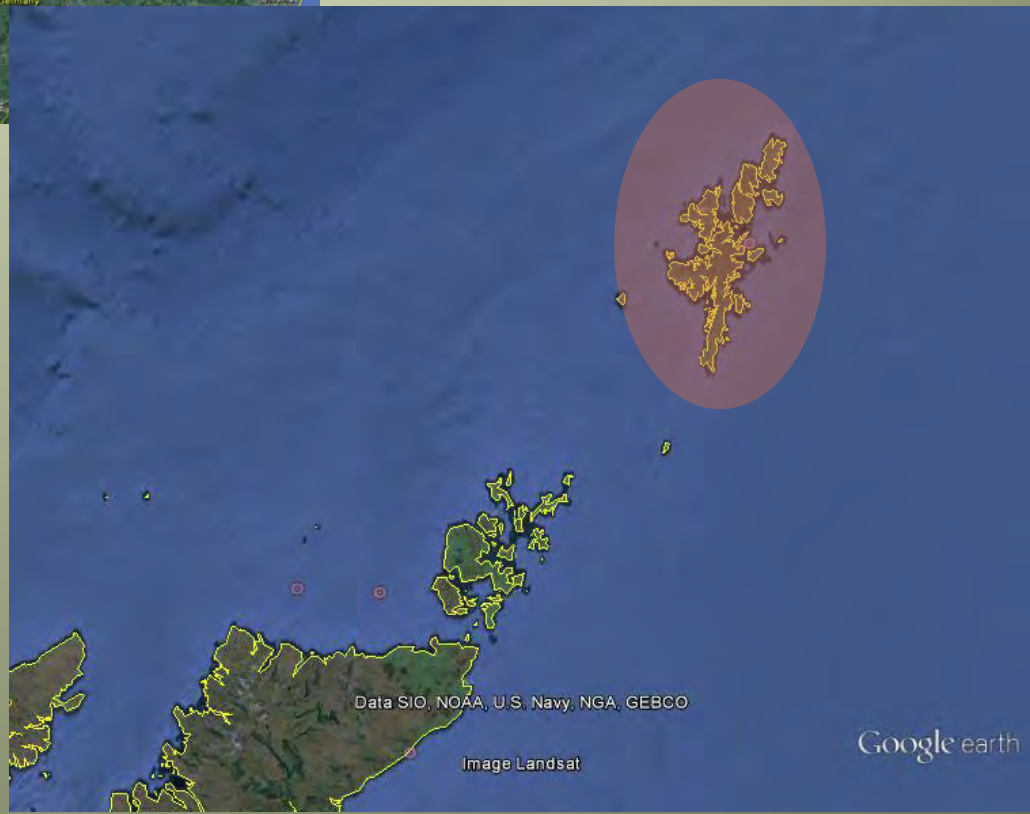
A climate link to the exceptional 2013 bloom of *Dinophysis* in Scottish waters and its associated diarrhetic shellfish poisoning event?

Callum Whyte, Sarah Swan, Keith Davidson

kda@sams.ac.uk www.sams.ac.uk

Shetland: > 50% of UK rope grown mussel production

Weekly regulatory monitoring of HABs at ~ 12 sites and Biotoxins at ~ 20 sites



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25 July 2013 Last updated at 19:02

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Shetland shellfish sites close after high toxin levels found

All shellfish harvesting sites in Shetland have closed and mussels from the islands withdrawn from sale after unusually high levels of toxins were detected.

A total of 11 shellfish harvesting areas in waters to the north and west of Shetland have been shut

The Food Standards Agency said the naturally-occurring toxins can cause acute food poisoning.

The move came after about 70 people in south-east England reported symptoms of diarrhetic shellfish poisoning.

The cases have been linked to the eating of mussels from Shetland.

It was after the harvest of these mussels that the FSA recorded the high levels of toxins during its weekly monitoring programme.

According to the FSA, the toxins are produced by marine phytoplankton and levels are typically higher in summer.

A total of 11 harvesting areas in waters to the north and west of the islands have been shut by Shetland Islands Council and businesses operating in
commercial

'Unprecede

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Advice on shellfish safety

Last updated: 25 July 2013

Following detection by the FSA of

In addition, the FSA has been informed that approximately 70 people in south east England have reported symptoms consistent with diarrhetic shellfish poisoning (see 'Science behind the story' below). The vast majority of cases occurred between 13 and 15 July.

particular harvesting area in Shetland, Scotland. After these mussels were harvested, an unusually high toxin level was detected by the FSA's weekly monitoring programme. The area has been closed, and as a precautionary measure the industry has voluntarily suspended all commercial harvesting from the waters around Shetland until toxin levels subside.

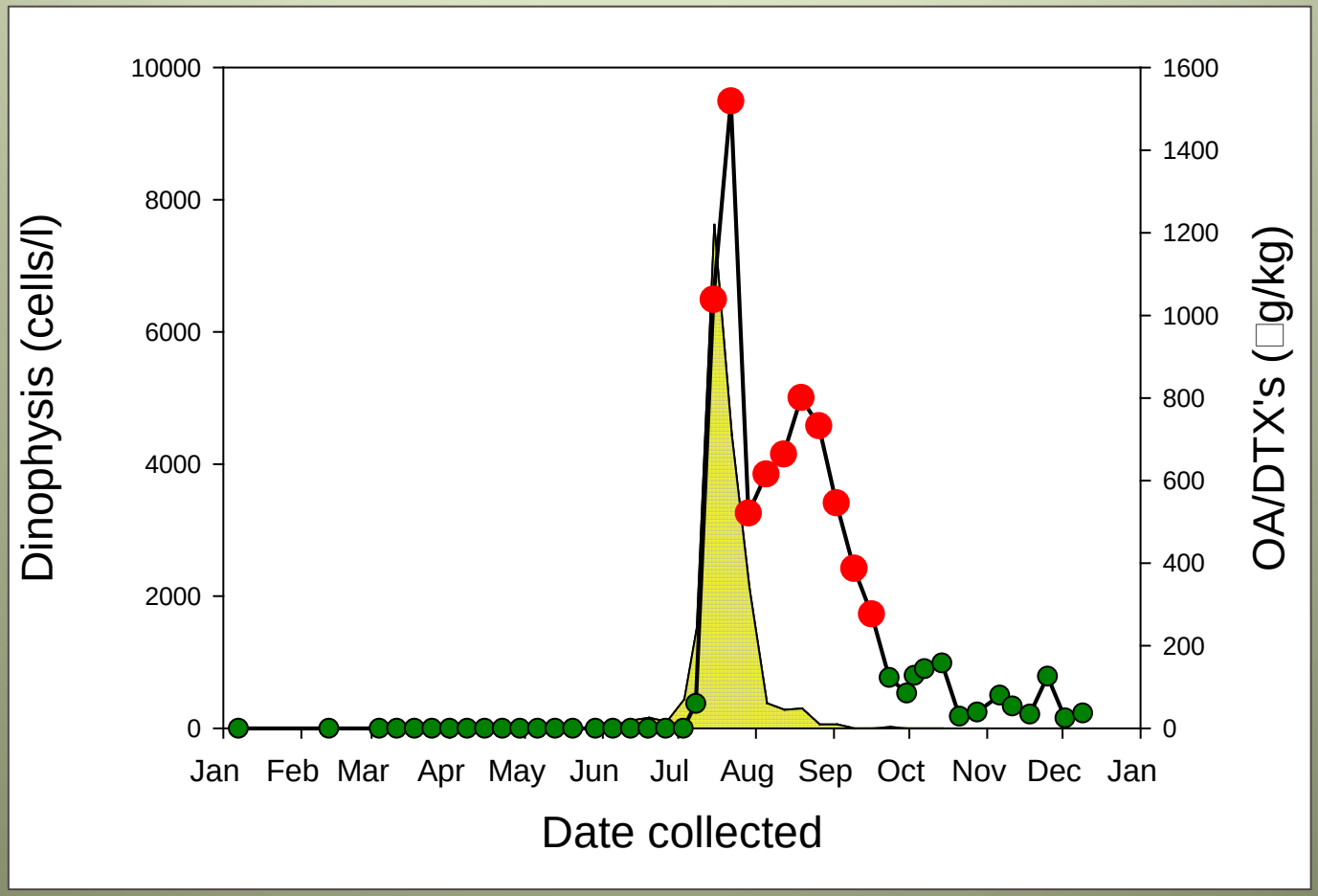
The business that supplied the shellfish, Shetland Mussels, has contacted its customers and advised the FSA that all of the mussels from this batch have either been consumed or disposed of. The local authority is investigating and liaising closely with the FSA.

The mussels had been supplied to a number of restaurants, some through a number of intermediary suppliers. Customers reported illness after eating at: Belgo in Covent Garden, Holborn, Clapham and Bromley; Zero Degrees in Blackheath and Reading; The Phoenix near Hook, Hampshire; Boulevard Brasserie in Covent Garden; and Pig's Ears in Richmond. These premises acted appropriately by notifying the relevant authorities when the cases of illness were identified.

