**LME 58 – Kara Sea**

**Bordering countries:** Russian Federation.

**LME Total area:** 970,089 km²

### List of indicators

<table>
<thead>
<tr>
<th>Category</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>LME overall risk</td>
<td>2</td>
</tr>
<tr>
<td>Productivity</td>
<td>2</td>
</tr>
<tr>
<td>Chlorophyll-A</td>
<td>2</td>
</tr>
<tr>
<td>Primary productivity</td>
<td>3</td>
</tr>
<tr>
<td>Sea Surface Temperature</td>
<td>3</td>
</tr>
<tr>
<td>Fish and Fisheries</td>
<td>4</td>
</tr>
<tr>
<td>Annual Catch</td>
<td>4</td>
</tr>
<tr>
<td>Catch value</td>
<td>5</td>
</tr>
<tr>
<td>Marine Trophic Index and Fishing-in-Balance index</td>
<td>5</td>
</tr>
<tr>
<td>Stock status</td>
<td>5</td>
</tr>
<tr>
<td>Catch from bottom impacting gear</td>
<td>5</td>
</tr>
<tr>
<td>Fishing effort</td>
<td>6</td>
</tr>
<tr>
<td>Primary Production Required</td>
<td>6</td>
</tr>
<tr>
<td>Pollution and Ecosystem Health</td>
<td>6</td>
</tr>
<tr>
<td>Nutrient ratio, Nitrogen load and Merged Indicator</td>
<td>6</td>
</tr>
<tr>
<td>Nitrogen load</td>
<td>7</td>
</tr>
<tr>
<td>Nutrient ratio</td>
<td>7</td>
</tr>
<tr>
<td>Merged nutrient indicator</td>
<td>7</td>
</tr>
<tr>
<td>POPs</td>
<td>7</td>
</tr>
<tr>
<td>Plastic debris</td>
<td>7</td>
</tr>
<tr>
<td>Mangrove and coral cover</td>
<td>8</td>
</tr>
<tr>
<td>Reefs at risk</td>
<td>8</td>
</tr>
<tr>
<td>Marine Protected Area change</td>
<td>8</td>
</tr>
<tr>
<td>Cumulative Human Impact</td>
<td>8</td>
</tr>
<tr>
<td>Ocean Health Index</td>
<td>9</td>
</tr>
<tr>
<td>Socio-economics</td>
<td>9</td>
</tr>
<tr>
<td>Population</td>
<td>9</td>
</tr>
<tr>
<td>Coastal poor</td>
<td>10</td>
</tr>
<tr>
<td>Revenues and Spatial Wealth Distribution</td>
<td>10</td>
</tr>
<tr>
<td>Human Development Index</td>
<td>10</td>
</tr>
<tr>
<td>Climate-Related Threat Indices</td>
<td>10</td>
</tr>
</tbody>
</table>
LME overall risk
This LME falls in the cluster of LMEs that exhibit a significant influence of capacity-enhancing fisheries subsidies.
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 high.

Productivity

Chlorophyll-A
The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (14.2 mg.m\(^{-3}\)) in October and a minimum (0.325 mg.m\(^{-3}\)) during April. The average CHL is 0.998 mg.m\(^{-3}\). Maximum primary productivity (522 g.C.m\(^{-2}.y\(^{-1}\)) occurred during 1998 and minimum primary productivity (221 g.C.m\(^{-2}.y\(^{-1}\)) during 2010. There is a statistically insignificant decreasing trend in Chlorophyll of -44.5 % from 2003 through 2013. The average primary productivity is 317 g.C.m\(^{-2}.y\(^{-1}\), which places this LME in Group 3 of 5 categories (with 1 = lowest and 5= highest).
Sea Surface Temperature
From 1957 to 2012, the Kara Sea LME #58 has warmed by 0.60°C, thus belonging to Category 3 (moderate warming LME). The Kara Sea warming was accentuated by a single event, the 1995 maximum, which occurred concurrently in the Laptev Sea. Interannual variability was moderate, with a magnitude of 0.5°C, similar to the Laptev Sea. The thermal history of the Kara Sea is negatively correlated with the Arctic Oscillation (AO) index. In this respect, the Kara Sea is similar to the Beaufort Sea LME #55. At the same time, the Kara Sea SST appears to be decorrelated from the adjacent Laptev Sea LME #57's SST since the latter is negatively correlated with the AO index. This pattern can be explained by the lack of oceanographic connection between the Kara and Laptev seas. Indeed, the only significant connection between these seas is through the shallow Vilkitsky Strait, which is covered with sea ice year-round. The very fast warming from <1.0°C in 2004 to 0.2°C in 2012, at a rate of >1.2°C in 8 years, is unprecedented for the Arctic Ocean marginal seas. The rate of this most recent warming is among the fastest decadal warming rates observed in the World Ocean.
Fish and Fisheries
The Kara Sea benefits from the occasional intrusion of "warm" water, with accompanying fauna. However, except for these occasional strays, the fish fauna of the Kara Sea is species poor with the bulk of the fisheries catches contributed by the genus *Coregonus*, (Subfamily *Coregoninae*, Family *Salmonidae*) known as "whitefishes" or "sig" in Russian. Six of their species make up about 80% of the total fisheries landing in the LME. Their declining catches are explained in part by extreme pollution of the estuaries and coastal areas and by overfishing.

