation criteria must, therefore, consider at least one of the following objectives:

- **Health and welfare:** To meet physical and environmental requirements for the health and welfare of cultured species;
- **Environment and conservation:** To account for environmentally significant and protected areas and species; and
- **Multi-use overlaps:** To reduce the potential for direct overlap with existing uses of coastal and marine areas.

Some objectives and factors were considered out of the project scope, such as those that are best derived through local consultation. We did not consider criteria related to how aquaculture impacts culturally significant areas, nor the potential for conflict/synergies or societal impacts/benefits from aquaculture. This information requires additional knowledge of the spatial compatibility of overlapping uses (Kannen, 2014) and a strong baseline knowledge of the cultural values of areas (Gee et al., 2017). Therefore, considerations for social values and perceptions should ideally be derived from discussions with potentially affected individuals, communities, and rights-holders relevant to specific development projects or during site-level assessments.

We also did not consider factors that require complex analysis or models to evaluate. For example, we did not consider criteria related to the impacts or vulnerabilities of aquaculture from climate change. While climate change is anticipated to exacerbate or add risks to aquaculture (Beveridge et al., 2018; Mackintosh et al., 2023; Awotunde, 2024; Neokye et al., 2024), modelling the anticipated the predicted impacts is complex, and currently still being developed (Brugère, 2015).

Finally, this assessment is based on present-day conditions, technologies, standard industry practices and current regulations in Nova Scotia. We acknowledge that aquaculture is a rapidly evolving industry, and that technologies, management measures, and policies can quickly change. Future or subsequent assessments should consider changes in planning and siting considerations as well as the state of data availability, so that assessments remain current and relevant.

1.2 Purpose of report

This report is designed to provide information to inform the decision about which criteria to include in the assessment of the potential for aquaculture development in Nova Scotia. Here, we define *criteria* broadly as considerations that are evaluated to determine how well different areas meet various suitability objectives. For example, the assessment of temperature data considers how areas are exposed to thresholds beyond which the health and welfare of aquatic species may be compromised. Individual criteria can be broken down into more specific sub-criteria, providing additional depth to the assessment. For example, temperature can be evaluated by combining suitability as it relates to both i) superchill, and ii) heat stress, each of which represent different temperature thresholds of concern for aquatic animals.

This report provides an overview of the criteria selection process used in the CCS, including a list of properties under which criteria were evaluated (**Section 2**). The proposed criteria for inclusion are described (**Section 3**), as well as the criteria excluded (**Section 4**). Supplementary information on how criteria were considered can be found in the attached **Appendices**. **Appendix i** details the criteria selection evaluation rubric and summary evaluation scores. Full evaluation scores are provided in **Appendix ii** for finfish and **Appendix iii** for shellfish aquaculture. How criteria will be measured, analyzed, and classified will be detailed in subsequent documents.

2 Criteria selection process

To select the criteria, an evidence-based and collaborative process was undertaken to propose scientifically valid and expert-informed criteria, applicable to the specific objectives and scope of the project. Criteria selection involved collaboration with network partners (i.e., Fisheries and Oceans Canada (DFO)) and subject-matter experts, brought together as part of advisory committees established under the CCS project[7].

Criteria were selected to represent a range of considerations applicable to present-day aquaculture siting and planning in Nova Scotia's coastal waters. Finfish and shellfish aquaculture may require different criteria due to different biophysical requirements, environmental interactions, and culture techniques. The criteria selection process, therefore, assessed whether to include criteria based on factors relevant to each of the four aquaculture species being assessed.

The proposed criteria have been selected to reflect current marine conditions, sector needs, industry regulations, and aquaculture practices and technologies, as well as the existing state of knowledge and data availability at the time of the assessment. New or different criteria may become relevant and should be considered in future iterations or adaptations of the analysis.

2.1 Guidelines for criteria selection

To ensure the credibility of the analysis and enhance the value of criteria and the end-product, criteria were evaluated in the context of project objectives and reflect best practices in MCDA literature. Ultimately, the set of criteria should be as simple as possible but comprehensive to capture the process' complexity to meet objectives and goals (Belton and Stewart, 2002). Furthermore, including more criteria would dilute the influence of each individual criterion, as each criterion would carry a lower weight relative to the total number considered. Limiting the number of criteria can thus promote clarity, simplicity, and efficiency in the analysis process.

While there are no standard rules or guidelines on the number of criteria appropriate for MCDA applications, some basic requirements have been acknowledged to support the rigour and validity of criteria (Malczewski and Rinner, 2015; Cinelli et al., 2020). Criteria must meet the needs of this assessment, be rooted in scientific rigour, and incorporate high-quality data considering both theoretical and practical considerations required in data collection, analysis, and visualization. Selecting criteria should be guided by assessing several pertinent selection properties. These include ensuring a criterion's relevance to the project, its rateability and clarity of scoring, while

[7] Which include a Technical Oversight Committee (TOC) and three Data Committees (DCs).

also considering the validity of its scale, data coverage and accessibility, measurement reliability, and minimizing redundancy with other criteria. Each selection property is described below.

2.1.1 Relevance to scope

A criterion's relevance to scope refers to the degree to which a criterion is pertinent, applicable, and meaningful in the context of the project (as detailed in **Section 1.1**.). In the context of this assessment, sufficient evidence is required to validate the criterion's importance to evaluating the potential for aquaculture (suitability), either through regulatory guidance or as identified in the scientific literature. As such, criteria should clearly measure one or more of the objectives of the project and be linked to measuring aquaculture suitability as it applies to either species health and welfare, environment and conservation, or multi-use overlaps. These criteria are designed to reflect considerations that producers would need to address or plan for during licensing and leasing process[8]. While several criteria may be relevant to aquaculture suitability, criteria may be excluded if they do not fit within the project's objectives or scope (see **Section 4**).

2.1.2 Rateability

The rateability of a criterion refers to the strength of scientific evidence available to inform the classification of the criteria. The knowledge and information available to describe suitability of criteria for aquaculture is a critical component of selecting criteria that are operational for use in the MCDA process (Keeney and Gregory, 2005). It must be clear how changes in the criteria properties influences the potential for aquaculture development. In some cases, justification may be derived from existing guidelines, regulations, or best practices. Other justification may come from scientific evidence of established relationships or thresholds, such as the critical temperature thresholds of cultured species. The justification may be weaker in cases where scoring into suitability classes would rely solely on expert opinion or precautionary designations[9]. Additionally, justification may be weak where the criterion is challenging to justify or classify. This can occur if suitability depends highly on specific management or operational choices, or where the criterion may vary considerably over time and/or space (also see **Scale validity**).

2.1.3 Scoring clarity

A criterion's scoring clarity refers to the extent to which explanation is required for the measurement and/or classification of a criterion. It also refers to the ease with which the criterion's data and the rationale for scoring can be communicated and understood by a variety of interest holders and end-users. To promote clear communication and useability of the analysis, criteria should be understandable to anyone interested in the analysis and outputs (Keeney and Gregory, 2005). This applies to both the data underlying the analysis, but also to the interpretation of the final classifications. Criteria should be clear to those wishing to use and interpret the outputs, and to the end-users and stakeholders who want to be informed about the analysis. Spatial datasets

[8] Such as the eight factors to be considered in decisions related to marine aquaculture sites set forth by the Nova Scotia Aquaculture License and Lease Regulations.

[9] Such as using precautionary buffers around features, which can act as protective mechanisms to account for uncertainties or minimize risk (Holzer and Olsen, 2021).

that are overly complex or requires specialized knowledge to understand and to be justified are less ideal as they reduce the value of the final outputs. Clearly defining the criterion is needed to be effectively assessed and classified for suitability (Dodgson et al., 2009).

2.1.4 Scale validity

The scale validity refers to the appropriateness of the criterion and its resolution to the spatial scale of the project. Here, this means selected criteria should reflect considerations appropriate for regional-level assessment (see **Table 1**). This scale does not consider specific industry practices, culture techniques/technologies, or management plans, focusing rather on variables that may influence government and producer decisions when exploring an area's potential. Criteria more relevant to site-level or bay-level suitability assessments are thus excluded (**Section 4**). Site and bay-level criteria require higher resolution data[10] and methods of analysis[11] that can accommodate the recognized variability that is needed for a meaningful evaluation of the potential for aquaculture at the regional level of assessment.

The criterion data should also be at a resolution appropriate for a regional level, which for the purpose of this analysis, can be represented at scales ranging from tens to hundreds of metres. This resolution can capture some local variations in environmental conditions and marine uses, while still providing a comprehensive view of the region. Spatial resolutions at the scale of one kilometre or larger were considered too coarse for our AOA, since they would not be sufficient to capture variability of coastal ecosystems and their interactions with aquaculture.

2.1.5 Coastal coverage

A criterion's coastal coverage refers to the availability of the criterion's data across the coast of Nova Scotia (i.e., the Area of Analysis (AOA); **Figure 1**). The suitability assessment methods used within the GIS-MCDA process involve calculating and aggregating suitability scores for all criteria across each 'cell' within a gridded AOA[12]. To effectively compare suitability across areas (e.g., 'cells'), the analysis requires available data for every criterion within a cell to compute an aggregated suitability score. If a cell is missing data for one criterion, a combined suitability score can not be calculated. This will ultimately lead to gaps in the coverage of suitability across the AOA. Therefore, a criterion's data should have relatively complete coverage across the AOA to minimize the extent of potential 'unassigned' areas.

2.1.6 Data accessibility

The data accessibility of a criterion refers to the ability or ease at which the criterion can be measured and used within the suitability assessment. Being able to generate, access, or use the criterion is critical for making the criterion operational within the GIS-MCDA analysis (Keeney and Gregory, 2005; Malczewski and Rinner, 2015). The criterion's data must be available or measurable

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[10] Generally, within the metres to tens of metres resolution.

[11] For example, through carrying capacity models or tools.

[12] For analysis, the AOA will be gridded so that the geographic area is divided into an array of equally sized 'cells', often squares with each cell representing a geographic unit (can be in squared metres or kilometres) and assigned an attribute unit (in this case, a suitability score).

within the project's timeline and resources and should be evaluated in the context of available time, personnel, expertise, and data. To promote transparency and access to data, the use of publicly accessible data is preferred. Criteria that are relevant but may not be currently accessible are acknowledged in **Section 4**, and could be included in the future as data becomes available.

2.1.7 Measurement reliability

The measurement reliability of a criterion refers to the confidence and uncertainty related to the criterion's measurement at the scale of assessment, including the use of scientifically robust methods and data. Where data needs to be collected and analyzed for this assessment, methods should be reliable, transparent, and clear. Methods must also be available to accurately collect or analyze datasets at the appropriate resolution for regional-level assessment of aquaculture potential. In some cases, measurement of criteria may be available, but not necessarily spatially mapped at the necessary scale (**Scale Validity**). In addition, novel methods or emerging areas of research may add uncertainty to the assessment and should be considered carefully.

2.1.8 Redundancy to other criteria

A criterion's redundancy to other criteria refers to whether criteria can be considered exceptionally like other criteria, in that the data is similar or it measures a similar phenomenon. Redundancy can also happen if the criterion's data is included in the data of another criterion measuring a similar phenomenon, such that including both would consist double counting. In GIS-MCDA applications, double counting is problematic, and redundant criteria should be removed in an aim for simplicity and accuracy (Dodgson et al., 2009; Malczewski and Rinner, 2015). Therefore, criteria should be mutually exclusive (i.e., not counted in other criteria) to avoid inflating or exaggerating the influence of individual criterion. In addition, measuring and classifying criteria should be possible independent of the knowledge or data from other criteria. This means that judgements about suitability scoring should not require any information not contained in the criteria.

3 Proposed criteria for inclusion

The proposed criteria described below were identified in consideration of the selection properties outlined above (**Section 2**), drawing from relevant scientific literature and regulatory frameworks, ongoing assessment of available data, and feedback from the subject-matter experts and CCS Committees. For more information about the evaluation of criteria, see the attached **Appendix i**.

Below are the proposed criteria relevant to the objectives regarding the sustainability and planning of finfish and shellfish aquaculture in Nova Scotia (**Table 2**). For each criterion, we describe its relevance and importance for aquaculture, as well as generally how it influences the potential for aquaculture development. Detailed information on how criteria would be measured or classified is not included here, but will become available in subsequent project reports, as this is dependent on underlying datasets and ongoing discussions with decision-makers and experts.

Table 2. Proposed criteria and their applicability across finfish and shellfish aquaculture.

Criterion	Sub-criterion	Finfish		Shellfish	
		Salmon	**Trout**	**Mussels**	**Oysters**
Temperature	Superchill	✓	✓		
	Heat stress	✓	✓	✓	
Depth	Bathymetry	✓	✓	✓	✓
Exposure	Ice conditions	✓	✓	✓	✓
	Wind and wave conditions	✓	✓	✓	✓
Water quality	Shellfish Harvest Area Classification			✓	✓
	MSX presence				✓
Wild salmon	Wild salmon rivers	✓			
Important coastal areas	Coastal wetlands	✓	✓	✓	✓
	Terrestrial protected areas and parks	✓	✓	✓	✓
	Critical habitat for species at-risk	✓	✓	✓	✓
	Important bird habitat	✓	✓	✓	✓
Navigation	Navigation routes	✓	✓	✓	✓
	Fishing vessel traffic	✓	✓	✓	✓
Coastal access	Coastal access	✓	✓	✓	✓
Allocated use areas	Existing aquaculture	✓	✓	✓	✓
	Marine protected and conserved areas	✓	✓	✓	✓
	Anchorage areas	✓	✓	✓	✓
	Designated navigation features	✓	✓	✓	✓
	Private water lots	✓	✓	✓	✓
	Marine Renewable Energy Areas	✓	✓	✓	✓
	Submerged structures	✓	✓	✓	✓
	At-sea disposal sites	✓	✓	✓	✓

3.1 Water temperature

Water temperature is critical for health and growth of cultured species and is a primary indicator of overall water quality. Cultured finfish species (Atlantic salmon (*Salmo salar)* and Rainbow trout (*Oncorhynchus mykiss*)) have preferred temperature ranges for optimal growth, and generally grow well in water temperatures between 5 to 20 °C (Thyholdt, 2014; Sambraus et al., 2018; Calado et al., 2021; Pandey et al., 2021). Water temperatures above this optimal range may lead to negative health effects and poor welfare outcomes, including increased stress of farmed fish and reduced immunity to diseases (Gamperl et al., 2020; Beemelmanns et al., 2021). Prolonged high water temperatures during the summer months may at times be lethal, especially when they co-occur with hypoxia (Thyholdt, 2014; Forseth et al., 2017). Shellfish generally have high thermal tolerances, with American oysters (*Crassostrea virginica*) surviving temperatures up to 49 °C (Galtsoff, 1964). However, increased water temperatures may be an issue for blue mussels (*Mytilus edulis*), with upper thermal limits for performance and survival at around 25°C (Stantec, 2009; Smith and Ramsay, 2022). Periods of extreme low temperatures can also be detrimental to fish health, as mortality (e.g. superchill events) can occur when water temperatures reach below when fish blood freezes (around -0.7 °C for salmon and trout) (Saunders et al., 1975). Compared to finfish, shellfish are more tolerant to cold temperatures, and have lower temperature thresholds around the freezing point of sea water (-2 °C) (Fisheries and Oceans Canada, 2003). In some parts of Nova Scotia, water temperatures occasionally fall outside the preferred temperature range for finfish, and sometimes for mussels, reinforcing the need to consider temperature variability when determining suitability for aquaculture.

3.2 Water depth

Water depth is a critical consideration for aquaculture siting, as operations require adequate depth to install infrastructure (i.e., netting and lines). In Nova Scotia, typical net depths for finfish farms are between 8 to 10 metres, with most existing farms sited in water depths less than 20 metres, with only a few sites located in deeper waters (Brewer-Dalton et al., 2015). Shellfish aquaculture generally occupies depths within the intertidal zone (for oyster culture) up to a maximum of 20-35 metres. However, at shallow depths, cultured shellfish may be exposed to air, which during hot summer temperatures, can lead to mortality (Clements et al., 2018). Water depth may also be correlated with water flow, which is important for the thermal regulation of finfish, especially in sites where water temperatures vary at different depths (Oppedal et al., 2011). Higher water flow can also help transport waste away from cages, maintaining the health of benthic marine habitats below cages (Sara et al., 2006; Borja et al., 2009; Sanz-Lazaro et al., 2021). As a result, accounting for the optimal depth ranges is important for aquaculture suitability for both health and welfare of cultured species and for environmental considerations.

3.3 Exposure

In Nova Scotia, risks from exposure to adverse environmental conditions can have negative consequences on operations, as well as for the health and welfare of cultured species. While higher

energy areas may offer advantages for finfish aquaculture production (i.e., water flow and oxygen provision), exposure to strong waves can negatively affect fish behaviour and lead to stress (Johannesen et al., 2020; Johannesen et al., 2022). For shellfish aquaculture, exposure can negatively affect shellfish growth, as strong wave movements can affect shellfish feeding or lead to damage of shells (Campbell and Hall, 2019). Highly energetic environments can also create operational safety concerns, as aquaculture structures, moorings, and equipment can become damaged or fail (Beveridge, 2004). In addition, aquaculture operations may be exposed to risks from sea ice that develops in the winter across parts of Nova Scotia. Damage and/or failure of cage infrastructure can result in economic losses for producers or accidental escape of farmed fish into the marine environment. For shellfish, ice can scour equipment and crush the animals, leading to mechanical damage and mortality of shellfish.

3.4 Water quality

Water quality refers to the chemical, physical, and biological characteristics of water, including the presence of pathogens. Water quality is critical for aquaculture, and directly influences the health and growth of cultured species. As filter feeders, shellfish are particularly vulnerable to various environmental contaminants from agricultural or industrial discharge, including metals, toxins, excess nutrients, and pathogens which can accumulate in shellfish, potentially leading to health risks for consumers (Brown et al., 2020b; CFIA, 2019). Additionally, excessive nutrients can contribute to eutrophication, potentially leading to harmful algal blooms (HABs) that elevate the risk of health conditions, like paralytic shellfish poisoning (PSP) (Brown et al., 2020a; Lapointe et al., 2015; Wu et al., 2019). In Nova Scotia, shellfish aquaculture water quality is regulated, and areas classified under the Canadian Shellfish Sanitation Program (CSSP), which can prohibit harvesting from areas due to poor water quality or presence of contaminants (Canadian Aquaculture Industry Alliance, n.d.; CFIA, 2020). These harvest areas classifications also have implications for producers, who may be required to adjust their operational processes.

3.5 Important coastal habitats

Across Nova Scotia, many coastal areas serve as important habitats for species and biodiversity. For example, several coastal islands are protected wilderness areas or conservation easements, as they are recognized for their rich coastal biodiversity or as habitat for marine and migratory birds[13]. Many terrestrial parks and protected areas in Nova Scotia are also located in coastal areas and play important roles in the protection and conservation of wildlife and biodiversity in the province. Aquaculture may have adverse interactions with species or can have local effects on habitats. For example, physical culture structures may reduce the light that reaches the seabed, potentially impacting natural seagrass or eelgrass communities under conditions where there is extensive overlap (Primavera, 2006; Forrest et al., 2009). Due to the presence of aquaculture structures including cultured species, feed, and/or release of nutrients, various wildlife including fish, marine mammals, and birds have been observed around aquaculture sites (Dempster et al.,

[13] For examples, see protection efforts through the Nova Scotia Nature Trust - https://nsnt.ca/

2010; Callier et al., 2018; Barrett et al., 2019). This attraction may lead to unintentional entanglement, mortality, or habitat exclusion of wildlife. While these risks can largely be mitigated through proper infrastructure design and management practices, considering aquaculture proximity to coastal areas recognized as critical and / or sensitive (for protected and threatened species) helps to further minimize the potential for negative interaction.

3.6 Wild salmon

Ongoing efforts to maintain healthy ecosystems and re-establish wild populations of Atlantic salmon is a priority under Canada's *Wild Atlantic Salmon Conservation Policy* (Fisheries and Oceans Canada, 2018) given the multiple threats facing existing populations such as river obstructions, reduced water quality, marine ecosystem changes, climate change, and aquaculture (Dadswell et al., 2021). Through accidental escapes, farmed salmon have been found in rivers over 100 kilometres from aquaculture sites (Solem et al., 2013), and may compete for resources or breed with wild salmon, leading to genetic changes in natural populations (Bradbury et al., 2020a; Bradbury et al., 2020b). It has been suggested that proximity of aquaculture sites to rivers occupied by wild salmon may also increase the likelihood of spreading disease and parasites to migrating wild salmon under some conditions (Johansen et al., 2011; Mordecai et al., 2021). The sustainability of wild salmon is a key consideration during aquaculture licensing and leasing (Province of Nova Scotia, 2015), and important in safeguarding the conservation of wild salmon in Nova Scotia.

3.7 Coastal access

The geographic location and natural conditions of coastal Nova Scotia make it an ideal location for recreation and tourism. Coastal development can alter how the public is able to use and enjoy the coast, for activities such as swimming, boating, kayaking, surfing, fishing, and hiking. Aquaculture can introduce structures in the marine environment and on adjacent lands that can potentially impede access to marine areas, potentially displacing existing recreational and tourism users (Shafer et al., 2010). Therefore, considering main areas that provide coastal access to the public, for recreation, tourism, or other use can provide an indicator of potential overlap with recreation and tourism users, and is thus an important criterion for the overall suitability of aquaculture (Perez et al., 2003).

3.8 Navigation

Nova Scotia's coastal waterways play an important role in the province's economy and reflect a complex network of coastal areas, ports, and fishing grounds. These waterways include primary traffic routes used by large commercial vessels such as cruise ships and shipping containers to central ports. In addition, other frequented routes exist for smaller vessels across marine waters where fishing vessels conduct their activities or come to port along Nova Scotia's numerous fishing ports. When selecting locations for aquaculture operations, it is imperative to allocate adequate space for navigational areas to uphold the public's right to access navigable waters and

safeguard navigational safety[14]. Ensuring navigational safety is also important, as aquaculture facilities in highly navigated areas may increase the risk of maritime accidents (Yoo and Jeong, 2020; European Boating Association, 2021). As such, considering highly navigated marine areas in aquaculture siting is essential to balance safety, regulatory compliance, and community relations.

3.9 Areas allocated for other uses

In selecting sites for aquaculture development, it is crucial to account for marine areas already allocated for other commercial, conservation, or administrative purposes. These areas are spatially incompatible or may legally restrict aquaculture. For example, some coastal areas are designated to maintain ecological integrity and biodiversity, and are legally protected to activities which could potentially disturb living marine organisms or their habitat (Government of Canada, 2004). Alternatively, some locations are unsuitable for aquaculture due to existing spatial constraints; for instance, certain areas have restrictions for navigational purposes, including designated anchorage areas and specific shipping or ferry routes. Other regions with existing infrastructure like submarine cables and pipelines, private water lots, anchorage areas, marine renewable energy areas, and marine disposal sites could also constrain aquaculture development. These areas are critical to aquaculture siting, since they reflect a spatial constraint on suitability.

4 Criteria excluded from the assessment

Some criteria were not practical or appropriate to include in the assessment, based on an evaluation of selection properties described above (**Section 2**). Below, we provide an overview of additional criteria considered for inclusion, their relevance, and why they were not included in the analysis (**Table 3**). For some criteria, multiple reasons contributed to the recommendation to exclude. For detailed rationales and evaluation of excluded criteria see **Appendix ii** (finfish) and **Appendix iii** (shellfish). In some cases, if data for criteria that met selection properties were to become available in the future, their inclusion is recommended.

[14] Aquaculture site selection in Canada must adhere to the *Canadian Navigable Waters Act*, which secures that waters capable of navigation remain open and accessible to the Canadian public (Government of Canada, 1985; Province of Nova Scotia, 2015; Transport Canada, 2020).

Table 3. Sub-criteria excluded from suitability analysis and main reason why.

Sub-criterion	Rationale for consideration	Primary reason for exclusion
Sea surface temperature	Aquaculture should be sited in areas where average temperatures are within established temperature ranges optimal for growth.	Identifying optimal growth conditions are beyond the project scope[15].
Ocean slope	Aquaculture should be sited in areas where the bottom slope is suitable for robust mooring of farms and to optimize water exchange and waste dispersion.	Mooring and farm construction, are considerations for site level assessments and are beyond the project scope.
Substate	Substrate type will influence mooring and assimilative capacity of the seafloor.	Mooring considerations at the site level are beyond the project scope.
Ocean currents	Aquaculture should be sited in areas with adequate current to enable water exchange for oxygen supply to fish and food supply to shellfish while enhancing dispersal of wastes.	Criterion has high temporal and spatial variability – more relevant for bay or site-level assessments.
Ocean flushing	Aquaculture does not perform well in areas with poor flushing, which could increase water temperature, decrease dissolved oxygen supply, and lead to algal blooms.	Criterion has high temporal and spatial variability – more relevant for site-level assessments.
Predominant wind/wave direction and speed	Aquaculture site orientation and construction may account for the direction and speed of site-level wind and waves.	Farm operation and construction at the site level are beyond the scope of assessment.
Salinity	Aquaculture should be sited in areas to avoid extreme salinity fluctuations and to remain within salinity tolerances of cultured species.	Criterion has high temporal and spatial variability – more relevant for bay or site-level assessments.
Dissolved oxygen	Aquaculture should be sited in areas with adequate dissolved oxygen required for species' respiratory and metabolic processes.	Areas of low dissolved oxygen are rare around Nova Scotia and criterion has high variability – more relevant for site-level assessments.
Turbidity	Aquaculture should not be located in areas of high turbidity, which can negatively impact water quality, shellfish feeding, and health.	Criterion has high temporal and spatial variability – more relevant for site-level assessments.
Chlorophyll	Shellfish aquaculture should be located in areas within optimal ranges of chlorophyll which is a proxy for good shellfish nutrition	Criterion has high temporal and spatial variability – more relevant for site-level assessments.
Primary productivity	Aquaculture should be located in areas with sufficient primary productivity to ensure nutrient availability required by shellfish.	Criterion has high temporal and spatial variability – more relevant for site-level assessments.
Point discharges	Aquaculture should not be near areas with domestic effluent or industrial discharges into coastal areas.	Criterion already included in dataset of CSSP approved shellfish harvest areas.

