Indicators and trends

Monitoring climate change adaptation

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Indicator name			Version
NM7 Number of Harmful Algal Blooms (HAB)			01/08/16

Indicator type:	Risk/opportunity	Impact	Action
		X	

SCCAP Theme	SCCAP Objective	CCRA risk/opportunity
Natural Environment	N2 Support a healthy and diverse natural environment with the capacity to adapt N3 Sustain and enhance the benefits, goods and services that the natural environment provides	MA1 Risk of harmful algal blooms due to changes in ocean stratification; MA30 Damage to cultured aquatic species

At a glance

- There is a great deal of variability in HAB occurrence data and the role of climate change in these trends is uncertain.
- Currently there is insufficient data to present a quantitative indicator. To understand the impacts of climate change, the appropriate monitoring with associated environmental parameters will need to be performed into the future to ensure that changes in the HAB community can be recorded and the relationship with environmental drivers understood.
- Some species have warranted attention because of their continued/increasing impact on native ecosystems or the aquaculture/shellfish industries, e.g. *Karenia mikimotoi.*
- The occurrence of shellfish toxin producing HABs have generally been reported more often in Scottish waters although there has been a decline in the last decade for most groups of toxins.
- Changes in sea surface temperature are thought to favour many HAB species, particularly flagellates.

Latest Figure	Trend
There is a great deal of interannual variability in HAB occurrence data and the role of climate change in these trends is currently uncertain.	• Key species of HABs continue to be observed in UK waters. These include high biomass species such as *Karenia mikimotoi* and shellfish toxin producing HABs. • The distribution of HABs in the UK shows regional variation with impacts largely observed in regions with a strong Atlantic influence.

Why is this indicator important?

Photosynthetic algae, or phytoplankton, play a crucial role in marine ecosystems. As primary producers they occupy the lower trophic levels and can support complex food webs. Algal blooms, which constitute a natural part of the phytoplankton temporal cycle, can have a negative impact on marine ecosystems. These 'Harmful Algal Blooms' or HABs can impact natural marine populations and also affect human populations through food resources such as fish and shellfish. HABs can impact marine species through the clogging of gills and anoxia, which leads to mortalities, or through the production of toxins that can accumulate in filter feeding shellfish, which although not harmful to the shellfish, can pose a severe risk to human health (Bresnan et al, 2013). This has important implications for the shellfish industry which albeit smaller in Scotland than the rest of the UK still provides a mainstay in some Scottish communities.

Climate change can have an impact on HABs in a variety of ways (Hallengraeff, 2010). These can include changes in sea surface temperature, changes in wind direction, mixed layer depth, ocean acidification, UV radiation and feedback mechanisms (Bresnan et al, 2013). Predicting how these changes will influence HABs in the future is challenging, with expected impacts to include changes in abundance, changes in the seasonality of growth, range expansions of warm water species and pole ward shifts for cold water species (Hallengraeff, 2010).

What is happening now?

There is a great deal of interannual variability in HAB occurrence data and the role of climate change in these trends is uncertain (Bresnan et al, 2013). However, some key species have warranted attention because of their continued/increasing impact on native ecosystems or the aquaculture/shellfish industries. Blooms of *Kerenia mikimotoi*, a high biomass dinoflagellate HAB, have impacted Scottish coasts and caused significant mortalities in native fish species. Although this species is not seen every year, it has been suggested there is a likely link between climate change and an increase in its occurrence (Bresnan et al, 2013).

The occurrence of shellfish toxin producing HABs have generally been reported more often in Scottish waters although there has been a decline in the last decade for most groups of toxins (Bresnan et al, 2013). These groups include paralytic shellfish poisoning (PSP) toxins, lipophilic shellfish poisoning (LST) toxins and amnesic shellfish poisoning (ASP) toxins. However, due to their potential impacts on human health their occurrence is closely monitored by the Food Standards Agency (FSA) and the shellfish industry.

What has happened in the past?

The North Sea phytoplankton communities have responded in a variety of ways to separate warming and cooling periods during recent decades (Edwards et al, 2002; 2006). Generally, there has been an increase in phytoplankton biomass linked to changes in temperature rather than nutrient enrichment in regions of the North-East Atlantic and North Sea over winter months (Bresnan et al, 2013). However, changes in the distribution of phytoplankton taxa were genera specific, with some increasing in abundance but on the whole there has been a decrease in abundance along the east coast of the UK (Edwards et al, 2006). More recent coastal records have shown an increase in the abundance of HAB species along the west coast of Scotland, however, the role of climate change in these changes is uncertain (Bresnan et al, 2013).

What is projected to happen in the future?

Changes in sea surface temperature are thought to favour many HAB species, particularly flagellates (Bresnan et al, 2013). Hallegraeff (2010) suggest an increase in sea surface temperature would facilitate a northerly range expansion of warm water species. Changes in the duration of seasonal stratification events will also impact the occurrence of some HAB species leading to earlier onset and later declines (Bresnan et al, 2013).

Currently there is insufficient data to present a quantitative indicator. To understand the impacts of climate change, the appropriate monitoring with associated environmental parameters will need to be performed into the future to ensure that changes in the HAB community can be recorded and the relationship with environmental drivers understood.

Providing an early warning of the location, timing and magnitude of HABs would be of great value to coastal managers and the aquaculture industry. However, this is not straightforward due to the different life cycles and variable toxicity of different genera and species as well as local and regional variability in oceanography and hydrography (Davidson *et al*, 2016). Currently there is an informal and ad-hoc 'early warning' system for *Karenia* blooms. BBSRC funded research (The Scottish Association for Marine Science and Marine Scotland Science) is looking at developing a more comprehensive early warning system for *Karenia* using satellites/ models and developing HAB risk advice for siting of shellfish farms.

Patterns of change

The distribution of HABs in the UK shows regional variation with impacts largely observed in regions with a strong Atlantic influence, i.e. the west and north coasts of Scotland, although no clear trend can be attributed to climate change.

Interpretation of indicator trends

Long term trends have been interpreted by specialists within the Marine Climate Change Impacts Partnership (MCCIP) group. The data is readily available but requires specialist knowledge to process and interpret the data (i.e. how to process and interpret the test levels/results).

Limitations

Most of the monitoring is in coastal areas and there is a lack of data for more offshore areas. Note that the sampling programme is almost entirely predicated on the location of shellfish harvesting areas – rather than detecting HABs per se – this is a limitation on assessing the overall pattern and distribution of HABs.

References

Bresnan, E., Davidson, K., Edwards, M., Fernand, L., Gowen,R., Hall, A., Kennington, K., McKinney, A., Milligan, S., Raine, R. & Silke, J. (2013*) Impacts of climate change on harmful algal blooms*, MCCIP Science Review 2013, 236-243, doi:10.14465/2013.arc24.236-243

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Hallegraeff, G.M. (2010) Ocean climate change, phytoplankton community responses and harmful algal blooms: a formidable predictive challenge. *J. Phycology*, 46(2), 220-235

Further information

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

Special edition of *Harmful Algae*: Volume 53, Pages 1-166 (March 2016)
Applied Simulations and Integrated Modelling for the Understanding of Toxic and Harmful Algal Blooms (ASIMUTH). Edited by Keith Davidson, Marcos Mateus, Beatriz Reguera, Joe Silke and Marc Sourisseau

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Marine Scotland Science (MSS) - data collected by Marine Scotland Science (MSS) (contact Eileen Bresnan)

Appendix One: Indicator metadata and methodology

Table 1: Indicator metadata

	Metadata
Title of the indicator	NM7 Number of Harmful Algal Blooms (HAB)
Indicator contact: Organisation or individual/s responsible for the indicator	**Anna Moss** (CXC, University of Dundee)
Indicator data source	**FSS** – Food Standards Scotland website monitoring of shellfish farm closures **MSS** - HAB data for *Karenia mikimotoi* from 4 inshore sites
Data link: URL for retrieving the indicator primary indicator data.	**FSS** – Food Standards Scotland website (most recent reports):- http://www.foodstandards.gov.scot/food-safety-standards/advice-business-and-industry/shellfish which links to the following Scotland's Aquaculture dataset website (contains the archived data):- http://aquaculture.scotland.gov.uk/data/data.aspx **MSS** - HAB data for *Karenia mikimotoi* from 4 inshore sites – contact MSS

Table 2: Indicator data

	Indicator data
Temporal coverage: Start and end dates, identifying any significant data gaps.	**FSS –** Biotoxin monitoring 30/03/2009 to 24/03/2015; Phytoplankton monitoring 01/03/2009 to 24/03/2015 **MSS -** Past 10 years
Frequency of updates: Planned or potential updates	**FSS –** Biotoxin and phytoplankton are weekly updates but are compiled on a monthly basis **MSS:-** Unknown
Spatial coverage: Maximum area for which data is available	**FSS –** All shellfish harvesting areas in Scotland **MSS -** *Karenia mikimotoi* from 4 inshore sites in Scotland
Uncertainties: Uncertainty issues arising from e.g. data collection, aggregation of data, data gaps	A potential level of uncertainty arises from the fact that the sampling regime is predicated largely on shellfish harvesting areas which may not necessarily produce the same result as a stratified sampling programme specifically designed to assess HABs more generally in

	Scottish/UK waters. With respect to offshore data, the FSS no longer monitors this directly, but relies upon reporting from the food production chain – i.e. the processors are expected to conduct tests for HAB contamination of shellfish.
Spatial resolution: Scale/unit for which data is collected	**FSS –** point locations **MSS** – point locations
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. **FSS -** download from website **MSS –** contact MSS

Table 3 Contributing data sources

Contributing data sources Data sets used to create the indicator data, the organisation responsible for them and any URLs which provide access to the data.
FSS – Food Standards Scotland website monitoring of shellfish farm closures **MSS** - HAB data for *Karenia mikimotoi* from 4 inshore sites

Table 4 Indicator methodology

Indicator methodology The methodology used to create the indicator data
Long term trends have been interpreted by specialists within the Marine Climate Change Impacts Partnership (MCCIP) group. The data is readily available but requires specialist knowledge to analyse and interpret the data.