Business responsibilities

It is the legal responsibility of all food businesses to put in place appropriate controls to ensure that only food safe for consumption is placed on the market. The FSA is reminding all UK companies involved in the sale of shellfish to ensure that biotoxin

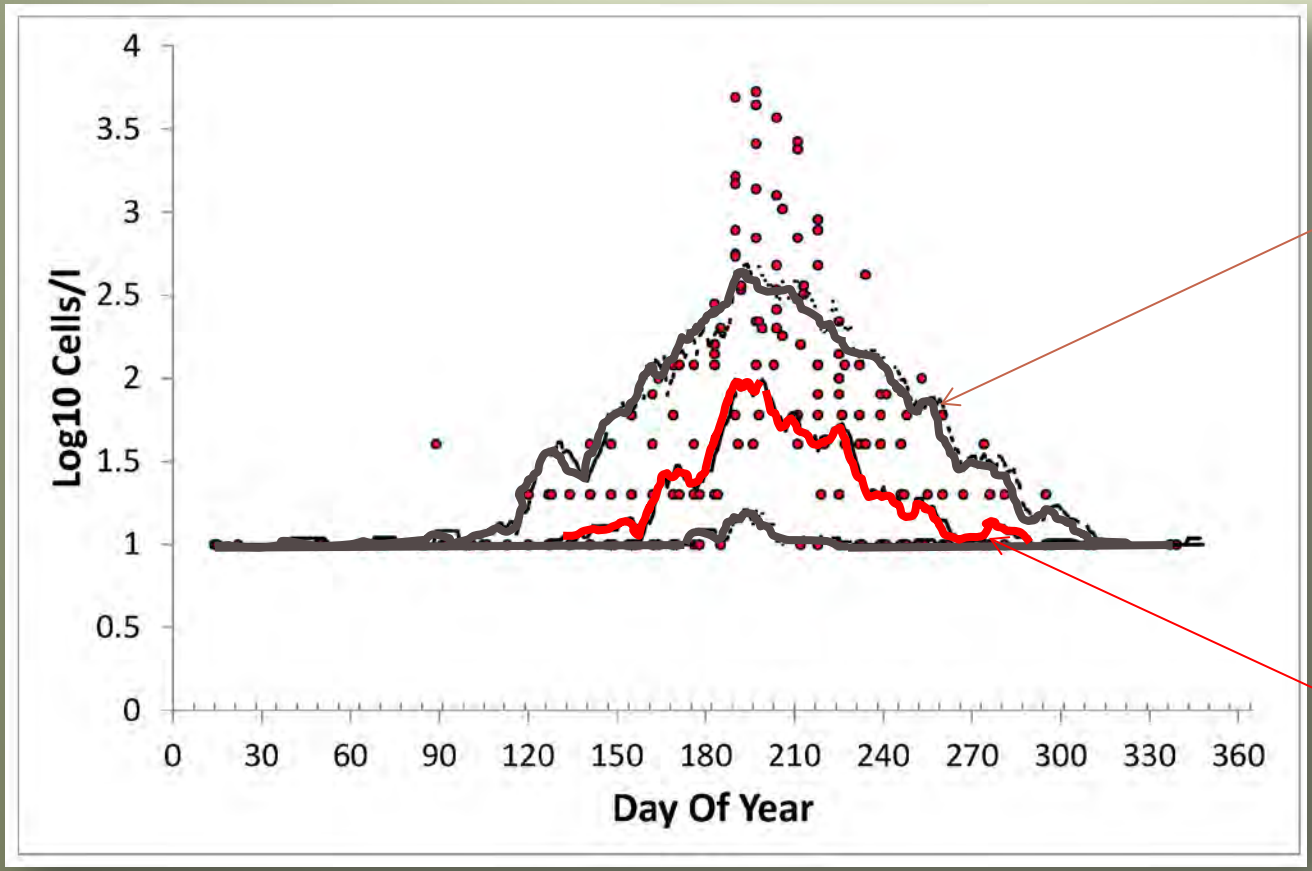
Dinophysis numbers and OA/DTX's recorded in Seggi Bight during 2013



OA/DTX's above action level

Dinophysis

Shetland Islands 2013 unusually high numbers of *Dinophysis*



Blue lines represent 5th and 95th percentiles i.e. 90 % of the observations made between 2006 and 2012 lie within this envelope

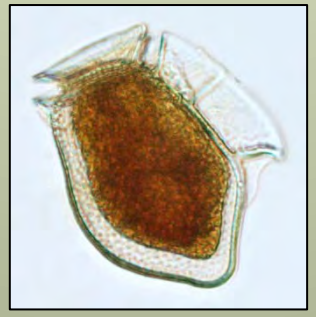
Red line represents the 2006 to 2012 median

Red circles represent *Dinophysis* abundance in 2013

What caused the bloom?

Nutrients

Temperature



Meteorology

Oceanography

Prey

Dinophysis

Advected genera – blooms potentially develop offshore

Can potentially be "blown" toward coastal aquaculture sites

Journal of Marine Systems 83 (2010) 150–157

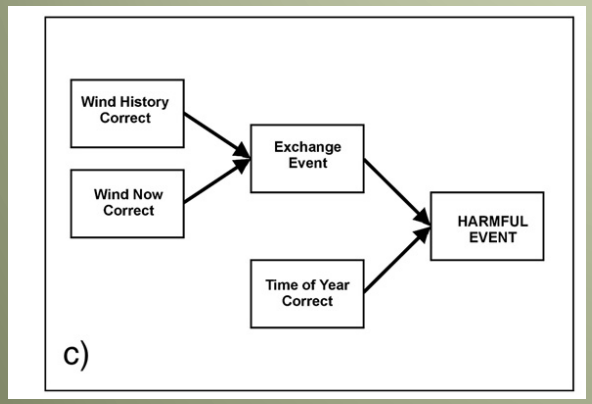
Contents lists available at ScienceDirect

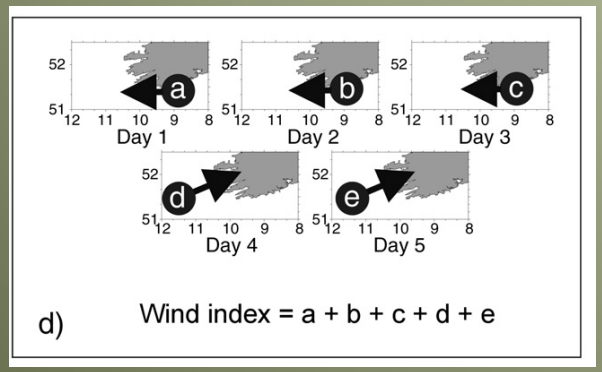
Journal of Marine Systems

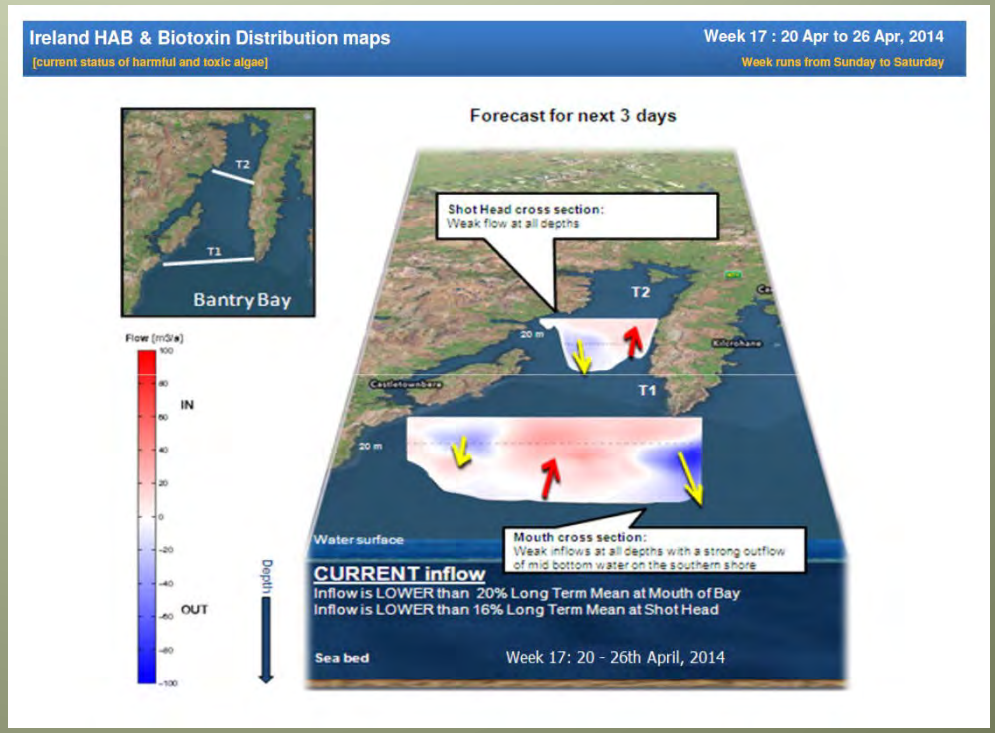
journal homepage: www.elsevier.com/locate/jmarsys

A simple short range model for the prediction of harmful algal events in the bays of southwestern Ireland

Robin Raine [a,*], Georgina McDermott [a,1], Joe Silke [b], Kieran Lyons [b], Glenn Nolan [b], Caroline Cusack [a,2]

