Bordering countries: East Timor, Indonesia
LME Total area: 2,289,597 km²

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LME overall risk
This LME falls in the cluster of LMEs that exhibit low to levels of economic development (based on the night light development index) and high pollution from plastic debris.
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 very high.

Productivity

Chlorophyll-A
The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.369 mg.m$^{-3}$) in August and a minimum (0.205 mg.m$^{-3}$) during April. The average CHL is 0.256 mg.m$^{-3}$. Maximum primary productivity (421 g.C.m$^{-2}$.y$^{-1}$) occurred during 1999 and minimum primary productivity (329 g.C.m$^{-2}$.y$^{-1}$) during 2013. There is a statistically significant decreasing trend in Chlorophyll of -15.8 % from 2003 through 2013. The average primary productivity is 380 g.C.m$^{-2}$.y$^{-1}$, which places this LME in Group 4 of 5 categories (with 1 = lowest and 5= highest).
Primary productivity

From 1957 to 2012, the Indonesian Sea LME #38 has warmed by 0.54°C, thus belonging to Category 3 (moderate warming LME). The thermal history of the Indonesian Sea since 1957 included a cooling epoch through 1967, when SST dropped to 27.8°C, and steady warming ever since. The all-time minimum of 1967 occurred simultaneously with the all-time minimum in the Sulu-Celebes Sea LME #37 and only a year prior to the all-time minimum of 1968 in the West-Central Australian Shelf LME #44 and a minimum of 1968 in the North-West Australian Shelf LME #45. This sequence of events can be explained by advection of the low-temperature signal of 1967 from the Indonesian Sea toward Western Australia with the Indonesian Throughflow. The 1982 minimum occurred simultaneously in the North and Northeast Australian Shelf LMEs #39-40, but not off Western Australia; this can be explained by long-time variability of circulation pattern. The 1998 all-time maximum of >29.1°C was likely caused by the El Niño 1997-98.
Fish and Fisheries
The fisheries of the Indonesian Sea LME are very complex and diverse. Although much of the catch comes from its artisanal sector, industrial fisheries contribute considerably more in terms of value, since they target high-value shrimp and tuna stocks. Major species caught in the LME include tuna, sardines, anchovy, mackerel, as well as a range of reef fishes. Reef fisheries are vital to subsistence fishers and their families in the region but are also important in supplying high value products for expanding international, national and local markets.

Annual Catch
Total reported landings in the LME have increased steadily from the 1950s, with a sharp increase from less than half a million t to over one million t in the mid-1970s, probably a statistical artifact.

Catch value
In 1998, the total reported landings reached 1.9 million t and the value of the reported landings, showing a trend similar to landings, reached close to 2 billion US$ (in 2005 real US$) in 1996.

Marine Trophic Index and Fishing-in-Balance index
The MTI shows an increase from the early 1980s, due to increased landings of predatory species such as tuna. This interpretation is confirmed by the increase in the FiB index during the same period, documenting a steady expansion of the fisheries in the region. Note, however, that these indices may be skewed by the high level of unidentified fishes in the underlying landings statistics.
Stock status
The Stock-Catch Status Plots indicate that about 30% of the stocks in the LME are either overexploited or have collapsed, with 55% of the catch from fully exploited stocks. Again, the high level of taxonomic aggregation in the underlying landings statistics must be noted.

Catch from bottom impacting gear
The percentage of catch from the bottom gear type to the total catch increased from 14% in the 1950s to its first peak at around 35% in 1980. Then, this percentage kept decreasing and fluctuated between 16% and 20% in recent decade.
Fishing effort
The total effective effort continuously increased from around 20 million kW in the 1950s to its peak around 745 million kW in 2005.

Primary Production Required
The primary production required (PPR) to sustain the reported landings in this LME is increasing, and is currently at 30% of the observed primary production.
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 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 moderate (3). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.
POPs
Data are available for three samples at two locations in Jakarta Bay. One was collected in 2007, while the others were collected in 2012. Extremely high average concentrations (ng.g\(^{-1}\) of pellets) of PCBs (263, range 14-756) and DDTs (210, range 14-590), both corresponding to risk category 5 of the five risk categories (1 = lowest risk; 5 = highest risk) were observed in a sample collected in 2012, though minimal and low concentrations were observed in the other two samples including one collected in 2012. The average concentration of HCHs was 1.9 (range 1.1- 3.5), risk category 1. Continuous monitoring is recommended.

<table>
<thead>
<tr>
<th>Locations</th>
<th>PCBs Avg. (ng/g)</th>
<th>DDTs Avg. (ng/g)</th>
<th>HCHs Avg. (ng/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>263</td>
<td>210</td>
<td>1.9</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 the highest 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 relative importance of these sources in this LME. The abundance of floating plastic in this category is estimated to be on average over 400 times higher 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
0.49% of this LME is covered by mangroves (US Geological Survey, 2011) and 1.13% 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 250. 15% of coral
reefs cover is under very high threat, and 27% 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 18% and 29% for very high and high threat categories respectively. By year 2030, 34% 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 45% by 2050.

