SUBMISSION TO THE

NUNAVUT WILDLIFE MANAGEMENT BOARD

FOR

Information: X **Decision:** **Recommendation:**

Issue: Update on a proposed adaptive narwhal management system for Northern and Eastern Baffin Island.

Figure 1. Narwhal (*Monodon monoceros*) by G. Kuehl 2000.

Background

The 2013 *Integrated Fisheries Management Plan for Narwhal in the Nunavut Settlement Area* (IFMP) incorporated a Harvest Allocation Model developed to support the sustainable allocation of narwhal harvests among Nunavut communities on Northern and Eastern Baffin Island (NEBI). The Harvest Allocation Model takes into consideration that a community may harvest from a mixture of narwhal stocks outside the summer residency period, and the model accounts for this migratory mixing of narwhal stocks by linking harvests in different communities and different seasons to the Total Allowable Harvest (TAH) established for each stock. The Harvest Allocation Model is used to assess proposed annual allocation scenarios and ensure that the combined harvest attributed to a stock does not exceed its TAH.

The Qikiqtaaluk Wildlife Board (QWB) submitted a Request for Decision to the Nunavut Wildlife Management Board (NWMB) in June 2020 and an updated request in March 2022 (Appendix 1) to replace the Harvest Allocation Model with a proposed system that merged the three stocks within NEBI and a single year-round harvesting season methodology. The QWB stated the "summer-stock management system was not supported by Inuit Qaujimajatuqangit [IQ], and unduly restricted harvesting by Inuit". The NWMB acknowledged concerns that the assumptions used to determine the narwhal stock boundaries and the Harvest Allocation Model used to inform the 2013 IFMP do not reflect available IQ, specifically narwhal movement patterns. The NWMB called on co-management partners to consider the evidence about narwhal stock definitions presented by the QWB while undertaking revisions to the narwhal IFMP (Appendix 2).

To support consideration of the QWB proposal and the revision of the IFMP, Fisheries and Oceans Canada (DFO) requested updated Science advice on stock delineation and the sustainability risks associated with alternative management approaches.

Science Information

In January 2026, DFO Science published a Science Response with two objectives: (1) to review the assumptions and available scientific evidence related to narwhal stock delineation; and (2) to assess the sustainability risks associated with the management system proposed by the QWB (Appendix 3). Biological markers, including stable isotopes, trace elements, contaminants, and genetics, together with movement information demonstrating summer and annual site fidelity, corroborate differentiation among some narwhal summering aggregations. In line with DFO's precautionary approach, in cases where stock delineation is complex, it is generally more precautionary to assume greater subdivision than to assume less. Accordingly, the Science Response advised that narwhal be managed at the smallest scale supported by available evidence of stock structure.

The risk assessment examined several potential management scenarios. The scenario most closely aligned with the QWB's recent proposal consisted of two management units: one combining the Admiralty Inlet, Eclipse Sound, and East Baffin Island stocks within NEBI, and another comprising the Somerset Island stock. If the three NEBI stocks do not mix fully, the assessment estimated a 46–100% risk of decline in the Eclipse Sound stock (the smallest summer aggregation) over the next 20 years, depending on how the combined harvest is allocated.

Update

Following publication of the 2026 Science Response, the Narwhal Working Group met in the months of February, June, and September of 2026 to discuss and develop an alternative to the current Harvest Allocation Model. The objective of an alternative approach is to provide greater flexibility through all-season tags while maintaining safeguards to ensure that harvests remain sustainable for the Admiralty Inlet, Eclipse Sound, and East Baffin Island stocks.

The Working Group has collaboratively developed a draft system called the 'Interim Adaptive Narwhal Management System for Northern and Eastern Baffin Island (NEBI)'. Under the draft system, the tags available in the NEBI area would equal the sum of the annual TAHs for the Admiralty Inlet, Eclipse Sound, and East Baffin Island stocks. Each stock would retain its individual TAH, but the total number of NEBI tags would equal the sum of the three annual TAHs. These tags will be available for the QWB to allocate to the communities of Arctic Bay, Pond Inlet, Clyde River, Qikiqtarjuaq, Pangnirtung, and Iqaluit. Tags issued to these communities will be all-season tags and labelled as NEBI tags. NEBI tags may be used throughout the three zones shown in Figure 2.

Following a harvest, the hunter is responsible for indicating, in the designated space on the physical tag, the zone (1, 2 or 3; see Figure 2) where the harvest occurred as well as the date of harvest. DFO will use the date and location of harvest to estimate the number of narwhals harvested from each stock and will share this information at an annual NEBI narwhal harvest forum with Working Group members and communities. For this system to provide reliable stock-specific harvest estimates, it is essential that hunters accurately and completely record the harvest location and date of each harvest on each tag.

Under the proposed draft system, the estimated harvest attributed to an individual stock could exceed that stock's annual TAH in a particular year, even though the total number of NEBI tags would not exceed the combined annual TAHs. Previous Science advice indicated that some interannual harvest variation may be potentially sustainable, provided that cumulative hunting mortality attributed to each stock over five consecutive years does not exceed five times its annual TAH (Appendix 4). Annual reporting and discussion at a NEBI narwhal harvest forum would allow co-management partners and communities to identify concentrations in the timing or location of harvest and consider adjustments before the five-year limit is reached.

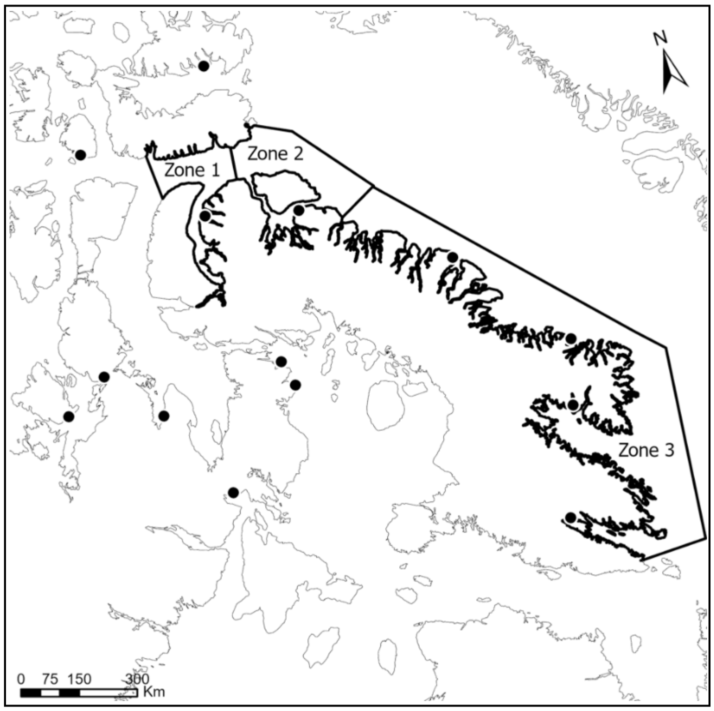

Figure 2. Map indicating the Northern and Eastern Baffin Island (NEBI) area. The area is divided into three zones.

If the estimated total harvest within a stock during the previous five years exceeds the sum of the applicable annual TAHs for that stock over the same five-year period, temporary measures to maintain vital and healthy narwhal populations may be considered. These temporary measures may include, but are not limited to, a reduction in TAH, or Non-quota limitations (NQLS) such as shortened seasons, or a return to stock-specific tags for some or all of the stocks within NEBI. The system is considered adaptive because estimated stock-specific harvests would be reviewed annually and management measures could be taken through regulating harvesting practices, developing or modifying by-laws, or establishing/modifying NQLs or TAH through NWMB Decision when necessary to protect individual stocks.

Consultation

This draft system was co-developed by the Narwhal Working Group with representatives from DFO, Kitikmeot Regional Wildlife Board (KRWB), Kivalliq Wildlife Board (KWB), QWB, Nunavut Tunngavik Incorporated (NTI), and NWMB staff.

DFO plans to conduct written consultations with the Ikajutit Hunters and Trappers Association (HTA), Mittimatalik HTA, Nangmautaq HTA, Nattivak HTA, Pangnirtung HTA, Amaruq HTA, Kitikmeot Regional Wildlife Board (KRWB), Kivalliq Wildlife Board (KWB), QWB, and Nunavut Tunngavik Incorporated (NTI) prior to submitting a request for decision to NWMB.

Next Steps

Subject to consultation and finalization of the proposal, the Working Group intends to bring the proposed system forward for consideration by the NWMB, potentially as early as the first meeting of 2027. If approved through the decision-making process, the targeted implementation date would be the 2027–28 narwhal harvesting season, which opens on April 1st, 2027.

Prepared by: Ricky Di Rocco, Alexis Burt and Tyler Jivan, Fisheries Management;
Marianne Marcoux and Cortney Watt, Science;
Arctic Region, Fisheries and Oceans Canada.

Date: 11 September 2026

Appendices

Appendix 1 - 2022 Submission to the Nunavut Wildlife Management Board - Establishment of an Inuit System of Narwhal Management in the Waters of Northern and Eastern Baffin Island, 2022

Appendix 2 - NWMB Decision on Qikiqtaaluk Wildlife Board's Request for Modifications to the Baffin Bay Narwhal Management System

Appendix 3 - DFO Canadian Science Advisory Secretariat Science Response 2026/002 - Considerations for a New Narwhal Management System: Sustainability of Narwhal Around Northern and Eastern Baffin Island

Appendix 4 - DFO Canadian Science Advisory Secretariat Science Advisory Report 2015/006 - Sustainability of a flexible system of total allowable annual catches of narwhals (*Monodon monoceros*)

SUBMISSION TO THE

NUNAVUT WILDLIFE MANAGEMENT BOARD (NWMB)

Regular Meeting No. RM 001-2022

FOR

Information: ☐ **Decision:** ☒

Issue: ***Establishment of an Inuit System of Narwhal Management in the Waters of Northern and Eastern Baffin Island, 2022***

Background:

Assertion of Primacy of Inuit Systems of Wildlife Management Decisions in Nunavut

In December 2020, the Qikiqtaaluk Wildlife Board (QWB) adopted the legal position to assert that the Nunavut Agreement, a constitutionally protected treaty between the Inuit of Nunavut and the Crown of Canada, intended to provide primacy to Inuit Systems of Wildlife Management with respect to decision-making processes and outcomes regarding wildlife and wildlife harvesting by Inuit. This primacy extends to Inuit Qaujimajatuqangit (IQ) because IQ is the basis for Inuit Systems of Wildlife Management. In this context, "primacy" refers to what comes first and remains most important. Inuit Systems of Wildlife Management are specifically recognized in sub-section 5.1.2(e) of the Nunavut Agreement. Several other sections of Article 5 of the Nunavut Agreement point out the special rights and roles that Inuit have in wildlife management and harvesting in Nunavut. Science and scientific systems of wildlife management are not specifically recognized or mentioned in Article 5 of the Nunavut Agreement.

More specifically, the QWB asserts that any wildlife management plan, recommendation or measure established or implemented by the NWMB or Fisheries and Oceans Canada (DFO) must give primacy to Inuit rights, Inuit Systems of Wildlife Management, and Inuit Qaujimajatuqangit. Such a view is supported by the Nunavut Agreement and the United Nations Declaration on the Rights of Indigenous Peoples.

Summary of Applicable Inuit Qaujimajatuqangit about Narwhal in the Waters of Northern and Eastern Baffin Island

In 2018, the QWB Executive and the Hunters and Trappers Organizations (HTOs) learned that DFO did not plan to review and revise the 2013 Integrated Fisheries Management Plan for Narwhal in the near future. As a result, the QWB Executive and HTOs began discussing improvements to narwhal management in the waters of Northern and Eastern Baffin Island (NEBI) based on Inuit Qaujimajatuqangit (IQ) and began developing the Inuit System of Narwhal Management, initially proposed to the NWMB in May 2020.

IQ about NEBI narwhal is far too extensive to describe fully here. IQ is orally transmitted among Inuit in every community, covering knowledge collected by many past generations to the current day across all waters that community members collectively and regularly travelled almost every day from the floe fledge in spring to the end of the fall migration of the narwhal. Harvesters, elders, youth, women and men all have roles in the IQ system and collectively share their knowledge within and between communities. The HTOs develop the best consensus-based decisions in keeping with IQ principles and practices, and Inuit Systems of Wildlife Management among affected Inuit communities, largely as Inuit have always done since time immemorial.

In January 2020 Eric Ootoovak, then Chairperson of the Mittimatalik HTO, told DFO scientists and managers repeatedly and emphatically that “there are no summer stocks” during a survey planning workshop in Winnipeg. Eric was referring to three hypothetical summer stocks delineated by DFO in the above-mentioned 2013 science-based management plan. According to IQ, the three summer stocks of narwhal do not actually exist in reality within the waters of NEBI!

In January 2020, DFO could not provide the needed evidence showing multi-year fidelity of narwhal to any one of the three hypothetical parts of NEBI waters. DFO offered no clear methods or plans to obtain the required information (C. Watt, DFO, Winnipeg, pers. com.). DFO’s telemetry data shows that narwhal may move from one area to other areas in the same open-water season in which they were tagged within and beyond NEBI waters.

At that 2020 workshop, delegates from all six HTOs agreed that DFO‘s 2013 hypothetical summer-stock management system was not supported by Inuit Qaujimajatuqangit, and unduly restricted harvesting by Inuit in contravention of sections 5.3.3 and 5.6.50 of the Nunavut Agreement.

Below are some conclusions about the narwhal in NEBI waters based on generations-old, up-to-date, peer-reviewed Inuit Qaujimajatuqangit:

- Narwhal move freely throughout the NEBI area (see Appendix A). Their distributions and abundances change across NEBI waters between years, showing that individual narwhal do not always return to the same specific areas within NEBI waters every year.
- Narwhal also move freely and widely from day to day, from week to week and from month to month in NEBI waters, and their local distributions and abundances change accordingly. Groups of narwhal are seen moving out of and into major inlets and sounds, and among various smaller fiords and bays, throughout the open-water period.
- In spring, narwhal arrive at various areas in NEBI waters at varying times each year, depending on the development of open water within variable patterns at the floe edges, leads in the ice in various areas, and ice break-up into summer. These patterns and their timing vary from year to year, and can affect the abundance and distributions of narwhal across NEBI waters into August and September.
- Throughout the open-water period, narwhal move as needed for their biological needs like birthing and mating, as well as in response to environmental factors like changing food concentrations, killer whales, and ships. Narwhal also probably move in response to factors largely unknown to humans.
- Underwater sounds are probably important factors that influence the real-world, real-time distributions and abundances of the narwhal because narwhal can hear other narwhal, other whales, predators, ships and other sources of sound across very long distances.
- Inuit manage their harvesting in real time as narwhal move throughout the open-water season because the movements, distributions and abundances of NEBI narwhal cannot be predicted accurately months in advance.

In the opinion of the QWB, the following proposed Inuit System of Narwhal Management for the waters of NEBI is based on strong evidence from generations of up-date IQ. It will enable Inuit to better manage their harvesting of NEBI narwhal, so they can effective conservation this very important species and resource.

Further, the QWB and affected HTOs conclude that the following proposed Inuit System of Narwhal Management for the waters of NEBI is strongly and legally supported by the Nunavut

Agreement, including but not limited to the following sections: 5.1.2 (e), (g) and (h), 5.1.3 (a)(v) and (b) (iii) and (v), 5.1.4, 5.3.3 (a), 5.6.50, 5.7.3 and 5.7.6.

