Indicators and trends

Monitoring climate change adaptation

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Indicator name			Version
NM9b Frequency of escapes from fish farms due to weather			25/09/16
Indicator type:	**Risk/opportunity**	**Impact**	**Action**
		X	

SCCAP Theme	SCCAP Objective	CCRA risk/opportunity
Natural Environment	N3 Sustain and enhance the benefits, goods and services that the natural environment provides	MA30 Damage to cultured aquatic species

At a glance

- A total of 2.5 million fish escaped due to bad weather between 1995 and 2015 from Scottish fish farms, of which 21% escaped during a single storm event in 2005.
- Although escape events are less likely to be the result of weather than a non-weather cause, when they are, they are far costlier and on average resulted in six times more fish escaping.
- The North-East Atlantic is predicted to experience increased storm activity but there is a lack of consensus on the future storm and wave climate.

Latest Figure	Trend
2015: There were 7 escape events[1] from saltwater fish farms resulting in the loss of 318,096 fish. 300,000 of these were Atlantic salmon lost in a single weather event impacting on the Western Isles.	There is no discernible trend at present.

Why is this indicator important?

Over 99% of the UK marine finfish aquaculture industry is concentrated in Scotland (Gubbins *et al*, 2013). Most of the stock rearing occurs in farm cages situated in coastal locations. The prediction of wind speeds and therefore storminess is very complex and still uncertain at this time. In general, the North-East Atlantic is predicted to experience increased storm activity (Leckebusch *et al*, 2006). If climate change increases the frequency and intensity of storms as projected, farm cages will be more likely to get damaged, leading to increased numbers of fish farm escapes and greater economic

[1] Escape events were included if the final count for number escaped was higher than zero

losses. Storm frequency and intensity are important on two levels; for current practices based in more inshore areas and for future practices which may involve expansion of the industry into more offshore areas and by definition more exposed locations.

In addition to the economic losses due to fish farm escapes there is also the risk of impact on the surrounding ecosystem, including hybridisation with wild populations and competition for food and habitat.

What is happening now?

The Scottish finfish aquaculture industry is largely made up of salmonid farms (Atlantic salmon [*Salmo salar*] and Rainbow trout [*Oncorhynchus mykiss*]) with some Brown trout [*Salmo trutta*].

There were seven escape events during 2015 from saltwater[2] fish farms resulting in the loss of 318,096 fish. The majority (300,000 or 94%) of these were Atlantic salmon lost in a single weather event resulting in escapes from a farm in the Western Isles (Table 1).

Table 1 Scottish seawater fish farm escapes due to weather in comparison to all escape events

	Escape events due to weather		Escaped fish due to weather	
Year	**Number of escape events**	**Proportion of all escape events (%)**	**Number of escaped fish**	**Proportion of all escaped fish (%)**
1995	1	100	20,000	100
1996	0		0	
1997	0	0	0	0
1998	0	0	0	0
1999	2	25	110,000	54
2000	4	31	561,237	91
2001	1	11	9,000	17
2002	4	40	300,755	85
2003	2	17	10,150	9
2004	1	11	45,000	60
2005	8	62	218,322	52
2006	0	0	0	0
2007	2	18	14,400	16
2008	3	38	34,047	55
2009	0	0	0	0
2010	0	0	0	0
2011	2	25	370,225	92
2012	1	33	25,623	75
2013	0	0	0	0
2014	0	0	0	0
2015	1	14	300,000	94
Total	32	19	2,018,759	61

[2] There were no escape events in 2015 from freshwater farms resulting in any fish being recorded as escaping

There is now legislation making it compulsory to report all fish farm escapes (Aquaculture and Fisheries (Scotland) Act 2007). In addition, the industry's Code of Good Practice[3], coupled to recently agreed technical standards for marine cage fish farms should contribute to an overall reduction in escapes. It is expected that these standards will be introduced into legislation.

What has happened in the past?

A total of 2.5 million fish escaped between 1995 and 2015 due to bad weather from all Scottish fish farms[4], with 2 million of these being from saltwater farms. One storm event in 2005 resulted in losses from eight different farms and the overall loss of half a million fish, with approximately 160,000 of those being from salt water farms.

