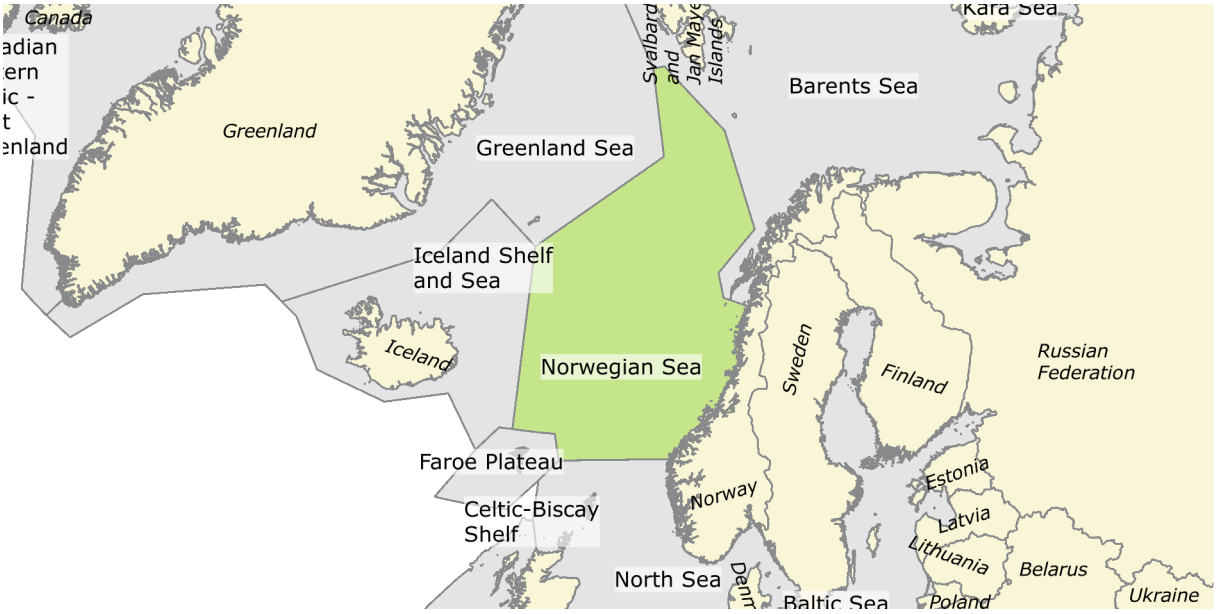
LME 21 – Norwegian Sea



Bordering country: Norway
LME Total area: 1,109,613 km^2

Contents

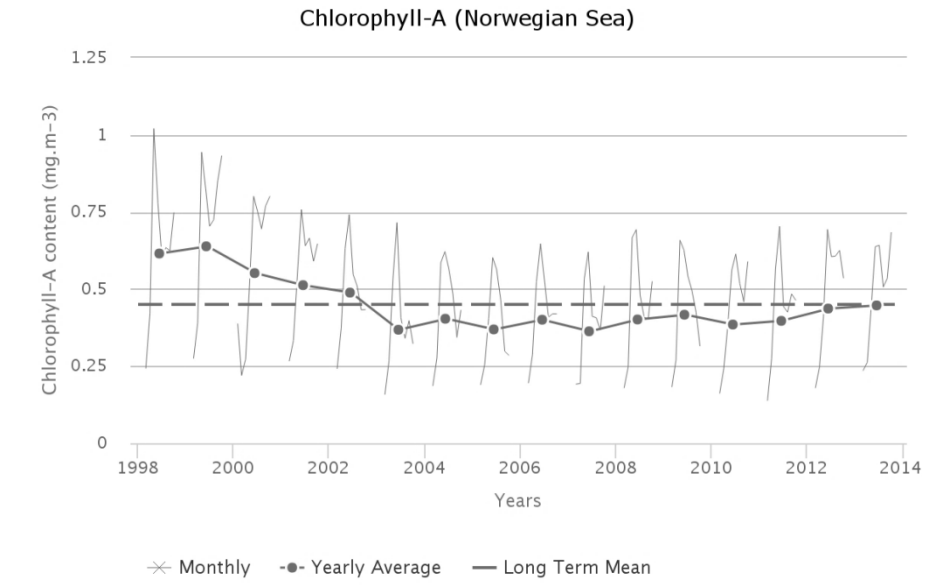
LME overall risk

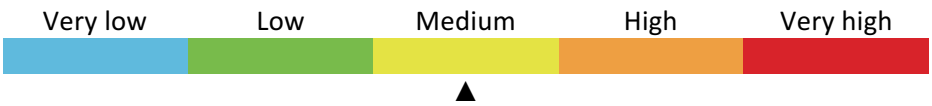
Results unavailable

Productivity

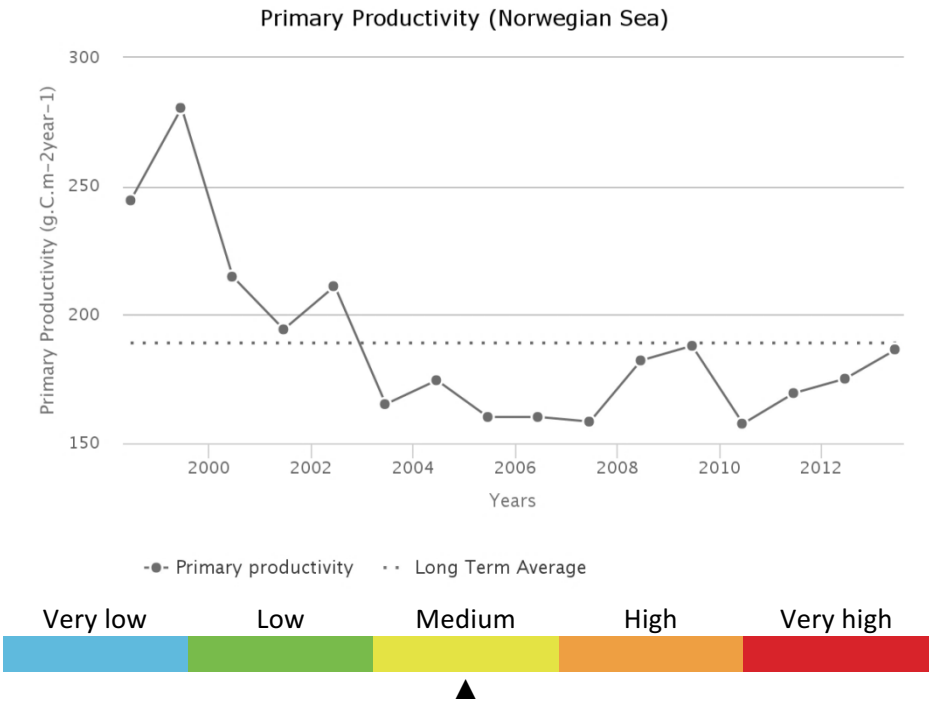
Chlorophyll-A

The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.689 mg.m^{-3}) in June and a minimum (0.184 mg.m^{-3}) during March. The average CHL is 0.450 mg.m^{-3}. Maximum primary productivity (281 g.C.m^{-2}.y^{-1}) occurred during 1999 and minimum primary productivity (158 g.C.m^{-2}.y^{-1}) during 2010. There is a statistically insignificant increasing trend in Chlorophyll of 11.0 % from 2003 through 2013. The average primary productivity is 189 g.C.m^{-2}.y^{-1}, which places this LME in Group 3 of 5 categories (with 1 = lowest and 5= highest).