Recommendations:

1. The QWB and six affected HTOs of Arctic Bay, Pond Inlet, Clyde River, Qikiqtarjuaq, Pangnirtung and Iqaluit make the following recommendations for decision by the NWMB to implement an Inuit System of Narwhal Management in the waters of Northern and Eastern Baffin Island (NEBI) in accordance with sections 5.1.2 and 5.2.33 of the Nunavut Agreement:
    a) Delineate only one narwhal management unit in the waters of NEBI in accordance with Inuit Qaujimajatuqangit, as per the map and boundary points described in Appendix A;
    b) Amalgamate and total the current TAHs and BNLs for Admiralty Inlet, Eclipse Sound and East Baffin Island into a single annual TAH and BNL for narwhal in the proposed NEBI narwhal management unit of the six communities (see Appendix B);
    c) Continue the current annual inter-regional allocation of the BNL for Somerset Island narwhal to be harvested by Inuit in Arctic Bay (i.e., 51) and Pond Inlet (i.e., 53), to avoid impacts on allocations to other HTOs in the Kitikmeot and Qikiqtaaluk Regions;
    d) Establish only one annual season for management of narwhal in the waters of NEBI; and enable the issuance of "all-season" tags (valid from April 1 to March 31, inclusive) annually by DFO to the six affected HTOs;
    e) Enable the QWB to allocate the proposed NEBI BNLs among the six affected HTOs, and any future changes in the BNLs, among the six HTOs, based on IQ and other information, as per clauses 5.1.2(e) and (h), and 5.7.6. of the Nunavut Agreement;
    f) Continue to carry-forward unused allocated tags from one year to the next for each HTO;
    g) Support the QWB's and HTOs' jurisdictions to establish by-laws to govern how the BNLs, including carry-forward tags, may be allocated, how narwhal may be harvested, and generally how narwhal harvesting may be managed among the six HTOs under section 5.7.6 of the Nunavut Agreement, and locally near each of the six communities under section 5.7.3 of the Nunavut Agreement.
2. This proposal was developed by the QWB in close consultation with the six affected HTOs, and all six HTOs have supported the proposal. Therefore, the QWB waives the need for a Public Hearing by the NWMB, of course at the NWMB's discretion.
3. To facilitate initial implementation of this proposal in 2022-23, the NWMB may prefer to approve interim implementation for a period of 1-5 years with subsequent reviews, at the NWMB's discretion
4. The NWMB could encourage the creation of a forum whereby the QWB, the HTOs, DFO and other co-management partners may exchange information on IQ, science and harvest management strategies and methods related to NEBI narwhal on an as-needed basis, at the NWMB's discretion.

Prepared by: Michael Ferguson, Qikiqtaaluk Wildlife Board

Date prepared: February 1, 2022

April 14, 2022

Hon. Joyce Murray
Minister of Fisheries and Oceans Canada
Government of Canada

Dear Joyce Murray:

Re: NWMB Decision on Qikiqtaaluk Wildlife Board's Request for Modifications to the Baffin Bay Narwhal Management System

NWMB Decision

At the Nunavut Wildlife Management Board's (NWMB or Board) Regular Meeting (RM001-2022) on March 9, 2022, the Qikiqtaaluk Wildlife Board presented a proposal requesting the Board to approve changes to the narwhal management system for the East Baffin Island, Eclipse Sound and Admiralty Inlet management units.

In its submission to the NWMB, the Qikiqtaaluk Wildlife Board (QWB) proposed the following modifications to the narwhal management system:

1. Combine East Baffin Island, Eclipse Sound and Admiralty Inlet management units into one management unit referred to by the Qikiqtaaluk Wildlife Board as Northern and Eastern Baffin Island (NEBI);
2. Establish a single Total Allowable Harvest (TAH) for narwhals in the waters of Northern and Eastern Baffin Island by merging the current TAHs for the narwhal stocks of East Baffin Island, Eclipse Sound and Admiralty Inlet;
3. Continue the allocation of 104 migratory season tags from the Somerset Island stock to two Qikiqtaaluk communities: Pond Inlet (53) and Arctic Bay (51);
4. Remove the seasonal non-quota limitation and establish one annual hunting season;
5. Enable the Qikiqtaaluk Wildlife Board to allocate the proposed NEBI TAHs among the six affected Hunters and Trappers Organizations (HTOs);
6. Support the Qikiqtaaluk Wildlife Board's and HTOs' jurisdictions to establish by-laws;
7. Continue to carry-forward unused allocated tags from one year to the next for each HTO.

The Qikiqtaaluk Wildlife Board's submission relied, in part, on a legal position adopted by its Executive Committee in December 2020 to assert that the *Nunavut Agreement* intended to give primacy to Inuit systems of wildlife management. In its submission, the Qikiqtaaluk Wildlife Board stated that “science and scientific systems of wildlife management are not specifically recognized or mentioned in Article 5 of the *Nunavut Agreement*”.

At the NWMB’s March 10, 2022, In-Camera Meeting (IC001-2022), the Board made the following decision:

> RESOLVED that, Pursuant to Section 5.2.34(d)(i) of the *Nunavut Agreement*, the Nunavut Wildlife Management Board is not ready to modify the management system for Baffin Bay narwhal at this time.
>
> Furthermore, the NWMB understands and acknowledges concerns that assumptions used to determine narwhal stock boundaries and the harvest allocation model used in the 2012 integrated fisheries management plan (IFMP) for the Baffin Bay narwhal population do not reflect Inuit Qaujimajatuqangit for narwhal movement. The NWMB confirms its willingness to receive updates to the IFMP that address and accommodate these concerns. The NWMB advises all co-management partners we will be particularly alert to assessing potential impacts of any proposed revisions or alternatives to the narwhal harvest allocation system on the conservation purpose of the current system, and on harvesters.

Reasons for NWMB Decision

In reaching its decision, the Board considered the Qikiqtaaluk Wildlife Board’s submission, oral and written submissions from the Department of Fisheries and Oceans (DFO) staff, and oral submissions from co-management partners.

The narwhal IFMP

DFO developed the narwhal IFMP through a consultative process that included input from all co-management partners. The main objectives of the narwhal IFMP are to maintain vital, healthy narwhal populations capable of sustaining harvesting needs while respecting the *Nunavut Agreement* and Fisheries and Oceans Canada’s precautionary approach to wildlife management. Based on the narwhal IFMP, the Baffin Bay narwhal population is managed as four individual stocks (East Baffin Island, Eclipse Sound, Admiralty Inlet and Somerset Island). This management strategy is intended to reduce potential local depletion. In addition, the division of the harvest season into a migratory and a summer season and the use of that harvest allocation model are intended to reduce the risk of over-exploitation that may occur when a smaller stock is assumed to be part of a larger and wider-ranging population. In 2012, the NWMB decided and the Minister accepted, to approve the narwhal IFMP on the condition that it be reviewed in 2017.

QWB Proposal

The QWB's proposal reflects concerns expressed by Inuit regarding the narwhal harvest management system. The QWB challenges the current definition of narwhal summer aggregation areas, arguing that the 2012 delineations and underlying assumptions do not reflect Inuit Qaujimajatuqangit of narwhal behaviour. Over the course of NWMB proceedings on narwhal management, including the 2012 IFMP proceeding, the NWMB has heard Inuit consistently share that narwhal move from one area to another during the summer. The NWMB understands Inuit have pointed out the delineation of summering stocks relied on a relatively small number of satellite tags and raised concerns about the reliability of the harvest allocation model assumptions.

The NWMB is aware that since 2012, new science and Inuit Qaujimajatuqangit information is now available, and a review of the narwhal IFMP is already overdue. The NWMB acknowledges that Inuit systems of wildlife management must be recognized in the Nunavut wildlife management systems, including the narwhal IFMP. The QWB and its constituent Hunters and Trappers Organizations express frustration with a narwhal management system that co-management partners increasingly accept needs to be updated. The longer this process takes, the more time passes since 2017 when the review was expected. Co-management partners need to take these concerns seriously and address themselves to make changes where warranted. The NWMB is aware that DFO has initiated a co-management working group to review the narwhal IFMP. The issues raised by the QWB are crucial for co-management partners and particularly for DFO to consider as the work of the working group proceeds. The NWMB supports a collaborative review process that considers and uses available Inuit Qaujimajatuqangit.

The QWB request to amalgamate management boundaries, remove non-quota limitations and to discontinue the use of the harvest allocation model represent significant changes to the narwhal management system and as proposed, they are to occur all at once. The QWB has not sufficiently explained how key features of their proposal would be implemented. This includes the justifying of its proposal with reference to potential future by-laws detailing its authority to allocate harvest and how their proposed management system would mitigate the risk of local depletion, which is an important conservation purpose justifying the current approach to management units in the Integrated Fisheries Management Plan. The NWMB is also concerned that potential impacts to harvesters in the Kitikmeot Region are not adequately understood or addressed.

Response from parties

The NWMB received submissions from other co-management partners at its Regular Meeting in March 2022. The NWMB heard from representatives of the Kitikmeot Regional Wildlife Board (KRWB) who were uncertain about potential negative impacts on Kitikmeot narwhal harvesters. KRWB stated that they desired more information on the potential impacts of the QWB proposal on the Somerset Island stock before they can decide if they support it. The NWMB accepts that the KRWB was not given sufficient time to study, understand and respond to the QWB's proposal.

The NWMB considered submissions on the QWB proposal from DFO. DFO raised concerns about potential impacts on harvesting in other regions, possible impacts on the sustainability of the flexible quota system and the possibility of local depletion.

Co-management partners also raised possible implications of the QWB's proposal for the international trade of narwhal products from Nunavut. Work is underway within DFO to review this concern and technical advice on the risk of a non-detrimental finding under CITES is pending.

The NWMB is concerned that making changes to the narwhal integrated management system at this time may have negative consequences to narwhal conservation, particularly if a viable alternative management system (including the necessary by-laws) is not available for the NWMB to review and consider when the proposal is received.

Primacy

In its proposal, the QWB asserted the intended "primacy" of Inuit systems of wildlife management as a justification for its proposal to remove existing conservation measures. When asked about this legal position, neither the QWB representative nor their legal counsel chose to provide any response. The NWMB acknowledges the primary role Inuit have in wildlife harvesting in Nunavut.[1] Article 5 recognizes the need for an effective system of wildlife management that recognizes Inuit systems of wildlife management that contribute to wildlife conservation.[2] However, without further explanation, the NWMB is not persuaded by the QWB's argument of primacy for Inuit systems of wildlife management in this case.

The *Nunavut Agreement* calls for wildlife management that *recognizes* Inuit systems that contribute to conservation. While addressing Inuit rights, the NWMB takes significant account of conservation principles when making its decisions. The NWMB understands its wildlife co-management mandate requires accounting for both Inuit Qaujimajatuqangit *and* science (science is a fundamental feature of modern conservation and conservation is a critical objective of the NWMB's wildlife management mandate). A combination of both worldviews tends to form the basis for NWMB decisions depending on the circumstances. However, the NWMB is not able to support a proposal that relies on an assertion of Inuit "primacy" without that position being explained.

By-laws

The NWMB makes decisions on the information before it. There were no QWB by-laws on narwhal harvest management provided to the NWMB for review. In this case, the QWB proposes an as-yet undrafted RWO by-law to replace an existing narwhal management system. The NWMB concerns itself with the effectiveness of any proposed management system that intends to satisfy a conservation purpose. There are unresolved questions about the specific mechanics of the proposed approach beyond the contributions of Inuit Qaujimajatuqangit to the definition of narwhal stock boundaries. The input of co-management partners is essential to the success of the Nunavut wildlife co-management system. Understanding the scope and content of a proposed approach to conservation requires co-management partner input and NWMB review. A proposal must be sufficiently developed for the NWMB to be confident it can achieve its intended aims. As submitted, the QWB proposal is not able to do so.

Co-Management

The QWB proposal does not appear to have made material changes to a similar proposal submitted almost two years ago. In this current proposal, the QWB relied on

[1] NA, s. 5.1.3(b)(ii)
[2] NA, s. 5.1.2(e)

Inuit Qaujimajatuqangit evidence, unexplained strategic legal positions, promised by-law development and assertive conduct to advance a proposal that includes potential impacts on effective conservation. The NWMB takes issue with QWB's characterization of the current state of co-management work on the narwhal management system as duress. The NWMB reminds all parties that saying disrespectful things about others has no place in its proceedings.

The QWB is one part of co-management. The NWMB is another. There are other partners, which include the RWOs, HTOs, Nunavut Tunngavik Inc. and DFO that are co-management partners for narwhal. The NWMB is aware of how important consultation with Inuit is where their rights could be affected. The term consultation can be used for the Crown's duty to consult (which would include any approval of the QWB's application by the Minister), and the NWMB's duty of fairness (which requires notice and the opportunity to respond before it makes decisions). Other co-management partners brought important factors to light in the consideration of the QWB proposal, persuading the NWMB that more discussion, or consultation, is necessary. The NWMB is particularly attentive to perspectives from Inuit who will be directly affected, notably Inuit in the Kitikmeot including KRWB and Kitikmeot HTOs that harvest narwhal, as well as the Arctic Bay HTO who would face significant impact from the proposal to modify or remove the Admiralty Inlet stock definition. Based on the submissions of the KRWB and NTI in the Regular Meeting, the NWMB understands more time is needed to study, understand and respond to the proposal and its potential impacts. In describing the consultation as inadequate, the NWMB re-states this is in relation to the NWMB's duty of fairness and *not* the Crown's duty to consult.

In this decision, the NWMB provides its perspective on these key issues as the review proceeds. The current narwhal conservation system seems to be generally functional, is now under active review and draws its origins from a decision made after a co-management proceeding. The issues involved in narwhal management are also complex. Changing one part of the system, such as the definition of stock boundaries, will impact other parts of the narwhal management system. Those impacts require adequate explanation, or at least additional time for co-management partners to understand. The NWMB will not remove a conservation measure without a better understanding of the impacts of what will replace it. In this case, the QWB has not met the burden of introducing sufficient evidence to support its application.

Conclusion

The NWMB supports a collaborative approach with respectful communication on the revision of the IFMP and calls on co-management partners to make a sincere effort at constructive dialogue. Going forward, the NWMB intends to have a more active role in contributing to the work of the narwhal working group. NWMB calls on co-management partners to consider the evidence about narwhal locations and stock definition presented by the Qikiqtaaluk Wildlife Board during work to revise the narwhal IFMP. Inuit evidence about current narwhal stock definitions in East Baffin Island, Eclipse Sound, Admiralty Inlet and Somerset Island, with potential implications to the harvest allocation for those narwhal stocks, must be seriously considered as part of the IFMP revision process.

The NWMB looks forward to your reply and completion of the *Nunavut Agreement* Article 5 decision-making process. If you have any questions regarding this letter, please do not hesitate to contact the NWMB.

Sincerely,

Daniel Shewchuk

Daniel Shewchuk
Chairperson
Nunavut Wildlife Management Board

cc: Gabriel Nirlungayuq, Department of Fisheries and Oceans Canada.

Minister of
Fisheries and Oceans

Ministre des
Pêches et des Océans

Ottawa, Canada K1A 0E6

June 10, 2022

Mr. Daniel Shewchuk
Chairperson
Nunavut Wildlife Management Board
Box 1379
Iqaluit, Nunavut
X0A 0H0

Dear Mr. Shewchuk:

Thank you for your correspondence of April 14, 2022 in which you conveyed the Nunavut WildlifeManagement Board's (NWMB) decision with respect to the Qikiqtaaluk Wildlife Board's (QWB) Request for Modifications to the Baffin Bay Narwhal Management System. I wish to commend the members of the Board and its staff for the thorough and thoughtful analysis that has informed the Board's decision:

"RESOLVED that, Pursuant to Section 5.2.34(d)(i) of the *Nunavut Agreement*, the Nunavut Wildlife Management Board is not ready to modify the management system for Baffin Bay narwhal at this time."

Pursuant to Section 5.3.18 of the *Nunavut Agreement,* I accept the Board's decision to not modify the management system for Baffin Bay narwhal at this time.

I am pleased to learn of the NWMB's intention to take a more active role in the work of the Narwhal Working Group. In my view, a collaborative co-management review of the Integrated Fisheries Management Plan for Narwhal in the Nunavut Settlement Area (IFMP) offers a better approach to exchange information and develop recommendations collaboratively. I look forward to the outcome of this review, and the recommendations proposed to better reflect the most current information from all knowledge streams, especially Inuit Qaujimajatuqangit pertaining to narwhal movement.

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My department remains committed to working with all Nunavut co-management organizations to make resource management decisions that respect the *Nunavut Agreement* and include the best available knowledge sources and systems. I look forward to our continued collaboration in the co-management of the Nunavut narwhal fishery.

Yours sincerely,

The Honourable Joyce Murray, P.C., M.P.
Minister of Fisheries, Oceans and the Canadian Coast Guard

CONSIDERATIONS FOR A NEW NARWHAL MANAGEMENT SYSTEM: SUSTAINABILITY OF NARWHAL AROUND NORTHERN AND EASTERN BAFFIN ISLAND

CONTEXT

The Qikiqtaaluk Wildlife Board (QWB) submitted a Request for Decision to the Nunavut Wildlife Management Board (NWMB) in June 2020 and March 2022. They proposed an evidence-based modification to the existing management system for the Baffin Bay narwhal (*Monodon monoceros*). The NWMB acknowledged concerns that the assumptions used to determine the narwhal stock boundaries and the harvest allocation model used to inform the 2013 Integrated Fisheries Management Plan (IFMP) do not reflect Inuit Qaujimajatuqangit (IQ), specifically narwhal movement patterns. The NWMB called on co-management partners to consider the evidence about narwhal stock definitions presented by the QWB while revising the narwhal IFMP. In order to revise the IFMP in a manner that addresses these concerns, Fisheries and Oceans Canada (DFO) Science advice is requested regarding new information to support narwhal stock delineation, and assessing the risks of managing the Baffin Bay narwhal population based on combining different narwhal stocks with and without seasonal harvesting windows. The results from this meeting will contribute to future revisions to the IFMP for narwhal in the Nunavut Settlement Area.

The objectives of this peer review will be to provide Science advice on the sustainability of Baffin Bay narwhal by:

1. Reviewing assumptions and currently available scientific evidence related to stock delineation;
2. Conduct a risk assessment for each of the scenarios listed below to inform sustainability:
    a) Four independent stocks (East Baffin Island [EBI], Eclipse Sound [ES], Admiralty Inlet [AI], and Somerset Island [SI]): An updated version of the 2011 Harvest Allocation Model (HAM) (Richard 2011) based on the latest scientific knowledge (including narwhal movements between management units as described in DFO 2020), both with (1A) and without (1B) separate seasons.
    b) Three separate management units without summer and migratory seasons: i) combined EBI and ES, ii) AI, and iii) SI stocks.
    c) Three separate management units without summer and migratory seasons: i) combined ES and AI, ii) EBI, and iii) SI stocks.
    d) Two separate management units without summer and migratory seasons: i) combined EBI, ES and AI, and ii) SI stocks.
    e) A single management unit comprised of the EB, ES, AI and SI stocks without summer and migratory seasons.
    f) Sustainability of the current harvest in ES without summer and migratory seasons.

g) The maximum sustainable harvest that could be allocated to any hunting region in Baffin Bay.

3. Identifying uncertainties, challenges, and limitations to the risk assessment.

This Science Response Report results from the Canadian Science Advisory Secretariat (CSAS) regional peer review held on January 14, 2025, on the Considerations for a New Management System: Sustainability of Narwhal in Northern and Eastern Baffin Island.

REVIEWING ASSUMPTIONS AND CURRENTLY AVAILABLE SCIENTIFIC EVIDENCE RELATED TO STOCK DELINEATION

Narwhals are mid-sized toothed whales that live in the Atlantic part of the Arctic Ocean. In the summer, they can be found in the inshore bays and fjords of the Canadian Arctic archipelago and Greenland (Watt 2017). When autumn arrives and fast ice forms, narwhals migrate to Baffin Bay and Davis Strait (Figure 1; Shuert et al. 2022). In the spring, narwhals gather along the ice edges on the east coast of Baffin Island and along the ice edges of West Greenland (Heide-Jørgensen et al. 2013). Narwhals are hunted during their spring and fall migration from communities along the migration route.

Sustainable management of hunting typically divides species into management units, or stocks (hereafter referred to as stocks) that are thought to be self-sustaining, and often defined using a multiple lines of evidence approach (Hobbs et al. 2019, IWC 2000, IWC 2002) that may include genetic indicators, residency time, site-fidelity, or other life history characteristics (Begg et al. 1999, Hobbs et al. 2019). Movement of animals among hunting regions, and hunting regions in which hunters have access to more than one stock, pose a particular challenge for ensuring individual stocks are managed sustainably (Allen and Singh 2016). Management units should be defined such that local decline in abundance is avoided, and that local stock declines will recover to healthy levels on a management timescale (the timeframe within which recovery is expected or idealized); the scale of ‘local’ (geographic area) depends on management objectives. Preservation of stocks is advantageous because variability in genetics and/or culture provides species resiliency (Brakes et al. 2019), which is particularly important in the Arctic, where the climate is changing at an unprecedented rate (Rantanen et al. 2022). In cases where stock delineation is complex, it is generally more precautionary to assume greater subdivision than to assume less (Taylor 1997, Taylor and Dizon 1999). Localized stock declines are probable if site fidelity is not expressly considered in harvest management (Cope and Punt 2009).

Richard (2010) summarized the history of stock designations for Canadian narwhal. Two management stocks were initially identified: the High Arctic stock (later named the Baffin Bay stock) and the Northern Hudson Bay stock (Strong 1988). Tracking evidence of individual fidelity to summer aggregation areas supported the refining of the Baffin Bay stock into further sub-units. Richard (2010) used four types of information to define summer stocks: 1) seasonal range and aggregations based on local knowledge and reports (not reviewed herein as it is outside the scope of DFO Science’s review to evaluate Inuit Qaujimajatuqangit), 2) appearance and behaviour (not reviewed herein as it is outside the scope of DFO Science’s review to evaluate Inuit Qaujimajatuqangit), 3) genetics and contaminants, and 4) seasonal range and aggregations based on satellite telemetry data. Evidence from genetic, contaminant and tracking data supports the definition of the Northern Hudson Bay summer aggregation as a separate stock, while the evidence for defining Baffin Bay stocks was strongest from tracking data and weakest from genetics and contaminants; however, Richard (2010) argued that differences among stocks may be overshadowed by the fact that many landed animals are caught during seasons of migration, thus resulting in a mix of different stocks being sampled. Ultimately, Richard (2010) recommended an approach to reduce the chances of a localized stock decline by considering summer aggregations as separate stocks to provide scientific advice on Total Allowable Landed Catch (TALC). Richard (2011) developed a decision tool for resource managers, referred to as the Harvest Allocation Model (HAM). The allocation tool is based on a spatial model of the source and degree of stock mixtures that are hunted and produces possible solutions that maximize the catch, particularly for communities with large historic narwhal catches, while minimizing the risk of over-exploitation of any one stock. The major assumption of this tool is that whales are available to hunters in other regions during migration based on their migration route and in proportion to their summer stock size. This tool was considered an improvement over assuming that harvesters only take from the summer aggregation in their local area (Richard 2011).

As a result of that science advice and subsequent consultation, management of narwhal in Canada currently considers seven stocks, including six in the Baffin Bay population (Doniol-Valcroze et al. 2015) plus one in northern Hudson Bay (excluded in this response). Management of harvests by summer stocks is considered a precautionary approach (Richard 2010, Doniol-Valcroze et al. 2015). The Precautionary Approach is a general philosophy to managing threats of serious or irreversible harm where there is scientific uncertainty (DFO 2006, 2009). The Government of Canada developed the Federal Framework for the Precautionary Approach to ensure that caution would be applied consistently across disciplines in the government, and this became policy in 2003 (DFO 2006, 2009). Under this policy, risk tolerance levels are defined (e.g., <5% risk of decline is very low risk, 25-50% is moderate risk, and 75-95% is high risk), and management is responsible for choosing their risk tolerance level.

The six Baffin Bay narwhal stocks currently recognized in Canada are: 1) Somerset Island (SI), 2) Admiralty Inlet (AI), 3) Eclipse Sound (ES), 4) East Baffin Island (EBI), 5) Jones Sound (JS), and 6) Smith Sound (SS) (Richard 2010, Doniol-Valcroze et al. 2015) (Figure 1). All six summer stocks were surveyed in 2013 (Doniol-Valcroze et al. 2015). There are two other Baffin Bay summering aggregations, in Melville Bay and Inglefield Bredning, but these two stocks are found only in Greenland during the summer and are not considered in DFO's management of Canadian narwhal harvests. Scientific evidence for the stock delineation in Baffin Bay narwhal relies on multiple lines of evidence, which are reviewed below.

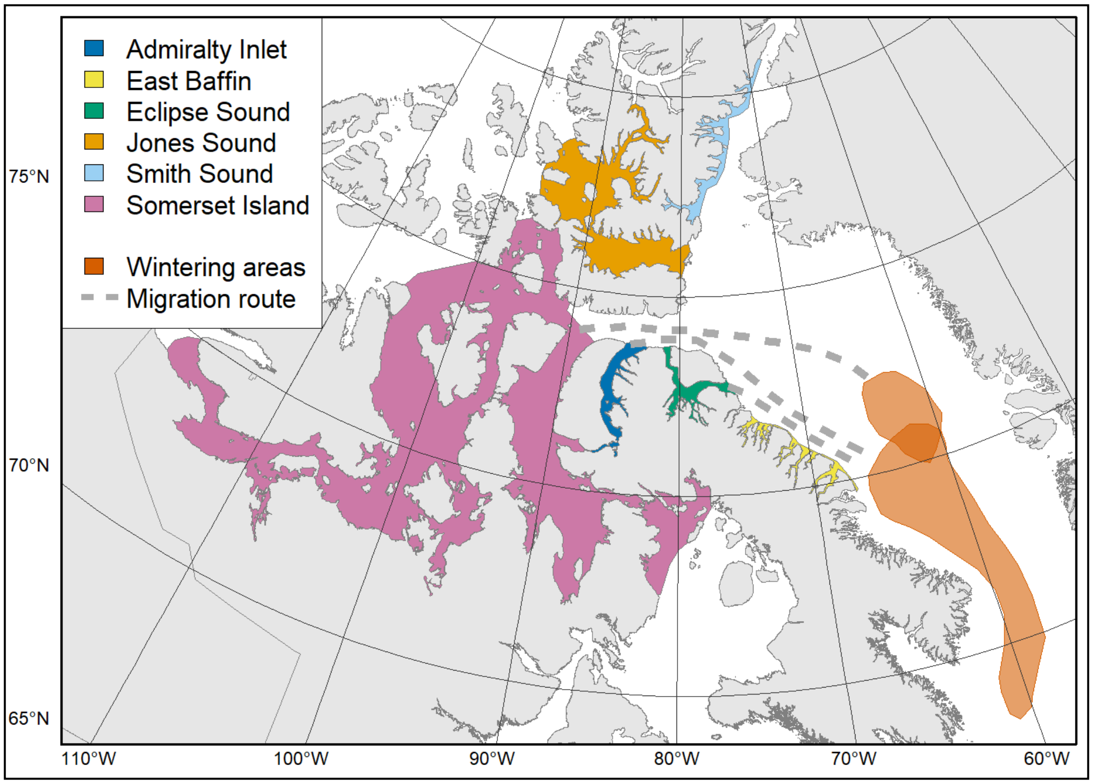

Figure 1. Map of the current summer management areas in Canada for narwhal from Baffin Bay with approximate wintering areas and migration routes (adapted from Heide-Jørgensen et al. 2013). Blue is Admiralty Inlet, yellow is East Baffin, green is Eclipse Sound, orange is Jones Sounds, light blue is Smith Sound, pink is Somerset Island, dark orange is the overwintering areas, and the dashed line is the migration route.

Contaminant Data

Analysis of pollutant loads in marine mammal tissues has been useful for discriminating between populations of marine mammals with limited knowledge on migration patterns (Frank et al. 1973, Taruski et al. 1975). Contaminant concentrations vary due to prey composition in different foraging locations and can be used to discriminate marine mammal populations (Aguilar 1987). A study using organochlorine contaminants showed that narwhals from several different hunting locations, including JS, ES, and EBI, had different contaminant profiles (de March and Stern 2003). The study included 125 narwhal samples, 18 from JS, 25 from ES, and 64 from EBI.

Stable Isotope and Trace Element Data

Chemical composition of tissues can act as a biological tag to discriminate among groups of animals that inhabit different areas (Kerr and Campana 2014). Watt et al. (2012a) used discriminant analysis of stable isotopes of nitrogen and carbon in narwhal skin and found a significant difference between the AI and ES stocks in the spring and summer, and in a model that included all hunting areas regardless of season (Watt et al. 2012a). This study relied on 129 samples from ES and 76 samples from AI (Watt et al. 2012a). Following this, stable isotope and trace element analyses were used in conjunction with narwhal skin from five stocks in the eastern Canadian Arctic based on collections from 1990 to 2015 (Watt et al. 2019a). In this study, they defined biomarkers representing the migratory season as those from hunts occurring from 26 April to 31 July, although this also integrates some of the signal from the wintering area; they refer to this time frame as the migratory period. They defined the summer residency period as 1 August to 30 September, and there were no samples collected after 30 September (Watt et al. 2019a). Discriminant analysis showed a significant difference between AI (n=19) and ES (n=47) stocks in the summer residency period, and both differed from JS (n=31) and SI (n=14) (Watt et al. 2019a). During the spring migration season (n=55), there was more overlap and less distinction among stocks, but 75% of whales were still classified correctly to their defined summer stock in both the migration and summer residency periods (91% for ES, 68% for AI, and 64% for SS; Watt et al. 2019a). Stable isotopes and trace element analysis provide a promising method to distinguish stocks, but these analyses were limited based on sample size and did not include narwhal harvested in summer in East Baffin Island (Watt et al. 2019a). A strong harvest sampling program that provides information on the location and timing of sample collection is needed to explore these methods further.

