

Indicator name			Version
NM1 Changes in average sea surface temperature (SST)			31/03/16
Indicator type:	Risk/opportunity	Impact	Action
	X		
SCCAP Theme	SCCAP Objective	CCRA risk/opportunity	
Natural Environment	<p>N2 Support a healthy and diverse natural environment with the capacity to adapt</p> <p>N3 Sustain and enhance the benefits, goods and services that the natural environment provides</p>	<p>MA1: Risk of harmful algal blooms due to changes in ocean stratification</p> <p>MA4a/b: Changes in fish catch latitude/centre of gravity</p> <p>MA6: Distribution of marine alien/invasive species</p> <p>MA23: Plankton blooms</p> <p>MA30: Damage to cultured aquatic species</p> <p>Mar1: Species migration (marine)</p>	

At a glance

- General increase in sea surface temperatures during the 20th Century
- Seas in all of the regions are predicted to continue warming
- The global long term rise in sea surface temperature can be seen with a high degree of confidence. However, there is much more uncertainty over smaller temporal and spatial scales

Latest Figure

Year	2008	2009	2010	2011	2012
Mean SST (°C)	10.18	10.38	10.50	10.28	10.00

Mean annual SST at the Fair Isle monitoring station to the east of Orkney for the 5 years leading up to 2012 (adapted from ICES Report on Ocean Climate, Beszczynska-Möller & Dye (2013)).

Trend

- There has been a general increase in sea surface temperatures during the 20th Century, which has been more pronounced in the last three decades particularly for the north-east Atlantic.
- In the UK as a whole, sea surface temperatures have been increasing at rates up to six times greater than the global average.
- However, there is uncertainty when trying to disentangle natural variation in temperature from that of anthropogenic forcing.

Why is this indicator important?

Temperature change is a crucial risk associated with climate change and therefore sea surface temperature (SST) is an intuitive indicator for the high level monitoring of changes in the marine environment. Changes in temperature can lead to associated impacts such as the increased risk of harmful algal blooms, changes in the distribution and occurrence of key commercial fish species, changes in the distribution of marine non-native species, changes in the intensity, duration and geolocation of plankton blooms, damage to temperature sensitive aquaculture species and altered species migration. The risk of increases in SST and associated impacts pose a real threat to the Scottish marine environment. However, these must be considered in a broader context due to the variability seen at smaller temporal and spatial scales.

Sea-surface temperatures can be monitored through the use of satellite data and in-situ observations. The use of satellite data requires specialist knowledge and modification due to changes in atmospheric conditions; these adjustments can be made using the in-situ observations (Dye et al, 2013). Depending on the network, SST observations can allow the examination of long and short-term trends.

What is happening now?

In the past 30 years the average sea surface temperature has risen in the North Atlantic, with 2000 - 2009 being the warmest on record (IPCC, 2013). Surface waters around Ireland and the UK have warmed quickly, increasing by between 0.1 and 0.5°C decade⁻¹ (Dye et al 2013). The most recent warming can be seen at more local scales in Scottish records for offshore stations monitoring the Fair Isle Current water (East of Orkney, water entering the North Sea from the Atlantic) (Fig. 1) and even the deeper water Faroe Shetland Channel (Shetland Shelf, North Atlantic water) (Fig. 2). The pattern is much more variable and less clear for more inshore locations.

What has happened in the past?

There is a great deal of spatial variability in SST around the UK, with some regions showing temperature changes at different rates, but in general there is a similar long-term warming trend to the rest of the North Atlantic (Fig. 1 & 2). The UK also shows significant temporal variability relative to this warming trend which can be seen as a cooling phase between 1900 and 1930, warming from 1930 to 1960, cooling between the late 1960s and 1990 and then generally warming again from 1990 to present (Dye et al, 2013).

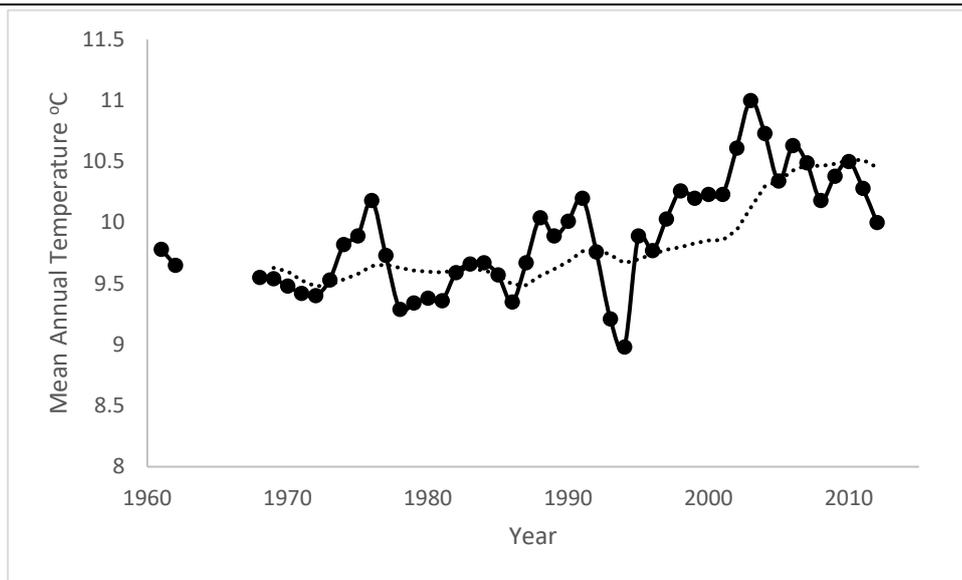


Figure 1. Mean annual SST at the Fair Isle monitoring station to the east of Orkney (solid line) with a 10 year running mean (dashed line) (adapted from ICES Report on Ocean Climate, Beszczynska-Möller & Dye (2013)).

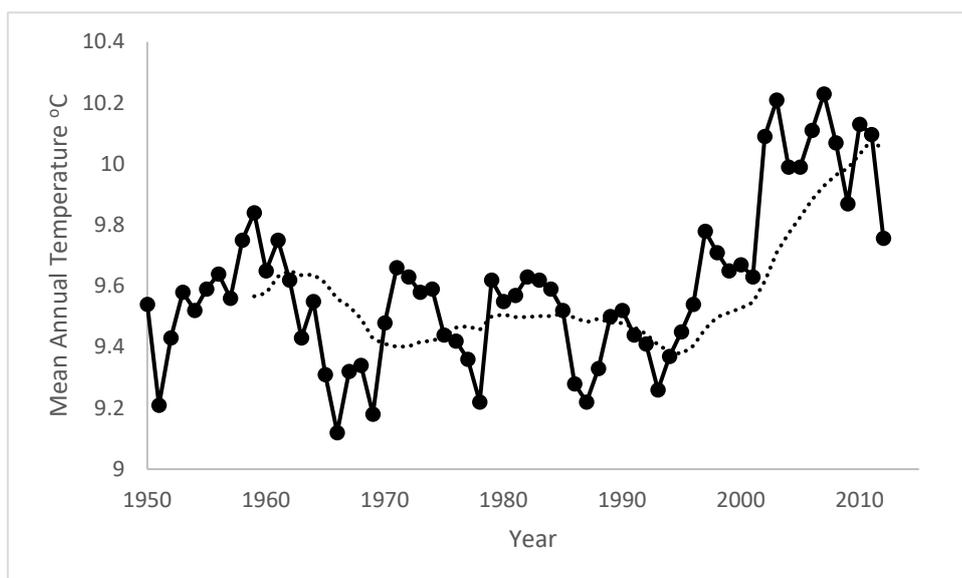


Figure 2. Mean annual SST at the Faroe Shetland Channel monitoring station (solid line) with a 10 year running mean (dashed line) (adapted from ICES Report on Ocean Climate, Beszczynska-Möller & Dye (2013)).

What is projected to happen in the future?

The global long term rise in SST can be seen with a high degree of confidence (IPCC, 2013). However, there is much more uncertainty over smaller temporal and spatial scales (Hawkins and Sutton, 2009). The background warming trend in SST is superimposed upon natural variability which also occurs at varying temporal and spatial scales. Therefore, in the future some regions will continue to show warming while others show no change or even periodic cooling (Hawkins et al., 2011).

The UK Climate Projections 2009 project that SST warming will continue in all regions of all seas (UKCP09; Lowe et al., 2009). Annual SST are predicted to rise by approximately 1.5-2.5°C in open ocean, shelf edge and the northern North Sea by 2070–2098 (relative to the 1961–1990 average) whereas larger rises are predicted for the shallower Irish, Celtic and southern North Seas (Dye et al, 2013). However, these predictions are based on a single model and need to be considered in the context of a wider range of models before a full assessment can be made (Dye et al, 2013).

Patterns of change

Regional variation

Despite the underlying warming in SST, there is a great deal of regional variation. Scottish waters are no different and each region shows its own temporal and spatial patterns. Data HadISST1.1 data set (Rayner et al., 2003) shows that the east coast of Scotland has warmed at a slightly faster rate than the west coast over the past 30 years. The UK Climate Projections 2009 predict that SST warming will show a greater change on the east coast compared to the west coast of Scotland (UKCP09; Lowe et al., 2009).