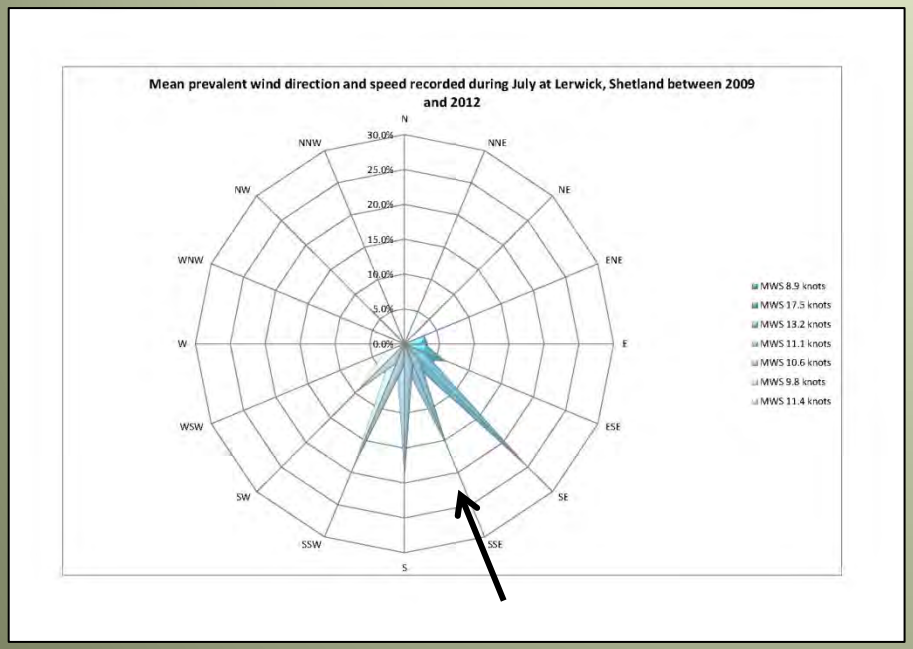






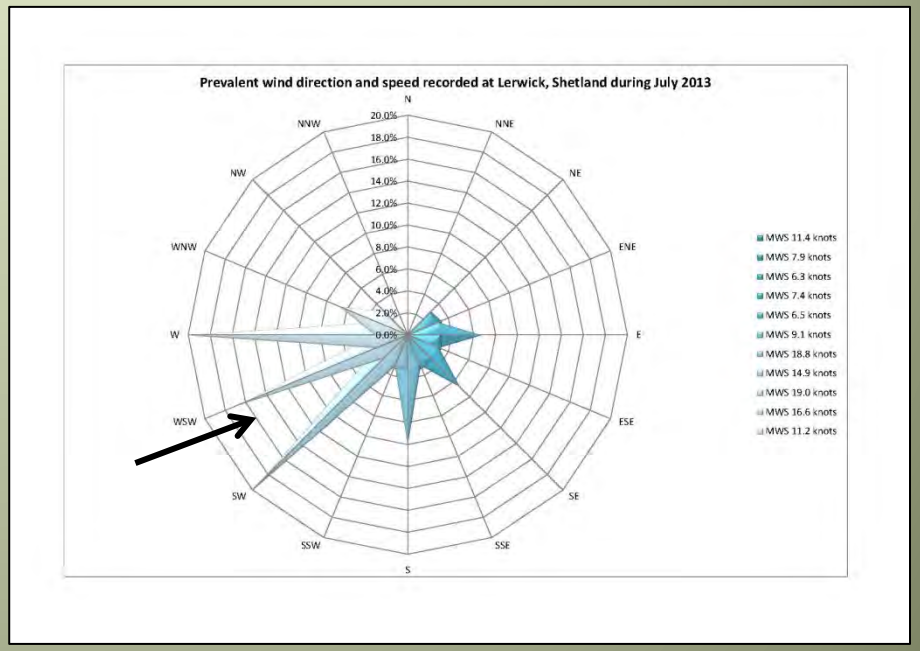
Prevalent wind direction July

Average wind direction for July recorded between 2009 and 2012



On average winds tend to blow from the South East

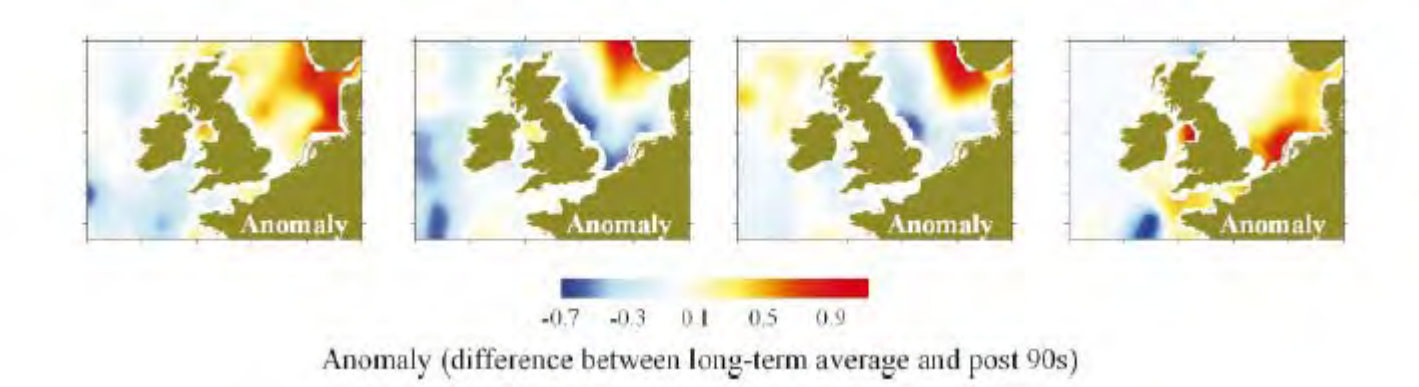
Wind direction recorded during July 2013



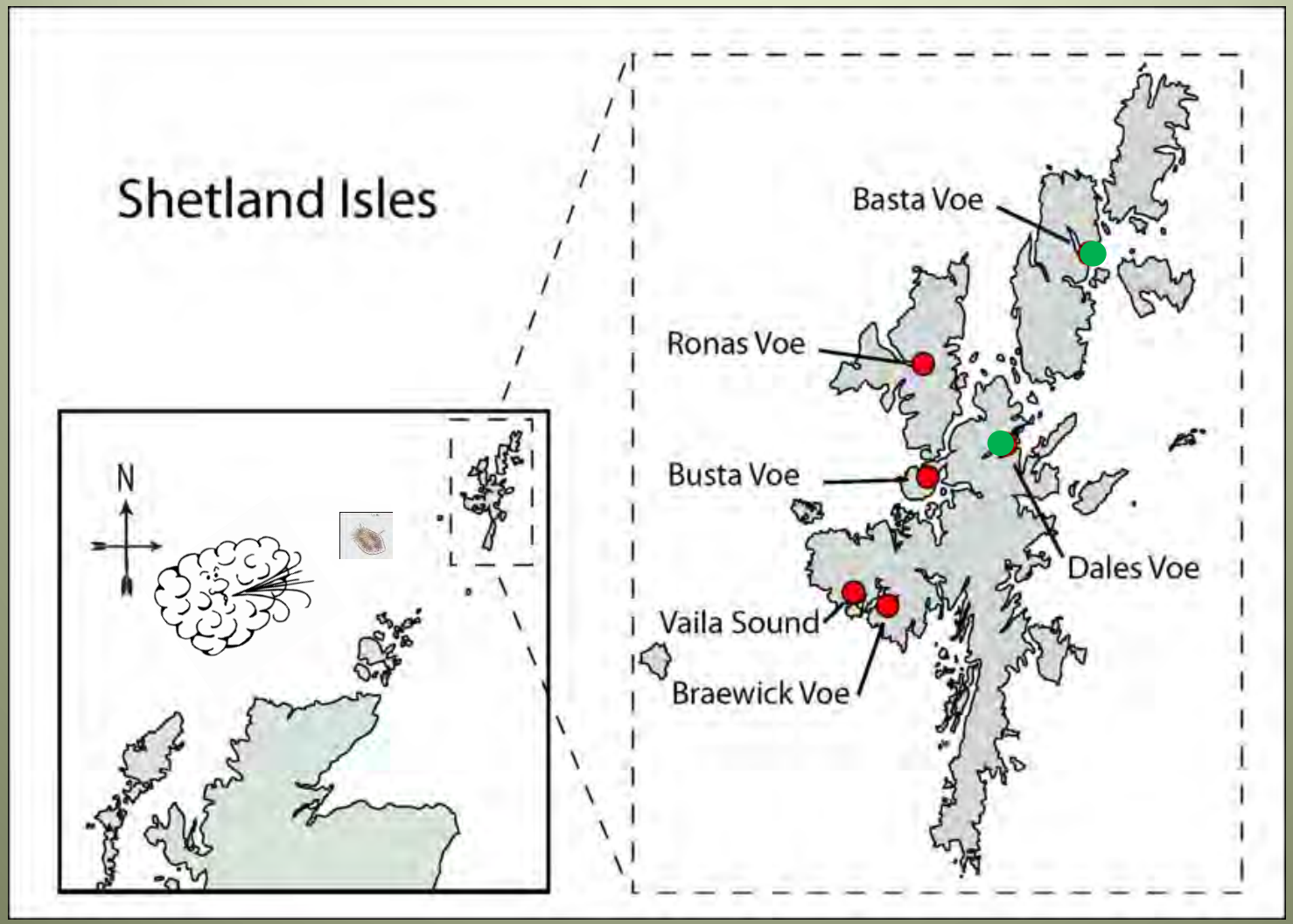
On average winds tended to blow from the West

Data provided by British Atmospheric Data centre for Lerwick

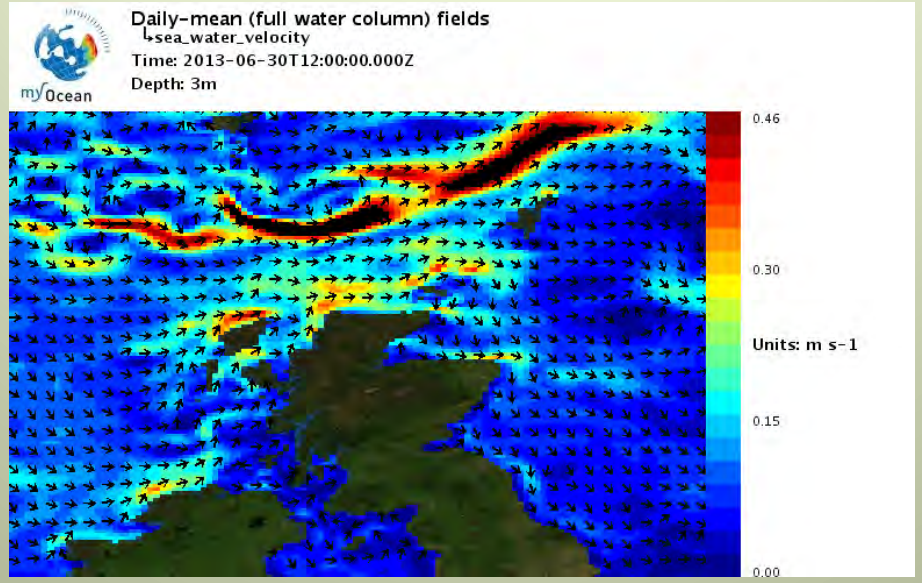
Prorocentrum spp *Ceratium furca* D*inophysis* spp *Noctiluca* spp



