LME 12 – Caribbean Sea

**Bordering countries:** Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, British Virgin Islands, Cayman Islands, Colombia, Commonwealth of Dominica, Costa Rica, Cuba, Dominican Republic, Grenada, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, France (Martinique), Mexico, Montserrat, Netherland Antilles, Nicaragua, Panama, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago, Turks and Caicos Islands, United States Virgin Islands, Venezuela

**LME Total area:** 3,305,077 km²

This LME is **GEF eligible**

**List of indicators**

<table>
<thead>
<tr>
<th>Category</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>LME overall risk</td>
<td>Merged nutrient indicator</td>
</tr>
<tr>
<td>Productivity</td>
<td>POPs</td>
</tr>
<tr>
<td>Chlorophyll-A</td>
<td>Plastic debris</td>
</tr>
<tr>
<td>Primary productivity</td>
<td>Mangrove and coral cover</td>
</tr>
<tr>
<td>Sea Surface Temperature</td>
<td>Reefs at risk</td>
</tr>
<tr>
<td>Fish and Fisheries</td>
<td>Marine Protected Area change</td>
</tr>
<tr>
<td>Annual Catch</td>
<td>Cumulative Human Impact</td>
</tr>
<tr>
<td>Catch value</td>
<td>Ocean Health Index</td>
</tr>
<tr>
<td>Marine Trophic Index</td>
<td>Socio-economics</td>
</tr>
<tr>
<td>Fishing-in-Balance index</td>
<td>Population</td>
</tr>
<tr>
<td>Stock status</td>
<td>Coastal poor</td>
</tr>
<tr>
<td>Catch from bottom impacting</td>
<td>Revenues and Spatial Wealth Distribution</td>
</tr>
<tr>
<td>gear</td>
<td>Human Development Index</td>
</tr>
<tr>
<td>Fishing effort</td>
<td>Climate-Related Threat Indices</td>
</tr>
<tr>
<td>Primary Production Required</td>
<td>Governance</td>
</tr>
<tr>
<td>Pollution and Ecosystem Health</td>
<td>Governance architecture</td>
</tr>
<tr>
<td>Nutrient ratio, Nitrogen load</td>
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<tr>
<td>Nutrient ratio</td>
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</tr>
</tbody>
</table>
LME overall risk
This LME falls in the cluster of LMEs that exhibit low to medium levels of economic development (based on the night light development index) and medium levels of collapsed and overexploited fish stocks.
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 (0.159 mg.m\(^{-3}\)) in January and a minimum (0.121 mg.m\(^{-3}\)) during May. The average CHL is 0.141 mg.m\(^{-3}\). Maximum primary productivity (260 g.C.m\(^{-2}\).y\(^{-1}\)) occurred during 1998 and minimum primary productivity (206 g.C.m\(^{-2}\).y\(^{-1}\)) during 2013. There is a statistically insignificant increasing trend in Chlorophyll of 5.29 % from 2003 through 2013. The average primary productivity is 232 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
Between 1957 and 2012, the Caribbean Sea LME #12 has warmed by 0.15°C, thus belonging to Category 4 (slow warming LME). This LME went through three phases over the last 50 years: (1) cooling until 1974; (2) a cold phase with two cold spells, in 1974-1976 and 1984-1986; (3) warming since 1986. Using the year of 1985 as a true breakpoint, the post-1985 warming exceeded 0.9°C, from <27.4°C in 1985 to 28.3°C in 2010. Both cold spells were synchronous with cold events across the Central American Isthmus, in the Pacific Central-American Coastal LME #11. The first cooling period was interrupted by a major warm event (peak) of 1968-1970, when SST peaked at 28.2°C in 1969. This event was confined to the Caribbean Sea. None of adjacent LMEs experienced a pronounced warming in 1968-1970. All significant maxima and minima of SST in the Caribbean Sea correlate strongly with El Niños and La Niñas respectively (National Weather Service/Climate Prediction Center, 2007). This strong correlation is a good example of atmospheric teleconnections across the Central American Isthmus. This link is so strong that El Niños’ and La Niñas’ effects in the Caribbean Sea have comparable magnitudes with their counterparts in the Pacific Central-American Coastal LME #11 on the other side of the Isthmus.
Fish and Fisheries

The fisheries of the Caribbean Sea LME are based on a diverse array of resources, and those of greatest importance are spiny lobster (*Panulirus argus*), queen conch (*Strombus gigas*), penaeid shrimps, reef fish, continental shelf demersal fish, deep slope and bank fish and large coastal pelagics such as king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*S. maculatus*), dolphinfish (*Coryphaena hippurus*) and amberjack (*Seriola spp.*). In addition, fisheries based on stocks of large oceanic fish such as yellowfin tuna, skipjack tuna, Atlantic blue marlin and swordfish, have expanded considerably.