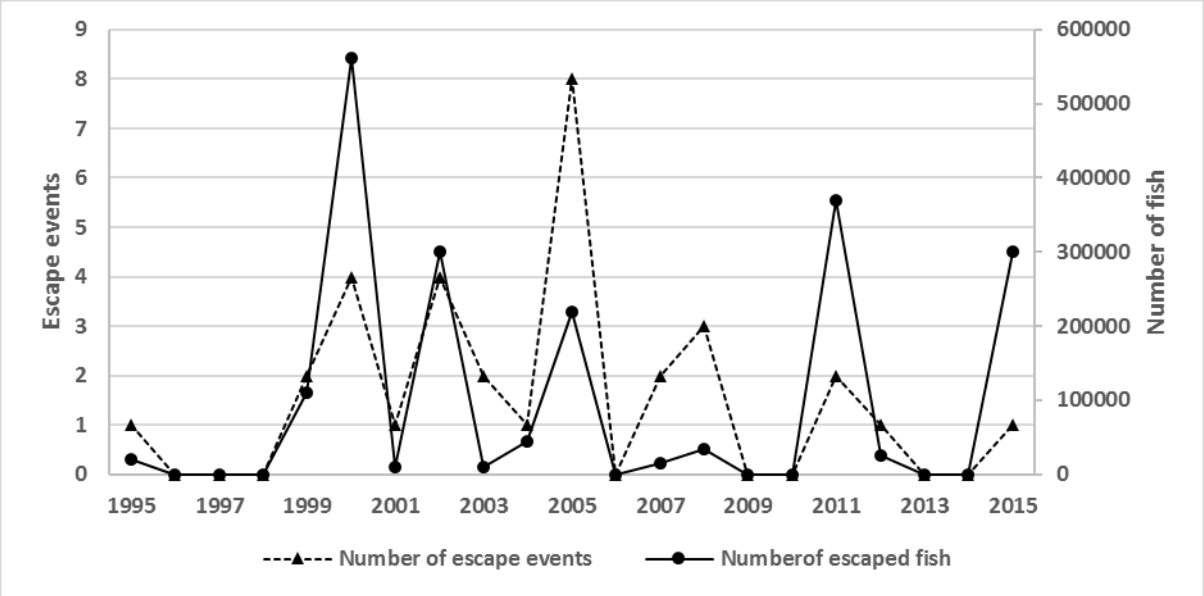

Figure 1 Weather related escape events and numbers of fishing escaping from saltwater fish farms in Scotland (1995-2015)

The number of events and number of fish escaping as a result is extremely variable and there has been no significant trend over this 20-year period (Figure 1).

Although weather related events represented just 19% of all escape events from seawater fish farms, these accounted for over 60% of the total number of fish which escaped (Table 1).

Table 2 Average number of fish escaping from an escape event in Scottish seawater fish farms (1995-2015)

Mean number of fish escaping per incident		
All events	**Non-weather events**	**Weather events**
18,273	**9,239**	**58,187**

[3] http://www.thecodeofgoodpractice.co.uk/index.php

[4] In total 4.3 million fish escaped during the same period, including those due to bad weather

In summary, Table 2 shows that although weather related events were less likely to occur during this period than non-weather events (e.g. as a result of human error, wear and tear or predation), they were far costlier when they did and on average resulted in six times more fish escaping.

What is projected to happen in the future?

The prediction of wind speeds and therefore storminess is very complex and still uncertain at this time. The uncertainty increases when you try and predict regional differences, such as those in Scotland. However, forecasts project an increase of up to 10% in the 20-year return period daily mean wind speeds in some seasons in Scotland (Gubbins *et al* 2013). In general, the North-East Atlantic is projected to experience increased storm activity (Leckebusch *et al*, 2006). In the short term, climate change is unlikely to have a significant effect on the farmed marine fish industry (MCCIP, 2012). However, if legislation and technical standards for fish farms fail to track the potential changes in storm frequency and intensity then the risks of escapes will continue or even increase. This will be particularly significant if the farmed finfish sectors expand into more exposed offshore locations.

Patterns of change

Although the implications of storm events on fish farms is clear, there is a lack of consensus on future storm and wave projections and it is unclear how the fish farm industry might respond.