Genetic Data

Genetic studies on narwhals have focused both on nuclear (nDNA) and mitochondrial (mtDNA) DNA. Population geneticists use nDNA to identify genetic populations (Waples and Gaggiotti 2006), but mtDNA allows identification of geographic patterns in maternally inherited loci, which is particularly important for narwhal because they are hypothesized to be matrifocal in social structure (Palsbøll et al. 1997, Whitehead 1998).

nDNA

Petersen et al. (2011) genetically profiled 268 narwhals using 15 microsatellite markers and, using principal component analyses (PCA), were able to differentiate some summer narwhal aggregations. The analysis suggested that narwhals from JS (n=42) and SI (n=12) summering stocks were differentiated, but there was no discrimination among the Baffin Island narwhal stocks (n = 89) (Petersen et al. 2011). In 2024, de Greef et al. (2024) used whole genome sequencing of tissues of 60 narwhals and found that despite low overall genetic variation there was evidence of genetic structure supporting two groupings in the Baffin Bay population: 1) JS and SI (western Baffin Island (Aujuittuq (Grise Fiord; n=10), Qausuittuq (Resolute Bay; n=8), and Taloyoak (n=5)); and 2) AI, ES, and EBI (Panniqtuuq (Pangnirtung; n=1), Qikiqtarjuaq (n=4), Kangiqtugaapik (Clyde River; n=2), Mittimatalik (Pond Inlet; n=4), Ikpiarjuk (Arctic Bay; n=9), Kugaaruk (n=3), Igloolik (n=2)) (de Greef et al. 2024). Identification of these groups remained consistent in PCAs that were filtered for different time frames for harvesting months.

mtDNA

Narwhal mtDNA has also been explored, and despite overall low genetic variation, the frequencies of common haplotypes differed between eastern Canada and Greenland. Still, samples from Canada were grouped (n=29) (Palsbøll et al. 1997). Another study evaluating mtDNA in 433 narwhals found that narwhals from JS (n = 39) were weakly differentiated from those hunted in other Canadian locations, but no differences were found among Canadian harvest locations (de March et al. 2003). Postma (2017) re-evaluated mtDNA in 93 narwhal samples and found that narwhals had low genetic variability (only 1.3% variability within their DNA) and did not detect any structure. However, both authors acknowledged that the power to detect differences may have been low because of small sample sizes (de March et al. 2003, Postma 2017). A re-investigation into narwhal mtDNA from a greater number of samples in Canada may assist in genetic delineation, as it has in beluga whales (*Delphinapterus leucas*), the narwhal’s closest living relative (Montana et al. 2024). However, samples from subsistence harvests, environmental DNA, or remote biopsy of free-ranging narwhal are needed to conduct such a study.

Satellite Telemetry Data

Annual site fidelity

Nine satellite-linked tags equipped on narwhals transmitted for a full year, allowing for the assessment of inter-annual site fidelity based on individuals that returned in spring to the summering area where they were tagged the previous year (Table 1). Six of the eight whales re-entered the area where they were tagged the previous year. Two other whales were close to (and heading toward) the summering area where they had been tagged the previous summer, but contact with the transmitter was lost before they were inside the summering range (Heide-Jørgensen et al. 2013). The last narwhal that had a tag for over a year was tagged in ES in late August 2010, and it did not return to ES the following summer (Table 1; Watt et al. 2012b).

Table 1. Satellite tags that have lasted over one year to provide information on narwhal site fidelity (adapted from Heide-Jørgensen et al. 2013, with additions from Watt et al. 2012b).

Putative stock	Years	n	Observation	Reference
Somerset Island	2001-2002	2	Two whales tagged in 2001 returned to the summering area the following year	Heide-Jørgensen et al. 2003
Somerset Island	2001 & 2006	1	One whale tagged in 2001 was resighted in Lancaster Sound 5 years later while on its return migration toward Somerset Island	Heide-Jørgensen et al. 2008
Admiralty Inlet	2004-2005	1	One whale tagged in 2004 returned to the ice edge at Admiralty Inlet in June–July 2005 but departed again and went east in Lancaster Sound, passing the ice edge at Navy Board Inlet en route to the north coast of Baffin Island. Contact was lost before the August destination could be determined.	Dietz et al. 2008
Admiralty Inlet	2009-2010	1	One whale migrated back to the mouth of Admiralty Inlet and was last recorded a few tens of kilometres inside the inlet in June 2010	Heide-Jørgensen et al. 2013
Eclipse Sound	2010-2011	1	One female narwhal tagged in August 2010 in Eclipse Sound, overwintered in the Davis Strait, and when she returned north, she continued travelling west, past Eclipse Sound and into Admiralty Inlet on July 28, 2011. This female remained in Admiralty Inlet for at least two months until the tag stopped transmitting on October 10, 2011	Watt et al. 2012b
Northern Hudson Bay	2006-2007	2	Two whales tagged in Lyon Inlet in 2006 were tracked back to the same general area in June the following year	Westdal et al. 2010
Melville Bay	2007-2008	1	One whale tagged in 2007 returned the following year to the exact same area	Heide-Jørgensen et al. 2013

Summer site fidelity

One hundred and three satellite tags have provided information on the summer site fidelity of narwhal in Canada to summering grounds. These tags show that most (99/103; 96%) narwhals tend to remain in the summer aggregation areas where they were captured in the summer season (Dietz et al. 2001, Dietz et al. 2008; Marcoux and Watt 2021; Table 2). However, four narwhals (three in 2017 and one in 2010) tagged in ES visited the AI management area within the summer (24 July to 24 August) or the summer they were tagged. In 2017, this corresponded to 36 days spent in the AI management area out of the total 250 days (14%) of the summer period, during which the nineteen narwhals were tagged (Marcoux and Watt 2021).

Table 2. Total number of satellite tags equipped on narwhal in the summer (24 July to 24 August) and the proportion of those tags that were available to hunters in another summer aggregation in the summer season. Note that whales were not usually tagged at the beginning of the defined summer period and therefore only represent a portion of the summer season (see Table A1 for tagging dates and the contribution of each of the tags to the summer season; see Figure A1 and A2 for tagging tracks in the summer and outside of the summer, respectively).

Stock	Number available	Total tagged narwhal	Comments
Somerset Island	0	16	All narwhal tags remained in the Somerset Island management area in the summer.
Admiralty Inlet	0	40	All narwhal tags remained in the Admiralty Inlet management area in summer.
East Baffin Island	NA	NA	No whales have been satellite tagged in East Baffin Island
Eclipse Sound	4	47	4 of 47 narwhal tagged in Eclipse Sound were available to hunters in the Admiralty Inlet management area in summer. Another 11 satellite tags have been equipped on narwhal from Eclipse Sound, but they were not equipped until fall and therefore do not contribute information on the proportion available in another management area in summer.

CONDUCT A RISK ASSESSMENT FOR EACH OF THE SCENARIOS

DFO Science was requested to assess the risk of managing narwhal under seven different scenarios that separate or amalgamate management units as defined above. The requested scenarios only involve four of the six Baffin Bay narwhal stocks that are currently recognized in Canada, and as a result, Jones Sound and Smith Sound stocks are not evaluated herein.

The goal of this assessment was not to redefine narwhal stocks, but rather to assess the risk of decline associated with each scenario based on the existing stock delineation used for narwhal management in Canada (Richard 2010). The risk assessment aims to evaluate the impact of each scenario on the sustainability of the narwhal. How DFO considers sustainability depends on whether the stock is data-rich or data-poor. For a stock to be considered data-rich, it requires three or more abundance estimates over a 15-year period, the last estimate being ≤ 5 years old, and current information on fecundity and/or mortality; in this case, sustainable levels of harvest are considered using reference points based on maximum sustainable yield (Hammill and Stenson 2007). For data-poor stocks, such as narwhal, DFO uses the potential biological removal (PBR) to determine sustainability (Hammill and Stenson 2007). The goal of PBR is to allow the stock to reach its maximum sustainable population size (the number of animals that will result in maximum productivity of the population) (Wade 1998). In the assessment of each scenario below, we rely on PBR to evaluate the level of harvest that would maximize the productivity of the stock.

In all cases, the PBR was calculated following Wade (1998) (see below) for each scenario, and the PBR was then divided by the loss rate (1.28 [Richard 2008]) to calculate a revised total allowable landed catch (TALC) for all possible scenarios.

$$PBR = 0.5 * R_{Max} * N_{Min} * F_R$$

Where: $N_{Min} = N/exp\ (z \sqrt{ln\ (1+CV^2)})$

the 20th percentile of the log-normal distribution of the estimated population size (Table 1) (Wade 1998) calculated from N, the abundance estimate, and its associated coefficient of variation (CV).
z = a standard normal variate and equals 0.842 for the 20th percentile.

R_{Max} = maximum rate of increase for the stock. The default for cetaceans when the rate is unknown is 0.04. It is then multiplied by 0.5 to simulate the effect of logistic density-dependent growth.

F_R = recovery factor set to 1.0 for a healthy stock (Wade and Angliss 1997) to be consistent with the recovery factor used in the most recent published science advice (Doniol-Valcroze et al. 2015).

TALC = PBR/loss rate (1.28)

Where loss rate is the total hunting mortality (considers the number of animals landed, the animals struck and lost, and the number of animals wounded and escaped, divided by two (assuming half of the animals wounded and escape later die of their wounds)) divided by the landed catch (Richard 2008).

Abundance estimates and CVs from the individual stocks were added together; for instance, for Scenario 2, EBI and ES abundances were added together (from Table 2), which results in a smaller CV, larger N_{Min}, and a larger PBR for combined stocks (Wade 1998).

We then used a model, first described by Wade (1998) and later used by Richard and Young (2015) and by Watt et al. (2019b), to evaluate the risk of decline of the smallest stock (Eclipse Sound) based on the new PBRs calculated. The population dynamics model uses a discrete form of the generalized logistic equation minus PBR. In the model, we assume the full TALC is taken every year, and we do not recalculate PBR since the time-lag for revising quotas is unknown.

The population model used here includes a random parameter for process error, W_t, to reflect natural variation in population processes:

$$N_{t+1} = W_t * (N_t + N_t * R_{max}\ [1 - (N_t /K)^{\theta}] - PBR)$$

where:

$$W_t = exp\ (z * 0.05 - 0.05^2 / 2)$$

z = is a random normal deviate = (-2*Log(Uniform(0,1))*Cos(2*π*Uniform(0,1))

Since there is little evidence for what a realistic fixed value for defining process error is for any marine mammal population, we used the same arbitrary value of 0.05 used by Richard and Young (2015). This value is consistent with the hypothesis that population dynamics of long-lived narwhals are not highly variable (Richard and Young 2015).

N_t = stock size at year t; N0 for ES starts at 2016 with an abundance estimate of 12,039 (Marcoux et al. 2019)

R_{max} = maximum net recruitment rate set as the default value for cetaceans of 0.04 (see above)

K = the pre-exploitation size or carrying capacity of the stock, assumed at 25,000 (Richard and Young 2015)

θ = the density-dependent shape parameter, 1 in this case for maximum net productivity at 50% K (logistic growth)

We ran 10,000 model simulations and present the median and 95% confidence interval of the stock abundance projection for each scenario. We also estimated the probability that the stock declines 20 years in the future.

Scenario 1

Four independent stocks (EBI, ES, AI, and SI): An updated version of the HAM (Richard 2011) based on the latest scientific knowledge and including narwhal movements between management units as described in DFO (2020), both with (1A) and without (1B) separate seasons.

The first part of this Scenario (1A) assumed that the EBI, ES, AI and SI are independent stocks as described in Richard (2011) and that hunters from Pond Inlet, Arctic Bay, Qikiqtarjuaq and Clyde River have access to a mix of stocks during the fall and spring migration (i.e., with separate seasons). The assumption from Richard (2011) that narwhals do not mix in the summer was updated to account for a small proportion of narwhals from ES that visit AI during the summer (9.76%; see Table 2).

The HAM tool (Richard 2011) was used to evaluate this scenario. As suggested in Richard (2011), catches were fixed for the western communities (Resolute Bay, Gjoa Haven, Taloyoak, Kugaaruk, Igloolik and Hall Beach), using the value of their current quota (450 narwhals; DFO 2023); however, for Pangnirtung and Iqaluit we did not fix catches but instead included them within EBI since the summer hunt of narwhal comes from this stock.

One of the inputs of this tool is the proportion of the hunt in each stock that occurs in the summer. For this input, we calculated the proportion of the hunt in summer from catch statistics from the most recent publicly available data (2006 to 2015; Watt and Hall 2018), where summer was defined as 24 July to 24 August. Summer dates are currently defined by the individual Hunters and Trappers Organizations/Associations in Canada; however, the dates of 24 July-24 August are being used in these scenarios as they are defined based on narwhal telemetry data collected over the past 30+ years that show that some narwhal move among stocks after 24 August. Additionally, these dates are used by the joint scientific working group of the North Atlantic Marine Mammal Commission (NAMMCO) on the Population Status of Narwhal and Beluga in the North Atlantic and the Canada/Greenland Joint Commission on Conservation and Management of Narwhal and Beluga (JCNB) (NAMMCO-JCNB Joint Working Group 2021).

Based on these dates, the proportion of the harvest taken in the summer was 0.47, 0.48 and 0.24 for communities in AI, ES, and EBI, respectively.

The TALC was based on the most recent abundance estimates and science advice available for this population (Doniol-Valcroze et al. 2015, Marcoux et al. 2019) (Table 3). The current quotas, however, are decided upon through co-management and are currently 450 for Somerset Island, 195 for Admiralty Inlet, 190 for Eclipse Sound, and 300 for East Baffin Island (DFO 2023).

Based on the tagging information presented above, we assumed that 9.76% of the narwhals from ES moved to AI during the summer. Therefore, the narwhal hunt from AI is a mix of both stocks, the abundance of the AI stock (N) plus the number of narwhals (9.76% of 12,049 or 1,175) that move from ES to AI.

We explored iterations of the tool, starting with catches 50 below the TALC up to the value of the TALC, without exceeding it. We sought to optimize solutions that 1) maximize the sum of all the catches, 2) maximize the catch in AI, 3) ES and 4) EBI, while maintaining the total catch per stock below the TALC (Table 4, Figure 2). In this scenario, there is a 38.5% probability that the ES stock declines in the next 20 years.

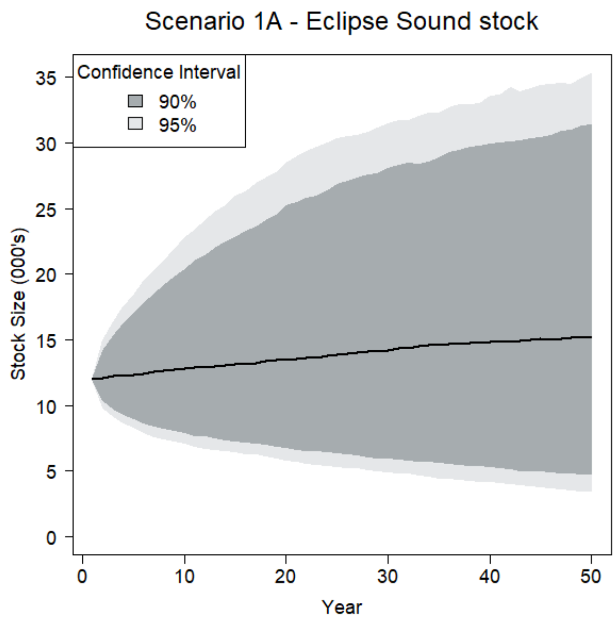

Figure 2. Stock abundance median projection for Scenario 1A that maximizes catch in Eclipse Sound (ES) while maintaining the total catch per stock below the TALC.

For the second part of the Scenario (1B), if there are no migratory harvest tags (i.e., without separate seasons), then we assume that the entire catch comes from summering aggregations of four stocks: AI, ES, EBI and SI narwhal. In this case, the PBRs and TALCs for each stock are indicated in Table 4. For this scenario to be sustainable, the entire hunt should take place during the summer season, as defined from 24 July to 24 August. With that scenario, there is a 38.5% chance that the ES stock declines in the next 20 years. Alternatively, we evaluated a scenario where the harvest only occurs during the migratory season (i.e., before 24 July and after 24 August) and calculated sustainable TALCs (Table 4).

For scenarios 2-5, we were not provided information on how the TALCs from the newly calculated PBRs would be allocated across management units. As a result, we have run three theoretical possibilities to evaluate risk under each scenario. The first is a worst case scenario (A) in which the entire PBR is allocated to Eclipse Sound, (B) represents allocation to management units in proportion to their abundance (which is an assumption of the HAM as well), and (C) represents if harvests were allocated to management units proportionally to the number of people living in communities included in the management unit (albeit excluding the census for Iqaluit, which is the only city in Nunavut and that only harvests narwhal occasionally).

*Table 3. Potential biological removal (PBR) and Total Allowable Landed Catch (TALC) for the Admiralty Inlet (AI), Eclipse Sound (ES), East Baffin Island (EBI), and Somerset Island (SI) narwhal stocks using the most recent published abundance estimates and coefficient of variance (CV) for narwhal stocks in Canada. *Indicates the largest TALC which could be sustainably allocated to any hunting region in Canada, regardless of the time of year.*

Stock	Year	Abundance (CV)	PBR	TALC
AI	2013	35043 (0.42)	498	389
ES	2016	12039 (0.23)	150	117*
EBI	2013	17555 (0.35)	264	206
SI	2013	49768 (0.20)	842	658

Table 4. Potential biological removal (PBR) and Total Allowable Landed Catch (TALC) using the most recent published abundance estimates for narwhal stocks in Canada. The summer proportions used in the Harvest Allocation Model were 0.47, 0.48 and 0.24 for Admiralty Inlet (AI), Eclipse Sound (ES), and East Baffin Island (EBI), respectively, and the resulting TALCs for the migratory season (TALCM) and summer season (TALCS) are presented. Scenarios were explored up to the maximum TALC for AI, ES, and EBI stocks, while also considering that 9.76% of ES whales are available in AI.

Scenario	Stock	PBR	$TALC_M$	$TALC_S$	$TALC_{M+S}$
1A With season - maximizes cumulative harvest and the harvest in AI and EBI	AI	498	208	181	389
	ES	132	54	49	103
	EBI	264	157	49	206
	SI	576	-	-	450$^{\pm}$
With season - maximizes harvest in ES	AI	434	181	158	339
	ES	150	61	56	117
	EBI	233	138	44	182
	SI	576	-	-	450$^{\pm}$
1B Without season – summer hunt only	AI	513	0	400	400
	ES	135	0	104	104
	EBI	264	0	206	206
	SI	842	0	450 ±	450$^{\pm}$
Without season – migration hunt only - maximizes harvest in AI and EBI	AI	444	347	0	347
	ES	73	57	0	57
	EBI	264	206	0	206
	SI	576	450	0	450$^{\pm}$
	AI	421	329	0	329

Scenario	Stock	PBR	$TALC_M$	$TALC_S$	$TALC_{M+S}$
Without season – migration hunt only - maximizes harvest in ES and EBI	ES	96	75	0	75
	EBI	264	206	0	206
	SI	576	450	0	450$^{\pm}$

$^{\pm}$ *As suggested in Richard (2011), the TALC for Somerset Island (SI) was fixed to reflect the current quota.*

Scenario 2

Three separate management units without summer and migratory seasons: i) combined EBI and ES, ii) AI, and iii) SI stocks.

If there are no migratory harvest tags, then we assume the entire catch comes from a fully mixed summering aggregation of three stocks: EBI-ES, AI, and SI narwhal, respectively. If the assumption that the whales in ES-EBI are fully mixed is not met, a worst-case scenario is that the whole harvest of the ES-EBI sustainable take is allocated to the smallest portion of that stock (ES). The model simulations for this scenario indicate that the ES stock would reach zero in approximately 39 years (Figure 3A) and has an 84.1% chance of decreasing in the next 20 years. If harvest is allocated in proportion to stock or population abundance and the assumption that whales in ES-EBI are fully mixed is not met, the ES stock has a 46.2% and 43.2% probability of decline in the next 20 years, respectively (Figure 3B and C).

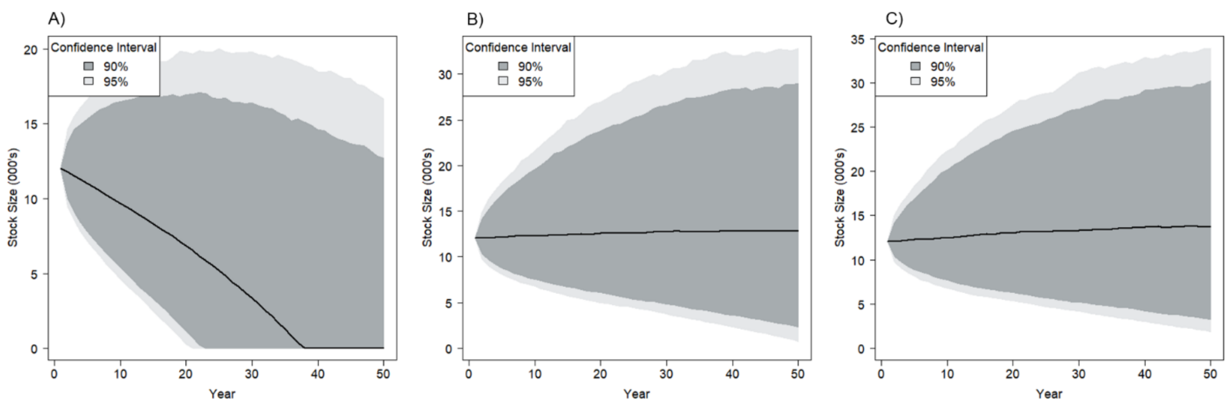

Figure 3. Stock abundance median projection for Eclipse Sound (ES) (the smallest stock) for Scenario 2 if the assumption that the ES and the East Baffin Island (EBI) narwhals mix in summer is incorrect and BRPBR is allocated A) fully to the ES summering ground, B) in proportion to the stock abundance, or C) in proportion to census population for each management unit.

Scenario 3

Three separate management units without summer and migratory seasons: i) combined ES and AI, ii) EBI, and iii) SI stocks.

If there are no migratory harvest tags, then we assume the entire catch comes from a fully mixed summering aggregation of three stocks: AI-ES, EBI and SI narwhal, respectively. If the assumption that the whales in AI-ES are fully mixed is not met, a worst-case scenario is that the whole harvest of the AI-ES sustainable take is allocated to the smallest portion of that stock (ES), and this would drive the ES stock to zero in approximately 23 years (Figure 4A) and has a 96.5% chance of decreasing in the next 20 years. If harvest is allocated in proportion to stock or population abundance and the assumption that whales in AI-ES are fully mixed is not met, the ES stock has a 44.0% and 78.6% chance of decline in the next 20 years, respectively (Figure 4B and C).

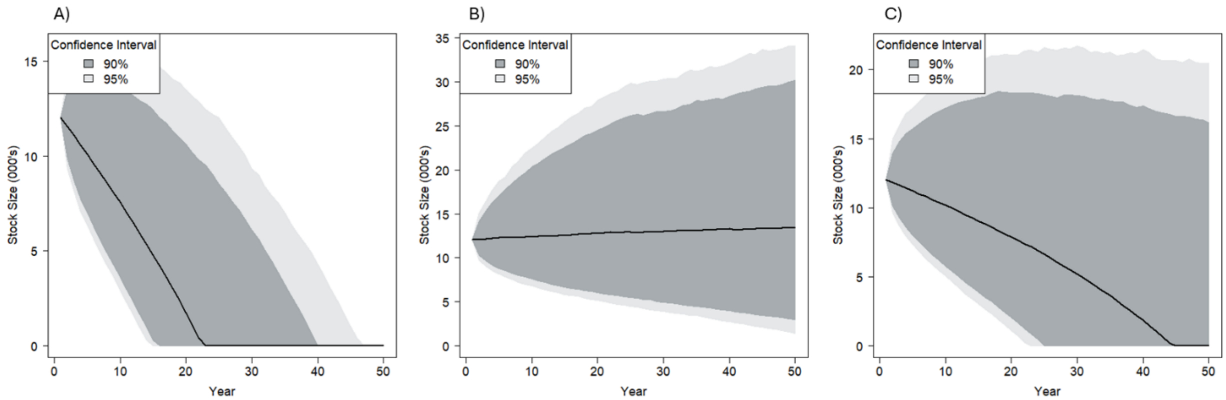

Figure 4. Stock abundance median projection for Eclipse Sound (ES) (the smallest stock) for Scenario 3 if the assumption that the ES and Admiralty Inlet (AI) narwhals mix in summer is incorrect and Potential Biological Removal (PBR) is allocated A) fully to the ES summering ground, B) in proportion to the stock abundance, or C) in proportion to census population for each management unit.

Scenario 4

Two separate management units without summer and migratory seasons: i) combined EBI, ES and AI, and ii) SI stocks.

If there are no migratory harvest tags, then we assume the entire catch comes from a fully mixed summering aggregation of two stocks: EBI-ES-AI and SI narwhal, respectively. If the assumption that the whales in EBI-ES-AI are fully mixed is not met, a worst-case scenario is that the whole harvest of the EBI-ES-AI sustainable take is allocated to the ES portion, and this would drive the ES stock to zero in approximately 15 years (based on median prediction, Figure 5A) and has a 99.7% chance of decreasing in the next 20 years. If harvest is allocated in proportion to stock or population abundance and the assumption that whales in EBI-ES-AI are fully mixed is not met, the ES stock has a 46.2% and 57.8% chance of decline in the next 20 years, respectively (Figure 5B and C).

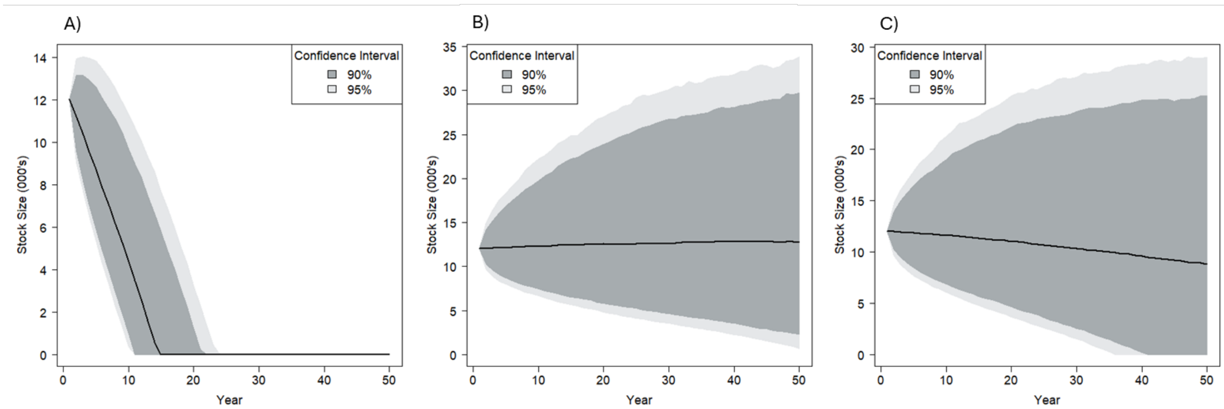

Figure 5. Stock abundance median projection for Eclipse Sound (ES) (the smallest stock) for Scenario 4 if the assumption that the ES, East Baffin Island (EBI), and Admiralty Inlet (AI) narwhals mix in summer is incorrect and Potential Biological Removal (PBR) is allocated A) fully to the ES summering ground, B) in proportion to the stock abundance, or C) in proportion to census population for each management unit.

Scenario 5

A single management unit comprised of the EB, ES, AI and SI stocks without summer and migratory seasons.

If there are no migratory harvest tags, then we assume the entire catch comes from a fully mixed single stock; EBI-ES-AI-SI. If the assumption that the whales in EBI-ES-AI-SI are fully mixed is not met, a worst-case scenario is that the whole harvest of the EBI-ES-AI-SI sustainable take is allocated to the ES portion, and this would drive the ES stock to zero in approximately 8 years (Figure 6A) and has a 100% chance of decreasing in the next 20 years. If harvest is allocated in proportion to stock or population abundance and the assumption that whales in EBI-ES-AI-SI are fully mixed is not met, the ES stock has a 48.6% and 54.6% chance of decline in the next 20 years, respectively (Figure 6B and C).

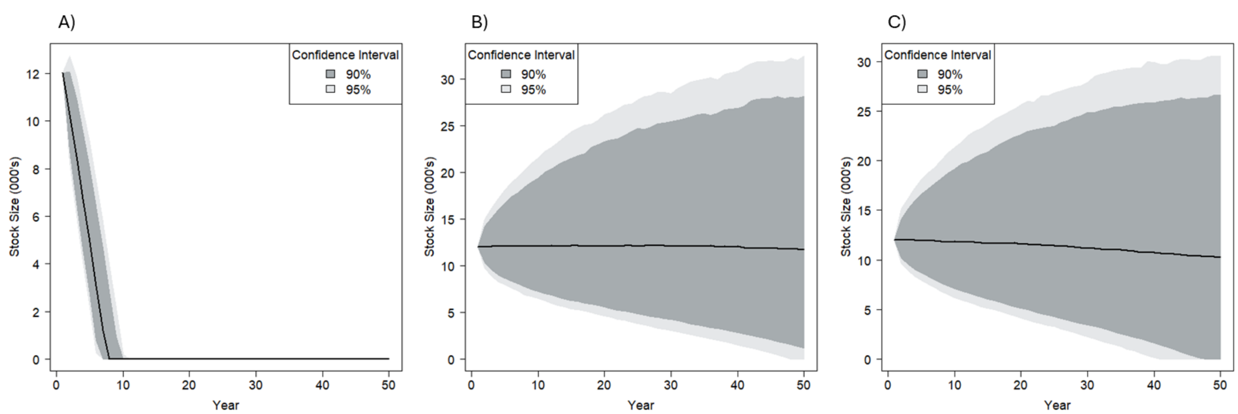

Figure 6. Stock abundance median projection for Eclipse Sound (ES) (the smallest stock) for Scenario 5 if the assumption that the ES, East Baffin Island (EBI), Admiralty Inlet (AI), and Somerset Island (SI) narwhals mix in summer is incorrect and Potential Biological Removal (PBR) is allocated A) fully to the ES summering ground, B) in proportion to the stock abundance, or C) in proportion to census population for each management unit.

Scenario 6

Sustainability of the current harvest in ES without summer and migratory seasons.

We were also requested to evaluate the sustainability of the current harvest and assess risk to the Eclipse Sound stock, considering the median harvest over the last ten years, irrespective of the harvest dates. At this level of harvest, there is a 42.9% chance of decline in the next 20 years (Figure 7).

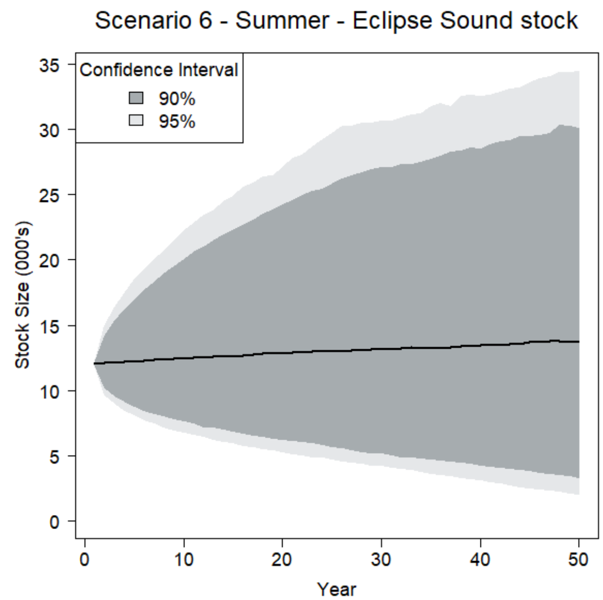

Figure 7. Stock abundance median projection for Eclipse Sound (ES) for Scenario 6.

Scenario 7

The maximum sustainable harvest that could be allocated to any hunting region in Baffin Bay.

This scenario was difficult to assess; however, we interpreted this as the maximum number of narwhal that could be harvested regardless of location, season, or management unit. The maximum sustainable TALC which could be taken anywhere at any time of year is 117 total for SI, AI, ES, and EBI together (Table 3). This is much less than the total annual harvests that could be sustainable if harvests are allocated with consideration of location, season, and management unit.

IDENTIFYING UNCERTAINTIES, CHALLENGES, AND LIMITATIONS TO THE RISK ASSESSMENT

All of the methods described above that have been used as evidence for narwhal stock delineation are limited by sample size. Many of the chemical methods rely on harvest samples that are provided by hunters on a voluntary basis. The number of animals that have been satellite tagged is also limited due to ethical, logistical, and financial considerations. Investigations of annual site fidelity rely on only a few tags (n = 9) that have lasted over a year. Summer site fidelity relies on more tags, but these whales were only tagged for a portion of the summer season (Table A1). For instance, if a whale was tagged on August 22 and remained in its summering area during summer, this site fidelity only represents a few days post-tagging.

Finally, while there have been > 100 satellite tags deployed on narwhals, this is only a small fraction of the total narwhal population (estimated at ~ 142,000; Doniol-Valcroze et al. 2015).

The drivers of narwhal movements are still not well understood, but are probably influenced by a combination of different factors. Narwhals in Eclipse Sound may be displaced by an increased level of vessel traffic from mining and cruise ships (Dawson et al. 2018), ice breaking, and anthropogenic development (Mayette et al. 2024). In addition, killer whales (*Orcinus orcas*) frequent Arctic waters in the summer and can impact narwhal movement and behaviour (Breed et al. 2017). None of these factors were considered in this assessment.

It was challenging to run a risk assessment without knowing how the harvest may be allocated; therefore, some assumptions needed to be made to conduct the risk assessments. We assumed a worst-case scenario where A) all takes are attributed to the smallest stock (ES), and other scenarios where allocations occurred in proportion to B) the estimated stock abundance, and C) the census population for communities within the management areas. These may or may not be realistic, but without an understanding of how allocations would be considered, it was the most reasonable approach. The modelled scenarios presented are also constrained by some sources of uncertainty. PBR calculations were based on assuming a recovery factor of 1 and a maximum productivity rate of 0.04. We used a recovery factor of 1 for all the scenarios, but if we combine management units, a lower recovery factor may be considered since there is added uncertainty in stock delineation with combined units. Regarding maximum productivity rates, Taylor et al. (2007) calculated a maximum population growth rate of 0.03, which may be more applicable for long-lived narwhal. For the scenarios presented here, we used the same values utilized in previous DFO Science Advice for calculating PBR for narwhal in Canada for comparability (Doniol-Valcroze et al. 2015); however, we acknowledge that more consideration into the values of these factors is warranted for advising on sustainable harvest levels, which is outside the scope of this assessment.

Scenarios 1A and 1B are based on the current HAM used to allocate narwhal to hunting regions in Canada. Our assessment of the scenario only evaluated possible iterations up to the TALC for each summering area. However, scenarios that exceed the TALC in some stocks (e.g., AI) are possible and could have also been explored.

The hypothetical scenarios depend upon the dates defined as summer versus migration. For this exercise, we chose dates that align with the timing of the aerial surveys and movement of narwhal based on available telemetry data. However, there is evidence that the timing of fall migration has changed (Shuert et al. 2022), and although there are no consistent trends in the harvest dates for narwhal hunts (Watt and Hall 2018), this change in migration could impact timing of hunts. These are important considerations, but were outside the scope of this assessment.

CONCLUSIONS

The modelled scenarios presented here for narwhal surrounding Baffin Island demonstrate that there is a risk of decline (probabilities ranging from 43-100% in Scenarios 2-5) in local areas if the narwhal aggregations are not fully mixing in the summer and the full TALC is hunted from the smallest portion of the stock (i.e., worst case scenario), or in proportion to stock size or population abundance. Canada's precautionary approach to fisheries management suggests a 5-25% risk of decline is a low-risk category (DFO 2009) and all of the scenarios that amalgamated stocks (Scenarios 2-5) resulted in a > 43% probability of decline. Even considering the current median harvest (Scenario 6), there is still a 42.9% chance of stock decline in 20 years in ES; this results in a medium risk of decline because the current quotas are based on an abundance estimate from 2004 (Richard et al. 2010) rather than on newer abundance estimates from 2013 (Doniol-Valcroze et al. 2015) or 2016 (Marcoux et al. 2019), while our assessment used the best available current published information (from 2016; Marcoux et al. 2019). Therefore, scenarios that propose to amalgamate currently defined management units, or those that do not use the most up-to-date abundance information, pose a serious risk to narwhal.

Stable isotopes, trace elements, contaminants, annual site fidelity from 8/9 satellite tags (89%) which lasted over a year, summer site fidelity from 99/103 (96%) satellite tags equipped on whales in the summer, and new genetic evidence (De Greef et al. 2024) corroborate separation among some summering aggregations. DFO's precautionary approach framework suggests we should be cautious if scientific information is uncertain, unreliable, or inadequate (DFO 2006) and therefore, narwhal should be managed on the smallest scale for which there exists some evidence of stock structure. In this assessment, we did not consider mixing on the wintering grounds where whales are available to Greenland hunters, and we would strongly urge managers to consider that whales from summering aggregations in Canada are harvested annually on the wintering grounds in Greenland (ranging anywhere from ~ 200-550 whales annually; NAMMCO 2023). In addition, the current narwhal management framework assumes that narwhal are available in proportion to their abundance. However, narwhals exhibit divergent fall migration strategies with some individuals choosing an offshore route while others select an inshore route (Shuert et al. 2023). For beluga whales, smaller at-risk populations have been shown to migrate closer to shore compared to large not-at-risk populations, which predisposes them to greater hunting mortality (DFO 2024). A more advanced model that considers Greenland harvests and the proportion of whales that are realistically available to hunters in different hunting regions based on movement (Watt et al. 2020) should be considered and has been developed by the NAMMCO-JCNB Joint Working Group (2021). A time-series of abundance estimates for narwhal, as well as information from harvested narwhals (e.g., samples to evaluate genetics, reproductive parameters, and age and sex structure of the hunt), would significantly improve our confidence in modeling the population dynamics of these stocks.

A high Arctic cetacean survey of all the Baffin Bay narwhal stocks in Canada was conducted in August 2023 and is currently being analyzed. These additional abundance estimates will add to a time-series of estimates for all of the narwhal stocks, which may allow a model-based precautionary approach for developing science advice for management in these regions (Hammill and Stenson 2003). It is recommended that management of Baffin Bay narwhals be based on currently defined summering stock aggregations until a better understanding of mixing and site fidelity within the population has been developed. Otherwise, there is a risk of local decline, as shown in the scenarios above. This stock delineation approach is consistent with previous science advice and the precautionary approach.

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SOURCES OF INFORMATION

Aguilar, A. 1987. Using organochlorine pollutants to discriminate marine mammal populations: a review and critique of the methods. Mar. Mamm. Sci. 3(3): 242–262.

Allen, A.M., and Singh, N.J. 2016. Linking movement ecology with wildlife management and conservation. Front. Ecol. Evol. 3:155.

Begg, G.A., Friedland, K.D., and Pearce, J.B. 1999. Stock identification and its role in stock assessment and fisheries management: an overview. Fish. Res. 43:1–8.

Brakes, P., Dall, S.R.X., Aplin, L.M., Bearhop, S., Carroll, E.L., Ciucci, P., Fishlock, V., Gord, J.K.B., Garland, E.C., Keith, S.A., McGregor, P.K., Mesnick, S.L., Noad, M.J., di Sciara, G.M., Robbins, M.M., Simmonds, M.P., Spina, F., Thornton, A., Wade, P.R., Whiting M.J., Williams, J., Rendell, L., Whitehead, H., Whiten, A., Rutz, C. 2019. Animal cultures matter for conservation. Science. 363(6431): 1032-1034.

Breed, G.A., Matthews, C.J.D., Marcoux, M., Higdon, J.W., LeBlanc, B., Petersen, S.D., Orr, J., Reinhart, N.R., and Ferguson, S.H. 2017. Sustained disruption of narwhal habitat use and behaviour in the presence of Arctic killer whales. PNAS. 114(10): 2628-2633.

Cope, J.M., and Punt, A.E. 2009. Drawing the lines: resolving fishery management units with simple fisheries data. Can. J. Fish. Aquat. Sci. 66(8): 1256–1273.

Dawson, J., Pizzolato, L., Howell, S.E.L., Copland, L., and Johnston, M.E. 2018. Temporal and spatial patterns of ship traffic in the Canadian Arctic from 1990-2015. Arctic. 71: 15-26.

de Greef, E., Müller, C., Thorstensen, M.J., Ferguson, S.H., Watt, C.A., Marcoux, M., Petersen, S.D., and Garroway, C.J. 2024. Unraveling the genetic legacy of commercial whaling and population dynamics in Arctic bowhead whales and narwhals. Global Change Biology. 30: e17528.

de March, B.G.E., and Stern, G. 2003. Stock separation of narwhal (*Monodon monoceros*) in Canada based on organochlorine contaminants. DFO Can. Sci. Advis. Sec. Res. Doc. 2003/079. ii + 16 p.

de March, B.G.E., Tenkula, D.A., and Postma, L.D. 2003. Molecular genetics of narwhal (*Monodon monoceros*) from Canada and West Greenland (1982-2001). DFO Can. Sci. Advis. Sec. Res. Doc. 2003/080. i + 19 p.

DFO. 2006. A harvest strategy compliant with the precautionary approach. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/023.

DFO. 2009. A fishery decision-making framework incorporating the precautionary approach. Fisheries and Oceans Canada, Ottawa, ON. (accessed June 2024).

DFO. 2020. Information related to the delineation of the Eclipse Sound and Admiralty Inlet narwhal stocks. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/048.

DFO. 2023. Arctic Region Variation Order 2023-001. Fisheries and Oceans Canada, Ottawa, ON. (accessed June 2024).

DFO. 2024. Conservation implications of moving the northern boundary of the Belcher-Islands and Eastern Hudson Bay beluga total allowable take zone south of its current location. DFO Can. Sci. Advis. Sec. Sci. Resp. 2024/026.

Dietz, R., Heide-Jørgensen, M.P., Richard, P., Orr, J., Laidre, K.L., and Schmidt, H.C. 2008. Movements of narwhals (*Monodon monoceros*) from Admiralty Inlet monitored by satellite telemetry. Polar Biol. 31: 1295-1306.

Dietz, R., Richard, P.R., and Acquarone, M. 2001. Summer and fall movements of narwhals (*Monodon monoceros*) from northeastern Baffin Island towards northern Davis Strait. Arctic 54(3): 244–261.

Doniol-Valcroze, T, Gosselin, J.F., Pike, D., Lawson, J., Asselin, N., Hedges, K., and Ferguson, S. 2015. Abundance estimates of narwhal stocks in the Canadian High Arctic in 2013. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/060. v + 36 p. (Erratum April 2022).

Frank, R., Ronald, K., and Bruan, H.E. 1973. Organochlorine residues in harp seals (*Pagophilus groenlandicus*) caught in eastern Canadian waters. J. Fish. Res. Board Can. 30: 1053-1063.

Hammill, M.O., and Stenson, G.B. 2003. Application of the precautionary approach and conservation reference point to the management of Atlantic seals: a discussion paper. DFO Can. Sci. Advis. Sec. Res. Doc. 2003/067: iii + 17 pp.

Hammill, M.O., and Stenson, G.B. 2007. Application of the precautionary approach and conservation reference points to management of Atlantic seals. ICES Journal of Marine Science 64: 702–706.

Heide-Jørgensen, H.P., Dietz, R., Laidre, K. L., Richard, P., Orr, J., Schmidt, H.C. 2003. The migratory behaviour of narwhals (*Monodon monoceros*). Can. J. Zool. 81: 1298-1305.

Heide-Jørgensen, M.P., Dietz, R., Laidre, K., Nicklen, P., Garde, E., Richard, P., and Orr, J. 2008. Resighting of a narwhal (*Monodon monoceros*) instrumented with a satellite transmitter. Arctic. 61: 395–398.

Heide-Jørgensen, M.P., Richard, P., Dietz, R., and Laidre, K.L. 2013. A metapopulation model for Canadian and West Greenland narwhals. Anim. Conserv. 16: 331–343.

Hobbs, R.C., Reeves, R.R., Prewitt, J.S., Desportes, G., Breton-Honeyman, K., Christensen, T., Citta, J.J., Ferguson, S.H., Frost, K.J., Garde, E., Gavrilo, M., Ghazal, M., Glazov, D.M., Gosselin, J.-F., Hammill, M., Hansen, R.G., Harwood, L., Heide-Jørgensen, M.P., Inglangasuk, G., Kovacs, K.M., Krasnova, V.V., Kuznetsova, D.M., Lee, D.S., Lesage, V., Litovka, D.I., Lorenzen, E.D., Lowry, L.F., Lydersen, C., Matthews,C.J.D., Meschersky, I.G., Mosnier, A., O'Corry-Crowe, G., Postma, L., Quakenbush, L.T., Shpak, O.V., Skovrind, M., Suydam, R.S., and Watt, C.A. 2019. Global review of the conservation status of monodontid stocks. Mar. Fish. Rev. 81(3–4):1–53.

IWC (International Whaling Commission). 2000. Status of monodontid whales. In: Report of the scientific committee. J. Cetacean Res. Manage. (Suppl. 2): 243-252.

IWC (International Whaling Commission). 2002. Annex I - Report of the Working Group on Stock Definition. In: Report of the Scientific Committee. J. Cetacean Res. Manage. 4 (Suppl.): 261-281.

Kerr, L.A., and Campana, S.E. 2014. Chapter 11: Chemical composition of fish hard parts as a natural marker of fish stocks. *In* Stock Identification methods 2nd ed. Edited by S.X. Cadrin, L.A. Kerr, and S. Mariani. Academic Press, San Diego, Calif. pp. 205–234.

Marcoux, M., and Watt, C. A. 2021. Eclipse sound narwhal (*Monodon monoceros*) movement and hunt composition and its relevance to stock delineation. DFO Can. Sci. Advis. Sec. Res. Doc. 2020/067. iv + 25 p.

Marcoux, M., Montsion, L.M., Dunn, J.B., Ferguson, S.H., and Matthews, C.J.D. 2019. Estimate of the abundance of the Eclipse Sound narwhal (*Monodon monoceros*) summer stock from the 2016 photographic aerial survey. DFO Can. Sci. Advis. Sec. Res. Doc. 2019/028. iv + 16 p.

Mayette, A., Shuert, C.R., Hussey, N.E., and Marcoux, M. 2024. Proximity analysis between icebreakers and narwhals in Tasiujaq. Nunavut, Canada. J. Wildl. Manag. 88(8): e22655.

Montana, L., Bringloe, T.T., Bourret, A., Sauvé, C., Mosnier, A., Ferguson, S.H., Postma, L., Lesage, V., Watt, C.A., Hammill, M.O., and Parent, G.J. 2024. Reduced representation and whole-genome sequencing approaches highlight beluga whale populations associated to eastern Canada summer aggregations. Evol. Appl. 17(12): e70058.

NAMMCO (North Atlantic Marine Mammal Commission). 2023. Narwhal – 9: Narwhal hunting and utilisation. (accessed January 2025).

NAMMCO-JCNB Joint Working Group. 2021. Report of the joint working group meeting of the NAMMCO Scientific Committee Working Group on the population status of narwhal and beluga in the North Atlantic and the Canada/Greenland Joint Commission on conservation and management of narwhal and beluga scientific working group. December 2021, Winnipeg, Canada.

Palsbøll, P.J., Heide-Jørgensen, M.P., and Dietz, R. 1997. Population structure and seasonal movements of narwhals, *Monodon monoceros*, determined from mtDNA analysis. Heredity 78: 284-292.

Petersen, S.D., Tenkula, D., and Ferguson, S.H. 2011. Population genetic structure of narwhal (*Monodon monoceros*). DFO Can. Sci. Advis. Sec. Res. Doc. 2011/021. vi + 20 p.

Postma, L.D. 2017. Genetic diversity, population structure and phylogeography among belugas (*Delphinapterus leucas*) in Canadian waters: broad to fine-scale approaches to inform conservation and management strategies. Thesis (PhD) University of Manitoba, Winnipeg, Man. 296 p.

Rantanen, M., Karpechko, A.Y., Lipponen, A., Nordling, K., Hyvärinen, O., Ruosteenoja, K., Vihma, T., and Laaksonen, A. 2022. The Arctic has warmed nearly four times faster than the globe since 1979. Comm. Earth Environ. 3: 168.

Richard, P.R. 2008. On determining the Total Allowable Catch for Nunavut odontocete stocks. DFO Can. Sci. Advis. Sec. Res. Doc. 2008/022. iv + 12 p.

Richard, P.R. 2010. Stock definition of belugas and narwhals in Nunavut. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/022. iv + 14 p.

Richard, P.R. 2011. Allocation model for landed catches from Baffin Bay narwhal stocks. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/056. iv + 27 p.

Richard, P.R., and Young, R. 2015. Evaluation of the sustainability of a flexible system of total allowable annual catches of narwhals (*Monodon monoceros*). DFO Can. Sci. Advis. Sec. Res. Doc. 2015/006: v + 13 p.

Richard, P.R., Laake, J.L., Hobbs, R.C., Heide-Jørgensen, M.P., Asselin, N.C., and Cleator, H. 2010. Baffin Bay narwhal population distribution and numbers: aerial surveys in the Canadian High Arctic, 2002-04. Arctic. 63: 58-99.

Shuert, C.R., Marcoux, M., Hussey, N.E., Heide-Jørgensen, M.P., Dietz, R., and Auger-Méthé, M. 2022. Decadal migration phenology of a long-lived Arctic icon keeps pace with climate change. PNAS. 119: e2121092119.

Shuert, C.R., Hussey, N.E., Marcoux, M., Heide-Jørgensen, M.P., Dietz, R., and Auger-Méthé, M. 2023. Divergent migration routes reveal contrasting energy-minimization strategies to deal with differing resource predictability. Mov. Ecol. 11(1): 31.

Strong, J.T. (1988) Status of the narwhal, *Monodon monoceros*, in Canada. Canadian Field-Naturalist 102(2): 391-398.

Taruski, A.G., Olney, C.E., and Winn, H.E. 1975. Chlorinated hydrocarbons in cetaceans. J. Fish. Res. Board Can. 32(11): 2205-2209.

Taylor, B.L. 1997. Defining “population” to meet management objectives for marine mammals. *In* Molecular Genetics of Marine Mammals. Edited by A.E. Dizon, S.J. Chivers, and W.F. Perrin. The Society for Marine Mammalogy, Lawrence, KS. pp. 49–65.

Taylor, B.L., and Dizon, A.E. 1999. First policy then science: why a management unit based solely on genetic criteria cannot work. Mol. Ecol. 8: S11–S16.

Taylor, B.L., Chivers, S.J., Larese, J., and Perrin, W.F. 2007. Generation length and percent mature estimates for IUCN assessments of cetaceans. Southwest Fisheries Science Center Administrative Report LJ-07-01. 24 p.

Wade, P.R. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Mar. Mamm. Sci.14(1): 1-37.

Wade, P.R., and Angliss, R. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS workshop April 3-5, 1996, Seattle, Washington. NOAA Technical Memorandum NMFS-OPR-12. U.S. Department of Commerce, Washington, DC. 93 p.

Waples, R.S., and Gaggiotti, O. 2006. What is a population? An empirical evaluation of some genetic methods for identifying the number of gene pools and their degree of connectivity. Mol. Ecol. 15: 1419–1439.

Watt, C.A. 2017. Narwhal Biology: An overview. *In* Narwhal: Revealing an Arctic Legend. Edited by K. Johnson, W.W. Fitzhugh and M.T. Nweeia. International Polar Institute and Arctic Studies Center, Washington, D.C. 233 p.

Watt, C.A., and Hall, P. 2018. Catch statistics for narwhal (*Monodon monoceros*) in Canada from 1970-2015. Can. Tech. Rep. Fish. Aquat. Sci. 3270: vi + 224 p.

Watt, C.A., Ferguson, S.H., Fisk, A., and Heide-Jørgensen, M.P. 2012a. Using stable isotope analysis as a tool for narwhal (*Mondon monoceros*) stock delineation. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/057. iv + 29 p.

Watt, C.A., Orr, J., LeBlanc, B., Richard, P., and Ferguson, S.H. 2012b. Satellite tracking of narwhals (*Monodon monoceros*) from Admiralty Inlet (2009) and Eclipse Sound (2010-2011). DFO Can. Sci. Advis. Sec. Res. Doc. 2012/046. iii + 17 p.

Watt, C.A., Hornby, C., and Ferguson, S.H. 2019a. Trace element and stable isotope analysis elucidate stock structure in a narwhal (*Monodon monoceros*) population with no genetic substructure. Can. J. Zool. 97: 1084-1091.

Watt, C.A., Marcoux, M., Dunn, J.B., Hodgson, R., Moore, R., and Ferguson, S.H. 2019b. Effect of the 2015 narwhal (*Monodon monoceros*) entrapment on the Eclipse Sound narwhal stock. DFO Can. Sci. Advis. Sec. Res. Doc. 2019/030. iv + 12 p.

Watt, C.A., Doniol-Valcroze, T., Witting, L., Hobbs, R.C., Guldborg Hansen, R., Lee, D.S., Marcoux, M., Lesage, V., Garde, E., Ferguson, S.H., and Heide-Jørgensen, M.P. 2020. Hunt allocation modeling for migrating animals: the case of Baffin Bay narwhal, *Monodon monoceros*. Marine Fisheries Review. 81: 125-136.

Westdal, K., Richard, P., and Orr, J. 2010. Migration route and seasonal home range of the Northern Hudson Bay narwhal (*Monodon monoceros*). *In* A little less Arctic: top predators in the world's largest northern inland sea, Hudson Bay: 71–91. Edited by S.H. Ferguson, L.L. Loseto, and M.L. Mallory. Springer Nature, Dordrecht, Netherlands. pp. 71-92.

Whitehead, H. 1998. Cultural selection and genetic diversity in matrilineal whales. Science. 282: 1708-1711.

APPENDIX

Table A1. Dates of satellite tag deployment in Somerset Island (SI), Admiralty Inlet (AI), and Eclipse Sound (ES) and the number of days within the total defined summer (July 24-August 24) where tags provided information on summer site fidelity.

Stock	Individual ID	Deployment Date (yyyy/mm/dd)	Duration (days)	# of summer days out of 32 days (July 24-Aug 24)
SI	1	2000-08-14	65	11
SI	2	2000-08-14	99	11
SI	3	2000-08-17*	9	8*
SI	4	2000-08-16	74	9
SI	5	2000-08-17	104	8
SI	6	2000-08-17	118	8
SI	7	2000-08-17	89	8
SI	8	2000-08-19	15	6
SI	9	2000-08-23	421	2
SI	10	2000-08-24	381	1±
SI	11	2001-08-12	47	13
SI	12	2001-08-12	74	13
SI	13	2001-08-07	134	18
SI	14	2001-08-12	12	13
SI	15	2001-08-09	134	16
SI	16	2001-08-09	84	16
SI	17	2001-08-08	12	17
AI	1	2003-08-14*	131	11*
AI	2	2003-08-16	136	9
AI	3	2003-08-16	210	9
AI	4	2003-08-18	133	7
AI	5	2003-08-18	134	7
AI	6	2003-08-16	73	9
AI	7	2003-08-18	236	7
AI	8	2003-08-21	83	4
AI	9	2003-08-20	26	5
AI	10	2003-08-20	51	5
AI	11	2003-08-21	113	4
AI	12	2003-08-21	23	4
AI	13	2003-08-21	33	4
AI	14	2004-08-11	37	14
AI	15	2004-08-13	108	12
AI	16	2004-08-15*	140	10*

Stock	Individual ID	Deployment Date (yyyy/mm/dd)	Duration (days)	# of summer days out of 32 days (July 24-Aug 24)
AI	17	2004-08-13	280	12
AI	18	2004-08-24*	161	1*±
AI	19	2004-08-22	128	3
AI	20	2004-08-22	169	3
AI	21	2004-09-07*	23	NA*±
AI	22	2004-09-07*	21	NA*±
AI	23	2004-09-10*	12	NA*±
AI	24	2005-08-17*	148	8*
AI	25	2005-08-17*	175	8*
AI	26	2005-08-18*	132	7*
AI	27	2005-08-18*	220	7*
AI	28	2005-08-19*	133	6*
AI	29	2005-08-20*	15	5*
AI	30	2005-08-21*	64	4*
AI	31	2005-08-22*	117	3*
AI	32	2005-08-22*	24	3*
AI	33	2005-08-22*	9	3*
AI	34	2005-08-22*	95	3*
AI	35	2005-08-22*	163	3*
AI	36	2005-08-23*	151	2*
AI	37	2005-09-02*	18	NA*±
AI	38	2009-08-15	193	10
AI	39	2009-08-15	260	10
AI	40	2009-08-17	291	8
AI	41	2009-08-17	299	8
AI	42	2009-08-18	145	7
AI	43	2009-08-17	320	8
AI	44	2009-08-16	176	9
AI	45	2009-08-17	723	8
ES	1	1997-08-22*	16	4*
ES	2	1997-08-08	30	17
ES	3	1998-08-19	46	6
ES	4	1997-08-21	14	4
ES	5	1997-08-24	76	1
ES	6	1998-08-14	7	11
ES	7	1998-08-21	165	4
ES	8	1998-08-25	71	0
ES	9	1998-08-25	40	0

Stock	Individual ID	Deployment Date (yyyy/mm/dd)	Duration (days)	# of summer days out of 32 days (July 24-Aug 24)
ES	10	1999-08-12	80	13
ES	11	1999-08-13	69	12
ES	12	1999-08-15	80	10
ES	13	1999-08-15	84	10
ES	14	1999-08-21	45	4
ES	15	1999-08-21	211	4
ES	16	1999-08-21	5	4
ES	17	2010-08-21	252	4
ES	18	2010-08-21	292	4
ES	19	2010-08-22	410	3
ES	20	2010-08-22	189	3
ES	21	2010-08-24	151	1
ES	22	2011-08-16	128	9
ES	23	2011-08-16	180	9
ES	24	2011-08-16	314	9
ES	25	2011-08-19	126	6
ES	26	2011-08-19	302	6
ES	27	2011-08-18	201	7
ES	28	2011-08-18	221	7
ES	29	2012-08-13	30	12
ES	30	2012-08-14	128	11
ES	31	2012-08-17	128	8
ES	32	2012-08-18	124	7
ES	33	2012-08-19	119	6
ES	34	2016-08-22	81	3
ES	35	2016-08-18	3	7
ES	36	2016-08-22	86	3
ES	37	2016-08-29	9	NA±
ES	38	2016-08-29	20	NA±
ES	39	2017-07-31	126	25
ES	40	2017-08-01	57	24
ES	41	2017-07-31	78	25
ES	42	2017-08-03	84	22
ES	43	2017-08-03	84	22
ES	44	2017-08-03	218	22
ES	45	2017-08-05	64	20
ES	46	2017-08-12	77	13
ES	47	2017-08-16	50	9

Stock	Individual ID	Deployment Date (yyyy/mm/dd)	Duration (days)	# of summer days out of 32 days (July 24-Aug 24)
ES	48	2017-08-30	66	NA±
ES	49	2017-09-02	84	NA±
ES	50	2017-09-02	40	NA±
ES	51	2017-09-03	44	NA±
ES	52	2017-09-03	69	NA±
ES	53	2017-09-10	53	NA±
ES	54	2017-09-11	52	NA±
ES	55	2017-09-11	72	NA±
ES	56	2017-09-11	66	NA±
ES	57	2018-08-17	55	8
ES	58	2018-08-17	80	8

*For most tags, deployment date and number of days in the summer was calculated based on the date narwhals were captured. For a few individuals (*), this information was not available and the date of the first transmission of a location was used as deployment date.
±Deployment was too late to contribute to assessment of summer residency.

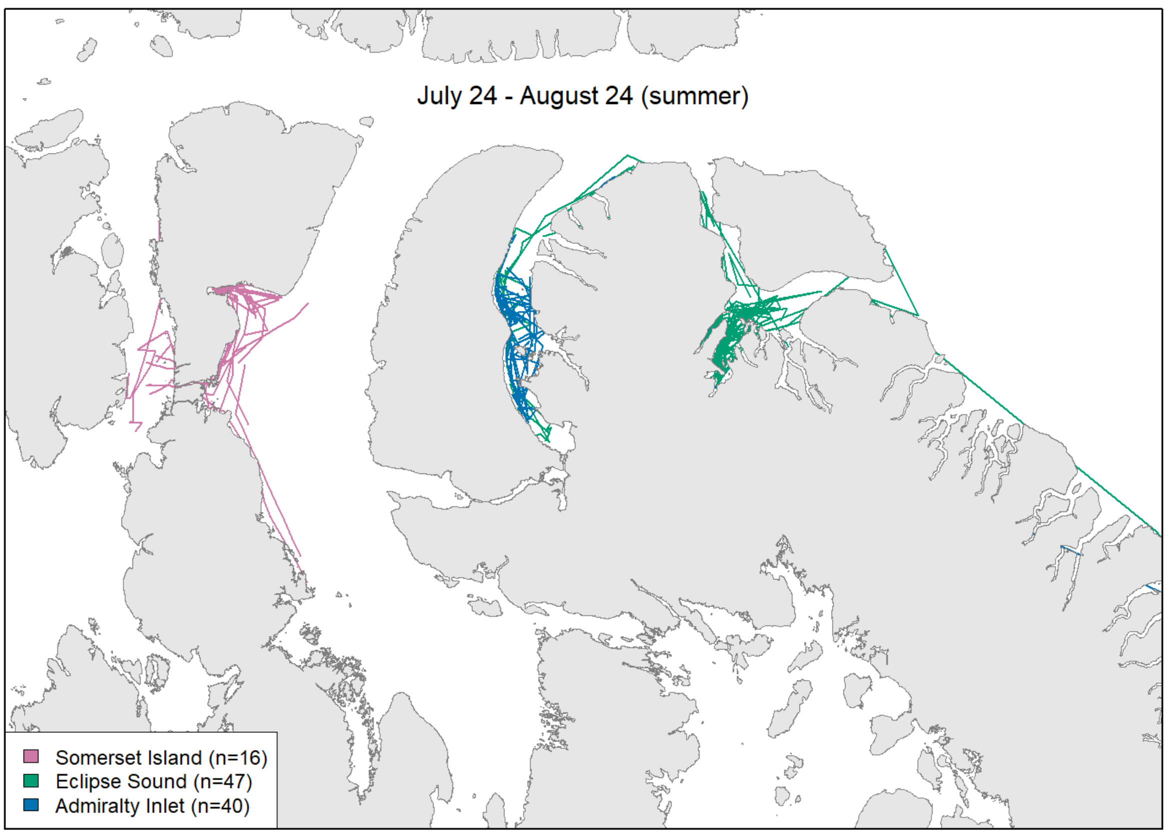

Figure A1. Telemetry tracks of all satellite tags from Somerset Island (pink), Admiralty Inlet (blue), and Eclipse Sound (green) from Table A1 for summer (July 24-August 24).