Edwards et al. 2006 Limnol Oceangr 51:820-829

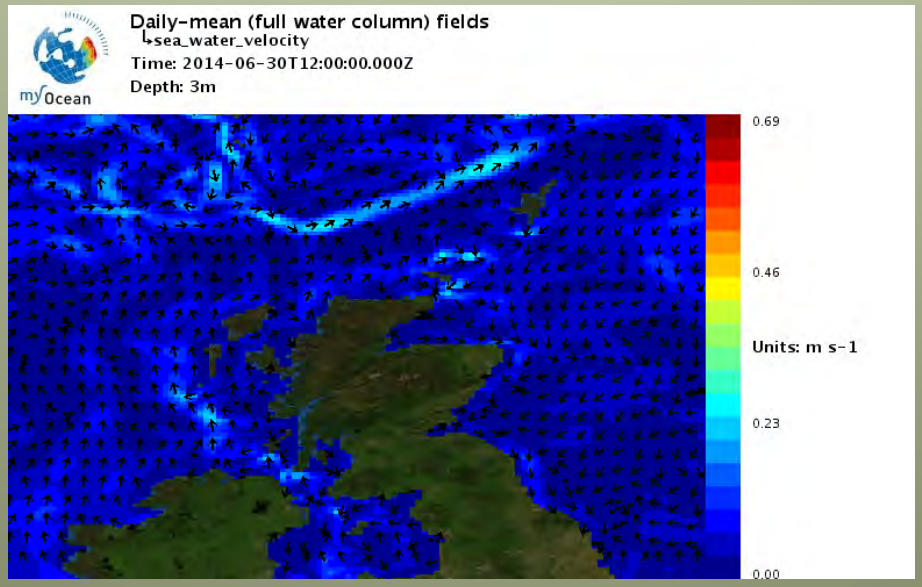

Shetland Isles
N
Basta Voe
Ronas Voe
Busta Voe
Dales Voe
Vaila Sound
Braewick Voe

2013



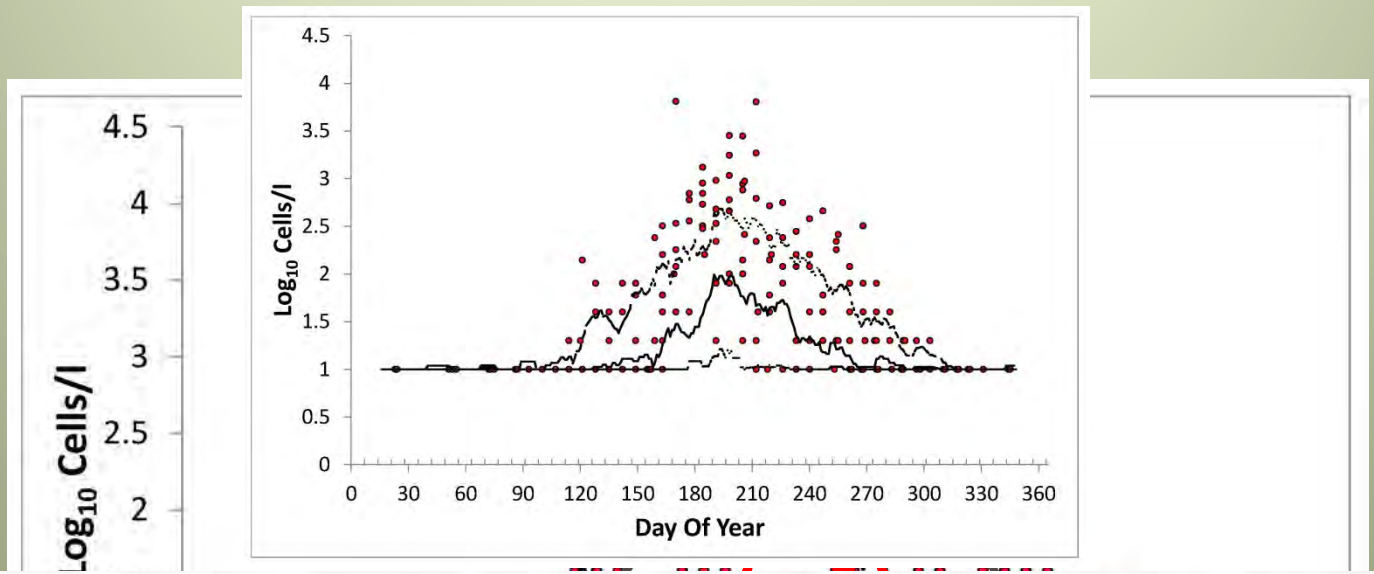
Coastal bloom

2014



No coastal bloom

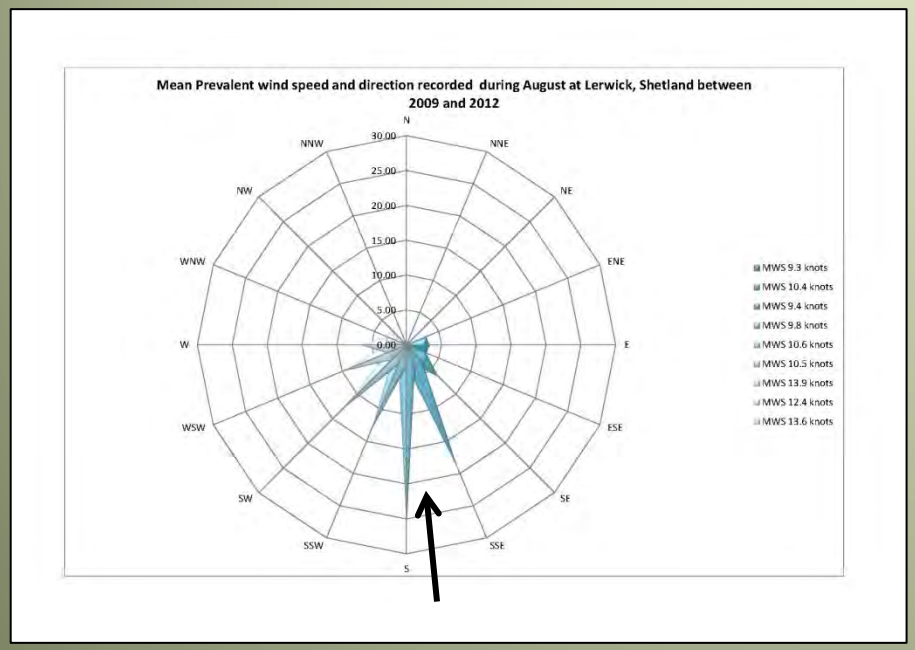
Shetland Islands 2006 again unusually high numbers of *Dinophysis*



Year	Significant	Higher	Lower	χ^2		May-August	Significant
2006	x	x		29.57	p<0.001	May-August	x
2007	x	x		5.80	p<0.05	May-August	
2008	x		x	4.57	p<0.05	May-August	
2009				1.67		May-August	
2010	x	x		5.23	p<0.05	May-August	
2011				2.49		May-August	
2012				0.08		May-August	
2013	x	x		52.47	p<0.001	May-August	x

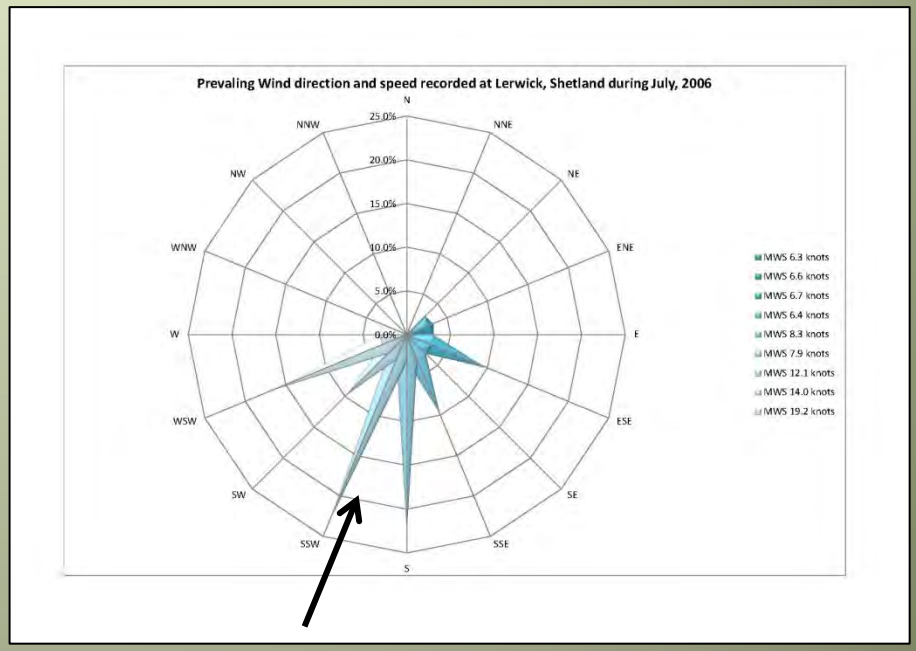
Prevalent wind direction 2006

Average wind direction for July recorded between 2009 and 2012



On average winds tend to blow from the South

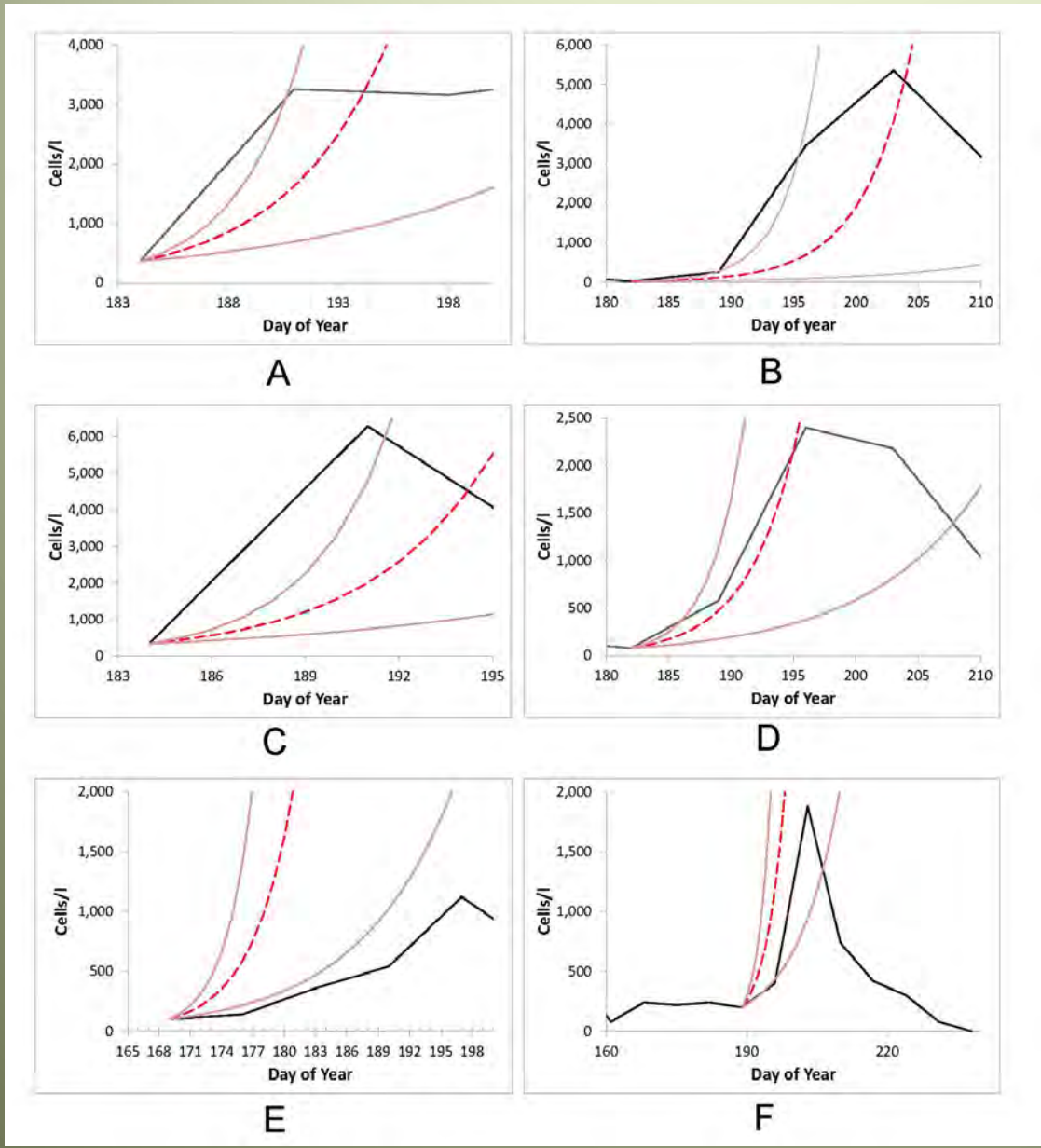
Wind direction recorded during July 2006



On average winds tended to blow from the SSW

Data provided by British Atmospheric Data centre for Lerwick

Growth rates or wind driven accumulation



Dinophysis numbers

Exponential growth – ideal conditions

± 1 standard deviation

A: Braewick Voe
B: Ronas Voe
C: Vaila Sound
D: Busta Voe
E: Basta Voe
F: Dales Voe

Harmful Algae News No. 49/ 2014

An exceptional *Dinophysis* driven toxic algae event in the Scottish Shetland Islands

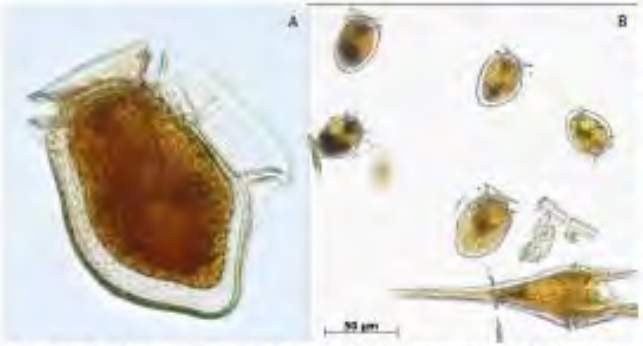


Fig. 1. Dinophysis from field populations in the Shetlands. A. Dinophysis acuta; B. Dinophysis acuminata complex

event for the industry was significant, making headlines on both local and national news.

Although the numbers of *Dinophysis* observed in the waters around Shetland had exceeded the regulatory monitoring programmes warning levels for several weeks preceding the event, toxicity testing indicated concentrations of biotoxins, although finite and rising, were below the regulatory threshold.

Two days after the event, however, the monitoring programme indicated that its numbers had risen very rapidly to unexpectedly large values in the waters around the islands, with associated high shellfish toxicity. Action was immediately taken to suspend operations in the area but, unfortunately, not before one of the farms harvested and shipped some of the affected mussels. While this incident was exceptional, it is instructive to analyse the causes behind it and

Harmful Algae 39 (2014) 365–373

Contents lists available at ScienceDirect

Harmful Algae

journal homepage: www.elsevier.com/locate/hal

Changing wind patterns linked to unusually high *Dinophysis* blooms around the Shetland Islands, Scotland

Callum Whyte *, Sarah Swan [1,2], Keith Davidson [1,2]

Microbial and Molecular Biology Department, Scottish Association for Marine Science, Scottish Marine Institute, Oban, Argyll PA37 1QA, United Kingdom

A link to climate change?

The North Atlantic Oscillation (NAO) is a measure of the relative strengths and Positions of a permanent low-pressure system over Iceland (the Icelandic Low) and a permanent high-pressure system over the Azores (the Azores High).

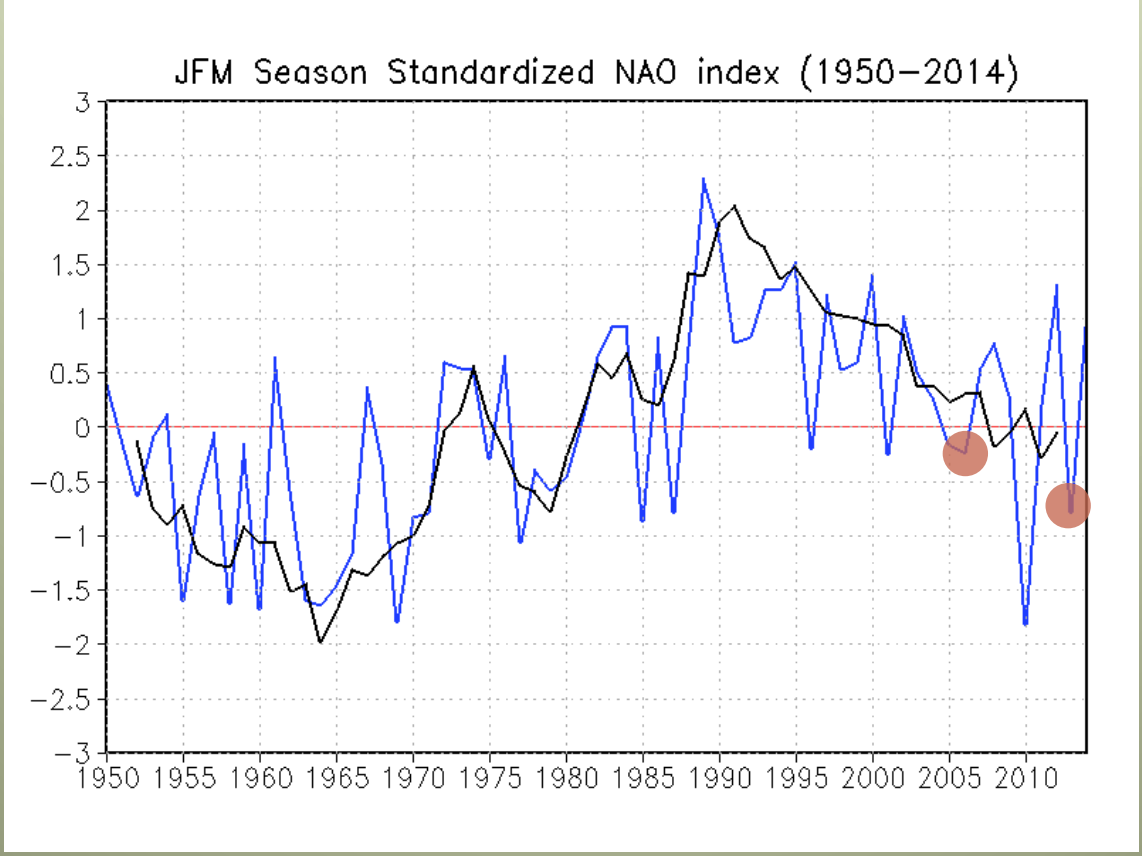
The NAO dictates climate variability in the N. Atlantic (Hurrell et al. 2003) and is thought to control the direction and strength of westerly winds into Europe.