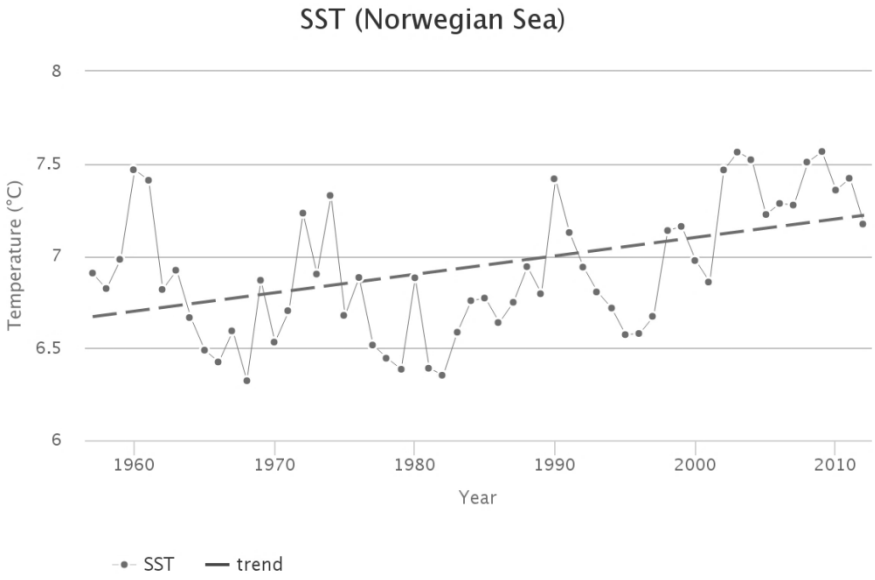


Primary productivity



Sea Surface Temperature

From 1957 to 2012, the Norwegian Sea LME #21 has warmed by 0.55°C, thus belonging to Category 3 (moderate warming LME). After exceeding 7.4°C in 1960, SST decreased to the absolute minimum of 6.3°C in 1968, increased up to 7.3°C, then dropped again below 6.4°C by 1982. From this coldest point, SST rose back to 7.6°C in 2008 and slightly declined afterward. The SST minimum in 1965-1966 was a regional manifestation of a global cold spell. Despite its proximity to Iceland, the Norwegian Sea LME has a distinctly different thermal history. The difference can be explained by the location of the North Atlantic Current: south and east of Iceland but west of Norway. The SST minima in 1977-79, 1986-87, and 1993-1996 have been caused by the well-documented “Great Salinity Anomalies” (GSAs) transported by the North Atlantic Current and its extension, the Norwegian Current (Dickson et al., 1988; Belkin et al., 1998; Belkin, 2004). The cold anomaly of 1993-1996 travelled with the Norwegian Current to the Barents Sea to contribute to a cold anomaly in winters 1997-1998 and 1998-1999 reported by Matishov et al. (2012).



Fish and Fisheries

Results are unavailable for this LME.

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 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 very low (1). 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.

