State of the Tarium Niryutait Marine Protected Areas (TNMPA) Report: Inventory of Monitoring From 2010–2016

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2021

Canadian Manuscript Report of
Fisheries and Aquatic Sciences 3301

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Canadian Manuscript Report
of Fisheries and Aquatic Sciences 3301

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STATE OF THE TARIUM NIRYUTAIT MARINE PROTECTED AREAS (TNMPA) REPORT: INVENTORY OF MONITORING FROM 2010–2016

by

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Cat. No. Fs 97-4/3301E-PDF ISBN: 978-0-660-30348-2 ISSN 1488-5387

Correct citation for this publication:

Brewster, J. D., Hansen-Craik, K., Harwood, L.A., and Blakeston, C. 2021. State of the Tarium Niryutait Marine Protected Areas (TNMPA) Report: Inventory of Monitoring from 2010–2016. Can. Manuscr. Rep. Fish. Aquat. Sci. 3301: x + 84 p.

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The Tarium Niryutait Marine Protected Area (TNMPA) was one of the first MPAs established in Canada, and the first Canadian Arctic MPA. The three sub-regions: Niaqunnaq (Shallow Bay), Okeevik (East Mackenzie Bay), and Kittigaryuit (Kugmallit Bay) that make up the TNMPA were chosen as they are important Inuvialuit harvesting areas for beluga whale. The TNMPA was designated in 2010 with the conservation objective (CO) "*To conserve and protect beluga whales and other marine species, their habitats, and their supporting ecosystem*". As stated in the TNMPA Monitoring and Management plans, the MPA monitoring indicators (ecological, socio-economic, and governance) are to be assessed every five to six years to ensure they are supporting the CO. The TNMPA is within the Inuvialuit Settlement Region boundaries, therefore the Inuvialuit governing and advisory bodies (i.e., Western Arctic Marine Protected Area (WAMPA), Hunters and Trappers Committees (HTCs), Inuvialuit Game Council (IGC)), as well as co-management partner (Fisheries Joint Management Committee (FJMC)), and researchers working within the TNMPA reviewed these indicators. Additionally, Inuvilauit and co-managment partners reviewed the status of indicator implementation from 2010–2016. Through engagement with partners it was decided to perform a qualitative assessment for the first State of the TNMPA Report. Here, we inventoried the indicator data available, identified whether each indicator supports the TNMPA CO, clarified goals of each indicator, and identified gaps in monitoring. This report encompasses recommendations for future monitoring indicators that will be reviewed by MPA advisory bodies. Indicators that are deemed feasible and suitable for future TNMPA monitoring will inform the new iterations of the TNMPA Monitoring and Management plans, and prepare for the second iteration of the State of the TNMPA Report, which may include some quantitative assessments of indicators.

RÉSUMÉ

Brewster, J. D., Hansen-Craik, K., Harwood, L., and Blakeston, C. 2021. State of the Tarium Niryutait Marine Protected Areas (TNMPA) Report: Inventory of Monitoring from 2010–2016. Can. Manuscr. Rep. Fish. Aquat. Sci. 3301: x + 84 p.

La zone de protection marine Tarium Niryutait (ZPMTN) a été l'une des premières ZPM établies au Canada, et la première dans l'Arctique canadien. Ses trois sous-régions, Niaqunnaq (baie Shallow), Okeevik (est de la baie Mackenzie) et Kittigaryuit (baie Kugmallit), ont été choisies parce qu'elles constituent d'importantes zones de chasse au béluga pour les Inuvialuit. La ZPMTN a été établie en 2010 afin « *de conserver et de protéger les bélugas et d'autres espèces marines, leurs habitats et les écosystèmes qu'ils habitent* ». Comme en font mention les plans de surveillance et de gestion de la ZPMTN, les indicateurs de surveillance (écologiques, socioéconomiques et de gouvernance) doivent être évalués tous les cinq à six ans pour garantir qu'ils contribuent à l'atteinte de l'objectif de conservation. Comme la ZPMTN se trouve à l'intérieur des limites de la région désignée des Inuvialuit, ces indicateurs ont été évalués par les organismes directeurs et consultatifs inuvialuits (la zone de protection marine de l'Arctique de l'Ouest [ZMPA], les comités de chasseurs et de trappeurs [CCP], le Conseil inuvialuit de gestion du gibier [CIGG] et le partenaire de cogestion, c.-à-d. le Comité mixte de gestion de la pêche [CMGP]) ainsi que des chercheurs travaillant dans la ZPMTN. En concertation avec les partenaires, il a été décidé d'effectuer une évaluation qualitative dans le cadre de ce premier *rapport sur l'état de la ZPMTN*. Dans ce rapport, nous avons dressé l'inventaire des données sur les indicateurs, déterminé si chaque indicateur contribue à l'atteinte de l'objectif de conservation, clarifié les cibles pour chaque indicateur et relevé les lacunes dans la surveillance. Le rapport contient également des recommandations sur les futurs indicateurs de surveillance, lesquelles ont été formulées par les chercheurs, les Inuvialuit et les partenaires de cogestion. Les recommandations présentées ici seront examinées par les organismes consultatifs de la ZPM. Les indicateurs jugés faisables et appropriés pour la surveillance future de la ZPMTN serviront à produire les nouvelles versions des plans de surveillance et de gestion de la ZPMTN et paveront la voie au deuxième *rapport sur l'état de la ZPMTN*, qui comprendra une évaluation quantitative des indicateurs de surveillance de la ZPMTN évalués selon un processus officiel auquel participeront des représentants du Secteur des sciences et des organismes consultatifs de la ZPM.

LIST OF ABBREVIATIONS

AIS: Automatic identification system

ANMPA: Anguniakvia niqiqyuam Marine Protected Area

BSBMP: Beaufort Sea Beluga Management Plan

C&P: Conservation and protection

CBMP: Community-Based Monitoring Program

CEPA: Canadian Environmental Protection Act

CO: Conservation Objective

CP: Conservation Priority

CPUE: Catch per unit effort

CSAS: Canadian Science Advisory Secretariat

CWHC: Canadian Wildlife Health Cooperative

DFO: Department of Fisheries and Oceans Canada

EBS: Eastern Beaufort Sea

EISC: Environmental Impact Screening Committee

FJMC: Fisheries and Joint Management Committee

HTC: Hunters and Trappers Committee

IFA: Inuvialuit Final Agreement

IGC: Inuvialuit Game Council

IOMP: Integrated Oceans Management Plan

IRC: Inuvialuit Regional Corporation

ISR: Inuvialuit Settlement Region

MPA: Marine protected area

NRCan: Natural Resources Canada

TLK: Traditional and local knowledge

TNMPA: Tarium Niryutait Marine Protected Area

UAV: Unmanned aerial vehicle

WAMPA: Western Arctic Marine Protected Area Steering Committee

1 INTRODUCTION

The Tarium Niryutait Marine Protected Areas (TNMPA) is Canada's first Arctic MPA and was designated under Canada's *Oceans Act* (1996) in 2010. The boundary of the TNMPA consists of three separate sub-regions covering approximately 1800 km^2 of: Niaqunnaq (Shallow Bay), Okeevik (East Mackenzie Bay), and Kittigaryuit (Kugmallit Bay; Figure 1). The TNMPA lies within the Canadian Beaufort Sea and the Inuvialuit Settlement Region (ISR) (Figure 1). The establishment of the TNMPA was a collaborative effort by Fisheries and Oceans Canada (DFO), the Inuvialuit, co-management partner Fisheries Joint Management Committee (FJMC), private industry and local stakeholders to ensure long-term conservation and protection of the biological resources within the Mackenzie Estuary. Both the Beaufort Sea Beluga Management Plan (BSBMP) and subsequent MPA were driven by the need to protect and sustain the Eastern Beaufort Sea (EBS) beluga (*Delphinapterus leucas*) population and ensure the continuation of Inuvialuit traditional beluga subsistence harvest into the future (FJMC 2013). Therefore, the Conservation Objective (CO) developed for the TNMPA is,

"To conserve and protect beluga whales and other marine species, their habitats, and their supporting ecosystem".

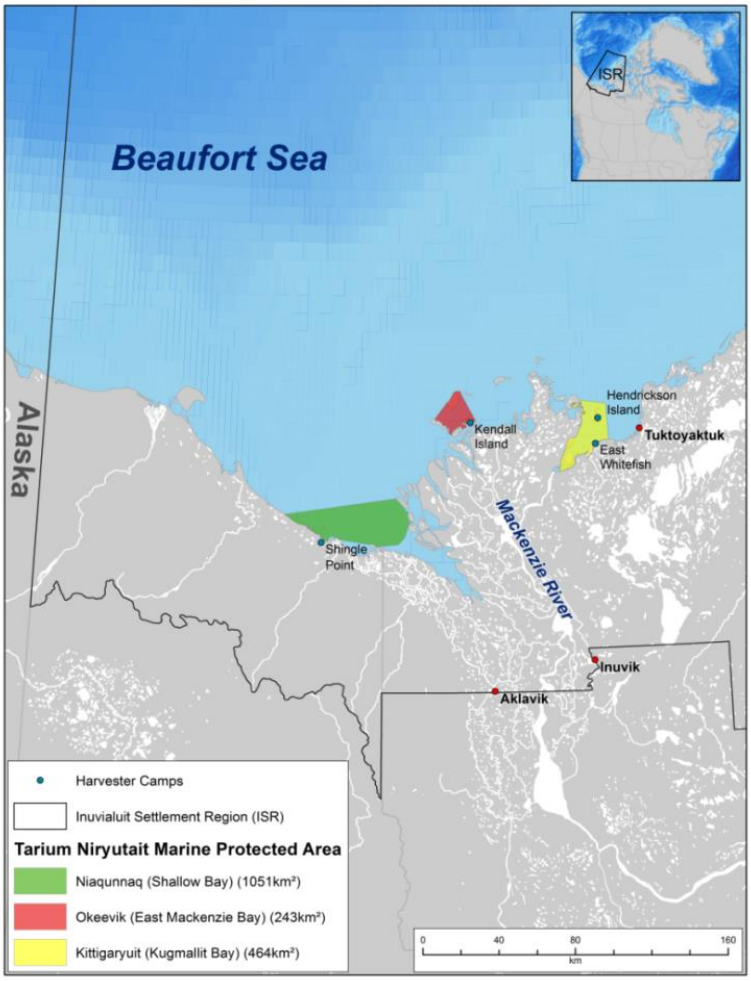


Figure 1. Map of the Tarium Niryutait marine protected areas, including the three sub-regions: Niaqunnaq, Okeevik, and Kittigaryuit, the harvesting camps (Shingle Point, Kendall Island, Hendrickson Island, and East Whitefish), and delta communities that harvest within the TNMPA.

The Mackenzie Estuary provides important estuarine summering habitat for EBS beluga (Fraker et al. 1979, Norton and Harwood 1986) and a variety of fish species (e.g., Carmack and Macdonald 2002, Brewster et al. 2016a). Furthermore, the area has been utilized by Inuvialuit for subsistence harvesting of beluga and fish since approximately 1300 CE (McGhee 1974, Alunik et al. 2003). Every spring, EBS beluga migrate from their wintering grounds in the Bering Sea to the Canadian Beaufort Sea via offshore open water leads. They typically reach Canadian waters in May and June (Fraker et al. 1979, Norton and Harwood 1986), and enter into TNMPA waters (specifically Kugmallit Bay, Shallow Bay and East Mackenzie Bay) following the break-up of an offshore ice bridge late June to early July (Byers and Roberts 1995, Norton and Harwood, 1986, Hornby et al. 2014; Figure 1). As the ice melts during this time and the Mackenzie River opens, anadromous fishes such as Arctic cisco (*Coregonus autumnalis*), migrate downstream to coastal waters of the nearshore Mackenzie Estuary (Gallaway et al. 1983, Coad and Reist 2017). The diversity and abundance of fishes harvested in the TNMPA continue to support Inuvialuit families from the delta communities of Aklavik, Inuvik and Tuktoyaktuk (Figure 1).

Designation of the TNMPA provided a regulatory mechanism to support the goals and objectives of the BSBMP (FJMC 2013) and the Beaufort Sea Integrated Oceans Management Plan (IOMP) (DFO 2009). It also supports the basic goals of the Inuvialuit as expressed through the three principals of the Inuvialuit Final Agreement (IFA):

1. To preserve Inuvialuit cultural identity and values within a changing northern society;
2. To enable Inuvialuit to be equal and meaningful participants in the northern and national economy and society; and
3. To protect and preserve the Arctic wildlife, environment and biological productivity (Western Arctic Land Claim 1987).

1.1 GOVERNANCE

The TNMPA is managed and monitored jointly between DFO, co-management partner FJMC. The TNMPA Management Plan (DFO and FJMC 2013a) provides the framework to guide management of the TNMPA. In 2010, DFO Science provided a comprehensive list of 82 ecological indicators, as well as some socio-economic indicators, for monitoring the TNMPA (DFO 2010). The remaining socio-economic and governance indicators were later identified and incorporated within the TNMPA Monitoring Plan (DFO and FJMC 2013b). The Management and Monitoring plans were developed to support the regulatory framework, collect baseline information to establish and monitor thresholds, and to assess the effectiveness of regulations and other management activities in meeting the CO (DFO and FJMC 2013a,b).

The TNMPA Monitoring and Management plans are each considered living documents to be reviewed approximately every six (6) years by the Western Arctic Marine Protected Area Steering Committee (WAMPA). WAMPA was formed in 2014 and tasked with providing regional guidance in the development of the Monitoring and Management plans for the two current Western Arctic MPAs. The establishment of WAMPA also ensures Inuvialuit involvement from community and co-management perspectives in the monitoring and management of Western Arctic MPAs. WAMPA membership currently includes a representative from each of the TNMPA delta communities' (i.e., Inuvik, Tuktoyaktuk, and Aklavik) Hunters and Trappers Committees (HTCs), the Anguniaqvia niqiqyuam MPA (ANMPA) representative from the Paulatuk HTC, DFO (Science, Oceans, and Northern Operations sectors), and the FJMC. This committee is overseen by the Inuvialuit Game Council (IGC), the Inuvialuit Regional Corporation (IRC), and DFO. The Inuvialuit MPA Coordinator position was established at the Joint Secretariat to enhance Inuvialuit capacity in MPA management, and serves as Secretariat to WAMPA alongside DFO Oceans. With the establishment of the second Western Arctic MPA, ANMPA in

2016, the governance structure was expanded to include TNMPA and ANMPA specific Working Groups to facilitate stronger community involvement in the management of the MPAs; while keeping the regional coordination guidance and oversight of WAMPA the same.

The TNMPA Management Plan identified six priority activities for the first six year cycle (2010–2016). These are:

1. Establishment of TNMPA management and steering committees;
2. Education, outreach, and awareness;
3. Enforcement and compliance of the regulations;
4. Monitoring and research;
5. Reporting; and
6. Review process of the TNMPA Monitoring and Management Plans.

1.2 SCOPE OF THE ASSESSMENT

This report qualitatively examined a suite of monitoring indicators (ecological, socio-economic, and governance) as identified in the TNMPA Monitoring Plan (DFO and FJMC 2013b), reviewed the implementation of the collection of data for each indicator (i.e., how many times each indicator was measured and recorded) between 2010 and 2016, and examined existing monitoring programs that support the CO since the establishment of the TNMPA 2010 to 2016. The intended audience for this report are MPA advisory bodies (i.e., WAMPA, ANMPA and TNMPA Working Groups), co-management partners (i.e., FJMC), Inuvialuit governing bodies (i.e., IGC, IRC, HTCs), and other collaborators.

The qualitative review included a summary of indicator data (i.e., programs that support the indicators, years of data collection, collection methods, relevance of indicators from both science and traditional knowledge perspectives) to inform on the efforts to date, and identify gaps in current monitoring programs. Recommendations made by knowledge holders (i.e., Inuvialuit governing bodies, harvesters, co-managers, researchers), together with the results of the qualitative review of indicators, formed the basis for this report and will serve as background document for future quantitative assessments and iterations of the plans. The completion of this report took approximately three years, and since the beginning of this process monitoring and management have increased. The establishment of MPA Working Groups under WAMPA occurred in 2018, prior to the planning and development of this report. Steps forward on the MPA Working Group's review of this report with guidance from WAMPA is described in the *Conclusions and Next Steps* section (Section 7). It is important to state that this report does not replace quantitative assessments of indicator data, nor does it dictate what the next iteration of the TNMPA Monitoring Plan will be. This is just the first step to inventory, and engage on indicators identified in the current monitoring plan, as well as document supporting literature, programs and perspectives.

Four assessment objectives are outlined in the current TNMPA Monitoring plan, which speak to indicator data inventory, evaluating the effectiveness of indicators, identify if the indicators support the CO, and make recommendations to support priorities in monitoring. Since this report focuses on the qualitative review and inventory of indictors, objectives of this report are to:

1. To produce an inventory of the current efforts to collect and report on indicators listed in the TNMPA Monitoring Plan (DFO and FJMC 2013b);
2. Determine if the indicators currently being measured should continue as part of reporting on the TNMPA CO; and

3. Make recommendations to support priorities in monitoring the TNMPA where gaps in monitoring exist.

Through the quantitative assessment of data collected for each indicator, as part of the second State of the TNMPA, is expected to meet the remaining objectives (i.e., effectiveness of the indicators to support the TNMPA) as stated in the TNMPA Monitoring plan (DFO and FJMC 2013b). The scope of this report includes recommendations based on indicators as written in the current TNMPA Monitoring Plan (DFO and FJMC 2013). Therefore, indicators names and categories were not changed through this process. Instead, discussions on how to improve wording and understanding of indicators, and methods in monitoring were discussed. Future steps will have to be taken to update indicators prior to the new iteration of the monitoring plan.

2 METHODS

2.1 ECOLOGICAL INDICATOR CATEGORIES

A total of 29 ecological indicators were identified in the TNMPA Monitoring Plan, of which 15 ecological indicators (DFO and FJMC 2013b) were identified for assessment in the *State of the TNMPA Report*. The indicators were grouped into 5 categories:

1. Ecosystem structure and function;
2. Population structure of key species;
3. Health of key species;
4. Anthropogenic noise; and
5. Physical and Chemical Environment.

Ecological indicators under categories 1– 4 were identified as indicators to be assessed in the *State of the TNMPA Report* (DFO and FJMC 2013b). Of the 28 ecological indicators, 13 indicators (many of which were part of the *Physical and Chemical Environment* category), were identified as indicators not to be assessed in this report (DFO and FJMC 2013b).

2.2 SOCIO-ECONOMIC AND GOVERNANCE INDICATOR CATEGORIES

Socio-economic and governance indicators identified in the TNMPA Monitoring Plan (DFO and FJMC 2013b) were grouped into the following categories:

Socio-Economic Indicator Theme:

1. Hydrocarbon development;
2. Tourism;
3. Transportation;
4. Harvesting;
5. Employment related to the TNMPA; and
6. Fisheries Act applications, Canada Environmental Protection Act (CEPA) applications.

Cultural Integrity Indicators Themes:

1. Use of TNMPA areas for subsistence harvesting;
2. Consumption of country foods; and
3. Perception of health of the TNMPA marine ecosystem by Inuvialuit harvesters.

Governance Indicators Themes:

1. Institutional management structures established and functioning;
2. Increased awareness, education, and outreach related to the TNMPA and its conservation objective;
3. Contributing to national network of MPAs;
4. Contributing to broader national and international Arctic monitoring programs;
5. Engagement with other DFO sectors; and
6. Six-year review of Management Plan and Monitoring Plan.

2.3 ECOLOGICAL INDICATOR ASSESSMENT

Monitoring efforts in the TNMPA began in response to the need for beluga population monitoring and protection of important summering grounds based on Zone 1a of the BSBMP (FJMC 2013). Prior to the establishment of the TNMPA, beluga monitoring programs (e.g., Harwood et al. 2002) were conducted to acquire harvest statistics, harvest-based metrics and tissue samples for contaminants analyses. The TNMPA Monitoring Plan identifies ecological indicators used to monitor beluga, marine fishes, and important habitats.

The TNMPA Management Plan (DFO and FJMC 2013a) suggested using a "Traffic Light Approach" to communicate complex data, results, and other findings associated with key indicators. This precautionary approach involves using reference limits that could evaluate an indicator over time, identify trends, characterize the status of indicators, and identify any required management actions (Caddy 1999). In this approach, trends are presented to management in the form of colour codes where trends marked as red indicate high importance and need of immediate management action (e.g., indicator trend declining or increasing toward a negative outcome), followed by orange (e.g., indicator trend is fluctuating), and green, an indicator marked as low importance in regards to management action (i.e., trend is indicating a positive outcome or stable) (Caddy 1999). However, sufficient data with which to examine trends, establish a baseline or identify thresholds were unavailable or have not been fully assessed for most indicators between the years of 2010–2016. Additionally, threshold and reference limits necessary to perform a Traffic Light Approach have not been examined and analyzed for the important indicators in the categories *Population Structure of Key Species* and *Health of Key Species* for beluga (e.g., body condition, disease, length). Consequently, this report was limited to a qualitative review of the implementation of the 15 ecological indicators (DFO and FJMC 2013b) used to monitor the TNMPA from 2010–2016, and evaluate their relevance to the CO. An inventory of data collected for each ecological indicator data was summarized, with the understanding that the next iteration of this report may be quantitative in nature. The status of implementation of each indicator in support of the CO was assessed by counting the number of times it was measured annually from 2010–2016 (See Appendix 1).

2.3.1 Scientific Research: An Inventory of Monitored Indicators

A meeting was held in Winnipeg, MB, October 2017, to identify the inventory of ecological indicators previously identified (DFO 2010, Loseto et al. 2010) and presently being used to monitor and manage the TNMPA. Participants were selected if they had direct involvement in research within the TNMPA. Representatives of Natural Resources Canada (NRCan), Canadian Wildlife Health Cooperative (CWHC), and researchers from academia also participated in the assessment because they conduct research and/or monitoring programs that collect selected or supporting indicators for the MPA (see Table 1). The number of times each indicator was

measured between 2010 and 2016 (i.e., implementation of indicators; Appendix 1) was relayed to participants, who were then asked to evaluate indicators relative to their field of expertise using the following criteria:

1. What has the indicator been used to measure in the past (i.e., what was it designed to measure), and has this indicator been monitored from 2010–2016
2. How does this indicator inform the CO?
3. Does this indicator measure parameters within or outside the TNMPA
4. Is this an important indicator to continue to monitor within the TNMPA based on published literature on each indicator?

Participants were then also asked to rank each ecological indicator as selected, supporting, research, or new, based on the relevance of each indicator to the CO (ecological indicator rank definitions found in Table 1). These same rankings were used for the socio-economic and governance indicators (introduced later in this document), in addition to pressure/ threats ranking (Table 1). These rankings are meant to clarify monitoring goals for the TNMPA going forward.

Both the amalgamation of expert opinion and documentation of published literature of existing programs inform which indicators are recommended for monitoring, and the identification of monitoring priorities. Results of this assessment will be used to inform WAMPA and the TNMPA Working Group decisions with regard to continued monitoring of the TNMPA, and provide information for future iterations of the TNMPA Monitoring and Management plans.

Table 1. Categories developed during State of TNMPA Report Engagement meetings to define indicator relevance to the TNMPA Conservation Objective (CO).