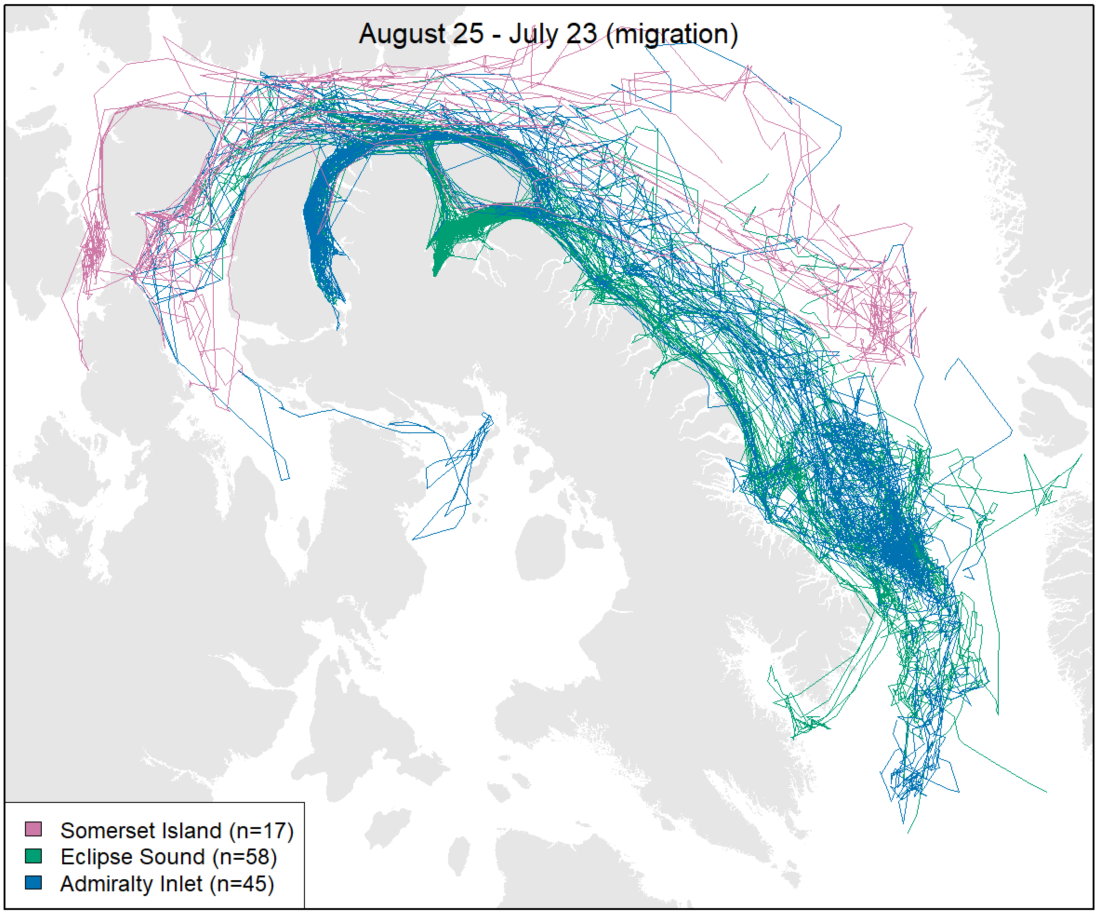

Figure A2. Telemetry tracks of all satellite tags from Somerset Island (pink), Admiralty Inlet (blue), and Eclipse Sound (green) from Table A1 for outside of the summer season (migration August 25-July 23).

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ᐃᖃᓗᓕᕆᔨᒃᑯᑦ ᐃᒪᓕᕆᓂᕐᒧᓪᓗ. 2026. ᐃᓱᒪᒃᓴᖅᓯᐅᕈᑎᒃᓴᑦ ᓄᑖᒧᑦ ᑑᒑᓕᖕᓂᑦ ᐊᐅᓚᑦᑎᓂᕐᒧᑦ ᐋᖅᑭᒃᓱᖅᓯᒪᔾᔪᑎ: ᒪᑭᑕᔪᓐᓇᕐᓂᕐᒥᑦ ᑑᒑᓕᖕᓂᑦ ᖃᓂᒋᔮᖓᓂ ᕿᑭᖅᑖᓗᒃ ᐅᐊᓐᓇᖓᓂ ᐊᒻᒪᓗ ᑲᓇᖕᓇᖓᓂ. ᐃᒪᕐᒥᐅᑕᓕᕆᔨᒃᑯᑦ ᑲᓇᑕᒥ ᖃᐅᔨᓴᓂᕐᒧᑦ ᐅᖃᐅᔾᔨᕆᐊᓂᕐᒧᑦ ᑎᑎᕋᕐᕕᖓ ᖃᐅᔨᓴᓂᕐᒧᑦ ᑭᐅᓂᕐᒧᑦ 2026/002.

Fisheries and Oceans Canada / Pêches et Océans Canada
Ecosystems and Oceans Science / Sciences des écosystèmes et des océans

Central and Arctic Region
Canadian Science Advisory Secretariat
Science Advisory Report 2015/006

SUSTAINABILITY OF A FLEXIBLE SYSTEM OF TOTAL ALLOWABLE ANNUAL CATCHES OF NARWHALS (*Monodon monoceros*)

Narwhal (Monodon monoceros) by R. Phillips.

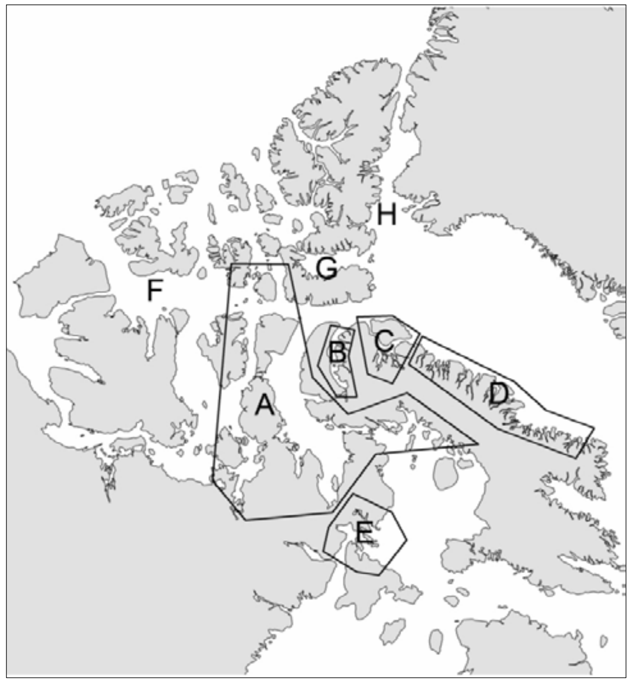

Figure 1. Approximate areas where Canadian summering aggregations of narwhals occur: A - Somerset Island, B - Admiralty Inlet, C - Eclipse Sound, D - East Baffin Island, E - Northern Hudson Bay. Other areas where narwhals are known to occur in summer: F - Parry Islands, G - Jones Sound, H - Smith Sound) [adapted from DFO 2011].

Context

There are presently five recognized narwhal summering stocks in the Canadian Arctic: Somerset Island, Admiralty Inlet, Eclipse Sound, East Baffin Island, and Northern Hudson Bay (Fig.1 A-D). Hunts on these narwhal stocks are managed by setting an annual Total Allowable Landed Catch (TALC) for each stock for a five-year period. The TALC is based on a Potential Biological Removal (PBR) estimate calculated for each stock, minus estimated hunting losses (i.e., struck and lost). The present analysis is in response to requests by Resource Management (RM) for peer reviewed science to address the questions of sustainability of a flexible TALC system for narwhals. There are also narwhals summering in Jones Sound, Smith Sound and the Parry Islands water (Fig. 1 F-H). Their stock definition and status is uncertain but advice given here would apply once assessments allow the setting of total allowable land catch limits.

SUMMARY

- There is a desire on the part of Inuit to have a "flexible quota system" management provision implemented in narwhal hunts, similar to what was employed under Community Based Management (CBM) of narwhal in Nunavut, i.e., to carry-over (credit) unused Total Allowable Landed Catch (TALC) for use in the subsequent hunting season or to borrow (debit) from the following years' TALC for use in the current hunting season
- Results of a deterministic model to investigate the robustness of a flexible TALC system clearly indicate that, for the scenarios investigated, such a management approach is sustainable, as long as the total hunting mortality over the five year period does not exceed five times the annual PBR.
- Key assumptions of the deterministic model are:
  a. birth and death rates are constant,
  b. PBR is updated every ten years with new abundance estimates,
  c. Hunting loss is a constant fraction of TALC, and
  d. flexible hunting limits are adhered to by all and landed catches are reported exactly (i.e., no implementation errors).
- Process error model results, which account for some variability of birth and death rates, showed a greater risk of the population becoming depleted under certain credit or debit scenarios but the risk was similar to the base scenario run for comparison where no debit or credit was applied.
- Better estimates of hunting loss rates would increase confidence in model results. These model results do not account for impacts of large ice entrapment mortality. These are rare events and have been the subject of previous science advice. A more detailed assessment of population trend would be warranted were there evidence of deterministic environmental effects on narwhal birth and death processes.

INTRODUCTION

There are presently five recognized narwhal summering stocks in the Canadian Arctic: Somerset Island, Admiralty Inlet, Eclipse Sound, East Baffin Island, and Northern Hudson Bay. Hunts on these narwhal stocks are managed by setting an annual Total Allowable Landed Catch (TALC) for each stock that remains constant for a five-year period. The TALC is based on a Potential Biological Removal (PBR) estimate calculated for each stock, minus estimated hunting losses. The present analysis is in response to requests by Resource Management (RM) for peer reviewed science to address the questions of sustainability of a flexible TALC system for narwhals.

Question 1: Is it sustainable if Arctic Bay and Pond Inlet exchange their unused spring and fall Marine Mammal Tags for use by either community during their migratory (spring/fall) narwhal hunts? The same question was also posed for Clyde River and Qikiqtarjuaq.

Question 2: Harvest credit (or carry-over) in a five year period:

a. Is 100% carry-over for one year sustainable?
b. What % carry-over for one year is sustainable?
c. What % cumulative carry-over is sustainable over consecutive years (up to five years)?

Question 3: Harvest debit (or borrow-back) in a five year period:

a. Is 100% borrowing from the following year sustainable once in a five year period?

b. What % borrowing from the following year is sustainable?

c. Can the total five consecutive years' total allowable catch be allocated to each year, in a five year period, any way the hunters choose as long as the sum of the five-years of catch does not exceed that total?

Question 4: How sustainable would a hunting mortality of five times the total allowable catch if applied to any one year of a five year period?

ASSESSMENT

Question 1: This question was addressed by previous science advice (Richard 2011). In short, the two communities in question,

a. Arctic Bay and Pond Inlet, or

b. Clyde River and Qikiqtarjuaq, are hunting from the mixed stocks in spring and fall and therefore are taking from the same stocks' TALCs.

Consequently, the harvest credits are transferable between Arctic Bay and Pond Inlet, or between Clyde River and Qikiqtarjuaq without invalidating previous advice on the sustainability of the affected stocks.

The remaining four questions required new analyses. They were performed using a variant of the Wade (1998) PBR robustness trial method, where a proportion of the PBR for a stock was either carried over (credited) to the subsequent year to make-up for a low catch year or borrowed (debited) from the next year if a given year's catch was higher than the annual PBR. Several scenarios were modelled in deterministic projections for 100 years, as in Wade (1998), varying start populations from 5,000 to 15,000 and recovery factors from 0.5 to 1. The details of the simulations are given in Richard and Young (2015).

In all cases, more than 95% of projected populations reached sizes in excess of the Maximum Net Productivity Level. The results of these simulations of flexible catch limits did not depart much from the base models, where no credits or debits were exercised.

The same simulations were done with an added parameter for process error, i.e., a parameter simulating variation in population dynamics (Richard and Young 2015). This process error, arbitrarily set at 0.05, to reflect our belief that narwhals do not have highly variable population dynamics, resulted in more variable results for debit or credit scenarios than the deterministic runs, but none of scenario results were significantly worse than the results of base models without debits or credits.

These results indicate that a system of flexible Total Allowable Landed Catches is sustainable, as long as the total hunting mortality over each five-year period does not exceed five times the PBR for that period. The modelling results also show that the choice of a fixed recovery factor of 1 does not significantly increase the risk to sustainability of credit or debit scenarios.

Sources of Uncertainty

The above conclusions are based on models with some important assumptions. The first is that TALCs are a constant fraction of total hunting mortality, i.e., that hunting losses are constant and very similar to what was used to provide TALC advice for narwhal stocks (0.28 from Richard 2008). Hunting losses may in fact vary from area to area, from season to season and with different hunting methods. Unfortunately, we have insufficient data at present to determine those variations and apply them in modelling. Nevertheless, the PBR method has been shown to be robust to under-estimates of actual hunt mortality (Wade 1998).

Second, we assume that sources of human-induced narwhal mortality other than total hunting mortality (landed catch and hunting loss) are negligible. We have no reason to believe otherwise at present.

Third, we assume that flexible hunting limits are adhered to by all and that landed catches are reported exactly, that there are no implementation errors. Presently, we know of no reason to believe that narwhal landed catches are not reported accurately, but there have been no independent studies to verify this assumption. Perhaps this concern is moot as the latest records of narwhal catches (DFO) indicate that landed catches are, in many cases, lower than TALCs.

The models do not take into account the impact of rare ice-entrapment mortality, nor do they include environmental effects that might negatively impact birth and death processes in narwhal populations. Large ice entrapments are rare but can have a significant short-term impact on population trend. Science advice on one such entrapment event can be found in DFO (2012). Environmental impacts on birth and death processes in narwhal populations are unknown at present but, should there be evidence of long-term negative effects, more detailed narwhal population assessments would be needed.

CONCLUSIONS

These results are encouraging for the implementation of flexible TALCs, as they show little additional risk to the narwhal stocks from implementation of flexible TALCs. If a flexible TALC system is implemented, the five-year total landed catch should not exceed five times the annual TALC for each stock.

SOURCES OF INFORMATION

This Science Advisory Report is from the October 20-24, 2014 Annual Meeting of the National Marine Mammal Peer Review Committee (NMMPRC). Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

DFO. 2011. Advice regarding the genetic structure of Canadian narwhal (*Monodon monoceros*). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/021.

DFO. 2012. Effect of 2008 ice entrapment on the Eclipse Sound narwhal total allowable landed catch. DFO Can. Sci. Advis. Sec. Sci. Resp. 2012/020.

Richard, P.R. 2008. On determining the Total Allowable Catch for Nunavut odontocete stocks. DFO Can. Sci. Advis. Sec. Res. Doc. 2008/022: iv + 12 p. (Erratum September 2008).

Richard, P.R. 2011. Allocation model for landed catches from Baffin Bay narwhal stocks. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/056: iv + 27 p. (Erratum December 2011)

Richard, P.R., and Young, R. 2015. Evaluation of the sustainability of a flexible system of total allowable annual catches of narwhals (*Monodon monoceros*). DFO Can. Sci. Advis. Sec. Res. Doc. 2015/006. iv + 13 p.

Wade, P.R. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Mar. Mamm. Sci. 14: 1-37.

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