Annual Catch
Catch value

![Catch Value (Kara Sea)](chart)

**Marine Trophic Index and Fishing-in-Balance index**
Given the very low quality of the underlying catch data, the catch-based indicators for this LME (such as PPR, MTI or FiB) are likely to be very unreliable.

**Stock status**

![Stock Status](chart)

**Catch from bottom impacting gear**
The percentage of catch from the bottom gear type to the total catch increased from 5% in the early 1950s to the peak at around 52% in 1999.
Fishing effort
Then, this percentage fluctuated around 36% in recent decade. The whole time series data of fishing effort in this region is not available.

Primary Production Required
Given the very low quality of the underlying catch data, the catch-based indicators for this LME (such as PPR, MTI or FiB) are likely to be very unreliable.

Pollution and Ecosystem Health

Pollution

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 low (level 2 of the five risk categories, where 1 = lowest risk; 5 = highest risk). Based on a “current trends” scenario (Global Orchestration), this increased to moderate in 2030 and remained moderate in 2050.

Nutrient ratio
The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was moderate (3). 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 low (2). According to the Global Orchestration scenario, this increased to moderate in 2030 and remained the same in 2050.

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2030</th>
<th>2050</th>
</tr>
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<tbody>
<tr>
<td>Nitrogen load</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Nutrient ratio</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Merged nutrient indicator</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

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

POPs
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.
Ecosystem Health

Mangrove and coral cover
Not applicable.

Reefs at risk
Not applicable.

Marine Protected Area change
The Kara Sea LME experienced an increase in MPA coverage from 3,799 km\(^2\) prior to 1983 to 41,102 km\(^2\) by 2014. This represents an increase of 982%, within the low category of MPA change.

Cumulative Human Impact
The Kara Sea LME experiences below average overall cumulative human impact (score 1.56; maximum LME score 5.22), but which is still above the LME with the least cumulative impact. 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, all four connected to climate change have the highest average impact on the LME: ocean acidification (0.49; maximum in other LMEs was 1.20), UV radiation (0.30; maximum in other LMEs was 0.76), sea level rise (0.24; maximum in other LMEs was 0.71), and sea surface temperature (0.50; maximum in other LMEs was 2.16). No other stressors had any significant impact in this LME.
Ocean Health Index

The Kara Sea LME scores below average on the Ocean Health Index compared to other LMEs (score 68 out of 100; range for other LMEs was 57 to 82). 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 decreased 1 point compared to the previous year, due in large part to changes in the score for natural products. This LME scores lowest on food provision, natural products, and tourism & recreation goals and highest on artisanal fishing opportunities, coastal protection, carbon storage, coastal economies, lasting special places and habitat biodiversity goals. It falls in risk category 4 of the five risk categories, which is a relatively high 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 675,511 km². A current population of 277 thousand in 2010 is projected to decrease to 135 thousand in 2100, with a density of 41 persons per 100 km² in 2010 increasing to 20 per 100 km² by 2100. About 40% of coastal population lives in rural areas, and is projected to be increase in share to 53% in 2100.

<table>
<thead>
<tr>
<th></th>
<th>Total population</th>
<th>Rural population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2010</td>
<td>2100</td>
</tr>
<tr>
<td>Total population</td>
<td>276,868</td>
<td>135,355</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 low-risk category based on percentage and in the low-risk category using absolute number of coastal poor (present day estimate).

Coastal poor
33,824

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 $0.83 million for the period 2001-2010. Fish protein accounts for 14% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013 $5 126 million places it in the low-revenue category. On average, LME-based tourism income contributes 6% 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>826,300</td>
<td>14.0</td>
<td>5,126,283,120</td>
<td>6.1</td>
<td>0.8522</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 high HDI and low-risk category. Based on an HDI of 0.782, this LME has an HDI Gap of 0.218, 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 very high-risk category (very low 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 high-risk (high threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is medium. In a sustainable development scenario, the risk index from sea level rise in 2100 is very low, and increases to low under a fragmented world development pathway.

<table>
<thead>
<tr>
<th>Climate Threat</th>
<th>Contemporary Threat</th>
<th>SSP1</th>
<th>SSP3</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>2100</td>
<td></td>
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</tr>
<tr>
<td>0.6401</td>
<td>0.3360</td>
<td>0.3034</td>
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</table>

Legend:
- Very low
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- High
- Very high