Indicator Type	**Definition of Indicator Type**
Selected Indicator	Indicator directly informs the TNMPA CO and is selected in the current TNMPA Monitoring Plan to be assessed every 5 to 6 years
Supporting	Indicator was perceived to indirectly informing the TNMPA CO as it was not to be assessed every 5 to 6 years as stated in the current TNMPA Monitoring Plan
Pressure/Threats	Socio-economic and governance indicators that indirectly informs the TNMPA CO by monitoring potential threats/stressors as identified through engagement meetings
Research Indicator	Indicator is important to research and informs the TNMPA CO. Potential to become an indicator for monitoring if it is continually monitored
New Indicator	Recommended indicator as a result of Inuvialuit/co-management and science engagement. Potential to become an indicator for monitoring

2.3.2 Inuvialuit/Co-management: An Inventory of Monitored Indicators

The involvement of MPA advisory and Inuvialuit governing bodies, and co-managers is essential to the success of TNMPA monitoring and management efforts. To that end, a separate meeting was held in Inuvik, NT in November, 2017 with Inuvialuit traditional and local knowledge (TLK) holders from WAMPA, IGC, FJMC, and HTCs' members/monitors from Inuvik, Aklavik, and Tuktoyaktuk. Both the implementation of each indicator over time (Appendix) and results of the indicator discussion from the science meeting were presented to participants. Here, participants were asked to provide their knowledge of each ecological indicator, along with their opinion of

the status of each indicator (Table 2) to qualify how well they felt the indicators were being monitored and managed from 2010–2016.

Similar to the science meeting, Inuvialuit participants were also asked to categorize each ecological indicator using Table 1.

Table 2. Value assigned to each indicator by Inuvialuit and co-management participants for ecological indicators and socio-economic and governance indicators by DFO Oceans, HTC and harvester participants through indicator engagement.

Status of Indicator Data	Colour Code	Definition of Status
Good	G	The number of times the indicator has been measured and monitored between 2010 and 2016 is good and contributes information to support the TNMPA CO
Adequate	A	The number of times the indicator has been measured and monitored between 2010 and 2016 is improving and is contributing information to support the TNMPA CO
Poor	P	The indicator data was not collected between 2010 and 2016, therefore does not contribute enough information to support the TNMPA CO
Poor 2	P2	The indicator data has not been consistently monitored from 2010 to 2016 (although data may have been collected), therefore does not contribute enough information to support the TNMPA CO
New	NEW	Recommended new indicator to monitor based on this assessment

2.4 SOCIO-ECONOMIC AND GOVERNANCE INDICATOR ASSESSMENT

In addition to ecological indicator assessments, socio-economic and governance indicators identified in the TNMPA Monitoring Plan (DFO and FJMC 2013b) were assessed to determine if they: a) inform the TNMPA CO; and b) have been monitored and managed consistently from 2010–2016. Socio-economic indicators aim to assess changes to the economic and cultural landscape that may occur as a result of TNMPA establishment and management. Governing indicators assist managers in assessing the success of management measures identified in the Management Plan (DFO and FJMC 2013a).

The framework employed an evaluation of the socio-economic and governance indicators using a multiple-choice questionnaire to identify the status of each indicator (Appendix 2). Participants of the socio-economic and governance indictor assessment questionnaire were identified as experts in the field and included members from the Aklavik (n = 5), Inuvik (n= 4), and Tuktoyaktuk (n = 5) HTCs, IGC (n = 1), IRC (n = 2), co-management participants from FJMC (n = 4), and DFO (n = 2) involved in the management or designation of the TNMPA. The questionnaire was accompanied by a table showing the number of times each indicator was measured between 2010–2016 (Appendix 3). Definitions for each socio-economic and governance indicator were given to participants prior to completing the questionnaire. Multiple-choice questionnaires were made available to participants and used to assess the implementation of socio-economic and governance indicators. Options for responses were: too low, sufficient, too high, and not enough information to answer the question. Participants were encouraged to comment on each indicator and identify modifications that could improve the current indicator list to better inform the CO.

3 RESULTS AND DISCUSSION

Ecological indicators for the TNMPA were categorized into two groups by workshop participants (researchers and Inuvialuit/co-managers); those measured within the TNMPA and those measured outside the TNMPA. Some TNMPA monitoring indicators measure parameters from species collected within the TNMPA but they are influenced by factors/variables that exist outside the TNMPA as well (e.g., mercury levels in important species identified in the TNMPA CO, blubber thickness). However, those indicators were viewed as important to continue to monitor since they are accessed while in the TNMPA (i.e., through monitoring programs), inform the TNMPA CO, and inform on health of subsistence species important to Inuvialuit.

The CO developed for the TNMPA is broad in its scope, and as a result, direct linkages between indicators and objectives of the Monitoring and Management plans are often complex. Therefore, the CO was unpacked during Inuvialuit/co-management meetings to better refine the Conservation Priority (CP) for the TNMPA; which was identified as: *"to conserve beluga, and fish species important to Inuvialuit subsistence and prey of beluga, and their habitat within the TNMPA".* This CP reflects data collected by current monitoring programs within the TNMPA. Thus, indicators going forth should support the CP as well as the TNMPA CO.

ECOLOGICAL INDICATOR ASSESSMENT: INSIDE THE TNMPA

3.1 ECOSYSTEM STRUCTURE AND FUNCTION: BIODIVERSITY

3.1.1 Number of species in the TNMPA

Currently, there is no dedicated monitoring program to address biological diversity within the TNMPA, largely due to feasibility and cost (Table 3). Stewart (2013) provided a comprehensive literature review of species reported to occur within- and outside the TNMPA. The corresponding data pre-dated the establishment of the TNMPA (1975–2004), and further efforts toward a biodiversity inventory were discontinued. Monitoring efforts within the TNMPA have largely focused on beluga and those fish species important to subsistence and beluga diets, as noted in the new CP identified in this report (DFO and FJMC 2013b). Fish monitoring programs were established and implemented within the Shallow Bay sub-region (Shingle Point Harvest Camp, Yukon) since 2010 and beluga monitoring has largely focused on the remaining sub-regions: Okeevik and Kugmallit Bay. To date monitoring programs have been restricted to the summer months (July-August) when beluga aggregate in the area, and harvesting of anadromous fish occur. Although 16 fish species were consistently observed at Shingle Point between 2011 and 2013 (Brewster et al. 2016a), 21 species have been identified from the area (through the Arctic Coastal Ecosystem Study [ACES], L.L. Loseto, DFO, Winnipeg, MB, unpublished data, 2019). Biodiversity is recognized as a key component of healthy ecosystems. Since biodiversity is difficult to measure in the TNMPA and other marine Arctic areas, indirect measures are often used. For example, Choy et al. (2017) reported an increase in the diversity of prey in beluga diets using dietary biomarkers (stable isotopes and fatty acids) of whales harvested within the TNMPA between 2011 and 2014, which could indicate a shift in prey availability and contribute information on potential offshore prey. Therefore, biodiversity was not recommended for direct monitoring in future iterations of the TNMPA Monitoring Plan. Instead, participants suggested focusing the biodiversity indicator on the Number of Key Species within the TNMPA (i.e., fishes and beluga). The assessment of ecological indicators identified a lack of fish monitoring programs in the Okeevik and Kugmallit Bay sub-regions of the TNMPA as a gap. DFO Fisheries Management recently established a sentinel fishers' program in Tuktoyaktuk

Harbour and efforts are being made to incorporate the program into regular TNMPA fish monitoring at East Whitefish (Kugmallit Bay), Kendall Island and Garry Island (Okeevik).

Biodiversity, although important may be too difficult to monitor directly. Instead trophic interactions in CO species should be continued, As well as expanding fish monitoring. Aspects of trophic structure have been assessed within the TNMPA since 2010 through research on fish and beluga stable isotopes (Table 3) and fatty acids under the Health of Key Species category for fish and beluga. These strategies can report on the diets of key species and other trophic levels present in the TNMPA. It is recommended that these research tools continue to be monitored to inform on trophic structure within the TNMPA.

3.1.2 Unusual species

Unusual species (i.e., non-native species to the area) as an indicator can inform on broader components of an ecosystem such as species range expansions and introductions, as well as early warning indicators for some level of environmental change. Records of unusual species can come from a variety of sources, including existing fish monitoring programs, diet studies, and harvester observations. The Arctic Salmon Project was initiated due to specific concerns regarding the increased numbers of salmon observations within the ISR. Arctic salmon species were highlighted as a species of concern by Inuvialuit/co-management (through the State of the TNMPA Report engagements, Inuvik, NT, oral presentation, 2017) and science participants (through the State of the TNMPA Report engagements, Winnipeg, MB, oral presentation, 2017) in light of northern range expansion of Pacific salmon species leading to the possible competition for resources of native species of char (e.g., Dolly Varden [*Salvelinus malma*] and Arctic Char; Dunmall et al. 2013,2016), along with the introduction of new diseases and parasites.

Continued monitoring of unusual species in the TNMPA as an indicator of change was recommended, with emphasis on salmon species. Observations of unusual species during monitoring and harvesting activities will continue to be part of the ongoing reporting process for the TNMPA.

The need to detect linkages between environmental indicators and changes in community composition (e.g., range expansions, presence/absence, and changes in abundance) was emphasized. Unusual weather events were highlighted by Inuvialuit/co-management participants as a concern and recommended it to be included as a monitoring indicator for the next TNMPA Monitoring Plan. This will allow for linkages to be made between harvest numbers and environmental factors within the TNMPA. An example used by Inuvialuit participants included the 2016 storms in Kugmallit Bay and Shallow Bay, where flooding and high winds influenced harvest numbers and destroyed houses. Inuvialuit/co-management participants highlighted that these events affected beluga harvest numbers in 2016 , by reducing days with optimal hunting weather. Thus, Unusual Events was recommended as an additional indicator for future monitoring, using strategies such as observations of storms as a measure (e.g., water temperature, salinity, turbidity, and observations). There is opportunity to include this indicator in Inuvialuit monitoring programs such as the Joint Secretariat Community-Based Monitoring Program.

Table 3. Monitoring efforts for collection of TNMPA ecological indicator data under the Ecosystem Structure & Function Indicator category. Information presented under Indicator Category, Indicator or Sub-category, Indicators Currently Used or Suggested for Monitoring, and Use in the State of TNMPA Report are taken from the 2013 TNMPA Monitoring Plan (DFO and FJMC 2013b). Ecological indicators that support socio-economic indicators are identified under Link to Socio-economic Indicators with their associated socio-economic indicator category. Detailed information for socio-economic and governance indicators is provided in the current Monitoring Plan (DFO and FJMC 2013b).

Indicator Category	**Indicator or Sub-category**	**Indicators Currently Used or Suggested for Monitoring**	**Use in the State of TNMPA Report**	**Available Data**	**Dataset Description**	**Programs Supporting Indicator**	**Link to Socio-economic Indicators**
Ecosystem Structure & Function	Biodiversity	Number of species in the TNMPA	Yes	Historical: 1975–2004 (intermittent)	Literature review only (Stewart 2013)	None	Economic/Harvesting
		Unusual species	Yes	Historical: 1978–2012 (intermittent includes data for Western Canadian Arctic) Current: 2016–present (TNMPA specific)	Harvest records, TLK from across the TNMPA (Dunmall et al. 2013; 2016),	Arctic Salmon Program (Dunmall et al. 2013); fish monitoring programs; harvest records	None
	Trophic structure	Stable isotopes	No	Current: 2010–present	Fish dorsal muscle tissue Beluga dorsal muscle and liver (Choy et al. (2017)	Arctic Coastal Ecosystem Study; Beluga Health Monitoring Program	None

3.2 POPULATION STRUCTURE OF KEY SPECIES: BELUGA

3.2.1 Indicator category

Through the State of the TNMPA engagement meetings, the need to clarify the scope and objective of indicators was noted. For example, some participants recommended the indicatory category *Population Structure of Key Species* be renamed *Population-Level Variables of Key Harvested Species*. Additionally, through this review it was highlighted that methods used to measure indicators were identified as indicators themselves. For the scope of this report these parameters are adjusted in Table 12. Although discussed here, indicators, categories grouping indicators, and tools/methods used to measure indicators will need to be fully assessed during a future quantitative review.

3.2.2 Catch per unit effort (CPUE) or number of beluga harvested

The CPUE or number of beluga harvested indicator relates to harvests of beluga while in the TNMPA (Table 4). The program was initiated by the oil and gas industry (from 1973–1980), and standardized in 1980 to monitor biological variables such as standard length and age (Fraker and Fraker 1979, Norton and Harwood 1986, Harwood and Norton 1996). The number of beluga harvested within the TNMPA between early June and August was recorded and monitored by DFO (1980–1986) and then led by FJMC (1987–present). Harvest numbers per community provide important information on hunting success, struck and loss, and beluga relative abundance while in the TNMPA during June-August, since harvests from each community are harvested in specific sub-regions of the TNMPA. As such, the continued use of this indicator was recommended.

CPUE provides additional information about the harvest by identifying variables that affect the outcome of a hunt (i.e., time and effort necessary for a successful harvest, number of harvesters). A recent study revealed that climate-induced impacts and changes in socio-economic issues (e.g., shifts in values, increasing financial pressures) result in decreased beluga hunting effort by the community of Aklavik (Worden 2019). It was recommended to record important harvest information such as number of whales landed and CPUE in a consistent manner was highlighted by both science (through the State of the TNMPA Report engagements, Winnipeg, MB, oral presentation, 2017) and Inuvialuit participants (through the State of the TNMPA Report engagements, Inuvik, NT, oral presentation, 2017) to improve our capacity to interpret shifts or trends in the annual number of beluga harvested per community. This would involve the inclusion of variables such as search time for each harvest, number of whales chased, and number harvested per hunt; which would inform on patterns of whale movements and aggregations within the TNMPA during the harvesting season and on.

It was recommended at both workshops that monitoring continues for total number of beluga harvested, including time and location of harvest, but that the indicator be expanded to capture additional information on effort, particularly through collection of harvester observations. This supporting information would improve the interpretation of harvest data, and has been included in the beluga monitors forms as part of the core FJMC Beluga Monitoring Program. Ideally, CPUE would be calculated, but this would require the collection of information on effort not only for landed whales, but also for instances where effort did not result in a landed whale (not typically reported). Additional contextual information would be required to standardize a ‘unit of effort’ based on gear type and other related factors (e.g., boat and motor, number of hunters searching, experience level of captain and harpooner). Research focusing on documenting TLK and assessing whale behavior in the context of harvest practices and environmental change has increased in recent years. Beluga monitors have been trained to collect harvest and climatic

(i.e., weather) information through questionnaire sheets and, more recently, the *Arctic Marine Observer App* has been developed to collect real time data on harvest, animal, and environmental components (Ostertag et al. 2018).

3.2.3 Date of first arrival/peak/last whales

Both TLK and scientific research have documented the seasonal migration patterns of EBS beluga into the TNMPA. Indicators used in the past to inform beluga arrival dates to the estuary include date of first harvest, peak harvesting, and date of last harvest. Recent changes in both hunter practices and beluga behavior as they relate to environmental parameters (e.g., weather, ice conditions were also identified through these indictors (Scharffenberg 2018, Scharffenberg et al. 2019)) and socio-economic factors (e.g., employment commitments, expenses). Dates of harvest can be used to detect changes in harvester practices, and be influenced by a number of variables such as beluga arrival into the estuary, weather conditions for hunting, and feasibility of hunting (Scharffenberg 2018). Prior to entering into the Mackenzie Estuary and TNMPA, beluga aggregate seaward along the fast ice bridge off the Mackenzie shelf in late May (Harwood and Smith 2002). Beluga entry into the TNMPA has been strongly and clearly influenced by the timing of break-up of the fast ice bridge that spans the outer Mackenzie Estuary (Fraker, 1977, Fraker et al. 1979, Norton and Harwood 1986, Hornby et al. 2016). For example, harvester observations and Scharffenberg et al. (2019) reported that both variability in ice bridge break-up and an increase in unusual weather events (i.e., increase in storms) affect harvests in Kugmallit Bay (through the State of the TNMPA Report engagements, Inuvik, NT, oral presentation, 2017, Scharffenberg 2018). In 1985, the ice bridge across Kugmallit Bay broke up later than previously recorded and as a result, beluga remained in the Shallow Bay estuary for an extended period of time. Consequently, subsistence harvests in Kugmallit Bay were lower and occurred later than in previous years (Norton and Harwood 1986). Harvest dates for the first whale of the season have been used in the past as a proxy for the first arrival of beluga to the TNMPA in spring; however, the variability associated with sea-ice clearance timing and extent (Stroeve et al. 2012, Overland and Wang 2013), changes in hunter behavior, and ice bridge break-up dates (Loseto et al.2018) all influence the timing of beluga entry into the estuary (Norton and Harwood 1986, Hornby et al.2014).

3.2.4 Distribution within TNMPA

Distribution of beluga while in the TNMPA (among the three sub-regions, and within one sub-region) can inform on habitat use of the area (e.g., important feeding areas, molting), and aid in understanding why beluga aggregate in the TNMPA sub-regions each summer. The last systematic aerial survey to document beluga distribution within and beyond the TNMPA was completed in 1992. Although current data pertaining to distribution of beluga while in the estuary has not been collected using the same method, more feasible monitoring technologies are currently being explored. Annual aggregation areas of beluga were assessed in the summer months of 1977–1985 and again in 1992 (Harwood et al. 2014a), where historical ‘hotspots’ were identified: two in Niaqunnaq (Shallow Bay), three in Kittigaryuit (Kugmallit), and two in Okeevik (Beluga Bay). The identification of these important aggregation areas gave rise to calls for seafloor assessments to determine if beluga spatial distribution could be defined by substrate type, relating to the molting hypothesis, as beluga are thought to come to the estuary to molt their skin in the freshened water (St. Aubin et al. 1990). However, Whalen et al. 2020 found a limited association between bottom substrate and beluga distribution. Scharffenberg et al. (2019) found that environmental drivers such as warmer, low salinity waters, and wind direction and speed were better predictors of beluga presence. Beluga vocalizations can also be used to determine presence/absence, but is not useful in quantifying habitat use by beluga (L. Loseto DFO Winnipeg, MB, pers. comm., 2018). More recently, the use of unmanned aerial

vehicles (UAVs or drones) was of limited use for determining beluga distribution, largely due to high turbidity in the Mackenzie Estuary (Scharffenberg 2018, Scharffenberg et al. 2019). The Kugmallit Bay sub-region where the majority of the harvest takes place may be an important habitat for rearing and socialization (Norton and Harwood 1986, Harwood et al.2015). Despite their limited use in turbid areas, UAVs can provide valuable information on group composition and improve monitoring programs associated with this indicator (Scharffenberg 2018).

All participants highlighted the importance of monitoring environmental (e.g., unusual events, storms), oceanographic (e.g., water temperature, salinity, turbidity, ice bridge break-up), biological (e.g., age, sex, length, girth) indicators along with TLK (e.g., beluga behavior, time of harvest); this is critical to track changes in the environment and to interpret changes in beluga use of the estuary. Using tools such as the *Arctic Marine Observer App* and monitor forms (used to document harvester observations upon harvest) to document observations of marine mammal presence and weather (e.g., air temperature, turbidity, storms) could provide information on why and where beluga aggregate within the TNMPA. Although these measures have been collected since the TNMPA was designated, are indicators under the Physical and Chemical Environment category of the TNMPA Monitoring Plan (not to be assessed in this report), they have not been consistently monitored through the TNMPA Monitoring Plan or selected as an indicator to be assessed. This information is necessary to inform on changes in beluga condition and behavior in response to environmental conditions over time, and has been recommended to be an indicator under Physical and Chemical Environment for future monitoring. Recommendations were made to have research focus on identifying the link between environmental and oceanographic conditions and beluga and fish, and also direct monitoring to ensure data being collected reflect these linkages In light of drivers such as weather, new methods to document first arrival of beluga to the TNMPA (e.g., hydrophones, visual monitoring with cameras) and the addition of ice bridge break-up dates, will improve our understanding of habitat use and movements. Participants recommended the inclusion of sea-ice MODIS imagery and acoustic and visual monitoring (via hydrophones and cameras, respectively) to document beluga arrival and departure to the MPA. Participants recommended clarifying that methods described are informing on the indicator *date of first/peak/last arrival* indicator, whereas documenting the dates of harvest measure the *date of first/peak/last harvest* indicator. Together these method of monitoring would capture information on harvest dates and ice-break up dates (i.e., when beluga have access into the TNMPA).

The combination of these indicators would improve long-term monitoring plans by providing additional information with respect to beluga movements and behaviour in the TNMPA, while also clarifying the impacts of socio-economic (e.g., cost of gas, harvester availability) impacts on harvests.

Additionally, all participants recommended using acoustic and drone monitoring, and harvest observations (via the *Arctic Marine Observer App* and TLK questionnaires) as strategies to collect data for beluga while in Kugmallit Bay on an annual basis. Marine observation forms were developed and provided to hired beluga monitors as of 2017 (included in beluga harvest monitors' binders as part of the Beluga Health Monitoring Program) to record daily observations for fish, birds and marine mammals for the TNMPA. Participants at the science workshop recommended the use of larger and more costly aerial surveys and tagging programs to monitor beluga movements in and out of the TNMPA on a 5–10 year basis. In summer 2018, year one of a two-year beluga tagging program was completed, during which time 10 whales were instrumented with satellite-linked transmitters (L. Loseto pers. comm.). These data will provide information on beluga distribution and movement within the TNMPA, and migration routes outside the TNMPA.

An aerial survey is being proposed for 2019–2020 to assess the abundance of the EBS beluga population and will contribute to understanding contemporary patterns of beluga distribution within, and outside of, the TNMPA boundaries. Finally, there was also a recommendation to conduct aerial surveys similar to Wolf et al. (2018) to document the habitat use of beluga while in the TNMPA throughout high use season (June to August) annually, and compare to whale distributions identified in the 1970s aerial survey (Fraker et al. 1979). It was also noted that a greater understanding of aggregation and migration patterns in the other sub-regions (Okeekik and Niaqunnaq) is needed to increase understanding of beluga behavior in the MPA.

3.2.5 Size, age, sex structure

Standardized measurements of harvested belugas (e.g., sex, age, body condition, maturity) have been recorded consistently since 1980 in association with annual Inuvialuit subsistence harvests within the TNMPA (Table 4, through the Beluga Health Monitoring Program, L.L. Loseto, DFO, Winnipeg, MB, FJMC, Inuvik, NT, unpublished data, 2019). These data, coupled with the Inuvialuit harvesters observations (documented on beluga monitor forms as part of the Beluga Health Monitoring Program), have characterized the size, sex and age of beluga that enter the TNMPA and are harvested. In order to maintain a sustainable harvest, Inuvialuit direct harvesting efforts toward males (approximately 4:1 males to females) and avoid females with calves (Harwood et al. 2015, FJMC and DFO Database). Of the females harvested, 66 percent carried a first term or full term fetus (Harwood et al. 2015, FJMC and DFO Database). Inuvialuit participants shared that some harvesters tend to choose timing (typically end of July-August) and location of their hunts so as to land larger whales with thicker muktuk. Using historical harvest data for over 2,000 whales, Harwood et al. (2015) identified a decrease in the size at age of harvested male whales in Kugmallit Bay since 2007. Hunters explained that this shift related to hunter selection as hunters now have less time to seek out larger whales due to harsher weather conditions such as higher winds (P. Gruben, Inuvik, NT, pers. comm., 2017).

All participants recognized the continuing need to monitor important biological indicators as a means of tracking changes, informing research questions, and identifying linkages to environmental indicators. Aging beluga by analyzing the teeth has been the common method used (Stewart et al. 2006). No, recommendations were made to change this indicator, Recommendations were made to consider replacing the aging technique based on teeth with a method that uses eyeballs when available; as unlike teeth, eyeballs do not erode over time (Pleskach et al. 2016). Utilizing harvester TLK regarding body condition and sex was deemed necessary to building the beluga database. For example, Inuvialuit participants highlighted that “harvested whales were fat this year (2017) and fed more families”, and that the quality and amount of oil or *uksuk* also reflects the health of the whale (Ostertag et al. 2018, 2019). The need to use environmental factors to monitor indicators such as change in blubber thickness and body size (i.e., girth, stand length) was recognized as important, as well as providing results and updates of scientific research to the communities.

Table 4. Monitoring efforts for collection of TNMPA ecological indicator data under Population Structure of Key Species: Beluga category. Information presented under Indicator Category, Indicator or Sub-category, Indicators Currently Used or Suggested for Monitoring, and Use in the State of TNMPA Report are taken from the 2013 TNMPA Monitoring Plan (DFO and FJMC 2013b). Ecological indicators that support socio-economic indicators are identified under Link to Socio-economic Indicators with their associated socio-economic indicator category. Detailed information for socio-economic and governance indicators is provided in the current Monitoring Plan (DFO and FJMC 2013b).

