Indicator	
25	Sea level rise and extreme weather conditions.
Measurement	
25.2	Rise in sea level relative to land.

What should the measurement tell us?

The position and height of the sea relative to the land (relative sea level - RSL) determines the location of the shoreline. Although global fluctuations in sea level may result from the growth and melting of continental glaciers and large-scale changes in the configuration of continental margins and ocean floors, there are many regional processes that result in rise or fall of RSL that affect one coastline and not another. These include: thermal expansion of ocean waters, changes in meltwater load, crustal rebound from glaciation, uplift or subsidence in coastal areas related to various tectonic processes (e.g. seismic disturbance and volcanic action), fluid withdrawal, and sediment deposition and compaction. RSL variations may also result from geodetic changes such as fluctuations in the angular velocity of the Earth or polar drift. Tide-gauge records suggest an average global sea-level rise over the last century of 0 to 3mm per year, though there is no firm evidence of acceleration in these rates. Indeed, a recent study by the US Environmental Protection Agency predicts that global sea level is likely to rise 15cm by 2050 (about 3mm/year) as a result of human-induced climate warming[(3)].

Many geomorphological changes in the marine coastal zone are affected by fluctuations in relative sea level (RSL)[(1)]. Changes in RSL may alter the position and morphology of coastlines, causing coastal flooding, waterlogging of soils and a loss or gain of land. They may also create or destroy coastal wetlands and salt marshes, inundate coastal settlements, and induce salt-water intrusion into aquifers, leading to salinisation of groundwater. Coastal ecosystems are bound to be affected, for example, by increased salt stress on plants. A changing RSL may also have profound effects on coastal structures and communities. Low-lying coastal and island states are particularly susceptible to sea-level rise. It is estimated that 70% of the world's sandy beaches are affected by coastal erosion induced by RSL rise.

Variations in sea levels are natural responses or consequences of climate change, geoidal variations, movements of the sea floor and other earth processes outlined above. It has been suggested that human actions including drainage of wetlands, withdrawal of groundwater (which eventually flows to the sea) and deforestation (which reduces terrestrial water storage capacity), may currently contribute about 0.5mm/year to a global rise in sea level. Human-induced climate change is also of obvious importance. Local changes may be caused by large engineering works nearby, such as river channelling or dam construction, that influence sediment delivery and deposition in deltaic areas[(3)]

Parameters	
(i)	Annual mean sea level relative to land (millimetres).

Coverage	
Spatial	**Temporal**
Coastal zone of the reference region.	Annually. To characterise significant temporal variations, long-term series are necessary (30 years of data if possible).

Data sources

Mean sea level data are obtained from tide gauge measurements. The Permanent Service for Mean Sea Level (PSMSL) is the global data bank for long term sea level change information from tide gauges. The relative sea level data can be obtained from their web page (http://www.pol.ac.uk/psmsl/)

In order to construct time series of sea level measurements at each station, the monthly and annual means have to be reduced to a common datum. This reduction is performed by the PSMSL using the tide gauge datum history provided by the supplying authority, forming the 'REVISED LOCAL REFERENCE' (or 'RLR') dataset.

For scientific purposes, the RLR dataset is preferred for the purpose of this indicator calculation rather than the METRIC, although the latter, which contains the total PSMSL data holdings, can also be analysed bearing in mind the datum continuity considerations.

Without the provision of full benchmark datum history information, records will remain as 'Metric only' in the databank and not as RLR. It is a good general rule, therefore, that 'Metric' records should never be used for time series analysis or for the computation of secular trends - without datum continuity their only use is in studies of the seasonal cycle of mean sea level.