**Annual Catch**

Total reported landings in this LME, which is probably underestimated showed a general increase to about 430,000 t in the 1998, followed by a slight decline.

**Catch value**

The reported landings peaked at just under 1 billion US$ (in 2005 value) in 1978.
Marine Trophic Index and Fishing-in-Balance index
The decline of the MTI is almost linear over the reported period, representing a classic case of ‘fishing down’ of the food web in the LME. Indeed, the decline in the mean trophic level would have been greater than the expansion of the fisheries from the mid-1950 to the mid-1980s as implied by the increasing FiB index.

Stock status
The Stock-Catch Status Plots indicate that nearly 60% of the commercially exploited stocks in the LME are either overexploited or have collapsed and these stocks now contribute 50% of the reported landings.
Catch from bottom impacting gear
The percentage of catch from the bottom gear type to the total catch increased slightly from 11% in late 1950s to the peak at 25% in 1978. Then, this percentage fluctuated around 20% in the recent few decades.

Fishing effort
The total effective effort continuously increased from around 40 million kW in the 1950s to its peak at 240 million kW in the mid- 2000s.
Primary Production Required

The primary production required (PPR) to sustain the reported landings in the LME reached 3% of the observed primary production in 1994, and fluctuated between 2.5 to 3% in recent years.

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 moderate (level 3 of the five risk categories, where 1 = lowest risk; 5 = highest risk). Based on a “current trends” scenario (Global Orchestration), this increased to high in 2030 and remained high in 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 moderate (3). According to the Global Orchestration scenario, this increased to high in 2030 and remained the same in 2050.
POPs
Data are available only for two samples at two locations in Barbados and Trinidad & Tobago. These locations show minimal concentration for all the indicators. The average concentration (ng.g\(^{-1}\) of pellets) was 4 (range 2 – 6 ng.g\(^{-1}\)) for PCBs, 3 (range 2 – 3 ng.g\(^{-1}\)) for DDTs, and 0.9 (range 0.8 – 1.1 ng.g\(^{-1}\)) for HCHs. All three averages correspond to risk category 1 of the five risk categories (1 = lowest risk; 5 = highest risk). This is probably due to minimal anthropogenic activities involving the use of POPs (PCBs in industries and DDT and HCH pesticides in agriculture).

<table>
<thead>
<tr>
<th>Locations</th>
<th>PCBs (ng/g)</th>
<th>Risk</th>
<th>DDTs (ng/g)</th>
<th>Risk</th>
<th>HCHs (ng/g)</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>0.9</td>
<td>1</td>
</tr>
</tbody>
</table>

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

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 high 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 there is good evidence from sea-based direct observations and towed nets to support this conclusion.

Ecosystem Health

Mangrove and coral cover
0.35% of this LME is covered by mangroves (US Geological Survey, 2011) and 0.64% by coral reefs (Global Distribution of Coral Reefs, 2010).

Reefs at risk
This LME has a present (2011) integrated threat index (combining threat from overfishing and destructive fishing, watershed-based and marine-based pollution and damage) of 221. 13% of coral reefs cover is under very high threat, and 18% under high threat (of the 5 possible threat categories, from low to critical). When combined with past thermal stress (between 1998 and 2007), these values increase to 23% and 32% for very high and high threat categories respectively. By year 2030,
29% of coral cover in this LME is predicted to be under very high to critical level of threat from warming and acidification; this proportion increases to 40% by 2050.

**Marine Protected Area change**
The Caribbean Sea LME experienced an increase in MPA coverage from 6,463 km² prior to 1983 to 143,096 km² by 2014. This represents an increase of 2,114%, within the medium category of MPA change.