Indicator Category	**Indicator or Sub-category**	**Indicators Currently Used or Suggested for Monitoring**	**Use in the State of TNMPA Report**	**Available Data**	**Dataset Description**	**Programs Supporting Indicator**	**Link to Socio-economic Indicators**
Population Structure of Key Species	Beluga	Catch per unit effort (CPUE) or total number harvested	Yes	Historical & Current: Consecutively 1974–present	Beluga harvest numbers for the TNMPA DFO (1980–1986) and then led by FJMC (1987- present)	Beluga Health Monitoring Program	Economic/Harvesting; Cultural Integrity/ Use of TNMPA Areas for Subsistence Harvesting; Cultural Integrity/ Consumption of Country Foods; Economic/ Employment Related to TNMPA
		Date of first arrival/peak/last whales	Yes	Historical & Current: aerial surveys 1977 1985, 2011–2013 (intermittent) 1980–present	Date of harvests (Harwood and Smith 2002; Scharffenberg 2018; Fraker, 1977, Fraker et al. 1979, Norton and Harwood 1986, Hornby et al. 2016).	Beluga Health Monitoring Program; Aerial surveys	Economic/Harvesting; Cultural Integrity/ Use of TNMPA Areas for Subsistence Harvesting
		Size, age, sex structure	Yes	Historical & Current: 1974–present (intermittent)	Size (standard length since 1980;auxillary and maximum girth since 2000); Age (teeth since 1993); Sex (reproductive organs since 2000) (Harwood et al. 2015, FJMC and DFO Database); Stewart et al. 2006).	Beluga Health Monitoring Program	No

Table 4. Continued

Indicator Category	Indicator or Sub-category	Indicators Currently Used or Suggested for Monitoring	Use in the State of TNMPA Report	Available Data	Dataset Description	Programs Supporting Indicator	Link to Socio-economic Indicators
Population Structure of Key Species	Beluga	Annual aerial surveys	No	Historical: 1977–1985, 1992	Aerial surveys for beluga presence in and outside of the TNMPA (1992 (Harwood et al. 2014a), Scharffenberg 2018, Scharffenberg et al. 2019).	None. Aerial survey anticipated in 2019–2020	No
		Distribution within the TNMPA	Yes	Historical: 1992 Current	Historical: Aerial survey (1992) Current: Kugmallit bay focus of TLK questionnaires documenting harvester observations; drone surveying areas	Beluga Health Monitoring Program	Economic/Harvesting; Cultural Integrity/Use of TNMPA Areas for Subsistence Harvesting

3.3 POPULATION STRUCTURE OF KEY SPECIES: FISHES

There was consensus among all participants at each workshop that monitoring fish populations through the Arctic Coastal Ecosystem Study (ACES, 2010 - present) and Dolly Varden Char (2011 -present) monitoring programs should continue. Priority was given to fish species important to Inuvialuit subsistence and beluga diet, which coincides with the CP identified by Inuvialuit participants during this assessment.

3.3.1 CPUE or total number of fish harvested

The Dolly Varden Char Monitoring Program is the only long-term monitoring program within the TNMPA that assesses the total number of fish harvested (Loewen et al. 2013). Monitoring this indicator is consistent with the CO and CP and provides necessary information used in stock assessments for this important subsistence species (Gallagher et al. 2013, 2018). This indicator was viewed by participants as important to monitor. ACES is another long-term monitoring program, but sets an annual sample size (n = 20, ACES database [L.L. Loseto, DFO ACES data, Winnipeg, MB, unpublished data, 2019]) to inform on habitat use, trophic linkages, and shifts in habitat use and diet. In support of the TNMPA Inuvialuit priorities (i.e., CP), the ACES program monitors populations of five fish species that are important to subsistence and beluga diet (see Table 5). These five species are associated with different habitat types (e.g., benthic vs. pelagic, freshwater vs coastal vs marine). Although ACES does not directly measure the total number of fish harvested, it does address important questions regarding fish populations in the area, such as develop baseline information on habitat use and diet of fish species and track shifts in fish populations' overtime. It was recommended for both the ACES and Dolly Varden Char monitoring programs to continue as tools to measure the number of key species (see Recommendations Section 3.1.2.1) and number of fish harvested (Table 6). Recommendations to expand the ACES program to Kugmallit Bay were made to address fish monitoring gaps in other sub-regions of the TNMPA.

Capturing CUPE from the fish monitoring programs has been a challenge. Still, it was highlighted as important to try to capture in the monitoring plan. Incorporating the timing of first/peak/last capture (similar to that used for beluga) in fish monitoring programs was recommended for inclusion into the TNMPA Monitoring Plan. Including harvest times of the most commonly harvested species at Shingle Point (e.g., Arctic Cisco and Dolly Varden Char) would increase our knowledge of species-specific seasonal migrations particularly with respect to environmental indicators (e.g., turbidity, weather) and the impacts of environmental condition on the presence and distribution of species within the TNMPA.

3.3.2 Size, age, sex structure

Data pertaining to size, age, and sex structure are typically collected during the ACES and Dolly Varden Char monitoring programs (Table 6). Indicators of size (e.g., fork length), sex, and age are important biological characteristics used to assess fish populations and to inform important research questions relevant to diet, disease, and nursery habitats.

The indicators listed as sex and body weight in the TNMPA Monitoring Plan are in actuality methods or strategies to measure structure of harvest. A recommendation was made to continue their use along with size and age in monitoring programs to inform on population health.

Table 5. Fish species collected during the Arctic Coastal Ecosystem Study (ACES) and Dolly Varden Char Monitoring Program at Shingle Point, YT. Species currently being monitored through ACES are indicated with an asterisk (*). The years each species were collected are included.

Species	**Years Data Were Collected**
*Arctic Cisco (*Coregonus autumnalis*)	2010–2017
Arctic Flounder (*Pleuronectes glacialis*)	2010–2016
Arctic Lamprey (*Lethenteron camtschaticum*)	2012
*Broad Whitefish (*Coregonus nasus*)	2010, 2011, 2013–2018
Burbot (*Lota lota*)	2010–2012, 2015, 2016
Dolly Varden Char (*Salvelinus malma*)	2011–2018
Fourhorn Sculpin (*Myoxocephalus quadricornis*)	2010–2013, 2015, 2016
Inconnu (*Stenodus leucichthys*)	2010–2013, 2015
Lake Trout (*Salvelinus namaycush*)	2016
Lake Whitefish (*Coregonus clupeaformis*)	2010–2013, 2015
Least Cisco (*Coregonus sardinella*)	2010–2016
Longnose Sucker (*Catostomus catostomus*)	2011, 2012
Ninespine Stickleback (*Pungitius pungitius*)	2012
Northern Pike (*Esox lucius*)	2011–2013
Pacific Herring (*Clupea pallasii*)	2010–2013, 2015
Pink Salmon (*Oncorhynchus gorbuscha*)	2011
*Rainbow Smelt (*Osmerus mordax*)	2010–2013, 2015, 2017, 2018
Round Whitefish (*Prosopium cylindraceum*)	2010–2013
*Saffron Cod (*Eleginus gracilis*)	2010–2018
*Starry Flounder (*Platichthys stellatus*)	2010–2018

Table 6. Monitoring efforts for collection of TNMPA ecological indicator data under the Population Structure of Key Species: Fish category. Information presented under Indicator Category, Indicator or Sub-category, Indicators Currently Used or Suggested for Monitoring, and Use in the State of TNMPA Report are taken from the 2013 TNMPA Monitoring Plan (DFO and FJMC 2013b). Ecological indicators that support socio-economic indicators are identified under Link to Socio-economic Indicators with their associated socio-economic indicator category. Detailed information for socio-economic and governance indicators is provided in the current Monitoring Plan (DFO and FJMC 2013b).

Indicator Category	Indicator or Sub-category	Indicators Currently Used or Suggested for Monitoring	Use in the State of TNMPA Report	Available Data	Dataset Description	Programs Supporting Indicator	Link to Socio-economic Indicators
Population Structure of Key Species	Fish	Catch per unit effort (CPUE) or total number harvested	Yes	Current: 2011–present	Number of Dolly Varden Char Harvested at Shingle Point, YT (Loewen et al. 2013; database [L.L. Loseto, DFO ACES data, Winnipeg, MB, unpublished data, 2019]).	Dolly Varden Char Monitoring Program	Economic/Harvesting; Economic/Employment Related to TNMPA
		Size structure, age, sex	Yes	Historical: 2001–2005 (Tariaq) Current: 2010–present (ACES: size and sex); 2010–2013(ACES: age); 2011–present (Dolly Varden Char)	Collect from harvest fishes at Shingle Point, YT (Database [L.L. Loseto, DFO ACES data, Winnipeg, MB, unpublished data, 2019])	ACES Dolly Varden Char Monitoring Program	None

3.4 ANTHROPOGENIC NOISE

3.4.1 Number of vessels transiting the TNMPA

The decrease of seasonal sea-ice cover across the Beaufort Sea is resulting in increased accessibility of the Western Arctic to vessel traffic (Stephenson et al. 2011, Pizzolato et al. 2016). These increases in vessel traffic and associated noise pollution were highlighted as a concern, particularly in relation to monitoring beluga presence within the TNMPA and migration routes. Consistent monitoring of large vessels (i.e., vessels > 300 gross tonnage) via the Automatic Identification System (AIS) was recently improved through DFO Conservation and Protection (C&P) division by consistently monitoring large vessels entering the TNMPA annually (Table 7). Research efforts in the area are ongoing and were initiated as a result of community concerns regarding increasing vessel traffic in the Beaufort Sea and potential impacts to marine mammals (Girdlestone et al. 2017, Halliday et al. 2017). All participants were particularly interested in assessing the linkages between number of vessels and the body condition and distribution of beluga throughout the TNMPA over time.

All participants recommended consistent monitoring of large vessel transiting through and near the TNMPA, and the need to assess the impacts to beluga presence/absence and distribution. The need to expand vessel tracking capabilities to include small vessels (e.g., adventure crafts) and dates of small vessel transit was of high importance to Inuvialuit participants. Since small vessels (< 300 gross tonnage) are not required to have AIS installed on the vessel, tracking them has been difficult and was recognized as a gap in vessel monitoring. It was suggested that the weather station camera installed in Kugmallit Bay (through the Beluga Health Monitoring and Climate Change Geoscience programs) could record small vessels in the estuary. Additionally, Inuvialuit participants voiced their concerns about potential impacts associated with large vessel depth sounders on beluga behavior and migration. To mitigate these concerns, information on best practices when transiting in or around the TNMPA (e.g., avoiding MPAs when possible, slowing down to 10 knots when marine mammals are near, avoiding substance harvesting and migration times) was suggested to be included in future management plans. Plans to assess the impacts of vessel traffic within and near the TNMPA via acoustic monitoring of beluga vocalizations is ongoing in an effort to assess potential impacts of vessel noise on beluga (L. Loseto, Winnipeg, MB, pers. comm., 2018).

Table 7. Monitoring efforts for collection of TNMPA ecological indicator data under the Anthropogenic Noise category. Information presented under Indicator Category, Indicator or Sub-category, Indicators Currently Used or Suggested for Monitoring, and Use in the State of TNMPA Report are taken from the 2013 TNMPA Monitoring Plan (DFO and FJMC 2013b). Ecological indicators that support socio-economic indicators are identified under Link to Socio-economic Indicators with their associated socio-economic indicator category. Detailed information for socio-economic and governance indicators is provided in the current Monitoring Plan (DFO and FJMC 2013b).

Indicator Category	**Indicator or Sub-category**	**Indicators Currently Used or Suggested for Monitoring**	**Use in the State of TNMPA Report**	**Available Data**	**Dataset Description**	**Programs Supporting Indicator**	**Link to Socio-economic Indicators**
Anthropogenic Noise	Large vessels (> 300 gross tonnage)	Number of vessels transiting TNMPA	Yes	Current: 2015–2016	Automatic Identification System (AIS) (Stephenson et al. 2011, Pizzolato et al. 2016; Girdlestone et al. 2017, Halliday et al. 2017).	Conservation and compliance (C&P) DFO	Economic/Tourism; Economic/Transporting; Economic/Hydrocarbon Development; Economic/Fisheries Act Applications, CEPA Applications

AIS=Automated Information System; DFO = Fisheries and Oceans Canada; C&P=Conservation and Protection; CEPA=Canadian Environmental Protection Act

ECOLOGICAL INDICATOR ASSESSMENT: OUTSIDE THE TNMPA

3.5 HEALTH OF KEY SPECIES: BELUGA

3.5.1 Blubber thickness

Beluga body condition was assessed as part of the ISR-wide Beluga Health Monitoring Program and included measurements of girth, blubber thickness, total length, fluke length, age, sex, and catch statistics (spatial and temporal). Blubber thickness was recorded in 1,104 belugas between 2000–2016 in multiple locations across the TNMPA (Table 8), and was used to reflect current year body condition (Table 9). Inter-annual variation in blubber thickness was monitored over time, and comparisons were made between 1) whales landed inside the TNMPA with those outside the TNMPA, and 2) whales landed among the three sub-regions of the TNMPA (MacMillan et al. 2018). MacMillan (2018) found differences in blubber thickness among males landed within the three TNMPA sub-regions, and suggested hunter preference, timing of harvest, and other variables may have influenced results. The annual and seasonal variability in blubber thickness among whales, uncertainty of current sampling techniques (e.g., human error) make this indicator difficult to evaluate. Understanding linkages between body condition indices and other factors that may influence beluga condition (e.g., season, reproductive status, habitat suitability) is a challenge. Results from MacMillan (2018) also suggest that measuring blubber thickness in millimeters (mm) rather than centimeters (cm) will increase precision. Also the angle of the ruler and position of whale were highlighted by science participants as factors to consider when taking measurements.

It was recommended that girth be incorporated into TNMPA Monitoring Plan in addition to blubber thickness, because girth may be more susceptible to change than blubber thickness and is useful as a measure of body condition, particularly when combined with blubber thickness. Participants agreed on the importance of developing a standardized scale to measure beluga health and assess trends in body condition over time and recommended continued monitoring of both blubber thickness and girth, and that both environmental and climate indicators are included in these assessments to accurately inform on beluga condition and to determine if linkages exist. Currently, a body condition scale is used in the Beluga Health Monitoring Program for the TNMPA to standardize harvesters' observations when visually interpreting body condition (Ostertag et al. 2018). The scale incorporates an assessment of whale backbones using categorizations such as "healthy" or "thin". Participants recommended that the use of this scale continue. These data may also provide a better understanding of the supporting ecosystem.

Table 8. The locations, years collected (from 2000–2016) and number of blubber thickness samples collected from the TNMPA sub-regions.

TNMPA Sub-Region	Years	Sample Sizes (n)
Shallow Bay	2000–2005, 2007, 2013	31
Okeevik	2000–2007, 2009–2016	279
Kugmallit Bay	2000–2016	794

3.5.2 Mercury in muscle

Mercury concentrations in EBS beluga muscle have been monitored since the 1980s and represent the most comprehensive dataset for any beluga population (Table 9). Methyl mercury (the form of mercury found in muscle) is neurotoxic, bioaccumulates (builds up in living

organisms), and biomagnifies (concentration increases up the food chain). Methyl mercury concentrations in beluga are monitored primarily through diet, which provides information about beluga health and ecosystem processes (Loseto et al. 2008). Although mercury concentrations in beluga harvested in the TNMPA are not reflective of mercury levels present in the TNMPA, the indicator remains a concern to Inuvialuit. Concentrations of mercury in Inuvialuit subsistence fishes and beluga prey have not been thoroughly assessed, along with terrestrial sources of mercury into the marine environment. The process by which mercury accumulates in beluga tissues through their diet and terrestrial sources (e.g., erosion), is not fully understood (Loseto et al. 2009, Loseto et al. 2015, Macdonald and Loseto 2010).

Mercury levels have declined in belugas sampled since the 1990s to early 2000s however, these declines do not coincide with emission reductions (Loseto et al. 2015). The importance of beluga to Inuvialuit subsistence highlights the need for continued monitoring and understanding of these levels.

3.5.3 Disease/parasite/abnormalities

The presence or absence of diseases, parasites and abnormalities are useful parameters to consider when assessing changes in the health of wildlife. Some diseases such as brucellosis (caused by the bacteria *Brucella* spp) are known to negatively affect reproduction in cetaceans (Hernández-Mora et al. 2013). However, lesions consistent with brucellosis have not been observed in male or female reproductive organs of EBS belugas harvested within the TNMPA (Lair and Couture, Montreal, QC, pers comm., 2017). Serological testing of TNMPA beluga for the presence of *Brucella* antibodies (i.e., animals exposed to *Brucella*) has been performed annually in Kugmallit Bay since the mid-1980s (FJMC and DFO Database), and is ongoing. *Brucella* serology results is independent of body condition, and on its own may not support the TNMPA CO pertaining to beluga health. Consequently, the presence of *Brucella* antibodies (those considered seropositive) were analyzed to determine associations to sex, age, and body condition (O. Nielson, Winnipeg, MB, pers comm., 2017). Results indicated significant positive correlations between *Brucella* seropositivity and beluga age, suggesting that older beluga are more likely to be seropositive (O. Nielson, Winnipeg, MB, pers comm., 2017). This phenomenon has been observed in other species, and likely reflects an increased chance of older whales to be exposed, and a general decrease in immune function with age (Treanor et al. 2015). *Brucella* may decrease reproductive success by causing infertility and abortions as seen in other mammals (Nielson et al. 2001). While it appears that brucellosis does not pose a significant outward effect on EBS beluga health at present, stressors such as climate change and vessel noise may affect beluga immune function and/or exposure to *Brucella*, and the a potential threat to reproductive success makes this an important indicator. Additionally, from the Inuvialuit participant's perspective, an indicator does not always need to reflect change to be meaningful. It was recommended that serological tests for *Brucella* continue in the TNMPA. Continued passive monitoring via visual observations for tissue abnormalities was recommend during both harvest activities and stranding events is also recommended. This monitoring will help assess long-term trends, particularly in light of additional stressors such as increased vessel traffic and environmental change.

All participants also supported continuation of tissue collection as an indicator of beluga health, particularly from whales that appear to be in poor health. This type of information, combined with necropsy data, can provide meaningful insight on emerging health issues in beluga populations over time. The collection of blood and swabs to test for emerging diseases was also recommended, in addition to more efficient and timely reporting of results to communities. A protocol to fast-track results to communities is currently being drafted. It was recognized that

beluga indicators should be regularly reassessed, which is consistent with the five- to six-year cycle associated with the Monitoring Plan.

The presence of pseudaliid lungworms (*Halocercus monoceris, H. taurica* and *Stenurus arctomarinus*) has been associated with verminous pneumonia and juvenile fatality in St. Lawrence belugas (Lair et al. 2014). Pseudaliid lungworms were observed in some individuals of Beaufort Sea beluga during health assessments in 2015 and 2016, and additional tests are being conducted to determine the species and prevalence (E. Couture, pers. comm.). Research focusing on the presence of lung worms in association with pneumonia and brucellosis, and the transmission pathways of *Halocerus* in beluga were recognized as important in assessing beluga health (Hernández-Mora et al. 2013).

Visual abnormalities on the skin of belugas are currently documented as part of the monitoring program and incorporate both scientific and harvester observation. Healed scarring, possibly associated with the herpes virus, was observed on some beluga intermittently through the Beluga Health Monitoring Program harvested within the TNMPA, but was not considered to be as severe as the active skin lesions reported in belugas infected with the herpes virus in Alaska (Nielsen et al. 2018). Full necropsies were performed on beluga harvested from Hendrickson Island (n = 10 in 2015; n = 16 in 2016), to determine the health of the EBS beluga subpopulation associated with Kugmallit Bay. Preliminary analyses indicated that beluga harvested at Hendrickson Island are healthy. Abnormalities continue to be documented through the Beluga Health Monitoring Program and are used to identify current and emerging new diseases, abnormalities, and parasites.

Toxoplasmosis (an infection caused by the single-celled parasite *Toxoplasma gondii*) in beluga is a relatively recent concern to Inuvialuit in the Western Arctic; however, exposure has been reported in both animals and people since the 1970s and 1980s (Jenkins et al. 2013). *Toxoplasma gondii* can be transferred through the consumption of raw or undercooked tissues of wild and domestic animals, as well as from food and water contaminated with cat feces (Dubey 2010). Toxoplasmosis affects reproductive rates in marine mammals (Sharma et al. 2018) and has been detected in beluga stranded in the St Lawrence Estuary (Iqbal et al. 2018). In 2009–2013, genetic histochemical and serological tests detected a unique type(s) of *Toxoplasma* in EBS belugas (Haman et al. 2013), and resulted in calls for continued parasitological research focusing on beluga in the TNMPA. Since 2014, blood from 81 beluga harvested in Kugmallit Bay (Hendrickson Island and East Whitefish) have been tested for *T. gondii* antibodies to identify if individuals were exposed to toxoplasmosis in their life time. Only one animal tested positive for Toxoplasmosis antibodies in the blood. Toxoplasmosis DNA was not detected in hearts (n = 56 sampled), and only one (of n = 22) had DNA present in the brain. False negatives are a possibility with these tests (i.e., ELISA tests, Sharma et al. 2018); however, these tests work very well in other wildlife (Sharma et al. 2019). At this time, there is no reason to suspect that *Toxoplasma* is causing health problems in beluga that are harvested in the ISR, but monitoring is recommended since *Toxoplasma* can negatively affect reproductive success and has been found in stranded beluga elsewhere (i.e., St. Lawrence beluga). It is important to note and ensure appropriate communication to Inuvialuit subsistence harvesters that the consumption of country foods is safe to eat. Since both brucellosis and toxoplasmosis can impact beluga reproductive success, these diseases remain valuable research indicators of beluga health and as such, support the TNMPA CO.

Inuvialuit participants identified micro-plastics as a concern with respect to beluga health and recommended that micro-plastics be added as a measure of health monitoring. Through the Beluga Health Monitoring Program, whole stomachs and subsections of intestines and colons from seven whales harvest at Hendrickson Island (2017 and 2018) were sampled for micro-plastic analysis (Moore et al. 2020). The Vancouver Aquarium is researching micro-

plastic accumulation in the Beaufort Sea Ecosystem and is analyzing micro-plastics in beluga as well as fish; including species known to be prey of beluga (e.g., Saffon Cod, Arctic Cod, Arctic Cisco, sculpin, and flounder) to determine possible micro-plastic transfer through diet. Preliminary results show low amount of micro-plastics in beluga, where most micro-plastics are observed in the feces, suggesting that the majority are excreted (R. Moore, Fisheries Joint Management Committee Annual Meeting, Winnipeg, MB, Oral presentation, 2019). Although micro-plastics were not assessed in 2010–2016, it is a current concern to Inuvialuit partners and was recommended to continue by collecting beluga feces when available, through the Beluga Health Monitoring Program.

3.5.4 Length/weight relationships

Length weight relationships of beluga harvested in Kugmallit Bay in 2015 and 2016 were compared to those of St. Lawrence belugas. Weighing whales on Hendrickson Island is challenging due to associated costs and time. These challenges are exacerbated by unpredictable weather conditions, which also increase the risk that hunters will be stranded while attempting to weigh their harvests due to inclement weather. Additionally, factors such as beluga habitat preference (e.g., females and young males are more common within the estuary) during harvest activities and harvester preferences for larger males determines which whales are sampled (through the Beluga Health Monitoring Program, L.L. Loseto, DFO, Winnipeg, MB, FJMC, Inuvik, NT, unpublished data, 2019, Loseto et al. 2006), and as a result of this bias, is a poor indicator of length/weight relationships within the TNMPA.