[15] Temperature is included through consideration of lower and upper thresholds (Table 2).

Sub-criterion	Rationale for consideration	Primary reason for exclusion
Agricultural and forestry runoff	Aquaculture should not be located near areas where runoff from activities (e.g., agriculture and forestry) can reduce water quality.	Criterion already included in dataset of CCSP approved shellfish harvest areas.
Algal blooms	Aquaculture operations can be impacted by harmful algal blooms which can cause mechanical damage to fish gills, deplete oxygen, and produce toxins.	Efforts required to complete dataset of high-risk locations to fill spatial gaps is beyond the time and resources available.
Aquatic Invasive Species (AIS)	Aquaculture should not be located in areas susceptible to AIS due to their detrimental impacts on water quality.	Consideration requires data on intensity or timing of AIS which is not available.
Disease transfer	Aquaculture should be located with adequate distance between farms to minimize the potential for disease transfer between farms.	Highly dependent on local operations - best evaluated during site-level assessments.
Eelgrass habitat	Aquaculture should not be positioned over dense eelgrass meadows, to reduce potential impacts from shading or sedimentation	Efforts required to complete data for missing spatial coverage is beyond available resources.
Ecologically and Biologically Significant Areas	Aquaculture operations should be sited at appropriate distances away from areas of high biological or ecological significance.	Very large areas, reflect too broad of consideration for this assessment.
Important marine species habitats	Aquaculture should be sited to minimize potential interactions with important marine species (fish, cetaceans, corals, etc.).	Mapped habitats are not available within the area of analysis.
Species migration paths	Aquaculture siting should account for areas and paths used by threatened or endangered species.	Comprehensive spatial data currently non-existent or know travel routes are very broad.
Commercial fishing	Aquaculture should consider the access of users to important fishing areas	Resolution of available datasets are too coarse.
Indigenous fisheries	Aquaculture should not be located in significant areas for Indigenous fishing	Lack of spatial dataset – best considered through local consultation.
Recreation areas	To minimize potential spatial overlaps, aquaculture should avoid marine areas of high density for recreation and tourism.	Data unavailable; would require large-scale participatory data.
Noise footprint	Aquaculture should be located to minimize their noise footprint for adjacent marine users or coastal occupants.	Criterion operation-specific (gear, size of farms, etc.) – best evaluated during site selection and design.
Viewshed	Aquaculture siting should consider potential effects on the surrounding seascape, and aesthetic appeal of coastal areas.	Limited scientific evidence to support classification, and effects are highly subjective.
Dredging areas	Aquaculture should not be located in areas designated for dredging activities, which can alter water quality for cultured species.	Recent maps are unavailable.
Derelict vessels and shipwrecks	Aquaculture cannot be located above submerged vessels due to safety hazards and to preserve culturally important sites.	Location of known sites is often restricted to avoid vandalism. Local consultation required.

Sub-criterion	Rationale for consideration	Primary reason for exclusion
Archaeological sites	Aquaculture should be situated with an appropriate buffer around important cultural heritage or archeological sites.	Location of sites is often restricted to avoid artifact vandalism and theft. Local consultation required.
Oil and gas structures	Aquaculture cannot be located with existing oil and gas structures (spatial constraint).	None, currently, within area of analysis.

Some criteria considered were excluded since they did not fit within the project's goals and objectives. While biophysical considerations are included, criteria that were primarily associated with mooring or operational needs were excluded. Some criteria were considered more relevant to identifying optimal growing conditions for cultured species (e.g. average water temperatures) and were excluded. These considerations are best suited for more site-level assessments and depend on specific industry practices.

In some cases, criteria were considered highly relevant to aquaculture (e.g. current, primary productivity, and dissolved oxygen) but have high spatial or temporal variability at local scales, such that accurate reflection on suitability requires higher resolution data and analysis. For example, consideration for current flow, including flushing rate, is important for water quality to ensure adequate oxygen supply to cultured finfish and transport of nutrients to cultured shellfish, but can be influenced by a myriad of factors (Ministry for Primary Industries, 2013). These criteria are certainly relevant to aquaculture suitability but were excluded since they were considered more relevant or appropriately evaluated at the site level, including during site-selection processes.

Other criteria considered were only available at coarse resolutions that would require substantial downscaling so that data can be represented at higher resolutions needed for this analysis. For example, commercial fisheries catch and effort data for both pelagic and inshore lobster fisheries exist, but only on coarse resolutions that are not appropriate for this level of assessment. Significant downscaling of datasets is not recommended as it can lead to issues influencing the accuracy, output resolution, and robustness of the data (Ramirez-Villegas and Jarvis, 2010).

Finally, some criteria considered were excluded due to lack of available data or adequate coverage of data across the AOA (**Figure 1**). For a few criteria, available data simply did not overlap or intersect the study area. This occurred where data was only available for offshore coastal areas beyond 3 kilometres[16]. Other datasets were available but had substantial gaps in coverage across the entire AOA. For example, distribution maps of eelgrass areas in Nova Scotia have recently become available through DFO's NETForce project (Gomez et al., 2021). However, this is an ongoing project and distribution has only been mapped for the coastal areas around the Scotian

[16] For example, species distribution data has been mapped for several important species of fish and invertebrates, but collected through DFO research vessel surveys, which largely operate in offshore waters beyond our AOA (Bundy et al., 2017).

Shelf, resulting in significant gaps in spatial coverage of data. AOA. As data becomes available, these criteria should be re-evaluated and reconsidered for inclusion in future iterations of the suitability assessment.

5 Conclusions

In reflection of multiple potential criteria for inclusion in the Coastal Classification System (CCS) for aquaculture in Nova Scotia, this report identifies a comprehensive list of considerations for a high-level regional assessment of areas of potential for shellfish and finfish aquaculture. These identified criteria consider a range of objectives, including the health and welfare of cultured species, environment and conservation considerations, and potential overlaps with other marine uses. A total of 8 criteria (24 sub-criteria) for finfish and shellfish, with some species-specific differences, are proposed (**Table 1**), representing the specific considerations that contribute to the assessment of aquaculture suitability. For shellfish aquaculture, the addition of water quality criteria is the key differences in the composition of criteria. Of the 60 sub-criteria assessed, 37 were evaluated to be inadequate for inclusion in the current assessment. The primary reasons for exclusion of many criteria were either due to lack of data availability and/or coverage within our area of analysis, or due to the complexity and variability of the consideration, such that it was evaluated to be not appropriate for a regional-level assessment.

The proposed list of criteria reflects comprehensive efforts to identify the criteria most appropriate for this regional-level assessment of aquaculture potential for development. The criteria selection process outlined here provides a thorough and transparent method of identifying the most appropriate, available, and high-quality data for assessment of aquaculture suitability reflecting present-day conditions and knowledge. The final criteria included in the assessment may change based on expert feedback and public consultation, or further investigations into the use and assessment of data during the analysis process. Recognizing that future state conditions, data availability, and aquaculture technologies change, future iterations of the CCS assessments should re-evaluate criteria against the selection properties outlined above, to enable future additions or changes.

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Appendix i: Summary and description of criteria evaluation

July 4, 2024

Prepared by:

Jenny Weitzman
Therese Wilson
James Cunningham
Laila Nargis
Leah Lewis-McCrea
Gregor Reid

27 Parker Street · Dartmouth, Nova Scotia · B2Y 4T5

CMAR.CA

Introduction

Evaluation of criteria for inclusion in the suitability assessment was completed by scoring each criteria based on how appropriate they meet the needs of the assessment (**Table 1**).

Table 1. Description of rating and scores assigned during criteria evaluation.

Rating	Description	Score
Not appropriate	Fails to meet minimum requirements to be considered for inclusion	**N/A**
Poor	Only somewhat appropriate to meet the needs of the suitability assessment	**1**
Adequate	Considered adequate to meet the needs of the suitability assessment	**2**
Exceptional	Highly suited for inclusion in the suitability assessment	**3**

Criteria were evaluated by calculating the average score across eight selection properties considered important in ensuring criteria are relevant and fit-for purpose (**Table 2**). Two key inclusion conditions were identified:

1) Criteria must not fail to meet the minimum requirements for *any* property (i.e., score ≠ N/A).
2) For criteria that met minimum requirements (i.e., score ≥ 1), the criterion must have an average score considered 'adequate' (i.e., average ≥ 2) in an aim to include only the most relevant, parsimonious group of criteria.

A summary of which criteria are proposed for inclusion and exclusion for all criteria considered and their final score is provided in **Table 3**. For organizational purposes, criteria are grouped broadly into "Biophysical", "Conservation", and "Ocean Use" groups[1]. For more description and rationale for the scoring of criteria against each property, see **Appendix ii** (for finfish aquaculture) and **Appendix iii** (for shellfish aquaculture).

Version Control			
Status	**Version**	**Date**	**Rationale**
Draft	0.1	March 5, 2024	First draft
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[1] The name, and composition of these groupings have not yet been finalized and are subject to change.

Table 2. Description of ratings applicable to each of the eight criteria selection properties.

Selection Property	Rating			
	Not appropriate (N/A)	**Poor (1)**	**Adequate (2)**	**Exceptional (3)**
RELEVANCE TO SCOPE	Criterion can not be linked to any of the project goals/objectives.	Criterion may indirectly support one (or more) of project goals/objectives, but linkage and/or importance for aquaculture is unclear and/or indirect.	Identified as important by regulators and experts. Criterion clearly supports one (or more) of project goals/objectives.	Strong evidence that the criterion is an important consideration for identifying potential areas for aquaculture for a regional assessment.
RATEABILITY	Basis for linkage to aquaculture suitability is weak, and scant evidence/expertise exists to generate classification levels.	Little empirical evidence or justification available to generate classification levels. Scoring will rely fully on expert opinion or precautionary principles	Some empirical evidence to generate classification levels may exist, but scoring will rely primarily on expert opinion.	Strong scientific evidence available to classify the criteria or identification in legislative instruments.
SCORING CLARITY	Interpretation of data and/or classification requires significant expert knowledge to understand and incorporate.	Criterion data and/or scoring requires substantial explanation and clarification, although can be understood without expert and/or technical knowledge.	Criterion data and/or scoring may require some explanation and clarification.	Clear goals and objectives of criteria can be developed. Data and suitability classification can be easily communicated to public.
SCALE VALIDITY	Criterion is more relevant at the site selection scale or for broader-scale planning.	Dataset would require substantial manipulation to appropriate resolution. Criterion largely considered inappropriate for regional-level assessment.	Resolution of the dataset mostly aligns with the assessment but may require some interpolation. Criterion can be relevant for regional-level considerations appropriate for aquaculture siting .	The criterion measures a regional-level phenomenon relevant to aquaculture planning and the spatial resolution of dataset is available.
COASTAL COVERAGE	Data exists within ≤50% of the Area of Analysis (AOA).	Large areas of the AOA are data deficient, having significant gaps in final product.	Only minor gaps in spatial coverage of data, or AOA can be fully covered through interpolation.	Data has full spatial coverage across the AOA.
DATA ACCESSIBILITY	Spatial data does not exist and can not be expected to be gathered given the time, resources, and expertise.	Data is partially available or may have confidentiality limitations on use.	Source of data can be identified and can be collected within the project's timeline. The expertise, resources, and data are adequately available.	Data can be accessed easily and readily available for manipulation, if required.
MEASUREMENT RELIABILITY	Poor confidence in data; Large uncertainty and/or difficult to define. No appropriate methods for criterion measurement.	Potentially large uncertainty and variability in data; methods available but have unproven reliability.	Some expected uncertainty in data that can be accounted for. Data may be novel, but there is confidence that methods are considered scientifically valid.	Data has high confidence and reliability and can be measured using well-established methods applied consistently.
REDUNDANCY TO OTHER CRITERIA	The measurement and/or classification of criteria is strongly dependent on the data of other criteria.	Influence or correlation with another criterion may require choosing between criteria. Inclusion of both would consist double counting of data.	Criterion may be influenced by and/or correlated with other criteria, but the correlation does not influence the score or can be adjusted for through grouping.	Criterion can be measured and classified independently of the data or score from any other criteria. Data is not included in any other criterion layer (no double-counting).

Table 3. Summary of criteria considered for inclusion for both finfish and shellfish aquaculture, including their average evaluation score and inclusion recommendation. Superscripts indicate criteria that are included only for specific species (S- salmon, T-trout, M-mussels, O-oysters).

		Finfish		Shellfish	
Criterion	**Sub-criterion**	**Average Score**	**Inclusion**	**Average Score**	**Inclusion**
BIOPHYSICAL					
Temperature	Heat stress	2.0	Include	2.0	Include[M]
Temperature	Superchill	2.0	Include	1.4	Exclude
Temperature	Sea surface temperature	1.6	Exclude	1.6	Exclude
Bathymetry	Ocean depth	2.8	Include	2.3	Include
Bathymetry	Ocean slope	N/A	Exclude	N/A	Exclude
Bathymetry	Substate	N/A	Exclude	N/A	Exclude
Exposure	Ice conditions	2.1	Include	2.1	Include
Exposure	Wind and wave conditions	2.4	Include	2.4	Include
Exposure	Ocean current	N/A	Exclude	N/A	Exclude
Exposure	Ocean flushing	N/A	Exclude	N/A	Exclude
Exposure	Wind/wave direction	N/A	Exclude	N/A	Exclude
Exposure	Wind speed	N/A	Exclude	N/A	Exclude
Water quality	Shellfish Harvest Area Classifications	N/A	Exclude	2.4	Include
Water quality	Aquatic Invasive Species	1.5	Exclude	1.6	Exclude
Water quality	Salinity	N/A	Exclude	N/A	Exclude
Water quality	Dissolved oxygen	N/A	Exclude	N/A	Exclude
Water quality	Turbidity	N/A	Exclude	1.8	Exclude
Water quality	Chlorophyll	N/A	Exclude	1.8	Exclude
Water quality	Primary productivity	N/A	Exclude	N/A	Exclude
Water quality	Point discharges	1.9	Exclude	N/A	Exclude
Water quality	River runoff	1.3	Exclude	1.4	Exclude
Water quality	Agricultural runoff	N/A	Exclude	N/A	Exclude
Water quality	Forestry runoff	N/A	Exclude	N/A	Exclude
Water quality	Algal blooms	N/A	Exclude	N/A	Exclude
Water quality	Other aquaculture sites (proximity)	N/A	Exclude	N/A	Exclude
Water quality	MSX presence	N/A	Exclude	2.1	Include[O]
CONSERVATION					
Wild Salmon	Wild salmon rivers	2.4	Include[S]	N/A	Exclude
Important coastal habitats	Coastal wetlands	2.8	Include	2.8	Include
Important coastal habitats	Terrestrial protected areas and parks	2.0	Include	2.0	Include
Important coastal habitats	Eelgrass habitat	N/A	Exclude	N/A	Exclude
Important coastal habitats	Critical habitat for species at-risk	2.6	Include	2.6	Include
Important coastal habitats	Species migration paths	N/A	Exclude	N/A	Exclude
Important coastal habitats	Important bird habitat	2.5	Include	2.5	Include
Important coastal habitats	Important fish habitat	N/A	Exclude	N/A	Exclude
Important coastal habitats	Important cetacean habitat	N/A	Exclude	N/A	Exclude
Important coastal habitats	Important coral/sponge habitat	N/A	Exclude	N/A	Exclude
Important coastal habitats	Important invertebrate habitat	N/A	Exclude	N/A	Exclude
Important coastal habitats	Lobster presence	1.5	Exclude	1.3	Exclude
Important coastal habitats	Ecologically and Biologically Significant Areas	N/A	Exclude	N/A	Exclude

		Finfish		Shellfish	
Criterion	**Sub-criterion**	**Average Score**	**Inclusion**	**Average Score**	**Inclusion**
OCEAN USE					
Navigation	Fishing traffic	2.3	Include	2.3	Include
Navigation	Navigation routes	2.1	Include	2.1	Include
Coastal access	Coastal accessibility	2.0	Include	2.0	Include
Recreation and Tourism	High-use recreation and tourism areas	N/A	Exclude	N/A	Exclude
Fishing Activity	Lobster fisheries	N/A	Exclude	N/A	Exclude
Fishing Activity	Other commercial fisheries	1.6	Exclude	1.6	Exclude
Fishing Activity	Indigenous fisheries	N/A	Exclude	N/A	Exclude
Social uses	Viewshed	1.8	Exclude	1.8	Exclude
Social uses	Noise footprint	N/A	Exclude	N/A	Exclude
Allocated use areas	Anchorage areas	2.9	Include	2.9	Include
Allocated use areas	Designated navigation features	2.9	Include	2.9	Include
Allocated use areas	Existing aquaculture	2.9	Include	2.9	Include
Allocated use areas	Private water lots	2.6	Include	2.6	Include
Allocated use areas	Submerged structures	2.9	Include	2.9	Include
Allocated use areas	Marine Renewable Energy Areas	2.8	Include	2.8	Include
Allocated use areas	Marine protected and conserved areas	2.9	Include	2.9	Include
Allocated use areas	At-sea disposal sites	2.9	Include	2.9	Include
Allocated use areas	Dredging areas	N/A	Exclude	N/A	Exclude
Allocated use areas	Derelict vessels and shipwrecks	N/A	Exclude	N/A	Exclude
Allocated use areas	Archaeological sites	N/A	Exclude	N/A	Exclude
Allocated use areas	Oil and gas structures	N/A	Exclude	N/A	Exclude

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Appendix ii: Criteria scoring – Finfish Aquaculture

July 4, 2024

Prepared by:

Jenny Weitzman
Therese Wilson
James Cunningham
Laila Nargis
Leah Lewis-McCrea
Gregor Reid

27 Parker Street · Dartmouth, Nova Scotia · B2Y 4T5

CMAR.CA

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Draft	0.1	March 5, 2024	First draft
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Introduction

Each criterion considered for inclusion is described below. Criteria are grouped broadly into "Biophysical", "Conservation", and "Ocean Use" groups[1]. Criteria proposed for inclusion are described first, followed by criteria considered but ultimately excluded from proposed list. See the table of contents below to navigate across criteria.

Criteria for inclusion

Biophysical Criteria

Heat Stress

Rationale for consideration: Finfish exposed to prolonged periods of elevated water temperatures can experience stress, which in extreme cases can lead to mortalities.
Final decision: Include
Average score: 2.0 (ADEQUATE)

Property	Description	Score
Relevance to scope	Temperature is a key biophysical parameter important for siting and welfare considerations of finfish aquaculture. Heat stress directly influences the health and welfare of cultured species and, in extreme cases, can lead to mortalities.	3
Rateability	Heat stress thresholds are established, though there is some uncertainty.	3
Scoring clarity	The analysis and methods (i.e., interpolation) require some explanation.	2
Scale validity	Interpolation of data was required to produce datasets at the appropriate resolution.	2
Coastal coverage	Spatial dataset will be based on point data with disperse coverage; interpolation will be applied to areas between point data.	1
Data accessibility	Spatial datasets will be generated using data from CMAR's Coastal Monitoring Program for this assessment.	2
Measurement reliability	Measuring heat stress relies on analysis and interpolation of point data and can be estimated using likelihood calculations. Novel datasets and methods combined with interpolation, will likely introduce uncertainties.	1
Redundancy to other criteria	At shallow water depths, heat stress may have overlaps in trends with bathymetry, but can be assessed and classified relatively independently.	2

[1] The name and composition of these groupings have not yet been finalized and are subject to change.

Superchill

Rationale for consideration: Some parts of Nova Scotia have regular periods of extreme low temperatures (e.g. superchill events) which can kill fish. This occurs when the water temperature drops to -0.7 ºC.
Final decision: Include
Average score: 2.0 (ADEQUATE)

Property	Description	Score
Relevance to scope	Temperature is a key biophysical parameter important for siting and welfare considerations of finfish aquaculture. Superchill events can lead to fish mortality.	3
Rateability	Superchill thresholds are well established, and effects are well documented.	3
Scoring clarity	The risk-based approach and methods (i.e., interpolation) require some explanation.	2
Scale validity	Interpolation of data was required to produce datasets at appropriate resolution.	2
Coastal coverage	Spatial dataset will be based on point data with disperse coverage; Interpolation will be applied to areas between point data.	1
Data accessibility	Spatial datasets will be generated using data from CMAR's Coastal Monitoring Program for this assessment.	2
Measurement reliability	Documenting superchill temperatures spatially relies on analysis and interpolation of point data using likelihood calculations. Novel datasets and methods combined with interpolation, will likely introduce uncertainties.	1
Redundancy to other criteria	At relevant temperatures, the parameter may have overlaps in trends with ice exposure but can be assessed and classified relatively independently.	2

Ocean Depth

Rationale for consideration: Aquaculture should be located in areas with adequate ocean depth to ensure sufficient, culture space, and water flow, which is important for dispersal of nutrient wastes and supplying for dissolved oxygen to fish.
Final decision: Include
Average score: 2.8 (ADEQUATE)

Property	Description	Score
Relevance to scope	Ocean depth affects water flow and waste dispersal, and adequate oxygen supply to fish.	3
Rateability	Minimum depth requirements for most culture techniques well established in industry. Scientific evidence of depth requirements for finfish aquaculture will be augmented by expert advice.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Criterion relevant to regional planning and datasets are available at appropriate spatial resolution.	3
Coastal coverage	Data is available across the entire spatial area of analysis.	3
Data accessibility	Bathymetry data available from public datasets (e.g. GEBCO) and accessible.	3
Measurement reliability	Measurable and an accepted method of measurement	3
Redundancy to other criteria	There are correlations with temperature and exposure (i.e., ice, waves, and wind) but can be assessed and classified relatively independently.	2

Ice Conditions

Rationale for consideration: Aquaculture operations may be exposed to risks from different types of sea ice which can threaten infrastructure and fish welfare.
Final decision: Include
Average score: 2.1 (ADEQUATE)

Property	Description	Score
Relevance to scope	Sea ice develops across large areas of Nova Scotia and is a key for operational and siting considerations. Increased risks can require producers to adapt technologies and/or introduce management measures.	2
Rateability	Ice exposure is an operational risk for producers but can also lead to increased welfare and stress from cage deformations. The definition of ice risks and classification can be determined through industry experiences and expert feedback.	2
Scoring clarity	The risk-based approach and methods require explanation to explain how different ice considerations are incorporated.	2
Scale validity	Criterion relevant to decision-making at the regional level and data resolution is appropriate for this scale, although more local-scale ice dynamics are not captured.	2
Coastal coverage	Ice exposure risk generated at appropriate resolutions across the area of analysis.	3
Data accessibility	Spatial data generated from remote sensing data and model projections to support assessment.	2
Measurement reliability	Spatial data products are being developed by the Nova Scotia Community College's Applied Geomatics Research Group. Measurements use well-established methods though data will likely be analyzed based on risk, which will introduce some uncertainty.	2
Redundancy to other criteria	Some correlation with other criterion (e.g. temperature and depth) but can be evaluated relatively independently.	2

Wind and Wave Conditions

Rationale for consideration: Exposure of aquaculture to high wind and waves can threaten infrastructure and affect fish welfare.
Final decision: Include
Average score: 2.4 (ADEQUATE)

Property	Description	Score
Relevance to scope	Consideration of exposure (wind and waves) is an important physical parameter for site selection since given risk to infrastructure, operational management, and fish welfare.	3
Rateability	Some scientific evidence on the impacts of significant wave height on aquaculture, which will be supplemented by expert and industry insights to capture local contexts.	2
Scoring clarity	Exposure modelling and data require some explanation.	2
Scale validity	Criterion relevant to regional planning and dataset will be created at the appropriate spatial resolution.	3
Coastal coverage	Wind and wave exposure modelling generated at appropriate resolutions across the area of analysis.	3
Data accessibility	Spatial data generated for assessment purposes will be developed during the project timeline based on previous ocean wave modelling by DSA Ocean.	2
Measurement reliability	Interpolation of datasets from wave modelling has some uncertainties, though these can be accounted for.	2
Redundancy to other criteria	Correlations with depth although data can be classified relatively independently.	2

Conservation Criteria

Wild Salmon Rivers

Rationale for consideration: Atlantic salmon aquaculture operations in close proximity of wild salmon rivers may have the potential for negative interactions.
Final decision: Include (Trout – Exclude*)
Average score: 2.4 (ADEQUATE)

