LME 66 – Canadian High Arctic / North Greenland

Bordering countries: Greenland, Canada.
LME Total area: 600,000 km²

List of indicators

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<td></td>
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<tr>
<td>Merged nutrient indicator</td>
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LME overall risk
This LME falls in the cluster of LMEs that exhibit high percentages of rural coastal population, high numbers of collapsed and overexploited fish stocks, as well as high proportions of catch from bottom impacting gear.
Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is low.

Productivity

Chlorophyll-A
The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.414 mg.m$^{-3}$) in August and a minimum (0.205 mg.m$^{-3}$) during May. The average CHL is 0.456 mg.m$^{-3}$. Maximum primary productivity (412 g.C.m$^{-2}$.y$^{-1}$) occurred during 1999 and minimum primary productivity (147 g.C.m$^{-2}$.y$^{-1}$) during 2010. There is a statistically insignificant increasing trend in Chlorophyll of 17.8 % from 2003 through 2013. The average primary productivity is 218 g.C.m$^{-2}$.y$^{-1}$, which places this LME in Group 3 of 5 categories (with 1 = lowest and 5 = highest).
### Primary productivity

![Primary Productivity Graph]

**Primary Productivity (Canadian High Arctic North Greenland)**

- **Very low**
- **Low**
- **Medium**
- **High**
- **Very high**

### Sea Surface Temperature

From 1957 to 2012, the Canadian High Arctic-North Greenland LME #66 has warmed by 0.13°C, thus belonging to Category 4 (slow warming LME). This LME is covered with sea ice in winter. In summer, some straits become ice-free, especially in the 2000s-2010s. Still, SST measurements in this region should be treated with caution. Between 1957-2012, SST warming was extremely slow until 1997, when SST abruptly increased between 1997-1998 and remained relatively high through 2012. Qualitatively, this pattern is similar to that in the Central Arctic (LME #64). The main – and significant – difference is the timing of regime shift. In the Central Arctic, it occurred between 2006-2007, nine years after the above-mentioned regime shift in the Canadian High Arctic-North Greenland LME. Clearly, these regime shifts are not related to one another.
Fish and Fisheries

The Canadian High Arctic LME supports around 70 species and the major targeted species is Atlantic cod (Gadus morhua).

Annual Catch

Total reported landings reached a historic high of 2,100 t in 1962, followed by a sharp decline to around 640t in 1963. The total landings kept declining and fluctuated around 240 t in the recent few decades.

Catch value


Marine Trophic Index and Fishing-in-Balance index

The MTI fluctuated around 4 from 1950 to late 1960s and then declined steadily to around 3 in the early 1980s. The FiB index keeps decreasing from 1950 to 2010, showing that there is no spatial expansion of fisheries in this region.
Stock status
As the catch data does not include most of the subsistence and artisanal catches in this LME, the stock status plots cannot realistically reflect the status of stocks in this region.

Catch from bottom impacting gear
Both the indicators of catch from bottom impacting gear type and fishing effort do not reflect the situation in this LME because of insufficient data. The percentage of catch from the bottom gear type to the total catch was lower than 5% before 1977. It then reached its first peak at 40% in 1991. After that, this percentage dropped to around 7% in 1996. It ranged between 20 and 42% in the recent decade. Given the very low quality of the underlying catch data and insufficient data information, both the indicators of catch from impacting gear type and fishing effort are likely to be very unreliable.
Fishing effort
The whole time series of effort data in the LME region is incomplete and only one year of effective effort data in this LME is available (i.e., about 3000 kW in 2002). Given the very low quality of the underlying catch data and insufficient data information, both the indicators of catch from impacting gear type and fishing effort are likely to be very unreliable.

Primary Production Required
The primary production required (PPR) to sustain the reported landings in this reached its maximum at 60% in 1962 and then declined to less than 5% in the following year. The PPR then ranges between 0.5 to 2% in the recent few decades.
Pollution and Ecosystem Health

Nutrient ratio, Nitrogen load and Merged Indicator

Human activities in watersheds are affecting nutrients transported by rivers into LMEs. Large amounts of nutrients (in particular nitrogen load) entering coastal waters of LMEs can result in high biomass algal blooms, leading to hypoxic or anoxic conditions, increased turbidity and changes in community composition, among other effects. In addition, changes in the ratio of nutrients entering LMEs can result in dominance by algal species that have deleterious effects (toxic, clog gills of shellfish, etc.) on ecosystems and humans.