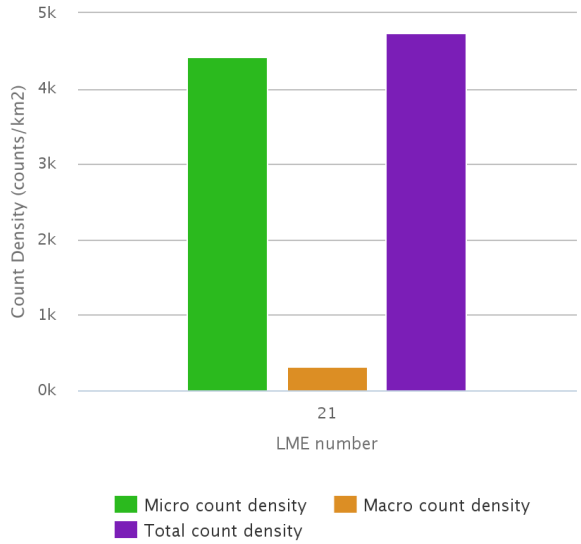
2000	2030	2050

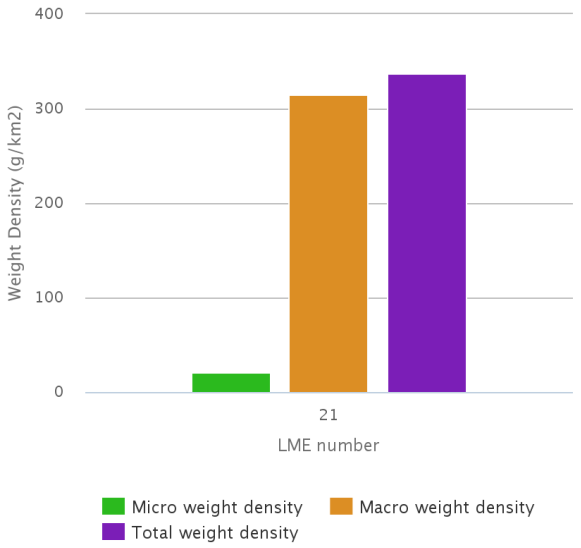
Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator
1	1	1	1	1	1	1	1	1

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 moderate 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 high values are due to the relative importance of these sources in this LME. The abundance of floating plastic in this category is estimated to be on average over 12 times lower that those LMEs with lowest values. There is limited evidence from sea-based direct observations and towed nets to support this conclusion.





Ecosystem Health

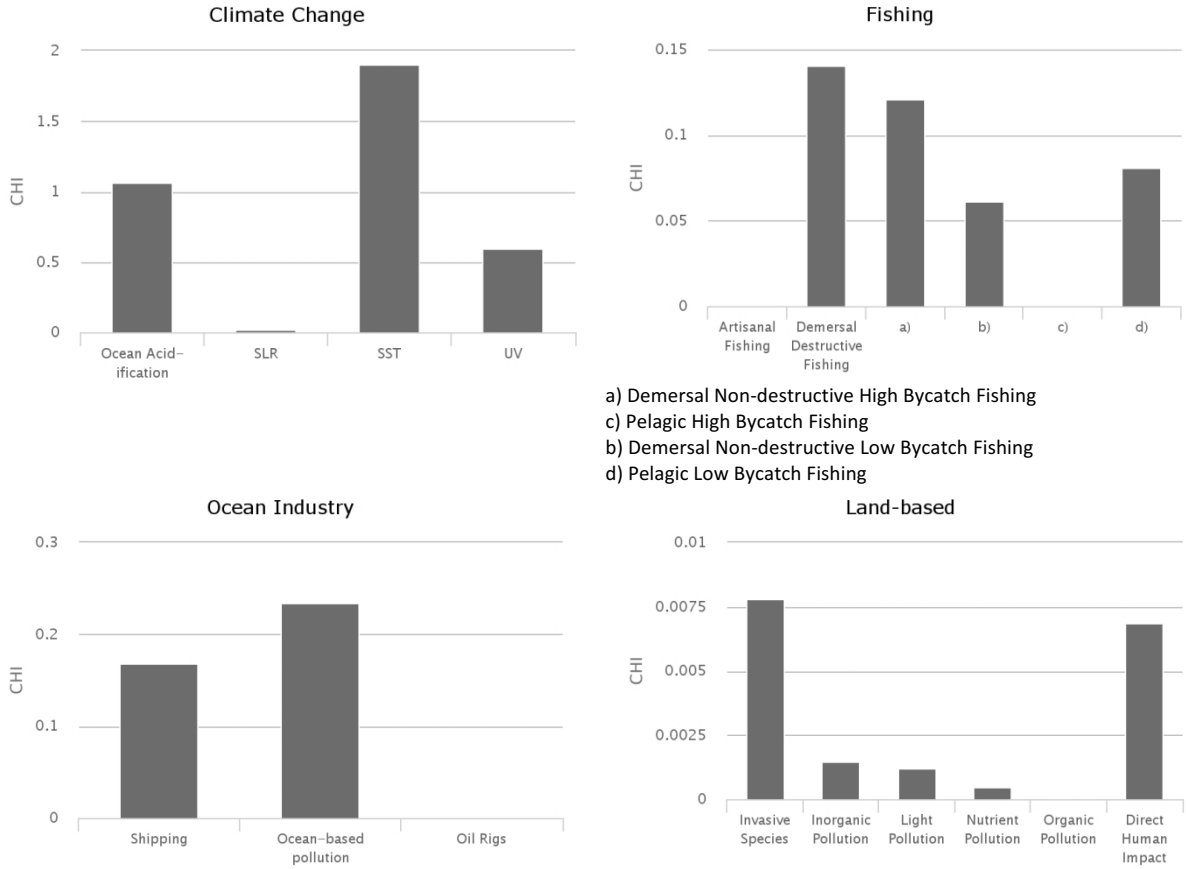
Mangrove and coral cover
Not applicable.