A large difference in the pressure at the two stations (a high NAO+ year) leads to increased westerlies

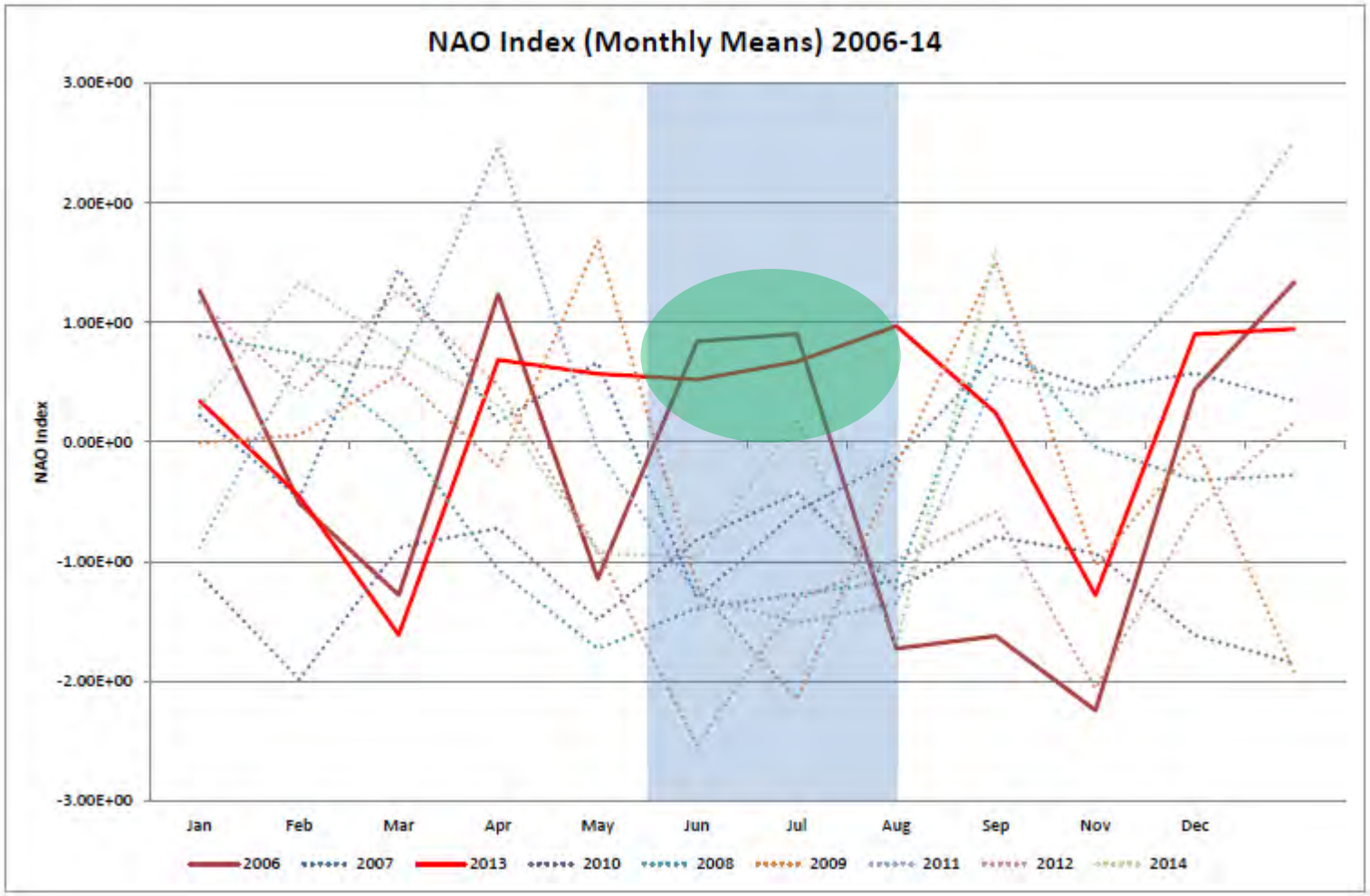
There is a trend of increased winter NAO over recent decades, with modelling indicating this is in response to increasing concentrations of greenhouse gases (Gillet et al. 2003).

Hurrell et al. (2003), Gillet et al. (2003) The North Atlantic Oscillation:
Climatic Significance and Environmental Impact Geophysical monographs 134

Winter NAO (blue) and 5 year running mean (black)



http://www.cpc.ncep.noaa.gov/products/precip/CWlink/pna/JFM_season_nao_index.shtml


NAO Index (Monthly Means) 2006-14
3.00E+00
2.00E+00
1.00E+00
0.00E+00
-1.00E+00
-2.00E+00
-3.00E+00
NAO Index
Jan
Feb
Mar
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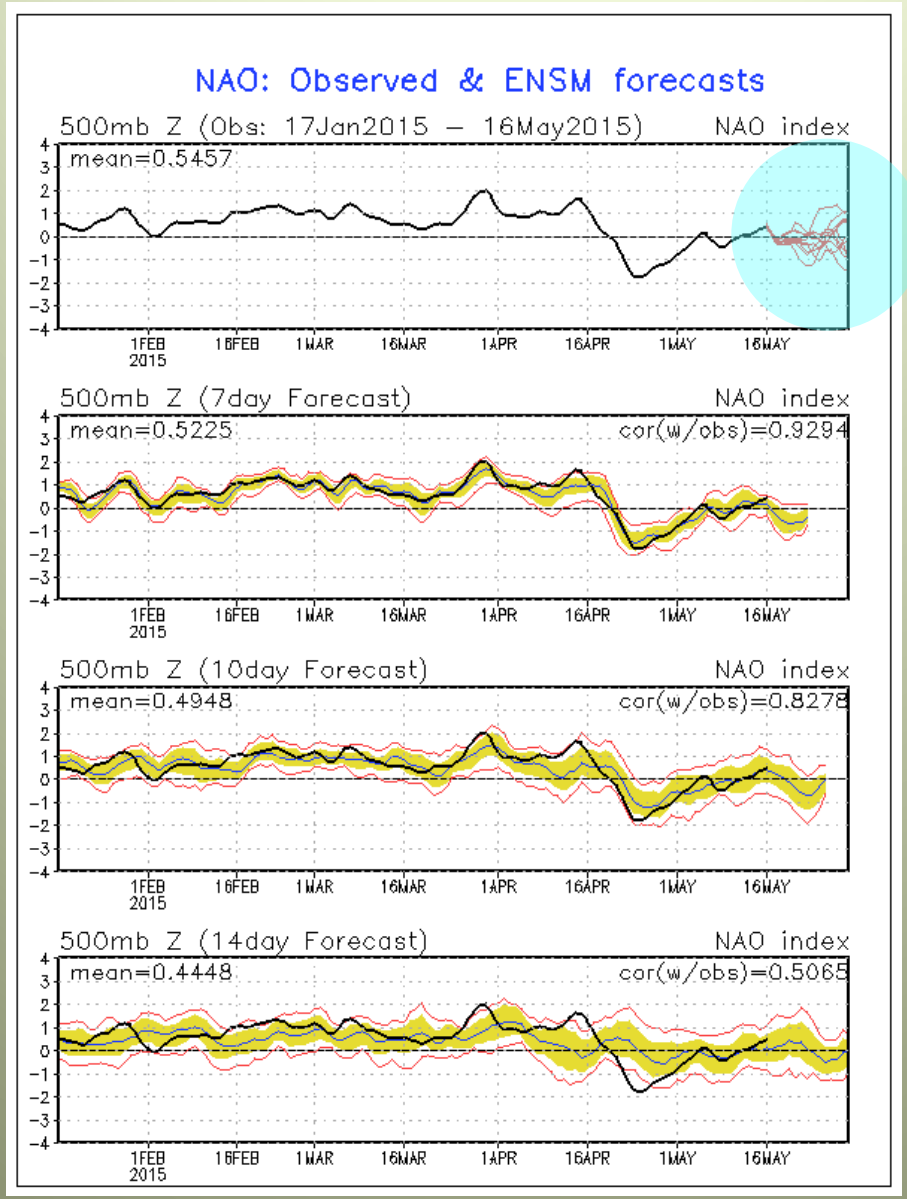
2006
2007
2013
2010
2008
2009
2011
2012
2014



http://www.cpc.ncep.noaa.gov/products/precip/CWlink/pna/nao.shtml

Coastal areas up to 60 nautical miles from Lerwick, Shetland

The coastal areas forecast for up to 60 nautical miles from Lerwick, Shetland. Issued by the Met Office, on behalf of the Maritime and Coastguard Agency

Valid from Saturday 16 May 2015 at 1800 UTC

General situation: An unstable westerly airflow will continue to affect Shetland and surrounding waters.

Forecast

Wind : West or southwest 5 to 7, occasionally 4 later.

Sea state : Rough or very rough, but moderate just east of Shetland.

Weather : Squally showers.

Visibility : Good, occasionally moderate.

Outlook

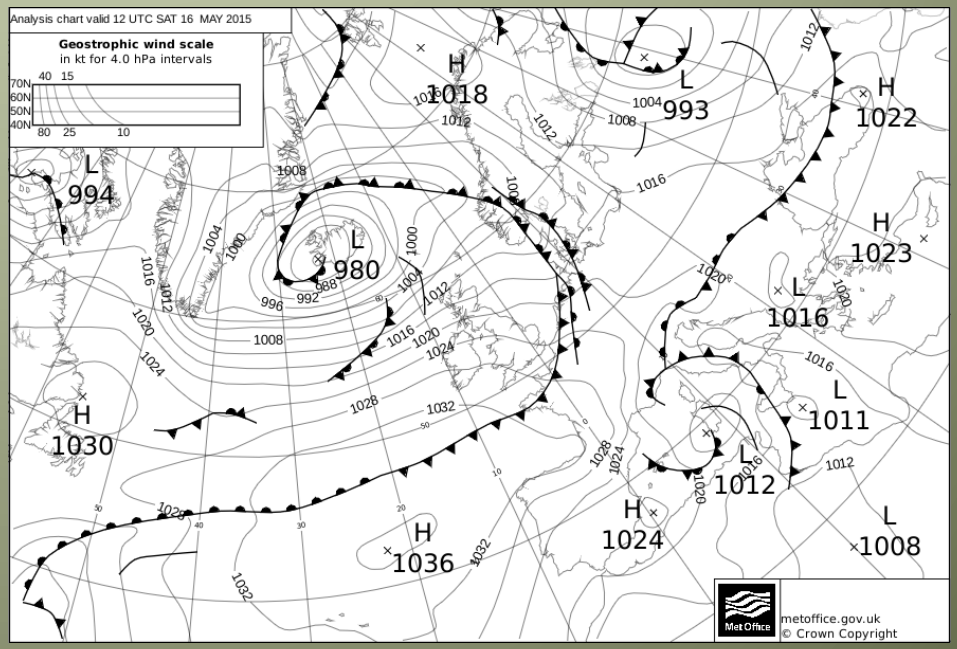
Valid : for 12 Hours from 0600 UTC on Sunday 17 May until 1800 UTC on Sunday 17 May

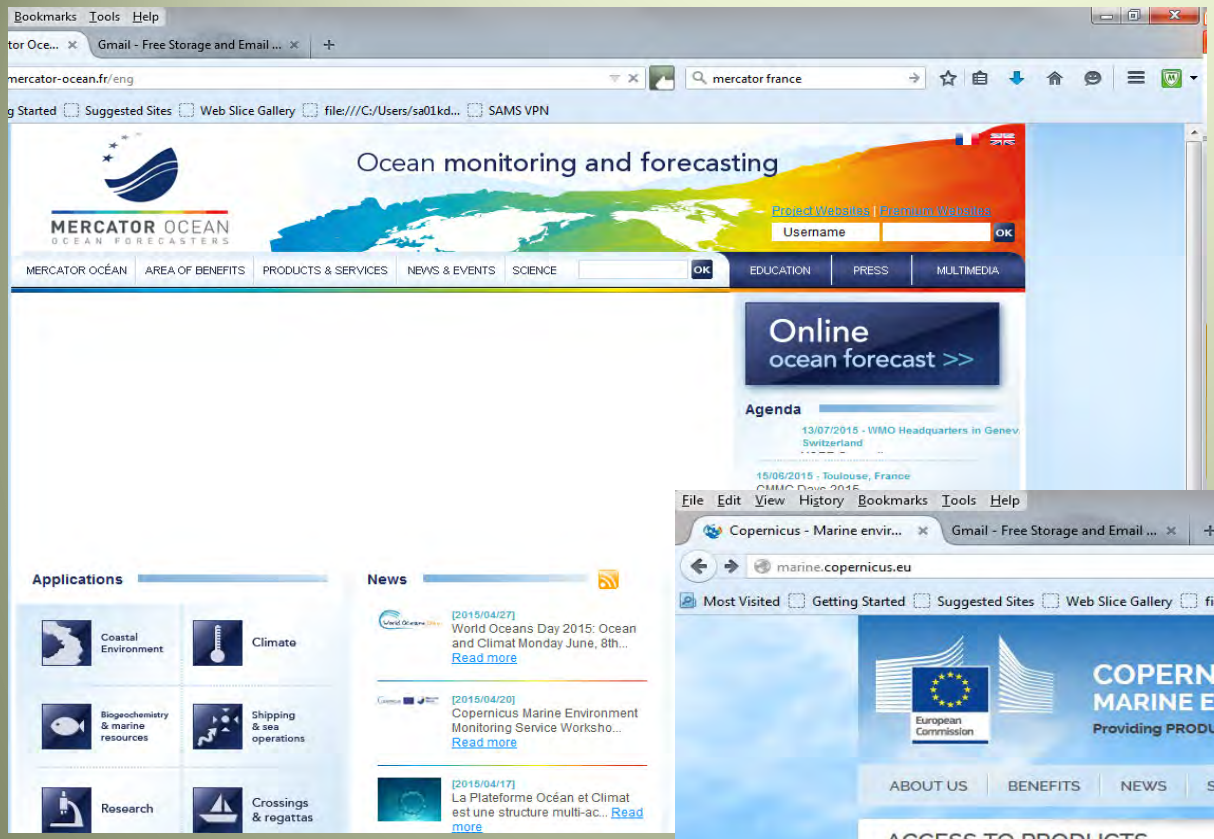
Wind : West 4 or 5 backing southwest 3 or 4.

Sea state : Rough or very rough, but moderate just east of Shetland.

Weather : Showers.

Visibility : Mainly good.

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Bulletins

Shetland Bulletin on the status of harmful & toxic algae Week 16, 13th - 19th Apr 2015

Status of biotoxins & harmful algae present in Shetland

Biotoxin	Status	Location & comments
PSP		Sixteen sites were tested this week. Toxins were detected at low levels in Parkgate and Cole Deep.
OA/DTX/PTX		Seventeen sites were tested this week. Toxins were detected at low levels in Seggi Bight, North Flotta and East Burwick Mussels.
ASP		One site was tested this week. Toxins were not detected.
YTX		Seventeen sites were tested this week. Toxins were not detected.
AZA		Seventeen sites were tested this week. Toxins were not detected.

Species	Status	Location & comments
Alexandrium		Eleven sites were sampled this week. *Alexandrium* was detected above threshold in Braewick Voe, Sandsound Voe and East of Linga.
Dinophysis		Eleven sites were sampled this week. *Dinophysis* was not detected.
Pseudo-nitzschia		Eleven sites were sampled this week. *P-nitzschia* was detected at low levels in all sites.
Prorocentrum lima		Eleven sites were sampled this week. *P.lima* was not detected.

Biotoxin & Species				
PSP	<RL	RL - 399 µg/kg	400 - 800 µg/kg	>800 µg/kg
OA/DTX/PTX	<RL	1 - 79 µg/kg	80 - 160 µg/kg	>160 µg/kg
ASP	<LOQ	LOQ - 9.9 mg/kg	10 - 20 mg/kg	>20 mg/kg
YTX	<RL	1 - 1.7 mg/kg	1.8 - 3.75 mg/kg	>3.75 mg/kg
AZA	<RL	1 - 79 µg/kg	80 -160 µg/kg	>160 µg/kg
Alexandrium	<20 cells/l	n/a	20 cells/l	≥ 40 cells/l
Dinophysis	<20 cells/l	20 - 79 cells/l	80 - 99 cells/l	≥100 cells/l
Pseudo nitzschia	<20 cells/l	20 - 39,999 cells/l	40,000 - 49,999 cells/l	≥50,000 cells/l
Prorocentrum lima	<20 cells/l	20 - 79 cells/l	80 - 99 cells/l	≥100 cells/l

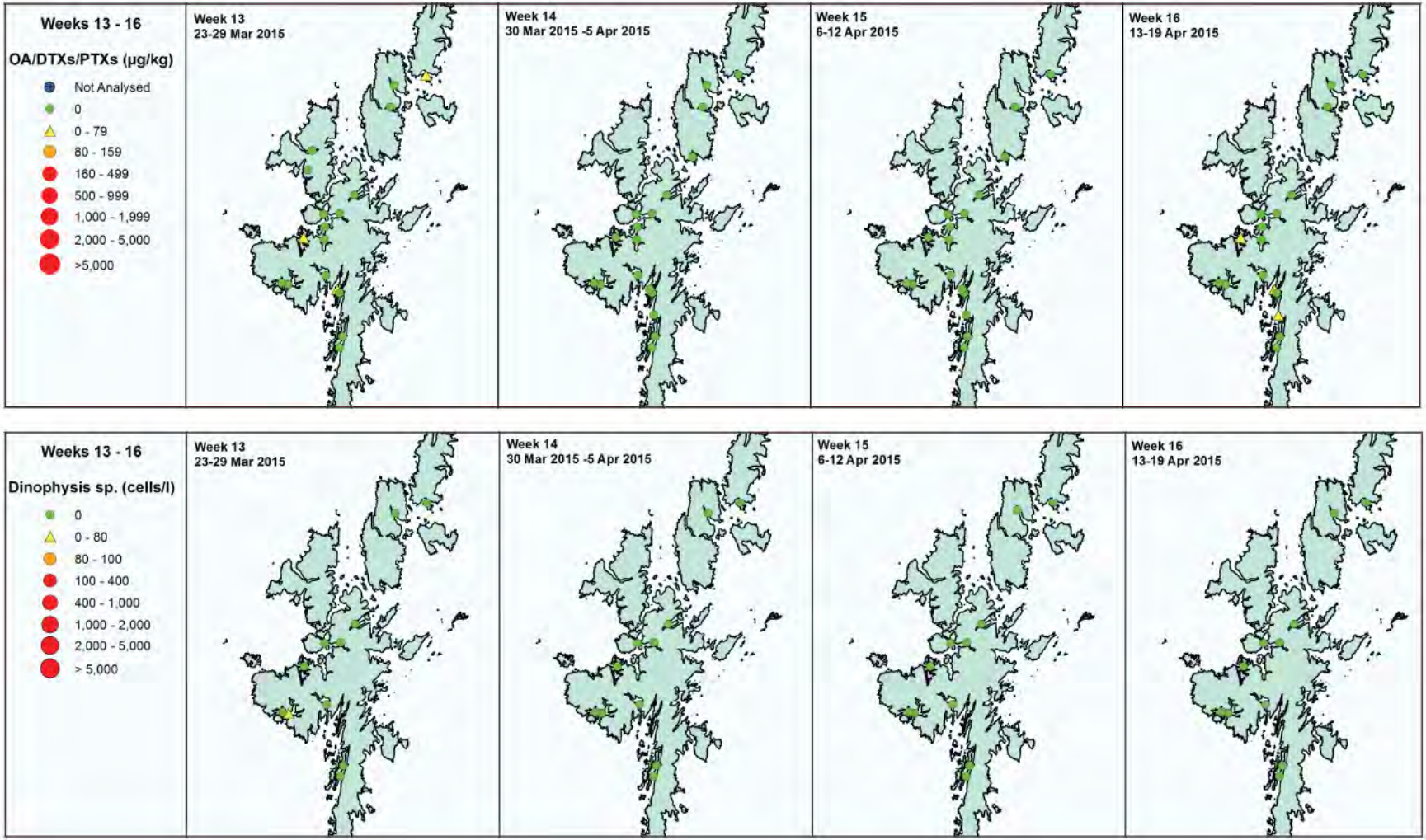
NOTE:

This page is intended as a quick overview of the situation in the Shetland Islands. If the status for a particular species or biotoxin is amber or red please check the relevant pages in the bulletin for more details and specific locations.