Property	Description	Score
Relevance to scope	Reducing the decline of wild salmon populations while supporting population recovery is a conservation priority. Atlantic salmon aquaculture may have the potential for negative interactions with wild Atlantic salmon. Considerations for wild salmon are a key factor in Nova Scotia Aquaculture License and Lease Regulations.	3
Rateability	Some evidence available to support classification ranges, although it will largely be discussed through project experts. *Little evidence of interactions with trout (=N/A)	2
Scoring clarity	Ratings for salmon rivers require some explanation.	2
Scale validity	Criterion is relevant to regional planning and dataset will be created to be at the appropriate spatial resolution.	3
Coastal coverage	Assessments will encompass rivers from across the province, with potentially minor gaps in coverage due to lack of comprehensive data on specific rivers.	3
Data accessibility	Assessment of wild salmon rivers is being conducted for this assessment, which requires additional project resources but can be accomplished within the project timeline.	2
Measurement reliability	Recent information on salmon river population status is sparce. Data is being compiled, assessed, and classified based on significance for wild salmon. The assessment framework being established through expert review, but some uncertainty is expected.	1
Redundancy to other criteria	Data is largely independent of other types of data.	3

Coastal Wetlands

Rationale for consideration: Finfish aquaculture operations may have the potential to interact with important and sensitive wetland habitats in Nova Scotia.
Final decision: Include
Average score: 2.8 (ADEQUATE)

Property	Description	Score
Relevance to scope	Wetlands are important and sensitive habitats in Nova Scotia, supporting various wildlife.	3
Rateability	There is some evidence for interaction with aquaculture, although classification will largely rely on consultation with experts and network partners.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	The criterion is relevant to regional planning and datasets are largely available at appropriate spatial resolution.	3
Coastal coverage	Data is available across the entire province.	3
Data accessibility	Datasets are available and publicly accessible through the Canadian National Wetlands Inventory	3
Measurement reliability	Measurement is straight forward, and analysis can be done through commonly applied path-distance methods in GIS.	3
Redundancy to other criteria	There may be some overlap with other important habitat designations (including protected areas and parks).	2

Terrestrial Protected Areas and Parks

Rationale for consideration: Aquaculture should be located to minimize potential interactions with sensitive coastal species or habitats, protected due to their high biodiversity or ecological vulnerability.
Final decision: Include
Average score: 2.0 (ADEQUATE)

Property	Description	Score
Relevance to scope	Several coastal islands are protected wilderness areas or conservation easements, as they are recognized for their rich coastal biodiversity or as habitat for marine and migratory birds. The potential impacts from aquaculture may be variable and are often unclear.	2
Rateability	Nearshore aquaculture may have potential to interact with terrestrial habitat/species. Though the potential for impacts is unclear as are the designation of adequate buffers.	1
Scoring clarity	Data does not involve complex analysis, although criterion rationale requires some explanation, as there could be multiple potential variables.	2
Scale validity	Criterion mostly represents terrestrial habitats, and interactions are often best evaluated at a site-level (and highly operation-specific).	1
Coastal coverage	Data is available across the entire spatial area of analysis.	3
Data accessibility	Public datasets (e.g. The Nova Scotia Protected Areas System and National Parks and National Park Reserves of Canada Legislative Boundaries) are available and accessible.	3
Measurement reliability	Datasets are compiled, maintained, and updated by the Government of Nova Scotia and monthly by the National Research Council, respectively. Measurement is straight forward, and analysis can be done using commonly applied path-distance methods in GIS.	3
Redundancy to other criteria	Parameter may have some overlap with other habitat and species areas (including wetlands, critical habitats, or avifauna habitats).	1

Critical Habitat for Species At-Risk

Rationale for consideration: Marine species listed as threatened or endangered under the Species at Risk Act (SARA) have critical habitats identified and are legally protected from activities that could impact habitat.
Final decision: Include
Average score: 2.6 (ADEQUATE)

Property	Description	Score
Relevance to scope	Proximity to marine areas recognized as important to minimize potential interactions with human activities. Critical habitat for protected species, may be located in coastal waters close to shore and therefore have the potential to overlap with aquaculture activities.	3
Rateability	Scoring suitability of aquaculture in relation to critical habitats should consider potential interactions with at-risk species, but may best be evaluated with species distribution, migration, or foraging habitats through more local-scale assessments. Scoring will thus rely on precautionary approaches, drawing on experts and network partners.	1
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Specific species-interactions and risks with aquaculture are best evaluated at more local scale assessments. Though, boundaries of critical habitats are established by DFO processes that are appropriate for regional-scale assessment.	2
Coastal coverage	Data is available identifying critical habitats across the entire province.	3
Data accessibility	Public datasets are accessible through DFO (Critical Habitat for Species at-risk).	3
Measurement reliability	Critical habitat for aquatic species at risk are identified by DFO.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Important Bird Habitat

Rationale for consideration: Physical structures, along with aggregation of feed and nutrients associated with aquaculture may interact with birds in a variety of ways. Several important species nest and forage in coastal areas around Nova Scotia, within critically important habitat.
Final decision: Include
Average score: 2.5 (ADEQUATE)

Property	Description	Score
Relevance to scope	Potential interactions of human activities with a critical bird habitat is an important consideration for aquaculture siting.	3
Rateability	Aquaculture has the potential to interact with bird species or their critical habitat. Based of proximity to habitats, some setback distances have been established, often at a species-specific level. Scoring will require consultation with network partners.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Identifying key areas can be relevant to regional planning, with available datasets at appropriate spatial resolution.	2
Coastal coverage	Data may not represent all habitats recognized.	2
Data accessibility	Several important bird habitat areas are identified in public datasets (e.g. NS Significant Habitat Dataset and IBA Important Bird Areas).	3
Measurement reliability	Measurement is straight forward and required analysis can be done through commonly applied path-distance methods in GIS.	3
Redundancy to other criteria	Important bird habitat may be accounted for indirectly in other layers, such as wetlands. There may also be some overlap with other habitat designations (e.g. protected areas).	2

Ocean Use Criteria

Fishing Traffic

Rationale for consideration: Aquaculture should consider space to accommodate navigation of high-use areas for fishing vessels.
Final decision: Include
Average score: 2.3 (ADEQUATE)

Property	Description	Score
Relevance to scope	Marine developments should allow sufficient space to accommodate vessel traffic, such as those by fishing. The public right of navigation and other adjacent marine users is a key decision-making factor in the Nova Scotia Aquaculture License and Lease Regulations.	3
Rateability	Scoring can be based on distribution of density data to identify hotspots of fishing vessel traffic.	3
Scoring clarity	Interpreting criteria rationale and data does not require expert knowledge but would require some explanation and clarification.	2
Scale validity	Spatial data on fishing traffic hotspots is relevant to regional-level planning.	3
Coastal coverage	Spatial datasets have mostly complete coverage across the area of analysis, although data does have some uncertainty	2
Data accessibility	Fishing vessel traffic data is available (e.g., Vessel Density Mapping of 2019), although more comprehensive VMS datasets was acquired from DFO. Spatial data products will be generated for assessment purposes.	2
Measurement reliability	Vessel traffic data will be assessed based spatial analysis of VMS data. There is some uncertainty in available vessel traffic datasets. Using VMS data to identify vessel traffic hotspots is a common practice and established.	2
Redundancy to other criteria	There could be some correlation with other data sources such as coastal access points and overlap with AIS data.	1

Navigation Routes

Rationale for consideration: Aquaculture should consider space to accommodate public navigation.
Final decision: Include
Average score: 2.1 (ADEQUATE)

Property	Description	Score
Relevance to scope	Marine developments should allow sufficient space to accommodate vessel traffic. The public right of navigation and other adjacent marine users is a key decision-making factor in the Nova Scotia Aquaculture License and Lease Regulations.	3
Rateability	While some guidance is available on suggested buffers for designated traffic routes (e.g. shipping lanes, ferry routes), scoring will rely on expert input and network partner advice.	2
Scoring clarity	Interpreting criteria rationale and data does not require expert knowledge but would require some explanation and clarification.	2
Scale validity	Spatial data on common marine transit routes is relevant to regional-level planning.	3
Coastal coverage	Spatial datasets have mostly complete coverage across the area of analysis, although data may not capture all vessel traffic.	2
Data accessibility	Some vessel traffic data available (e.g., Vessel Density Mapping of 2019 AIS Data in the Northwest Atlantic), although more comprehensive AIS datasets was acquired from DFO. Spatial data products will be generated for assessment purposes.	2
Measurement reliability	Navigation routes will be identified based spatial analysis of AIS data. There is some uncertainty in available datasets. Some methods for identifying navigation corridors exist, although a novel method my be required for this project.	1
Redundancy to other criteria	There could be some correlation with other data sources such as coastal access points and fishing vessel traffic.	2

Coastal Accessibility

Rationale for consideration: Aquaculture siting should consider space which may be accessed or shared with other users, such as tourism and recreation, as aquaculture can potentially impede access to navigable areas.
Final decision: Include
Average score: 2.0 (ADEQUATE)

Property	Description	Score
Relevance to scope	Aquaculture may have the potential to affect navigation and access of coastal users to marine areas. The public right of navigation and other adjacent marine users is a key decision-making factor in the Nova Scotia Aquaculture License and Lease Regulations.	3
Rateability	Data provides an indicator of access to coastal areas. More comprehensive evaluation should be explored at local levels. Some recommended proximity distances have been suggested, but scoring will largely rely on expert input and precautionary designations.	1
Scoring clarity	Interpreting criteria rationale and data does not require expert knowledge but would require some explanation and clarification.	2
Scale validity	Key access points provide relevant information for regional level analysis and planning, although could be more comprehensively evaluated at site-level to explore variabilities of different types of access points or users.	2
Coastal coverage	Coverage is mostly adequate, with only some gaps in potential access points possible due to lack of available validation of points.	2
Data accessibility	Coastal access points will be compiled from several public datasets for the assessment.	2
Measurement reliability	There is some uncertainty in methods, but the approach is based on previous robust scientific methods.	2
Redundancy to other criteria	There is likely to be some correlation with other data (e.g., navigation channels).	2

Anchorage Areas

Rationale for consideration: Aquaculture cannot be located in areas already designated as allocated anchorage sites/areas.
Final decision: Include
Average score: 2.9 (ADEQUATE)

Property	Description	Score
Relevance to scope	Aquaculture can not occur in existing anchorage areas (constraint) to maintain safe navigation.	3
Rateability	Recognition as a constraint means the classification is straightforward though considerations around buffers is needed	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Datasets are available at the appropriate spatial resolution and relevant to regional-level considerations.	3
Coastal coverage	Spatial datasets have complete coverage across the area of analysis.	3
Data accessibility	Public datasets (e.g. Canadian Anchorages and Anchorage Areas) are available and accessible.	3
Measurement reliability	Data is maintained and updated regularly by DFO and the Canadian Hydrographic Service (CHS). Analysis is straightforward and a buffer can be easily applied.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Designated Navigation Features

Rationale for consideration: Aquaculture would be constrained in areas already designated for navigation (e.g., shipping and ferry routes, traffic separation zones, sight lines from lighthouses etc.)
Final decision: Include
Average score: 2.9 (ADEQUATE)

Property	Description	Score
Relevance to scope	Aquaculture is not allowed (constraint) in areas designated for traffic purposes (e.g., designated ferry routes) or to protect navigational safety (e.g., lighthouse sight lines).	3
Rateability	Recognition as a constraint means the classification is straightforward. Consideration around buffers is required, and different buffers may be needed for different features.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Criterion relevant to regional planning and dataset available at appropriate spatial resolution.	3
Coastal coverage	Spatial datasets have complete coverage across the area of analysis.	3
Data accessibility	Public datasets (e.g. Vessel Traffic Routes) are available and accessible.	3
Measurement reliability	Data is maintained and updated weekly by the DFO and CHS. Analysis is straight forward and requires only consideration of buffers.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Existing Aquaculture

Rationale for consideration: New aquaculture sites cannot be sited in existing aquaculture lease areas (and relevant buffers) due to physical constraints and requirements for mooring and operational logistics.
Final decision: Include
Average score: 2.9 (ADEQUATE)

Property	Description	Score
Relevance to scope	New aquaculture sites cannot be placed where existing aquaculture lease areas exist.	3
Rateability	Recognition as a constraint means the classification is straightforward. Consideration of buffers is required.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	The dataset is available at the appropriate spatial resolution.	3
Coastal coverage	Spatial datasets have complete coverage across the area of analysis.	3
Data accessibility	Public datasets (e.g. Nova Scotia Marine Aquaculture Leases) are available and accessible.	3
Measurement reliability	Analysis is straight forward and requires only potential buffers applied to features. Data is compiled, maintained, and updated by the NSDFA. is straight forward.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Private Water Lots

Rationale for consideration: Aquaculture cannot legally be located in already privately-owned water lots.
Final decision: Include
Average score: 2.6 (ADEQUATE)

Property	Description	Score
Relevance to scope	Several coastal properties in Nova Scotia have privately owned water lots. Aquaculture cannot be located in these areas.	3
Rateability	Recognition as a constraint means the classification is straightforward. Consideration of buffers is required.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Criterion may be more relevant for local site selection but remains an important constraint in nearshore areas.	2
Coastal coverage	Spatial property data is available across the area of analysis.	3
Data accessibility	Spatial property identification data is available though needs to be provided by network partners (private data request).	2
Measurement reliability	Analysis is straight forward and requires only potential buffers applied to features.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Submerged Structures

Rationale for consideration: Aquaculture cannot operate over submerged infrastructure due to required substrate moorings.
Final decision: Include
Average score: 2.9 (EXCEPTIONAL)

Property	Description	Score
Relevance to scope	Aquaculture cannot operate over submerged infrastructures such as telecommunication cables due to interference with moorings and legal restrictions.	3
Rateability	As this is a constraint, classification is straightforward.	3
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Criterion relevant to regional planning and dataset available at appropriate spatial resolution.	3
Coastal coverage	Spatial datasets have complete coverage across the area of analysis.	3
Data accessibility	The location of key structures is available on request from network partners.	2
Measurement reliability	Analysis is straight forward and requires only potential buffers applied to features.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Marine Renewable Energy Areas

Rationale for consideration: Several areas in Nova Scotia are allocated as Marine Renewable Energy Areas (MREA) used for exploration of energy production. Aquaculture can not occur in these areas already allocated for this use.
Final decision: Include
Average score: 2.8 (EXCEPTIONAL)

Property	Description	Score
Relevance to scope	Several areas in Nova Scotia are allocated as Marine Renewable Energy Areas used for exploration of energy production. Aquaculture can not occur in these areas already allocated for this use.	3
Rateability	Recognition as a constraint means the classification is straightforward. Consideration of buffers is required.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Dataset available at appropriate spatial resolution.	3
Coastal coverage	Spatial datasets include all known approved MREAs and therefore have complete coverage across the area of analysis.	3
Data accessibility	Dataset is available at request through network partners.	2
Measurement reliability	Distinct boundaries of MREAS are allocated by Nova Scotia Department of Natural Resources and Renewables. Analysis is straight forward and requires only potential buffers applied to features.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Marine Protected and Conserved Areas

Rationale for consideration: Aquaculture can not be located within legally protected marine areas
Final decision: Include
Average score: 2.9 (EXCEPTIONAL)

Property	Description	Score
Relevance to scope	Within legally protected marine areas, large-scale developments are generally prohibited.	3
Rateability	Recognition as a constraint means the classification is straightforward. Consideration of buffers is required.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Dataset is available at appropriate spatial resolution.	3
Coastal coverage	Spatial datasets have complete coverage across the area of analysis.	3
Data accessibility	Public datasets (e.g. Canadian Protected and Conserved Areas Database (CPCAD)) are available and accessible.	3
Measurement reliability	The CPCAD data is compiled and managed by ECCC, in collaboration with federal, provincial, territorial, and other reporting authorities that provide the data. Analysis is straight forward and requires only potential buffers applied to features.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

At Sea-Disposal Sites

Rationale for consideration: Aquaculture can not be located above areas designated as at-sea disposal sites due to potential contamination risks.
Final decision: Include
Average score: 2.9 (EXCEPTIONAL)

Property	Description	Score
Relevance to scope	Several at-sea disposal sites are licensed in Nova Scotia's coastal waters. These represent allocated areas where any aquaculture operation would be excluded.	3
Rateability	Recognition as a constraint means the classification is straightforward. Consideration of buffers is required.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Dataset is available at appropriate spatial resolution.	3
Coastal coverage	At Sea Disposal Sites are regularly updated through ECCC, ensuring full coverage.	3
Data accessibility	Public dataset (e.g. Active and Inactive Disposal at Sea Sites in Canadian Waters) is available from ECCC.	3
Measurement reliability	Data is maintained and updated annually by ECCC. Analysis is straight forward and requires only potential buffers applied to features.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Criteria Excluded

Biophysical Criteria

Sea Surface Temperature

Rationale for consideration: Aquaculture should be sited in areas where average temperatures are within established temperature ranges optimal for growth.
Final decision: Exclude
Average score: 1.6 (POOR)

Property	Description	Score
Relevance to scope	Sea Surface Temperatures (SST) provide indication of average temperatures do not identify critical thresholds (e.g. heat stress, etc.). These temperatures are more relevant for identifying optimal growth conditions, which is beyond scope of assessment.	1
Rateability	Average temperatures are relevant to identifying general growth considerations for finfish, but they only provide an indicator at the surface (whereas fish normally in depths between 5-20 m below the surface). Therefore, SST is only a rough indicator of growth conditions, and so scoring would have some uncertainty.	2
Scoring clarity	The calculation of satellite-derived SST requires some explanation.	2
Scale validity	Available datasets are at coarse resolutions and not appropriate the scale of assessment.	1
Coastal coverage	Available datasets have major gaps in coverage, especially in nearshore environments close to the coast.	1
Data accessibility	Datasets are available through publicly accessible satellite-modeling (e.g. DFO BNAM model), though data may not be available for small time steps (e.g. daily).	3
Measurement reliability	Some identified limitations with using satellite-derived and modeled SST data.	2
Redundancy to other criteria	Data can be integrated into the calculation of temperature threshold layers (overlap).	1

Ocean Slope

Rationale for consideration: Aquaculture should be sited in areas where the slope of the bottom is suitable for construction of farms and cage drainage.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	The bottom slope of the area could affect farm construction. Mooring considerations and farm construction are beyond the scope of assessment.	N/A
Rateability	There is evidence of slope requirements for finfish sites, although this can be operation-specific.	2
Scoring clarity	The slope is calculated using bathymetry data, which would require some explanation.	2
Scale validity	Criterion is relevant for the site-level to capture operation-specific requirements.	N/A
Coastal coverage	Coverage is available around all of Nova Scotia but some areas have greater uncertainty or minor gaps.	2
Data accessibility	Bathymetry data is available from various sources (e.g., GEBCO).	2
Measurement reliability	Ocean slope can be represented from bathymetry data (e.g. GEBCO).	3
Redundancy to other criteria	Accounted for in bathymetry.	1

Substrate

Rationale for consideration: Aquaculture should be sited in areas with appropriate substrate type to meet mooring and operational considerations.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Different substrate types are readily accounted for by different mooring considerations with respect to substrate require high level data resolution at the site level, which is beyond the scope of assessment. Substrate type is also not considered an impediment for aquaculture site selection under most circumstances.	N/A
Rateability	General considerations for substrate type are well understood for different producers but may vary considerably across smaller scales and different operations. Scoring would rely on expert and industry insights.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Criterion is best evaluated at the site-level scale. Available datasets at very coarse scale, not representative of fine-scale variability that is important for siting.	N/A
Coastal coverage	Substrate Classification mapping of the Inshore Scotian Shelf and the Bay of Fundy exists with coverage across the area of analysis, though at a very coarse scale.	3
Data accessibility	Public dataset is available (e.g., A substrate classification for the Inshore Scotian Shelf and Bay of Fundy, Maritimes Region) and accessible.	3
Measurement reliability	Dataset was produced by the DFO based on previous geological characterizations from NRCan. In areas where geological descriptions were unavailable digital elevation models and substrate samples from NRCan, CHS and DFO Science were used. Dataset is considered coarse with high uncertainty and local variability at smaller scales.	1
Redundancy to other criteria	Data is largely independent of other types of data.	3

Ocean Current

Rationale for consideration: Aquaculture should be sited in areas with adequate current to allow greater water exchange between farms and surrounding water, allowing sufficient oxygen supply to farmed fish, and enabling waste dispersal from cages.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Adequate currents are an important consideration for planning and site selection for fish welfare, and current data is typically collected at prospective locations.	3
Rateability	Suitable current speeds are well established and understood, but suitability also often evaluated in the context of other ocean variables.	2
Scoring clarity	Implications for current speed would require some explanation to non-technical users.	2
Scale validity	Current is highly variable at local levels and of limited applicability at regional-level scales.	N/A
Coastal coverage	Local-scale current speed data collection is sporadic and does not cover the entire coastline. (sparse), not are model outputs (e.g. FVCOM) available for all locations.	N/A
Data accessibility	Available only for some locations.	N/A
Measurement reliability	There is confidence in data collected, but complex ocean models are needed to estimate (interpolate) current between these locations.	2
Redundancy to other criteria	Related to exposure modelling and correlated to depth.	1

Ocean Flushing

Rationale for consideration: Aquaculture should not be sited in areas with poor flushing, which could increase water temperature, decrease dissolved oxygen, and cause an increase in algal blooms.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Flushing rate is recognized as an important criterion for aquaculture at local site selection scales and is better suited for application in carrying capacity models.	2
Rateability	The dynamics of flushing rates on aquaculture are generally well understood, but often evaluated in the context of other ocean variables.	2
Scoring clarity	Flushing rate can generally be calculated through a range of basic to complex modelling processes which require some explanation.	2
Scale validity	Criterion is relevant for the local site selection scale or bay-scale carrying capacity modelling.	N/A
Coastal coverage	Not available for all bays across the province.	N/A
Data accessibility	Where flushing rate has been calculated and published, information is easily accessible, but for most bays around the province, field data collection would be required to calculate flushing rate.	1
Measurement reliability	Flushing rate calculations and predictions are more accurate in clearly defined bays with, but less accurate at fine scales or in geographically complex systems.	1
Redundancy to other criteria	Influences many water quality metrics. Flushing rate is of limited usefulness in isolation.	N/A

Wind/Wave Direction

Rationale for consideration: Aquaculture site orientation and construction can be influenced by the direction and speed of wind and waves in the area.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Indirectly relates to the magnitude of stress on gear, which is more of an operational constraint beyond the scope of assessment.	N/A
Rateability	Implications for aquaculture suitability are highly operation specific and can not be taken in isolation.	2
Scoring clarity	Relatively easy to explain, but variation in would also need to be communicated.	2
Scale validity	Wind and wave directional data has greater importance at the aquaculture site selection scale and is not well qualified at this scale most locations around the province.	N/A
Coastal coverage	Wind direction has adequate coverage at coarse scales, but wave direction is not well defined for most locations.	2
Data accessibility	Some data accessible exists but would require considerable effort to adjust the scale of analysis or collect additional data where gaps exist.	2
Measurement reliability	It is possible to report predominant wind and wave direction at the scale of analysis, with some uncertainty.	2
Redundancy to other criteria	Maximum wave exposure modelling embodies this parameter.	N/A

Wind Speed

Rationale for consideration: Aquaculture site orientation and construction can be influenced by the direction and speed of wind and waves in the area.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Wind speed is recognized as an important consideration for site orientation and selection. It can indirectly relate to the magnitude of stress on gear. It is rarely an absolute limiter, but may dictate infrastructure engineering needs, which in turn affect cost and therefore, more an operational consideration beyond the scope of assessment.	N/A
Rateability	Maximum wind speed is important for site selection, orientation and infrastructure design. Implications are highly operation specific.	3
Scoring clarity	Wind speeds are often highly linked to other parameters, with mostly indirect effects on farms. Understanding the role/effects of wind would require a fair bit of explanation.	1
Scale validity	The scale of data for wind speed is at the provincial level.	2
Coastal coverage	Generating wind speed data across the entire area of analysis would require substantial interpolation from point data.	1
Data accessibility	Some accessible data it would require analysis to adjust to the scale of analysis.	2
Measurement reliability	Interpolation of wind speed data at scale would be required for assessment, but it is possible with existing data. There is some uncertainty with the use of terrestrial wind gauges.	2
Redundancy to other criteria	Wave exposure parameter modelling accounts for this parameter.	N/A

Shellfish Harvest Area Classifications

Rationale for consideration: In Nova Scotia, regulatory compliance of shellfish harvesting is based on water quality as regulated by the Canadian Shellfish Sanitation Program (CSSP).
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	The CSSP does not apply to finfish aquaculture.	N/A
Rateability	The CSSP does not apply to finfish aquaculture.	N/A
Scoring clarity	Areas classified are well-defined and described through the CSSP though there are potential management mitigation strategies for culture. Some explanation required.	2
Scale validity	Criterion is relevant to both regional planning and site selection. The dataset is available at appropriate spatial resolution.	3
Coastal coverage	Area classifications covers areas assessed by the CSSP across the entire province. Areas without classifications are considered "unclassified".	2
Data accessibility	Public datasets (e.g. Shellfish Water Classification Program – Shellfish Harvest Area Classification in Canada) are available and accessible.	3
Measurement reliability	The CSSP classifies areas through regular monitoring efforts. Shellfish harvest areas are classified as to their suitability for harvesting, according to accepted water quality standards, but classifications and status of closure may vary over time.	2
Redundancy to other criteria	Runoff inputs and outfalls are considered within CSSP designation.	2

Aquatic Invasive Species

Rationale for consideration: Aquaculture should not be located in areas susceptible to Aquatic Invasive Species (AIS) due to their detrimental impacts on water quality.
Final decision: Exclude
Average score: 1.5 (POOR)