Preliminary results indicated that length-weight curves developed for the St. Lawrence beluga population are not useful in describing trends in body condition for EBS beluga because the latter population is generally healthier (DFO 2000), and contains larger individuals (through the Beluga Health Monitoring Program, L.L. Loseto, DFO, Winnipeg, MB, FJMC, Inuvik, NT, unpublished data, 2019, St. Lawrence beluga sampling, S. Lair, Faculté de Médecine Vétérinaire, Université de Montréal St-Hyacinthe, QC, unpublished data, 2017). The two populations may be morphologically distinct because of differences in home range and migration, or other factors related to their life history and habitats. It was suggested to develop a body condition curve specific to belugas harvested in the TNMPA using TLK for monitoring. The practice of weighing meat, muktuk, and organs (correcting for fluid loss) as was done in various Hudson Bay regions (Sergeant 1969) was not of interest to Inuvialuit harvesters. However, predicting weight based on the parameters of length and girth as demonstrated in Eastern Chukchi Sea (Suydam 2009) and Hudson Bay (Doidge 1990) was of interest. There was a recommendation to record the number of pails (5 gallon) of muktuk one whale provides along with the standard length, harvesting techniques and name of each hunter. This could serve as a measure of body condition over time through a subsistence perspective, when the situation allows (i.e., if muktuk is transferred directly into pales after harvest).

Table 9. Monitoring efforts for collection of TNMPA ecological indicator data under the Health of Key Species: Beluga category Information presented under Indicator Category, Indicator or Sub-category, Indicators Currently Used or Suggested for Monitoring, and Use in the State of TNMPA Report are taken from the 2013 TNMPA Monitoring Plan (DFO and FJMC 2013b). Ecological indicators that support socio-economic indicators are identified under Link to Socio-economic Indicators with their associated socio-economic indicator category. Detailed information for socio-economic and governance indicators is provided in the current Monitoring Plan (DFO and FJMC 2013b).

Indicator Category	**Indicator or Sub-category**	**Indicators Currently Used or Suggested for Monitoring**	**Use in the State of TNMPA Report**	**Available Data**	**Dataset Description**	**Programs Supporting Indicator**	**Link to Socio-economic Indicators**
Health of Key Species	Beluga	Blubber thickness	Yes	Historical: 2000–present	Measurements taken from harvest whales (*Bradford et al. 2012, George et al. 2015, MacMillan 2018)*	Beluga Health Monitoring Program	Cultural Integrity: Consumption of country foods; Cultural Integrity: Perception of health of the TNMPA marine ecosystem by Inuvialuit harvesters
		Lipids	No	Current: 2010–present	Blubber	Beluga Health Monitoring Program	None
		Fatty acids	No	Current: 2010–present	Blubber (Loseto and Stern, 2009)	Beluga Health Monitoring Program	None
		Chronic stress impacts	No	Current: 2007–present	Cortisol levels in blood and blubber (Loseto et al. 2015)	Beluga Health Monitoring Program	Cultural Integrity: Perception of health of the TNMPA marine ecosystem by Inuvialuit harvesters
		Mercury in muscle	Yes	Historical & Current: 1984–2016	Total mercury concentrations (Loseto et al. 2008, Loseto et al. 2009, Loseto et al. 2015).	Beluga Health Monitoring Program	Cultural Integrity: Consumption of country foods; Cultural Integrity: Perception of health of the TNMPA marine ecosystem by Inuvialuit harvesters

Table 9. Continued.

Indicator Category	Indicator or Sub-category	Indicators Currently Used or Suggested for Monitoring	Use in the State of TNMPA Report	Available Data	Dataset Description	Programs Supporting Indicator	Link to Socio-economic Indicators
Health of Key Species	Beluga	Disease/parasite/ abnormalities	Yes	Historical & Current: *Brucella* mid–1980s present Current: *Toxoplasmosis* 2015–present	Presence/absence of Brucella (Beluga Health Monitoring Program, S. Lair and E. Couture, Faculté de Médecine Vétérinaire, Université de Montréal St-Hyacinthe, QC, unpublished data, 2019, L.L. Loseto, DFO, Winnipeg, MB, FJMC, Inuvik, NT, unpublished data, 2019, O. Nielson, Winnipeg, MB, pers comm., 2017)	Beluga Health Monitoring Program	Cultural Integrity: Consumption of country foods; Cultural Integrity: Perception of health of the TNMPA marine ecosystem by Inuvialuit harvesters
		Length/weight relationships	Yes	Current: 2015–2016 (intermittent)	Dependent on weighing whales (Beluga Health Monitoring Program, L.L. Loseto, DFO, Winnipeg, MB, FJMC, Inuvik, NT, unpublished data, 2019, St. Lawrence beluga sampling, S. Lair, Faculté de Médecine Vétérinaire, Université de Montréal St-Hyacinthe, QC, unpublished data, 2017)	Beluga Health Monitoring Program	Cultural Integrity: Perception of health of the TNMPA marine ecosystem by Inuvialuit harvesters

3.6 HEALTH OF KEY SPECIES: FISH

3.6.1 Mercury in muscle

Mercury levels in fish as an indicator for health monitoring have been relatively inconsistent over time (Table 10). Thus far, research programs have included one study of eight species between 2002–2006 (Loseto et al. 2008) and another of seven species between 2012–2013 (Brewster et al. 2018). Inuvialuit participants indicated the need to monitor this indicator more consistently in order for it to meaningfully contribute information to the knowledge gap of mercury exposure in coastal fish species and inform on mercury exposure to top predators, like beluga through diet.

Inuvialuit participants were interested in monitoring mercury levels in subsistence fish species, and indicated that this could be facilitated by partnering with other government departments with a mandate related to human health (e.g., GNWT Health Department) in regards to subsistence. Inuvialuit participants requested that monitoring efforts alternate years and focus on a few species. The recommended species based on the CP (fish species important to beluga prey and subsistence) was Arctic Cisco. Other species such as Saffron Cod (*Eleginus gracilis*) and Rainbow Smelt (*Osmerus mordax*) have also been reported in beluga diets (Quackenbush et al. 2015, Loseto et al. 2009) and could be included in mercury studies. Tran et al. (2016) analyzed mercury data collected from Dolly Varden Char in the Baggage River in 1991 and reported that anadromous fish exhibited higher total mercury concentrations than resident (non-anadromous) individuals, regardless of age. This and other studies suggest that understanding life history, size, and age of individuals are important factors affecting mercury concentration. Participants identified a gap in knowledge regarding mercury accumulation in beluga and linkages to prey species, particularly in the TNMPA where consistent fish research is conducted only at Shallow Bay.

3.6.2 Disease/parasites/abnormalities

Range expansions of diseases and parasites with increasing temperatures in the Arctic remain a concern. Thus, improving baselines and assessments for diseases and parasites in TNMPA species could provide an indication of change. The population of Dolly Varden Char harvested at Shingle Point, Yukon has been monitored (e.g., CPUE, harvest numbers, DNA, aging, length and weight measurements) annually since 2011. DFO (2017) concluded that Dolly Varden Char in the TNMPA were generally healthy. The primary concern in this case is the increasing presence of non-native salmon species in Beaufort Sea coastal environments and rivers, which may result in the introduction of new parasites and diseases to Arctic ecosystems. Currently, no studies in the TNMPA have focused on fish diseases, parasites, or abnormalities. Inuvialuit participants noted that red spots are being observed on fish captured at Tuktoyaktuk Harbour (near the Kugmallit Bay sub-region) more frequently. Parasitic infections in TNMPA fish was identified as a concern of Shingle Point harvesters, particularly with regard to Arctic Cisco (Brewster et al. 2016). Engagement with science participants indicated that although species of parasite, including *Dibothriocephalus plerocercoid*, *Discocotyle, Diplostomum metacercaraia*, and *Ergasilus* (i.e., gill lice) were found in Least Cisco (*Coregonus sardinella*) in 2011, they were in low prevalence and intensity. No further parasite studies were conducted after this.

Science participants indicated that parasites and disease are separate parameters and recommend that they should not be considered as one indicator. In order to use parasitic infections as a primary indicator, decisions would need to be made with respect to which parasite species are best to evaluate fish health, and what fish species are most important to monitor. Parasites are part of a healthy ecosystem and can serve as an indicator of trophic interactions throughout the food web. In order to properly assess the effects of parasites on fish,

body condition and large sample sizes must be examined. Parasitic infections would need to be monitored annually or seasonally, would include necropsies of whole fish, and would require costly and extensive laboratory work. Inuvialuit participants suggested that parasitic infections in Arctic Cisco be used as a measure for this research indicator. The development of a platform to effectively incorporate observations of abnormalities and disease into the Monitoring Plan was suggested, and supported in earlier recommendations for fish monitoring. Participants recommended using harvest observations to record the presence of disease and abnormalities in future monitoring plans.

Table 10. Monitoring efforts for collection of TNMPA ecological indicator data under the Health of Key Species: Fish category. Information presented under Indicator Category, Indicator or Sub-category, Indicators Currently Used or Suggested for Monitoring, and Use in the State of TNMPA Report are taken from the 2013 TNMPA Monitoring Plan (DFO and FJMC 2013b). Ecological indicators that support socio-economic indicators are identified under Link to Socio-economic Indicators with their associated socio-economic indicator category. Detailed information for socio-economic and governance indicators is provided in the current draft of the Monitoring Plan (DFO and FJMC 2013b).

Indicator Category	Indicator or Sub-category	Indicators Currently Used or Suggested for Monitoring	Use in the State of TNMPA Report	Available Data	Dataset Description	Programs Supporting Indicator	Link to Socio-economic Indicators
Health of Key Species	Fish	Mercury in muscle	Yes	Historical: 1991 Current: 2004, 2010, 2012–2013 (intermittent)	Total mercury concentrations in dorsal muscle (Brewster et al. 2018, Loseto et al. 2008)	ACES	Cultural Integrity: Perception of health of TNMPA marine ecosystem by Inuvialuit harvesters
		Length/ weight relationship	No	Current: Dolly Varden Char: 2011–present ACES: 2010–present	Length and weight measured (FJMC and DFO Database, Loseto et al. 2006, Suydam 2009, Doidge 1990)	Dolly Varden Char Monitoring Program ACES	Cultural Integrity: Perception of health of TNMPA marine ecosystem by Inuvialuit harvesters
		Fatty acids	No	Current: 2010–present	Half fish (excluding gastrointestinal intestinal tract)	ACES	None
		Disease/parasites/ abnormalities	Yes	No	(DFO, 2017, Brewster et al. 2016).		Cultural Integrity: Perception of health of TNMPA marine ecosystem by Inuvialuit harvesters

ACES = Arctic Coastal Ecosystem Study

4 RECOMMENDATIONS FOR FUTURE MONITORING AND MANAGEMENT

4.1 IDENTIFIED INDICATOR GAPS IN MONITORING DISCUSSED DURING THE WORKSHOPS

4.1.1 Physical and Chemical Environment

A number of monitoring gaps were identified in the current TNMPA Monitoring Plan, the most prevalent of which pertained to the biophysical indicators of environmental (e.g., erosion, storms) and oceanographic (e.g., water temperature, salinity) features under *Physical and Chemical Environment* (Table 11). Under the current TNMPA Monitoring Plan, indicators in this category are supporting indicators that are not recommended for assessment. Acoustic data have been collected in the TNMPA since 2011 and oceanographic data have been collected since 2014. Historical oceanographic (Hopky et al. 1994) and physical seabed (i.e., sediments) (Pelletier 1984) data collected in the 1980s are available for the general area. Sediment and geological studies have been part of ongoing research in the TNMPA, but have not been consistently done (Table 11). Turbidity has been measured through the Climate Change Geoscience Program (NRCan), in partnership with the Beluga Health Monitoring Program and ACES, and is an important indicator of beluga and fish habitat suitability and utilization. Participants recommended adding *turbidity* as a sub-category of *Oceanography*. Both science and Inuvialuit participants agreed that indicators under *Physical and Chemical Environment* should be considered primary indicators and monitored annually (Table 11). The need to better understand linkages between environmental indicators and beluga and fish indicators was also strongly recommended. For example, the indicator *timing of ice break-up* informs that of *date of first/peak/last arrival of beluga*. Understanding linkages between environmental and biological/ecological indicators will provide a better understanding of the ways in which environmental changes affect ecosystem function in the TNMPA.

Table 11. Monitoring efforts for collection of TNMPA ecological indicator data under the Physical and Chemical Environment category. Information presented under Indicator Category, Indicator or Sub-category, Indicators Currently Used or Suggested for Monitoring, and Use in the State of TNMPA Report are taken from the 2013 TNMPA Monitoring Plan (DFO and FJMC 2013b). Ecological indicators that support socio-economic indicators are identified under Link to Socio-economic Indicators with their associated socio-economic indicator category. Detailed information for socio-economic and governance indicators is provided in the current Monitoring Plan (DFO and FJMC 2013).

Indicator Category	**Indicator or Sub-category**	**Indicators Currently Used or Suggested for Monitoring**	**Use in the State of TNMPA Report**	**Available Data**	**Dataset Description**	**Programs Supporting Indicator**	**Link to Socio-economic Indicators**
Physical and Chemical Environment	Ice Phenology	Ice distribution and timing of ice break-up	No	Historical	Satellite imagery	Climate Change and Geoscience Program	None
	Oceanography	Mackenzie River flow	No	Current: Dolly Varden Char: 2011–present ACES: 2010–present Historical and Current: WSC	WSC data from water level and flow stations available online.	Dolly Varden Char Monitoring; ACES; Water Survey Canada	None
		Temperature / salinity, chlorophyll *a*	No	Current: 2010–present (salinity and temperature); 2010 (chlorophyll *a*)	CTD measurements for temperature and salinity (Hopky et al. 1994)	ACES Beluga Health Monitoring Program; Climate Change and Geoscience Program	None

WSC = Water Survey of Canada'

Table 11. Continued.

Indicator Category	Indicator or Sub-category	Indicators Currently Used or Suggested for Monitoring	Use in the State of TNMPA Report	Available Data	Dataset Description	Programs Supporting Indicator	Link to Socio-economic Indicators
Physical and Chemical Environment	Physical Habitat	Bathymetry	No	Historical: Dating back to 1980s Current: Kugmallit Bay 2013–present	Sonar data for Kugmallit Bay Historical CHS nautical charts for Okeevik and Shallow Bay regions (Whalen, Loseto, Hornby, Harwood, and Hansen-Craik, 2019).	Climate Change and Geoscience Program	None
		Substrate texture	No	Historical: dating back to 1980s Current: 2013–2015 for Kugmallit Bay	Historical seabed grainsize measurements (Available online)	Climate Change and Geoscience Program	None
		Coastline erosion	No	Historical: 1972–2000 Current: 2000–present	ArcGIS shoreline vectors depleting erosion rates at 100 m interval along the coast (digital data available online, Hynes et al. 2014)	Climate Change and Geoscience Program	None

4.1.2 Beluga behaviour through harvest TLK

Beluga behavior is a valuable indicator missing from the current TNMPA Monitoring Plan. Inuvialuit observations of beluga behavior during past harvests support monitoring indicators such as beluga distribution within the estuary and arrival into the TNMPA. Participants agreed that CPUE should be recorded regularly and consistently when possible, during harvesting activities to aid in the monitoring of behavior in response to weather and other factors. Examples of harvester observations shared during this assessment that would be useful to the program included:

"Female whales will move away from a pod with calves to try to detour harvesters, whereas male pods will stay together while hunted."

"It is easier to harvest whales earlier in the season; later in the season whales are better at getting away."

"The whales are coming from the West. There are stories from the past of whales coming from the East, and that like to go into bays and lakes – a few pods chasing flounders, coneys (i.e., Inconnu) or whatever fish."

CPUE (from harvester and monitor observations), annual aerial and acoustic data will increase our understanding of beluga distribution and harvest numbers within the TNMPA. Indicators for beluga distribution, arrival, and harvest numbers are included in Table 4 and recommendations provided by Inuvialuit and science participants for future monitoring of whale distribution and behavior are reflected (section 3.2.5). Additionally, the beluga harvest monitoring forms (through the Beluga Health Monitoring Program, L.L. Loseto, DFO, Winnipeg, MB, FJMC, Inuvik, NT, unpublished data, 2019) were updated in 2018 to support the collection of harvesters TLK about beluga behavior and health.

4.1.3 TNMPA as beluga rearing habitat

Monitoring the reproductive success of beluga while in the TNMPA was identified as a gap in monitoring; however, given the low number of females harvested, adequate sample sizes are not available to assess reproductive rates or trends in reproductive output using harvested samples (Harwood et al. 2015). Kugmallit Bay is an important calf rearing area for beluga in the summer months (FJMC and DFO Database). For example, Harwood et al. (2014a) observed 298 calves at the surface within the TNMPA during aerial surveys (1977–1985 and 1992) conducted from late June to early August. Calves are also regularly observed alongside females by hunters in Kugmallit Bay, and harvested females typically have a fetus present (FJMC and DFO Database). It is uncertain if beluga come to the estuary for calving, since there has been some sightings of calves in the offshore.

Identifying an accurate and economically feasible indicator to measure reproductive success is a challenge that has not been fully addressed. Recommendations to incorporate TLK observations such as the number of calves observed by harvesters, as well as location and time of observations, into the beluga monitoring program was suggested as a way to monitor reproductive success as an indicator. However, double counting and high turbidity in the water (low visibility) serves as challenges to accurately measuring this indicator. Inuvialuit participants reported that calves are normally seen with pods of whales and that during a hunt, larger whales (presumably females) will try to detour harvesters away from the pod and calves. Currently marine observation forms, the *Arctic Marine Observer App* and beluga harvest monitoring forms have been incorporated into the Beluga Health Monitoring Program and allow for harvesters and beluga monitors to document the seasonal presence of calves while in the TNMPA. The number

of calves observed per hour or per day can be recorded for comparison over time. New technologies (e.g., drone and aerial surveys), and harvester observations were recommended to document the seasonal presence of calves while in the estuary. Science participants proposed that calf activity could be used as a proxy for reproductive activity and could be assessed by recording vocalizations (contact calls) between mother and calf using hydrophones during the Beluga Monitoring Program (through the Beluga Health Monitoring Program, L.L. Loseto, DFO, Winnipeg, MB, unpublished data, 2011–2019).

4.2 RECOMMENDATIONS FOR FUTURE MONITORING ECOLOGICAL INDICATORS

Recommendations gathered through engagement with science, Inuvialuit, and co-management partners were incorporated into the new TNMPA ecological indicator monitoring table (Table 12). Based on recommendations from partners, the original ecological indicator table (DFO and FJMC 2013b) was modified to include Indicator Type, Indicator within/outside TNMPA, and Status of Monitoring of Indicators categories. These categories were added to clarify the goals and current status of monitoring for these indicators. Additionally, a description of basic methods to measure existing indicators were incorporated into the table. Potential new indicators were also identified.

There were many comments made by participants which challenged whether some indicators were in fact that, or instead methods used to measure these indicators (e.g., trophic structure versus stable isotopes and fatty acids). Indicators should be based on SMART goals that create measurable objectives; therefore, should clearly inform research objectives and decision making. There needs to be clarity on how indicators are being monitored, and how they will indicate when and if change occurs over time. There also is a need to choose indicators that inform what we are trying to monitor; indicators are better if they can inform on big picture information. These discussions will need to be addressed during the quantitative assessment. Participants agreed most of the indicators currently being monitored informed the TNMPA CO, however, *Physical Environment* indicators need to be linked with biological indicators and be assessed in future reporting. Indicators such as beluga behavior and calves in the TNMPA should be added.

Table 12. Proposed list of ecological monitoring indicators based on results of the State of TNMPA Report engagement. New criteria include: Indicator Type, Indicator within/outside TNMPA, and Status of Monitoring of Indicators. Status of Monitoring of Indicators was scored as Good (G), Adequate (A), or Poor (P) by Inuvialuit participants. Indicators under recommended are updated to reflect the engagement feedback.

Category	Element	Indicators Recommended for monitoring	Indicator Type	Indicator within (√) or outside (×) TNMPA	Strategy for Monitoring	Status of Monitoring of Indicators
Ecosystem Structure and Function	Number of Key Species	Number of marine mammals and fish species in TNMPA	Selected	√	Harvester observations; monitoring and sentinel programs	**A**
		Unusual species	Supporting	√	Harvester observations; monitoring and sentinel programs	**G**
	Trophic Structure	habitat use and feeding ecology	Research	×	Beluga Health Monitoring Program Method stable isotopes.	
Population-Level Variables of Key Species	Beluga	Total number harvested	Selected	√	Beluga Health Monitoring Program	**G**
		Catch per unit effort of harvest (CPUE)	Selected	√	Beluga Health Monitoring Program (e.g., research and harvester notes)	**P**
		Date of arrival/peak/last whales harvested	Selected	√	Beluga Health Monitoring Program (i.e., harvest dates)	**G**
		Date of arrival/last recorded occurrence of beluga	New	√	Sea ice MODIS imagery; acoustic and visual monitoring through hydrophones and camera, respectively	**NEW**
		Size, age, sex structure	Selected	√	Beluga Health Monitoring Program	**G**
		Distribution of beluga	Selected	√	Annual surveys within the TNMPA; aerial surveys conducted on a 5–10 year basis for distribution inside and outside TNMPA; local observations, Arctic Observer App	**A**
		Beluga behavior	New	√	Harvester observations	**NEW**
		Number of calves in estuary	New	√	Harvester observations (i.e., number of calves observed per hunt)	**NEW**
	Fish	Total number harvested	Supporting	√	Fish monitoring programs	**A**
		CPUE	Supporting	√	Research and harvester notes as part of fish monitoring programs	**P**
		Date of first arrival/last subsistence fish	New	√	Harvester notes for Dolly Varden Char and ACES	**NEW**
		Size, age, sex	Selected	√	Fish monitoring programs	**G**

Note: Refer to Table 1 for description of *Indicator Type;* ACES = Arctic Coastal Ecosystem Study

Table 12. Continued.

Category	Element	Indicators Recommended for monitoring	Indicator Type	Indicator within (√) or outside (×) the TNMPA	Strategy for Monitoring	Status of Monitoring of Indicators
Health of Key Species	Beluga	Blubber thickness & girth	Selected	×	Beluga Health Monitoring Program	**G**
		Diet and stress	Research	×	Lipids, fatty acids, hormones, stomach content analyses	
		Mercury	Selected	×	Analysis of muscle	**G**
		Disease	Selected	×	Beluga Health Monitoring Program(i.e., brucellosis)	**G**
		Parasites	Research	×	Beluga Health Monitoring Program (i.e., *Toxoplasma gondii*)	
		Contaminants	Research	×	Beluga Health Monitoring Program (i.e., microplastics)	
	Fish	Mercury	Selected	×	Fish monitoring programs	**P**
		Diet	Research	×	Fatty acids and stomach content analyses	
		Parasites	Research	√	Fish monitoring programs; research studies	
Physical and Chemical Environment	Ice Phenology	Ice distribution and timing of break-up	Selected	×	NRCan; harvester notes	**P2**
	Oceanography	Mackenzie River flow	Supporting	√	Environment Canada	**P2**
		Water temperature, salinity, turbidity	Selected	√	Within the TNMPA and at drainage locations (Mackenzie River)	**P2**
	Physical Habitat	Coastline erosion	Selected	√	Bathymetry; water depth	**P2**
		Unusual event	New	√	TLK on unusual weather while in the TNMPA (i.e., winds, storms)	**NEW**
Anthropogenic Noise		Number of vessels transiting TNMPA	Selected	√	Number of vessels transiting the TNMPA (large vessels and adventurers); Beluga Health Monitoring Program (e.g., acoustic monitoring)	**A**

Note: Refer to Table 1 for description of *Indicator Type;* ACES = Arctic Coastal Ecosystem Study

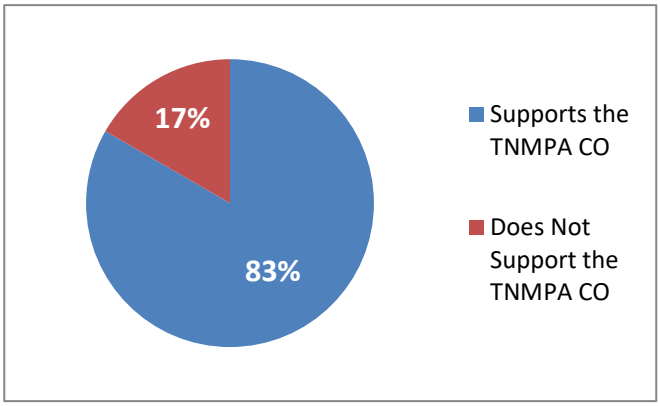
5 PERSPECTIVES ON SOCIO-ECONOMIC AND GOVERNANCE INDICATORS

Results of the socio-economic and governance questionnaires (Supplement 2) are summarized in the sections below. DFO Oceans and the Inuvilauit MPA Coordinator met with each of the TNMPA HTCs (Inuvik, Aklavik, and Tuktoyaktuk) to review the questionnaires and allow for open discussions. These discussions were useful in summarizing the HTC recommendations for each indicator and the identification of regional goals. Discussion led to recommendations for the modification of socio-economic and governance indicators to meet local goals and clarify methods for monitoring. Participants of the socio-economic and governance indicators assessment included representatives of the HTCs (Aklavik: n = 5, Inuvik: n = 4, Tuktoyaktuk: n = 5), IGC (n = 1), IRC (n = 2), FJMC (n = 4), and DFO employees involved with the TNMPA management (n = 2). Recommendations from co-management partner participants (FJMC), and DFO (DFO Oceans Program) were grouped together in their respective organizations, whereas HTCs, IRC, and IGC were combined as Inuvialuit in this assessment based on discussions with partners. Questionnaire results and recommendations made by Inuvialuit, FJMC and DFO representatives are presented below. Participants were asked whether each indicator supports the TNMPA CO; results of this were tallied and presented in a pie chart for each respective indicator.