Interpretation of indicator trends

The number of escapes is highly variable and does not have a significant relationship to the fluctuations in the size of the industry (Figure 2)

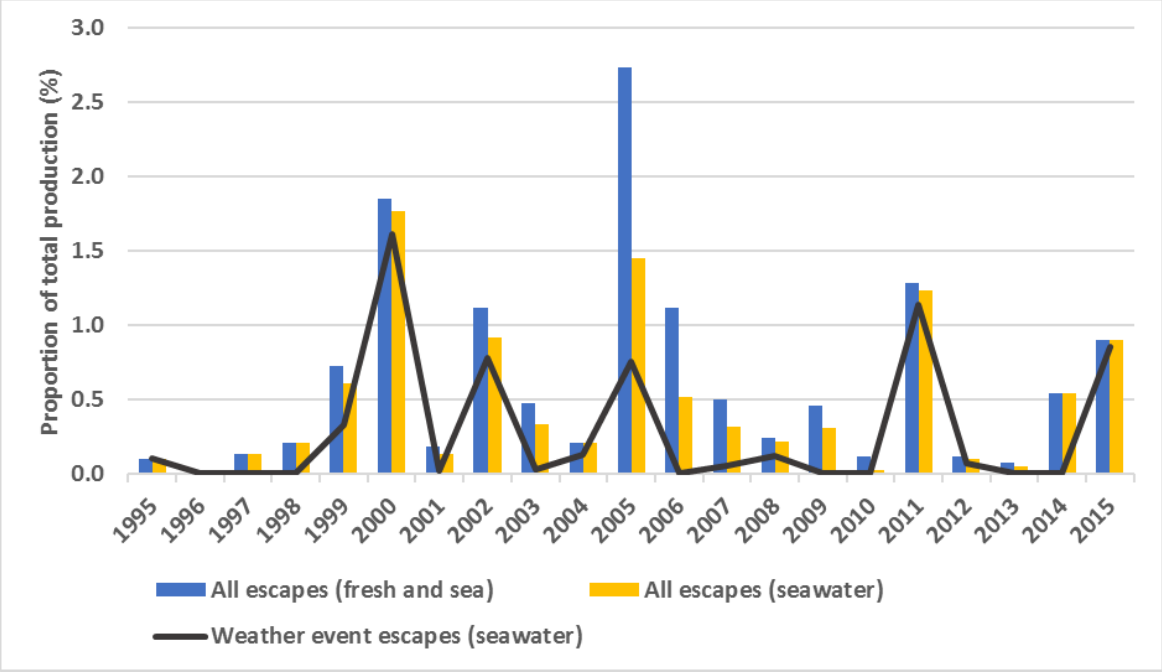

Figure 2 Fish farm escapes as a proportion (%) of total production numbers[5]

[5] Total production numbers calculated by adding the numbers harvested year 0, 1 & 2 for each year

A long-term increase in escapes or escape events due to bad weather would imply the industry is vulnerable to the increasing storm frequency and intensity and the industry and/or legislation is failing to adapt to the changing environment. However, this data could be confounded by other factors such as malpractice, actions of predators and equipment failure.

Greater industry responsibility/awareness and the legislation making it compulsory to report all fish farm escapes are likely reasons for the reduction in escapes. However, capacity to police and implement existing legislation is still a limiting factor. Recently agreed technical standards for marine cage fish farms should contribute to an overall reduction in escapes and it is expected that these standards will be introduced into legislation.

Limitations

Legislation making it compulsory to report all fish farm escapes was only introduced in 2012 (Aquaculture and Fisheries (Scotland) Act 2007), therefore it is not clear to what extent escapes prior to this date went unreported.

Comparative total production figures are based on Atlantic salmon alone (total production numbers calculated by adding the numbers harvested year 0, 1 & 2 for each year). Fish farming of other species accounts for just approximately 3% of total tonnage, therefore only salmon production numbers were used. Production data did not distinguish between fresh and seawater farms, therefore comparison figures present data on escapes from all (freshwater and sea water) farms as well.

Published escape data contained inconsistent entries for numbers of fish escaping and therefore it was necessary to adjust fish escape numbers to enable analysis (e.g. conversion of text to numerical data, use of a midpoint figure where a range was given etc.)- see methodology for more detail.