Property	Description	Score
Relevance to scope	AIS can act as biofouling organisms on finfish cage systems. This can be costly for producers to remove, and if it accumulates, can reduce water flow and oxygen provision to cages, although this largely depends on local management practices. Does not often lead to fish mortality or widespread fish health issues.	1
Rateability	Impacts would largely depend on management practices. Classification likely requires advice from experts and industry.	2
Scoring clarity	The dataset requires some clarification to explain modelling and aggregation of species.	1
Scale validity	Specific impacts or risks from AIS is best evaluated at the site-level. Identifying general areas where species are present or most intense can provide an indicator of additional risks producers may face, which is appropriate for regional level assessment..	2
Coastal coverage	Modelled data that is available does not extend fully across the area of analysis, with notable gaps.	1
Data accessibility	Modelled distribution data available and accessible (e.g. Species distribution models and occurrence data for marine invasive species hotspot identification). However, risks to producers are more based on intensity and timing of spread, which has not been spatially mapped.	1
Measurement reliability	Marine invasive hotspot modelling is done through monitoring and occurrence data through DFO. The data is based on predictive models with accepted uncertainty. Measurement would require combining multiple species hotspots with some uncertainty.	1
Redundancy to other criteria	While there may be some relationships with temperature and particle availability, data can be treated as largely independent.	3

Salinity

Rationale for consideration: Finfish have defined salinity tolerances, where extreme salinity fluctuations can negatively affect water quality and influence growth and health of species.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Salinity outside of optimal ranges can influence fish growth and health. However, salinity ranges in Nova Scotia generally do not exhibit extreme fluctuations that would be critical for fish health.	1
Rateability	Cultured species have specific salinity tolerances that would affect health and welfare. Salinity tolerances are well established. High variability at local scales is more of an issue.	1
Scoring clarity	Salinity effects are well understood and can be clearly communicated.	3
Scale validity	Spatial datasets at coarse resolutions. Variations in salinity are highly site-specific (due to various inputs, local patterns in current and flushing, etc.). Consideration is more relevant at the site selection scale.	N/A
Coastal coverage	The data available (point locations) contains large gaps and cover multiple time frames.	1
Data accessibility	At the appropriate resolution, nearshore salinity is only available for point locations.	1
Measurement reliability	Ocean salinity mapping efforts (e.g. satellite data) at inappropriate spatial resolutions, would require significant downscaling and would introduce considerable uncertainty.	1
Redundancy to other criteria	Shifts in salinity may be accounted for in other layers (e.g. distance to rivers).	1

Dissolved Oxygen

Rationale for consideration: Finfish species rely on dissolved oxygen for respiration is an important factor for optimizing growth and health
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Inadequate levels of dissolved oxygen (DO) can lead to stress, reduced growth, and, in extreme cases, mortality. DO is a key parameter for monitoring and siting, but is often applied at the site-level. On a regional scale, DO is generally not an issue in Nova Scotia.	3
Rateability	DO is an important water quality parameter for finfish, with optimal ranges and thresholds well-documented. Yet, thresholds vary with other ocean parameters (e.g. temperature and salinity) and exhibit high spatial variability at local scales, depending also on culture and management practices, making assessments more relevant at the site-level.	1
Scoring clarity	Implications of dissolved oxygen on cultured species are relatively easy to describe, although the creation of a spatial layer may be technical and require some explanation.	1
Scale validity	Recognized small-scale spatial and temporal variability within coastal bays - most relevant for local assessments or bay-scale carrying capacity modelling.	N/A
Coastal coverage	Due to large gaps in the data available and limited data in nearshore areas a risk-based approach or interpolation would be required.	N/A
Data accessibility	There are no provincial-scale spatial datasets available; only point locations are available. Necessary efforts to complete coverage are not within the project timeline and resources.	1
Measurement reliability	DO can be measured through in-situ measurements or satellite data.	1
Redundancy to other criteria	DO is influenced by other parameters at the local level, including ocean mixing, temperature, current flow, flushing rate, etc.	2

Turbidity

Rationale for consideration: High turbidity may have implications for aquaculture, primarily in relation to shellfish aquaculture.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Hydrodynamic requirements for finfish aquaculture mean sites are rarely in nearshore areas where turbidity would be an issue.	N/A
Rateability	Consideration mostly relevant for requirements for shellfish aquaculture.	N/A
Scoring clarity	The inclusion of turbidity requires an explanation for why it is relevant and how it is measured.	1
Scale validity	Turbidity has recognized small-scale spatial and temporal variability within coastal bays.	1
Coastal coverage	Satellite images and data exist across the province and provide information that can be used to identify turbid waters.	2
Data accessibility	Satellite data is free and accessible online but may require some work to use.	2
Measurement reliability	Measurement is straightforward but involves complex image analysis or site-specific measurements relevant during site selection.	2
Redundancy to other criteria	Data is largely independent of other data. There may be some overlap with river runoff.	2

Chlorophyll

Rationale for consideration: For finfish species, high chlorophyll concentrations may be related to creation of algal blooms.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Since finfish are not filter-feeding organisms, chlorophyll is not considered a key parameter for growth of fish. May be linked to algal blooms, but generally not an issue in Nova Scotia.	N/A
Rateability	Consideration is mainly relevant to requirements for shellfish aquaculture.	N/A
Scoring clarity	Criterion would require some explanation, including how datasets were derived.	2
Scale validity	High variability across temporal and spatial scales means criterion is best evaluated through bay-scale assessments or assessments of carrying capacity.	1
Coastal coverage	Satellite data is available, although there are substantial gaps in data (due to cloud coverage).	2
Data accessibility	Satellite data is available online, but data format can be challenging to manipulate.	2
Measurement reliability	There is some uncertainty in satellite derived data, as data rely on ocean colour to generate inferences of in-situ values.	2
Redundancy to other criteria	Consideration within carrying capacity models.	2

Primary Productivity

Rationale for consideration: Relevant for understanding ecosystem function surrounding finfish aquaculture sites, with potential relation to creation of algal blooms, although mostly relevant to shellfish aquaculture.
Final decision: EXCLUDE
Average score: N/A (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Primary productivity refers to the rate at which photosynthetic producers convert energy from the sun into organic materials which may influence conditions surrounding finfish sites. Most appropriately considered within the context of carrying capacity and ecosystem functioning.	1
Rateability	Not clear; threshold values will vary between local ecosystems and bays.	1
Scoring clarity	Criterion would require significant explanation and context.	N/A
Scale validity	High variability across temporal and spatial scales means criterion is best evaluated through bay-scale assessments for determining carrying capacity.	N/A
Coastal coverage	Minimal data has been collected within a handful of areas of interest, but this is a small fraction of NS coastline.	N/A
Data accessibility	Data must be collected manually and analysis is lengthy, costly, and intensive.	1
Measurement reliability	Scientific methods are used to measure carbon dioxide uptake or oxygen consumption.	2
Redundancy to other criteria	Considered within carrying capacity models.	N/A

Point Discharges

Rationale for consideration: Aquaculture should not be located in areas where domestic effluent or industrial discharges release nutrients or contaminants into coastal areas.
Final decision: Exclude
Average score: 1.9 (POOR)

Property	Description	Score
Relevance to scope	Domestic effluent or industrial discharges can release nutrients or harmful contaminants into the marine environment, which can cause harm to cultured fish in close proximity.	3
Rateability	Impacts are likely affected by multiple variables and classification would rely heavily on expert advice.	1
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Criterion considered mostly relevant at the site-selection level due to high variability.	1
Coastal coverage	There are some gaps in spatial data on the location of all outfalls across the area of analysis.	1
Data accessibility	There are some gaps in spatial data on the location of all outfalls across the area of analysis that would require additional resources to identify.	2
Measurement reliability	Measurement is straight forward, and analysis can be done through commonly applied path-distance methods in GIS.	3
Redundancy to other criteria	Parameter is considered in shellfish closure areas and has some overlap with the location of small craft harbours and population centres.	1

River Runoff

Rationale for consideration: Aquaculture should not be located in areas that would be highly exposed to riverine inputs that could release nutrients or contaminants into coastal areas.
Final decision: Exclude
Average score: 1.3 (POOR)

Property	Description	Score
Relevance to scope	If within very close distances, river runoff could create water quality concerns, but it is not often an issue of high importance for finfish since it often does not occur close to sources.	1
Rateability	Impacts to finfish can be highly variable and are likely affected by multiple factors at the site-level. Classification would rely on expert advice.	1
Scoring clarity	River runoff impacts may require complex analysis that would require substantial explanation to end-users.	1
Scale validity	Impacts from riverine inputs exhibit local-scale environmental variability to be more comprehensively captured at the site-level.	1
Coastal coverage	Some information required to map river runoff is available, but others require site-specific information that is not available across the entire spatial area of analysis.	1
Data accessibility	Spatial data could be generated for assessment. Although, more complex analysis is required to appropriately capture river-specific impacts are beyond this project.	1
Measurement reliability	Simple methods of measurement are available (i.e., through indirect metrics such as proximity to rivers) at regional level.	3
Redundancy to other criteria	The impacts from river inputs relate to other variables and can be linked to changes in salinity and turbidity. River data also captured in wild salmon river criterion.	1

Agricultural Runoff

Rationale for consideration: Aquaculture should not be located in areas where agricultural discharges release nutrients or contaminants into coastal areas.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	If within very close distances, agricultural runoff could create water quality concerns, but it is not often an issue of high importance for finfish since it often does not occur close to sources.	1
Rateability	Proximity to sources of agricultural runoff is not generally an issue for finfish aquaculture, since is does not often occur close to sources (to meet depth requirements). Effects would depend highly on the management of agricultural practices. Some established buffers exist which will be supplemented with additional expert opinion.	N/A
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Proximity to easements where runoff may be an issue can be adequately addressed at the provincial level since there is existing information on where these activities occur and watershed delineation, although there are local variabilities.	2
Coastal coverage	Data is available across the entire spatial area of analysis.	3
Data accessibility	Dataset is available through network partners.	2
Measurement reliability	Accuracy of data is high due to collection from network partners.	3
Redundancy to other criteria	In the context of critical sources of runoff, this is already accounted for in CSSP.	N/A

Forestry Runoff

Rationale for consideration: Aquaculture should not be located in areas where forestry discharges release nutrients or contaminants into coastal areas.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	If within very close distances, forestry runoff could create water quality concerns, but it is not often an issue of high importance for finfish since it often does not occur close to sources.	1
Rateability	Proximity to sources of forestry runoff is not generally an issue for finfish aquaculture, since finfish aquaculture activities are not often conducted close to sources (to meet depth requirements).	N/A
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Proximity to easements where runoff may be an issue can be adequately addressed at the provincial level since there is existing information on where these activities occur and watershed delineation, although there are local variabilities.	2
Coastal coverage	Data is available across the entire spatial area of analysis.	3
Data accessibility	Dataset is available through network partners	2
Measurement reliability	Accuracy of data is high due to data collection from network partners.	3
Redundancy to other criteria	In the context of critical sources of runoff, this is already accounted for in CSSP.	N/A

Algal Blooms

Rationale for consideration: Aquaculture operations can be impacted if within areas of high likelihood of blooms, which can lead to mechanical damage to fish gills, depletion of local oxygen levels, and exposure to toxins.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Harmful algal blooms (HABs) are relevant for monitoring and management in aquaculture. HABs have been linked to mechanical damage to fish gills, depletion of local oxygen levels, and exposure to toxins.	2
Rateability	Areas experiencing frequent algal blooms and HABs are not ideal for finfish aquaculture, as they can endanger finfish health and cause severe economic impacts. Classification is likely based on the risk of events occurring, which is difficult to estimate.	1
Scoring clarity	Criterion rationale and data products likely require some explanation.	2
Scale validity	Likely consideration appropriate for regional-level assessment, but would require substantial interpolation of point data.	1
Coastal coverage	Only localized data collection efforts.	N/A
Data accessibility	The necessary efforts required to complete the dataset for missing spatial coverage are beyond the time and resources available.	N/A
Measurement reliability	Methods for estimation are novel and emerging.	1
Redundancy to other criteria	Correlations with multiple parameters, likely creating redundancies across other parameters (e.g. water quality, temperature, and proximity to sources of nutrients and pollution).	1

Other aquaculture sites (proximity)

Rationale for consideration: Aquaculture should be located with adequate distance between farms to minimize potential transfer of disease between farms.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Proximity to existing aquaculture sites is considered important for potential disease transfer between farms. Disease transmission is critical for the health and welfare of cultured species.	3
Rateability	There is some guidance on proximity distances from other jurisdictions and existing suitability assessments but would also require input from experts and network partners.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Consideration for disease transmission is considered more relevant for site selection processes or bay-scale assessment.	N/A
Coastal coverage	Considering in the context of proximity to existing sites, all sites across the area of analysis are available; data is available across the entire spatial area of analysis.	3
Data accessibility	Public datasets on the location and extent of existing aquaculture sites are available and accessible (e.g. Nova Scotia Marine Aquaculture Leases).	3
Measurement reliability	If considering in the context of proximity to existing sites, data is compiled, maintained, and updated by the NSDFA. Measurement is straight forward, and analysis can be done through commonly applied path-distance methods in GIS.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

MSX Presence

Rationale for consideration: Multinucleated sphere "X" (MSX) has caused high mortalities of oysters in the Bras D'Or area. Areas with high prevalence should be avoided for oysters.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	MSX only influences oysters, so criterion is not relevant for finfish.	N/A
Rateability	MSX only influences oysters, so criterion is not relevant for finfish.	N/A
Scoring clarity	Calculation of data and interpolation to spatial dataset requires explanation.	2
Scale validity	Maps of Declared Areas are somewhat coarse for the regional scale of assessment. Interpolation of data is required to produce datasets at the appropriate resolution.	2
Coastal coverage	Coverage only applies to Bras D'Or and surrounding areas. Some interpolation is required to extend beyond point data. Though it can be reasonably assumed that MSX is not present at other locations around the province.	2
Data accessibility	Maps of Declared Areas for aquatic animal disease relevant to Cape Breton (i.e., MSX) are available from CFIA to identify broad exposure areas. Higher resolution presence maps require some interpolation and quantification metrics being developed in this project.	2
Measurement reliability	Declared Area maps are broad. The collection of additional data and use of a novel methods for quantifying MSX spatial data will introduce considerable uncertainties.	1
Redundancy to other criteria	Data is largely independent of other types of data.	3

Conservation Criteria

Eelgrass Habitat

Rationale for consideration: Aquaculture should be located away from critical areas for eelgrass, to reduce potential impacts from shading, sedimentation, or nutrient releases.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Eelgrass habitats are important and sensitive habitats in Nova Scotia and are a required consideration in aquaculture regulations.	3
Rateability	Evidence of finfish aquaculture and seagrass interactions originate largely from the Mediterranean; reporting potential losses up to 300m from farms. However impacts can be variable and sometimes positive, with limited empirical evidence in Nova Scotia.	2
Scoring clarity	Data products created would require some explanation.	2
Scale validity	Criterion could be used for regional-level planning but can be more comprehensively captured at the bay or site-level.	2
Coastal coverage	Presence of eelgrass data available sporadically across the province. Mapped data to identify habitat suitability or hotspots available through the National Eelgrass Dataset for Canada (NetForce) project were only created for the Scotian Shelf of Nova Scotia.	1
Data accessibility	Spatial datasets on eelgrass presence and habitat suitability available and accessible (e.g. NetForce). The necessary efforts required to complete the spatial dataset for missing spatial coverage are beyond the time and resources available by the project.	N/A
Measurement reliability	Some methods to map the suitability of habitat or habitat hotspots for eelgrass in Nova Scotia are relatively novel (e.g. see NetForce project).	2
Redundancy to other criteria	There may be some overlap with other important habitat designations, as some protected areas include eelgrass habitat.	2

Species Migration Paths

Rationale for consideration: Aquaculture should be sited away from key areas and paths used by species during critical migration life stages (for example, wild Atlantic salmon).
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Aquaculture may be placed in critical migration path of important species (e.g., Atlantic salmon), potentially interfering with migration or transmitting diseases.	3
Rateability	Impacts highly variable and classification would rely on expert opinion.	2
Scoring clarity	Data would not necessarily require complex analysis and is anticipated to be relatively easy to communicate.	3
Scale validity	Criterion relevant to regional planning.	3
Coastal coverage	Consistent spatial data is non-existent.	N/A
Data accessibility	Consistent spatial data is non-existent	N/A
Measurement reliability	Key migration routes have not been identified.	N/A
Redundancy to other criteria	May be accounted for in other layers (i.e., critical habitat, salmon rivers).	1

Important Fish Habitat

Rationale for consideration: Aquaculture should not be located in areas that would have potential impacts on fish species and habitats that are important for conservation and management initiatives.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Aquaculture operations may act as both deterrents or attractors for important fish species, altering migration and increasing potentially negative interactions.	3
Rateability	The degree and nature of interactions with aquaculture are likely highly variable based on local operations, making rating challenging.	1
Scoring clarity	Data would not require complex analysis, although rationale would require some explanation (species-specific consideration).	2
Scale validity	Potential interactions with specific fish species are best evaluated through local site selection or management practices.	N/A
Coastal coverage	All data in the described habitats are based on research vessel surveys from DFO trawls, all beyond the area of analysis (offshore).	N/A
Data accessibility	Species distribution data has been mapped for several important fish species through DFO (Bundy et al., 2017) but layers could be available by request.	2
Measurement reliability	Spatial data aggregated across multiple years, involves some interpolation but highlights general species distribution and habitats.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Important Cetacean Habitat

Rationale for consideration: Aquaculture should minimally impact areas recognized as important for cetacean species. Some interactions with aquaculture operations are possible (e.g. entanglement, attraction).
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Several key cetacean species inhabit waters in Nova Scotia and are a key conservation concern. Some interactions with aquaculture operations are possible (e.g., entanglement, attraction), but this is highly farm-specific.	2
Rateability	Infrastructure associated with finfish farming can be obstacles for the movement and migration of cetaceans. There are also risks of entanglements at the site-level, although this is highly gear-specific. There is little evidence to support the scoring.	1
Scoring clarity	Data would not require complex analysis, although rationale would require some explanation (species-specific consideration).	2
Scale validity	Potential interactions with cetaceans are best suited for local site selection or management practices.	N/A
Coastal coverage	Described data are largely based on species distribution models and sighting data from offshore DFO research vessels surveys from DFO, mostly beyond the AOA (e.g. offshore).	N/A
Data accessibility	Some datasets are publicly available based on whale sightings data, or to delineate important habitat (e.g., Blue whales, and Northern Bottlenose Whales), but not for all species of cetaceans or areas.	2
Measurement reliability	Data collected based on long-term datasets from DFO sighting and mapping efforts.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Important Coral/Sponge Habitat

Rationale for consideration: Aquaculture should not be located in areas that would have potential impacts on important benthic species and habitats.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Some corals and sponges are highly sensitive and recognized as a conservation priority. Organic loading from aquaculture could having potential impacts on benthic habitats containing these species.	3
Rateability	Organic loading on benthic environments is a consideration for aquaculture at the site selection scale. There is little existing evidence on the interactions with benthic species considered in this dataset (sponges etc.).	1
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Dataset available at appropriate spatial resolution.	3
Coastal coverage	The majority of described habitat areas are beyond the 3 km spatial extent of the project.	N/A
Data accessibility	Public datasets identifying significant benthic habitat for corals and sponges are available through DFO and accessible (e.g. Delineation of Coral and Sponge Significant Benthic Areas in Eastern Canada (2016)).	3
Measurement reliability	Significant benthic areas identified and mapped by DFO based on locations of concentrations of corals and sponges from research vessel trawl data.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Important Invertebrate Habitat

Rationale for consideration: Aquaculture should minimally impact areas recognized as important or critical for invertebrate species since aquaculture may lead to organic loading on benthic environments and changes on benthic communities.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Organic loading on benthic environments is a consideration for aquaculture at the site-level. Potential impacts during production are assessed with NSDFA's Environmental Monitoring Program and compliance with the federal Aquaculture Activities Regulations.	3
Rateability	Organic loading on benthic environments is a consideration for aquaculture at the site selection scale. Suitable proximity distances for specific invertebrate species are not well established and are likely reliant primarily on expert advice.	2
Scoring clarity	Data would not require complex analysis, but rationale would require some explanation.	2
Scale validity	Proximity to specific invertebrates/benthic habitats is likely most relevant for site selection, since most benthic habitats occur at small spatial scales.	1
Coastal coverage	All data in described habitats are based on research vessel surveys from DFO trawls, all beyond the area of analysis (i.e., offshore).	N/A
Data accessibility	Species distribution data has been mapped for several important invertebrates through DFO (Bundy et al., 2017) but could be available by request.	2
Measurement reliability	Spatial data aggregated across multiple years, involves some interpolation but highlights general species distribution and habitats.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Lobster Presence

Rationale for consideration: Lobster are key species for commercial fisheries. Potential interactions with lobster is an important consideration for aquaculture siting.
Final decision: Exclude
Average score: 1.5 (POOR)

Property	Description	Score
Relevance to scope	Organic loading on benthic environments is a consideration for aquaculture at the site selection scale, with interactions with lobster an important consideration.	3
Rateability	Organic loading on benthic environments is a consideration for aquaculture at the site selection scale. There is variation in evidence on impacts to lobster. Suitable proximity distances are not well established and will likely be reliant primarily on expert advice.	1
Scoring clarity	Data would require explanation, as habitat suitability is based on modelled data.	1
Scale validity	The resolution of the dataset is coarse and likely not appropriate for the scale of analysis.	1
Coastal coverage	Coverage across the area of analysis, although is less accurate to nearshore waters.	1
Data accessibility	Habitat suitability model data available from a published paper (Greenan et al., 2019), would require a request for access (i.e., not public).	2
Measurement reliability	Data from research vessel surveys, which do not sample inshore waters and thus model relies on interpolation, are cited as not appropriate for inshore suitability of habitat.	1
Redundancy to other criteria	There are potential overlaps with other data, including navigation routes.	2

Ecologically and Biologically Significant Areas (EBSAs)

Rationale for consideration: Aquaculture operations should be sited away from areas of high biological or ecological significance
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS))

Property	Description	Score
Relevance to scope	EBSAs are important for conservation goals. Their designations reflect recognized important areas for conservation priorities, reflecting unique or key ecosystems.	3
Rateability	The broad nature of EBSAs, consisting of multiple species, habitat types, etc., would mean proximity ratings based solely on expert opinion.	1
Scoring clarity	The broad nature of EBSA designation would require some additional explanation on a case-by-case basis.	1
Scale validity	Areas are too large, and data is too coarse for the scale of assessment.	N/A
Coastal coverage	Data is available across the entire spatial area of analysis.	3
Data accessibility	Public datasets are available accessible (e.g. Ecologically and Biologically Significant Areas).	3
Measurement reliability	Dataset and EBSA Designation is done through a thorough designation process under DFO. Layer calculation would be simple and done through commonly applied path-distance methods in GIS.	3
Redundancy to other criteria	Data is likely incorporated in other layers at a finer scale (e.g. other habitat layers and protected areas, etc.).	1

Ocean Use Criteria

High-Use Recreation and Tourism Use Areas

Rationale for consideration: To minimize potential spatial overlaps, aquaculture should minimize impacts to marine areas that are of high use for recreation and tourism.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Aquaculture operations can potentially interact with or create conflicts with recreation and tourism. Identifying areas used most can help aquaculture reduce negative interactions with coastal users.	2
Rateability	Recognition of potential interactions, but often considered on a more qualitative basis. Classification would largely be based on expert input and precautionary designations.	1
Scoring clarity	Interpreting data does not require expert knowledge but would require some explanation and clarification.	2
Scale validity	Criterion is relevant to regional planning but could be more effectively/comprehensively evaluated at the local scale.	2
Coastal coverage	There is sparse comprehensive data available, as only localized use-mapping efforts have been undertaken in Nova Scotia at the site-level.	1
Data accessibility	Adequate analysis of coastal use areas would require participatory mapping efforts beyond the available resources.	N/A
Measurement reliability	Measurement of use areas at the provincial scale requires large-scale participatory methods, with some uncertainty.	2
Redundancy to other criteria	There is likely correlation with other sources of data (i.e., proximity to access points).	1

Lobster Fisheries

Rationale for consideration: To minimize potential spatial overlaps, aquaculture should minimally impact areas with important fishing activities such as lobster.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Consideration for fishery activities in adjacent marine waters is a key decision-making factor in the Nova Scotia Aquaculture License and Lease Regulations. Yet, conflicts may be more relevant to the displacement of activity rather than linked to catch data.	1
Rateability	Few empirical studies have explored the linkage between total lobster catches and proximity to aquaculture (for a review, see Horricks et al., 2022).	1
Scoring clarity	Interpreting data does not require expert knowledge but would require some explanation and clarification because lack of defined impacts/interactions.	2
Scale validity	Criterion is relevant to regional planning but is comprehensively evaluated at a local scale. Data only available at spatial resolutions that are too coarse for this level of analysis.	N/A
Coastal coverage	Coarse spatial datasets have complete coverage across the area of analysis.	3
Data accessibility	Public datasets are available and accessible (e.g., Inshore Lobster Landings and Fishing Effort).	3
Measurement reliability	Landings and effort mapping compiled by DFO, but have some inherent uncertainty associated with fisher-reported data.	2
Redundancy to other criteria	Spatial overlaps are possible with other data, such as navigation since fishing areas may depend on proximity to port.	1

Other Commercial Fisheries

Rationale for consideration: To minimize potential spatial overlaps, aquaculture should minimally impact areas with important fishing activities.
Final decision: Exclude
Average score: 1.6 (POOR)