Reefs at risk
Not applicable

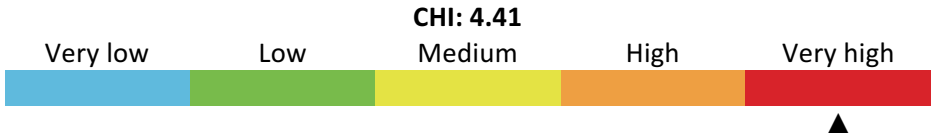
Marine Protected Area change
Not applicable.

Cumulative Human Impact
The Norwegian Sea LME experiences well above average overall cumulative human impact (score 4.41; maximum LME score 5.22), which is also well above the LME with the least cumulative impact. It falls in risk category 5 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, three connected to climate change have

the highest average impact on the LME: ocean acidification (1.07; maximum in other LMEs was 1.20), UV radiation (0.60; maximum in other LMEs was 0.76), and sea surface temperature (1.90; maximum in other LMEs was 2.16). Other key stressors include commercial shipping, ocean based pollution, pelagic high-bycatch commercial fishing, and all three types of demersal commercial fishing (demersal destructive, non-destructive low-bycatch, and non-destructive high-bycatch).

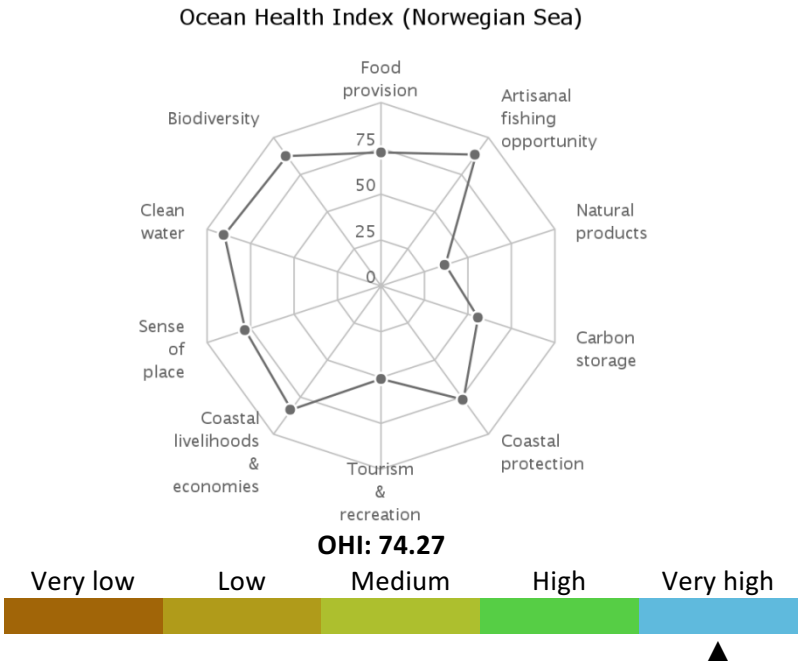


a) Demersal Non-destructive High Bycatch Fishing
c) Pelagic High Bycatch Fishing
b) Demersal Non-destructive Low Bycatch Fishing
d) Pelagic Low Bycatch Fishing



