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Consultations and discussions were undertaken with a range of organisations and individuals throughout the supply chain including suppliers to the industry, fish farmers and supermarkets as well as wider stakeholders such as non-governmental organisations (NGOs) and academics. Regulators and industry bodies from various salmonid producing nations also provided information for the project. They all engaged with interest and their contributions were essential to the successful conclusion of this project.

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It should be noted that this is an independent report which is presented in good faith and represents the views of the authors.

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Executive Summary

1. This study aimed to investigate and assess escape incidents in respect of Scottish finfish farming, using existing information and research undertaken specifically for this project. The study included a literature review, desk based research, detailed consultations with fish farmers and suppliers. Key findings are summarised below.

Magnitude and Causes of Escape Incidents

2. Between May 2002 and October 2009 (inclusive) there were 136 reported escape incidents, resulting in 2.18 million reported escaped fish. Figures peaked in 2005 due to a particularly severe storm which was responsible for 12 escape events and 821 thousand (k) escaped fish. Whilst 2008 saw the lowest losses to date, 2009 surpassed this figure (with 14 escape incidents and the loss of 141k farmed finfish as of the end of October) and hence there is no indication that the trend is towards zero or minimal escapes. Escapes range from between 0.5 fish per tonne of farmed fish produced (2003 and 2008) to 6.6 fish per tonne in 2005, although if 2005 is excluded the average is between 0.5 and 2.6 fish per tonne of production.

3. Containment requirements in Scotland are primarily delivered through voluntary adherence to the Code of Good Practice for Scottish Finfish Farming (CoGP) introduced in 2006. Within the trout farming sector, the CoGP was benchmarked against an existing farm management scheme (Quality Trout UK (QTUK)) to ensure parity of the standards and trout farms are thus inspected and audited against the QTUK standard, itself containing the same containment requirements as the CoGP and subject to similar independent audit and reporting. Both documents seek to address all industry husbandry standards and are not specifically containment standards. Whilst there has been a reduction in the number of escape *incident*s since 2006 and some indication of a reduction in the number of escaped *fish* (although trends in the latter are less well developed), there is no indication that the trend is towards complete containment.

4. Sixty per cent of all escape incidents during the reporting period were from sea water cages. Seventy five per cent of all escape incidents were Atlantic salmon, with rainbow trout the second most important species by far. Therefore, to improve containment, it is necessary to address both sea water and freshwater operations and to focus on salmon and rainbow trout.

5. Other salmon and trout producing countries also experience escapes. Whilst comparisons of statistics should be treated with caution due to differences in the size and nature of industries (i.e. husbandry methods) and in the way data are collected, it is apparent that there are some differences between countries and provinces. Fish farmers in British Columbia and Newfoundland and Labrador have experienced some years without an escape incident. Considering the number of escapes per tonne of production, Newfoundland and Labrador and British Columbia have typically had the lowest in recent years, with Chile the highest and Norway and Scotland in between.

6. One main objective of this study has been to characterise Scottish escape incidents in order to obtain a greater understanding of the causes of escapes based on detailed discussions with fish farmers. Where possible, each incident has been characterised in terms of the immediate cause(s) (e.g. hole in the net), the underlying causes (e.g. chafe/snag) and contributory factors (e.g. use of equipment, weather etc). A total of 134 incidents have been characterised for this project meaning that just two remained uncharacterised.

7. The body of the report and accompanying annexes provide detailed breakdowns of escape incidents since statutory reporting was introduced in Scotland – between May 2002 and October 2009 – according to immediate and underlying causes as well as identifying contributory factors. The box below highlights the most important immediate (IC) and underlying causes (UC).

The highest number of incidents (26%) were due to holes in the net (IC) caused by predation (UC) although this only accounted for the third highest number of escaped fish (12%).
The second highest number of incidents (17%) were due to holes in the net (IC) caused by chafe/snag (UC) which resulted in the fourth highest amount of escaped fish (9%).
The third highest number of incidents (7%) were a result of cage/mooring failure (IC) caused by the use of inappropriate cages (UC). This accounted for by far the highest number of escaped fish (23%) and was very much influenced by the January 2005 storm[1].
The fourth highest number of incidents (4%) were due to cage/mooring failure (IC) caused by the use of inappropriate moorings (UC). This was responsible for the second highest number of escaped fish (16%) and, again, was largely related to the January 2005 storm.
All other immediate causes each accounted for 5% or fewer of incidents and included fish handling, net under water, freshwater screen failure, vandalism, helicopter bucket incident, transfer pipe failure, flooding and well boat collision. Whilst most of these incidents accounted for a relatively small number of escaped fish, there was one particularly large net under water incident and flooding, although accounting for just 1% of incidents resulted in 5% of escaped fish.

8. The insight into escape incidents provided by the above information suggests that more detailed and more accurate information on escape incidents should be supplied by industry. This should include the immediate investigation of significant incidents by persons with appropriate technical knowledge and industry experience.

Observations and Recommendations

9. There has been an increasing use of plastic circular cages and mooring grids which were considered more appropriate than their steel counterparts for use in more exposed locations, as well as a general increase in the specification of

[1] More information on the storm event is provided in Volume 2.

equipment at cage sites. This has led many farmers to be confident that their sites would withstand a storm of the severity of the January 2005 event.

10. Whilst many cage sites are designed and specified by professionals, some have been and continue to be developed on the basis of a farmer's experience. This is of concern since it does not necessarily ensure a robust design. Further, environmental monitoring was not always sufficient to provide a satisfactory basis for installation design.

11. It is recommended that a technical standard be developed which sets out the minimum requirements for *new* and *modified* cage sites in both sea water and freshwater. Compliance should be mandatory. This should be based on appropriate environmental monitoring data and designs (based on worst case conditions) undertaken or verified by professionals. An appropriate vehicle would be the proposed ISO aquaculture standard or a Scottish technical standard and it is recommended that the Scottish aquaculture industry should commit to a technical standard suited to Scottish circumstances as well as fully engaging in the development of an ISO standard.

12. This technical standard should address site layout, moorings, cages, nets and maintenance. It should be based on a locality classification such that more exposed sites require more robust equipment. It should also specify a return period[2] and engineering standards to be used for the basis of designs and require that installations can suffer the failure of at least one key component without a breakdown of the overall system.

13. The integrity of *existing* cage sites should also be assessed. A staged approach is recommended, with an initial screening so as to focus on those which may not have been designed by a mooring professional or where the original specification may now be out of date. Any sites where installations may be of concern should be required to upgrade.

14. A standard protocol for net testing is required. Whilst concerns about the efficacy of net testing are noted, this is the only mechanism available to help the industry assess net condition and its use should be enforced forthwith across all sectors of the industry.

15. A number of operational and training issues were identified which could help reduce the likelihood of escape incidents at cage sites from predators and chafe/snag. These should be included in a revised CoGP and QTUK which should apply across the entire industry[3]. One key measure is the visual inspection of nets on a regular basis. A risk assessment approach is recommended to ensure that the measures taken are appropriate to the site; guidance and examples of assessment methodology and mitigation measures should be provided.

[2] Such as a one in fifty year storm, one in a hundred or other as appropriate confirmed after discussion with meteorologists and engineers.

[3] Whilst the majority of farmed finfish in Scotland is currently produced in accordance with these standards, a small proportion is not.

16. Industry standards such as the CoGP /QTUK should be used to address more minor causes of escapes, including those from freshwater tank sites and during fish transfer operations. This should include the use of mortality tanks or similar to prevent escapes from freshwater tanks reaching the external environment and the specification of screen materials for land-based sites.

17. Compliance with the new and revised protocols should be enforced through widening the scope of the Government's containment inspections undertaken by Marine Scotland. .

18. Training is a key issue. Consideration should be given to including containment and aquaculture engineering within a national qualification scheme for aquaculture. However, staff who are unlikely to become involved on such schemes should also receive training on the importance of containment and on the measures required to ensure effective containment on the equipment they are using prior to starting work. The lack of opportunity for staff to train on unstocked sites where they can appreciate the consequences of different actions is of concern and consideration should be given to a national training centre (which could also be used as a research centre). Containment should also be included in the syllabus of training courses for operators of boats, forklifts and cranes.

19. Whilst net tensioning is a key defence against predator attack, no information on the required tension is available to farmers. Similarly, farmers did not have information on the ability of different weighting systems and approaches to net design to help address both predator attack and chafe/snag issues. Nor do farmers have technical information on the ability of different cages and related equipment to withstand different environments. Therefore, research in these areas is recommended.

20. Farmers reported that one acoustic deterrent device (ADD) had delivered consistent results in preventing seal attack at sea water sites over recent months. These findings should be monitored over the medium term since if this continues to be successful it could be very beneficial to the industry and consideration should then be given to making its use mandatory.

21. There is no indication that net innovation or closed containment technology will provide practical or cost-effective solutions in the near future, although international research projects on these issues should be monitored.

22. The recently established Scottish Government Improved Containment Working Group, along with industry representatives, should play a pivotal role in the establishment of a new approach to containment. This should include input into setting up any new technical standard and promoting any new standard to the management boards of existing standards – e.g. CoGP / QUTK reviewing the existing CoGP and QTUK. They should also direct and review escape investigations and have the powers to recommend protocol changes accordingly.

23. Most farmers take the issue of containment seriously, as is evident in the high level of investment in new equipment and in experimentation with the use of

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