**Cumulative Human Impact**
The Caribbean Sea LME experiences an above average overall cumulative human impact (score 4.21; maximum LME score 5.22), which is well above the LME with the least cumulative impact. It falls in risk category 4 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 (1.11; maximum in other LMEs was 1.20), UV radiation (0.52; maximum in other LMEs was 0.76), and sea surface temperature (1.82; maximum in other LMEs was 2.16). Other key stressors include commercial shipping and ocean based pollution.
LME 12 – Caribbean Sea
Transboundary Water Assessment Programme, 2015

**Climate Change**

<table>
<thead>
<tr>
<th>CHI</th>
<th>Ocean Acidification</th>
<th>SLR</th>
<th>SST</th>
<th>UV</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.5</td>
<td>1.5</td>
<td>2</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**Fishing**

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

**CHI: 4.21**

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

**Ocean Industry**

<table>
<thead>
<tr>
<th>CHI</th>
<th>Shipping</th>
<th>Ocean-based pollution</th>
<th>Oil Rigs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>0</td>
</tr>
</tbody>
</table>

**Land-based**

- Invasive Species
- Inorganic Pollution
- Light Pollution
- Nutrient Pollution
- Organic Pollution
- Direct Human Impact

<table>
<thead>
<tr>
<th>CHI</th>
<th>Invasive Species</th>
<th>Inorganic Pollution</th>
<th>Light Pollution</th>
<th>Nutrient Pollution</th>
<th>Organic Pollution</th>
<th>Direct Human Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.15</td>
<td>0.10</td>
<td>0.05</td>
<td>0.02</td>
<td>0.01</td>
<td>0.005</td>
<td>0.001</td>
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</tbody>
</table>
Ocean Health Index

The Caribbean Sea LME scores well below average on the Ocean Health Index compared to other LMEs (score 60 out of 100; range for other LMEs was 57 to 82). This score indicates that the LME is far from its optimal level of ocean health, although there are some aspects that are doing well. Its score in 2013 remained unchanged compared to the previous year. This LME scores lowest on food provision, natural products, coastal protection and tourism & recreation goals and highest on artisanal fishing opportunities and coastal economies goals. It falls in risk category 5 of the five risk categories, which is the highest level of risk (1 = lowest risk; 5 = highest risk).

Ocean Health Index (Aleutian Islands)

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 Caribbean 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 littoral area includes the eastern coast of the Yucatan Peninsula, the Atlantic coast of Central America, Colombia and Venezuela, and 24 Caribbean island states covering a total of 794,777 km². A current population of 84 million is projected to reach to 127 million in 2100, and density increasing from 106 persons per km² in 2010 to 159 per km² by 2100. About 42% of coastal population lives in rural areas, and is projected to increase in share to 46% in 2100.
Coastal poor

The indigent population makes up 32% of the LME’s coastal dwellers. The Caribbean Sea LME places in the very high-risk category based on percentage and absolute number of coastal poor (present day estimate).

Coastal poor

26,619,339

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. The Caribbean Sea LME ranks in the high revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $810 million for the period 2001-2010. Fish protein accounts for 9% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013 $90,454 million places it in the very high revenue category. On average, LME-based tourism income contributes 18% 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 Caribbean Sea LME falls in the category with medium risk.

Fishing and tourism spatial wealth distribution:

<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>810,509,428</td>
<td>8.7 90,454,384,76018.0</td>
<td>18.0</td>
<td>0.7499</td>
<td></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 Caribbean Sea LME HDI belongs to the medium HDI and high-risk category. Based on an HDI of 0.718, this LME has an HDI Gap of 0.282, 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 Caribbean Sea LME is projected to assume a place with the very low risk category (very high HDI) in 2100 under a sustainable development pathway or scenario. Under a fragmented world scenario, this LME is estimated to place in the very high-risk category (very low HDI) because of reduced income level and increased population size compared to estimated income and population values in a sustainable development pathway.

<table>
<thead>
<tr>
<th>HDI 2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDI</td>
</tr>
<tr>
<td>SSP1</td>
</tr>
<tr>
<td>SSP3</td>
</tr>
</tbody>
</table>

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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/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 Caribbean Sea LME is within the very high-risk (very 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 very high. In a sustainable development scenario, the risk index from sea level rise in 2100 is lowest, and increases to high risk under a fragmented world development pathway.

Governance

**Governance architecture**

Three arrangements for transboundary fisheries in this LME - CRFM, OSPESCA and WECAFC - are connected. OLDEPESCA is minimally connected within the LME. None of the fisheries arrangements are connected with ICCAT. The arrangements for pollution and biodiversity that fall under the Cartagena Convention are connected via the CEP, but do not appear well connected with fisheries or with the IAC. No integrating mechanisms, such as an overall policy coordinating organization for the LME, could be found. There may be interaction amongst the arrangements through participation in each other’s meetings, but this appears to be informal.

The overall scores for the ranking of risk were: