

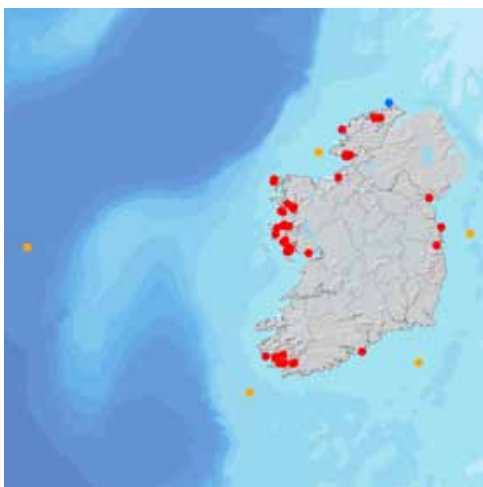
## 3.1 Ocean Surface and Sub-surface Temperature

*Glenn Nolan and Ned Dwyer*

The temperature of the oceans is influenced by a number of factors, including the amount of heat from the sun transferred to the water, surface and sub-surface circulation and current patterns. Global ocean surface temperatures have increased by approximately 0.7°C since the 1850s, with rapid warming since the 1960s. Monitoring of ocean temperature is important as thermal expansion due to warming, leading to sea-level rise. Temperature also determines both the plant and animal species present, thereby impacting biodiversity and fishing; it also influences the weather patterns and climate experienced on land.



Photo: © Ned Dwyer



**Map 3.1.** Location of sea surface temperature observation stations.

### Measurements

Sea surface temperature (SST) measurements are made at several sites around the Irish coast (red) by the Marine Institute. Water temperature data have been collected at Malin Head Co. Donegal (blue) by Met Éireann since 1958. This is the longest SST record available for the Irish region, although records for parts of the northeast Atlantic go back to 1850. Since 2000, the marine weather buoy network (orange) routinely collects sea surface and sub-surface temperature data from five offshore locations.

Sea surface temperature can also be inferred from satellite observations with an accuracy of greater than  $\pm 0.3^\circ\text{C}$ . For example, sensors on board the NASA *TERRA* satellite make daily measurements of SST.

'Sea surface temperature in Irish waters has increased at a rate of approximately 0.6°C per decade since 1994, which is unprecedented in the 150-year observational record.'

## Time-series and Trends

### Surface Temperature

Figure 3.1 shows the mean annual observed SST at Malin Head for the period 1961 to 2011<sup>12</sup> (right axis). The left-hand axis indicates anomalies (the difference between the mean annual temperature and the 1961 to 1990 reference mean value). This shows interannual variability from the 1960s to the 1980s and a progressive warming in the record from the early 1990s. This strongly ties in with the natural cycle of variability in the North Atlantic known as the 'Atlantic Multi-decadal Oscillation',

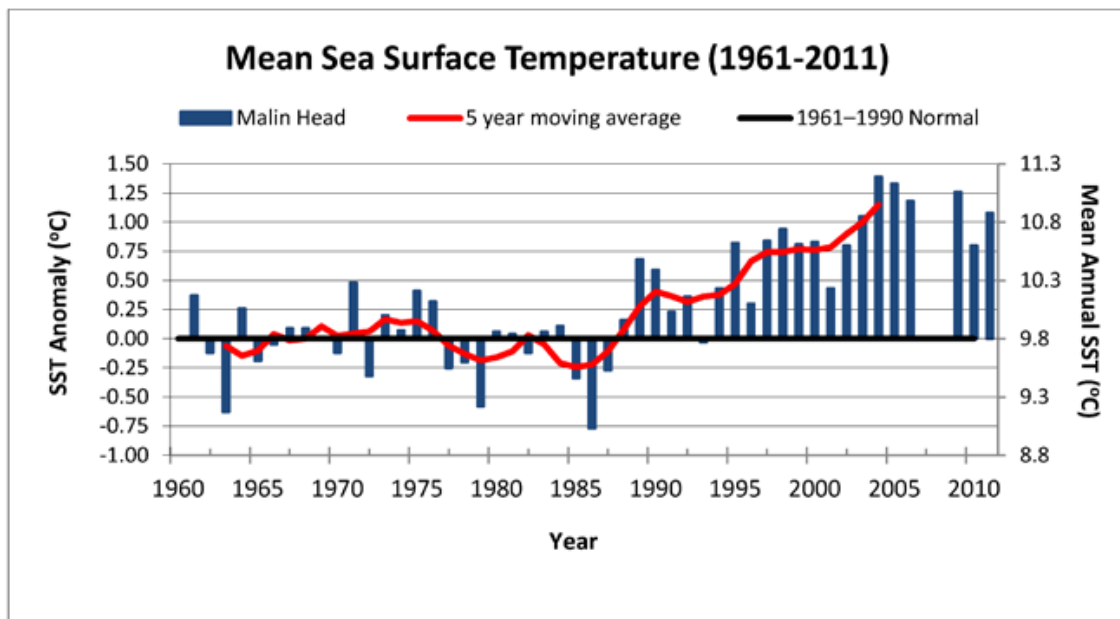
although approximately half of the recent warming is attributed to an underlying global warming trend.

The observations of SST from the offshore data buoys since 2000 are consistent with air-temperature observations made on land.

Figure 3.2 shows the SST around Ireland for May 2011 as determined from an average of a series of observations from the MODIS sensor on board the NASA *TERRA* platform. Temperatures around the island are in the approximate range of 10°C to 13°C.

### Sub-surface Temperature

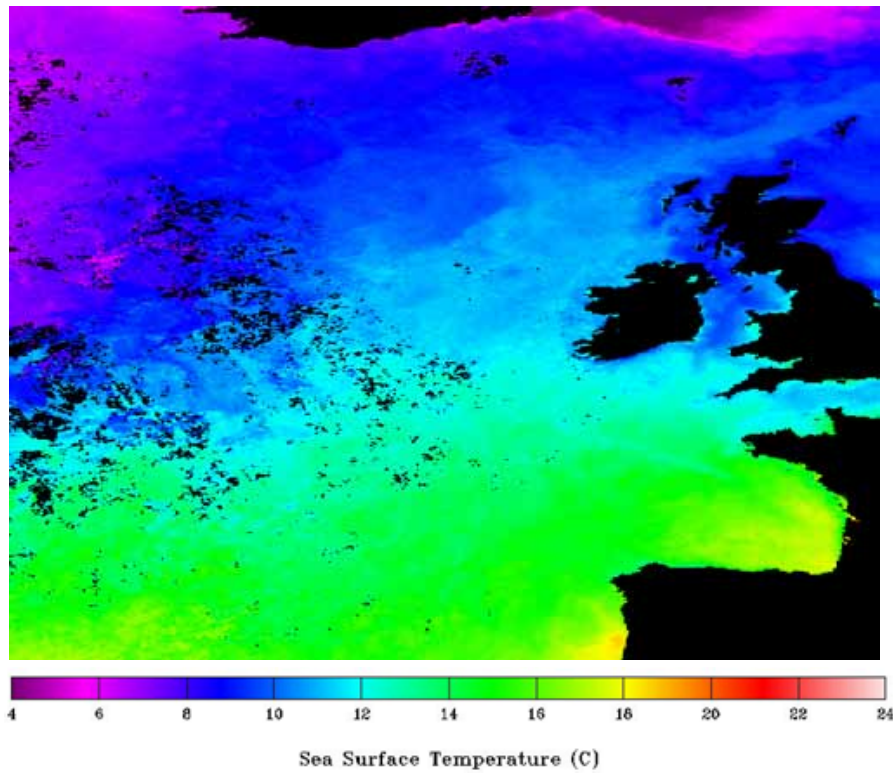
Over the last 50 years global ocean temperature has risen by 0.10°C approximately from the surface to a depth of 700 m. Since 2005 to the west of Ireland annual surveys have been carried out in the Rockall Trough to full depth. These are reported to the International Council for Exploration of the Sea (ICES) to summarise oceanic conditions in the Irish region.



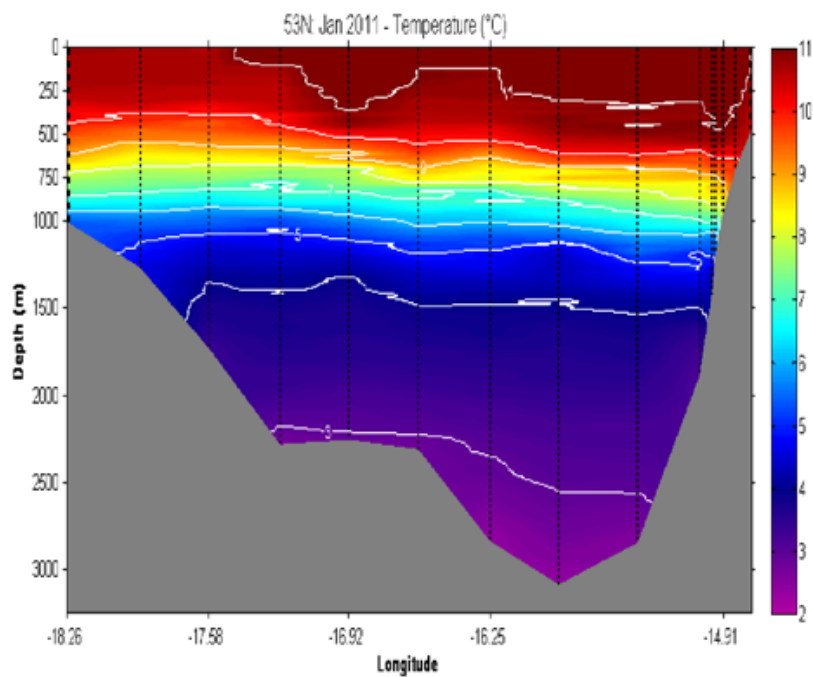
**Figure 3.1.** Mean annual sea surface temperature (SST) and anomalies measured at Malin Head (1961–2011).

<sup>12</sup> Bucket measurements were made up to 2007; a moored electronic sensor has been used subsequently. Time-series data have been merged by adjusting the bucket to the electronic measurements.

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**Figure 3.2.** Example of sea surface temperature-distribution derived from satellite-based radiometer observations for May 2011.



**Figure 3.3.** Deep-water temperature section for the Rockall Trough in January 2011 looking northward.

Figure 3.3 shows a typical deep water temperature section for the Rockall Trough in January 2011 looking northward. The near-surface water masses are evident in the 9°C–11°C range of the upper 750 m of the water column. The time-series of deep-water observations is too short to determine if any trend exists in the data.

**'It is vital that the temperature sensors at Malin Head and Ballycotton are resourced and maintained as long-term reference sites.'**

## Maintaining the Observations

The new temperature sensors at Malin Head are maintained by the Marine Institute on an annual basis. Data is now being recovered in real time. In 2011 a station was established to measure SST at Ballycotton, Co. Cork. Resources need to be allocated to ensure that this is maintained as a long-term reference station for the Celtic Sea. The Irish Marine Weather Buoy Network is funded under a Memorandum of Understanding with the Department of Transport. Funding for this network is negotiated on an annual basis. Deep sea sub-surface temperature observations are made annually and are funded under the National Development Plan Ship Time fund and through internal Marine Institute funding.

## Further Information and Data Sources

Cannaby, H. and Hüsrevoğlu, Y.S. (2009) Low frequency variability and long-term trends in Irish SST records, *ICES Journal of Marine Science*, Vol. 66, No. 7, pp. 1480–9.

Cannaby, H. and Nolan, G. (2009) Physical oceanography. *Irish Ocean Climate and Ecosystem Status Report 2009*. Nolan, G., Gillooly, M. and Whelan, K. (eds.) Marine Institute, Galway, Ireland, p. 100.

Rayner, N.A., Parker, D.E., Horton, E.B., Folland, C.K., Alexander, L.V., Rowell, D.P., Kent, E.C. and Kaplan, A. (2006) Global analysis of sea surface temperature, sea ice and night marine air temperature since the late nineteenth century, *Journal of Geophysical Research*, Vol. 108, pp. 4407–36, doi: 10. 1029/2002JD002670.

Malin Head Data (1958–2006) are archived by Met Éireann: <http://www.met.ie/climate/climate-data-information.asp>

Malin Head Data (since 2008) are archived by the Marine Institute and may be accessed on request: <http://www.marine.ie/home/publicationsdata/>

Information and observations from inshore SST measurement stations: <http://www.marine.ie/home/publicationsdata/data/IMOS/>

Information and observations from the Irish Marine Weather Buoy Network: [http://www.met.ie/marine/marine\\_observations.asp](http://www.met.ie/marine/marine_observations.asp)

Information and data from the UK Met Office's Hadley Centre: <http://www.metoffice.gov.uk/hadobs/>

Physical oceanographic parameters including SST observations derived from satellite measurements are available from NASA's distributed data and archive centre: <http://podaac.jpl.nasa.gov/>

Physical oceanographic parameters including SST observations derived from satellite measurements are available from the GMES MyOcean portal: <http://www.myocean.eu.org/>

Information and data from ESA's Climate Change Initiative, SST project: <http://www.esa-sst-cci.org/>