Property	Description	Score
Relevance to scope	Consideration for fishery activities in adjacent marine waters is a key decision-making factor in the Nova Scotia Aquaculture License and Lease Regulations. Conflicts may be more relevant to the displacement of activity rather than linked to catch data.	1
Rateability	Few empirical studies have explored the linkage between total catches for most fish species and proximity to aquaculture.	1
Scoring clarity	Interpreting data does not require expert knowledge but would require some explanation and clarification.	2
Scale validity	Catch data spatially mapped on a 10 km^2 grid; determined to be at a coarse scale that may be inappropriate for the scale of assessment.	1
Coastal coverage	Data resolution is coarse and there are some gaps in data close to shore.	2
Data accessibility	Public datasets are available and accessible (e.g. the Eastern Canada Commercial Fishing Data)	3
Measurement reliability	Commercial fishing catch data has been spatially mapped by DFO with some inherent uncertainty associated with calculation.	2
Redundancy to other criteria	Spatial overlaps possible with other data, such as navigation since fishing areas may depend on proximity to port.	1

Indigenous Fisheries

Rationale for consideration: Indigenous Peoples in Nova Scotia have the legal right to fish for food, social, ceremonial (FSC) and moderate livelihood purposes. Aquaculture should be located in areas that would not restrict access to Indigenous fishing.
Final decision: Exclude
Average score: 1.6 (POOR)

Property	Description	Score
Relevance to scope	Consideration for fishery activities in adjacent marine waters is a key decision-making factor in the Nova Scotia Aquaculture License and Lease Regulations. Interactions with areas used for Indigenous fisheries can be variable and best considered at the site-level. This factor is intertwined with social compatibility which is beyond the project scope.	1
Rateability	Considerations for displacement or impacts on Indigenous fisheries are highly variable and are most appropriately evaluated through local consultations at the site-level, specifically during site selection.	1
Scoring clarity	Interpreting data does not require expert knowledge but would require some explanation and clarification.	2
Scale validity	More appropriate for local site selection, with consultation with local communities.	N/A
Coastal coverage	Spatial data is not publicly available for the province.	NA
Data accessibility	Some Indigenous fishing activity has been mapped through broader commercial fisheries designations (i.e., Lobster Fishing Areas). However, not all Indigenous fishing activities have been mapped and the data can be considered sensitive in nature.	NA
Measurement reliability	Mapping may not be appropriate for wide public distribution.	2
Redundancy to other criteria	Spatial overlaps possible with other data, such as other fisheries data since…	1

Viewshed

Rationale for consideration: Aquaculture should be sited to minimize its visual impact on the surrounding seascape and alteration of the aesthetic appeal of coastal areas.
Final decision: Exclude
Average score: 1.8 (POOR)

Property	Description	Score
Relevance to scope	Aquaculture operations can impact viewshed appeal for some. This reflects an indirect use of seascape and reflects social uses beyond the scope of assessment.	1
Rateability	There are some recognized impacts of aquaculture on viewshed; Although highly variable and little empirical evidence is available to generate classification levels.	1
Scoring clarity	Viewshed analysis is a complex metric; and classification would require substantial explanation.	1
Scale validity	Parameter may be more suited to a more fine-scale, local process to identify key viewpoints in a specific area.	1
Coastal coverage	If collected, data could be available across the entire area of analysis.	3
Data accessibility	The layer generation would require additional resources but could be accomplished within the project timeline.	2
Measurement reliability	Can be measured through well-established methods of viewshed analysis, although there is some uncertainty associated.	2
Redundancy to other criteria	Data is largely independent of other types of data.	3

Noise Footprint

Rationale for consideration: Aquaculture should minimize their noise footprint as to not disrupt other marine users.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Noise footprint is best evaluated on a local scale and reflects more social conflicts which are beyond the scope of assessment.	1
Rateability	Recognition of the noise created through aquaculture operations, although little empirical evidence is available to generate classification levels, as much of the noise footprint is highly operation specific.	1
Scoring clarity	Interpreting data does not require expert knowledge but would require some explanation and clarification.	2
Scale validity	More appropriate for local site selection, highly dependent on gear, size of farms, etc.	N/A
Coastal coverage	No spatial datasets currently exist.	N/A
Data accessibility	Spatial data is non-existent and difficult to estimate at a regional scale.	1
Measurement reliability	Methods for calculating noise footprint exist, although challenging at this scale due to local farm-specific production specifics.	1
Redundancy to other criteria	Criterion has correlations with other proximity to land sources (coastal use areas, etc.).	2

Dredging Areas

Rationale for consideration: Aquaculture cannot be located above regularly dredged areas due to potential disturbances caused by dredging activities.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Regular dredging areas are considered unideal for aquaculture since the lease would obstruct regular maintenance, dredging barges, and high siltation rates of the environment.	3
Rateability	Aquaculture can not occur in areas regularly dredged. Recognition as a constraint means the classification is straightforward.	3
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Dataset available at appropriate spatial resolution.	3
Coastal coverage	Private or irregular dredging may not be well documented, compared to regular dredging locations.	1
Data accessibility	Some data is available publicly, while others are held privately. Up to date information on currently dredged areas that have not been mapped is currently under development.	N/A
Measurement reliability	Measurement accuracy is relatively good for reported/designated dredging areas.	2
Redundancy to other criteria	Data is largely independent of other types of data.	3

Derelict Vessels and Shipwrecks

Rationale for consideration: Aquaculture cannot be located above submerged vessels due to safety hazards and to preserve potentially culturally important sites.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Several derelict vessels and shipwrecks exist along the Nova Scotia coast, especially in shallow waters. Obstruction in the marine environment can pose safety issues when operating around aquaculture leases. These vessels can be removed, usually with some monetary cost.	3
Rateability	Recognition as a constraint means the classification is straightforward as aquaculture is not permitted over derelict vessels and shipwrecks to ensure the historical preservation of the vessel and reduce interaction with aquaculture infrastructure.	3
Scoring clarity	Interpreting data does not require expert knowledge but would require some explanation and clarification.	3
Scale validity	Most appropriately identified during local site selection, with consultation with local communities.	N/A
Coastal coverage	Minimal data is available from Coast Guard Canada; however, it is likely incomplete for the whole coastline (NS).	1
Data accessibility	Locational data is largely held privately and not appropriate for public use.	N/A
Measurement reliability	Reporting of locations may be unreliable and not appropriate for public use.	N/A
Redundancy to other criteria	Data is largely independent of other types of data but could overlap with archeological sites.	2

Archeological sites

Rationale for consideration: Aquaculture should minimally impact marine sites with cultural and archeological importance, which are also protected legally.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Known archaeological areas are protected under the Special Places Protection Act. Aquaculture should not occur in an archeological protected area. However, many archeological sites are not identified, and appropriately accounting for these areas would require local-scale assessments more appropriate for a site-level.	3
Rateability	Recognition as a constraint means the classification is straightforward. Consideration of buffers would be required.	2
Scoring clarity	Interpreting data does not require expert knowledge but would require some explanation and clarification.	3
Scale validity	To effectively incorporate, criteria is best considered and incorporated during local site selection processes, and with consultation with local communities.	N/A
Coastal coverage	Data on known sites is not publicly available. The location of unknown sites has not been mapped.	N/A
Data accessibility	The Nova Scotia Department of Communities, Culture, Tourism, and Heritage maintain records of known sites. Location data can be considered sensitive in nature.	N/A
Measurement reliability	Site mapping is not appropriate for wide public distribution due to sensitivity of data.	1
Redundancy to other criteria	Data is largely independent of other types of data but could overlap with shipwrecks.	2

Oil and gas structures

Rationale for consideration: Aquaculture cannot be located within existing oil and gas structures (spatial constraint).
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Marine oil and gas exploration exists in several areas across Nova Scotian's Scotian Shelf.	3
Rateability	Aquaculture would be constrained in these areas. Recognition as a constraint means the classification is straightforward. Some conversations with network partners are necessary to determine the required buffer.	2
Scoring clarity	Interpreting data does not require expert knowledge but would require some explanation and clarification.	3
Scale validity	Dataset available at appropriate spatial resolution.	3
Coastal coverage	No structures exist within the boundary of the area of analysis (all beyond 3 km offshore).	N/A
Data accessibility	The location of active Production Licences administered by the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB), as well as the surface locations for all wells drilled are available through CNSOPB.	2
Measurement reliability	Analysis is straight forward and requires only potential buffers applied to features.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

CENTRE FOR MARINE APPLIED RESEARCH

2024-FINAL.v.1.0

Appendix iii: Criteria scoring – Shellfish Aquaculture

July 4, 2024

Prepared by:

Jenny Weitzman
Therese Wilson
James Cunningham
Laila Nargis
Leah Lewis-McCrea
Gregor Reid

27 Parker Street · Dartmouth, Nova Scotia · B2Y 4T5

CMAR.CA

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Version Control			
Status	**Version**	**Date**	**Rationale**
Draft	0.1	March 5, 2024	First draft
Final	1.0	July 4, 2024	Adjustments made to reflect ongoing explorations of data and to incorporate feedback from advisory committee review

Introduction

Each criterion considered for inclusion is described below. Criteria are grouped broadly into "Biophysical", "Conservation", and "Ocean Use" groups[1]. Criteria proposed for inclusion are described first, followed by criteria considered but ultimately excluded from proposed list. See the table of contents below to navigate across criteria.

Criteria for Inclusion

Biophysical Criteria

Heat Stress

Rationale for consideration: Blue mussels exposed to periods of high-water temperatures can experience stress, which in extreme cases can lead to mortalities. Oysters are more tolerant to prolonged high temperatures.
Final decision: Include (Oysters – Exclude)*
Average score: 2.0 (ADEQUATE)

Property	Description	Score
Relevance to scope	Temperature is a key biophysical parameter important for siting and growth considerations, with heat stress leading to mortality of blue mussels in extreme cases.	3
Rateability	Heat stress temperatures defined for blue mussels and to be supplemented by industry and expert advice. *Oysters are more tolerant to prolonged high temperatures, with Nova Scotia waters rarely exceeding temperature thresholds (relevance = N/A).	3
Scoring clarity	The analysis and methods (i.e., interpolation) require some explanation.	2
Scale validity	Interpolation of data was required to produce datasets at the appropriate resolution.	2
Coastal coverage	Spatial dataset will be based on point data with disperse coverage; interpolation will be applied to areas between point data.	1
Data accessibility	Spatial datasets will be generated using data from CMAR's Coastal Monitoring Program for this assessment.	2
Measurement reliability	Measuring heat stress relies on analysis and interpolation of point data and can be estimated using likelihood calculations. Novel datasets and methods combined with interpolation, will likely introduce uncertainties.	1
Redundancy to other criteria	At shallow water depths, heat stress may have overlaps in trends with bathymetry, but can be assessed and classified relatively independently.	2

[1] The name and composition of these groupings have not yet been finalized and are subject to change.

Ocean Depth

Rationale for consideration: Aquaculture is best located in areas with adequate ocean depth to accommodate gear, vertical space to sinking infrastructure avoid ice and exposure of shellfish to air at low tide.
Final decision: Include
Average score: 2.3 (ADEQUATE)

Property	Description	Score
Relevance to scope	Site selection must balance minimum depth requirements for gear and to avoid risks from ice and air exposure and increased complexity and cost of mooring at deeper depths.	3
Rateability	Minimum depth requirements for most culture techniques are well established in industry. Depth requirements for shellfish aquaculture will be augmented by expert advice.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	While data scale is relevant to regional planning, available data has uncertainty at shallow nearshore depth, decreasing accuracy in shallow nearshore coastal locations.	1
Coastal coverage	Data is available across most of the area of analysis, although some uncertainty and gaps in nearshore waters relevant to shellfish aquaculture.	1
Data accessibility	Bathymetry data available from public datasets (e.g. GEBCO) and accessible.	3
Measurement reliability	Measurable and an accepted method of measurement.	3
Redundancy to other criteria	There are correlations with temperature and exposure (i.e., ice, waves, and wind) but can be assessed and classified relatively independently.	2

Ice Conditions

Rationale for consideration: Operators must manage shellfish culture operations to avoid ice damage and reduce mortality.
Final decision: Include
Average score: 2.1 (ADEQUATE)

Property	Description	Score
Relevance to scope	Sea ice that develops across some nearshore areas can create risks for aquaculture, possibly crushing and killing shellfish. Increased risks can require operators to choose different areas and/or introduce management measures (i.e., sinking/removing gear).	2
Rateability	Assessing ice risk must consider coverage thickness, movement, and type. Risk assessment is not straight forward and must in part rely on expert/industry advice.	2
Scoring clarity	The risk-based approach and methods require explanation to explain how different ice considerations are incorporated.	2
Scale validity	Criterion relevant to decision-making at the regional level and data resolution is appropriate for this scale, although more local-scale ice dynamics are not captured.	2
Coastal coverage	Ice exposure risk generated at appropriate resolutions across the area of analysis .	3
Data accessibility	Spatial data generated from remote sensing data and model projections to support assessment.	2
Measurement reliability	Spatial data products are being developed by the Nova Scotia Community College's Applied Geomatics Research Group. Measurements use well-established methods though data will likely be analyzed based on risk, which will introduce some uncertainty.	2
Redundancy to other criteria	Some correlation with other criterion (e.g. temperature and depth) but can be evaluated relatively independently.	2

Wind and Wave Conditions

Rationale for consideration: Exposure of aquaculture to high wind and waves can threaten infrastructure and affect shellfish welfare.
Final decision: Include
Average score: 2.4 (ADEQUATE)

Property	Description	Score
Relevance to scope	Consideration of exposure (wind and waves) is an important physical parameter for site selection since given risk to infrastructure, operational management, and shellfish welfare.	3
Rateability	Some scientific evidence on the impacts of significant wave height on aquaculture, which will be supplemented by expert and industry insights to capture local contexts.	2
Scoring clarity	Exposure modelling and data require some explanation.	2
Scale validity	Criterion relevant to regional planning and dataset will be created at the appropriate spatial resolution.	3
Coastal coverage	Wind and wave exposure modelling generated at appropriate resolutions across the area of analysis.	3
Data accessibility	Spatial data generated for assessment purposes will be developed during the project timeline based on previous ocean wave modelling by DSA Ocean.	2
Measurement reliability	Interpolation of datasets from wave modelling has some uncertainties, though these can be accounted for.	2
Redundancy to other criteria	Correlations with depth although data can be classified relatively independently.	2

Shellfish Harvest Area Classifications

Rationale for consideration: In Nova Scotia, regulatory compliance of shellfish harvesting is based on water quality as regulated by the Canadian Shellfish Sanitation Program (CSSP).
Final decision: Include
Average score: 2.4 (ADEQUATE)

Property	Description	Score
Relevance to scope	Shellfish operators must adhere to classifications and allowable harvest areas set out through the CSSP. Areas can be restricted to harvesting if there is significant presence of fecal coliform or contaminants.	3
Rateability	Implications of CSSP classifications is relatively straightforward, although scoring will rely on industry insights to understand risks and tolerance of classifications.	2
Scoring clarity	Areas classified are well-defined and described through the CSSP though there are potential management mitigation strategies for culture. Some explanation required.	2
Scale validity	Criterion is relevant to both regional planning and site selection. The dataset is available at appropriate spatial resolution.	3
Coastal coverage	Area classifications covers areas assessed by the CSSP across the entire province. Areas without classifications are considered "unclassified".	2
Data accessibility	Public datasets (e.g. Shellfish Water Classification Program – Shellfish Harvest Area Classification in Canada) are available and accessible.	3
Measurement reliability	The CSSP classifies areas through regular monitoring efforts. Shellfish harvest areas are classified as to their suitability for harvesting, according to accepted water quality standards, but classifications and status of closure may vary over time.	2
Redundancy to other criteria	Runoff inputs and outfalls are considered within CSSP designation.	2

MSX Presence

Rationale for consideration: Multinucleated sphere "X" (MSX) has caused high mortalities of oysters in the Bras D'Or area. Areas with high prevalence should be avoided for oysters.
Final decision: Include (Mussels – Exclude)*
Average score: 2.1 (ADEQUATE)

Property	Description	Score
Relevance to scope	MSX can cause high mortality for oyster culture and a prevalent issue in the Bras D'Or Lake, Nova Scotia. *MSX does not impact mussels (=N/A)	3
Rateability	MSX effects on oysters have been the subject of considerable study in recent years though there is no existing risk classification and will require development.	2
Scoring clarity	Calculation of data and interpolation to spatial dataset requires explanation.	2
Scale validity	Maps of Declared Areas are somewhat coarse for the regional scale of assessment. Interpolation of data is required to produce datasets at the appropriate resolution.	2
Coastal coverage	Coverage only applies to Bras D'Or and surrounding areas. Some interpolation is required to extend beyond point data. Though it can be reasonably assumed that MSX is not present at other locations around the province.	2
Data accessibility	Maps of Declared Areas for aquatic animal disease relevant to Cape Breton (i.e., MSX) are available from CFIA to identify broad exposure areas. Higher resolution presence maps require some interpolation and quantification metrics being developed in this project.	2
Measurement reliability	Declared Area maps are broad. The collection of additional data and use of a novel methods for quantifying MSX spatial data will introduce considerable uncertainties.	1
Redundancy to other criteria	Data is largely independent of other types of data.	3

Conservation Criteria

Coastal Wetlands

Rationale for consideration: Shellfish aquaculture operations may have the potential to interact with important and sensitive wetland habitats in Nova Scotia.
Final decision: Include
Average score: 2.8 (EXCEPTIONAL)

Property	Description	Score
Relevance to scope	Wetlands are important and sensitive habitats in Nova Scotia, supporting various wildlife.	3
Rateability	There is some evidence for interaction with aquaculture, although classification will largely rely on consultation with experts and network partners.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users	3
Scale validity	The criterion is relevant to regional planning and datasets are largely available at appropriate spatial resolution.	3
Coastal coverage	Data is available across the entire province.	3
Data accessibility	Datasets are available and publicly accessible through the Canadian National Wetlands Inventory.	3
Measurement reliability	Measurement is straight forward, and analysis can be done through commonly applied path-distance methods in GIS.	3
Redundancy to other criteria	There may be some overlap with other important habitat designations (including protected areas and parks).	2

Terrestrial Protected Areas and Parks

Rationale for consideration: Aquaculture should be located to minimize potential interactions with coastal species or habitats protected due to their high biodiversity or ecological vulnerability.
Final decision: Include
Average score: 2.0 (ADEQUATE)

Property	Description	Score
Relevance to scope	Several coastal islands are protected wilderness areas or conservation easements, as they are recognized for their rich coastal biodiversity or as habitat for marine and migratory birds. The potential impacts from aquaculture may be variable and are often unclear.	2
Rateability	Nearshore aquaculture may have potential to interact with terrestrial habitat/species. Though the potential for impacts is unclear as are the designation of adequate buffers.	1
Scoring clarity	Data does not involve complex analysis, although criterion rationale requires some explanation, as there could be multiple potential variables.	2
Scale validity	Criterion mostly represents terrestrial habitats, and interactions are often best evaluated at a site-level (and highly operation-specific).	1
Coastal coverage	Data is available across the entire spatial area of analysis .	3
Data accessibility	Public datasets (e.g. The Nova Scotia Protected Areas System and National Parks and National Park Reserves of Canada Legislative Boundaries) are available and accessible.	3
Measurement reliability	Datasets are compiled, maintained, and updated by the Government of Nova Scotia and monthly by the National Research Council, respectively. Measurement is straight forward, and analysis can be done using commonly applied path-distance methods in GIS.	3
Redundancy to other criteria	Parameter may have some overlap with other habitat and species areas (including wetlands, critical habitats, or avifauna habitats).	1

Critical Habitat for Species At-Risk

Rationale for consideration: Marine species listed as threatened or endangered under the Species at Risk Act (SARA) have critical habitats identified and are legally protected from activities that could impact habitat.
Final decision: Include
Average score: 2.6 (ADEQUATE)

Property	Description	Score
Relevance to scope	Proximity to marine areas recognized as important to minimize potential interactions with human activities. Critical habitat for protected species, may be located in coastal waters close to shore and therefore have the potential to overlap with aquaculture activities	3
Rateability	Scoring suitability of aquaculture in relation to critical habitats should consider potential interactions with at-risk species, but may best be evaluated with species distribution, migration, or foraging habitats through more local-scale assessments. Scoring will thus rely on precautionary approaches, drawing on experts and network partners.	1
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Specific species-interactions and risks with aquaculture are best evaluated at more local scale assessments. Though, boundaries of critical habitats are established by DFO processes that are appropriate for regional-scale assessment.	2
Coastal coverage	Data is available identifying critical habitats across the entire province.	3
Data accessibility	Public datasets are accessible through DFO (Critical Habitat for Species at-risk).	3
Measurement reliability	Critical habitat for aquatic species at risk are identified by DFO.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Important Bird Habitat

Rationale for consideration: Physical structures, along with aggregation of feed and nutrients associated with aquaculture may interact with birds in a variety of ways. Several important species nest and forage in coastal areas around Nova Scotia, within critically important habitat.
Final decision: Include
Average score: 2.5 (ADEQUATE)

Property	Description	Score
Relevance to scope	Potential interactions of human activities with a critical bird habitat is an important consideration for aquaculture siting.	3
Rateability	Aquaculture has the potential to interact with bird species or their critical habitat. Based of proximity to habitats, some setback distances have been established, often at a species-specific level. Scoring will require consultation with network partners.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Identifying key areas can be relevant to regional planning, with available datasets at appropriate spatial resolution.	2
Coastal coverage	Data may not represent all habitats recognized.	2
Data accessibility	Several important bird habitat areas are identified in public datasets (e.g. NS Significant Habitat Dataset and IBA Important Bird Areas).	3
Measurement reliability	Measurement is straight forward and required analysis can be done through commonly applied path-distance methods in GIS.	3
Redundancy to other criteria	Important bird habitat may be accounted for indirectly in other layers, such as wetlands. There may also be some overlap with other habitat designations (e.g. protected areas).	2

Ocean Use Criteria

Fishing Traffic

Rationale for consideration: Aquaculture should consider space to accommodate navigation in high-use areas for fishing.
Final decision: Include
Average score: 2.3 (ADEQUATE)

Property	Description	Score
Relevance to scope	Marine developments should allow sufficient space to accommodate vessel traffic, such as those by fishing. The public right of navigation and other adjacent marine users is a key decision-making factor in the Nova Scotia Aquaculture License and Lease Regulations.	3
Rateability	Scoring can be based on distribution of density data to identify hotspots of fishing vessel traffic.	3
Scoring clarity	Interpreting criteria rationale and data does not require expert knowledge but would require some explanation and clarification.	2
Scale validity	Spatial data on fishing traffic hotspots is relevant to regional-level planning.	3
Coastal coverage	Spatial datasets have mostly complete coverage across the area of analysis, although data does have some uncertainty	2
Data accessibility	Fishing vessel traffic data is available (e.g., Vessel Density Mapping of 2019), although more comprehensive VMS datasets was acquired from DFO. Spatial data products will be generated for assessment purposes.	2
Measurement reliability	Vessel traffic data will be assessed based spatial analysis of VMS data. There is some uncertainty in available vessel traffic datasets. Using VMS data to identify vessel traffic hotspots is a common practice and established.	2
Redundancy to other criteria	There could be some correlation with other data sources such as coastal access points and overlap with AIS data.	1

Navigation Routes

Rationale for consideration: Aquaculture should consider space to accommodate public navigation.
Final decision: Include
Average score: 2.1 (ADEQUATE)

Property	Description	Score
Relevance to scope	Marine developments should allow sufficient space to accommodate vessel traffic. The public right of navigation and other adjacent marine users is a key decision-making factor in the Nova Scotia Aquaculture License and Lease Regulations.	3
Rateability	While some guidance is available on suggested buffers for designated traffic routes (e.g. shipping lanes, ferry routes), scoring will rely on expert input and network partner advice.	2
Scoring clarity	Interpreting criteria rationale and data does not require expert knowledge but would require some explanation and clarification.	2
Scale validity	Spatial data on common marine transit routes is relevant to regional-level planning.	3
Coastal coverage	Spatial datasets have mostly complete coverage across the area of analysis, although data may not capture all vessel traffic	2
Data accessibility	Some vessel traffic data available (e.g., Vessel Density Mapping of 2019 AIS Data in the Northwest Atlantic), although more comprehensive AIS datasets was acquired from DFO. Spatial data products will be generated for assessment purposes.	2
Measurement reliability	Navigation routes will be identified based spatial analysis of AIS data. There is some uncertainty in available datasets. Some methods for identifying navigation corridors exist, although a novel method my be required for this project.	1
Redundancy to other criteria	There could be some correlation with other data sources such as coastal access points and fishing vessel traffic .	2

Coastal Accessibility

Rationale for consideration: Aquaculture siting should consider space which may be accessed or shared with other users, such as tourism and recreation, as aquaculture can potentially impede access to navigable areas.
Final decision: Include
Average score: 2.0 (ADEQUATE)