Socio-economic indicators aim to assess changes to the economic and cultural landscape that may occur as a result of TNMPA establishment. Where the management measures used to assess the success of the TNMPA is monitored through the governance indicators. Some of the indicators identified do not fall under DFO Oceans Management purview; however, these indicators provide information relevant to potential threats and stressors in the TNMPA and were recognized as important for monitoring. Goals for the socio-economic and governance indicators were not clearly defined in the TNMPA Monitoring and Management plans. Participants recognized the need for clear goals to ensure the indicators support the TNMPA CO and facilitate management decisions for the TNMPA. This will be the focus for the next iterations of the Monitoring and Management plans.

5.1 SOCIO-ECONOMIC INDICATORS

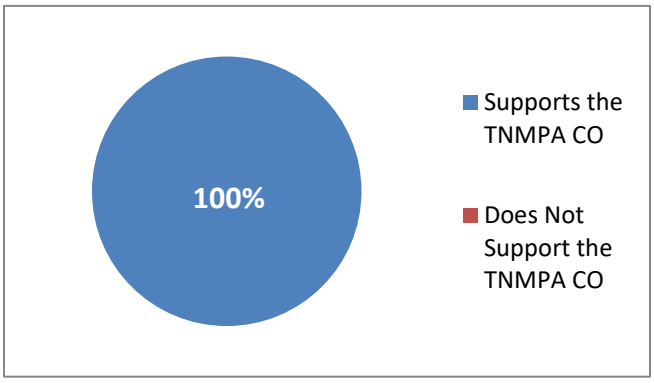
5.1.1 Annual number of hydrocarbon development applications



The first indicator assessed in the questionnaire was the number of hydrocarbon applications received for areas in and adjacent to the TNMPA. The question posed to participants was “is the number of hydrocarbon development applications directly supporting the TNMPA CO”. The purpose of this question was to assess the perceived effects (positive or negative) of hydrocarbon development on ecosystem health within the TNMPA, and on the economic potential of the area (Supplement 2). As mentioned, the goal associated for this and other socioeconomic indicators were not clear in the monitoring plan (e.g., indicator to monitor a threat or pressure, socioeconomic). Therefore, this as well as the desired state needs to be identified before it can be used as a useful indictor used for monitoring. The majority of participants (83%) felt that this indicator supported the TNMPA CO in that it would provide

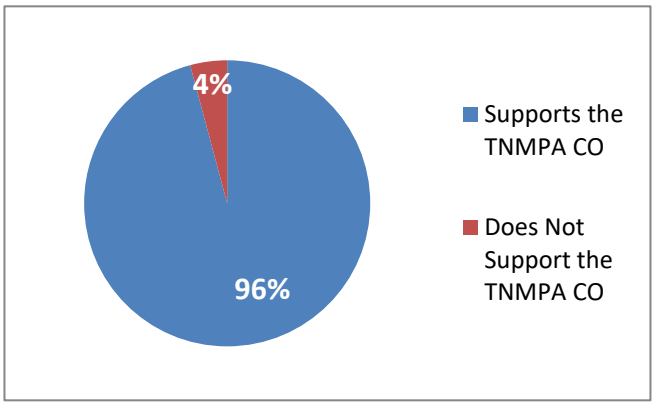
information relevant to the conservation and protection of important key species and habitat. Participants also expressed interest in the potential economic benefits of hydrocarbon development. No hydrocarbon applications were received for Canadian Beaufort Sea between 2010 and 2016 (Supplement 3). As a result, 30 percent (n = 7) of participants felt that the low number of applications indicated low economic potential, while 52 percent (n = 12) felt that there was not enough information to answer the question. Since the TNMPA was established in 2010 and allowed for hydrocarbon development in the Shallow Bay sub-region of the TNMPA (DFO and FJMC 2013), participants agreed that monitoring this indicator was important. Participants discussed the relevance of this indicator in light of the absence of applications and five-year moratorium placed on oil and gas development in the Beaufort Sea in 2016. Some participants believed that this indicator was more consistent with global economy, international trade and the price of crude oil than to ecosystem health. Although the perceived goal of this indicator was to measure economic potential, it is also considered to be an important indicator of potential threats or stressors to the TNMPA (e.g., oil spills). There was a recommendation to broaden this indicator to measure industrial development.

5.1.2 Annual number of ecotourism companies and income generated



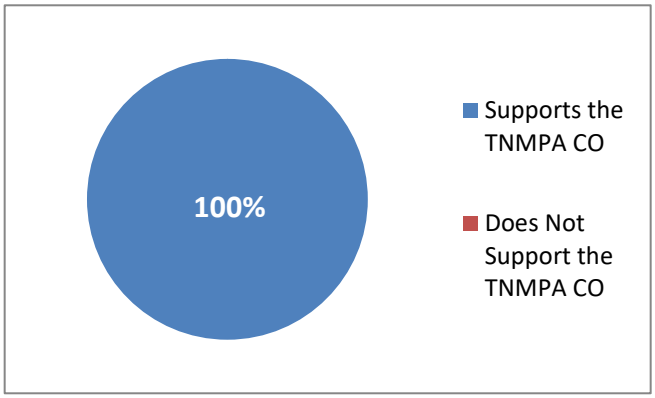
This indicator was monitored over time based on the number of active tourism companies in the area (determined by applications submitted to Environment Impact Screening Committee [EISC]; Supplement 3). All participants agreed that this indicator supports the TNMPA CO by increasing awareness of beluga, important fishes and marine conservation; however, many suggestions were made with respect to modifying the indicator to better monitor tourism activity in the TNMPA. The frequency and timing of tourism activities were identified as being important variables to monitor. It is difficult to document the number of tourism vessels (presumably small craft) in the TNMPA. Inuvialuit participants suggested talking to harvesters within the TNMPA and contacting local HTCs after the summer season to estimate the frequency and timing of tourism activities. Opinions regarding the usefulness of this indicator varied among Inuvialuit and FJMC participants. Some participants indicated that there was insufficient information to assess the indicator; others considered that the low number of tourism companies in the TNMPA did not contribute substantively to local economies, and still others indicated that the number of tourism activities was high enough to impact local habitat and biota. Specific recommendations were made to modify this indicator to focus on the frequency and timing of tourism activities conducted during the peak months (June-August). Consequently, a recommendation was made to change the indicator to *annual number of tourism companies entering the TNMPA*. It is recommended that future monitoring include consultations with local HTCs about active tourism within TNMPA boundaries to provide a more accurate measure of tourism. This is particularly important considering that the number of local tourism operators registered under EISC did not distinguish between activities within and outside of the TNMPA. The submission and approval of activity plans is a requirement for all Canadian MPAs, excluding the TNMPA. This tool has been proven useful in monitoring activities (i.e., research, monitoring, tourism, or educational) within the ANMPA, and was suggested to be incorporated into the TNMPA Regulations. This would allow for improved inventory of all activities within the TNMPA as well as help in mitigating the impacts tourism may have on the TNMPA ecosystem and Inuvialuit subsistence harvests.

5.1.3 Annual number of vessels transiting the TNMPA



Assessments of vessel traffic within the TNMPA are limited to large (> 300 gross tonnage) vessels as these are the only vessels that can be tracked using the Automatic Identification System (AIS). The majority (96%) of participants felt that this indicator directly supported the TNMPA CO. DFO and FJMC (n = 1) participants indicated that the number of large vessels transiting the TNMPA was low and as a result, did not contribute to MPA awareness (i.e., proxy for tourism) or local employment. Conversely, one Inuvialuit (n = 1) participant indicated that the number of large vessels was high and expressed concerns that these activities were overwhelming the communities and/or disrupting the habitat and marine species in the area. Other Inuvialuit participants (n = 16) indicated that there was insufficient information to assess potential impacts of this indicator on the TNMPA. This perspective looked at the number of vessels as a stressor on ecological indictors (e.g., noise as a primary stressor), rather than a socioeconomic indicator. Discussions around this indicator also focused on the need to monitor small vessels due to potential impacts to beluga (e.g., ship strikes, masking, behavioural disruption, stress, habituation) in the area, and potential interference with Inuvialuit subsistence harvests. Some participants recommended evaluating large and small vessels separately to capture size-specific impacts to marine mammal presence and subsistence harvests. The indicators *annual number of large vessels transiting the TNMPA*" and "*annual number of small vessels transiting the TNMPA"* were recommended by participants for incorporation into future monitoring programs for the TNMPA. Participants recommended that DFO consult with local HTCs and harvesters, and review weather station cameras (e.g., station in Kugmallit Bay) as measures to estimate the number of small vessels transiting the TNMPA during times of active tourism and harvesting (June–August). Participants agreed that projected decreases in sea-ice extent and increases in ship traffic throughout the Arctic emphasize the need to monitor both large and small vessels in the TNMPA over the long-term to assess potential impacts to subsistence harvests and biota.

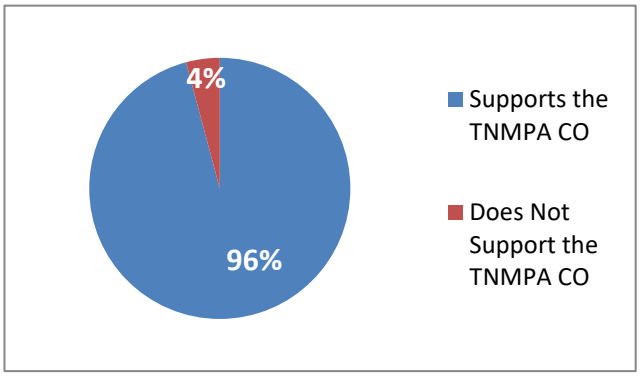
5.1.4 Annual number of beluga whales and other harvested species per area and community



Data for this indicator were limited to the number of belugas harvested by communities within each sub-region (i.e., Tuktoyaktuk and Inuvik in Kugmallit Bay; Inuvik in Okeevik; and Aklavik in Shallow Bay). One-hundred percent (100%) of DFO (n = 2) and FJMC (n =4) participants, and 88 percent (n =15) of Inuvialuit participants indicated that belugas were harvested in low or sufficient numbers in all areas and that current harvest levels were not a concern with regard to subsistence harvests and ecosystem health in the TNMPA. Two Inuvialuit participants felt that there was not enough information to answer the question since data presented to participants only include annual

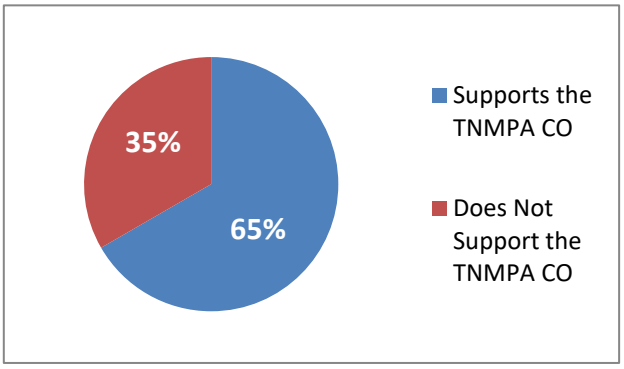
beluga harvests, and not subsistence fish species. However, all participants felt that the indicator supported the TNMPA CO. Since existing data were limited to beluga harvests, recommendations were made to include an indicator that focuses on domestically important fish species such as Broad Whitefish (*Coregonus nasus*), Arctic Cisco, and Dolly Varden Char. The modified indicators recommended include *annual number of belugas harvested per area* and *community and annual number of subsistence fish harvested per area and community".*

5.1.5 Number of person-years of employment directly supporting TNMPA for monitoring, surveillance, logistic, and administrative support



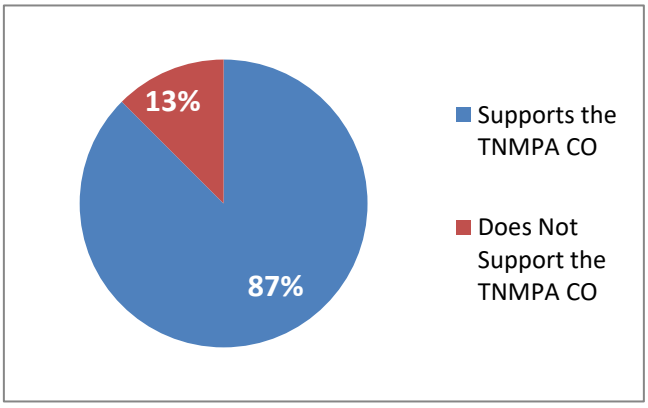
The use of this indicator relates to capacity for monitoring and economic potential in the TNMPA. For the purposes of this report, local employment was defined as follow: community members hired through local HTCs during the summer harvesting season (June-August). Employment activities included research assistants, beluga and fish monitors, youth positions, and boat contractors. The majority of Inuvialuit participants (n = 10) indicated that the number of local hires was sufficient to support community-based monitoring. Remaining participants felt that MPA-based employment between 2010–2016 was low but increasing as a result of recent monitoring programs. Hiring of community youth was highlighted as important. Responses by FJMC and DFO varied in that some (n = 3) felt that the number of local people employed was sufficient, while the remaining two participants agreed that the number remained low from 2010–2016 (S2). All participants but one from FJMC (i.e., 96%) agreed that this indicator supported the TNMPA CO. Local employment was recognized as being important in facilitating the collection of traditional and local knowledge (TLK). Participants suggested that the indicator be revised to *"annual number of local employment for the TNMPA*".

5.1.6 Annual number of Fisheries Protection applications for letters of advice or authorization related to Development of Significant Discovery Licenses (SDLs)



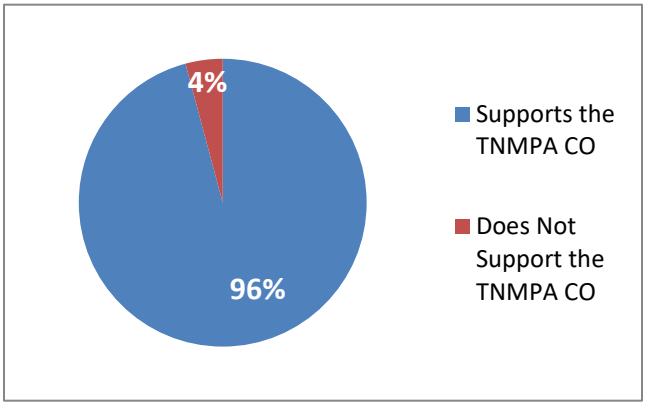
The annual number of Fisheries Protection applications for SDLs focused on activities such as dredging and pipeline installations. Sixty-five percent of participants felt that this indicator directly supported the TNMPA CO. All participants agreed that there was insufficient information to answer the question with respect to how the indicator impacts habitat and key species within the TNMPA. Those participants who felt that the indicator supported the TNMPA CO also believed in the importance of monitoring industrial development (e.g., oil and gas activities, harbor development). It was recommended to continue to monitor this indicator as it relates to potential stressors to the TNMPA ecosystem. There was also a suggestion to combine this with the first indicator "*annual number of hydrocarbon development applications*".

5.1.7 Annual number of applications for disposal at sea under Canadian Environmental Protection Act (CEPA) for ocean dumping



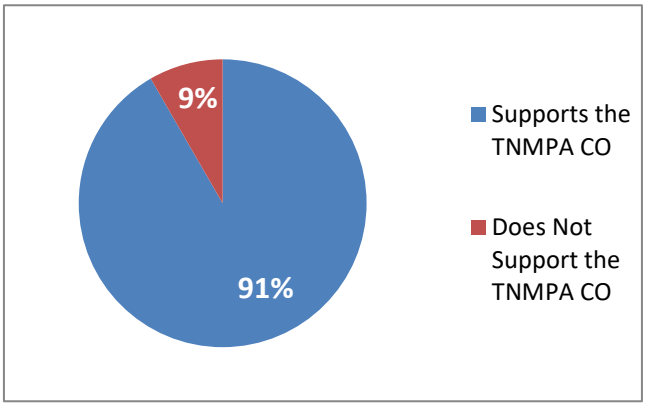
Data used to inform this indicator included applications for disposal at sea under CEPA, and did not include dumping of grey and ballast water during regular operation of marine vessels. The absence of incorporating regulated grey and ballast water dumping was identified as a gap by HTC participants. Most participants (87%) agreed that this indicator directly supported the TNMPA CO. However, these same participants felt that information with which to assess potential impacts to the TNMPA ecosystem was insufficient given that data on grey and ballast water disposal was not included. Some participants (DFO n=1; Inuvialuit n=1; FJMC n=1) agreed that ocean dumping did not directly affect the TNMPA since no applications had been made. Ocean dumping was viewed more as a measure of potential stressors to the TNMPA ecosystem than an economic indicator, particularly in light of increased shipping and tourism activities in the area.

5.1.8 Annual number of TNMPA DFO Conservation and Protection (C&P) patrols.



Since its establishment, the TNMPA has been patrolled once to three times annually by Conservation and Protection officers (C&P) via marine vessel or air patrols. Annual C&P patrols are required to enforce TNMPA Regulations, Fisheries Act, and Oceans Act regulations. Ninety-six percent of participants felt that this indicator supported the TNMPA CO. All participants agreed that the current number of patrols is too low, particularly during peak tourism and harvesting activities between July and August. Participants recommended bi-weekly patrols of the three sub-regions during June, July and August for best enforcement and compliance results. Similar to many of the socioeconomic and governance indicators identified in the monitoring plan, the goal was not evident and should be discussed prior to the development of the next iteration of the monitoring plan.

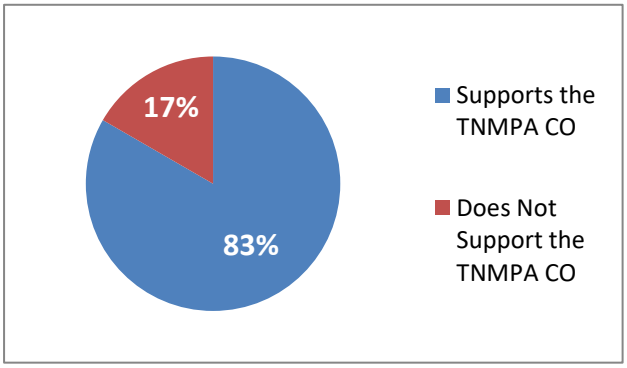
5.1.9 Annual number of violations of TNMPA regulations



The annual number of violations considered in this indicator was specific to the TNMPA Regulations. There were no violations between 2010 to 2016; nonetheless respondents still agreed that this indicator should continue to be monitored. This data did not include violations or conflicts related to tourism as that activity is not prohibited in the TNMPA Regulations. Currently, the effects of tourism on beluga harvesting in the TNMPA are of great concern to Inuvialuit. Ninety-one percent of participants (including all Inuvialuit participants) felt that this indicator directly supported the TNMPA CO; however, a gap in monitoring conflicts related to tourism was identified and recommendations were made to incorporate that into the Monitoring Plan. Inuvialuit participants suggested that having marine mammal observers on all research vessels would mitigate marine mammal-related ship strikes and disruption to migration routes. Additionally, participants emphasized the need to identify which organization is responsible for enforcing those violations affecting subsistence harvests.

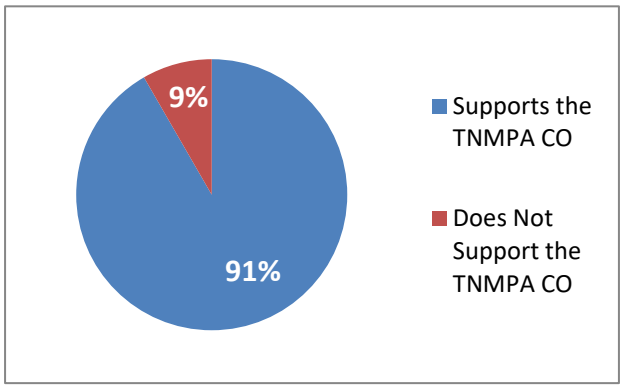
Participants recommended that a new indicator be added to monitor conflicts that are not listed in the TNMPA Regulations but are of regional concern. Water-based tourism is not permitted in the TNMPA in accordance with the Beaufort Sea Beluga Management Plan (BSBMP; Zone 1a) due to potential impacts to beluga and subsistence harvests. Despite guidelines for tourism activities outlined in the BSBMP, participants identified a need to properly enforce the relevant regulations. The indicator was refined as *number of conflicts affecting Inuvialuit subsistence harvests* to capture incidences where harvesting is disturbed by activities that are not listed in the TNMPA Regulations (e.g., tourism activities)

5.1.10 Percentage of harvesters by community



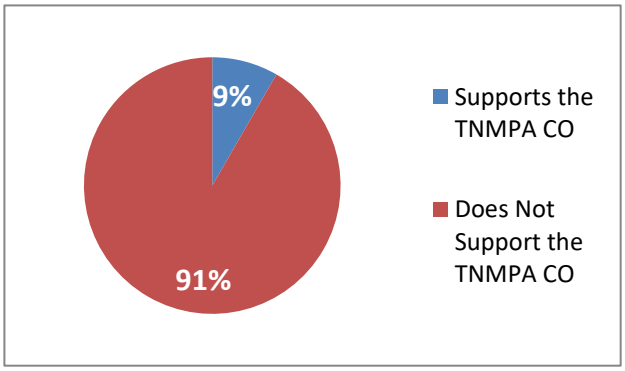
The HTC harvesters list was used to inform this indicator. Engagement with HTC participants indicated that percentage of harvesters by community was not an accurate representation of harvesting since it included both Inuvialuit and Gwich'in harvesters, in addition to harvesters that are actively and not actively harvesting, and marine and terrestrial harvests. Therefore, participants felt that there was insufficient information to accurately assess the impact the percent of harvesters has on the TNMPA ecosystem. Despite this uncertainty, 83 percent of participants viewed this indicator as one that supports the CO. Inuvialuit participants suggested that this indicator include only Inuvialuit harvests of beluga and subsistence fish within the TNMPA. Collaboration with the Inuvialuit Harvest Study (Joint Secretariat) was suggested as a means to further efforts related to this indicator.

5.1.11 Percentage of households consuming country foods



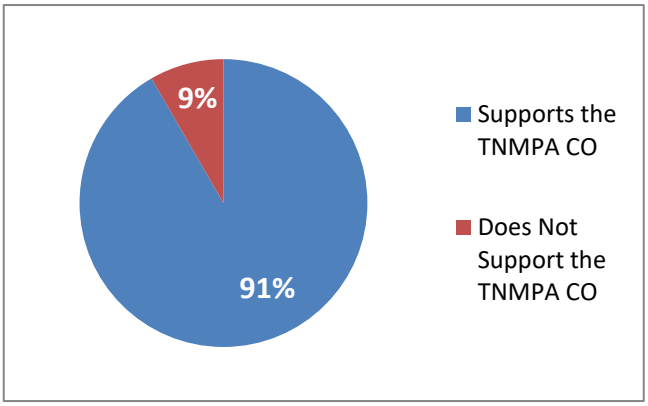
Information pertaining to the consumption of healthy foods has been collected periodically since 1993 and is currently managed by the IRC (Inuvialuit Indicators Database). However, data was not made available to participants for this assessment. As a result, some participants were not able to assess whether or not the indicator was useful in supporting the TNMPA CO. Despite this, 92% of participants agreed that the indicator would support the CO. All Inuvialuit participants supported the continued use of this indicator as a reflection of the cultural importance of subsistence harvests to families in the ISR. Subsequent data collections through the Inuvialuit Indicator Database will be used in future monitoring programs.

5.1.12 Annual kg of beluga and other species consumed



Due to the difficulty in accurately and consistently monitoring this indicator, all of the FJMC and most of the Inuvialuit participants (i.e., 91%) suggested discontinuing the *annual kg of beluga and other species consumed* as an indicator as it did not support the TNMPA CO. The indicators *annual number of beluga and other species harvested*, *percentage of harvesters by community,* and *percentage of households consuming country foods* were considered sufficient to monitor the importance of traditional harvests to Inuvialuit diet.

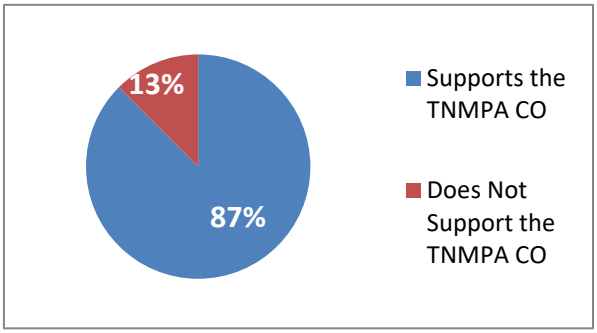
5.1.13 Number of positive/negative responses to whether the TNMPA is a healthy marine ecosystem



Perceptions of ecosystem health are subjective and as a result, are difficult to assess. The majority of participants (91%) indicated that positive and negative perceptions from local communities, specifically harvesters on the ecosystem health are important and could contribute to monitoring efforts in support of the TNMPA. Participants felt that there was insufficient information available to decide whether their perceptions of ecosystem health in the TNMPA were positive or negative. However, Inuvialuit participants felt that the overall response from Inuvialuit harvesters that are active in the TNMPA with respect to the health of the TNMPA ecosystem was relatively positive. Participants recommended additional community engagement during which relevant questions about ecosystem health can be posed.

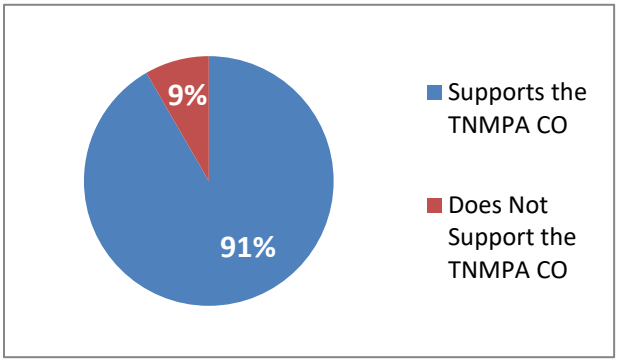
5.2 GOVERNANCE INDICATORS

5.2.1 Number of management meetings as percentage of work plans; percentage of collaborative meetings with quorum; number of stakeholder meetings to discuss TNMPA regulations



As a group, these indicators were proposed to monitor the number of meetings between DFO Oceans and Inuvialuit governing and advisory bodies (IGC, FJMC, WAMPA, HTCs, TNMPA Working Group) to ensure that Inuvialuit guidance is incorporated into TNMPA management decisions. Aklavik, Inuvik, and Tuktoyaktuk HTCs recommended reducing the number of socio-economic and governance indicators and combining the indicators to: *number of management meetings as a percentage of work plans*; *percentage of collaborative meetings with quorum*; and *number of stakeholder meetings to discuss TNMPA regulations.* The number of annual meetings between DFO Oceans and Inuvialuit governing bodies (FJMC, IGC, and HTC meetings) were presented to participants in order to assess the three indicators identified above. The majority (87%) of participants felt that the indicator *number of management meetings as a percentage of work plans* supported the TNMPA CO, whereas 83% felt that *number of stakeholder meetings to discuss TNMPA regulations* supported the CO. Fewer (74%) felt that the indicator *percentage of collaborative meetings with quorum* supported the CO. Participants recommended replacing the three indicators listed above, with *annual number of TNMPA management meetings with co-management partners and MPA advisory partners* as an indicator in future monitoring plans. Additionally, it was noted that meetings lead by researchers involved in individual monitoring programs within the MPAs were not accounted for in this questionnaire, and should be considered in future evaluations.

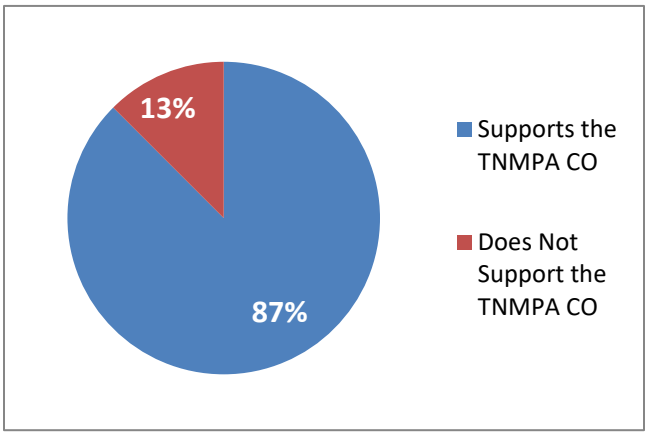
5.2.2 Percentage of key stakeholder groups attending collaborative meetings



This indicator is meant to assess whether or not there is sufficient Inuvialuit representation at TNMPA management meetings. The majority of participants (91%) agreed that stakeholder attendance at collaborative meetings supported the TNMPA CO as it reflects Inuvialuit representation in TNMPA management decisions. Participants recommended that monitoring continues for the indicator, as well as creation of a new indicator "*Percentage of Key Co-Management Groups Attending Collaborative Meetings"*. Data presented to participants included the percentage of Inuvialuit governing bodies (IGC, and HTC) and co-management partner (FJMC) present at meetings (e.g., annual FJMC, WAMPA meetings) compared to DFO. Response from participants ranged from "too low" to "sufficient" representation of partners attending meetings. Participants noted an increase of Inuvialuit representation in 2014 with the creation and development of WAMPA and further increases are anticipated with the creation of TNMPA Working Groups in 2019. In addition, increasing community engagement through the TNMPA WG will contribute to Inuvialuit contributions to TNMPA collaborative meetings.

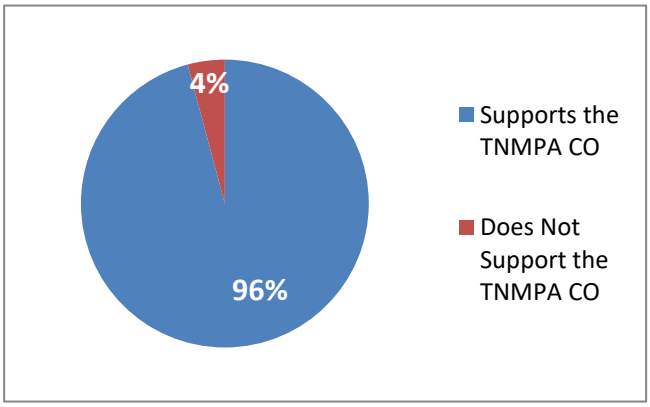
5.2.3 Number of visits to the TNMPA page on the Beaufort Sea Partnership (BSP) website

This indicator was proposed for use to monitor interest from stakeholders within and outside of the TNMPA. The number of visits to the TNMPA webpage is not currently monitored, and as a result, no data could be provided to participants for an assessment of the indicator. While both DFO participants believed that the indicator was not useful, 87 percent of participants viewed the indicator as important in supporting the TNMPA CO. Currently the DFO BSP Secretariat is working on a way to track site visits to the TNMPA webpage as a way to monitor awareness of current initiatives.

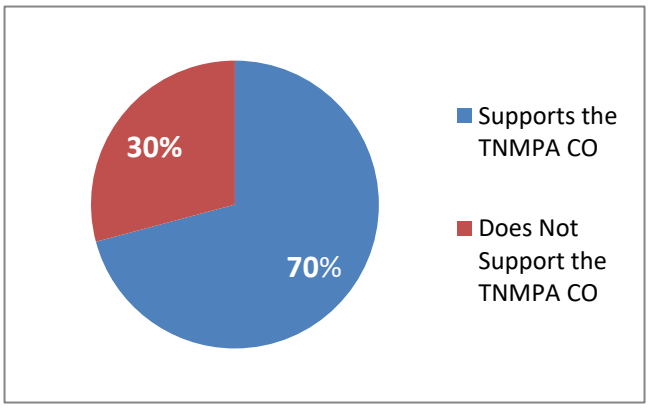


5.2.4 Number of education/outreach events within the ISR

The number of education and outreach events conducted in the ISR can be used to determine TNMPA awareness on a local level, and provide an opportunity for community members to comment on how the TNMPA is doing (i.e., feed into the indicator n*umber of positive/negative responses to whether the TNMPA is a healthy marine ecosystem*) Participants responses varied for this indicator; some felt that the number of events were “too low” (particularly by Aklavik and Tuktoyaktuk participants), others felt that they were “sufficient”, and some believed that insufficient information was available to answer the question. Despite that, 96 percent of participants felt that the indicator supported the TNMPA CO. The majority of Inuvialuit participants (n = 13) recommended combining this indicator with the similar *number of visits to local schools to talk about the TNMPA* to form a new indicator: *number of education/outreach events within the ISR to increase TNMPA awareness*”. In developing the next iterations of the TNMPA Monitoring Plan, methods to engage and track the number of people reached annually needs to be defined for successful monitoring of this indicator.

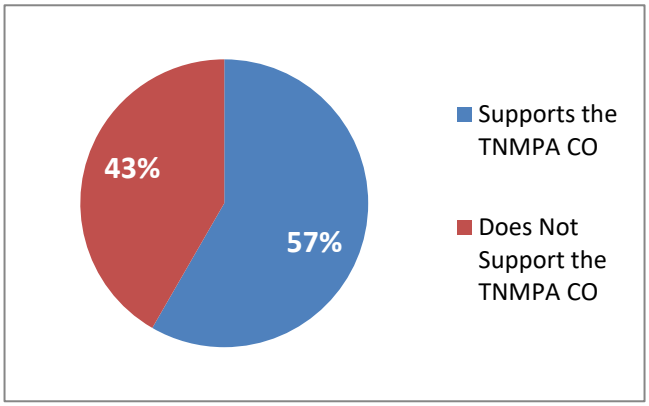


5.2.5 Number of local, regional, and national news reports about the TNMPA



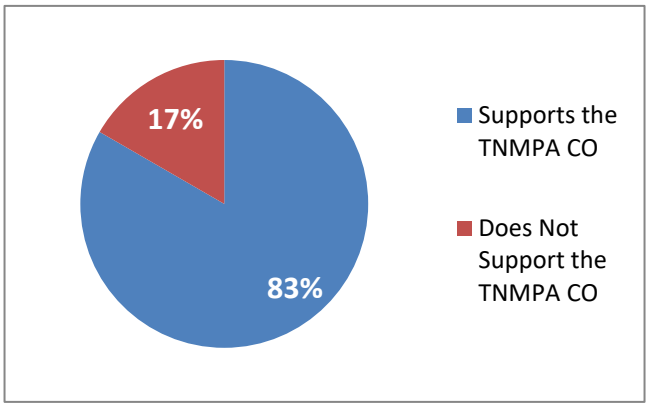
Monitoring the number of news reports featuring the TNMPA was recognized as being an important measure to monitor increasing awareness of the MPA at a local and national level. Inuvialuit and FJMC participants agreed that this indicator facilitated the protection of key species and subsistence harvesting through public awareness. Seventy percent of participants, including all Inuvialuit representatives, viewed the usefulness of this indicator as low in support of the TNMPA CO. Participants recommended linking the number of news reports with the number of large vessels and tourism to assess if this could be a measure of the impacts of increased TNMPA awareness on tourism in the region.

5.2.6 Number of network meetings per year attended by regional DFO Oceans staff



The goal of this indicator is to measure whether or not experiences and lessons learned from the TNMPA are being applied to other Canadian MPAs and vice versa. Opinions as to whether or not this indicator supported the TNMPA CO varied; 57 percent felt that the CO was supported and 43 percent felt otherwise. Participants generally believed that they were provided with insufficient information to assess the indicator's usefulness in supporting the CO. Most participants expressed an interest in being kept informed about other national MPAs.

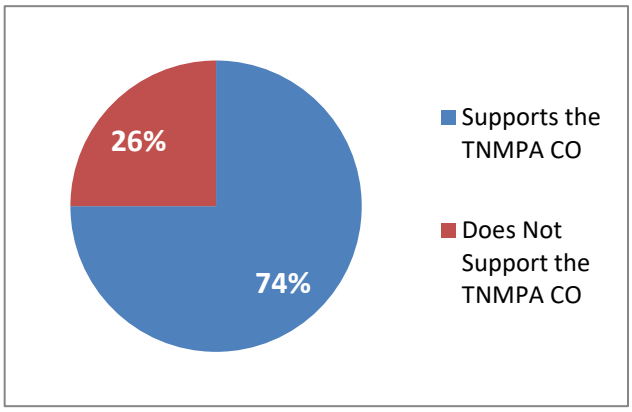
5.2.7 Degree of inclusion of TNMPA in consideration of national and international networks



The TNMPA was the first Arctic MPA in Canada and is one of the first MPAs designated in Canada. The TNMPA is unique in that its boundaries were chosen based on traditional and culturally important beluga harvesting grounds (FJMC 2013). The methodology used to establish the TNMPA informed that of Canada's second Arctic MPA, the Anguniaqvia niqiqyuam MPA, and will be used in future MPA development in Canada. Additionally, the governance structure established to monitor the TNMPA is useful to both current and future MPAs that overlap with traditional indigenous interests. Participants recommended

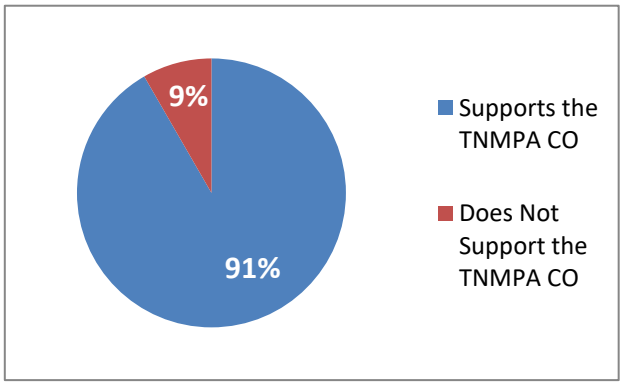
combining this indicator with the indicator *number of indicators and protocols from the TNMPA adopted by national and international Arctic monitoring programs*. The new indicator, defined as *number of indicators and protocols from TNMPA adopted by national and international MPAs and monitoring programs*, would be more useful in determining whether the TNMPA was considered in the development of other MPAs. The new indicator would be considered successful in supporting the TNMPA CO if the TNMPA was recognized as contributing to both national and international initiatives.

5.2.8 Number of monitoring workshops attended where TNMPA approach was profiled



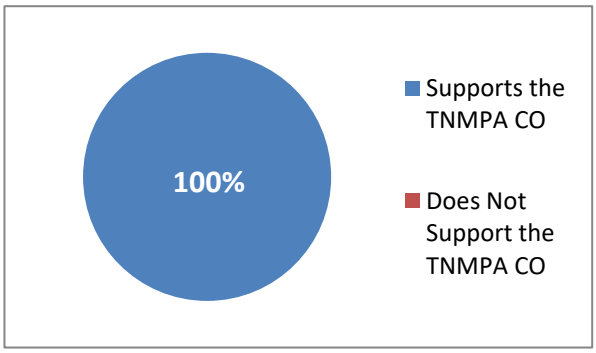
A total of two workshops (national and international) focusing on MPAs were conducted between 2010–2016 and as a result, participants felt as though there was insufficient information with which to assess this indicator. However, 74 percent of participants considered this indicator supportive of the CO. Inuvialuit participants suggested monitoring the number of times that DFO and Inuvialuit present information on the TNMPA as an indicator. Consequently, a new indicated called *number of monitoring workshops and conferences attended where the TNMPA approach is profiled* was recommended for future monitoring. Methods to monitor this indicator include presentations and workshops lead by DFO, partners (e.g., research partners, FJMC), and Inuvialuit representatives (e.g., TNMPA Working Group, WAMPA, Inuvialuit MPA Coordinator).

5.2.9 Number of meetings annually with Science, Fisheries Management, Fisheries Protection, Species at Risk; number of CSAS requests for Science advice on TNMPA monitoring



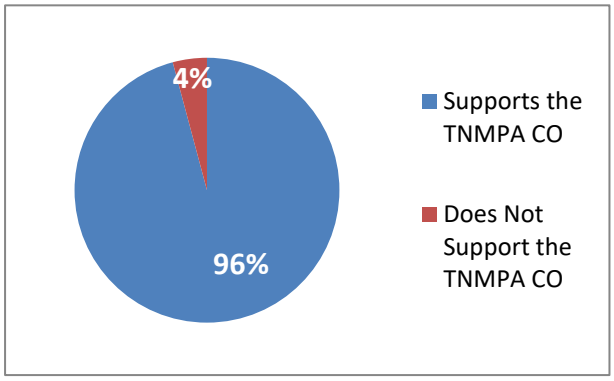
Through engagement with the HTCs, it was recommended that this indicator be split into two indicators, including number of meetings attended annually by Science, Fisheries Management, Fisheries Protection, and Species at Risk on the TNMPA and number of CSAS requests for Science advice on TNMPA monitoring. Monitoring these two indicators was viewed as important (i.e., 91%) in evaluating the amount of effort invested in monitoring and research focussed on the TNMPA which, in turn, would determine if capacity was sufficient to ensure effective management and monitoring of the TNMPA. Participants viewed the amount of available information with which to assess this indicator as either too low" or "sufficient". Participants recognized that annual meetings and CSAS requests had increased since the establishment of the TNMPA; and recommended that the methods used to monitor these indicators also include the number of reports produced as a result of meetings and CSAS requests. Inclusion of reports produced as a result of these indicators would inform management decisions for the TNMPA.

5.2.10 Number of Science projects approved by FJMC related to the TNMPA



The number of FJMC-approved research proposals associated with the TNMPA is a reflection of science awareness and capacity needed to support the TNMPA Monitoring and Management plans. Participants viewed this indicator as highly important to inform on monitoring and research that support the TNMPA monitoring indicators. The majority of participants (n = 21) indicated that the number of research proposals approved by FJMC was sufficient and all participants (100%) agreed that the indicator contributed to the TNMPA CO. In light of the establishment of WAMPA (2014) and more recently, the TNMPA Working Group (2019), participants felt that this indicator should be expanded to include projects approved by TNMPA-specific governing bodies. Capturing TLK projects developed in support of the TNMPA was also considered to be important. Consequently, a new recommended indicator was defined as follows *number of Science and TLK projects approved by WAMPA/TNMPA Working Group and FJMC related to the TNMPA"*. It was noted that not all approved research proposals may directly support the TNMPA monitoring indicators, but may inform on important research and lead to the identification of new monitoring indicators in the future.

5.2.11 Number of stakeholders engaged in the six-year review of TNMPA



Since this is the first review of the TNMPA, the participant responses for this indicator focused on whether it supports the TNMPA. Ninety-six percent of participants, including all HTC members' involved in this assessment, agreed that the engagement process is important and should continue to ensure Inuvialuit involvement when assessing the TNMPA Monitoring and Management plans. All participants agreed that this indicator directly supports the TNMPA CO, and that assessments of the indicator over time will inform on TNMPA awareness of partners (i.e., Inuvialuit advisory bodies and co-management partners).

5.3 SUMMARY OF RECOMMENDATIONS FOR FUTURE MONITORING SOCIO-ECONOMIC AND GOVERNANCE INDICATORS

Recommendations gathered through engagement with DFO, Inuvialuit, and co-management partners were incorporated into the TNMPA socio-economic and governance indicator monitoring tables (Table 13 and 14). The recommended socio-economic and governance indicator tables were reformatted similar to the new recommended ecological monitoring table (Table 12), in an effort to increase connectivity among the indicator categories. Additionally, Link to Socio-economic Indicators category was added to the ecological monitoring tables throughout the ecological indicator assessment (Tables 3–11) to identify the relationships between the indicators, and how they can work together in supporting the TNMPA CO. Throughout the socio-economic and governance indicator assessment two gaps were highlighted 1) the need to

clarify or identify goals of each indicator to ensure it meets the TNMPA CO; and 2) the need to create an additional category or sub-category of indicator related to pressures and threats. Much of the focus on some socio-economic indicators (e.g., annual number of hydrocarbon development applications, annual number of vessels transiting the TNMPA) was on potential threats and pressures to the TNMPA CO, rather than economic or social measures. These gaps need to be addressed with partners prior to the development of the new TNMPA Monitoring and Management plans.

There are several considerations that should be looked at before final socioeconomic and governance indicators will be chosen. These are best practices for all indicators but since socioeconomic indicators can be particularly hard to identify, they are of special interest here. First, the relevance to evaluation questions is very important. An indicator should help address predefined evaluation questions. The applicability in different settings is also important which means the degree to which an indicator is relevant in diverse settings. It would be helpful for indicators to tell a story of more than one data point if possible. This saves time, money and provides a richer dataset to work with. Indicators should work together to inform several areas so that the story of progress or regress is clear (MacDonald, 2013). Therefore, indicators should work together and be chosen together. The availability of data is another consideration. If there is no clear way to collect data or it is likely to be severely incomplete, that indicators usefulness should be reconsidered. Cultural relevance is another important consideration when choosing an indicator and how its data is collected. The content or focus and related data collection activities should determine whether or not the indicator and data collection methods are clear, relevant, and suitable (MacDonald, 2013). The level of resources required to measure the indicator data, including money, time and the knowledge and skills required. This discussion can be helped if indicator level of importance are decided upon (MacDonald, 2013). Indicators should also be written using neutral language. Finally, who will use data collected and how the information will be used needs to be decided before choosing indicators (MacDonald, 2013).

Table 13. Proposed socio-economic Monitoring Indicators based on results of the State of TNMPA Report engagement. Socio-economic indicator table is modified from the 2013 TNMPA Monitoring Plan (DFO and FJMC 2013). New criteria includes: Indicator Type and Status of Indicator Data. Status of Monitoring of Indicators was scored as Good (G), Adequate (A), or Poor (P) by Inuvialuit participants.

