

Escapes primarily caused by equipment failure

February 7 2013, by Torkil Marsdal Hanssen



A wellboat pumping fish out of a plastic sea-cage facility which was “completely incapacitated” due to the progressive collapse of the mooring system. Credit: Østen Jensen, Sintef

Equipment failure or operational error are behind three out of four farmed salmon escapes. Two out of three escapes are due to holes in sea cage nets.

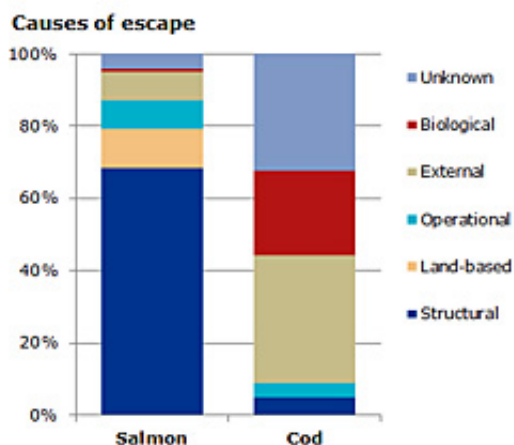
Researchers working on the SECURE project (Securing fish – farming technology and operations to reduce escapes) have analysed all escape incidents between 2006 and 2009 reported by Norwegian fish farms. Their efforts provide the industry and researchers with new insights into the factors leading to loss at Norwegian production facilities.

Structural failures most common

Equipment failure or damage is the major factor behind the escape of farmed salmon. Figures from the SECURE project show that 68 per cent of escapes occurred because of structural failure. An additional eight per cent were able to escape due to human error during operations. Eleven per cent of escapes took place from land-based facilities and an equal percentage escaped due to external factors. All in all, the researchers have revealed clear explanations for 96 per cent of the total escapes reported from 2006 to 2009.

Factors changing over time

"Common structural failures include problems with mooring lines, collapsed floating collars and holes torn in the netting of a sea cage. [Bad weather](#) is another factor contributing to structural failure and escape. We have also documented incidents of automatic feeding devices loosen and causing damage," says Østen Jensen, Research Manager with SINTEF Fisheries and Aquaculture and project manager of the SECURE project.



Causes of escape for salmon and cod, 2006-2009.

The escape incident reports reveal that equipment suppliers and fish farmers have managed to solve some of the equipment problems that previously led to a high number of escapes.

"Escapes caused by mooring or floating collar failure have become more and more rare. The greatest challenge now facing producers of salmon and trout is how to prevent wear and tear to the netting. Holes formed from chafing contact between the net and the sinker tube chain were responsible for more than 50 per cent of total escapees between 2008 and 2010," Dr Jensen says.

Fewer large-scale escape events

Operational error during activities such as delousing or maintenance, combined with fish transfer, account for close to 20 per cent of the escape figures. The last large-scale salmon escape event, in which 175 000 fish escaped a production facility in Trøndelag, occurred in connection with delousing.

"Large-scale escape events in which more than 10 000 fish are involved comprise 19 per cent of the total number of escapes during the period studied. As much as 91 per cent of all fish that escaped can be attributed to large-scale events," states Dr Jensen.

The reduction in the number of large escape events is the most significant factor behind the substantial reduction in the number of production salmon escapees from 2006 to 2009.

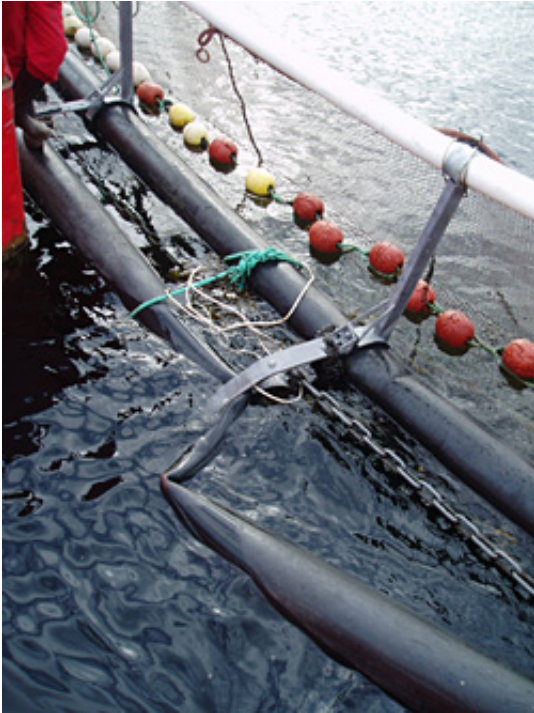
Characteristics of fish likely to escape

Behavioural differences among the various species of farmed fish also play into the risk of escape. Whereas only one per cent of salmon escapes can be attributed to biological factors, one out of every four escaped farmed cod got out through holes in the nets caused either by predators or the cod themselves.

"In contrast to salmon and trout, cod will often bite the netting and tear the net wall. The cod also display more interest in such [holes](#) and are far more eager than salmon or trout to try to swim through them," adds Østen Jensen.

Improved reporting

Fish farmers are required to report all escape events to the Directorate of Fisheries. SECURE project manager Østen Jensen says that escape incident reporting has improved substantially since the Norwegian Aquaculture Escapes Commission (AEC) introduced a notification template five years ago.

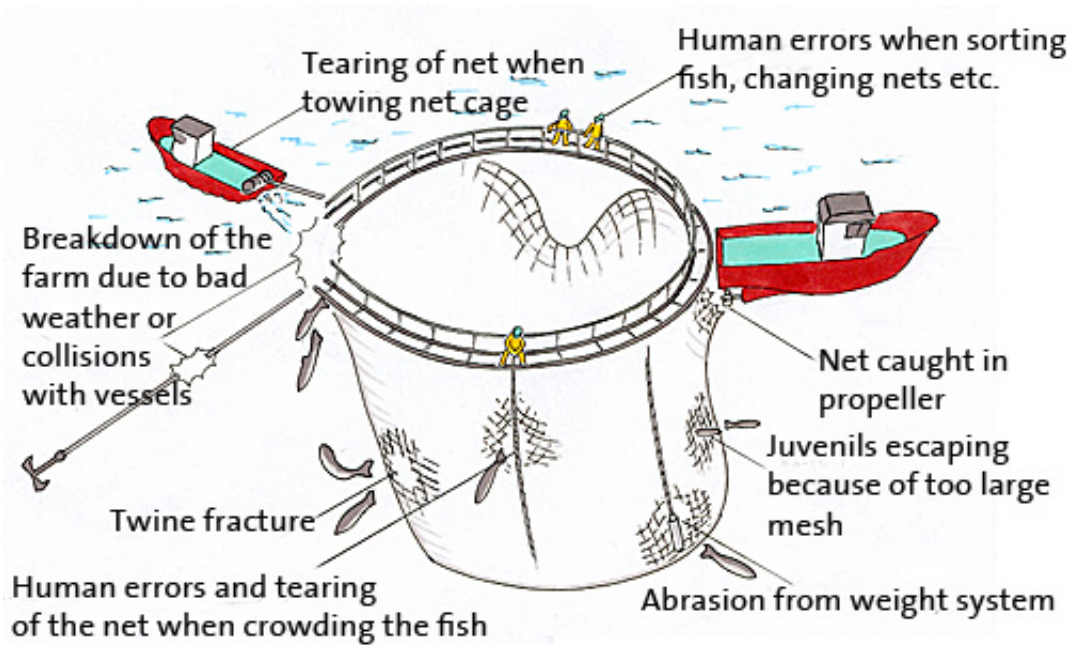


Visible damage to the floating collar caused by the progressive collapse of the mooring system. Credit: Østen Jensen, Sintef

Source for figures on the various causes of escapes among Atlantic [salmon](#), rainbow trout and Atlantic cod from 2006 to 2009:

Placing responsibility on suppliers

Two problem areas stand out in the efforts to reduce the risk of escapes in Norwegian aquaculture. Østen Jensen believes that both can be solved by the suppliers of aquaculture equipment.



The illustration shows common escape factors with special focus on holes in the nets and sea-cage operations. Credit: Mats A. Heide, Sintef

"If the aquaculture industry is ever going to realistically realise its vision of zero escapes from sea-based production facilities, it must solve two big challenges. The first is that weighting systems currently in use to maintain the shape and volume of the net pens lead to wear and tear in the netting. The second is finding ways to decrease the incidence of operational – or human – error," says Research Manager Østen Jensen of SINTEF Fisheries and Aquaculture.

Solutions can be developed

Dr Jensen, an engineer, points out that the key to solving both challenges can be found in the supplier industry:

"Improved product design and procedures can mitigate and, in part,

prevent both wear and tear as well as [human error](#) during operations at sea. Much of the equipment in use in sea-based facilities should be redesigned and simplified to make it difficult or impossible to use incorrectly. Under the SECURE project we have acquired the knowledge needed to develop better and more secure solutions. The next step is up to the suppliers," Dr Jensen believes.



A clear sign of cod curiosity: Instead of swimming around a panel of netting, the fish has tried to swim through an impassable hole. Photo: Project on escape-free net cages for cod

Suppliers have already begun applying the documented findings from the SECURE project to test new solutions. The Research Council of Norway allocated funding to two new research projects this year (Towards sustainable fish farming at exposed marine sites [SUSTAINFARMEX 2011-2014] and Exposed Farming) that have carried out modelling tests using nets with integrated sinker tubes.

Certification scheme improves safety

The SECURE project has documented a number of factors significant for avoiding net abrasion and tearing:

- Insufficient weighting of net-cages, use of exceedingly large nets, sea-current conditions and biofouling lead to net deformation and risk of abrasion and tearing.
- Washing nets by machine reduces the strength of net threads by 10-20 per cent after 4-5 washings.
- Attaching the sinker tube to the net has proven to be a more secure solution than than using sliding connectors.
- Conic net pens create more distance between the net and the chain, reducing the risk of abrasion and tearing. In spite of this, the majority of net pens are currently cylindrical in shape.

"Fish producers are able to buy freely on the market and can purchase nets and floating collars separately. It is by no means automatic that the net chosen will suit the selected floating collar when assembled. We need to have a more integrated approach to the design of [fish-farming](#) systems to ensure that components are compatible," explains Dr Jensen, who believes the introduction of facility certification is a step in the right direction.

Providing input for regulations

Starting 1 January 2013, all fish-production facilities in Norway must have certification stating that the facility is using compatible components.

"The SECURE project has provided knowledge of importance to the design of regulations that that will form the basis for facility certification, among other things. We have seen that the layout of a

facility combined with wave size can have unforeseen consequences. The highest wave does not always carry the greatest force. We have found examples where a low-crested wave exerts much greater force on a facility than a steep wave. Twice the force is not unusual, and this should obviously be incorporated into the specifications for the design and dimensions of a production facility," Østen Jensen concludes.

The Houdinis of the sea

Cod are better escape artists than other species of production fish, opting to swim through obstacles rather than around them.

As part of the SECURE project, researchers at Norwegian Institute of Food, Fishery and Aquaculture (Nofima) have analysed the behavioural characteristics of cod which make them more likely to escape than other production species. Using controlled experiments, researchers have studied how they behave in sea cages.

Cod constantly bite and nibble on the net threads, showing great interest in investigating anything that appears unnatural to their environment. This affects how net repair should be approached at cod-production facilities. Repairs are most effective when colours and shapes of the repaired netting conform to the original. The ends of threads need to be affixed so that the repair will not deviate in appearance from the rest of the netting.

More information: Source for figures on the various causes of escapes among Atlantic salmon, rainbow trout and Atlantic cod from 2006 to 2009:

Jensen Ø., Dempster T., Thorstad E. B., Uglem I., Fredheim A. 2010. Escapes of fish from Norwegian sea-cage aquaculture: causes, consequences, prevention. *Aquaculture Environment Interactions* 1: 71-83

Provided by The Research Council of Norway

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