References

Gubbins, M., Bricknell, I. & Service, M. (2013) *Impacts of climate change on aquaculture*. MCCIP Science Review 2013, 318-327, doi:10.14465/2013.arc33.318-327.

Leckebusch, G.C., Koffi, B., Ulbrich, U., Pinto J.G., Spangehl, T. & Zacharias, S. (2006) Analysis of frequency and intensity of European winter storm events from a multimodel perspective, at synoptic and regional scales. *Clim. Res*., 31, 59-74.

MCCIP (2012). *Marine Climate Change Impacts on Fish, Fisheries and Aquaculture*. (Eds. Frost M, Baxter JM, Buckley PJ, Cox M, Dye SR & Withers Harvey N) Summary Report, MCCIP, Lowestoft, 12pp.

Further information

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

Taylor, M. & Kelly, R. (2010) Assessment of Protocols and Development of Best Practice Contingency Guidance to Improve Stock Containment at Cage and Land-based Sites Volume 1: Report. pp 74. ISBN: 978-1-907266-30-0

Acknowledgements
Initial development of this indicator: Andrew Blight (MASTS) Marine Scotland Policy and Marine Scotland Science for advice Marine Climate Change Impacts Partnership (MCCIP)

Appendix One: Indicator metadata and methodology

Table 1: Indicator metadata

	Metadata
Title of the indicator	**NM9b Frequency of escapes from fish farms due to weather**
Indicator contact: Organisation or individual/s responsible for the indicator	**Anna Moss** (CXC, University of Dundee)
Indicator data source	Marine Scotland and Industry
Data link: URL for retrieving the indicator primary indicator data.	Marine Scotland data held on the Scotland's Aquaculture website:- (http://aquaculture.scotland.gov.uk/data/data.aspx)

Table 2: Indicator data

	Indicator data
Temporal coverage: Start and end dates, identifying any significant data gaps.	Data held for 01/01/1995 to present Pre 2012 – voluntary reporting of escapes Post 2012 All registered fish farms mandatory reporting
Frequency of updates: Planned or potential updates	Updated with each incident reported
Spatial coverage: Maximum area for which data is available	Scotland and Islands within Scottish territorial waters
Uncertainties: Uncertainty issues arising from e.g. data collection, aggregation of data, data gaps	Regulation and statutory data collection requirements will help reduce uncertainties
Spatial resolution: Scale/unit for which data is collected	Farm by farm
Categorical resolution: Potential for disaggregation of data into categories	Escapes are categorised by location, species, life stage, age, weight and numbers of fish
Data accessibility: Restrictions on usage, relevant terms & conditions	Statutory data - public domain

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.
Marine Scotland via Scotland's Aquaculture website: http://aquaculture.scotland.gov.uk/data/data.aspx Comparative data on total production numbers taken from The Scottish Fish Farm Production Surveys: http://www.gov.scot/Topics/marine/Fish-Shellfish/FHI/surveys

Table 4 Indicator methodology

Indicator methodology The methodology used to create the indicator data
Data source fish escapes: http://aquaculture.scotland.gov.uk/data/fish_escapes.aspx Data source production: 1997-2014 (Tables 25 and 28) http://www.gov.scot/Resource/0048/00484806.pdf 1995 (Table 21b) http://www.gov.scot/Resource/0045/00459903.pdf 1995 & 1996 (Table 24b) http://www.gov.scot/Resource/0045/00459905.pdf Data on fish farm escape events from saltwater farms due to 'Weather' events was compared to data on all farm types and all causes. 'Final number escaped' column was used for fish escape numbers. Due to inconsistencies in data entry, adjusted figures were created where necessary:

Original	**Adjusted**
Blank	'Initial number escaped' data used if present
Numbers as text	Converted to numerical
Entries with additional text	Interpreted into numerical data
Range given	Midpoint selected
'Unknown'	'1' to register as an event resulting in escapes

Only events which resulted in escapes of fish greater than zero were used in the analysis:

No. of escape events with zero escapes:	
All escapes	60
Seawater escapes	44
Seawater weather events	3

'Final escape reason' was utilised to identify weather related incidents. A few data entries were blank in this column and therefore an adjusted version was created using the 'Initial escape reason' in place of blanks.