Property	Description	Score
Relevance to scope	Aquaculture may have the potential to affect navigation and access of coastal users to marine areas. The public right of navigation and other adjacent marine users is a key decision-making factor in the Nova Scotia Aquaculture License and Lease Regulations.	3
Rateability	Data provides an indicator of access to coastal areas. More comprehensive evaluation should be explored at local levels. Some recommended proximity distances have been suggested, but scoring will largely rely on expert input and precautionary designations.	1
Scoring clarity	Interpreting criteria rationale and data does not require expert knowledge but would require some explanation and clarification.	2
Scale validity	Key access points provide relevant information for regional level analysis and planning, although could be more comprehensively evaluated at site-level to explore variabilities of different types of access points or users.	2
Coastal coverage	Coverage is mostly adequate, with only some gaps in potential access points possible due to lack of available validation of points.	2
Data accessibility	Coastal access points will be compiled from several public datasets for the assessment.	2
Measurement reliability	There is some uncertainty in methods, but the approach is based on previous robust scientific methods.	2
Redundancy to other criteria	There is likely to be some correlation with other data (e.g., navigation channels).	2

Anchorage Areas

Rationale for consideration: Aquaculture cannot be located in areas already designated as allocated anchorage sites/areas.
Final decision: Include
Average score: 2.9 (EXCEPTIONAL)

Property	Description	Score
Relevance to scope	Aquaculture can not occur in existing anchorage areas (constraint) to maintain safe navigation.	3
Rateability	Recognition as a constraint means the classification is straightforward though considerations around buffers is needed	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Datasets are available at the appropriate spatial resolution and relevant to regional-level considerations.	3
Coastal coverage	Spatial datasets have complete coverage across the area of analysis.	3
Data accessibility	Public datasets (e.g. Canadian Anchorages and Anchorage Areas) are available and accessible.	3
Measurement reliability	Data is maintained and updated regularly by DFO and the Canadian Hydrographic Service (CHS). Analysis is straightforward and a buffer can be easily applied.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Designated Navigation Features

Rationale for consideration: Aquaculture would be constrained in areas already designated for navigation (e.g., shipping and ferry routes, traffic separation zones, sight lines from lighthouses etc.)
Final decision: Include
Average score: 2.9 (EXCEPTIONAL)

Property	Description	Score
Relevance to scope	Aquaculture is not allowed (constraint) in areas designated for traffic purposes (e.g., designated ferry routes) or to protect navigational safety (e.g., lighthouse sight lines).	3
Rateability	Recognition as a constraint means the classification is straightforward. Consideration around buffers is required, and different buffers may be needed for different features.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Criterion relevant to regional planning and dataset available at appropriate spatial resolution.	3
Coastal coverage	Spatial datasets have complete coverage across the area of analysis.	3
Data accessibility	Public datasets (e.g. Vessel Traffic Routes) are available and accessible.	3
Measurement reliability	Data is maintained and updated weekly by the DFO and CHS. Analysis is straight forward and requires only consideration of buffers.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Existing Aquaculture

Rationale for consideration: New aquaculture sites cannot be sited in existing aquaculture lease areas (and relevant buffers) due to physical constraints and requirements for mooring and operational logistics.
Final decision: Include
Average score: 2.9 (EXCEPTIONAL)

Property	Description	Score
Relevance to scope	New aquaculture sites cannot be placed where existing aquaculture lease areas exist.	3
Rateability	Recognition as a constraint means the classification is straightforward. Consideration of buffers is required.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	The dataset is available at the appropriate spatial resolution.	3
Coastal coverage	Spatial datasets have complete coverage across the area of analysis .	3
Data accessibility	Public datasets (e.g. Nova Scotia Marine Aquaculture Leases) are available and accessible.	3
Measurement reliability	Analysis is straight forward and requires only potential buffers applied to features. Data is compiled, maintained, and updated by the NSDFA. is straight forward.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Private Water Lots

Rationale for consideration: Aquaculture cannot legally be located in already privately-owned water lots.
Final decision: Include
Average score: 2.6 (EXCEPTIONAL)

Property	Description	Score
Relevance to scope	Several coastal properties in Nova Scotia have privately owned water lots. Aquaculture cannot be located in these areas.	3
Rateability	Recognition as a constraint means the classification is straightforward. Consideration of buffers is required.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Criterion may be more relevant for local site selection but remains an important constraint in nearshore areas.	2
Coastal coverage	Spatial property data is available across the area of analysis .	3
Data accessibility	Spatial property identification data is available though needs to be provided by network partners (private data request).	2
Measurement reliability	Analysis is straight forward and requires only potential buffers applied to features.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Submerged Structures

Rationale for consideration: Aquaculture cannot operate over submerged infrastructure due to required substrate moorings.
Final decision: Include
Average score: 2.9 (EXCEPTIONAL)

Property	Description	Score
Relevance to scope	Aquaculture cannot operate over submerged infrastructures such as telecommunication cables due to interference with moorings and legal restrictions.	3
Rateability	As this is a constraint, classification is straightforward.	3
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Criterion relevant to regional planning and dataset available at appropriate spatial resolution.	3
Coastal coverage	Spatial datasets have complete coverage across the area of analysis.	3
Data accessibility	The location of key structures is available on request from network partners.	2
Measurement reliability	Analysis is straight forward and requires only potential buffers applied to features.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Marine Renewable Energy Areas

Rationale for consideration: Several areas in Nova Scotia are allocated as Marine Renewable Energy Areas (MREA) used for exploration of energy production. Aquaculture can not occur in these areas already allocated for this use.
Final decision: Include
Average score: 2.8 (EXCEPTIONAL)

Property	Description	Score
Relevance to scope	Several areas in Nova Scotia are allocated as Marine Renewable Energy Areas used for exploration of energy production. Aquaculture can not occur in these areas already allocated for this use.	3
Rateability	Recognition as a constraint means the classification is straightforward. Consideration of buffers is required.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Dataset available at appropriate spatial resolution.	3
Coastal coverage	Spatial datasets include all known approved MREAs and therefore have complete coverage across the area of analysis .	3
Data accessibility	Dataset is available at request through network partners.	2
Measurement reliability	Distinct boundaries of MREAS are allocated by Nova Scotia Department of Natural Resources and Renewables. Analysis is straight forward and requires only potential buffers applied to features.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Marine Protected and Conserved Areas

Rationale for consideration: Aquaculture can not be located within marine protected areas due to conservation objectives and regulations.
Final decision: Include
Average score: 2.9 (EXCEPTIONAL)

Property	Description	Score
Relevance to scope	Within legally protected marine areas, large-scale developments are generally prohibited.	3
Rateability	Recognition as a constraint means the classification is straightforward. Consideration of buffers is required.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Dataset is available at appropriate spatial resolution.	3
Coastal coverage	Spatial datasets have complete coverage across the area of analysis .	3
Data accessibility	Public datasets (e.g. Canadian Protected and Conserved Areas Database (CPCAD)) are available and accessible.	3
Measurement reliability	The CPCAD data is compiled and managed by ECCC, in collaboration with federal, provincial, territorial, and other reporting authorities that provide the data. Analysis is straight forward and requires only potential buffers applied to features.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

At Sea-Disposal Sites

Rationale for consideration: Aquaculture can not be located above areas designated as at-sea disposal sites due to potential contamination risks.
Final decision: Include
Average score: 2.9 (EXCEPTIONAL)

Property	Description	Score
Relevance to scope	Several at-sea disposal sites are licensed in Nova Scotia's coastal waters. These represent allocated areas where any aquaculture operation would be excluded.	3
Rateability	Recognition as a constraint means the classification is straightforward. Consideration of buffers is required.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Dataset is available at appropriate spatial resolution.	3
Coastal coverage	At Sea Disposal Sites are licensed sites regularly updated through ECCC, ensuring full coverage.	3
Data accessibility	Public dataset (e.g. Active and Inactive Disposal at Sea Sites in Canadian Waters) is available from ECCC.	3
Measurement reliability	Data is maintained and updated annually by ECCC. Analysis is straight forward and requires only potential buffers applied to features.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Criteria Excluded

Biophysical Criteria

Superchill

Rationale for consideration Some parts of Nova Scotia have previously reported periods of extreme low temperatures (e.g., superchill events), creating risks for aquaculture.
Final decision Exclude
Average score 1.4 (POOR)

Property	Description	Score
Relevance to scope	Temperature is a key biophysical parameter important for siting and growth considerations of shellfish aquaculture. While shellfish have large thermal tolerances, and mortality is only relevant at the freezing point of seawater (for ice development), producers must still consider mitigation to avoid ice risks (see ice below).	1
Rateability	Since shellfish have very low thermal tolerances, superchill not generally an issue and so rating would rely on precautionary or expert opinion.	1
Scoring clarity	The risk-based approach and methods (i.e., interpolation) require some explanation.	2
Scale validity	Interpolation of data was required to produce datasets at appropriate resolution.	2
Coastal coverage	Spatial dataset will be based on point data with disperse coverage; interpolation will be applied to areas between point data.	1
Data accessibility	Spatial datasets will be generated using data from CMAR's Coastal Monitoring Program for this assessment.	2
Measurement reliability	Documenting superchill temperatures spatially relies on analysis and interpolation of point data using likelihood calculations. Novel datasets and methods combined with interpolation, will likely introduce uncertainties.	1
Redundancy to other criteria	At relevant temperatures, the parameter may have overlaps in trends with ice exposure but can be assessed and classified relatively independently.	1

Sea Surface Temperature

Rationale for consideration Aquaculture should be sited in areas where average temperatures are within established temperature ranges optimal for growth.
Final decision Exclude
Average score 1.6 (POOR)

Property	Description	Score
Relevance to scope	Sea Surface Temperatures (SST) provide indication of average temperatures do not identify critical thresholds (e.g. heat stress, etc.). These temperatures are more relevant for identifying optimal growth conditions, which is beyond scope of assessment.	1
Rateability	Average SST can provide an indication of optimal growth conditions for shellfish. Variation in average temperatures is generally not considered an issue for shellfish in Nova Scotia, so scoring would rely heavily on precautionary approach or expert insights.	2
Scoring clarity	The calculation of satellite-derived SST requires some explanation.	2
Scale validity	Available datasets are at coarse resolutions and not appropriate the scale of assessment.	1
Coastal coverage	Available datasets have major gaps in coverage, especially in nearshore environments close to the coast.	1
Data accessibility	Datasets are available through publicly accessible satellite-modeling (e.g. DFO BNAM model), though data may not be available for small time steps (e.g. daily).	3
Measurement reliability	Some identified limitations with using satellite-derived and modeled SST data.	2
Redundancy to other criteria	Data can be integrated into the calculation of temperature threshold layers (overlap).	1

Ocean Slope

Rationale for consideration: Aquaculture should be sited in areas where the slope of the bottom is suitable for construction of farms.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	The bottom slope of the area could affect farm construction. Mooring considerations and farm construction are beyond the scope of assessment.	N/A
Rateability	There is evidence of slope requirements for shellfish sites, although this can be highly gear and operation-specific.	2
Scoring clarity	The slope is calculated using bathymetry data, which would require some explanation.	2
Scale validity	Criterion is relevant for the site-level to capture operation-specific requirements.	N/A
Coastal coverage	Coverage is available around all of Nova Scotia, but some areas have greater uncertainty or minor gaps.	2
Data accessibility	Bathymetry data is available from various sources (e.g. GEBCO).	2
Measurement reliability	Ocean slope can be represented from bathymetry data (e.g. GEBCO).	3
Redundancy to other criteria	Accounted for in bathymetry.	1

Substrate

Rationale for consideration: Aquaculture should be sited in areas with appropriate substrate type to meet mooring and operational considerations.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Different substrate types are readily accounted for by different mooring considerations with respect to substrate require high level data resolution at the site level, which is beyond the scope of assessment. Substrate type is also not considered an impediment for aquaculture site selection under most circumstances.	N/A
Rateability	General considerations for substrate type are well understood for different producers but may vary considerably across smaller scales and different operations. Scoring would rely on expert and industry insights.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Criterion is best evaluated at the site-level scale. Available datasets at very coarse scale, not representative of fine-scale variability that is important for siting.	N/A
Coastal coverage	Substrate Classification mapping of the Inshore Scotian Shelf and the Bay of Fundy exists with coverage across the area of analysis, though at a very coarse scale.	3
Data accessibility	Public dataset is available (e.g. A substrate classification for the Inshore Scotian Shelf and Bay of Fundy, Maritimes Region) and accessible.	3
Measurement reliability	Dataset was produced by the DFO based on previous geological characterizations from NRCan. In areas where geological descriptions were unavailable digital elevation models and substrate samples from NRCan, CHS and DFO Science were used. Dataset is considered coarse with high uncertainty and local variability at smaller scales.	1
Redundancy to other criteria	Data is largely independent of other types of data.	3

Ocean Current

Rationale for consideration: Aquaculture should be sited in areas with adequate current to allow greater water exchange between farms and surrounding water, allowing sufficient oxygen supply to cultured species.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Adequate currents are an important consideration for planning and site selection for the growth and welfare of cultured species.	3
Rateability	Suitable current speeds are well established and understood, but suitability also often evaluated in the context of other ocean variables.	2
Scoring clarity	Implications for current speed would require some explanation to non-technical users.	2
Scale validity	Current is highly variable at local levels and of limited applicability at regional-level scales.	N/A
Coastal coverage	Local-scale current speed data collection is sporadic and does not cover the entire coastline. (sparse), not are model outputs (e.g. FVCOM) available for all locations.	N/A
Data accessibility	Available only for some locations.	N/A
Measurement reliability	There is confidence in data collected, but complex ocean models are needed to estimate (interpolate) current between these locations.	2
Redundancy to other criteria	Related to exposure modelling and correlated to depth.	1

Ocean Flushing

Rationale for consideration: Aquaculture should not be sited in areas with poor flushing, which could increase water temperature, decrease dissolved oxygen, and cause an increase in algal blooms.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Flushing rate is recognized as an important site selection criterion for aquaculture at local site selection scales, in conjunction with other water quality metrics.	2
Rateability	The dynamics of flushing rates on aquaculture are generally well understood, but often evaluated in the context of other ocean variables.	2
Scoring clarity	Flushing rate can generally be calculated through a range of basic to complex modelling processes which require some explanation.	2
Scale validity	Criterion is relevant for the local site selection scale or bay-scale carrying capacity modelling.	N/A
Coastal coverage	Not available for all bays across the province.	N/A
Data accessibility	Where flushing rate has been calculated and published, information is easily accessible, but for most bays around the province, field data collection would be required to calculate flushing rate.	1
Measurement reliability	Flushing rate calculations and predictions are more accurate in clearly defined bays with, but less accurate at fine scales or in geographically complex systems.	1
Redundancy to other criteria	Influences many water quality metrics. Flushing rate is of limited usefulness in isolation.	N/A

Wind/Wave Direction

Rationale for consideration: Aquaculture site orientation and construction can be influenced by the direction and speed of wind and waves in the area.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Indirectly relates to the magnitude of stress on gear, which is more of an operational constraint beyond the scope of assessment.	N/A
Rateability	Implications for aquaculture suitability are highly operation specific and can not be taken in isolation.	3
Scoring clarity	Relatively easy to explain, but variation in would also need to be communicated.	2
Scale validity	Wind and wave directional data has greater importance at the aquaculture site selection scale and is not well qualified at this scale most locations around the province.	N/A
Coastal coverage	Wind direction has adequate coverage at coarse scales, but wave direction is not well defined for most locations.	2
Data accessibility	Some data accessible exists but would require considerable effort to adjust the scale of analysis or collect additional data where gaps exist.	2
Measurement reliability	It is possible to report predominant wind and wave direction at the scale of analysis, with some uncertainty.	2
Redundancy to other criteria	Maximum wave exposure modelling embodies this parameter.	N/A

Wind Speed

Rationale for consideration: Aquaculture site orientation and construction can be influenced by the direction and speed of wind and waves in the area.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Wind speed is recognized as an important consideration for site orientation and selection. It can indirectly relate to the magnitude of stress on gear. It is rarely an absolute limiter, but may dictate infrastructure engineering needs, which in turn affect cost and therefore, more an operational consideration beyond the scope of assessment.	N/A
Rateability	Maximum wind speed is important for site selection, orientation, and infrastructure design. Implications are highly operation specific.	3
Scoring clarity	Wind speeds are often highly linked to other parameters, with mostly indirect effects on farms. Understanding the role/effects of wind would require a fair bit of explanation.	1
Scale validity	The scale of data for wind speed is at the provincial level.	2
Coastal coverage	Generating wind speed data across the entire area of analysis would require substantial interpolation from point data.	1
Data accessibility	Some accessible data it would require analysis to adjust to the scale of analysis.	2
Measurement reliability	Interpolation of wind speed data at scale would be required for assessment, but it is possible with existing data. There is some uncertainty with the use of terrestrial wind gauges.	2
Redundancy to other criteria	Wave exposure parameter modelling accounts for this parameter.	N/A

Aquatic Invasive Species

Rationale for consideration: Aquaculture should not be located in areas susceptible to Aquatic Invasive Species (AIS) due to their detrimental impacts on water quality.
Final decision: Exclude
Average score: 1.6 (POOR)

Property	Description	Score
Relevance to scope	Several AIS are large fouling organisms that if present in large quantities, can reduce necessary water flow for shellfish and smother or lead to physical damage or mortality of organisms. Risks to shellfish health and to producers are based on intensity and timing, which is highly variable and context-specific, rather than presence.	2
Rateability	There may be variability between different species of AIS, and their intensity across areas and over time. Depending on the species, presence may not impact culture. Therefore, classification is not straight forward and requires advice from experts and industry.	2
Scoring clarity	The dataset requires some clarification to explain modelling and aggregation of species.	1
Scale validity	Specific impacts or risks from AIS is best evaluated at the site-level. Identifying general areas where species are present or most intense can provide an indicator of additional risks producers may face, which is appropriate for regional level assessment.	2
Coastal coverage	Modelled data that is available does not extend fully across the area of analysis, with notable gaps.	1
Data accessibility	Modelled distribution data available and accessible (e.g. Species distribution models and occurrence data for marine invasive species hotspot identification). However, risks to producers and shellfish health are more based on intensity and timing of spread, which has not been spatially mapped.	1
Measurement reliability	Marine invasive hotspot modelling is done through monitoring and occurrence data through DFO. The data is based on predictive models with accepted uncertainty. Measurement would require combining multiple species hotspots with some uncertainty.	1
Redundancy to other criteria	While there may be some relationships with temperature and particle availability, data can be treated as largely independent.	3

Salinity

Rationale for consideration: Maintaining stable and suitable salinity levels within the thresholds of shellfish tolerance is essential for promoting health and productivity of shellfish aquaculture.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Reaching salinities beyond thresholds would affect health and welfare, although. Salinity is not considered an issue for shellfish (oysters) in Nova Scotia since they are tolerant of varying salinity conditions. Salinity highly variable and more relevant at site-level.	1
Rateability	Cultured species have specific salinity tolerances that would affect health and welfare. Salinity tolerances are well established. Oysters have higher salinity tolerances than mussels. High variability at local scales makes scoring complicated.	2
Scoring clarity	Salinity effects are well understood and can be clearly communicated.	3
Scale validity	Spatial datasets at coarse resolutions. Variations in salinity are highly site-specific (due to various inputs, local patterns in current and flushing, etc.). Consideration is more relevant at the site selection scale.	N/A
Coastal coverage	The data available (point locations) contains large gaps and cover multiple time frames.	1
Data accessibility	At the appropriate resolution, nearshore salinity is only available for point locations.	1
Measurement reliability	Ocean salinity mapping efforts (e.g. satellite data) at inappropriate spatial resolutions, would require significant downscaling and would introduce considerable uncertainty.	1
Redundancy to other criteria	Shifts in salinity may be accounted for in other layers (e.g. distance to rivers).	1

Dissolved Oxygen

Rationale for consideration: Dissolved oxygen is essential for shellfish respiration and overall health and ensuring optimal growth and survival during culture.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Inadequate levels of dissolved oxygen (DO) can lead to stress, reduced growth, and, in extreme cases, mortality. DO is a key parameter for monitoring and siting, but is often applied at the site-level. At a regional-level, DO is generally not considered an issue since DO rarely reaches harmful levels in Nova Scotia, and due to the high tolerances species.	1
Rateability	DO is a key water quality parameter for shellfish aquaculture. Optimal ranges and thresholds for DO are well-documented. However, specific thresholds are highly variable based on other ocean parameters (e.g. temperature and salinity) and exhibit high spatial variability at local scales, making assessment for suitability more relevant at the site-level.	1
Scoring clarity	Implications of dissolved oxygen on cultured species are relatively easy to describe, although the creation of a spatial layer may be technical and require some explanation.	1
Scale validity	Recognized small-scale spatial and temporal variability within coastal bays - most relevant for local assessments or bay-scale carrying capacity modelling.	N/A
Coastal coverage	Due to large gaps in the data available and limited data in nearshore areas a risk-based approach or interpolation would be required.	N/A
Data accessibility	There are no provincial-scale spatial datasets available; only point locations are available. Necessary efforts to complete coverage are not within the project timeline and resources.	1
Measurement reliability	DO can be measured through in-situ measurements or satellite data.	1
Redundancy to other criteria	DO is influenced by other parameters at the local level, including ocean mixing, temperature, current flow, flushing rate, etc.	2

Turbidity

Rationale for consideration: High turbidity can affect the welfare of cultured shellfish, as highly turbid environments can obstruct the gills of bivalves and interfere with normal respiration and feeding.
Final decision: Exclude
Average score: 1.8 (POOR)

Property	Description	Score
Relevance to scope	Turbid environments are not suitable for some species of bivalves. Turbidity is relevant to the welfare of cultured bivalves since highly turbid areas may have negative effects on welfare.	2
Rateability	There are some established turbidity thresholds for shellfish, which would be supplemented by expert opinion.	2
Scoring clarity	The inclusion of turbidity requires an explanation for why it is relevant and how it is measured.	1
Scale validity	Turbidity has recognized small-scale spatial and temporal variability within coastal bays.	1
Coastal coverage	Satellite images and data exist across the province and provide information that can be used to identify turbid waters.	2
Data accessibility	Satellite data is free and accessible online but may require some work to use.	2
Measurement reliability	Measurement is straightforward but involves complex image analysis or site-specific measurements relevant during site selection.	2
Redundancy to other criteria	Data is largely independent of other data. There may be some overlap with river runoff.	2

Chlorophyll

Rationale for consideration: Aquaculture should be located in areas that contain adequate chlorophyll for cultured species, which are important for water quality and nutrient availability of shellfish.
Final decision: Exclude
Average score: 1.8 (POOR)

Property	Description	Score
Relevance to scope	Chlorophyll can be used to indicate nutrient availability and water quality for shellfish aquaculture. While not usually a limiting factor, food availability is more related to optimal growth. Food availability can become an issue with high densities, evaluated in the context of carrying capacity.	1
Rateability	Some empirical evidence of thresholds for chlorophyll. Highly variable on temporal and spatial scales, which would make scoring challenging and add uncertainty.	2
Scoring clarity	Criterion would require some explanation, including how datasets were derived.	2
Scale validity	High variability across temporal and spatial scales means criterion is best evaluated through bay-scale assessments, assessments of carrying capacity, or site-specific data.	1
Coastal coverage	Satellite data is available, although there are substantial gaps in data (i.e., due to cloud coverage).	2
Data accessibility	Satellite data is available online, but data format can be challenging to manipulate.	2
Measurement reliability	There is some uncertainty in satellite derived data, as data rely on ocean colour to generate inferences of in-situ values.	2
Redundancy to other criteria	Consideration within carrying capacity models.	2

Primary Productivity

Rationale for consideration: Aquaculture siting should consider primary productivity of an area, which can provide information on carrying capacity of an ecosystem for shellfish aquaculture.
Final decision: EXCLUDE
Average score: N/A (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Primary productivity refers to the rate at which photosynthetic producers convert energy from the sun into organic materials consumed by shellfish. Most appropriately considered within the context of carrying capacity and ecosystem functioning.	1
Rateability	Not clear; threshold values will vary between local ecosystems and bays.	1
Scoring clarity	Criterion would require significant explanation and context.	N/A
Scale validity	High variability across temporal and spatial scales means criterion is best evaluated through bay-scale assessments for determining carrying capacity.	N/A
Coastal coverage	Minimal data has been collected within a handful of areas of interest, but this is a small fraction of NS coastline.	N/A
Data accessibility	Data must be collected manually, and analysis is lengthy, costly, and intensive..	1
Measurement reliability	Scientific methods are used to measure carbon dioxide uptake or oxygen consumption.	2
Redundancy to other criteria	Considered within carrying capacity models.	N/A

Point Discharges

Rationale for consideration: Aquaculture should not be located in areas where domestic effluent or industrial discharges release nutrients or contaminants into coastal areas.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Domestic effluent or industrial discharges can release nutrients or harmful contaminants into the marine environment, which can cause harm to shellfish if very nearby.	3
Rateability	Impacts on water quality and shellfish health are variable and highly dependent on outfall management practices. Critical buffers have been established (through CSSP) but can be supplemented with expert opinion.	2
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Criterion considered mostly relevant at the site-selection level due to high variability.	1
Coastal coverage	There are some gaps in spatial data on the location of all outfalls across the area of analysis.	1
Data accessibility	There are some gaps in spatial data on the location of all outfalls across the area of analysis that would require additional resources to identify.	2
Measurement reliability	Measurement is straight forward, and analysis can be done through commonly applied path-distance methods in GIS.	3
Redundancy to other criteria	Parameter is considered in shellfish closure areas and has some overlap with the location of small craft harbours and population centres.	N/A

River Runoff

Rationale for consideration: Aquaculture should not be located in areas that would be highly exposed to riverine inputs that could release nutrients or contaminants into coastal areas.
Final decision: Exclude
Average score: 1.4 (POOR)

