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FEASIBILITY OF MANAGEMENT STRATEGY EVALUATION OF NORTHERN AND SOUTHERN BLUE SHARK IN ICCAT WATERS

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SUMMARY

This report evaluates the feasibility, cost, and timeline of conducting Management Strategy Evaluation (MSE) processes for the northern and southern Atlantic blue shark (BSH) stocks, following ICCAT Recommendations 23-10 and 23-11. The study builds on the 2023 stock assessment and prior simulation work, proposing a shared modeling framework using stock-specific operating models and management procedures (MPs). Two implementation options are examined: a two-year process with MP adoption by 2027, and a three-year process with adoption by 2028. Projected contracting costs range from €120,000- €210,000, depending on the timeline. Risks are categorized into technical, institutional, and financial domains, with particular emphasis on the consequences of delayed funding and data obsolescence. Conducting the work primarily within the SCRS - building on the western skipjack model - would strengthen institutional capacity and reduce costs. The report concludes that MSE development for both BSH stocks is technically feasible, cost-effective, and consistent with ICCAT's existing MSE framework, provided timely support, scientific coordination, and funding are secured. Early initiation is strongly recommended to avoid reconditioning and safeguard the utility of the 2023 assessment.

RÉSUMÉ

Le présent rapport évalue la faisabilité, les coûts et le calendrier de mise en œuvre des processus d'évaluation de la stratégie de gestion (MSE) pour les stocks de requin peau bleue (BSH) de l'Atlantique Nord et Sud, conformément aux Recommandations 23-10 et 23-11 de l'ICCAT. L'étude s'appuie sur l'évaluation des stocks de 2023 et sur des travaux de simulation antérieurs, et propose une plateforme de modélisation commune avec des modèles opérationnels et des procédures de gestion (MP) spécifiques à chaque stock. Deux options de mise en œuvre sont envisagées : un processus de deux ans avec adoption des MP en 2027, ou un processus de trois ans avec adoption en 2028. Les coûts de contractualisation sont estimés entre 120.000 et 210 000 €, selon l'option retenue. Les risques sont classés en catégories techniques, institutionnelles et financières, avec une attention particulière portée aux retards de financement et à la péremption des données. Une mise en œuvre principalement assurée par le SCRS—sur le modèle du listao occidental—renforcerait les capacités institutionnelles et réduirait les coûts. Le rapport conclut que le développement de la MSE pour les deux stocks de BSH est techniquement faisable, rentable et conforme au cadre existant de la MSE de l'ICCAT, à condition que le soutien, la coordination scientifique et le financement soient assurés en temps opportun. Un démarrage dès que possible est fortement recommandé pour éviter un reconditionnement et préserver la valeur de l'évaluation de 2023.

RESUMEN

Este informe evalúa la viabilidad, los costos y el cronograma para realizar la evaluaciones de estrategias de ordenación (MSE) para los stocks de marrajo dientuso (BSH) del Atlántico norte y sur, de acuerdo con las Recomendaciones 23-10 y23-11 de ICCAT. El estudio se basa en la evaluación de stocks de 2023 y en trabajos de simulación previos, proponiendo un marco de modelado compartido con modelos operativos y procedimientos de ordenación (MP) específicos para cada stock. Se analizan dos opciones: un proceso de dos años con adopción de MP en 2027, y otro de tres años con adopción desde ahora gasta 2028. Los costos proyectados de contratación oscilan entre 120.000 € y 210.000 €, según el cronograma. Los riesgos se agrupan

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en categorías técnicas, institucionales y financieras, con énfasis en los efectos del retraso en la financiación y la obsolescencia de datos. Llevar a cabo el trabajo principalmente dentro del SCRS - basándose en el modelo del listado occidental - reforzaría la capacidad institucional y reduciría los costes. El informe concluye que el desarrollo de MSE para ambos stocks de BSH es técnicamente viable, eficaz a nivel de costes y coherente con el marco existente de MSE de ICCAT, siempre que se garantice el apoyo oportuno, la coordinación científica y la financiación. Se recomienda encarecidamente un inicio temprano para evitar el reacondicionamiento y salvaguardar la utilidad de la evaluación de 2023.

KEYWORDS

Fisheries management; Management strategy evaluation; Shark fisheries; Blue shark; Fish stock assessment; Population dynamics; Harvest strategies; Management Procedures; Fishery models; North Atlantic Ocean; South Atlantic Ocean.

1. Introduction

1.1 Statement on mandate for feasibility study

ICCAT recommendations 23-10 and 23-11 request that the Standing Committee on Research and Statistics (SCRS) inform the Commission by 2025 on the feasibility, costs, options, and tentative roadmap for developing a Management Strategy Evaluation (MSE) framework for northern and southern blue shark stocks. This includes, inter alia, a Harvest Control Rule (HCR) with associated limit, target, and threshold reference points. PA4_823/2024 also proposes 2027 or 2028 adoption timelines. These recommendations define the core elements that this report is intended to address.

Table A1, in **Appendix 1** lists the acronyms used in this document.

1.2 Scope

To assess the feasibility of Management Strategy Evaluation (MSE) for blue shark, requires a clear definition of activities that fall within its scope. While this paper follows the ICCAT Glossary of MSE terms, a broader and more practical definition is required for feasibility planning. This expanded definition reflects not only technical simulations but also the institutional and participatory processes that are essential to ICCAT's decision-making.

According to the ICCAT Glossary, MSE is "a process whereby the performances of alternative harvest strategies are tested and compared using stochastic simulations of stock and fishery dynamics against a set of performance statistics." While accurate in a technical sense, this definition omits important procedural elements that influence both timelines and resource needs. In practice, ICCAT's MSEs have included extensive dialogue between scientists, managers, and stakeholders. These interactions help define management objectives, evaluate Candidate Management Procedures (CMPs), and finalize Management Procedures (MPs). Their role is as central as the scientific simulations themselves. But these procedural elements also impose costs. Therefore, this feasibility study adopts an operational definition of MSE that incorporates both technical modeling and participatory engagement.

For clarity, the term "closed-loop simulation" in this report refers specifically to the stochastic modeling component. This includes defining uncertainties, building operating models (OMs), generating performance statistics, and testing CMPs. While essential, modeling represents only one part of the broader MSE process, which also encompasses institutional decision-making and stakeholder communication.