There are, however, some 'Metric only' records which almost certainly can be used for time series work, even though the PSMSL does not have full benchmark datum histories. These include, in particular, all of The Netherlands 'Metric' data, the records of which are expressed relative to the national level system Normaal Amsterdamsch Peil (NAP). They also include a number of German 'Metric' records which are measured with respect to Normal Null (NN). Any such information is included in the station comments in the relevant documentation sections of the datasets supplied by the PSMSL. Even though these records are expressed relative to the national levelling systems, they are, in effect, relative to a local level as required for RLR purposes i.e. the records do not (as far as PSMSL knows) contain datum shifts contributed by re-levelling adjustments. In general, however, measurements relative to national levelling systems may well reflect such adjustments. This explains why the PSMSL has traditionally steered clear of classifying such data as RLR. (See http://www.pol.ac.uk/psmsl/datainfo/psmsl.hel for further comments on METRIC and RLR differences).

The RLR datum at each station is defined to be approximately 7000mm below mean sea level. This arbitrary choice was made many years ago in order to avoid negative numbers in the resulting RLR monthly and annual mean values. The detailed relationships at each site between RLR datum, benchmark heights, tide gauge zero, etc., are not normally required by analysts of the dataset, although they can be made available on request.

The detailed current contents of the PSMSL databank are described via files accessed from the PSMSL web page. In particular, the PSMSL home page refers to http://www.pol.ac.uk/psmsl/datainfo/, which describes how to access the MSL data sets.

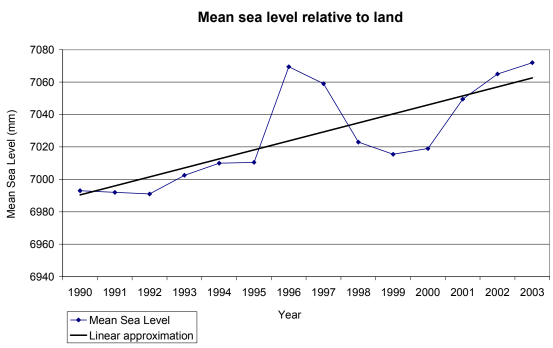
As an alternative to the information provided by the PSMSL, data can also be provided from national and regional administrations, institutes, centres and research units (e.g. Instituto Geográfico Nacional, Instituto Español de Oceanografía and Instituto Hidrografico de la Marina in Spain or Consiglio Nazionale delle Ricerche in Italy, etc.).

Methodology

	Steps	**Products**
1	From the PSML databank identify the existing tide gauges stations [(2)] in the reference region.	List of tide gauges in the reference region.
2	Obtain the annual mean sea level relative to land of each existing tide gauge in the reference region for the last 30 years, if possible.	Raw data of the period of time to be analysed.
3	Calculate the mean annual value of the mean sea level relative to land by adding all the values of all the tide gauges for a given year, then take the average of the readings to obtain a result per year.	Annual mean values of the relative sea level (millimetres) for the period studied. (Graph 1).

Presentation of the data

Graph 1 — Chart showing the annual mean sea level with linear trend.



Adding value to the data

To convert this to real coastal sensitivity, this information has to be jointly analysed with coastal characteristics since the same change in sea level acting on areas of different geomorphic characteristics will induce responses of different magnitude.

Aggregation and disaggregation
Aggregation is possible from the smallest census unit to national, European and worldwide levels. The trends from different stations would be used to produce an estimate of the sea level trend in a wider reference region. For larger scales it may be necessary to include regions along both west and east boundaries of each sea or ocean, for each wind regime, north and south of the equator to produce the best global average from the tide gauge records. The indicator could be disaggregated to the component impacts.

Notes

(1) The terms, *sea level* or *mean sea level* (MSL), refer to water level observations averaged over a time period (usually a month). *Sea level* is only a mean for a particular time period and it varies over longer time periods, on a monthly, inter-annual, and longer basis. This variation in sea level is measured relative to the land (to which the benchmarks are permanently attached). We therefore refer to this as *relative sea level* (the position and height of the sea relative to the land): if the land sinks (and the global sea level rises), it will appear that sea level is rising and, likewise, if the land rises (faster than global sea level rise) it will look like sea level is falling.

(2) To capture the spatial variability of the reference region, measurement points (tide gauges) must be well distributed along the coast, as far as possible.

(3) From the source: The US Global Challenge Research Information Office