An overview of escaped salmonids and their potential impacts in Tasmania.

The Tasmanian aquaculture industry produced 18,926 tonnes of HOGG (Head on, gilled and gutted) Salmonids in 2005/2006 (pers com, Tim Paice, DPIW). The industry is located in five Marine Farming Development Plan (MFDP) areas located in four distinct geographical areas of Tasmania. These are the Tamar Estuary MFDP in northern Tasmania, the Macquarie Harbour MFDP in western Tasmania, the Tasman Peninsula and Norfolk Bay MFPD on the Tasman Peninsula and the D'Entrecasteuax Channel and Huon River and Port Esperance MFDP's in southern Tasmania.

Fish are grown in either polar circles or steel system cages. These cages use a variety of net types to hold the fish, including standard polypropylene mesh antifouled nets, zinc mesh nets and brass mesh nets. The majority of these nets have a protective outer predator net to reduce stock loss. The industry predominantly use copper antifouled mesh nets and these have been proven to reduce fish mortalities from seal strikes and the frequency of net changes (pers comm, Trevor Dix, Tassal Operations Pty Ltd).

Escape background

An unavoidable consequence of sea-based marine farming of salmonids in Tasmania is the loss of stock from the cages into the marine environment. This has occurred since the industry began in the mid – 1980's, with losses occurring in all geographical areas for a number of different reasons. Losses can be contributed to either major escapes or minor losses called low level leakage (Naylor *et al* 2005). This low-level leakage may be the result of direct escapes through small holes in the nets, losses when handling the fish and losses from bird and seal strikes. Low level leakage over the course of the growing cycle equates to around 2 - 3% of fish stocked (pers comm, Trevor Dix, Tassal Operations Pty Ltd, Dave Wilkins, Sevrup Pty Ltd).

The annual smolt intake for 2004 was approximately 4.5 million (pers comm, Kevin Ellard, DPIW) which would equate to low level leakage of around 135 000 salmonids across the industry for that year. However, many of the fish that are counted in the 'leakage' figures are potentially removed from the cages through predation by birds, sharks or seals.

In addition to low level leakage, periodic large-scale losses also occur. It is a license condition that these losses are reported to DPIW.

Table 1 provides a summary of the most recent escapes reported to DPIW. This table documents the escape of approximately 250 000 salmonids ranging from 1.2 kg to over 3 kg. This number can be assumed to be conservative as anecdotal evidence suggest that some escapes have gone unreported.

Species Lost	Date of loss	Location	Reason	No. lost	App. size
Atlantic salmon	Late 2000	N W Bay bag system	storm	30,000	
Atlantic salmon	2000	Dover	tear	20,000	
Atlantic salmon	2002	Macquarie Harbour	unknown	20,000?	
Rainbow trout	2002	Macquarie Harbour	unknown	7,000	
Atlantic salmon	2003	Soldiers Point	storm	30,000	
Rainbow trout	2003	Tamar	tear	26,000	
Atlantic salmon	2003	Macquarie Harbour	unknown	25,000	
Atlantic salmon	2004	Macquarie Harbour	unknown	10,000	>3 kg
Rainbow trout	July 2004	Macquarie Harbour	storm	17,734 (count)	1.4 kg
Atlantic salmon	Nov 2004	Macquarie Harbour	tear	23,000	2.2 kg
Atlantic salmon	Dec 2004	Huon River	unknown	2000	>3 kg
Atlantic Salmon	April 2005	Dover	unknown	20,000 ?	1.2 kg
Atlantic salmon (triploids)	May 2005	Macquarie Harbour	hole	20,000 ?	4.1 kg
Atlantic salmon	July 2006	Roberts Point	Fish transfer	8,000	4kg

Table 1. Reported salmonid escape data for Tasmania for 2000 – 2006 (over 500 fish).

The number of escaped salmonids in Tasmania is much less that those reported internationally. World production of Atlantic salmon was 1.4 million tonnes in 2002. An estimate of farmed fish of escapes in the North Atlantic (native range of Atlantic salmon) was made at two million in 2002 (Schiermeier 2003). It is estimated that millions of Atlantic salmon have escaped on the West Coast of North America (Volpe *et al* 2000) and South America since salmonid farming was introduced to these areas (Soto *et al* 2001).

Environmental impacts

There are a number of issues of concern surrounding the escape of farmed fish including the potential for feral species to establish self sustaining populations, the potential impact on native fish through competition for food resources or predation and the potential for disease/parasite transfer from farmed fish to native fish.

Theoretically the unintentional release of farmed fish, increases the likelihood of escaped fish being present when conditions may favour colonisation (Naylor *et al* 2005). However, despite many attempts to establish Atlantic salmon for sport fisheries in numerous countries, these attempts generally failed as the fish showed poor colonisation ability (Naylor *et al* 2005). In contrast to this, escaped farmed salmonids have recently established successful breeding populations in Norway, Ireland, Eastern North America and the United Kingdom (See Hansen *et al* 1997). Incipient feral Atlantic salmon populations have also been documented in South America (Soto *et al* 2001, Pascual *et al* 2002) and in rivers in British Colombia (Volpe *et al* 2000).

In New Zealand, South America and Australia the impacts of Atlantic salmon escapes on native species has been poorly documented (Naylor *et al* 2005) but predation and competitive interaction by introduced salmonids in these regions has reshaped native fish communities (Crowl & Townsend 1992, Pascual *et al* 2002). In the case of Tasmania the introduction and establishment of wild breeding populations of rainbow

and brown trout to many of the State's waterways has resulted in the decline, and in one instance extinction, of native fish (See Jackson 2004).

The Tasmanian Aquaculture and Fisheries Institute (TAFI) has conducted limited research into the impacts of escaped salmonids in Macquarie Harbour. This work involved examining the stomach contents and condition of escaped fish in the harbour. Results indicated that escaped Atlantic salmon and rainbow trout were losing condition and did not appear to successfully forage outside of the nets, which supports the contention that escaped fish do not appear to thrive in the wild (*Steer et al* 2003). Some of the fish examined however, did have prey items in their stomachs that indicates they were feeding on native species and this suggests that more work should be undertaken to achieve a greater understanding of the fate of escaped fish in Tasmania as the TAFI work only involved a small sample size.

Social and Economic Impacts

A number of social and economic impacts may also be associated with escaped salmonids, but to date there has been little work done to estimate these losses. The aquaculture sector bears the direct losses in foregone revenue, loss of capital in the stock and poor public perceptions (Naylor *et al* 2005). Escapes can be seen as a bonus for recreational fisheries, providing extra revenue from new types of exotic fish. Introduced species are the mainstay of recreational fisheries in many counties like the United States, Australia and New Zealand (Naylor *et al* 2005). Recent work from Chile suggests that artisanal fishing effort is shifting towards the capture of escaped salmonids as these species are providing an alternate profitable income source to wild fish (See Soto *et al* 2001).

The economic and social consequence of salmonid escapes in Tasmania appears to vary with geographical area. In the southeast of the State escapes appear to be viewed by the recreational fishing sector as an eagerly anticipated source of sport whereas in Macquarie Harbour it is seen as a problem by the local recreational fishing community.

Estimating economic and social impacts should take into account positive values many people place on farmed salmon and therefore the social losses from escapes needs to be balanced with the gains associated with the aquaculture industry. To maximise net benefits improvements should be made to aquaculture technology and escape management. "Public policy should ensure that economic, social and ecological benefits from aquaculture are jointly achieved " (Naylor *et al* 2005).

Public policy

Even though there are a number of potential environmental, social and economic risks from salmonid escapes, there is little policy in place to addressing this in the major salmon growing regions (Naylor *et al* 2005). An overview of specific regulations as researched by Naylor *et al* 2005 is in Table 2 below.

Country	Facility design	Prevention and response plans	Monitoring and enforcement
United States (Maine)	Each aquaculture facility must employ a containment management system to prevent the escape of fish. Starting in may 2004, all Atlantic salmon placed in net pens must be of North American origin. The use of transgenic fish is prohibited. Timeline established for marking all new fish placed in net pens to identify the facility owner and confirm that the fish are from Maine	Each facility must report known or suspected escapes of more than 50 fish with an average weight of at least 2kg within 24 hours.	Certain agencies are authorised to inspect aquaculture facilities for compliance with general permit. Each containment management system will be audited at least once per year and within 30 days of a reportable escape.
United States (Washington)	All marine finfish hatched after 31 December 2003 must be marked so that they are individually identifiable to the aquatic farmer.	Aquaculture facilities must have an escape prevention plan and an escape reporting and recapture plan.	Aquaculture facilities must have procedures for monitoring the implementation of the escape prevention plan. Employees of the Washington Department of Fish and Wildlife are authorised to conduct inspections at aquaculture facilities.
Canada (British Columbia)	Regulations exist for construction, installation, inspection and maintenance, including comprehensive regulations for net cages and related structures.	Aquaculture facilities must have written escape response plans. Facilities must verbally report any escapes within 24 hours of the discovery of an escape or evidence suggesting an escape.	Inspectors are authorised to investigate facilities' compliance with aquaculture regulations. No requirement for monitoring by the licence holder. Monitoring only via Atlantic salmon Watch reporting system.
Canada (New Brunswick)	No escape regulations exist	No escape regulations exist	No escape regulations exist
Chile	No escape regulations exist	No escape regulations exist	No escape regulations exist
Faroe Islands	No escape regulations exist	No escape regulations exist	No escape regulations exist
Iceland	No specific requirement, but escape prevention is a general condition of aquaculture operating licenses.	Aquaculture operating licenses must specify plans to catch escaped fish. Escaped fish must be reported immediately.	Compliance with regulations is monitored twice annually. Failure to comply with regulations can result in loss of operator's licence. No system of public reporting on compliance.
Ireland	No specific requirement, but escape prevention is a general condition of aquaculture operating licences.	Facility owners must immediately report fish escapes and have contingency plans for fish escapes.	No systematic collection of data on contingency plans for fish escapes or plans for escape prevention. On-site audits of wear or fatigue on key-elements of aquaculture system.
Norway	No specific requirements for escape prevention, although regulations are under development. Farms are required to have nets in the sea around each site in winter for monitoring escaped farm fish.	Aquaculture facilities must keep contingency plans for limiting the size of escapes and recovering escaped fish. Escapes must be reported immediately.	Government operates "national program of action against escapes" and examines contingency plans and record keeping on operational procedures.
Scotland	For existing sites, a voluntary code of practice for stock containment addresses the design and construction of aquaculture equipment and procedures that could affect escapes. New sites must have escape prevention plans	For existing sites, a voluntary code of practice requires contingency plans for recapturing escaped fish. New sites must have contingency plans.	No evidence of government monitoring of escape prevention procedures or of contingency plans for escapes.
Tasmania (**Note : Updated by DPIW)**	Voluntary Code of Practice for gear maintenance and escape	The holder of a marine farming licence must take	Lease areas checked annually by inspectors. No specific

	mitigation.	reasonable precautions to prevent the release, deposit or escape into State waters of an introduced fish. Management Controls addressing fish escapes have been included in the current draft Macquarie Harbour Marine Farming Development Plan.	salmonid escape regulations exist.
South Australia (**Note: Non salmonid included by DPIW**)	Mandatory Policy is in place for prevention of escapes, a regulatory review is currently being conducted in relation to escapes.	Aquaculture licence holders must take all reasonable and practical measures to prevent the escapes of farmed animals. (details listed in this document)	Check enforcement

Table 2. Regulations of aquaculture escapes 2003 (Naylor *et al* 2005)

Tasmanian escape management policies and regulations

There is currently no specific salmonid escape legislation or regulations in place to manage the issue in Tasmania. There are a number of elements in place that provide a management framework. These include licence conditions to report significant escapes, legislation preventing intentional release of fish and an industry developed voluntary Code of Practice.

These elements are outlined below:

- The former Director, Marine Resources wrote to all salmonid marine farmers on the 3 July 2000 requesting lease holders to immediately report the escape of fin-fish marine farming stock into State waters, providing details of how the escape occurred and an estimate of the quantity of fish involved to the Manager Marine Farming Branch.

- A licence condition was introduced following a review of the marine farming monitoring program in 2004 that states "*The licence holder must report to the Director any significant incident of fish escapes within 24 hours of becoming aware of the escape. A significant escape is defined as any loss of licensed species to the marine environment in excess of 1000 individuals at any one time.*"

- Relevant legislation although not salmonid escape specific is contained in Section 125 (1) of the *Living Marine Resources Management Act 1995* which states:

  Unless otherwise authorised, a person must not release or deposit or allow to escape into State waters any introduced fish. (Penalty: Fine not exceeding 1000 penalty units).

  Section 125 (2) states:

  The holder of a marine farming licence must take reasonable precautions to prevent the release, deposit or escape into State waters of an introduced fish. (Penalty: Fine not exceeding 5,000 penalty units)

- The current Macquarie Harbour Marine Farming Development Plan includes a set of management controls specifically addressing fish escape. The proposed management controls are outlined below:
    - Lessees must not intentionally release into State waters fish of the species authorised in the relevant marine farming licence.
    - Lessees must report to the Manager Marine Farming Branch any significant incident of fish escapes within 24 hours of becoming aware of the escape. A significant escape is defined as any loss of licensed species to the marine environment in excess of 1000 individuals at any one time.
    - Lessees must recover escaped fish when and in a manner as directed by the Secretary.
- Permits are issued by the DPIW to authorise licensed salmon marine farmers to set nets to recover and dispose of escaped fish.

The Tasmanian Salmonid Growers Association Ltd produced a Working Draft Code of Practice in June 2004. Within this Code of Practice there is specific sections devoted to escapees and net maintenance, which are listed below.

Escapees

- Farms must minimise the risk of fish escaping, particularly during handling procedures (*eg*. freshwater bathing, grading, splitting, swim throughs) or as a result of predator attack (*eg*. holes in nets) or equipment failure (*eg*. cage/mooring failure during bad weather).
- Lessees must not intentionally release into State waters fish of species authorised in the relevant marine farming licence unless authorised to do so by that licence.
- Nets must be regularly checked, maintained and repaired.
- Escape of farmed salmon greater than 1000 fish into State waters must be immediately recorded and notified to the Manager, Marine Farming Branch, providing details of how the escape occurred and an estimate of the quantity of fish involved.
- Companies should consider developing contingency plans detailing actions to recover fish in the event of a large fish escape. Such plans must be verified as acceptable to the Manager, Marine Farming Branch.

Relevant net maintenance clauses

- Finfish cage nets must be at least 1 metre clear of the seabed at low tide under normal growing conditions unless otherwise specified in the relevant marine farming licence.

- Mesh size must be appropriate to the size of stock, including consideration of the variation in size within the population.

- Nets should preferably be of knotless construction, but must minimise skin abrasion and scale loss.

- Nets must be tensioned or weighted to prevent distortion resulting in a reduction of net volume and therefore crowding of the fish. The effectiveness of seal predator nets requires effective tensioning and/or weighting.

- Nets should be weighted such that the net hangs evenly, with weights only being attached to the net at appropriate locations (*eg*. load lines). Weighting systems should avoid severe loading on the net during rough sea conditions.

- Special care should be taken when lifting or winching weights so as to avoid net damage.

- Net integrity should be checked and repaired routinely during dives, after cleaning and prior to pumping or swimming fish into an empty cage net. Repairs undertaken by divers *in situ* should be properly repaired after net cleaning.

- Only approved antifoulants must be used to control fouling on nets. Antifoulants on nets add strength, reduce net and fish handling, increase net longevity, improve resistance to predator damage and assist in maintaining the nets profile in the water.

While the Code of Practice outlines some escape preventative measures it is only voluntary and its effectiveness is difficult to assess as it is currently unknown what the rate of uptake by the various industry members is. Tassal Operations Pty Ltd is currently implementing a net mesh strength-testing regime into its ISO auditing system. This could also be included within the Code of Practice.

Conclusion

While there has been a small amount of scientific research conducted into the fate of escapees management of this issue would benefit from further targeted studies. This research could determine the likelihood of escaped salmonids (either Atlantic salmon or rainbow and brook trout) establishing viable wild populations in Tasmania. It is currently deemed unlikely that these escaped salmonids will form viable populations in Tasmania (pers comm, Rob Freeman, Inland Fisheries Service).

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