An overall nutrient indicator (Merged Nutrient Indicator) based on 2 sub-indicators: Nitrogen Load and Nutrient Ratio (ratio of dissolved Silica to Nitrogen or Phosphorus - the Index of Coastal Eutrophication Potential or ICEP) was calculated.

Nitrogen load

The Nitrogen Load risk level for contemporary (2000) conditions was very low (level 1 of the five risk categories, where 1 = lowest risk; 5 = highest risk). Based on a “current trends” scenario (Global Orchestration), this remained the same in 2030 and 2050.

Nutrient ratio

The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was high (4). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

Merged nutrient indicator

The risk level for the Merged Nutrient Indicator for contemporary (2000) conditions was very low (1). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen load</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Nutrient ratio</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Merged nutrient indicator</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Legend:

- **Very low**
- **Low**
- **Medium**
- **High**
- **Very high**
**POP**

No pellet samples were obtained from this LME.

**Plastic debris**

Modelled estimates of floating plastic abundance (items km$^{-2}$), for both micro-plastic (<4.75 mm) and macro-plastic (>4.75 mm), indicate that this LME is in the group with relatively low levels of plastic concentration. Estimates are based on three proxy sources of litter: shipping density, coastal population density and the level of urbanisation within major watersheds, with enhanced run-off. The low values are due to the relative remoteness of this LME from significant sources of plastic. The abundance of floating plastic in this category is estimated to be on average over 40 times lower than those LMEs with the highest values. There is very limited evidence from sea-based direct observations and towed nets to support this conclusion.

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**Ecosystem Health**

**Mangrove and coral cover**

Not applicable.

**Reefs at risk**

Not applicable.

**Marine Protected Area change**

The Canadian High Arctic – North Greenland LME experienced an increase in MPA coverage from 37,888 km$^2$ prior to 1983 to 40,655 km$^2$ by 2014. This represents an increase of 7%, within the lowest category of MPA change.

**Cumulative Human Impact**

The Canadian High Arctic – North Greenland LME experiences one of the lowest overall cumulative human impact (score 0.56; maximum LME score 5.22). It falls in risk category 1 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, ocean acidification has the highest average impact on the LME (score 0.43; maximum in other LMEs was 1.20). Other key stressors include UV radiation and sea surface temperature.
Ocean Health Index
The Canadian High Arctic – North Greenland LME scores above average on the Ocean Health Index compared to other LMEs (score 74 out of 100; range for other LMEs was 57 to 82), but still relatively low. This score indicates that the LME is well below its optimal level of ocean health, although there are some aspects that are doing well. Its score in 2013 increased 2 points compared to the previous year, due in large part to changes in the score for clean waters. This LME scores lowest on natural products, carbon storage, tourism & recreation and lasting special places goals and highest on mariculture, artisanal fishing opportunities, coastal protection, coastal economies, and biodiversity goals. It falls in risk category 2 of the five risk categories, which is a moderate level of risk (1 = lowest risk; 5 = highest risk).
Socio-economics

Indicators of demographic trends, economic dependence on ecosystem services, human wellbeing and vulnerability to present-day extreme climate events and projected sea level rise, are assessed for this LME. To compare and rank LMEs, they were classified into five categories of risk (from 1 to 5, corresponding to lowest, low, medium, high and highest risk, respectively) based on the values of the individual indicators. In the case of economic revenues, the LMEs were grouped to 5 classes of revenues from lowest, low, medium, high and highest, as revenues did not translate to risk.

Population

The coastal area stretches over 442 031 km². A current population of 289 in 2010 is projected to decrease to 138 in 2100, with a density of 65 persons per 100 000 km² in 2010 decreasing to 31 per 100 000 km² by 2100. About 100% of coastal population lives in rural areas, and is projected to be the same in share in 2100.

<table>
<thead>
<tr>
<th>Total population</th>
<th>2010</th>
<th>2100</th>
<th>Rural population</th>
<th>2010</th>
<th>2100</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>289</td>
<td>138</td>
<td></td>
<td>289</td>
<td>138</td>
</tr>
</tbody>
</table>

Legend:
- Very low
- Low
- Medium
- High
- Very high

Coastal poor

The indigent population makes up 12% of the LME’s coastal dwellers. This LME places in the very low-risk category based on percentage and in the very low-risk category using absolute number of coastal poor (present day estimate).

<table>
<thead>
<tr>
<th>Coastal poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>34</td>
</tr>
</tbody>
</table>

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. This LME ranks in the very low-revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $0.45 million for the period 2001-2010. Fish protein accounts for 11% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013
Transboundary Water Assessment Programme, 2015

$216 million places it in the very low-revenue category. On average, LME-based tourism income contributes 4% to the national GDPs of the LME coastal states. Spatial distribution of economic activity (e.g. spatial wealth distribution) measured by night-light and population distribution as coarse proxies can range from 0.0000 (totally equal distribution and lowest risk) to 1.0000 (concentrated in 1 place and most inequitable and highest risk). The Night Light Development Index (NLDI) thus indicates the level of spatial economic development, and that for this LME falls in the category with high risk.

<table>
<thead>
<tr>
<th>Fisheries Annual Landed Value</th>
<th>% Fish Protein Contribution</th>
<th>Tourism Annual Revenues</th>
<th>% Tourism Contribution to GDP</th>
<th>NLDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>454,337</td>
<td>10.8</td>
<td>216,011,710</td>
<td>4.3</td>
<td>0.8213</td>
</tr>
</tbody>
</table>

Legend:  
- Very low  
- Low  
- Medium  
- High  
- Very high

Human Development Index

Using the Human Development Index (HDI) that integrates measures of health, education and income, the present-day LME HDI belongs to the very high HDI and very low-risk category. Based on an HDI of 0.899, this LME has an HDI Gap of 0.101, the difference between present and highest possible HDI (1.000). The HDI Gap measures an overall vulnerability to external events such as disease or extreme climate related events, due to less than perfect health, education, and income levels, and is independent of the harshness of and exposure to specific external shocks.

HDI values are projected to the year 2100 in the contexts of shared socioeconomic development pathways (SSPs). This LME is projected to assume a place in the very low risk category (very high HDI) in 2100 under a sustainable development pathway. Under a fragmented world scenario, the LME is estimated to place in a low-risk category (high HDI) because of reduced income levels and population values from those in a sustainable development pathway.

Climate-Related Threat Indices

The Climate-Related Threat Indices utilize the HDI Gaps for present-day and projected 2100 scenarios. The contemporary climate index accounts for deaths and property losses due to storms, flooding and extreme temperatures incurred by coastal states during a 20-year period from 1994 to 2013 as hazard measures, the 2010 coastal population as proxy for exposure, and the present day HDI Gap as vulnerability measure.

The Contemporary Threat Index incorporates a Dependence Factor based on the fish protein contribution to dietary animal protein, and on the mean contribution of LME tourism to the national GDPs of LME coastal states. The HDI Gap and the degree of dependence on LME ecosystem services define the vulnerability of a coastal population. It also includes the average of risk related to extreme climate events, and the risk based on the degrading system states of an LME (e.g. overexploited fisheries, pollution levels, decrease in coastal ecosystem areas).

The 2100 sea level rise threat indices, each computed for the sustainable world and fragmented world development pathways, use the maximum projected sea level rise at the highest level of warming of 8.5 W/m² in 2100 as hazard measure, development pathway-specific 2100 populations in the 10 m × 10 km coast as exposure metrics, and development pathway-specific 2100 HDI Gaps as vulnerability estimates.
Present day climate threat index of this LME is within the very low-risk (very low threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is very low. In a sustainable development scenario, the risk index from sea level rise in 2100 is very low, and remains the same even under a fragmented world development pathway.

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate Threat</td>
<td>0.2258</td>
<td>0.1455</td>
</tr>
<tr>
<td>Contemporary Threat</td>
<td>0.1249</td>
<td>0.2579</td>
</tr>
<tr>
<td>SSP1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSP3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend:
- Very low
- Low
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Governance

**Governance architecture**

None of the transboundary fisheries arrangements (NEAFC, ICCAT, NAMMCO and NASCO) appear to be integrated while the three arrangements for pollution and biodiversity appear to have the Arctic Council as an integrating arrangement for one set of issues and the OSPAR Convention for a second set of similar issues relating to pollution and biodiversity. Additionally, the specific biodiversity arrangements for marine mammals and polar bears do not appear to have any formal linkages. The Arctic Council is not a binding arrangement so its implementation is voluntary and country dependent. It does appear to have the potential to develop into an informal overall policy coordinating organization, although as mentioned, its policy coordination role with respect to fisheries is weak. Consequently, this LME has been assigned an overall integration score of 1.0 due to the presence of the Arctic Council.

The overall scores for the ranking of risk were:

<table>
<thead>
<tr>
<th>Engagement</th>
<th>Completeness</th>
<th>Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>77</td>
<td>1</td>
</tr>
</tbody>
</table>

Legend:
- Very low
- Low
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- High
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