Interpretation of indicator trends

Long term data shows the underlying warming trend in SST while on shorter timescales and at regional spatial scales there is a great deal of variability. This variability is caused by natural variation which has been described as the Atlantic Multi-decadal Oscillation (Knight et al., 2005).

Average SST was selected as it represents a consistent and long-term dataset in the marine environment. However, potentially the indicator could be improved by the use of multiple datasets (both inshore and offshore) in order to examine spatial variability. Further development of the indicator would analyse the rate of change, though in this initial analysis, average SST was considered as it removes much of the temporal variability and an examination of the long-term trend can itself be a measure of rate of change. Future developments will also consider maximum temperature effects on species and communities given that thermal stress is likely to be linked more to the maximum temperature than the average, or the latitude at which a particular temperature is reached.

Limitations

Some of the data requires specialist knowledge or procedures to process and interpret. The MetOffice data in particular is in a file format that needs specialist software to open and requires specialist knowledge to be able to analyse and interpret. The SEPA data also requires specialised processing because of gaps in the data which make the calculation of broad scale annual means difficult.

References

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Further information

MCCIP Report Cards and Scientific Reports - <http://www.mccip.org.uk/annual-report-card/2013.aspx>

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International Council for the Exploration of the Sea (ICES) data collected by Marine Scotland Science (MSS)

Met-Office

Appendix One: Indicator metadata and methodology

Table 1: Indicator metadata

	Metadata
Title of the indicator	NM1 Changes in average sea surface temperature (SST)
Indicator contact: Organisation or individual/s responsible for the indicator	Anna Moss (CXC, University of Dundee)
Indicator data source	SEPA – Monitoring buoy network ICES – Report on Ocean Climate (data collected by MSS) Met-Office - HadISST 1.1 (Global sea-Ice coverage and Sea Surface Temperature) Dataset
Data link: URL for retrieving the indicator primary indicator data.	SEPA:- http://www.sepa.org.uk/environment/environmental-data/monitoring-buoys-network/ ICES:- http://ocean.ices.dk/iroc/ Met-Office (MIDAS database) through the NERC Centre for Environmental Data Archival (CEDA) website:- http://catalogue.ceda.ac.uk/uuid/220a65615218d5c9cc9e4785a3234bd0 http://badc.nerc.ac.uk/browse (list of datasets on CEDA) Met Office HadISST 1.1 (Global sea-Ice coverage and Sea Surface Temperature) (1870-Present) dataset - http://catalogue.ceda.ac.uk/uuid/facafa2ae494597166217a9121a62d3c

Table 2: Indicator data

	Indicator data
Temporal coverage: Start and end dates, identifying any significant data gaps.	SEPA:- Alloa since 1988 Dunoon since 2009 Gunnat Ledge since 1993 Inner Clyde since 2011 ICES:-

	Various offshore stations around Scotland, some since 1950s. Most recent is 2012 Met-Office (MIDAS database):- 1870-present HadISST dataset
Frequency of updates: Planned or potential updates	SEPA – daily averages ICES – annual averages Met Office – HadISST updated monthly
Spatial coverage: Maximum area for which data is available	SEPA – monitoring buoys at four estuary locations ICES:- Various offshore stations in Scottish Sea areas (~7) Met-Office:- Global but can partition UK data
Uncertainties: Uncertainty issues arising from e.g. data collection, aggregation of data, data gaps	Satellite SST requires continuity of satellite missions and availability of adequate in-situ data for validation and bias adjustment
Spatial resolution: Scale/unit for which data is collected	SEPA – point locations ICES – point locations Met-Office – HadISST_1.1_SST monthly 1° area grids from satellite data validated by in-situ observations
Categorical resolution: Potential for disaggregation of data into categories	
Data accessibility: Restrictions on usage, relevant terms & conditions	Most freely available - depends on data source but may need to register to access the data. SEPA – data request via email found at the above url (Science.Advice@sepa.org.uk) ICES – Annual averages can be downloaded from the website Met-Office – need to register with the CEDA website to get access to the data

Table 3 Contributing data sources

<p>Contributing data sources</p> <p>Data sets used to create the indicator data, the organisation responsible for them and any URLs which provide access to the data.</p>
<p>SEPA – Monitoring buoy network ICES – Report on Ocean Climate (data collected by MSS) Met-Office - HadISST 1.1 (Global sea-Ice coverage and Sea Surface Temperature) Dataset</p>

Table 4 Indicator methodology

Indicator methodology

The methodology used to create the indicator data

Plot the averages (daily, monthly or annual depending on dataset) of the three datasets to monitor the long term trend in SST.

The Met-Office dataset is very complex and provides a significant amount of data which requires some specialist knowledge to process and interpret.