Category	Element	Indicators Recommended for Monitoring	Indicator Type	Strategies for Monitoring	Status of Indicator Data
Economic	Hydrocarbon development Industrial Development and Activities	Annual number of hydrocarbon development applications (including Significant Discovery Licence (SDLs) applications)/	Supporting Pressure/Threat	Data collected from Indigenous and Northern Affairs Canada (INAC) annual reports. Includes entire Canadian Beaufort Sea Data collected from *Fisheries Act* applications, *Canadian Environmental Protection Act* (CEPA) applications; Data includes industrial development activities (e.g., dredging, pipeline installation); Participants interested in monitoring this indicator in the Beaufort Sea	**G**
	Tourism	Annual number of ecotourism companies entering the TNMPA	Supporting	Data from GNWT Industry, Tourism and Investment (ITI) database; consult with HTCs to identify active local tourism operators in the TNMPA	**P**
	Transporting	Annual number of large vessels transiting the TNMPA	Supporting Pressure/Threat	AIS large vessels (> 300 gross tonnage) tracking through DFO Conservation and Protection	**A**
		Annual number of small vessels transiting the TNMPA	Supporting Pressure/Threat	Estimate numbers of small vessels (< 300 gross tonnage) through harvester/monitor observations, engagement with HTCs, and research cameras; Indicator focussed on small vessels related to tourism.	**NEW**
	Harvesting	Annual number of beluga harvested per area and community	Supporting	Data collected from Beluga Health Monitoring Program	**G**
		Annual number of subsistence fish species harvested per area and community	Supporting	Suggested species: Arctic Cisco, Dolly Varden Char, Broad Whitefish; Data collect from ACES and Dolly Varden Char monitoring programs; Sentinel fishers, harvesters green log books/HTCs; community-based monitoring programs	**NEW**
	Employment Related to TNMPA	Annual number of local employment for the TNMPA	Supporting	Number of local community members employed for TNMPA-related activities (e.g., surveillance, logistic, monitoring, research, contractors); Data collected through local HTCs	**A**

Note: Refer to Table 1 description of *Indicator Type*

Table 13. Continued.

Category	Element	Indicators Recommended for Monitoring	Indicator Type	Strategies for Monitoring	Status of Indicator Data
Economic	Industrial Development and Activities	Annual Number of applications for disposal at sea under CEPA for ocean dumping	Pressure /Threat	Data collected from applications submitted under CEPA for ocean dumping. Recommended to include ballast and grey water disposal	**P**
	Surveillance & Enforcement	Number of DFO Conservation and Protection (C&P) patrols	Supporting	Data collected from DFO C&P officers	**NEW**
		Number of violations of TNMPA Regulations	Supporting	Data collected from fines issued through DFO Conservation and Protection; TNMPA regulation violations (disruption to marine mammals, key species, and their habitats)	**G**
		Number of conflicts affecting Inuvialuit subsistence harvests	Supporting	Data collected from violations reported to HTCs, IGC, FJMC; indicator specific to the effects of tourism on subsistence harvests	**NEW**
Cultural Integrity	Use of TNMPA Sub-regions for Subsistence Harvesting	Percent of TNMPA harvesters by community	Supporting	Opportunity to work with the Community-Based Monitoring Program (CBMP) to filter HTC harvesters based on harvesting inside the TNMPA.	**P2**
	Consumption of Country Foods	Percent of households consuming country foods	Supporting	Data collected from Inuvialuit Indicators Database on a five year basis	**P**
	Perception of Health of TNMPA Marine Ecosystem by Inuvialuit Harvesters	Number of positive or negative responses as to whether the TNMPA is a healthy marine ecosystem	Supporting	Data collected through questionnaires during annual WAMPA meeting, TNMPA Working groups, community meetings	**P**

Note: Refer to Table 1 description of *Indicator Type*

Table 14. Proposed list of governance monitoring indicators based on results of the State of TNMPA Report engagement. Governance indicator table is modified from the 2013 TNMPA Monitoring Plan (DFO and FJMC 2013). Status of Monitoring of Indicators was scored as Good (G), Adequate (A), or Poor (P) by Inuvialuit participants

Category	Indicators Recommended for Monitoring	Indicator Type	Strategies for monitoring	Status of Indicator Data
Institutional Management Structures Established and Functioning	Annual number of TNMPA management meetings with co-management and MPA advisory partners	Supporting	Data collected on the annual number of meetings held with stakeholders (i.e., FJMC, IGC, WAMPA, HTCs) would inform on number of times Inuvialuit and co-management guidance is incorporated into management.	**G**
	Percentage of invited key co-management groups attending collaborative meetings	Supporting	Data regarding the percentage of Inuvialuit representation on key stakeholder groups as part of annual TNMPA meetings (i.e., FJMC, IGC, WAMPA, HTCs) and would inform on Inuvialuit representation in management decisions	**A**
Increase Awareness, Education, and outreach related to the TNMPA	Number of visits to TNMPA page on the Beaufort Sea Partnership (BSP) website	Supporting	Data collected on number of BSP website visits would measure stakeholder awareness of BSP initiatives	**P**
	Number of education/outreach events within the ISR to increase TNMPA awareness	Supporting	Number of times TNMPA is highlighted at education/outreach events (i.e., Oceans Day, ISR school visit and community meetings); recommended to focus on increasing TNMPA awareness and opportunities to Inuvialuit through school visits and community meetings	**P**
	Number of local regional and national news reports about the TNMPA	Supporting	Data collected from news reports published online (i.e., Canadian Broadcasting Corporation [CBC]); Recommended northern news reports (i.e., Tusaayaksat, Inuvik Drum, Up Here)	**P2**
Contributing to National and International Monitoring Programs MPA	Number of network meetings per year attended by regional Oceans staff	Supporting	Number of times regional DFO Oceans staff meet with DFO Oceans staff working on other MPAs	**A**
	Number of indicators and protocols from TNMPA adopted by national and international MPAs and monitoring programs	Supporting	Number of times components of the TNMPA monitoring or management plans, and/or governance structure are adopted into or provide guidance to other MPAs or monitoring programs.	**P**

Note: Refer to Table 1 description of *Indicator Type*

Table 14. Continued.

Category	Indicators Recommended for Monitoring	Indicator Type	Strategies for monitoring	Status of Indicator Data
Contributing to National and International Monitoring Programs MPA	Number of monitoring workshops and conferences attended where the TNMPA approach is profiled	Supporting	Data recorded for number of times community meetings are held that focus on the TNMPA; Data recorded for number of times the TNMPA is presented on at conferences and meetings outside of the ISR (e.g., ArcticNet, international meetings); Recommendation to record separately the number of times Inuvialuit representatives e.g., WAMPA, FJMC, HTC, TNMPA Working Group members) and DFO attend	**NEW**
Engagement with Other DFO Sectors	Number of meetings attended annually Science; Fisheries Management; Fisheries Protection; Species at Risk on the TNMPA	Supporting	Record the number of times DFO Oceans meets with other DFO sectors with regard to the TNMPA	**P2**
	Number of CSAS requests for Science advice on TNMPA monitoring	Supporting	Data collected from the number of CSAS requests relating to TNMPA monitoring; Number of reports resulting from the CSAS processes	**P2**
	Number of Science and TLK projects approved by WAMPA/TNMPA Working Group and FJMC related to the TNMPA	Supporting	Number of TNMPA related research proposals submitted and approved through FJMC	**G**
Six-year Review of Management Plan and Monitoring Plan	Number of stake holders engaged in six-year of TNMPA	Supporting	Record the number of stakeholders engaged in the review, including Inuvialuit governing bodies; Inuvialuit advisory bodies, and DFO	**G**

Note: Refer to Tables 1 and 2 for *Indicator Type* and *Status of Indicator Data* descriptions

6 COMMUNITY CONCERNS FOR FUTURE MONITORING AND RESEARCH IN THE TNMPA

During discussion with the Inuvialuit participants at the November workshop, proposed research questions of interest were raised and recorded; that were not necessarily associated with a specific monitoring indicators, but were viewed as important research questions for the future:

1. Assess impacts of turbidity on whale presence. For example, participants observed a higher than usual water clarity near Kugmallit Bay and Okeevik in 2017 and wondered if that affected beluga presence/absence;
2. Determine whether beluga feed in Kugmallit Bay. Elders and harvesters indicated that beluga forage in the area; however, stomach contents have been empty in harvested whales as contents are thought to be ejected from the stomach during hunting;
3. Assess the direct effects of depth sounders (including on personal pleasure crafts) on beluga behavior and migration in and near the TNMPA;
4. Address knowledge gaps pertaining to habitat use outside of the TNMPA. This gap will be partially addressed with data from 2018–2019 tagging studies, local observations, and the 2019 aerial survey;
5. Assess sources of mercury exposure of beluga outside of the TNMPA, with emphasis on overwintering habitat in the Bering Sea;
6. Assess the impacts of micro-plastics on beluga;
7. Develop a body condition curve for EBS beluga harvest in the TNMPA
8. Improve data sharing with Inuvialuit partners and users of the EBS beluga, coastal fishes, and physical habitat indicators;
9. Identify links between environmental factors that may have an effect on beluga and fish indicators (i.e., change in blubber thickness or body size);
10. Further assess and obtain results pertaining to recent research focused on cannibalism in resident Dolly Varden Char, particularly the consumption of eggs when in riverine environments;
11. Identify the cause of “red spots” frequently reported on multiple fish species (e.g., Arctic Cisco, Dolly Varden Char, and whitefishes);
12. Monitor flow rates and water quality at different locations along the Mackenzie Estuary to quantify its contributions of freshwater, sediments, and contaminants to the TNMPA; and
13. Monitor the past and present cabin locations of harvesters in the TNMPA to characterize environmental changes.

7 CONCLUSIONS

The state of the TNMPA was evaluated using the experiences and opinion of science, Inuvialuit and co-management participants. Results of this work are presented in a summary format in Tables 12–14. Recommendations provided within this report are meant to inform working groups and advisory bodies for the MPA to develop future iterations of the TNMPA Monitoring and Management plans and provides a space to document learning and reasoning behind new decisions. Since this was the first MPA established in the Arctic, many lessons have been

learned since the first Monitoring and Management plans were written. This work has identified gaps in knowledge that are important for future research and to catalogue the data that is being monitored currently. Key gaps at this time include biophysical measures of environmental and oceanographic (e.g., water temperature, salinity) data and links to ecological indicators (e.g., beluga and fishes).

This was the first State of the MPA Report developed which evaluates ecological, socioeconomic, and governance indicators. This report involved multiple engagement workshops with partners and three years to complete. Since the start of this report there has been new research and monitoring programs, and engagement forums established which will need to be considered. In addition many comments were made on how we define indicators since the plans were first developed. This was not in the scope of this report, but should be considered when developing new iterations and as we go forward in monitoring the TNMPA. Information prepared here will contribute to future qualitative and quantitative assessments of the indicators. There is a learning curve and room to improve when embarking on future iterations of the status reports, and guidance from partners on how we can improve this process in the future will be valued.

The TNMPA Management Plan outlines six priority activities for the first six years: establish a TNMPA management and steering committee, education, outreach and awareness, enforcement and compliance of the regulations, monitoring and research, reporting, and creating a review process (2013–2018). Below is a summary of the actions taken to date on each of the priority activities:

1. **Establish a TNMPA management and steering committee:** The WAMPA was established in 2014, and oversees and provides guidance for all activities within the Western Arctic MPAs. Upon designation of the Anguniaqvia niqiqyuam in the ISR in November 2016, the Steering Committee recommended that community level working groups be established in order to successfully manage and monitor both Arctic MPAs. As a result, the TNMPA and ANMPA Working Groups were established, allowing for greater representation of the HTCs associated with the MPAs and more effective communication with communities. Additionally, an Inuvialuit MPA Coordinator position was established at the Joint Secretariat in an effort to build capacity in toward managing the two MPAs.
2. **Education, outreach, and awareness:** This indicator was identified as an important governance indicator; education, outreach programs and other initiatives raise awareness of the TNMPA which supports the protection of key species (i.e., beluga and fishes) and important habitats, thus supporting the TNMPA CO. The results of these indicators suggest the need for increased education and awareness with local schools and at a community level within the ISR, as well as additional outreach and awareness initiatives both nationally and internationally.
3. **Enforcement and compliance of the regulations:** With increasing accessibly to the TNMPA as a result of decreased sea-ice extent, and construction of an all season road (i.e., Inuvik-Tuktoyaktuk Highway), tourism has become a rising concern to DFO and its partners as a potential risk to key species and subsistence harvesting. Tourism is not a regulated activity listed in the current TNMPA Regulations; however, participants identified the need for inclusion of such activities in TNMPA Regulations and appropriate enforcement during prime harvesting months.
4. **Monitoring and research:** Participants supported long-term monitoring programs associated with beluga, fish and ecosystem health as well as Inuvialuit subsistence harvests. Continuation of these programs was strongly recommended. The need to incorporate a Conservation Priority (CP) alongside the CO to focus monitoring and research

efforts was recommended; it is as follows: *"..to conserve beluga, and fish species important to Inuvialuit subsistence and prey of beluga, and their habitat within the TNMPA".* Monitoring physical environmental drivers (e.g., unusual weather events, erosion, water chemistry) was a key recommendation, alongside identifying linkages to biological indicators. The importance of including TLK from harvesters to inform on linkages between ecological processes (e.g., beluga presence/movements) and climate (e.g., storm events) was emphasized. Additionally, participants discussed the need to include the submission and approval of activity plans for any scientific research or monitoring, educational or tourism activities proposed within the TNMPA. The activity plan requirement was seen as an effective tool for monitoring activities within the ANMPA, and extending this requirement to the TNMPA Regulations was recommended.

5. **Reporting:** Providing monitoring results to the MPA Steering Committee, Working Groups and communities is essential to fostering a positive working relationship among partners. The five to six-year review process was supported by Inuvialuit, co-management and science partners and was recommended to continue. Indicators identified in the current monitoring plan (DFO and FJMC 2013) were classified into types (e.g., selected, supporting, Table 1.) based on whether they were to be assess in MPA status reports or not. To clarify goals in monitoring, all indicators identified in monitoring plans should be assessed through the review process to ensure the TNMPA CO is being successfully informed. Communication documents like the TNMPA Annual Reviews (Available at BSP website), which summarize all research, monitoring, and surveillance activities within the TNMPA during the summer months, are shared internally with DFO and with Inuvialuit partners. Participants indicated that these types of documents should be shared with communities to increase awareness of the TNMPA locally. Protocols addressing issues on timely reporting of fish and beluga health and suspected disease are being developed and improved. Inuvialuit partners recognized that science reports to IGC, HTC, and FJMC had increased in the recent years since the establishment of the TNMPA, and as monitoring programs have developed.
6. **Review process**: Workshop results associated with the *State of the TNMPA Report: Inventory of Indicators from 2010–2016* process indicated that monitoring, research, and reporting related to ecological indicators between 2010 and 2016 were successful in supporting the CO and revision of the Management and Monitoring plans. The consultation process was well received and provided a setting to obtain recommendations from science, co-management, and Inuvialuit participants. The process also supported the TNMPA Management Plan activity 6) to review the TNMPA Monitoring and Management plans. Improvements will be made to the Monitoring Plan in response to participant concerns pertaining to the changing climate and resulting impacts to the Beaufort Sea ecosystem. Recommendations for improvements to ecological, socio-economic, and governance indicators will also be considered in future iterations, as well as additional monitoring priorities identified during consultation. Reassessing the monitoring indicators on a five to six-year basis was supported throughout the consultation process to ensure monitoring indicators continue to support the TNMPA CO and CP identified in this assessment.
7. Existing Management Plan activities related to education, outreach, awareness, enforcement, and compliance of regulations were assessed through the socio-economic and governance questionnaire. The majority of proposed indicators were supported, albeit with recommendations for refinement to focus directly on the TNMPA management goals. Questionnaire results indicated the need to identify goals for each socio-economic and governance indicator and develop monitoring methods for each to ensure they support the TNMPA CO. It was especially unclear how or why the socio-economic indicators were

originally chosen and what they were designed to measure. Therefore, an important suggestion is that the definition of indicators change from items that would be helpful to monitor, to items that measure the state of the Marine Protected Area over time. Participants felt that while the socio-economic indicators may inform on potential stressors to the TNMPA ecosystem and as such are important to monitor, some of the proposed indicators were outside of DFO's mandate and therefore difficult to manage. Scoping and decisions on which indicators to continue to monitor moving forward will need to be discussed with MPA advisory and management bodies.

NEXT STEPS

The State of TNMPA Report: Inventory of Monitoring from 2010–2016 provides recommendations to refine the ecological, socio-economic, and governance indicators identified for the TNMPA, and includes community perspectives on whether the indicators inform the CO. Through engagements with WAMPA, it was decided that a quantitative assessment of ecological indicators would be useful in the next iteration of this report using the 2021 monitoring data. This will allow time to tease out drivers and identify thresholds for key indicators. The quantitative review of monitoring indicators will help to inform the state of each monitoring indicator (e.g., identify trends, thresholds) and improve our understanding on how the indicators are supporting the TNMPA (e.g., effectively measuring change, informing on the health of key species). Prior to the quantitative review, DFO and partners will work to assess ecological monitoring indicators that have not been consistently monitored, or do not have well-defined thresholds to indicate when management action should be taken to support the CO.

Since the development of this report, two MPA Working Groups have been established under WAMPA. Recommendations outlined in this report will be reviewed by the MPA advisory bodies to determine which are feasible and suitable for future monitoring of the TNMPA. Once reviewed and a quantitative assessment of indicators has taken place, new iterations of the TNMPA Monitoring and Management plans will be developed based on recommendations and guidance from MPA advisory bodies. Furthermore, it is recommended that where the knowledge (i.e., observations, stories, recommendations) of the Inuvialuit is used in future publications, there be a formal verification process to review a draft of the publication. This will help ensure the accuracy of information as it was recorded. This process needs to be discussed and supported by MPA advisory bodies, as well as follow the ISR Traditional Knowledge Research Policy (Joint Secretariat, Inuvik, NT, 2019).

ACKNOWLEDGMENTS

The first *State of the TNMPA Report* could not have been completed without the hard work and collaboration of our partners. We would like to thank our Inuvialuit (IGC, HTCs) and co-management (FJMC) partners for their participation in the qualitative ecological and socio-economic indicator assessments. Specifically, we would like to thank representatives from our Inuvialuit and co-management partners: Richard Cockney, Chuck Gruben, Manny Arey, Dennis Arey, Charles Pokiak, Emily Way-Nee, John Noksana Jr., Bertha Joe, and Jimmy Kalinek; science partners: Lisa Loseto, Shannon MacPhee, Ole Nielsen, Emilie Couture, Stéphane Lair, Emily Jenkins, Colin Gallagher, and Dustin Whalen who participated in the qualitative assessment meeting of ecological indicators. We also thank the IRC, IGC, Inuvik, Tuktoyaktuk, and Aklavik HTCs, DFO, and FJMC for participating in the socio-economic and governance indicator questionnaire. We thank WAMPA for their guidance throughout the evolution of this report, and DFO Oceans Program for financially supporting this assessment. Finally, the

authors would also like to thank Corinne Stairs, Joclyn Paulic, Chandra Chambers, Burton Ayles and Kayla Gagliardi for reviewing this report and providing valuable feedback.

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APPENDIX 1

The number of times each ecological indicator was monitored between 2010 and 2016 is presented below. Note that only indicators that were monitored were included. Full lists of ecological indicators for the TNMPA are provided in Tables 3–11 of the State of the TNMPA Report: Inventory of Monitoring Indicators from 2010–2016. The information in these tables were presented to both science and Inuvialuit participants during ecological assessment consultations held in October and November, 2017 and helped to inform results of the indicator assessment. Information in these tables were used to inform more than one indicator. For example harvest numbers and location of harvest were able to inform total number of beluga harvested, first/peak/last harvest, and distribution (among sub-regions) of the TNMPA. Indicators were organized by "*Indicatory Category: Indicator or Sub-category"* and then "*Indicators Currently Used or Suggested for Monitoring*" (see Tables 3–11).

POPULATION STRUCTURE OF HARVEST KEY SPECIES: BELUGA

Number of beluga harvested and date of first arrival/peak/last whales

Table 1. Number of times beluga harvest numbers and beluga harvest dates were recorded and monitored between 2010–2016.

Harvest Location	2010	2011	2012	2013	2014	2015	2016
East Whitefish	23	7	14	15	17	17	17
Kendall Island	17	25	16	16	11	10	6
Hendrickson Island	28	29	29	44	20	27	14
Shingle Point	2	1	1	3	0	2	2

Size, age, sex structure of harvest

Table 2. Number of times beluga age was recorded in total and monitored from 2010–2016.

Harvest Location	2010	2011	2012	2013	2014	2015	2016
East Whitefish	0	7	14	13	16	16	14
Kendall Island	0	25	16	5	5	10	6
Hendrickson Island	19	18	28	43	19	27	14
Shingle Point	0	1	1	3	0	0	0

Table 3. Number of times beluga length was recorded in total and monitored between 2010–2016.

Harvest Location	2010	2011	2012	2013	2014	2015	2016
East Whitefish	23	7	14	15	17	17	15
Kendall Island	17	25	16	14	11	10	6
Hendrickson Island	28	29	29	44	20	27	14
Shingle Point	0	0	0	2	0	0	0

Table 4. Number of times beluga sex were recorded in total and monitored between 2010–2016.

Harvest Location	Sex	2010	2011	2012	2013	2014	2015	2016
East Whitefish	Female	1	1	2	0	2	4	0
	Male	22	6	11	15	15	11	0
	Unknown	0	0	1	0	0	2	0
Kendall Island	Female	8	8	6	7	4	2	0
	Male	9	14	10	7	7	8	0
	Unknown	0	3	0	2	0	0	0
Hendrickson Island	Female	3	4	4	6	3	4	0
	Male	25	25	25	38	17	21	0
	Unknown	0	0	0	0	0	2	0
Shingle Point	Female	0	0	0	2	0	0	0
	Male	2	1	0	0	0	0	0
	Unknown	0	0	1	1	0	0	0

POPULATION STRUCTURE OF HARVEST KEY SPECIES: FISH

Number of fish harvested

Table 2. Number of times harvest numbers of individual fish species were recorded and monitored between 2010–2016. The 16 species here represent species consistently captured at Shingle Point, YT.

Fish Species	2010	2011	2012	2013	2014	2015	2016
Arctic Cisco	49	48	18	80	20	20	21
Arctic Flounder	0	50	37	40	6	20	13
Broad Whitefish	28	49	38	30	2	20	16
Burbot	4	4	5	0	0	3	1
Dolly Varden Char	0	184	316	123	416	269	264
Fourhorn Sculpin	0	59	18	31	0	12	20
Inconnu	30	31	30	37	0	20	0
Lake Whitefish	42	53	40	31	0	20	0
Least Cisco	41	39	39	34	20	20	9
Longnose Sucker	0	3	7	0	0	0	0
Northern Pike	0	1	3	4	0	0	0
Pacific Herring	2	7	1	11	0	1	0
Rainbow Smelt	47	8	12	27	0	9	0
Round Whitefish	20	0	23	49	0	0	0
Saffron Cod	20	44	40	46	20	20	19
Starry Flounder	5	37	15	27	7	20	5

Size, age, sex structure

Table 6. Number of times fork length of individual fish species were recorded and monitored between 2010–2016. The 16 species here represent species consistently captured at Shingle Point, YT.

Fish Species	2010	2011	2012	2013	2014	2015	2016
Arctic Cisco	34	48	18	31	10	16	20
Arctic Flounder	0	32	37	30	1	20	13
Broad Whitefish	9	49	38	29	0	19	16
Burbot	0	4	5	24	0	3	1
Dolly Varden Char	0	39	0	0	0	0	0
Fourhorn Sculpin	0	59	12	0	0	10	20
Inconnu	2	39	30	35	0	18	0
Lake Whitefish	18	52	40	24	0	24	0
Least Cisco	36	39	39	34	3	20	9
Longnose Sucker	0	0	7	0	0	0	0
Northern Pike	1	2	3	4	0	0	0
Pacific Herring	0	7	1	5	0	1	0
Rainbow Smelt	21	8	12	1	0	9	0
Round Whitefish	14	3	23	47	0	0	0
Saffron Cod	20	43	40	46	18	20	19
Starry Flounder	3	36	16	10	0	20	5
Unknown	0	0	24	0	0	0	0

Table 7. Number of times age of individual fish species were recorded and monitored between 2010–2016. The 16 species here represent species consistently captured at Shingle Point, YT.

Fish Species	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Arctic Cisco	28	38	53	31	0	0	0
Arctic Flounder	0	6	63	41	0	0	0
Broad Whitefish	10	12	34	30	0	0	0
Burbot	0	0	5	0	0	0	0
Dolly Varden Char	0	0	0	0	0	0	0
Fourhorn Sculpin	0	7	50	28	0	0	0
Inconnu	4	52	60	35	0	0	0
Lake Whitefish	19	2	40	28	0	0	0
Least Cisco	40	1	50	34	0	0	0
Longnose Sucker	0	0	8	0	0	0	0
Northern Pike	0	0	4	4	0	0	0
Pacific Herring	0	0	1	10	0	0	0
Rainbow Smelt	21	0	77	5	0	0	0
Round Whitefish	14	0	55	47	0	0	0
Saffron Cod	20	14	42	46	0	0	0
Starry Flounder	3	0	17	26	0	0	0

Table 3. Number of times sex of individual fish species were recorded and monitored between 2010–2016. The 16 species here represent species consistently captured at Shingle Point.

Fish Species	2010	2011	2012	2013	2014	2015	2016
Arctic Cisco	3	0	14	0	10	15	20
Arctic Flounder	0	0	28	0	0	20	13
Broad Whitefish	1	0	28	0	0	19	16
Burbot	0	0	5	0	0	3	1
Dolly Varden Char	0	0	0	0	0	0	0
Fourhorn Sculpin	0	0	26	0	0	10	20
Inconnu	1	0	56	0	0	18	0
Lake Whitefish	2	0	31	0	0	24	0
Least Cisco	20	0	35	0	3	20	9
Longnose Sucker	0	0	3	0	0	0	0
Northern Pike	0	0	3	0	0	0	0
Pacific Herring	0	0	1	0	0	1	0
Rainbow Smelt	19	0	0	0	0	9	0
Round Whitefish	10	0	3	0	0	0	0
Saffron Cod	20	0	42	0	18	20	19
Starry Flounder	3	0	16	0	0	20	4

ANTHROPOGENIC NOISE

Number of vessels transiting the TNMPA

Table 9. Number of times large vessels (> 300 tonne) transited within the TNMPA between 2010–2016.

Year	Number of Large Vessels
2015	2
2016	5

HEALTH OF KEY SPECIES: BELUGA

Blubber Thickness

Table 10. Number of times beluga blubber thickness was measured and recorded between 2010–2016.

Harvest Location	2010	2011	2012	2013	2014	2015	2016
East Whitefish	7	7	13	15	17	14	0
Kendall Island	16	21	16	11	9	10	0
Hendrickson Island	28	28	29	43	19	24	0
Shingle Point	0	0	0	2	0	0	0

Mercury in muscle

Table 11. Number of times beluga mercury concentrations were recorded and monitored between 2010–2016.

Harvest Location	2010	2011	2012	2013	2014	2015	2016
East Whitefish	0	7	14	0	17	17	0
Kendall Island	0	25	16	12	0	0	0
Hendrickson Island	20	18	29	44	20	27	14
Shingle Point	0	0	0	2	0	0	0

Disease/parasites/abnormalities

Table 12. Number of times beluga were tested for Brucella exposure and results were recorded and monitored between 2010–2016.

Harvest Location	2010	2011	2012	2013	2014	2015	2016
East Whitefish	0	7	0	5	17	16	17
Kendall Island	0	24	15	12	11	20	17
Hendrickson Island	20	17	29	30	19	27	13

LENGTH/WEIGHT RELATIONSHIPS

Table 13. Number of times beluga length/weight relationships were recorded and monitored between 2010–2016.

Harvest Location	2010	2011	2012	2013	2014	2015	2016
Hendrickson Island	0	0	0	0	0	16	10

HEALTH OF KEY SPECIES: FISH

Mercury in muscle

Table 14. Number of times mercury concentrations of individual fish species were recorded and monitored between 2010–2016. The seven species here were captured at Shingle Point, YT.

Fish Species	2010	2011	2012	2013	2014	2015	2016
Arctic Cisco	11	0	7	12	0	0	0
Arctic Flounder	0	0	8	12	0	0	0
Broad Whitefish	0	0	9	11	0	0	0
Fourhorn Sculpin	0	0	0	18	0	0	0
Pacific Herring	0	0	1	10	0	0	0
Rainbow Smelt	9	0	12	4	0	0	0
Round Whitefish	10	0	0	0	0	0	0
Saffron Cod	10	0	0	20	0	0	0

APPENDIX 2. STATE OF THE TNMPA ASSESSMENT: SOCIO-ECONOMIC AND GOVERNANCE INDICATORS QUESTIONNAIRE

Instructions: This questionnaire contains 28 multiple choice questions which require (2) two parts per question. First, please answer each question by choosing one answer (a,b,c, or,d). Refer to the supplementary material (S2) for the recorded data of each indicator used to monitor the TNMPA from 2010–2016. Some indicators speak to the TNMPA as a whole, while others are broken up by community; please use the provided data (S2) to answer each question. Additionally, each multiple choice question is accompanied by a question stating "Does this Indicator support the TNMPA"? Please answer "Yes" or "No" for each indicator. This will be used to assess if each indicator is directly supporting the TNMPA based on the Conservation Objective:

"to conserve and protect beluga whales and other marine species, their habitats and their supporting ecosystem."

Socio-economic Indicators

Category: Economic

1. Annual number of new applications for hydrocarbon development in or around the TNMPA.

Does this indicator support the TNMPA CO
YES NO

a. Annual number of new applications on hydrocarbon development is sufficient and not at a level deemed to have an impact on the TNMPA habitat and important species;

b. Annual number of new applications on hydrocarbon development is low and does not demonstrate economic potential;

c. Annual number of new applications on hydrocarbon development is high and is a concern to the protection and sustainment of habitat and species in the TNMPA;

d. There is not enough information (Table XX) to answer this question.

2. Annual number of ecotourism companies and income generated for ecotourism in the TNMPA (indicator measured by number of requests to HTCs for ecotourism in TNMPA)

Does this indicator support the TNMPA CO
YES NO

a. Is low and not significantly contributing to MPA awareness and local employment

b. Is sufficient and is contributing to MPA awareness and local employment

c. Is high and is concerning to the disruption of habitat and species within the TNMPA.

d. There is not enough information (Table XX) to answer this question

3. Annual number of vessel transiting the TNMPA

Does this indicator support the TNMPA CO
YES NO

a. Is low and not significantly contributing to MPA awareness and local employment

b. Is sufficient and is contributing to MPA awareness and local employment

c. Is too high and is overwhelming community resources, and is concerning to the disruption of habitat and species within the TNMPA.

d. There is not enough information (Table XX) to answer this question

4. Annual number of beluga and other species harvested per area and community

Does this indicator support the TNMPA CO YES NO

a. Is high and is a concern of stressing the ecosystem within the TNMPA
b. Is sufficient and not a concern to the ecosystem and harvesters hunting within the TNMPA
c. Is too low and a concern to the ecosystem and harvesters hunting within the TNMPA
d. There is not enough information (Table XX) to answer this question

5. Number of community member employment directly supporting TNMPA for monitoring surveillance, logistic

Does this indicator support the TNMPA CO YES NO

a. Is too high and creating burden for the relevant HTCs
b. Is sufficient and supporting community based monitoring and local employment
c. Is too low, and not supporting community based monitoring and local employment
d. There is not enough information (Table XX) to answer this question

6. Annual number of Fisheries Protection applications for advice or authorization related to development in the Significant Discovery Licenses (i.e., dredging, pipeline installment)

Does this indicator support the TNMPA CO YES NO

a. There are no applications for advice or authorization related to development in the SDLs
b. Is low and is not effecting the protection of habitat and species within the TNMPA
c. Is high and is a concern to the protection of habitat and species within the TNMPA
d. There is not enough information (Table XX) to answer this question

7. Annual number of applications for disposal at sea under the CEPA for ocean dumping

Does this indicator support the TNMPA CO YES NO

a. There are no applications for disposal at sea under the CEPA for ocean dumping
b. Is low and is a concern to the protection of habitat and species within the TNMPA
c. Is high and is a concern relevant to the protection of habitat and species within the TNMPA
d. There is not enough information (Table XX) to answer this question

8. Number of TNMPA DFO Conservation and Protection patrols

Does this indicator support the TNMPA CO YES NO

a. Is low and does not ensure compliance with the TNMPA Regulations?
b. Is sufficient to the monitoring and managing the habitat and species within the TNMPA
c. There is not enough information (Table XX) to answer this question

9. Number of violation of TNMPA regulations

Does this indicator support the TNMPA CO
YES NO

a. There are no violations
b. Is low and not a concern to the protection of habitat and species within the TNMPA
c. Is high and is a concern to the protection of habitat and species within the TNMPA
d. There is not enough information (Table XX) to answer this question

Category: Cultural Integrity

10. Percent of harvesters by community

Does this indicator support the TNMPA CO
YES NO

a. Is low and may reflect changes in environment, hunting practices, species shifts
b. Is high and indicates successful traditional harvests for the communities
c. There is not enough information (Table XX) to answer this question

11. Percent of households consuming country foods

Does this indicator support the TNMPA CO
YES NO

a. Is low and may reflect changes in environment, hunting practices, species shifts
b. Is high and indicates successful traditional harvests for the communities
c. There is not enough information (Table XX) to answer this question

12. Annual kg of beluga and other species consumed

Does this indicator support the TNMPA CO
YES NO

a. Is low and may reflect changes in environment, hunting practices, species shifts
b. Is high and indicates successful traditional harvests for the communities
c. There is not enough information (Table XX) to answer this question

13. Number of positive or negative responses as to whether the TNMPA is a healthy marine ecosystem

Does this indicator support the TNMPA CO
YES NO

a. Responses are mostly positive
b. Responses are mostly negative
c. There is not enough information (Table XX) to answer this question

Governance Indicators

Category: Institutional management structures established and functioning

14. Number of management meetings as percentage of work plans

Does this indicator support the TNMPA CO
YES NO

a. Is too low to ensure/contribute to? meaningful management of the TNMPA;
b. Is sufficient
c. Is to high
d. There is not enough information (Table XX) to answer this question

15. Percentage of key stakeholders groups attending collaborative meetings

Does this indicator support the TNMPA CO
YES NO

a. Is too low to contribute to meaningful management of the TNMPA;
b. Is sufficient
c. Is to high
d. There is not enough information (Table XX) to answer this question

16. Percentage of collaborative meetings with quorum

Does this indicator support the TNMPA CO
YES NO

a. Is too low to ensure meaningful management of the TNMPA;
b. Is sufficient
c. Is to high
d. There is not enough information (Table XX) to answer this question

Category: Increase awareness education and outreach related to the TNMPA and its conservation objective

17. Number of stakeholder meetings to discuss TNMPA regulations

Does this indicator support the TNMPA CO
YES NO

a. Is low and not increasing awareness of the TNMPA
b. Is sufficient and meeting the CO for monitoring and managing the TNMPA
c. There is not enough information (Table XX) to answer this question

18. Number of visits to the TNMPA page on the BSP website

Does this indicator support the TNMPA CO
YES NO

a. Is low and not increasing awareness of the TNMPA
b. Is sufficient and contributing to the awareness to the TNMPA
c. Is high and contributing to increase awareness to the TNMPA
d. There is not enough information (Table XX) to answer this question

19. Number of education /outreach events within the ISR (including national news reports)

Does this indicator support the TNMPA CO
YES NO

a. Is low and not contributing to the awareness to the TNMPA
b. Is sufficient and contributing to the awareness of the TNMPA
c. Is high and increasing awareness to the TNMPA
d. There is not enough information (Table XX) to answer this question

20. Number of visits to local schools to talk about the TNMPA

Does this indicator support the TNMPA CO
YES NO

a. Is low and not contributing to the local awareness to the TNMPA
b. Is sufficient and contributing to the local awareness of the TNMPA
c. Is high and increasing local awareness to the TNMPA
d. There is not enough information (Table XX) to answer this question

21. Number of local, regional, and national news reports about the TNMPA

Does this indicator support the TNMPA CO
YES NO

a. Is low and not contributing to the local awareness to the TNMPA
b. Is sufficient and contributing to the local awareness of the TNMPA
c. Is high and increasing local awareness to the TNMPA
d. There is not enough information (Table XX) to answer this question

Category: Contributing to national "network of MPAs"

22. Number of network meetings per year attended by regional Oceans staff

Does this indicator support the TNMPA CO
YES NO

a. Is low and not contributing to the awareness to the TNMPA
b. Is sufficient and contributing to the awareness of the TNMPA
c. Is high and increasing awareness to the TNMPA
d. There is not enough information (Table XX) to answer this question

23. Degree of inclusion of TNMPA in consideration of national and international networks

Does this indicator support the TNMPA CO
YES NO

a. Is low and not contributing to the awareness to the TNMPA
b. Is sufficient and contributing to the awareness of the TNMPA
c. Is high and increasing awareness to the TNMPA
d. There is not enough information (Table XX) to answer this question

Category: Contributing to broader national and international Arctic monitoring programs

24. Number of indicators and protocols from TNMPA adopted by national and international Arctic monitoring programs

Does this indicator support the TNMPA CO
YES NO

a. No indicators and protocols were adapted
b. Sufficient indicators and protocols were adapted
c. There is not enough information (Table XX) to answer this question

25. Number of monitoring workshops attended where TNMPA approach is profiled

Does this indicator support the TNMPA CO
YES NO

a. No monitoring workshops were attended where TNMPA approach is profiled
b. Sufficient number of monitoring workshops were attended where TNMPA approach is profiled
c. There is not enough information (Table XX) to answer this question

Category: Engagement with other DFO sectors

26. Number of meetings annually with Science; Fisheries Management; Fisheries Protection; Species at Risk; Number of CSAS requests for Science advice on TNMPA monitoring

Does this indicator support the TNMPA CO
YES NO

a. The number of meetings attended for advice on TNMPA monitoring is low and does not contribute to meaningful management of TNMPA
b. The number of meetings attended for advice on TNMPA monitoring is sufficient and not a concern for the monitoring and management of the TNMPA
c. There is not enough information (Table XX) to answer this question

Category: Six-year review of management plan and monitoring plan

27. Number of stake holders engaged in six-year of TNMPA

Does this indicator support the TNMPA CO
YES NO

a. Number of stakeholders engaged is low and a concern for the monitoring and management of the TNMPA
b. Number of stakeholders engaged is sufficient and not a concern for the monitoring and management of the TNMPA
c. There is not enough information (Table XX) to answer this question

APPENDIX 3.

The implementation of socio-economic and governance indicators listed in the Tarium Niryutait Marine Protected Area (TNMPA) Monitoring Plan (DFO and FJMC 2013). Recorded data includes how many times each indicator was monitored and recorded within the time frame 2010–2016. Descriptions are given to provide context to select indicators. Note: NA refers to data that was not available or not consistently monitored.

Table 1. Socio-Economic indicators used to measure the number of times each indicator was monitored from 2010–2016. Indicator data used to inform the TNMPA as a whole.

Indicator	2010	2011	2012	2013	2014	2015	2016	Description
1. Annual number of new applications for hydrocarbon development in or around the TNMPA.	0	0	7	5	1	0	0	Data covers all Beaufort Sea and was obtained from Northern Oil and Gas Annual Report 2016 (INAC 2016) Total "land" disposition as of Dec 1 2016 in BS is 2,709,717 hectars for exploration licences and 224,623 hectars. for SDL. There are currently 15 Els and 48SDLs in the BS.
3. Annual number of vessel transiting the TNMPA.	NA	NA	NA	NA	NA	5	5	Data collected from C&P tracking database. Records of vessel traffic in previous years are recorded as NA due to unreliable tracking, and or incompatible formatting of data sources.
6. Annual number of Fisheries Protection applications for advice or authorization related to development in the SDLs (i.e., dredging, pipeline installment)	0	0	0	0	0	0	0	Information provided by FPP, looking at SDL 28 and 25 both owned by Nytis Exploration, no relevant activity in or near TNMPA.
7. Annual number of applications for disposal at sea under the CEPA for ocean dumping	0	0	0	0	0	0	0	Emailed ECCC, zero disposals at sea in TNMPA.
8. Number of TNMPA DFO Conservation and Protection patrols	1*2#	1*2#	1*1+1#	1*1#	1*	2*	1*1#	*=Vessel Patrols; #=air patrols; += Winter Ice road
9. Number of violation of TNMPA regulations	0	0	0	0	0	0	0	Info received from T. Stein - DFO Conservation and Protection

Table 2. Socio-Economic indicators used to measure the number of times each indicator was monitored from 2010–2016. Indicator data used to inform each TNMPA sub-region by informing individual communities (Inuvik, Tuktoyaktuk, Aklavik) who utilize the three sub regions.

Indicator	**Location**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**Description**
2. Annual number of ecotourism companies and income generated for ecotourism in the TNMPA (indicator measured by number of requests to HTCs for ecotourism in TNMPA)	Tuktoyaktuk	3	3	4	4	3	3	3	Data gathered from ITI database
	Inuvik	2	2	1	1	1	1	1	-
	Aklavik	1	0	0	0	0	0	0	-
4. Annual number of beluga and other species harvested per area and community	Tuktoyaktuk	28	28	26	44	22	29	29	Data received from FJMC Beluga Database
	Inuvik	40	32	30	22	31	24	24	-
	Aklavik	4	1	2	3	2	2	2	Aklavik numbers include Shingle Point harvests and do not include one whale that washed up at Shingle in 2015
5. Number of community member employment directly supporting TNMPA for monitoring surveillance, logistic	Tuktoyaktuk	5	3	2	2	5	8	5	Number of community members employed for the TNMPA fish and beluga monitoring programs
	Inuvik	1	5	1	2	3	3	4	-
	Aklavik	2	2	2	3	4	4	4	-

Table 3. Cultural Integrity indicators used to measure the number of times each indicator was monitored from 2010–2016. Indicator data used to inform the TNMPA as a whole.

Indicator	2010	2011	2012	2013	2014	2015	2016	Description
11. Percentage of households consuming country foods	NA	NA	NA	NA	NA	NA	NA	Data has not been monitored or recorded in this format. Harvest numbers of beluga have recorded via community presently is used to measure this indicator.
12. Annual kg of beluga and other species consumed	NA	NA	NA	NA	NA	NA	NA	Data has not been monitored or recorded in this format. Harvest numbers of beluga have recorded via community presently is used to measure this indicator.
13. Number of positive or negative responses as to whether the TNMPA is a healthy marine ecosystem	0	0	0	0	0	0	2	Potential sources of info - Beluga Summit, Beluga RAP. Note State of the TNMPA Report assessment will occur approximately every 5 years and will contribute to this indicator

Table 4. Cultural Integrity indicators used to measure the number of times each indicator was monitored from 2010–2016. Indicator data used to inform each TNMPA sub-region by informing individual communities (Inuvik, Tuktoyaktuk, Aklavik) who utilize the three sub regions.

Indicator	Location	2010	2011	2012	2013	2014	2015	2016	Description
10. Percent of harvesters by community	Tuktoyaktuk	NA	NA	NA	NA	NA	51%	51%	% harvesters calculated for Tuktoyaktuk using full HTC harvesters list and 2016 population
	Inuvik	NA	NA	NA	NA	NA	7.50%	8.20%	Figures were calculated using the HTC active harvesters list and latest population statistic.
	Aklavik	NA	NA	NA	NA	NA	32%	32%	Figures were calculated using the HTC active harvesters list and latest population statistic DATA from Harvest monitoring program and latest community demographic.

Table 5. Governance indicators used to measure the number of times each indicator was monitored from 2010–2016. Indicator data used to inform the TNMPA as a whole.

Indicator	2010	2011	2012	2013	2014	2015	2016	Description
14. Number of management meetings as percentage of work plans	7	7	7	7	10	10	10	Numbers include IGC, FJMC, WAMPA, DFO Oceans/Science, BSP. Data adjusted to report # of meetings, not % as no TMPA work plans.
16. Percentage of collaborative meetings with quorum	7	7	7	7	10	10	10	4 IGC and 3 FJMC meetings annually; at least 3 WAMPA annually since establishment; note this does not include additional meetings set as required to address TNMPA activities that arise.
17. Number of stakeholder meetings to discuss TNMPA regulations	7	7	7	7	10	10	10	Note: same data as in indicator 14 and 16. Opportunity to combine indicators in the future.
18. Number of visits to the TNMPA page on the BSP website	NA	NA	NA	NA	NA	NA	NA	Action Item has been made to include BSP site visit statistics to webpage.
21. Number of local, regional, and national news reports about the TNMPA	1	NA	NA	NA	NA	2	4	Includes: Marketwired (press release), Nunatsiaq, CBC, CNW, Global Mail, Huffington Post, News Deeply.
22. Number of network meetings per year attended by regional Oceans staff	NA	NA	NA	NA	1	2	1	Data includes number of meetings specific to the Western Arctic Bioregion, and a community tour in 2016
23. Degree of inclusion of TNMPA in consideration of national and international networks	0	0	0	0	0	0	0	Not applicable since MPA network plans are still in draft form. Indicator will be reassessed if or when the plans

Indicator	2010	2011	2012	2013	2014	2015	2016	Description
24. Number of indicators and protocols from TNMPA adopted by national and international Arctic monitoring programs	0	0	0	0	0	0	0	Note with the designation of ANMPA in 2016, monitoring and management plans will draw from TNMPA plans. State of TNMPA Report will be shared with partners working on other MPAs
25. Number of monitoring workshops attended where TNMPA approach is profiled	0	0	0	0	0	0	2	Data includes Ecosystem Approach Working Group (EA) in Fairbanks Alaska, and IIBWC meeting in Barrow Alaska
26. Number of meetings annually with Science; Fisheries Management; Fisheries Protection; Species at Risk; Number of CSAS requests for Science advice on TNMPA monitoring	0	0	0	0	0	3	4	Includes 3 FJMC meeting annually and DFO Oceans/Science meeting in 2016
27. Number of Science projects approved by FJMC related to TNMPA	3	2	2	5	5	6	8	Data include research projects within the TNMPA
28. Number of stake holders engaged in six-year of TNMPA	7	7	7	7	8	8	8	Include three (3) local HTCs, FJMC, IGC, IRC, DFO, and WAMPA beginning in 2014

Table 6. Governance indicators used to measure the number of times each indicator was monitored from 2010–2016. Indicator data used to inform each TNMPA sub-region by informing individual communities (Inuvik, Tuktoyaktuk, Aklavik) who utilize the three sub regions.

Indicator	Location	2010	2011	2012	2013	2014	2015	2016	Description
15. Percentage of key stakeholders groups attending collaborative meetings	Tuktoyaktuk	NA	NA	NA	NA	50%	50%	50%	WAMPA Meetings focused on the guidance of monitoring and management activities was established in 2014. Paulatuk HTC representative, FJMC representative. IGC and IRC are the overarching input of all WAMPA decisions.
	Inuvik	NA	NA	NA	NA	50%	50%	50%	Note in 2018 the decision to expand community presence through ANMPA and TNMPA WG increases the percentage.
	Aklavik	NA	NA	NA	NA	50%	50%	Aklavik	Prior to the establishment of WAMPA, FJMC committee as co-management partners as well as consultations with IGC, and HTC guided TNMPA activities however the role and transparency of Inuvialuit stakeholder involvement was made evident with the establishment of WAMPA
20. Number of visits to local schools to talk about the TNMPA	Tuktoyaktuk	NA	NA	NA	NA	0	0	0	Note: includes Science Rendezvous participation (2016)
	Inuvik	NA	NA	NA	NA	2	4	7	Note: does not include DFO Science outreach
	Aklavik	NA	NA	NA	NA	0	0	0	-