Property	Description	Score
Relevance to scope	Riverine inputs are important for water quality monitoring and changes to salinity and turbidity. River outputs (nutrients etc.) can cause harm to cultured shellfish (mussels) if within close distances, or with prolonged exposure, depending on the contents of the runoff (chemical or organic).	2
Rateability	Impacts to shellfish can be highly variable and are likely affected by multiple factors at the site-level. Classification would rely on expert advice.	1
Scoring clarity	River runoff impacts may require complex analysis that would require substantial explanation to end-users.	1
Scale validity	Impacts from riverine inputs exhibit local-scale environmental variability to be more comprehensively captured at the site-level.	1
Coastal coverage	Some information required to map river runoff is available, but others require site-specific information that is not available across the entire spatial area of analysis.	1
Data accessibility	Spatial data could be generated for assessment. Although, more complex analysis is required to appropriately capture river-specific impacts are beyond this project.	1
Measurement reliability	Simple methods of measurement are available (i.e., through indirect metrics such as proximity to rivers) at regional level.	3
Redundancy to other criteria	The impacts from river inputs relate to other variables and can be linked to changes in salinity and turbidity. River data also captured in wild salmon river criterion.	1

Agricultural Runoff

Rationale for consideration: Aquaculture should not be located in areas where agricultural discharges release nutrients or contaminants into coastal areas.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Agricultural runoff can cause harm to cultured shellfish if within close distances. Agricultural runoff is an important water quality consideration and is incorporated in CSSP analysis and designations.	3
Rateability	Effects would highly depend on agricultural management practices. Some established buffers exist, which will be supplemented with additional expert opinion.	1
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Proximity to easements where runoff may be an issue can be adequately addressed at the provincial level since there is existing information on where these activities occur and watershed delineation, although there are local variabilities.	2
Coastal coverage	Data is available across the entire spatial area of analysis.	3
Data accessibility	Dataset is available through network partners.	2
Measurement reliability	Accuracy of data is high due to collection from network partners.	3
Redundancy to other criteria	In the context of critical sources of runoff, this is already accounted for in CSSP.	N/A

Forestry Runoff

Rationale for consideration: Aquaculture should not be located in areas where forestry discharges release nutrients or contaminants into coastal areas.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Forestry runoff can cause harm to cultured shellfish if within close distances. Forestry runoff is an important water quality consideration and is considered in CSSP designations.	3
Rateability	Effects would depend highly on the management of forestry practices. Some established buffers exist, which will be supplemented with additional expert opinion.	1
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Proximity to easements where runoff may be an issue can be adequately addressed at the provincial level since there is existing information on where these activities occur and watershed delineation, although there are local variabilities.	2
Coastal coverage	Data is available across the entire spatial area of analysis.	3
Data accessibility	Dataset is available through network partners	2
Measurement reliability	Accuracy of data is high due to data collection from network partners.	3
Redundancy to other criteria	In the context of critical sources of runoff, this is already accounted for in CSSP.	N/A

Algal Blooms

Rationale for consideration: Aquaculture operations can be impacted if within areas of high likelihood of blooms, which can lead to depletion of local oxygen levels and exposure to toxins.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance	Harmful algal blooms (HABs)-related toxins can accumulate in shellfish tissue potentially leading to health risks for consumers.	3
Rateability	Areas experiencing frequent algal blooms and HABs are not ideal for shellfish culture, as they can endanger shellfish and consumer health and cause severe economic impacts. Classification is likely based on the risk of events occurring, which is difficult to estimate.	1
Scoring clarity	Criterion rationale and data products likely require some explanation.	2
Scale validity	Likely consideration appropriate for regional-level assessment, but would require substantial interpolation of point data.	1
Coastal coverage	Only localized data collection efforts.	N/A
Data accessibility	The necessary efforts required to complete the dataset for missing spatial coverage are beyond the time and resources available.	N/A
Measurement reliability	Methods for estimation are novel and emerging.	1
Redundancy to other criteria	Correlations with multiple parameters, likely creating redundancies across other parameters (e.g. water quality, temperature, and proximity to sources of nutrients and pollution).	1

Other aquaculture sites (proximity)

Rationale for consideration: Proximity to existing sites can create operational hazards, and if shellfish aquaculture occurs in high densities, may lead to overloading carrying capacity of environment.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Distance to existing sites is a consideration for operational needs. Shellfish sites that are too close may compete for food, affecting the welfare of each site.	2
Rateability	There is some potential for overloading of the environment's carrying capacity in high biomass, but this is highly based on the scale of operation and carrying capacity of the area (best evaluated at site level). Classification would rely on expert or industry advice.	1
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Consideration for other sites in the context of carrying capacity is considered more relevant for site selection processes or bay-scale assessment.	N/A
Coastal coverage	Considering in the context of proximity to existing sites, all sites across the area of analysis are available; data is available across the entire spatial area of analysis.	3
Data accessibility	Public datasets on the location and extent of existing aquaculture sites are available and accessible (e.g. Nova Scotia Marine Aquaculture Leases).	3
Measurement reliability	If considering in the context of proximity to existing sites, data is compiled, maintained, and updated by the NSDFA. Measurement is straight forward, and analysis can be done through commonly applied path-distance methods in GIS.	3
Redundancy to other criteria	Data is largely independent of other types of data.	1

Conservation Criteria

Wild Salmon Rivers

Rationale for consideration: Shellfish aquaculture operations in proximity of rivers with high significance for salmon may increase the likelihood of potential interactions with wild Atlantic salmon.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Impacts from shellfish aquaculture are more related to species migration routes, and there is little evidence of shellfish aquaculture as a threat to river habitats.	N/A
Rateability	Interactions most likely depends on the scale and size of operations. Interactions are more related to species migration routes and little guidance for shellfish exist.	1
Scoring clarity	Ratings for salmon rivers require some explanation.	2
Scale validity	Criterion is relevant to regional planning and dataset will be created to be at the appropriate spatial resolution.	3
Coastal coverage	Assessments will encompass rivers from across the province, with potentially minor gaps in coverage due to lack of comprehensive data on specific rivers.	3
Data accessibility	Assessment of wild salmon rivers is being conducted for this assessment, which requires additional project resources but can be accomplished within the project timeline.	2
Measurement reliability	Recent information on salmon river population status is sparce. Data is being compiled, assessed, and classified based on significance for wild salmon. The assessment framework, being established through expert review, but some uncertainty is expected.	1
Redundancy to other criteria	Data is largely independent of other types of data.	3

Eelgrass Habitat

Rationale for consideration: Aquaculture should be located away from critical areas for eelgrass, to reduce potential impacts from shading, sedimentation, or nutrient releases.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Eelgrass habitats are important and sensitive habitats in Nova Scotia and are a required consideration in aquaculture regulations.	3
Rateability	Impacts of shellfish aquaculture on eelgrass are highly localized (e.g. due to shading) and considered to be variable (i.e., negative, neutral, and positive). Scoring would rely on expert opinion.	2
Scoring clarity	Data products created would require some explanation.	2
Scale validity	Criterion could be used for regional-level planning but can be more comprehensively captured at the bay or site-level.	2
Coastal coverage	Presence of eelgrass data available sporadically across the province. Mapped data to identify habitat suitability or hotspots available through the National Eelgrass Dataset for Canada (NetForce) project were only created for the Scotian Shelf of Nova Scotia.	1
Data accessibility	Spatial datasets on eelgrass presence and habitat suitability available and accessible (e.g., NetForce). The necessary efforts required to complete the spatial dataset for missing spatial coverage are beyond the time and resources available by the project.	N/A
Measurement reliability	Some methods to map the suitability of habitat or habitat hotspots for eelgrass in Nova Scotia are relatively novel (e.g. see NetForce project).	2
Redundancy to other criteria	There may be some overlap with other important habitat designations, as some protected areas include eelgrass habitat.	2

Species Migration Paths

Rationale for consideration: Aquaculture should be sited away from key areas and paths used by species during critical migration life stages (for example, wild Atlantic salmon).
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Infrastructure associated with shellfish farming can provide opportunity for interactions for movement and migration of fish, which are critical habitats for some species.	3
Rateability	Impacts highly variable and classification would rely on expert opinion.	2
Scoring clarity	Data would not necessarily require complex analysis and is anticipated to be relatively easy to communicate.	3
Scale validity	Criterion relevant to regional planning.	3
Coastal coverage	Consistent spatial data is non-existent.	N/A
Data accessibility	Consistent spatial data is non-existent	N/A
Measurement reliability	Key migration routes have not been identified.	N/A
Redundancy to other criteria	May be accounted for in other layers (i.e., critical habitat, salmon rivers).	1

Important Fish Habitat

Rationale for consideration: Aquaculture should not be located in areas that would have potential impacts on fish species and habitats that are important for conservation and management initiatives.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Aquaculture activities near or over fish habitats may impact migration and the presence of important species. Pseudofeces accumulation in poor flushing and low current environments is a potential. Parameter is likely best evaluated at the bay or local scale.	3
Rateability	The degree and nature of interactions with aquaculture are likely highly variable based on local operations, making rating challenging.	1
Scoring clarity	Data would not require complex analysis, although rationale would require some explanation (species-specific consideration).	2
Scale validity	Potential interactions with specific fish species are best evaluated through local site selection or management practices.	N/A
Coastal coverage	All data in the described habitats are based on research vessel surveys from DFO trawls, all beyond the area of analysis (offshore).	N/A
Data accessibility	Species distribution data has been mapped for several important fish species through DFO (Bundy et al., 2017) but layers could be available by request.	2
Measurement reliability	Spatial data aggregated across multiple years, involves some interpolation but highlights general species distribution and habitats.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Important Cetacean Habitat

Rationale for consideration: Aquaculture should not be located in areas recognized as important for cetacean species. Some interactions with aquaculture operations are possible (e.g., entanglement, attraction).
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Several key cetacean species inhabit waters in Nova Scotia and are a key conservation concern. Some interactions with aquaculture operations are possible (e.g., entanglement, attraction), but this is highly farm-specific.	2
Rateability	Infrastructure associated with finfish farming can be obstacles for the movement and migration of cetaceans. There are also risks of entanglements at the site-level, although this is highly gear-specific. There is little evidence to support the scoring.	1
Scoring clarity	Data would not require complex analysis, although rationale would require some explanation (species-specific consideration).	2
Scale validity	Potential interactions with cetaceans are best suited for local site selection or management practices.	N/A
Coastal coverage	Described data are largely based on species distribution models and sighting data from offshore DFO research vessels surveys from DFO, mostly beyond the AOA (e.g. offshore).	N/A
Data accessibility	Some datasets are publicly available based on whale sightings data, or to delineate important habitat (e.g., Blue whales, and Northern Bottlenose Whales), but not for all species of cetaceans.	2
Measurement reliability	Data collected based on long-term datasets from DFO sighting and mapping efforts.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Important Coral/Sponge Habitat

Rationale for consideration: Aquaculture should not be located in areas that would have potential impacts on important benthic species and habitats.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Some corals and sponges are highly sensitive and recognized as a conservation priority. The high biomass of shellfish aquaculture in an area could potentially exceed the carrying capacity to assimilate pseudofeces in areas with low flushing and currents. This needs to be evaluated at the site-level.	1
Rateability	Shellfish aquaculture is not likely compatible with areas for key coral/sponge significant habitat (most at depth, offshore). There is little existing evidence for interactions with benthic species considered in this dataset (e.g., sponges, etc.).	N/A
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Dataset available at appropriate spatial resolution.	3
Coastal coverage	The majority of described habitat areas are beyond the 3 km spatial extent of the project.	N/A
Data accessibility	Public datasets identifying significant benthic habitat for corals and sponges are available through DFO and accessible (e.g. Delineation of Coral and Sponge Significant Benthic Areas in Eastern Canada (2016)).	3
Measurement reliability	Significant benthic areas identified and mapped by DFO based on locations of concentrations of corals and sponges from research vessel trawl data.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Important Invertebrate Habitat

Rationale for consideration: Aquaculture should minimally impact areas recognized as important or critical for invertebrate species since aquaculture may lead to organic loading on benthic environments and changes on benthic communities.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Invertebrates are important for the overall health of benthic communities. Pseudofeces accumulation in areas of poor flushing and low currents is a potential problem, especially at high biomass. This parameter is likely best evaluated at the site-level.	1
Rateability	Some evidence of localized impacts on benthic habitats below shellfish farms (e.g., for shading or biofouling). Yet, these impacts are often gear-specific and best evaluated during site application or through management processes.	1
Scoring clarity	Data would not require complex analysis, but rationale would require some explanation.	2
Scale validity	Proximity to specific invertebrates/benthic habitats is likely most relevant for site selection, since most benthic habitats occur at small spatial scales.	1
Coastal coverage	All data in described habitats are based on research vessel surveys from DFO trawls, all beyond the area of analysis (i.e., offshore).	N/A
Data accessibility	Species distribution data has been mapped for several important invertebrates through DFO (Bundy et al., 2017) but could be available by request.	2
Measurement reliability	Spatial data aggregated across multiple years, involves some interpolation but highlights general species distribution and habitats.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Lobster Presence

Rationale for consideration: Lobster are key species for commercial fisheries. Potential interactions with lobster is an important consideration for aquaculture siting.
Final decision: Exclude
Average score: 1.3 (POOR)

Property	Description	Score
Relevance	Pseudofeces accumulation in areas of poor flushing and low currents is a potential problem, especially at high biomass where there is to overload the environment's carrying capacity. This parameter is likely best evaluated at the site-level.	1
Rateability	Some evidence of localized impacts on benthic habitats below shellfish farms (e.g. for shading or biofouling). However, these are often gear-specific and best evaluated during site application or through management processes.	1
Scoring clarity	Data would require explanation, as habitat suitability is based on modelled data.	1
Scale validity	The resolution of the dataset is coarse and likely not appropriate for the scale of analysis.	1
Coastal coverage	Coverage across the area of analysis, although is less accurate to nearshore waters.	1
Data accessibility	Habitat suitability model data available from a published paper (Greenan et al., 2019), would require a request for access (i.e., not public).	2
Measurement reliability	Data from research vessel surveys, which do not sample inshore waters and thus model relies on interpolation, are cited as not appropriate for inshore suitability of habitat.	1
Redundancy to other criteria	There are potential overlaps with other data, including navigation routes.	2

Ecologically and Biologically Significant Areas (EBSAs)

Rationale for consideration: Aquaculture operations should be sited away from areas of high biological or ecological significance.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS))

Property	Description	Score
Relevance to scope	EBSAs are important for conservation goals. Their designations reflect recognized important areas for conservation priorities, reflecting unique or key ecosystems.	3
Rateability	The broad nature of EBSAs, consisting of multiple species, habitat types, etc., would mean proximity ratings based solely on expert opinion.	1
Scoring clarity	The broad nature of EBSA designation would require some additional explanation on a case-by-case basis.	1
Scale validity	Areas are too large, and data is too coarse for the scale of assessment.	N/A
Coastal coverage	Data is available across the entire spatial area of analysis.	3
Data accessibility	Public datasets are available and accessible (e.g. Ecologically and Biologically Significant Areas).	3
Measurement reliability	Dataset and EBSA Designation is done through a thorough designation process under DFO. Layer calculation would be simple and done through commonly applied path-distance methods in GIS.	3
Redundancy to other criteria	Data is likely incorporated in other layers at a finer scale (e.g. other habitat layers and protected areas, etc.).	1

Ocean Use Criteria

High-Use Recreation and Tourism Areas

Rationale for consideration: To minimize potential spatial overlaps, aquaculture should minimize impacts to marine areas that are of high use for recreation and tourism.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Aquaculture operations can potentially interact with or create conflicts with recreation and tourism. Identifying areas used most can help aquaculture reduce negative interactions with coastal users.	2
Rateability	Recognition of potential interactions, but often considered on a more qualitative basis. Classification would largely be based on expert input and precautionary designations.	1
Scoring clarity	Interpreting data does not require expert knowledge but would require some explanation and clarification.	2
Scale validity	Criterion is relevant to regional planning but could be more effectively/comprehensively evaluated at the local scale.	2
Coastal coverage	There is sparse comprehensive data available, as only localized use-mapping efforts have been undertaken in Nova Scotia at the site-level.	1
Data accessibility	Adequate analysis of coastal use areas would require participatory mapping efforts beyond the available resources.	N/A
Measurement reliability	Measurement of use areas at the provincial scale requires large-scale participatory methods, with some uncertainty.	2
Redundancy to other criteria	There is likely correlation with other sources of data (i.e., proximity to access points).	1

Lobster Fisheries

Rationale for consideration: To minimize potential spatial overlaps, aquaculture should minimally impact areas with important fishing activities such as lobster.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Consideration for fishery activities in adjacent marine waters is a key decision-making factor in the Nova Scotia Aquaculture License and Lease Regulations. Yet, conflicts may be more relevant to the displacement of activity rather than linked to catch data.	1
Rateability	Few empirical studies have explored the linkage between total lobster catches and proximity to aquaculture (for a review, see Horricks et al., 2022).	1
Scoring clarity	Interpreting data does not require expert knowledge but would require some explanation and clarification because lack of defined impacts/interactions.	2
Scale validity	Criterion is relevant to regional planning but is comprehensively evaluated at a local scale. Data only available at spatial resolutions that are too coarse for this level of analysis.	N/A
Coastal coverage	Coarse spatial datasets have complete coverage across the area of analysis.	3
Data accessibility	Public datasets are available and accessible (e.g. Inshore Lobster Landings and Fishing Effort).	3
Measurement reliability	Landings and effort mapping compiled by DFO, but have some inherent uncertainty associated with fisher-reported data.	2
Redundancy to other criteria	Spatial overlaps are possible with other data, such as navigation since fishing areas may depend on proximity to port.	1

Other Commercial Fisheries

Rationale for consideration: To minimize potential spatial overlaps, aquaculture minimally impact areas with important fishing activities
Final decision: Exclude
Average score: 1.6 (POOR)

Property	Description	Score
Relevance to scope	Consideration for fishery activities in adjacent marine waters is a key decision-making factor in the Nova Scotia Aquaculture License and Lease Regulations. Conflicts may be more relevant to the displacement of activity rather than linked to catch data.	1
Rateability	Few empirical studies have explored the linkage between total catches for most fish species and proximity to aquaculture.	1
Scoring clarity	Interpreting data does not require expert knowledge but would require some explanation and clarification.	2
Scale validity	Catch data spatially mapped on a 10 km^2 grid, determined to be at a coarse scale that may be inappropriate for the scale of assessment.	1
Coastal coverage	Data resolution is coarse and there are some gaps in data close to shore.	2
Data accessibility	Public datasets are available and accessible (e.g. the Eastern Canada Commercial Fishing Data)	3
Measurement reliability	Commercial fishing catch data has been spatially mapped by DFO with some inherent uncertainty associated with calculation.	2
Redundancy to other criteria	Spatial overlaps possible with other data, such as navigation since fishing areas may depend on proximity to port.	1

Indigenous Fisheries

Rationale for consideration: Indigenous Peoples in Nova Scotia have the legal right to fish for food, social, ceremonial (FSC) and moderate livelihood purposes. Aquaculture should be located in areas that would not restrict access to Indigenous fishing.
Final decision: Exclude
Average score: 1.6 (POOR)

Property	Description	Score
Relevance to scope	Consideration for fishery activities in adjacent marine waters is a key decision-making factor in the Nova Scotia Aquaculture License and Lease Regulations. Interactions with areas used for Indigenous fisheries can be variable and best considered at the site-level. This factor is intertwined with social compatibility which is beyond the project scope.	1
Rateability	Considerations for displacement or impacts on Indigenous fisheries are highly variable and are most appropriately evaluated through local consultations at the site-level, specifically during site selection.	1
Scoring clarity	Interpreting data does not require expert knowledge but would require some explanation and clarification.	2
Scale validity	More appropriate for local site selection, with consultation with local communities.	N/A
Coastal coverage	Spatial data is not publicly available for the province.	NA
Data accessibility	Some Indigenous fishing activity has been mapped through broader commercial fisheries designations (i.e., Lobster Fishing Areas). However, not all Indigenous fishing activities have been mapped and the data can be considered sensitive in nature.	NA
Measurement reliability	Mapping may not be appropriate for wide public distribution.	2
Redundancy to other criteria	Spatial overlaps possible with other data, such as other fisheries data since…	1

Viewshed

Rationale for consideration: Aquaculture should be sited to minimize its visual impact on the surrounding seascape and alteration of the aesthetic appeal of coastal areas.
Final decision: Exclude
Average score: 1.8 (POOR)

Property	Description	Score
Relevance to scope	Aquaculture operations can impact viewshed appeal for some. This reflects an indirect use of seascape and reflects social uses beyond the scope of assessment.	1
Rateability	Recognized impacts of aquaculture on viewshed; although little empirical evidence is available to generate classification levels.	1
Scoring clarity	Viewshed analysis is a complex metric; and classification would require substantial explanation.	1
Scale validity	Parameter may be more suited to higher resolution bay or site level assessments, with local processes to identify key viewpoints in a specific area.	1
Coastal coverage	If collected, data could be available across the entire area of analysis.	3
Data accessibility	The layer generation would require additional resources but could be accomplished within the project timeline.	2
Measurement reliability	Can be measured through well-established methods of viewshed analysis, although there is some uncertainty associated.	2
Redundancy to other criteria	Data is largely independent of other types of data.	3

Noise footprint

Rationale for consideration: Aquaculture should minimize their noise footprint as to not to disrupt other marine users.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Noise footprint is best evaluated on a local scale and reflects more social conflicts which are beyond the scope of assessment.	1
Rateability	Recognition of the noise created through aquaculture operations, although little empirical evidence is available to generate classification levels, as much of the noise footprint is highly operation specific.	1
Scoring clarity	Interpreting data does not require expert knowledge but would require some explanation and clarification.	2
Scale validity	More appropriate for local site selection, highly dependent on gear, size of farms, etc.	N/A
Coastal coverage	No spatial datasets currently exist.	N/A
Data accessibility	Spatial data is non-existent and difficult to estimate at a regional scale.	1
Measurement reliability	Methods for calculating noise footprint exist, although challenging at this scale due to local farm-specific production specifics.	1
Redundancy to other criteria	Criterion has correlations with other proximity to land sources (coastal use areas, etc.).	2

Dredging Areas

Rationale for consideration: Aquaculture cannot be located above regularly dredged areas due to potential disturbances caused by dredging activities.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Regular dredging areas are considered unideal for aquaculture since the lease would obstruct regular maintenance, dredging barges, and high siltation rates of the environment.	3
Rateability	Aquaculture can not occur in areas regularly dredged. Recognition as a constraint means the classification is straightforward.	3
Scoring clarity	Data does not involve complex analysis and can be communicated to various end-users.	3
Scale validity	Dataset available at appropriate spatial resolution.	3
Coastal coverage	Private or irregular dredging may not be well documented, compared to regular dredging locations.	1
Data accessibility	Some data is available publicly, while others are held privately. Up to date information on currently dredged areas that have not been mapped is currently under development.	N/A
Measurement reliability	Measurement accuracy is relatively good for reported/designated dredging areas.	2
Redundancy to other criteria	Data is largely independent of other types of data.	3

Derelict Vessels and Shipwrecks

Rationale for consideration: Aquaculture cannot be located above submerged vessels due to safety hazards and to preserve potentially culturally important sites.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Several derelict vessels and shipwrecks exist along the Nova Scotia coast, especially in shallow waters. Obstruction in the marine environment can pose safety issues when operating around aquaculture leases. These vessels can be removed, usually with some monetary cost.	3
Rateability	Recognition as a constraint means the classification is straightforward as aquaculture is not permitted over derelict vessels and shipwrecks to ensure the historical preservation of the vessel and reduce interaction with aquaculture infrastructure.	3
Scoring clarity	Interpreting data does not require expert knowledge but would require some explanation and clarification.	3
Scale validity	Most appropriately identified during local site selection, with consultation with local communities.	N/A
Coastal coverage	Minimal data is available from Coast Guard Canada; however, it likely incomplete for the whole coastline (NS).	1
Data accessibility	Locational data is largely held privately and not appropriate for public use.	N/A
Measurement reliability	Reporting of locations may be unreliable and not appropriate for public use.	N/A
Redundancy to other criteria	Data is largely independent of other types of data but could overlap with archeological sites.	2

Archeological sites

Rationale for consideration: Aquaculture should minimally impact marine sites with cultural and archeological importance, which are also protected legally.
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Known archaeological areas are protected under the Special Places Protection Act. Aquaculture should not occur in an archeological protected area. However, many archeological sites are not identified, and appropriately accounting for these areas would require local-scale assessments more appropriate for a site-level.	3
Rateability	Recognition as a constraint means the classification is straightforward. Consideration of buffers would be required.	2
Scoring clarity	Interpreting data does not require expert knowledge but would require some explanation and clarification.	3
Scale validity	To effectively incorporate, criteria is best considered and incorporated during local site selection processes, and with consultation with local communities.	N/A
Coastal coverage	Data on known sites is not publicly available. The location of unknown sites has not been mapped.	N/A
Data accessibility	The Nova Scotia Department of Communities, Culture, Tourism, and Heritage maintain records of known sites. Location data can be considered sensitive in nature.	N/A
Measurement reliability	Site mapping is not appropriate for wide public distribution due to sensitivity of data.	1
Redundancy to other criteria	Data is largely independent of other types of data but could overlap with shipwrecks.	2

Oil and Gas Structures

Rationale for consideration: Aquaculture cannot be located within existing oil and gas structures (spatial constraint).
Final decision: Exclude
Average score: Not Applicable (DOES NOT MEET MINIMUM REQUIREMENTS)

Property	Description	Score
Relevance to scope	Marine oil and gas exploration exists in several areas across Nova Scotian's Scotian Shelf.	3
Rateability	Aquaculture would be constrained in these areas. Recognition as a constraint means the classification is straightforward. Some conversations with network partners are necessary to determine the required buffer.	2
Scoring clarity	Interpreting data does not require expert knowledge but would require some explanation and clarification.	3
Scale validity	Dataset available at appropriate spatial resolution.	3
Coastal coverage	No structures exist within the boundary of the area of analysis (all beyond 3 km offshore).	N/A
Data accessibility	The location of active Production Licences administered by the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB), as well as the surface locations for all wells drilled are available through CNSOPB.	2
Measurement reliability	Analysis is straight forward and requires only potential buffers applied to features.	3
Redundancy to other criteria	Data is largely independent of other types of data.	3

Coastal Classification Data Committee Membership

Biophysical Data Committee

Name	Role	Affiliation
Ramon Filgueira	Professor (Marine Affairs – Aquaculture)	Dalhousie University
Peter Kraska	Coastal Ecosystem Science Division Data Manager	Fisheries and Oceans Canada
Amanda Swim	Aquatic Animal Health Veterinarian - Manager	Nova Scotia Department of Fisheries and Aquaculture
Anthony Snyder	Aquatic Animal Health Veterinarian - Aquaculture Division	Nova Scotia Department of Fisheries and Aquaculture
Stephanie Hall	Aquatic Animal Health Program Specialist	Nova Scotia Department of Fisheries and Aquaculture
Melinda Watts	Aquaculture Development Advisor	Nova Scotia Department of Fisheries and Aquaculture
Anne Aubin	Seafood Industry Advisor	BC Ministry of Agriculture, Food and Fisheries

Ocean Use Data Committee

Name	Role	Affiliation
Kasia Rozalska	Spatial Planner - Marine Planning and Conservation	Fisheries and Oceans Canada (Maritimes Region)
Scott Coffen-Smout	Oceans Management Biologist - Marine Planning and Conservation	Fisheries and Oceans Canada (Maritimes Region)
Mark Flaherty	Professor (Geography – Aquaculture)	University of Victoria
Matthew King	Aquaculture Planning & GIS Officer	Nova Scotia Department of Fisheries and Aquaculture
Michael Devanney	Policy Analyst	ACOA-APECA; Agriculture and Agri-food Canada

Wild Salmon Data Committee

Name	Role	Affiliation
Kurt Samways	Parks Canada Research Chair in aquatic restoration	University of New Brunswick
Jason LeBlanc	Fisheries Biologist, Inland Fisheries Division	Nova Scotia Department of Fisheries and Aquaculture
Sarah Tuziak	Atlantic Salmon Coordinator	Fisheries and Oceans Canada
David Hardie	Aquatic Biologist	Fisheries and Oceans Canada
Nathaniel Feindel	Manager, Aquaculture Development	Nova Scotia Department of Fisheries and Aquaculture

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CENTRE FOR MARINE APPLIED RESEARCH

2024-Final.V1

Summary of feedback and response to working drafts of Report of Recommendations on Criteria for Consideration

May 10, 2024

Prepared by:

Jenny Weitzman
Therese Wilson
James Cunningham
Laila Nargis
Leah Lewis-McCrea
Gregor Reid

27 Parker Street · Dartmouth, Nova Scotia · B2Y 4T5

CMAR.CA

Compiled feedback from draft report

This feedback document contains summarized key points for revision, as recommended from review of the draft version of the report titled: "Recommendations on the Criteria for Inclusion" (hereafter referenced as 'the report') , as well as supporting appendices in March 2024 by the Coastal Classification System (CCS) Data Committees (Ocean Use, Biophysical, and Wild Salmon) as well as the Technical Oversight Committee. Feedback was gathered from written and e-mail submissions, and through discussions held at Committee meetings in March 2024. Names of individuals making specific recommendations are withheld. Small typographical errors identified by reviewers are not highlighted in this document but were all addressed appropriately. CMAR's response to provided feedback is provided below each point, in italics.

General report comments

- Highlighting the importance of the CCS being a living tool is important here, to highlight potential alterations that can happen with changes in technology, state of data, etc…

  A paragraph was added to the beginning of the document within the Criteria Selection process to highlight that criteria selection represents present-day considerations, and identifying the need for adaptation and re-consideration of criteria if suitability assessments are re-evaluated. This is also reiterated within the report at various places (for example, defining the Accessibility property and the report's Conclusions).

- Additional detail on the data sources for each parameter should be provided, including greater detail on how datasets created 'in-house' were derived.

  This report is designed to present decisions around whether to include or exclude criteria. At present, feedback on how criteria will be considered within the analysis or how they will be derived is not being solicited. This is an important point, which was emphasized through the addition of a couple sentences within the Introduction.

  The example data sources presented in Table 2 was intended to be for information purposes only to highlight the availability of datasets. To reduce confusion and improve consistency across the document, the column where example data sources were provided was removed from the report and specific datasets or sources of data were identified and described more within the relevant appendices.

- Reference to "smaller-scale" can be confusing. More appropriate terminology could be "fine-scale resolution" or "site-specific" is recommended.

  Where appropriate, reference to "smaller-scale" was replaced with recommended

terminology throughout the documents. Additionally, reflecting on the need to clarify the distinction between regional-level analysis adopted here, and the alternative site-level analysis (which were further clarified within the document), some references were changed to "site-level scale".

- Inconsistency in naming convention of parameters, whereby some appear more as 'data layers' and others as 'factors' (e.g., Turbidity vs. Risk of superchill). It is not always clear how things will be assessed given inconsistency. There is still some consideration over use of 'proximity' or other similar metrics (e.g., 'likelihood' vs. 'risk') which has not yet been decided.

  Acknowledging that the goal of this report is to provide information to make decisions around what criteria get considered, not how (i.e., the datasets involved or the analysis performed), language was simplified to better reflect this consideration.

  Since decisions around how criteria will be assessed for suitability is still being discussed, parameters were re-named to only note the consideration being factored in. These discussions will be further advanced as the project progresses and detailed in future reports, which was clarified in the Introduction (see response above). Parameters were re-named as necessary to rather reflect the 'consideration' or 'factor' rather than the specific data layer (for example: Likelihood of aquatic invasive species → Aquatic invasive species).

Criteria proposed for inclusion

Water Temperature

- Need for qualifiers for some of the temperature thresholds and impacts on fish health and welfare (see AAH specific comments for more information).

  Detailed comments were addressed as suggested and reworded appropriately.

Water depth

- Water depth is not always correlated with flow in several instances.

  To clarify, this paragraph was re-framed and adjusted to better highlight this potential variability.

- For shellfish aquaculture, risks due to water depth are often also linked to the presence of ice to prevent crushing of animals.

  A sentence was added to this section to add this consideration and the appendix was also adjusted to add this consideration.

Exposure

- Suggested for rewording since sea ice develops only across parts of Nova Scotia (not 'most') – within body and appendices

  This sentence was adjusted to replace 'most' with 'parts' in both the main document and appendices

Water quality

- **Shellfish Classification Areas**
  - Consider mention of practices such as 'relay' or 'depuration', and how areas are classified

    A sentence was added to explicitly bring in the classification of areas into suitability consideration, as well as the operational implications of the classification areas. Mention of specific mitigation practices was considered but not incorporated in this section as it would require more technical explanation and knowledge to effectively communicate.

- **Proximity to sources of riverine input**
  - Discussion among committee members led to suggestion that this parameter not to be included. Areas close to rivers can often be highly productive areas for oyster culture. In addition, while this parameter could be related to salinity, it is a coarse indicator, where salinity is not always directly related to river inputs.

    This parameter was re-evaluated and a decision was made to exclude. Evaluation within appendices was changed to reflect discussions.

- **MSX likelihood**
  - Consideration for inclusion questioned based on decision to exclude considerations for pests/pathogen/disease for finfish (i.e., consistency).

    In ongoing discussions with the Data Committees and experts, the decision to exclude disease transfer considerations for finfish (through the proximity to other aquaculture sites) was primarily based on the consideration that for finfish species, disease transmission risks were better evaluated at the site-level. If regional-level data for disease risk or transmission for finfish becomes available in the future, this should be considered in future iterations of this assessment. While

the appropriateness of disease risks at the site-level also applies to shellfish, where MSX has significant mortality/health implications for the oyster aquaculture industry, the consideration for MSX consists a substantial consideration that can be evaluated at the regional-level, where presence can create substantial limits to where aquaculture is suitable for development. Therefore, MSX presence was proposed as a criterion since it met the criteria evaluation properties, has substantial health and welfare implications for oysters, and a considerable siting considerations.

- **Likelihood of aquatic invasive species (AIS)**
    - Discussion around relevance for inclusion at this level of analysis, since it does not always limit siting, and presence does not always create issues, where issues created are highly variable depending on type of AIS and their intensity in specific areas

      This comment was very reasonable and reflected ongoing conversations about clarifying the relevance of criteria for consideration and the overall scope/goals of the assessment. The first draft highlighted the focus on limiting factors, however, it is more appropriate to say that the criteria considers both factors that would limit siting, but also key factors that the industry would need to consider in placing or planning their aquaculture operations. Effectively, it is key factors that would have conditions that aquaculture operators might use to consider an area, or might have to address, manage, or mitigate. This scope was clarified under the Relevance criteria selection property.

      In response to the inclusion of AIS, the local-scale variability was considered, and reflected in an adjusted evaluation for Scale property, which was reduced from a "Exceptional – 3" to "Adequate – 2". This reflects an addition of the consideration that understanding and considering the full risks and impacts from AIS is best evaluated at the local site level given these variabilities. However, this consideration for scale was still considered adequate since there are datasets available that could be relevant and appropriate for the regional-level, meeting the scale requirement for inclusion.

Proximity to wild salmon rivers

- Use of 'wild salmon rivers' implies the need to define what we are meaning by what is a 'wild' salmon and what is a 'wild salmon river'.

The definition of what a 'wild' salmon and a 'wild salmon river' reflects a consideration of how the criteria will be assessed, which will be further explored and described in subsequent project documentation. This is being actively discussed among the project team and Wild Salmon Data Committee and will be resolved and detailed during the analysis stage. The use of the terms 'wild salmon' is referenced to align with the wording used within the province's Aquaculture Licensing and Lease regulations.

- Is coverage of data accurate, given recognized knowledge and data gaps for many salmon populations across Nova Scotia?

  Recognizing the lack of information provided on the sources of data for this parameter (as well as many others), efforts were made to adjust appendices to provide more information to identify the source of data (or how data will be compiled). In this case, this parameter is a product of research that was developed to meet this project needs. This was clarified within the appendices.

Proximity to important coastal habitats

- **Critical habitat for species at risk – Mud Piddock**
  - Specification of Mud Piddock, while appropriate to the current state of this dataset, does not account for potential future additions of other species or areas. Consideration to expanding the scope of this parameter to also include both SARA-listed and COSEWIC-listed populations, thorough "Proximity to critical habitat and/or relevant at-risk species populations"

    Name of parameter was changed to "Critical habitat for species at-risk" as suggested to be broader and more encompassing. Additional detail on dataset were added to the appendix.

Navigation

- Clarity needed on how suggested parameters are measured, including source of data and how data were derived.

  See response to general comments. Additional information about the data sources of proposed parameters to be described further in appendices. To note, given the shift in renaming of parameters to reflect broader consideration/ factor, the two navigation parameters previously proposed (i.e., 'Major navigation channels' and 'Minor navigation channels') were replaced with a single sub-criteria (parameter) and re-named to 'Vessel traffic' to more accurately reflect the factor being considered.

Recreation and Tourism

- As currently framed, description of criteria presumes a negative interaction with recreation/tourism which may not always be the case. Do we have predictable information on how aquaculture interacts with tourism/recreation?

  This point was considerably acknowledged, particularly in reflection of the inclusion of recreation and tourism overlap considerations being primarily proposed through public coastal access, which we are proposed as an indicator of potential use of marine space for recreational and tourism users. To better reflect proposed parameters, we renamed the criteria "Recreation and Tourism" to "Coastal access". The associated text describing the criterion was re-written to better reflect only the coastal accessibility considerations, while maintaining the importance of tourism and recreational users within the body.

Allocated use areas

- **Marine Protected Areas**
  - Consideration for other area-based protected areas needed (e.g., marine refuges).

    To clarify, the parameter was more consistently renamed "Marine protected and conserved areas" which is consistent with the DFO naming convention of the source data layer of "Canada's marine protected and conserved areas". Clarification on inclusion of datasets that are considered within this parameter was added to the appendices, to highlight that this includes both MPAs and refuges.

Other criteria to consider

- Suggest including a parameter for existing known Indigenous fisheries, as it could be possible that areas that are suitable for proposed aquaculture sites may conflict with existing Indigenous fisheries (i.e. FSC and commercial communal).

  This parameter was included and evaluated through the criteria evaluation process. It did not meet the minimum requirements for inclusion and was thus added to the list of excluded criteria (and added to Table 2). Rationale for exclusion was added to the appendices, and based primarily on Accessibility and Scale parameters, which both were considered not appropriate. Similar to archeological sites, the delineation of locations can be considered sensitive in nature, and the proper assessment of suitability is one that is most appropriately, and essentially completed through consultations with local communities and Indigenous Peoples, at the site-level.

- Limited consideration for future-state considerations (for example, climate change vulnerabilities) in assessed criteria.

  The consideration for future-state conditions of the assessment was acknowledged by clarifying the goals and scope of the assessment, which is based on present-day conditions (added to Introduction, see other response to feedback). Specific reference to climate change was also added to highlight the need for future iterations to re-consider the criteria included. It was also added as an example to the Relevance parameter section to identify objectives and considerations beyond the scope of analysis (alongside socio-economic benefits of the industry and social acceptability considerations), but which require more complex or focused analysis.

Criteria proposed for exclusion

Eelgrass habitat

- Clarification required on data layers being assessed through criteria (predictive modelling or presence/absence). Re-consideration of assessment of spatial coverage property depending on data considered.

  Clarification of datasets used to evaluate criteria were added to appendices. In consideration of information, assessment score for "Spatial Coverage" of parameter was adjusted from N/A to 1 (Poor). Table 2 in the repot was adjusted to reflect more appropriate reason for exclusion being limitation of time and resources to address significant spatial gaps.

Commercial fishing data

- Given economic importance of fisheries in Nova Scotia, the limitations of resolution should be emphasized to justify exclusion.

  A sentence was added within the main body of the report of section 4 – criteria excluded to highlight the commercial catch data and emphasize the resolution limitations.

- Potential use of AIS and VMS data to capture important fishing activity should be noted

  The description of the Navigation criteria was revised, and a couple sentences added to highlight the types of vessel traffic considered. This included explicit note of traffic routes

for fishing activity. In addition, the appendix for this criterion was adjusted to provide additional details, and to note the link with fishing activity (see Relevance entry).

Carrying Capacity

- Given the complexity of carrying capacity as a model that combines multiple parameters already considered in this evaluation, removal of carrying capacity is justified.

  This parameter was removed as suggested, as it reflects an inconsistency in how parameters are defined and evaluated.

Primary productivity

- For shellfish, primary productivity is a key parameter for identifying optimal growth areas. It is separate than chlorophyll so should be added as a parameter for exclusion, since it is highly complex with considerable spatial variability that it is more appropriate for bay- or site-scale assessments

  Primary productivity was added to the evaluation and assessed through the criteria evaluation process. It did not meet minimum requirements, and thus was added to the list of excluded criteria (and see Table 2).

NOVA SCOTIA AQUACULTURE SCIENCE ADVISORY COMMITTEE
SCIENCE ADVICE

REQUEST ID#: NSASAC-2024-01

Title of Request:
Review and Validation of the Recommendations on the Criteria for Inclusion for the Regional Assessment of Aquaculture Development in Nova Scotia

SCIENCE ADVICE

Issue Requiring Science Advice (to be posed as a question):
Does the Committee feel that the process used for selecting the criteria is appropriate, and that the recommended list of criteria for inclusion is accurate and complete?

Summary of Committee Review:
The Nova Scotia Aquaculture Science Advisory Committee has reviewed the report titled, *Recommendations on the Criteria for Inclusion: A Report in Support of Regional Suitability Assessment of Coastal Aquaculture in Nova Scotia*, dated July 22, 2024, and supporting documentation presented in the corresponding Request for Science Advice. The Committee met on September 12, 2024, to discuss the information in the report and deliver science advice on the question described above. During the Nova Scotia Aquaculture Science Advisory Committee meeting, members discussed major and minor comments pertaining to the request. Major comments included the request for clarification on broader questions. Minor comments included grammatical corrections or smaller revisions for consistency and/or clarity. The Committee sought clarification on the reasoning for certain criteria not being considered in the assessments, particularly instances where reliable data was apparently available. The Committee noted that according to the report, important considerations for proper aquaculture siting (such as water resonance time, disease transfer, substrate type, and eelgrass habitat) will be excluded from the assessment and final product. Centre for Marine Applied Research (CMAR) and the Department of Fisheries and Aquaculture (the Department) provided clarification on the nature, scale, and objectives of the preliminary, suitability screening assessments. It was explained that there is pertinent information that would not be included in these high-level, large-scale assessments because this information is more appropriately considered during smaller-scale (bay level or site level)

assessments. These smaller scale assessments use higher resolution data to properly accommodate the variability of some considerations that cannot be appropriately captured in a lower resolution assessment. Additionally, data are not available for the entire assessment area (i.e., all of Nova Scotia's near-shore coastal waters, up to three kilometres from shore and the major jaws of land). The objective of these screening assessments is to identify general areas where opportunities could exist for future aquaculture development. Additional data to support an aquaculture application will still need to be gathered at the site-level and assessed by the Department and Network Agencies during the application process.

The Department provided background on the project, describing that the process is being approached as a continuum that will start broadly and include suitability screening assessments. The scope of the project needs to be attainable and can be expanded upon in future. Based on the research and work done to date on the project, CMAR recommended focusing on the criteria that can be delivered within the specified timeframe where confidence in the data is high. The process used to evaluate the considered criteria identified issues with some of the available relevant datasets. CMAR discussed concerns with inconsistency in data collection and gaps in coverage.

CMAR also explained to the Committee how some of the criteria not included in this project will be covered in other projects. For example, the FINS (Farming in Natural Systems) project, an Atlantic Fisheries Fund project led by CMAR to develop an aquaculture ecological carrying capacity modelling platform for selected bays in Nova Scotia. FINS will incorporate multiple published carrying capacity models, including organic deposition and sulfide production, dissolved nutrients, disease transfer risk, and phytoplankton (bivalve culture).

The Committee sought clarification on why the Department was doing this coastal regional scale analysis. The Department noted that looking at the province level sets a solid foundation for future work, with the results of these screening assessments being used to guide and inform the selection of smaller areas for more detailed assessments. It was also noted that local engagement and Consultation is absent at the regional level and recognized that more data are required to support an operation and application at the site-level. It was acknowledged that communication will be especially important to manage expectations with this project as the regulatory program will not change. The developed mapping tool will be a reference or information tool only.

The Committee also requested clarification on how this high-level product will be developed and used (for example, would there be one suitability score for an entire bay?). CMAR clarified that the spatial suitability analysis involves splitting the area of analysis into smaller, equal sized cells, and that the cell size (resolution) for this assessment will be approximately 200m x 200m. The final size of the cells will be based on the resolution of the datasets used for the spatial suitability analysis. On the final suitability maps, each cell will be given a different color (rating) based on the final suitability score for that cell.

The Committee requested clarification on whether assessments are being conducted for each of the four species separately (e.g., salmon, trout, mussels, oysters). CMAR confirmed that that four separate suitability maps would be published, one for each species assessed, and that details regarding how the information was integrated for each species would be elaborated upon in the next Request for Science Advice to the Committee.

The Committee also noted concerns with the statement that socio-economic considerations would not be included in the preliminary suitability assessments. Revision is required to provide clarity on the types of socio-economic factors that are excluded (like cultural and societal values and preferences), as well as clarity on when and how the excluded considerations will be reviewed and evaluated.

Clarification was also provided on the *Methods Review for Spatial Suitability Analysis in the Context of the Coastal Classification System (CCS)* report which was provided as supporting documentation. This report was started early in the process and is an overview of the options available for completing each phase of the process (e.g., standardization, scoring, weighting, and aggregation). Interim reports that will be submitted to the Committee will outline in detail the methodology used for scoring, weighting, and aggregation.

The Committee asked how often the data will be revisited and updated. CMAR explained that the analysis and the tool will be static in nature. It was indicated that the final technical report produced by CMAR will include recommendations on the frequency of updates to keep the coastal mapping tool relevant.

Advice of Committee:

Based on the review of the report and supporting documentation, discussions with Committee members, and clarification provided by CMAR and the Department, the Committee concluded that the report is well-written, comprehensive and presents a thorough and well-considered analysis to support this ambitious project. The Committee is satisfied with the scientific work completed by the Department and CMAR for this project and agrees that the criteria selected for inclusion are appropriate for the objectives, nature, and scale of the suitability screening assessments. It was also concluded that the reasons to exclude criteria are well-considered and legitimate.

Based on the question posed, the consensus of the Committee is that the process used for selecting the criteria for inclusion in the regional suitability assessment for aquaculture in Nova Scotia is appropriate, and the recommended list of criteria for inclusion is accurate and complete. There were no major concerns raised by Committee members regarding the process used for selecting the criteria, or the list of recommended criteria for inclusion as presented.

This conclusion is based on the following:

- The suitability screening assessments are the first step of a multi-step process. The developed coastal mapping tool will be dynamic and can be built upon as new, relevant data becomes available.
- The suitability screening assessments will include *some* of the constraints and thresholds that would impact future aquaculture development, helping to identify unsuitable or less suitable areas. This will result in the identification of general areas where opportunities could potentially exist for future aquaculture development. The assessment is not looking at optimal conditions.
- There are many important considerations that will not be included in these preliminary screening assessments. Therefore, it is not a definitive decision for what is "suitable".
- Results of these assessments will be used to guide and inform the additional scientific analysis, public engagement, and First Nations Consultation required to confirm if a selected site is suitable for the proposed aquaculture activities.
- Use of regulatory controls will continue to be used for farm-based decisions. To obtain a lease and license, additional work will be required – including more targeted assessments that incorporate the relevant environmental, social, cultural, and economic factors that were excluded from the screening assessments.

The Committee recommends that the coastal classification tool be updated on a regular basis with new or improved data to support the accuracy and usefulness of the tool. New datasets may become available that would improve measurement reliability of some of the excluded criteria. Additionally, the Committee recommends that context around the potential impacts of climate change on this tool be included in the report. It is expected that most of the criteria would not be impacted due to climate change (e.g., navigation routes), but some criteria (e.g., water temperature) would be affected. The tool should be updated on a regular basis and incorporate a well-tuned oceanographic monitoring program that measures changes and models that can feed into the tool.

The Committee recommends the commitment of continued funding for this project to ensure it can be updated in the future and continues to be a valuable tool. Additionally, the Committee notes that communications for this project will be particularly important to ensure the public and users have confidence in the final product.

The Committee ***advises*** the Department to address overarching concerns by ensuring that project objectives and existing regulatory processes are clearly communicated including the following:

- Provide more information on the purpose of the coastal mapping tool and its intended uses.
- Draw a clear link between large-scale provincial assessment and site level assessments.
- Promote awareness of how regulated processes cover the excluded information.

The Committee ***advises*** that future public-facing documents provide clarification on the following as identified through review of the report on *Recommended Criteria for Inclusion*:

- The impacts that the nature, scale, and objectives of the assessment have on the criteria selection should be made clear upfront, as well as confirmation of the requirement to continue to use the regulated processes to capture the excluded information.
- In relation to Section 1.1. (Scope of Assessment), provide clarification on what types of socio-economic factors are excluded to highlight that these are specific to cultural and societal values and preferences.
- In relation to Section 2.1.4 (Scale Validity), provide clarification on spatial resolution and how it will be consistent for each cell.
- In relation to Section 2.1.5 (Coastal Coverage), include more information regarding gaps in the coverage of suitability and how often this is expected to occur.
- In relation to Section 3 (Proposed Criteria for Inclusion), include more information / context on why these criteria have been recommended for inclusion.
- In relation to Section 4 (Criteria Excluded from the Assessment), add further clarification as to the reason that sub-criteria have been excluded from suitability analysis. It was noted that the most common reason for criteria exclusion is that it is more relevant for bay or site-level assessments.
- In relation to Tables 2 and 3, summary tables should provide further explanation and/or justification as described below:
    - Link scores to help identify reason(s) why criteria are not included.
    - Emphasize that exclusion of a criteria does not mean it is not important for consideration in aquaculture. The metric may not be relevant at this scale. For example, salinity almost always falls within the range that could support aquaculture but may not be optimal. Smaller-scale, more targeted assessments would aim to identify optimal conditions.
    - Emphasize that the included parameters are not the only important consideration for the proposed criteria (e.g., water quality considerations for oysters includes more than MSX exposure and shellfish harvest classification).

The Committee also identified minor edits to the *Methods Review for Spatial Suitability Analysis in the Context of Coastal Classification* supporting report, including minor grammatical corrections (provided to the Department) and a need to update the glossary.

APPROVAL

Approval Date	Name of Chair of Committee	Submission Date
October 16, 2024	Dr. Stefanie Colombo	October 17, 2024