Marine Protected Area change
The Indonesian Sea LME experienced an increase in MPA coverage from 2,016 km² prior to 1983 to 75,423 km² by 2014. This represents an increase of 3,642%, within the medium category of MPA change.

Cumulative Human Impact
The Indonesian Sea LME experiences an above average overall cumulative human impact (score 3.75; maximum LME score 5.22), which is also well above the LME with the least cumulative impact. It falls in risk category 3 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 (0.89; maximum in other LMEs was 1.20), UV radiation (0.46; maximum in other LMEs was 0.76), sea level rise (0.31; maximum in other LMEs was 0.71), and sea surface temperature (1.17; maximum in other LMEs was 2.16). Other key stressors include commercial shipping, ocean based pollution, pelagic low-bycatch commercial fishing, and all three types of demersal commercial fishing (demersal destructive, non-destructive low-bycatch, and non-destructive high-bycatch).
The Indonesian Sea LME scores below average on the Ocean Health Index compared to other LMEs (score 67 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 increased 1 point compared to the previous year, due in large part to changes in the score for coastal economies. This LME scores lowest on mariculture, coastal protection, carbon storage, coastal livelihoods, tourism & recreation, and iconic species goals and highest on artisanal fishing opportunities and coastal economies 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 756,153 km$^2$. A current population of 172,294 thousand in 2010 is projected to increase to 242,699 thousand in 2100, with a density of 228 persons per km$^2$ in 2010 reaching 321 per km$^2$ by 2100. About 58% of coastal population lives in rural areas, and is projected to decrease in share to 56% in 2100.

<table>
<thead>
<tr>
<th>Total population</th>
<th>Rural population</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>2100</td>
</tr>
<tr>
<td>172,293,928</td>
<td>242,699,415</td>
</tr>
<tr>
<td>100,139,797</td>
<td>137,086,093</td>
</tr>
</tbody>
</table>

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

Coastal poor

The indigent population makes up 14% of the LME’s coastal dwellers. This LME places in the low-risk category based on percentage and in the very high-risk category using absolute number of coastal poor (present day estimate).

<table>
<thead>
<tr>
<th>Coastal poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>23,807,269</td>
</tr>
</tbody>
</table>

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. This LME ranks in the high-revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $1,912 million for the period 2001-2010. Fish protein accounts for 54% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013
$53153$ million places it in the high-revenue category. On average, LME-based tourism income contributes $10\%$ 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>$1,912,412,118$</td>
<td>$54.2$</td>
<td>$53,152,730,017$</td>
<td>$10.5$</td>
<td>$0.8242$</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 low HDI and high-risk category. Based on an HDI of $0.675$, this LME has an HDI Gap of $0.325$, 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 increased population values from those in a sustainable development pathway.

<table>
<thead>
<tr>
<th>HDI 2100</th>
<th>HDI</th>
<th>SSP1</th>
<th>SSP2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$0.6753$</td>
<td>$0.8873$</td>
<td>$0.4904$</td>
</tr>
</tbody>
</table>

**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). 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 $8.5 \, \text{W/m}^2$ in $2100$ as hazard measure, development pathway-specific $2100$ populations in the $10 \, \text{m} \times 10 \, \text{km}$ 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 very high. In a sustainable development scenario, the risk index from sea level rise in 2100 is very low, and increases to very high risk under a fragmented world development pathway.

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>Contemporary</th>
<th>SSP1</th>
<th>SSP3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate Threat</td>
<td>0.7432</td>
<td>0.5087</td>
<td>0.4213</td>
<td>0.6934</td>
</tr>
</tbody>
</table>

Governance

Governance architecture

In this LME, there are three transboundary arrangements for fisheries, one each cover high seas highly migratory tuna and tuna-like fisheries in the Western Central Pacific (WCPFC) and the Indian Ocean (IOTC) and the remaining arrangement (APFIC, FAO) covers the fisheries within national jurisdiction. There does not appear to be any formal connection between the three arrangements, possibly as they have different areas of competence. However, it is to be expected that at some high level, the two Commissions (WCPFC and IOTC) for the large highly migratory fisheries would connect. In contrast, the arrangement for the Regional Seas Programme, the Coordinating Body of the Seas of South east Asia (COBSEA), covers both pollution and biodiversity, with linkages to the Partnership in Environmental Management for the Seas of East Asia (PEMSEA). However neither of the “within national jurisdiction” arrangements for fisheries or pollution/biodiversity appears to be integrated with the other or with the tuna arrangements. The specific biodiversity arrangement for turtles (IOSEA) does not appear to be integrated with any of the other arrangements in the LME. Further, no integrating mechanisms, such as an overall policy coordinating organisation for the LME, could be found. There may be interaction amongst the arrangements through participation in other intergovernmental partnerships or with each other’s meetings, but this appears to be informal.

The overall scores for ranking of risk were:

<table>
<thead>
<tr>
<th>Engagement</th>
<th>Completeness</th>
<th>Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>56</td>
<td>52</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Legend:

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