Activities that occur after the adoption of an MP—such as exceptional circumstances protocols or so-called health checks—are outside the scope of this feasibility analysis. While important for long-term implementation, they are not considered here. By focusing on activities leading up to initial MP adoption, this report aligns with the timeline requested by the Commission and supports a realistic evaluation of feasibility through 2027–2028.

2. Overview of MSE investment at ICCAT

With this operational definition of MSE established, we now turn to ICCAT's historical experiences to draw relevant insights for blue shark feasibility. ICCAT has implemented five MSE processes to date, with three resulting in MP adoption. These are: northern albacore (N-ALB), Atlantic Bluefin tuna (ABFT), northern swordfish (N-SWO). Two efforts are ongoing with MP adoption dates within the next 18 months: western skipjack (W-SKJ), and the multi-stock tropical tuna MSE (M-TRO). These experiences provide context for understanding the potential scope, duration, costs, and challenges of developing an MSE process for blue shark within ICCAT.

2.1 Timeline to completion

For the purpose of this feasibility assessment, we define the starting point of an MSE as the initiation of operating model (OM) development suitable for closed-loop simulation. This represents a clear shift from previous stock assessment work to MSE-specific modeling. Unlike standard assessments, OMs are explicitly designed to simulate future data, explore structural uncertainties, and integrate with simulation frameworks. Although scientific groundwork and Commission guidance may precede this step, we consider MSE work to formally begin when these specialized models are under development.

The endpoint is defined as the initial adoption of a Management Procedure (MP). Post-adoption tasks—such as developing Exceptional Circumstances Protocols or updating OMs for future MP reviews—are essential for long-term implementation but fall outside the scope of this analysis. By setting these boundaries, we focus the feasibility assessment on the core development phase: building OMs, evaluating CMPs, and preparing for MP adoption.

This framing allows for a consistent comparison of development timelines across ICCAT's existing MSEs. **Table 1** summarizes the duration of completed and ongoing MSE processes based on the start and end points defined above, following García *et al.* (2025).

2.2 Budget of previous MSE processes

Alongside time investments, financial costs are key considerations for assessing MSE feasibility. Here we characterize financial costs in MSE in terms of contract spending. There are substantial in-kind contributions in the form of meeting hours, data collection, preparation, and analysis by the ICCAT Secretariat and Contracting Party and Cooperating non-Contracting Parties (CPC) scientists. For a complete treatment, these in-kind contributions merit analysis. But lacking in-kind contribution data, we must confine our presentation of costs only in terms of contract expenditures for MSE development (which may include CPC scientists). For all MSE processes to date, ICCAT has paid for contractors to assist or complete the closed-loop simulations and to assist CPC scientists in developing CMPs. As such, the cost estimates presented here reflect only the contracted expenditures, providing a conservative baseline of the financial investment required. **Table 2** summarizes contracting expenditures by stock and year.

2.3 Historical review of MSE processes at ICCAT

Tables 1 and **2** quantify ICCAT's investment in MSEs, qualitative comparisons help explain the variation in time, cost, and complexity across past efforts. These differences stem from both technical factors (e.g., stock structure, assessment models) and institutional learning curves.

ICCAT's first MSEs - for northern albacore (N-ALB), Atlantic bluefin tuna (ABFT), and northern swordfish (N-SWO) - were foundational. They required concurrent development of technical frameworks (e.g., operating models, CMP tuning) and governance processes (e.g., defining objectives, engaging managers). This lack of precedent often led to delays and rework. For example, ABFT MSE, had to incorporate complex population dynamics without a pre-existing assessment model suitable for MSE, contributing to a high number of meetings and long development timelines. In contrast, the N-ALB MSE - though technically simpler - has been continuously refined since its adoption.

Although conceptually straightforward, the N-SWO MSE experienced major delays due to analyst turnover and OM reconditioning, extending its timeline, and increasing costs. The multi-stock tropical tuna (M-TRO) MSE involves more complexity by evaluating multiple species simultaneously, and thus serves less as a benchmark for single-stock processes like BSH.

The W-SKJ MSE offers a potential model of efficiency. Developed primarily by CPC scientists with contractor support, it achieved robust scientific outcomes at lower cost and in less time. It also fostered strong ownership within the SCRS, an important factor for long-term success.

In summary, the cost and duration of ICCAT's MSEs have been shaped more by institutional learning and process design than by inherent biological complexity. BSH is well-positioned to benefit from this accumulated experience. Its relatively well-understood stock structure, recent assessment, and absence of novel management paradigms point to a more tractable and efficient MSE process - particularly if a streamlined, CPC-led approach used for W-SKJ is adopted.

3. Existing BSH MSE work

Building on the review of ICCAT's past MSE processes - including timelines, costs, and institutional learning - we now shift focus to the existing technical groundwork for blue shark. This section outlines the models, simulations, and analytical tools already developed for BSH, which provide a foundation for a focused and efficient MSE process. A significant amount of work relevant to BSH MSE has already been completed. A key advantage is the recent 2023 stock assessment, which provides a credible foundation for constructing operating models (OMs) based on Stock Synthesis outputs and approved data. Additionally, multivariate priors developed by Cortes and Taylor (2023) can inform OM grids or be used for direct sampling via Stochastic Stock Reduction Analysis (Taylor, 2024a), though final model-weighting approaches will need to be defined by the Shark Species Group during the MSE process. These inputs formed the basis for exploratory North Atlantic closed-loop simulations conducted in 2024 (Carruthers 2024; Taylor, 2024a), demonstrating that MSE for BSH could be implemented in a compact, efficient framework.

Importantly, there is little evidence of overlap between the northern and southern Atlantic BSH stocks, and the biology of the stocks is very similar. As such, it would be appropriate to conduct two parallel MSEs - one for each stock - using a shared framework. The operating models would follow a common structure but differ in biological parameters and data inputs reflecting stock-specific uncertainties. Although the MSE platform would logically be the same for both stocks, distinct Management Procedures (MPs) would be adopted based on OM-specific performance and manager preferences. This approach balances stock-specific management needs with efficiency gains, leveraging shared assumptions, a unified software environment, plus consistent workflows for simulations, CMP tuning, and result presentation.

3.1 Objectives

3.1.1 Process and capacity building considerations

Beyond technical elements, the BSH MSE must also account for key considerations related to participation and implementation. The ICCAT Shark Working Group has articulated 'means objectives' (Gregory *et al.,* 2012) for the BSH MSE process. Specifically, they have emphasized the importance of being involved in the design, coding, and execution of closed-loop simulation - with targeted contractor support. This approach offers some important advantages: i) it reduces dependence on external contractors and associated costs, ii) it builds SCRS capacity to conduct MSE for BSH and other species.

3.1.2 Performance standards

As technical preparations advance, we must also consider the management objectives and performance indicators that will guide CMP development. ICCAT's five ongoing MSE processes—and one additional case where management objectives have been agreed to, but the MSE has not yet started (i.e., Southern ALB, S-ALB)—are all designed to achieve broadly similar management objectives. Although Panel 4 has yet to finalize objectives for blue shark, it plans to do so in 2025. Meanwhile, objectives adopted in previous MSEs can serve as a basis for exploring options for BSH. Even without final Commission approval, these precedents help define a likely range of performance expectations for CMP design.

A suite of Performance Indicator options (Taylor *et al.,* 2024) has already been outlined. All six MSEs conducted at ICCAT to date have four categories for management objectives: Stock Status, Safety, Yield, and Stability. The variation in performance indicators across these MSEs is relatively limited, with most differences confined to stability objectives. Notably, all the MSEs use B_{MSY} as the biomass target reference point and $40\%B_{MSY}$ - or a proxy - as the biomass limit reference point. These could provide a reasonable starting point for the initial exploration of CMP performance, unless managers' indicate otherwise.

Below are the management objectives agreed for another Panel 4 stock (N- SWO) in Rec. 24-10, with notation on if/how they are modified for other stocks:

- Stock Status: The stock shall have a 60% or greater probability of occurring in the green quadrant of the Kobe plot (no overfishing occurring and not overfished);
  - Identical or nearly identical to S-ALB (Res. 24-09), W-SKJ (Rec. 24-04), N-ALB (Rec. 21-04), ABFT (Rec. 23-07)
  - 50% or greater probability for E-SKJ, BET, YFT in M-TRO MSE (Res. 24-02)

- Safety: There shall be a 15% or less probability of the stock falling below the Biomass Limit Reference Point B_{LIM} of 40% of the Biomass at Maximum Sustainable Yield ($0.4B_{MSY}$) at any point during the 30-year evaluation period;
  - Identical or nearly identical to S-ALB, M-TRO, ABFT
  - 10% or less probability for W-SKJ
  - Same B_{lim} as N-ALB, but no safety objective for N-ALB MP

- Yield: Overall catch levels shall be maximized;
  - Identical or nearly identical to S-ALB, W-SKJ, M-TRO, N-ALB, ABFT

- Stability: Changes in Total Allowable Catch TAC (between consecutive management periods) shall be minimized, consistent with the specifications of the MP as described in Annex 1.
  - Nearly identical to N-ALB, but that MP limits TAC changes to 25% increase and 20% decrease when $B>B_{MSY}$
  - S-ALB limits TAC changes between management periods to 20%.
  - W-SKJ, M-TRO limits TAC changes between management periods to 25%.
  - ABFT limits TAC changes between management periods to 20% increase or 35% decrease.

Given the similarities, it might be reasonable for Panel 4 to direct the SCRS to start with the N-SWO management objectives and Performance Indicators in the initial development of an MSE for BSH, allowing for a timely technical process. Modifications and refinements could be incorporated later, once the Commission defines final objectives and reference points. This approach balances efficiency with flexibility and aligns with ICCAT's precedent for iterative refinement during MSE processes.

3.2 Data requirements for BSH MSE

In addition to clear objectives, a successful MSE requires robust and consistent data. The 2023 stock assessment used seven Catch Per Unit Effort (CPUE) indices for the northern stock (VEN-LL, SPN-LL, POR-LL, US-LL, JPN-LL, CTP-LL, MOR-LL) and four CPUE indices for the southern stock (SPN-LL, JPN, LL, CTP, LL, BRA-URY-LL). To avoid unnecessary OM conditioning, it would be most efficient to rely on the validated datasets from the 2023 assessment. As with other ICCAT MSEs, a 2-year data lag should be assumed due to ICCAT's reporting deadlines and meeting schedules. For example, for an MP to be implemented in January 2027, the TAC would need to be set in 2026 using data to apply the MP through to the end of 2024.

Two process options are available for parameterizing OMs. The first is to use the existing 2023 stock assessment data and the other is to request and assemble new data i.e., catch information, length composition information, and CPUE information. Using the 2023 stock assessment data can be done immediately and indeed OMs can be (and have been, Taylor 2024a) created on the basis of the existing SS files. The second option is to request and compile new data. This would require additional time for processing, review, and approval by the Shark Working Group. It would also extend timelines, transaction costs, and increase in-kind resource demands.

3.3 OMs and closed-loop simulations

The feasibility of a Management Strategy Evaluation (MSE) depends not only on data availability but also on the structure of operating models (OMs) and the implementation of closed-loop simulations. Two OM development approaches have already been applied to the North Atlantic blue shark: (1) a grid-based method (Carruthers, 2024) and (2) a multivariate sampling and clustering method (Taylor 2024a). Carruthers constructed eight reference case OMs by varying three key biological parameters—natural mortality (M), steepness (h), and relative depletion (SSBcurr/SSB0)—across two alternative values each. This design supports structured sensitivity testing across a plausible biological space. Although model weighting has yet to be finalized, the approach enables transparent evaluation of CMP performance.

In contrast, Taylor (2024a) used OpenMSE's Rapid Conditioning Model (RCM) to construct three reference OMs from multivariate samples of growth, steepness, and natural mortality derived from the prior distributions developed by Cortes and Taylor (2023). These samples were clustered based on CPUE trends, providing a data-informed approach for capturing structural uncertainty. Together, these two methods offer complementary strategies for OM development and demonstrate compatibility with ICCAT's technical framework.

With OMs in place, CMP evaluation was initiated. Carruthers (2024) evaluated three empirical CMPs using multiple TAC control rules, while Taylor (2024a) expanded this set to include a model-based "40:10" harvest rule. Both studies used OpenMSE's automated tuning functions, indicating that BSH CMPs can be efficiently designed, tested, and evaluated using existing infrastructure. Early results establish a technical foundation for advancing the BSH MSE.

3.4 Opportunities for efficiencies

With some groundwork completed and ICCAT's growing MSE experience, there are multiple avenues for improving the efficiency of BSH MSE relative to earlier efforts. Unlike the more complex and resource-intensive processes for ABFT and N-SWO, the BSH MSE presents a more tractable problem structure, which can support a more streamlined development process.

- A key efficiency gain lies in avoiding redundant work. For example, the N-SWO MSE required three rounds of OM reconditioning. By relying on the already-reviewed 2023 assessment data, the BSH MSE can minimize the risk of similar rework - provided CMPs are developed and adopted within a timely schedule.
- As noted earlier, the BSH MSE will likely not require substantially different performance indicators from those already used for N-SWO and other ICCAT stocks. Even if modified indicators are later adopted, a set of CMPs could be pretuned using the N-SWO objectives as a proxy, saving time and computational effort.
- Likewise, the uncertainties considered in the 2023 BSH assessment can serve as the basis for the reference OMs. The robustness set used for N-SWO (see Hordyk *et al.* 2024, Table 2) could also serve as a starting point for BSH.
- Developing the BSH MSE within the OpenMSE platform - as was done for southern swordfish (Taylor, 2024b), N-SWO, W-SKJ, and the simulations by Carruthers (2024) - could significantly improve efficiency. OpenMSE provides a library of over 100 CMPs and includes built-in tools such as the tune_MP function, allowing rapid tuning without the need for bespoke code development.
- A three-year management cycle can reasonably be assumed for CMP development, consistent with all ICCAT MPs adopted to date.
- To maintain consistency with Panel 4's MSE work for N-SWO, results from the BSH MSE should be presented using the same visual formats adopted in 2024, including the Shiny-based interactive visualization tool (Slick) used in simulations by Carruthers (2024) and Taylor (2024a).
- There is growing support among SCRS and Commission members for creating an Expert MSE Coordinator position within the ICCAT Secretariat. This role would oversee logistical and technical elements of all MSE processes - both in development and implementation - helping to ensure consistency across approaches. The Coordinator would also support efficient work planning, serve as a technical point of contact, and help apply efficiency strategies such as those outlined here. Given the common structure and challenges shared by ICCAT's MSEs, this role could substantially enhance institutional capacity.

The BSH MSE represents a more structured problem with relatively high degree of norm agreement (*sensu* Hoppe, 2010). Unlike ABFT, it does not require novel treatment of population dynamics, as the stock structure is well understood and broadly agreed upon. Nor does it involve a new management process - ICCAT has now completed multiple MSEs, including one within Panel 4. Furthermore, as discussed above, there is moderate consensus on management objectives and performance statistics, with only minor variations across stocks (Taylor *et al.* 2024). Taken together, these factors suggest that the BSH MSE is likely to be more tractable and less contentious than past efforts, supporting a more streamlined and efficient process.

4. Options, timelines, and corresponding requirements (costs) for BSH MSE

With the technical groundwork and institutional context established, this section presents two viable implementation pathways for the development and adoption of Management Procedures (MPs) for northern and southern Atlantic blue shark. These timelines are grounded in the outputs of the 2023 stock assessment, the existing simulation infrastructure, and the MSE experience gained across ICCAT. Section 4 outlines the corresponding cost estimates, key process considerations, and trade-offs to inform strategic decision-making by the SCRS and Commission.

4.1 Options and timelines

Based on the 2023 stock assessment and existing modeling infrastructure, two implementation options are proposed for developing and adopting Management Procedures (MPs) for the northern and southern Atlantic blue shark stocks:

- Option 1: Two-Year Schedule – MP Adoption by 2027
- Option 2: Three-Year Schedule – MP Adoption by 2028

Both options leverage ICCAT's recent experience with MSE processes and are compatible with the Commission's MSE roadmap. The two-year schedule is designed to capitalize on current momentum, deliver early results, and minimize idle time between technical and institutional phases. It assumes early formation of a BSH MSE Technical Team, streamlined SCRS engagement, and a CPC-led approach as successfully used in the W-SKJ MSE.

The three-year schedule offers a more iterative process, with additional opportunities for institutional review, tool refinement, and engagement. It provides more flexibility but extends adoption by one year and increases transaction costs and coordination demands.

Gantt charts and workplans for both schedules are provided in **Figures 1-3** and **Tables 3-4**. Although **Table 4** includes limited post-adoption activities (e.g., Exceptional Circumstances Protocols) in 2029 for context, this feasibility assessment is explicitly limited to activities leading up to MP adoption. The inclusion of post-adoption milestones reflects ICCAT's overall MSE roadmap but falls outside the scope of this analysis.

4.2 Comparative assessment of timelines

Both timelines follow the same core sequence of MSE tasks—operating model (OM) development, CMP testing, institutional review, and MP adoption—but differ significantly in the pacing and spacing of review milestones. The two-year schedule compresses technical and institutional engagement into a streamlined set of deliverables aligned with a 2027 target. In contrast, the three-year schedule spreads decision points across a longer horizon, with broader SCRS engagement and iterative refinement.

Key differences include the frequency of Panel 4 review, the timing of CMP selection, and the degree of emphasis on code review and visualization development. In the two-year schedule, CMPs are tuned and reviewed within a single feedback cycle; in the three-year plan, they undergo multiple rounds of evaluation. Discussions on decision-support tools, such as the Shiny App, are also revisited more frequently in the extended schedule, despite these tools already being operational with the Slick app.

Figure 3 illustrates these trade-offs clearly. Both options are consistent with ICCAT's MSE roadmap and technically achievable given current capacity. However, the choice reflects institutional priorities: the two-year schedule emphasizes speed and efficiency; the three-year schedule favors flexibility and broader engagement.

4.3 Estimated Costs

Cost projections for the BSH MSE are based on contracting expenditure patterns from previous ICCAT MSE processes. While in-kind contributions from CPC scientists and the Secretariat are significant, this analysis focuses on contracted expenditures to provide a conservative, comparable cost estimate.

The N-SWO MSE, completed over eight years, cost approximately €683,100 in contracting fees, averaging around €98,000 annually. In contrast, the BSH MSE is expected to incur lower annual costs - estimated at €60,000 to €70,000 - due to its shorter duration, use of shared modeling infrastructure, and greater reliance on SCRS participation. On this basis, the total projected contracting costs are:

- Two-year schedule: €120,000 - €140,000
- Three-year schedule: €180,000 - €210,000

The extended timeline may allow lower annual contractor input, but the overall cost remains modest - representing approximately 18-31% of the total cost of the N-SWO MSE, even though both BSH stocks are addressed concurrently.

4.4 Implementation considerations

The selection between the two implementation options involves a trade-off between the speed of delivery and the depth of engagement. Both schedules accommodate future refinements and evolving inputs. For example, results from ongoing Shark Research and Data Collection Program activities or new population dynamics studies could inform future OM reconditioning, regardless of the adopted timeline.

Contracting support for SCRS and Secretariat scientists will be essential in both scenarios. Developing a common modeling framework for both stocks - with stock-specific data inputs and management procedures - offers substantial efficiency gains. Shared infrastructure ensures consistency, reduces duplication, and enables comparative evaluation across stocks. If the SCRS leads the development process and acquires additional skills, as in the W-SKJ MSE, it would improve process ownership, further reduce short-term costs, and in the long term build institutional expertise.

4.5 Feasibility and recommendations

Developing MSEs for the northern and southern Atlantic blue shark stocks is both technically feasible and operationally realistic. A robust foundation is already in place, including validated stock assessments, preliminary simulations, and established tools for CMP design and performance visualization.

The shared biological structure of the two stocks, combined with existing modeling infrastructure, supports a dual-track approach using common tools with stock-specific customization. Both proposed timelines - two-year and three-year - are viable. The three-year schedule allows greater flexibility and consultation but the two-year schedule emphasizes early implementation and cost efficiency.

Ultimately, the choice depends on the Commission's management priorities and institutional capacity. Regardless of the path taken, sustained technical coordination, timely feedback, and focused contracting support will be essential. With these elements in place, the BSH MSE can be delivered effectively by 2027 or 2028, providing robust, science-based management procedures for both stocks.

5. Risk assessment

While MSE development for Atlantic blue shark is technically feasible, its success depends on managing a focused set of interdependent risks. These risks fall into three main categories: (1) Technical and Institutional Risks, (2) Engagement and Governance Risks, and (3) Financial and Resource Risks - including data currency. The following subsections describe these risks, their potential impacts, and mitigation strategies.

5.1 Technical and institutional risks

These risks relate to the timely delivery of operating models (OMs), the functioning of the technical team, and coordination within ICCAT's scientific and management structures.

Risk	*Description*	*Potential Impact*	*Mitigation Strategy*
Incomplete data validation	Delays in finalizing or agreeing on CPUE indices or input data.	Delayed OM development; potential reconditioning.	Use validated 2023 stock assessment data; avoid new data calls unless strictly necessary.
Unresolved uncertainty structures	Lack of agreement on primary vs. secondary uncertainties for OM grid.	OM review slowed; risk of inefficiencies.	Begin with uncertainty frameworks from N-SWO and W-SKJ; build on existing priors and OM templates.
Code development delays	Delays in tool development or external code review.	Slows CMP testing and stakeholder engagement.	Use OpenMSE and Slick; conduct early code review.
Delays in Technical Team formation	Late nomination of CPC and SCRS experts.	Missed early milestones; less continuity.	Initiate team formation by mid-2025; define Terms of Reference early.
Analyst turnover	Changes in modeling personnel.	Loss of continuity; delays.	Support SCRS-led work; build redundancy in staff assignments and training.

5.2 Engagement and governance risks

These include uncertainties around management guidance, stakeholder involvement, and institutional decision-making at the SCRS and Commission levels.

Risk	*Description*	*Potential Impact*	*Mitigation Strategy*
Delays in defining management objectives	Postponement of formal objectives or reference points.	Slows CMP design and tuning.	Begin with N-SWO objectives as provisional baseline; refine iteratively.
Limited CPC buy-in	Weak engagement from CPC scientists or managers.	Undermines legitimacy and implementation readiness.	Use SCRS-led approach; leverage Shiny app (Slick) for communication.

5.3 Financial and resource risks

This is the most cross-cutting risk category. It includes direct funding shortfalls and the indirect consequences of delay - particularly the risk of the 2023 assessment data becoming outdated. If the MSE is postponed significantly, the cost of reconditioning models or restarting after a new assessment becomes unavoidable, effectively resetting the process.

Risk	*Description*	*Potential Impact*	*Mitigation Strategy*
No or insufficient funding	Inability to contract technical support for OM development, simulation, facilitation.	If partial funding: reduced complexity, fewer CMPs, limited engagement. If no funding: MSE cannot proceed.	Secure early funding commitments; consider cost-sharing or phasing; reduce scope/complexity if needed; prioritize SCRS-led work and use OpenMSE.
Delayed contracting	Contracting mechanisms not activated in time.	Slows delivery of key simulations and documentation.	Secure administrative pathway by drafting SOW by Sept 2025; model after W-SKJ approach.
Data currency erosion (financial proxy risk)	MSE development is delayed long enough that the 2023 assessment becomes outdated.	Reconditioning of OMs or full reassessment required—imposing cost and delay equivalent to restarting.	Use 2023 dataset for OM development now; if delays are unavoidable, reassess full cost-benefit of continuing vs. restarting post-2027.

Data currency is thus not only a technical issue but also a financial one: prolonged delays mean the project may need to be restarted entirely, with new inputs, reconditioning, and re-tuning—all of which would require new resources and extended timelines.

5.4 Overall risk summary and conclusion

The BSH MSE is feasible and comparatively tractable, but timely resourcing and coordination are critical. The primary threat is not technical complexity, but failure to mobilize financial and institutional support early - especially by late 2025 or early 2026. **Table 5** summarizes the timeline-based risk tradeoff for the BSH MSE.

The two-year schedule (2025-2027) emphasizes speed and cost-effectiveness, but is less tolerant of delays and highly sensitive to funding gaps. A shortfall in contracting resources could stall OM development at the outset, or require significant downscaling (e.g., fewer MPs, limited robustness testing).

The three-year schedule (2025-2028) offers more engagement and resilience to delays. However, it imposes a higher coordination burden, higher transaction costs, and greater cumulative costs. It does not inherently reduce financial risk. If anything, extended timelines without adequate early funding could increase the probability of reassessing the stock because conditioning data becomes stale. The 2028 endpoint refers specifically to the initial adoption of Management Procedures (MPs), which is the terminal milestone considered in this feasibility assessment. While **Table 4** includes post-adoption activities in 2029 for completeness (e.g., implementation of Exceptional Circumstances Protocols), those tasks fall outside the defined scope of this study. However, their timing may influence planning if adoption is delayed.

In conclusion, the most significant determinant of success is early confirmation of financial and personnel resources. Without adequate funding and team formation by early 2026, the process risks delay or degradation. If the MSE is postponed too far, reconditioning may require doing a full stock assessment so that data are current. Restarting the MSE after significant delay would not only duplicate prior investments, but also require full reconditioning with updated data—effectively erasing the efficiency gains from using the 2023 stock assessment. A structured, SCRS-led approach with narrowly defined funding, scope, and engagement plans is the best path to timely delivery under either proposed schedule.

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Table 1. Summary of timeline to complete MSE by stock.

Stock	*Year OM Development Began*	*Year of MP Adoption*	*Development Time (Years)*
Northern Swordfish (N-SWO)	2016	2024	8
Atlantic Bluefin Tuna (ABFT)	2015	2022	7
Multi-stock Tropical Tunas (M-TRO)	2018	2026 *(TBC)*	8 *(projected)*
Northern Albacore (N-ALB)	2016	2021	5
Western Skipjack (W-SKJ)	2021	2025 *(TBC)*	4 *(projected)*

Note: "TBC" = To Be Confirmed. "Projected" = Based on current SCRS and Commission planning.

Table 2. Summary of contract spending on MSE by year (rows) and stock (columns).

Year	*ABFT*	*N-ALB*	*N-SWO*	*W-SKJ*	*M-TRO*
2018	143000	60000	65000		
2019	99725	10000	55000		140000
2020	136000	19200	110000	15000	35000
2021	150000	38000	178100	50000	
2022	160000	20000	90000	20000	30000
2023	40000	30000	90000	25000	50000
2024	5000	30000	95000	25000	50000
Mean annual expenditure	104818	29600	97586	27000	61000
Total cost	733725	207200	683100	135000	305000

Table 3. Tentative timeline for a 2/year schedule.

	Date	*Task*
2025	May/Sept	Formation of BSH MSE Technical Team
	November	Commission to agree preliminary operational management objectives (per MSE roadmap).
2026	January-May	Several BSH MSE Technical Team (TT) meetings to: Review and accept initial dataset for OM conditioning. Establish primary, secondary uncertainties, and long term research recommendations (i.e. what will be dealt with in this round, and what will be dealt with in subsequent conditioning). Propose OM reference and robustness sets based on those uncertainties.
	May	Analyst(s) to present to Sharks WG and collect feedback on: OM fit and behavior First draft of Trial Specifications Document (TSD) Proposed CMPs to test
	July	Analyst(s) to present to BSH MSE TT and collect feedback on: Preliminary CMP results Shiny App Decide on need for external review of code
	September	Sharks WG and SCRS Plenary to review progress to date and provide feedback, especially on: Reference and robustness OMs CMP design and performance
	November	Solicit feedback from Panel 4, especially on: Reference and robustness OMs CMP design and performance Tuning targets for CMPs
2027	January-May	BSH MSE TT to meet to develop and carry out a plan to respond to SCRS and Commission feedback
	March	Sharks WG to meet to: Adopt final reference and robustness OMs Adopt final TSD Review draft final MSE results
	July	Panel 4 Intersessional Meeting to review draft final MSE results and select shortlist of CMPs
	September	SCRS to: Run final CMPs to calculate the TAC in the first year for each CMP Provide written specifications for each CMP to include in a Commission measure
	October	Ambassador session to present final CMP results and answer final questions from Panel 4 members
	November	Commission to adopt MPs for North & South Atlantic BSH
2028	November Onwards	Commission to adopt Exceptional Circumstances Protocol for BSH MPs Apply the agreed schedule for future MSE and stock assessment updates, verifying exceptional circumstances, etc.

Table 4. Tentative timeline for a 3-year schedule.

	Date	Task
2025	May/Sept	Formation of BSH MSE Technical Team
	November	Commission to agree preliminary operational management objectives (per MSE roadmap)
2026	January-May	Several BSH MSE Technical Team (TT) meetings to: Consider the initial dataset (e.g., terminal year, CPUE updates) and main uncertainties for OM conditioning Consider and propose the set of initial primary and secondary uncertainties Propose initial OM reference and robustness sets based on those uncertainties
	May	Analyst(s) and BSH MSE TT to present to Sharks-SG and collect feedback on: Preliminary OM fit and behavior First draft of Trial Specifications Document (TSD) Discuss how results can be explored and disseminated (e.g., Shiny app) Discuss and propose on the need for external review of code
	September	Sharks WG and SCRS Plenary to review progress to date and provide feedback, especially on: OM grid Reference and robustness OMs Candidate Management Procedure (CMP design and specifications and performance Decide on the need for external review of code and its timeline
	November	Solicit feedback from PA 4, especially on: Reference and robustness OMs CMP design and performance Tuning targets for CMPs
2027	January-May	BSH MSE TT to meet to continue the technical work, following the SCRS and Commission feedback Finalize work on the OM, with suggestions on what should be in the main OM and robustness tests Start work on CPMs Continue work on results exploration and visualization (e.g, shiny app)
	May	Sharks WG to meet to: Adopt final OM, both for reference and robustness OMs Discuss preliminary results from CMPs
	July	Panel 4 Intersessional Meeting to review current MSE results, and select preferences in terms of design and characteristics of CMPs
	September	Sharks SG and SCRS to: Agree on the final OM, robustness tests, and shortlist of CMPs to be passed to PA4
	November	Panel 4 to review current MSE results, and discuss/agree on the shortlist of CMPs and its specifications to be further developed. At that stage, the CMPs can be further shortlisted or others added by PA4
2028	January-May	BSH MSE TT to meet to: Advance and finalize the technical work of the shortlist of CMPs selected Update the final versions for results exploration and visualization (e.g., shiny app)

	May	Sharks WG to meet to: Analise and adopt the final results on the shortlisted CMPs Plan to any additional future work needed, including ECP, etc Review draft final MSE results Agree on the final set of visualization tools (e.g., shiny app)
	September	SCRS to: Run final CMPs to calculate TAC1 for each shortlist CMP Provide written specifications for each CMP to include in a Commission measure
	October	Ambassador session to present final CMP results and answer final questions from Panel 4 members
	November	Commission to adopt MPs for North & South Atlantic BSH
2029	November Onwards	Commission to adopt Exceptional Circumstances Protocol for BSH MPs Apply the agreed schedule for future MSE and stock assessment updates, verifying exceptional circumstances, etc.

Table 5. Summary of timeline-based risk trade-offs for the BSH MSE.

Schedule	*Main Strengths*	*Key Risks*	*Overall Risk Profile*
Two-Year (2025–2027)	Speed, efficiency, lower total cost	Vulnerable to delay; high sensitivity to funding gaps and start-up slippage	Moderate, depending on resource mobilization and team formation
Three-Year (2025–2028)	Flexibility, broader consultation	Higher cumulative costs; risk of stale data, MSE drift, or reassessment if delayed	Moderate, more robust to delay, but financial risks still decisive if process extends too long
Cross-cutting	Shared models, OpenMSE, validated 2023 assessment	Lack of early financial support could compromise either timeline or force a restart	High-impact, unless financial planning and scope alignment occur early

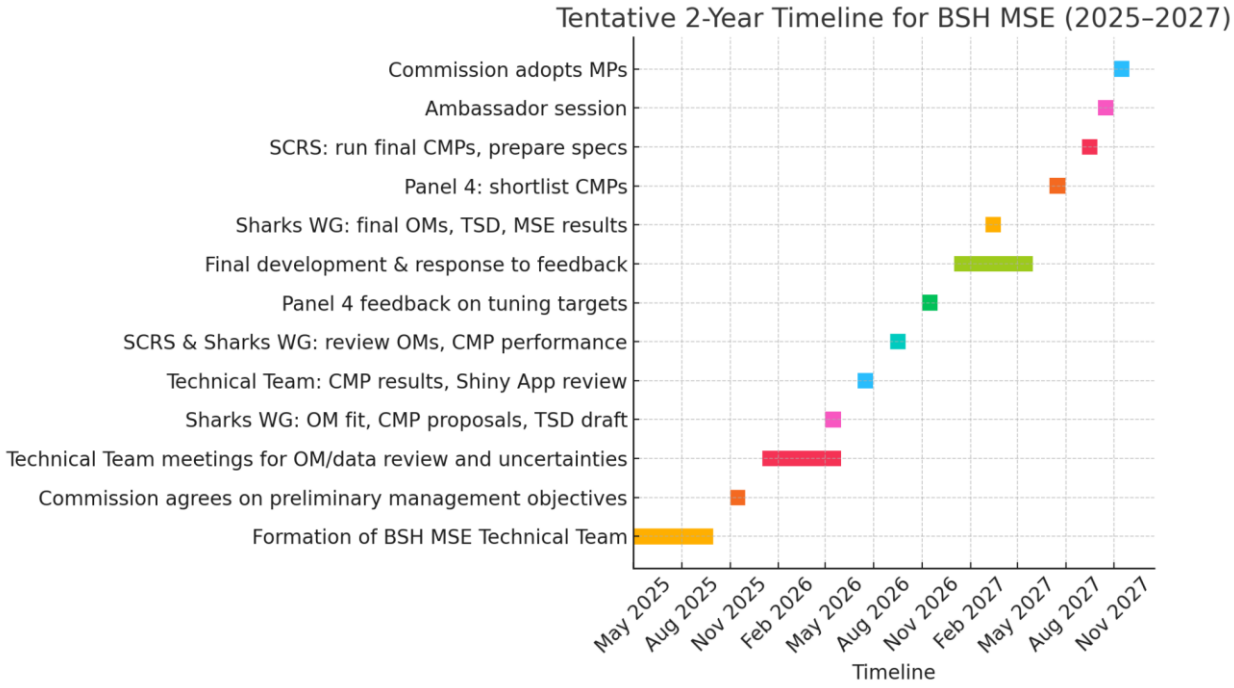

Figure 1. Gantt chart for two-year adoption option.

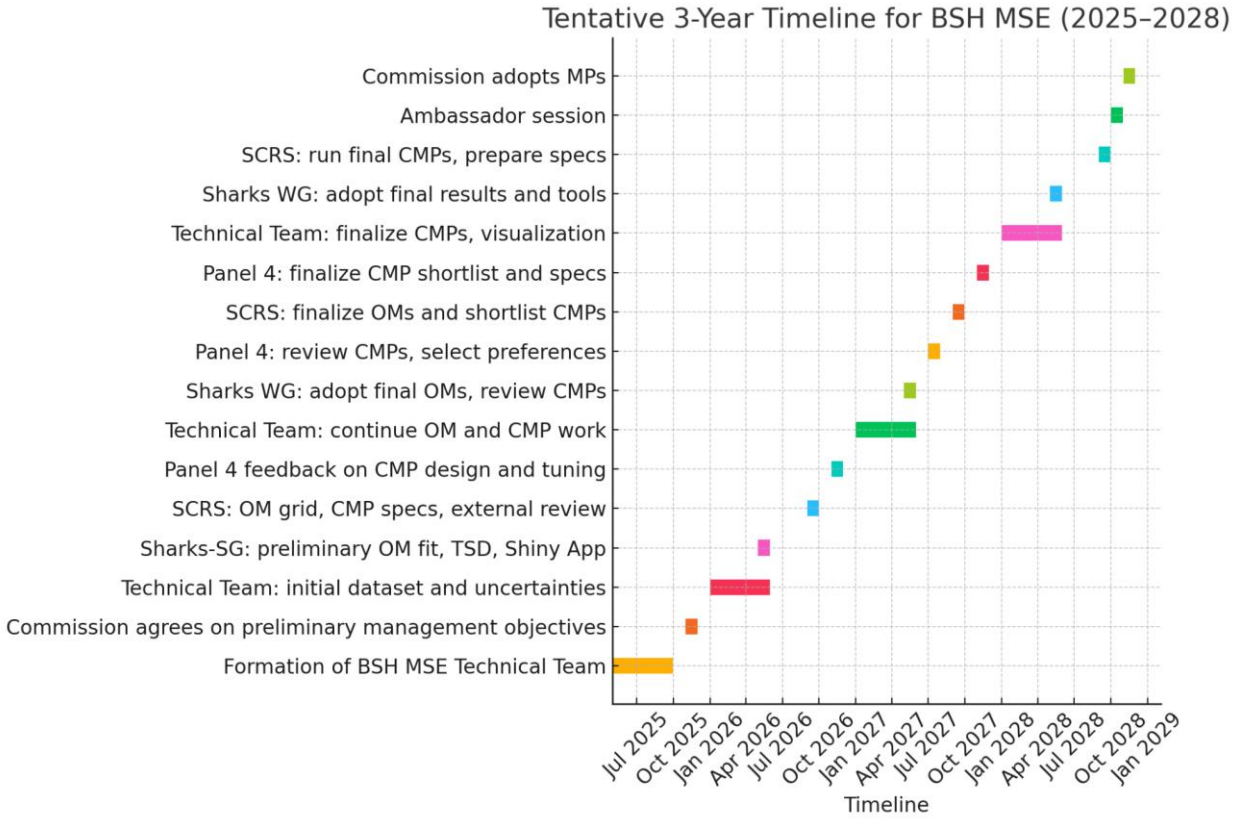

Figure 2. Gantt chart for a three-year adoption timeline.

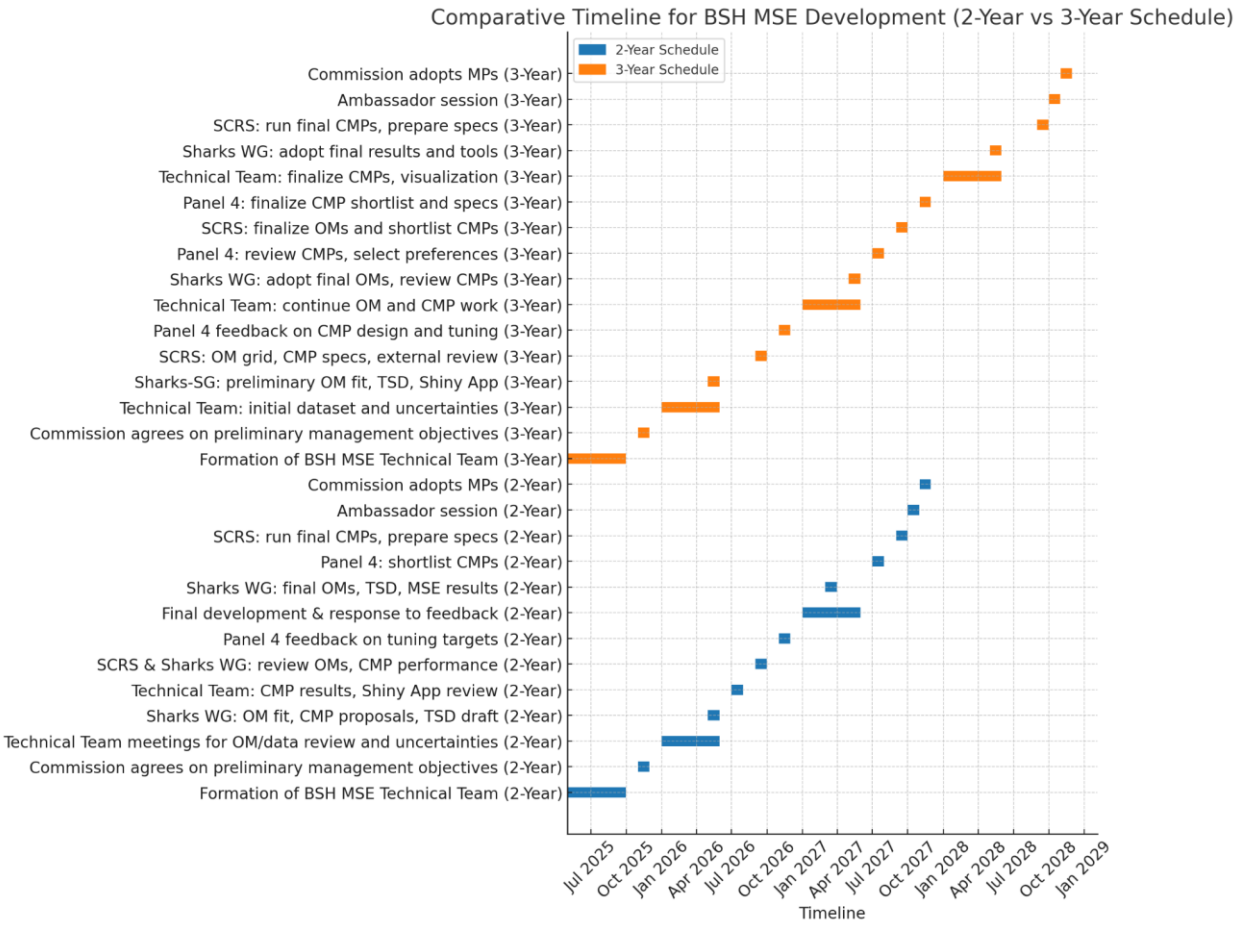

Figure 3. Comparative Gantt chart for both 2- and 3-year options.

Appendix 1

Table A1. Acronyms and definitions.

Acronym	*Definition*
ICCAT	International Commission for the Conservation of Atlantic Tunas
MSE	Management Strategy Evaluation
BSH	Blue Shark
MP	Management Procedure
SCRS	Standing Committee on Research and Statistics
CMP	Candidate Management Procedure
OM	Operating Model
CPUE	Catch Per Unit Effort
TAC	Total Allowable Catch
HCR	Harvest Control Rule
PG	Procédures de Gestion (Management Procedures in French)
ESG	Évaluation de Stratégie de Gestion (Management Strategy Evaluation in French)
ECP	Exceptional Circumstances Protocol
RCM	Rapid Conditioning Model
SS	Stock Synthesis
BLIM	Biomass Limit Reference Point
BMSY	Biomass at Maximum Sustainable Yield
CPC	Contracting Party and Cooperating non-Contracting Parties
W-SKJ	Western Skipjack
ABFT	Atlantic Bluefin Tuna
N-ALB	Northern Albacore
N-SWO	Northern Swordfish
M-TRO	Multi-stock Tropical Tunas
S-ALB	Southern Albacore
SG	Subgroup
PA4	Panel 4
SOW	Statement of Work (defining the scope, deliverables, and responsibilities for a specific project or service)