RL- reporting limit;
LOQ – Limit of quantification

Shetland Bulletin on the status of harmful & toxic algae Week 16, 13th - 19th Apr 2015

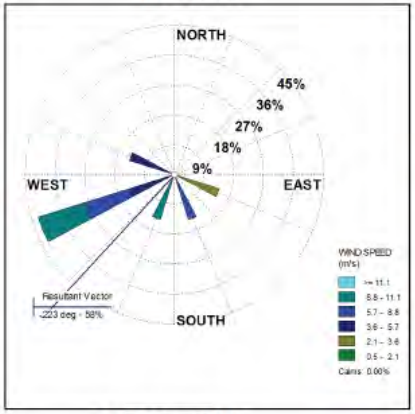
Diarrhetic shellfish poisoning toxins & causative phytoplankton



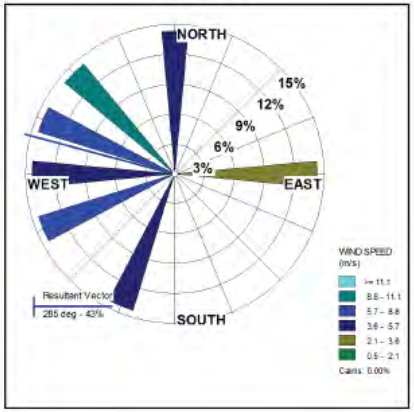
Shetland Bulletin on the status of harmful & toxic algae Week 16, 13th - 19th Apr 2015

Mean wind direction observed in Shetland for current and preceding three weeks

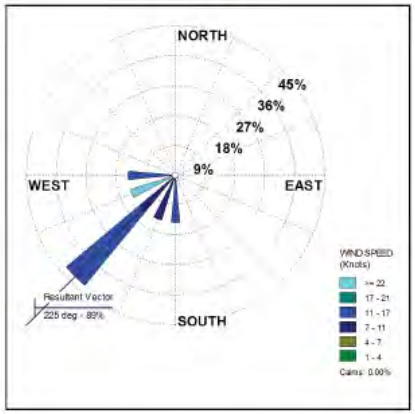
Week 13



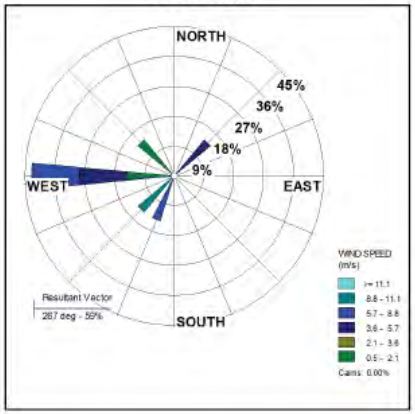
Week 14



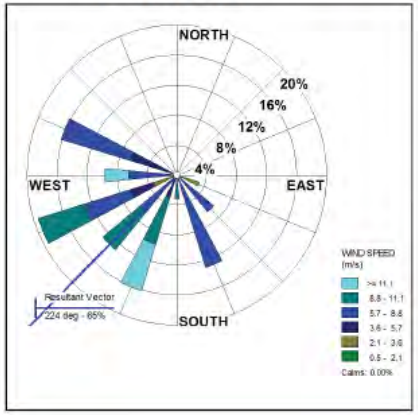
Week 15



Week 16



March 2015



Mean wind direction and speed observed in Shetland over the past four weeks. Higher wind speeds are shown in lighter shades. The percentage of time the wind blew from any particular direction is shown by the length of the triangle. The resultant vector, represented by the blue line, shows the average wind direction for the week. It is based on wind direction only and includes periods of calm which are not indicated on the diagram.

For information the mean wind direction for the month of March is also shown.

Status:

Over the past week the average wind direction has been from the West.

Predictions:

There is little chance that there will be wind blown *Dinophysis* blooms in Shetland this week at this time of the year.

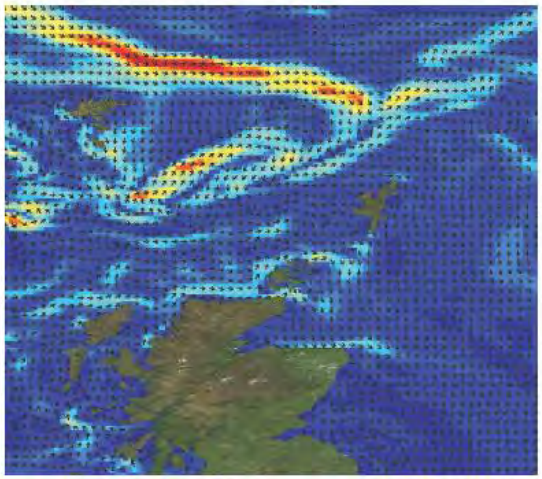
Why do we think this?

During the summer *Dinophysis* can bloom out at sea and at shelf fronts found off the West of Shetland. Westerly winds can then blow these blooms into shore. Wind for the past week has been predominantly from the West however at this time of the year wind blown blooms of *Dinophysis* are unlikely.

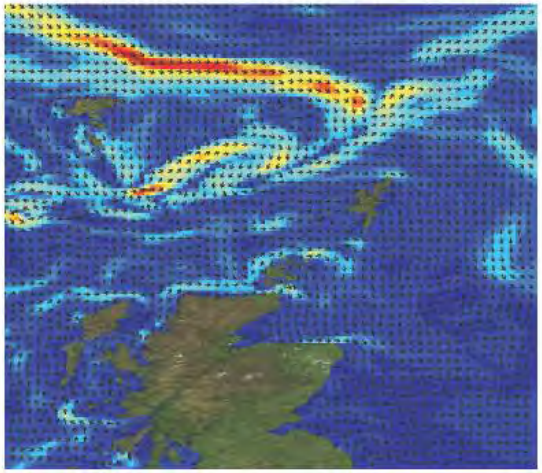
Shetland Bulletin on the status of harmful & toxic algae Week 16, 13th - 19th Apr 2015

Forecasted Sea Surface currents for the next five days

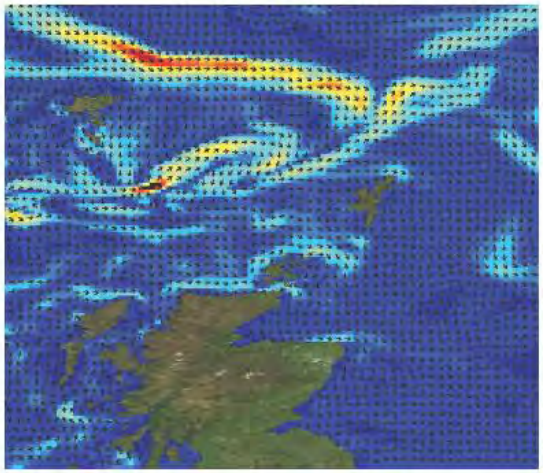
21 April 2015

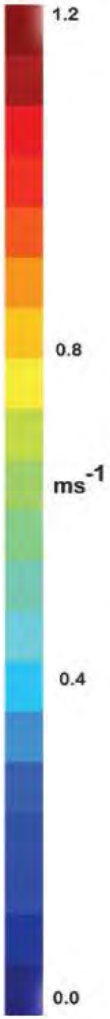


22 April 2015

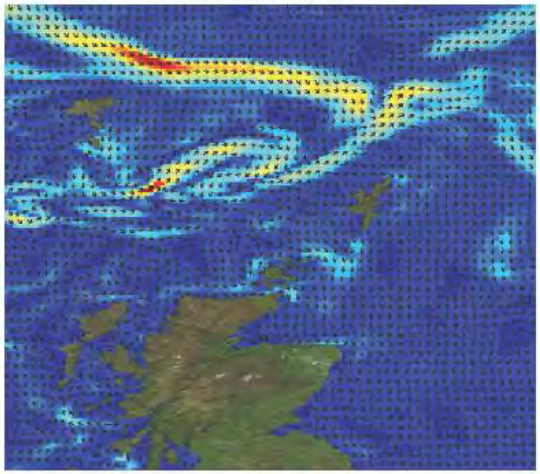


23 April 2015



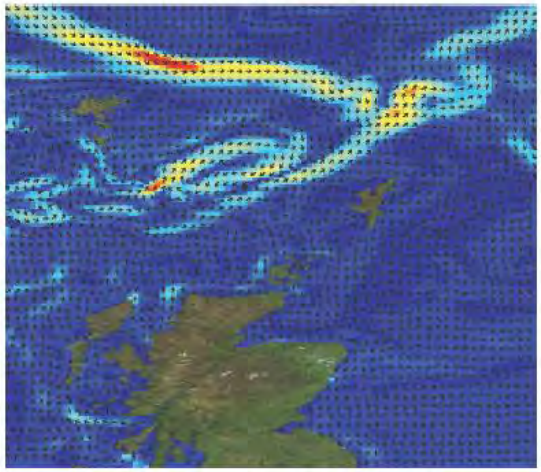


24 April 2015



These diagrams show the predicted current directions around Shetland for the next five days. Greens to reds indicate stronger currents. In general strong currents run parallel to the deep water channel between the Faroes and Shetland. Problems can arise when these currents turn Eastwards potentially carrying *Dinophysis* and *Karenia mikimotoi* blooms, from the shelf edge, into shore.

25 April 2015



Forecast provided by The forecasting Ocean Assimilation Model 7Km Atlantic margin Model (FOAM AMM7) courtesy of My Ocean.

Summary

Unusually large numbers of *Dinophysis* recorded on the West coast of Shetland during the summers of 2013 and 2006

Accumulation rates exceeded those expected from ideal growth conditions

Dinophysis is an advected species and the significantly high numbers observed during 2006 and 2013 appear to be related to the change in wind patterns which pushed *Dinophysis* into shore where they accumulated

This change in wind direction was related to positive NAO

Weekly risk assessment bulletins use predictions of winds and currents to assess risk of advective blooms

Thanks to….

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European Fisheries Fund

Sustainable aquaculture: health, disease, and the environment research programme