Ocean Health Index

The Norwegian Sea LME scores above average on the Ocean Health Index compared to other LMEs (score 79 out of 100; range for other LMEs was 57 to 82) but still relatively low. This score indicates that the LME is below its optimal level of ocean health, although there are some aspects that are doing well. Its score in 2013 increased 1 point compared to the previous year, due in large part to changes in the scores for coastal livelihoods and clean waters. This LME scores lowest on carbon storage and iconic species goals and highest on mariculture, artisanal fishing opportunities, and species biodiversity goals. It falls in risk category 1 of the five risk categories, which is the lowest 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 the Norwegian Sea 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 includes western Norway, from Nordland to Alesund, stretching over 91,219 km^2. A current population of 841 thousand in 2010 is projected to decrease to 586 thousand in 2100, with density decreasing from 9 persons per km^2 in 2010 to 6 per km^2 by 2100. About 46% of coastal population lives in rural areas, and is projected to decrease in share slightly to 44% in 2100.

Total population		Rural population	
2010	**2100**	**2010**	**2100**
840,903	585,562	387,956	257,429

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

Coastal poor

The indigent population makes up 8% of the LME's coastal dwellers. The Norwegian Sea places in the very low-risk category based on percentage and in the low risk category using absolute number of coastal poor (present day estimate).

Coastal poor
64,119

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. The Norwegian Sea LME ranks in the medium revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $470 million for the period 2001-2010. Fish protein accounts for 23% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of

US 2013 $6,315 million places it in the low revenue category. On average, LME-based tourism income contributes 7% 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 the Norwegian Sea LME falls in the category with high risk (low/ modestly developed).

Fisheries Annual Landed Value	% Fish Protein Contribution	Tourism Annual Revenues	% Tourism Contribution to GDP	NLDI
469,878,820	23.4	6,315,183,200	7.4	0.8086

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 Norwegian Sea LME HDI belongs to the highest HDI and lowest risk category. Based on an HDI of 0.940, this LME has an HDI Gap of 0.060, 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). The Norwegian Sea 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 medium-risk category (medium HDI) because of reduced income level compared to estimated income values in a sustainable development pathway.

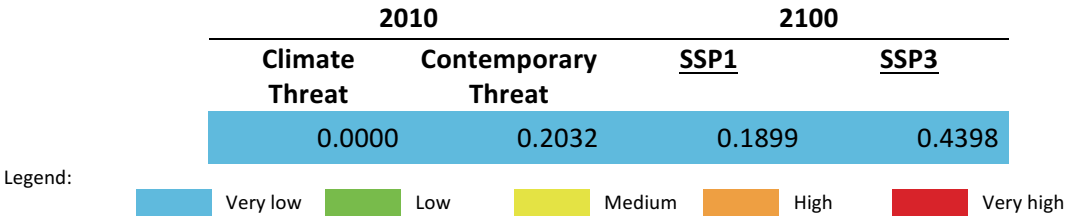
	HDI 2100	
HDI	SSP1	SSP3
0.9404	0.9805	0.7400

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

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, excluding fisheries).
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/m^2 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 to the Norwegian Sea 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 at very low risk under a fragmented world development pathway.



Governance

Governance architecture

In this LME, the policy cycles relating to the key issues of fisheries and pollution are associated with well-established transboundary arrangements that are among the strongest globally. However, there does not appear to be much integration among these processes. Since the LME is largely a single country one and Denmark has a focus on EBM, the integration may be taking place at the national level.

The overall scores for the ranking of risk were: