



Schemes to stock rivers with salmon, sea trout and brown trout from locally sourced broodstock

Operational instruction 570_11

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What's this document about?

This guidance helps staff determine fish removal and fish introduction applications to stock salmon, sea trout and brown trout derived from local broodstock rearing schemes.

Use it in conjunction with existing policy and procedural documents that cover our own stocking activities and the determination of Section 30 consents ([128_03 Determining Fish Movement Consents](#) and [129_03 Administering Fish Movement Consents](#)).

It also contains best practice guidelines, which local broodstock schemes must follow in order for the risks associated with such schemes to be minimised. These guidelines reflect the current best available science and will be updated as and when new information emerges.

Note: In this guidance, the term salmonid refers to salmon, sea trout and brown trout only.



Document details



Related documents



Feedback

Who does this apply to?

Area officers and Fisheries Technical Specialists with responsibility for permitting live fish movements

Contact for queries

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Background

What is supportive breeding (local broodstock schemes)?

Description

Supportive breeding involves capturing a fraction of a wild population, breeding the fish in captivity and releasing their progeny back into their native habitat to mix with the wild segment of the same population. All of the broodstock is obtained from the wild each year.

Advantages and disadvantages

In the past decades, hatchery or incubator box reared salmonids have been stocked in rivers throughout Europe and North America, in an attempt to restore failing fish stocks. The high survival of juveniles in the hatchery, relative to that in the wild, has often been cited in favour of such seemingly intuitive management practices. However, the vast majority of research shows that when released into the wild, hatchery reared salmonids have lower survival than wild juveniles of the same age.

Disadvantages explained

Those that do survive often have poor homing ability and less success in reproducing (for a comprehensive review see Ferguson, 2007; Fraser, 2008 and [570_11_SD01 Summary of pros and cons of hatchery production for salmon](#)). Such shortfalls are thought to be the result of hatchery practices (small number of broodstock, forced matings, insufficient crossings, artificial diet, lack of natural selection, and so on) which can lead to behavioural defects, domestication, inbreeding and a loss of genetic diversity in the receiving wild population.

For example Araki *et. al.* (2009) estimated that the relative reproductive fitness was only 37% in wild-born steelhead from two hatchery captive bred parents and 87% in fish from one captive bred and one wild parent, demonstrating that captive breeding can have a negative influence on the size of a population even in the generation following stocking.

When are local broodstock schemes an appropriate intervention?

Value of local broodstock schemes

Local broodstock schemes are only of value for stocks below the carrying capacity of their freshwater habitat. Therefore, local broodstock schemes should only be considered where there is a clearly identifiable bottleneck or problem with natural recruitment of the stock.

The only possible exception is for migratory salmonids when smolts are stocked, since evidence suggests density dependent mortality is rare in the marine environment. Supportive breeding using local, wild broodstock in theory reduces the risk of compromising the genetic integrity of locally adapted stocks, which would otherwise be affected if domesticated (farm strain) or non local strains of salmonids were stocked.

Changes to genetic make up of stock

However, there is strong evidence that hatchery practices can cause changes to the genetic make up of a stock, even when local broodstock are used.

Griffiths *et. al.* (2009) reported a study of a brown trout local broodstock scheme on the river Dart, which resulted in first generation offspring with significantly less genetic variation than their parents or any other wild river Dart trout population. The study concluded that the progeny of the broodstock scheme may not be suitable for supplementing trout stocks in the Dart, especially if the aim of the stocking was to conserve natural genetic diversity.

Can local broodstock scheme fish become domesticated?

A hatchery environment is very different to the wild. Fish are kept in different densities, photoperiod, temperature and flow to what they would normally experience in the wild. They are fed on artificial food from above and there is total lack of predators or shelter. Even short periods of time in a hatchery can result in behavioural (e.g. aggression), morphological (e.g. growth) and physiological (e.g. maturation) changes to the broodstock and their progeny. Consequently, they experience different selective pressures which leave them poorly adapted for surviving in the wild.

Hatchery practises such as forced matings and differential survival both of the broodstock and their progeny can result in significant genetic differences between the scheme progeny and the wild donor stock (e.g. Griffiths *et al.*, 2009). As a result, there is evidence that captive reared fry and smolts suffer high mortalities after stocking and have reduced fecundity when mature. In his extensive review of captive breeding programmes, Fraser (2008) concluded that “it would appear that as yet, humans have not generated a group of captive bred/reared fish that on average will perform equally to wild fish once they are released into the wild”.

Can a local broodstock scheme lead to interbreeding?

Broodstock schemes endeavour to boost a failing population by facilitating the survival of large numbers of fish from a limited number of families (the broodstock). When few broodstock are used and the life time survival of the hatchery fish is higher than that of the wild fish, the receiving population can become dominated by closely related individuals of a similar genetic makeup. It therefore becomes increasingly likely (through chance matings in the wild or by selecting new broodstock) that related individuals (parents and siblings) breed with each other.

Inbreeding

Fish, like most organisms, have two copies of each gene. Usually, each copy is different. When closely related individuals (having a large proportion of shared genes) breed, their offspring have both copies of many genes exactly the same. This is called “inbreeding”.

When an individual has two copies of a harmful gene as a result of inbreeding, it is suffering from “inbreeding depression”. Inbreeding depression is linked to increased susceptibility to disease, reduced growth and fecundity and can result in a reduction of the stock that is intended to be enhanced.

What is local adaptation?

Special adaptations

Salmonid populations in the UK exhibit a vast array of phenotypic (such as colouration) and life history traits (such as migration range, homing to natal stream, run timing and location of spawning). Such differences are an indication of special (local) adaptations needed to increase the chances of survival in a particular environment and have been shown to be stock specific.

Local adaptation is driven by natural selection and survival of the fittest. As a result, salmonids originating in a particular river (or even tributary) survive better in that environment than introduced fish (such as farmed or from a different river). In fact, when an introduced strain interbreeds with locally adapted fish, their offspring have been shown to have lower fitness. This is referred to as “outbreeding depression”.

Example

The following hypothetical example is a simple illustration of outbreeding depression and local adaptation.

White strain fish (such as farm origin brown trout, west coast sea trout, late spawning chalk stream salmon or broodstock salmonids collected at a trap low in a catchment with more than one stock) are stocked in a river containing black strain fish. The two interbreed and their offspring are black, white and grey. However, in this stream only the colour black gives adequate camouflage from predators and the white and grey fish perish.

Why is genetic diversity important?

Importance of genetic diversity

Warming rivers, changes in rainfall patterns, shifts in oceanic currents and food availability are few of the pressures that our salmonids are facing.

Genetic diversity is a prerequisite for populations and species to be able to respond to such environmental challenges. Loss of genetic diversity can lead to lowered abundance, lowered recruitment and greater uniformity in life history characteristics of a population.

Also genetic diversity results in phenotypic and behavioural diversity which can provide diverse angling opportunities and experiences. Genetic diversity in salmon and brown trout (priority Biodiversity Action Plan species) is an integral component of biodiversity and as such it should be safeguarded.

Our view on supportive breeding

We in the Environment Agency recognise that the effective management of our salmonids requires the conservation of genetic diversity within and between populations.

Supportive breeding to restore, mitigate or enhance salmonids can theoretically bring benefits, but unless carried out in accordance with ecological, genetic and evolutionary principles, it can also present risks to our fish stocks.

We need to assess and manage the risks when we determine whether to stock or to grant others consent to stock. Also we need consistency in the way we regulate our own and third party salmon, sea trout and brown trout broodstock schemes and stocking of the progeny of wild fish.

We believe that the risks involved in supportive breeding schemes are substantial and must be recognised and minimised by adhering to the guidance in this document.

Categories of stocking, requirements for consent, and Environment Agency involvement in local broodstock schemes

General

Stocking can be categorised into one of the following five broad categories:

- restoration;
- mitigation;
- enhancement;
- investigative;
- historic statutory/legal obligation.

If required, the Regional Senior Technical Specialist can advise on which is the appropriate category for any one scheme.

Our involvement in salmon, sea trout or brown trout stocking from locally sourced broodstock should depend on the reason for stocking.

Restoration stocking

Definition

Restoration stocking is defined as **stocking which is carried out after the removal of the factor(s) that has been limiting or preventing natural production.**

Restoration stocking may 'pump-prime' the restoration of historic populations where the population is extinct, with the aim of re-establishing self sustaining populations at carrying capacity. Alternatively, where there are extant native populations at low numbers, to rehabilitate stocks with the aim of increasing populations up to carrying capacity following mortalities, habitat and/or water quality improvements.

Pump-priming In many cases salmon, sea trout or brown trout populations have disappeared over a long time scale because of factors such as (long-term) water quality problems or the influence of an impassable physical barrier.

Actions to remove these limiting factors should be identified in the River Basin Management Plans as part of the Water Framework Directive planning process.

Following the removal of the limiting factor(s) pump-prime stocking may be appropriate to kick start these historic populations. Pump-priming could facilitate or accelerate the reintroduction of a population by initiating or supporting the recovery of a self-sustaining stock.

Rehabilitation Stock rehabilitation may be undertaken following water and/or habitat improvements dealing with shorter time scale issues. This may also include the replacement of fish following fish mortalities, or after other physically disruptive operations. However, the constraints to production must be identified and corrected first. Subsequently, the preferred option should be to allow for stock rehabilitation to occur naturally. A supportive breeding programme to accelerate recovery should only be invoked as a last resort, since the genetic and other risks involved in local broodstock schemes are high.

Criteria to grant consent For consent to be granted, in both cases, the following criteria should be met:

- Generic fish removal (byelaw) and fish introduction (currently Section 30 consent but from 2011, a site permit) requirements must be met.
- A Salmonid Stocking Plan must be submitted and approved.
- The proposed programme of stocking must be clearly set out relative to the accompanying restoration/mitigation plan of habitat improvement works.
- Restoration stocking should not normally be undertaken until all the identified limiting factors have been removed or ameliorated. However, where removal/amelioration requires a long-term programme of work, restoration stocking may be considered in parallel with the work programme, once this has started.
- Restoration stocking must be time-limited and should not continue in perpetuity.

Involvement in restoration stocking The table below explains Environment Agency’s involvement in restoration stocking.

| Internal schemes | Third party schemes |
|--|--|
| We may undertake restoration stocking in appropriate circumstances. Where possible we should recharge the costs in accordance with the polluter/impactor pays principle. | Where circumstances and resources allow, we may consider giving assistance to external parties for restoration stocking. This may include: <ul style="list-style-type: none"> ▪ help with broodstock collection; ▪ the development of a monitoring programme (including tagging); ▪ subsequent stocking-out of fish. Any such assistance is |

| | |
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| | discretionary. |
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Mitigation stocking

Definition

Mitigation stocking is defined as “**stocking that is conducted to mitigate against lost production due to a scheme or activity that cannot be prevented or removed**”.

Mitigation stocking must be attributable to a specific scheme or activity (e.g. the construction of reservoirs, power stations, barrages and impassable barriers that permanently eliminates production from part of a catchment).

Location

Ideally, mitigation stocking should be limited to parts of the catchment where juvenile stocks are depleted (e.g. because of lack of spawning), or where it will not compromise production of wild fish, and where water quality and flow conditions are such that survival may be expected to be reasonably high. However, situations may occur where this approach cannot be taken (e.g. where fish can not gain access, riverine habitat has been flooded or juveniles cannot be expected to migrate downstream past obstructions).

In such cases mitigation stocking will have to select appropriate life stages of fish and appropriate stocking locations which will not affect natural populations. Alternatively, or if the catchment is already at carrying capacity then mitigation obligations might be delivered in some other way (e.g. habitat restoration).

Criteria to grant consent

For consent to be granted, the following criteria should be met:

- Generic fish removal (byelaw) and fish introduction (currently Section 30 consent but from 2011, a site permit) requirements must be met.

-A Salmonid Stocking Plan must be submitted and approved.

Involvement in mitigation stocking

The table below explains Environment Agency’s involvement in mitigation stocking.

| Internal schemes | Third party schemes |
|--|--|
| We may undertake mitigation stocking, but all costs must be met by the body responsible for the scheme or activity giving rise to the mitigation requirement. Mitigation stocking should not be funded from the Environment Agency’s Fisheries budget. | Where circumstances and resources allow, we may give assistance to external parties for mitigation stocking. This may include: <ul style="list-style-type: none"> ▪ help with broodstock collection; ▪ the development of a monitoring programme (including tagging); ▪ subsequent stocking-out of fish. ▪ Any such assistance is discretionary. and we should only provide it if our costs are covered by the body causing the need for mitigation. |

Enhancement stocking

Definition Enhancement stocking is defined as **artificial production in excess of natural potential with the aim of increasing population size above natural carrying capacity to allow for increased harvest.**

Enhancement stocking includes:

- in most cases, stocking by fishery owners, angling clubs and others to maintain or improve the performance of a fishery;
- stocking to compensate for the effects of temporary adverse environmental factors or for the lack of suitable natural habitat (such as floods or drought, which may affect spawning success; lack of suitable spawning habitat where adequate nursery habitats exists);
- stocking above artificial barriers that prevent migration at all times (but note that extreme caution should be exercised in considering stocking under this scenario to ensure that native resident salmonid populations are not compromised).

Problems / difficulties

Enhancement stocking treats the symptoms of under-production, not the cause, and therefore it is not a long-term answer to stock sustainability. More fundamentally, there is evidence that there is a risk that such stocking may result in reduced returns.

In brown trout fisheries the presumption is that any stocking above carrying capacity will be with triploid fish.

Criteria to grant consent

For consent to be granted, the following criteria should be met:

- Generic fish removal (byelaw) and fish introduction (currently Section 30 consent but from 2011, a site permit) requirements must be met.
- a Salmonid Stocking Plan must be submitted and approved.

Involvement in enhanced stocking

The table below explains Environment Agency involvement in enhancement stocking.

| Internal schemes | Third party schemes |
|---|---|
| We should not directly fund enhancement stocking of salmon, sea trout or brown trout. | We may only provide operational assistance to enhancement stocking undertaken by external parties if circumstances and resources allow, our costs are covered by the third party and the following additional criteria are met: <ul style="list-style-type: none">▪ the proposed stocking can be expected to yield a net production gain;▪ the ecological and genetic risks have been assessed and are acceptable;▪ a monitoring programme, to |

| | |
|--|---|
| | <p>determine the long-term effectiveness of the stocking programme and to feed back into future consenting decisions has been agreed;</p> <ul style="list-style-type: none"> the stocking programme is consistent with wider aspirations (such as the sea trout and salmon component of River Basin Management Plans) and has broadly based local support. |
|--|---|

Investigative stocking

Definition

Investigative stocking is defined as **stocking that is used as a tool to investigate fisheries management issues.**

Stocking can be a useful tool in scientific studies. For example, in studying migration and behaviour, or in developing more effective breeding programmes.

Criteria to grant consent

For consent to be granted, the following criteria should be met:

- Generic fish removal (byelaw) and fish introduction (currently Section 30 consent but from 2011, a site permit) requirements must be met.
- a Salmonid Stocking Plan must be submitted and approved.

Involvement in investigative stocking

The table below explains Environment Agency involvement in investigative stocking.

| Internal schemes | Third party schemes |
|---|--|
| <p>We may undertake investigative stocking as part of a scientific study relating to fisheries management issues. However, the investigation should:</p> <ul style="list-style-type: none"> contribute to further advancement of knowledge; not be duplicated elsewhere; is appropriate to the circumstances; will not risk damage. | <p>Where circumstances and resources allow, we may consider giving assistance to external parties for investigative stocking. This may include:</p> <ul style="list-style-type: none"> help with broodstock collection; the development of a monitoring programme (including tagging); subsequent stocking-out of fish. <p>Any such assistance is discretionary and will in any case only be provided where our costs are covered by the third party, unless it is part of a mutually beneficial partnership.</p> |

Historic statutory/legal obligation for stocking in force

This category of stocking includes all existing legal or contractual obligations to stock and may include the replacement of fish following fish mortalities, or after land drainage and other physically disruptive operations as well as legal requirement or agreement for stocking to mitigate for schemes such as construction of reservoirs, power stations, barrages and impassable barriers.

These historic agreements may require stocking practices that this guidance no longer advocates. All efforts should be made to follow the best practice guidance laid out in this document as far as is practically possible for as long as these historic schemes remain.

For consent to be granted, the following criteria should be met:

Generic fish removal (byelaw) and fish introduction (currently Section 30 consent but from 2011, a site permit) requirements must be met.

Environment Agency involvement in historic statutory/legal obligation stocking

| Internal schemes | Third party schemes |
|---|--|
| <p>We may undertake historic legal agreement stocking, but all costs must be met by the body responsible for the scheme or activity giving rise to the requirement.</p> <p>Such stocking should not be funded from the Environment Agency's Fisheries budget.</p> | <p>Where circumstances and resources allow, we may give assistance to external parties for these historic stocking agreements.</p> <p>This may include, for example help with broodstock collection, the development of a monitoring programme (including tagging) or the subsequent stocking-out of fish.</p> <p>Any such assistance is discretionary and we should only provide it if our costs are covered by the body causing the need for this historic obligation.</p> |

Salmonid stocking plans for local broodstock schemes and scheme approval

A Salmonid Stocking Plan (SSP) must be produced by the applicant and is required for the determination of fish removal and fish introduction applications for local broodstock schemes (internal and third party). SSPs should contain the necessary information to support any conclusion in favour of stocking.

No fish removal or fish introduction consents (relevant to local broodstock schemes) should be granted, unless a Salmonid Stocking Plan has been submitted by the applicant and has received the approval of the local Area FRB or Fisheries Technical Team Leader. The production of a Salmonid Stocking Plan will be a likely condition of relevant site permits from 2011 under the Marine and Coastal Access Act 2009.

It is a requirement that all those who propose a local broodstock scheme should follow the best practice in Part 3 of this document. Otherwise clear explanation as to why deviation from the guidance carries acceptable risks should be provided in the SSP.

If the scheme is compliant with current policy and guidance, the proposed local broodstock scheme may go ahead, subject to review and approval by the Area FRB or Fisheries Technical Teams (consistent with the concept of a standard permit).

However, where a SSP is non-compliant it should be reviewed and modified to ensure compliance. If the proposal remains non compliant it should be referred to the Regional Senior Technical Specialists.

The National Sea Trout & Salmon Group or the National Trout & Grayling Fisheries Strategy Implementation Group can also provide advice when required. Where the issues making a SSP non-compliant cannot be resolved, the SSP must be rejected.

Monitoring

We or third parties proposing a local broodstock scheme, must consider monitoring to assess the efficacy of the stocking programme, as an integral part of the stocking plan. Predicting survival rates from such schemes is difficult and a net decrease in overall stock numbers cannot be safely ruled out. Hence, especially for the larger schemes, adequate monitoring is essential.

For Environment Agency stocking plans, monitoring is required. A decision not to monitor must be agreed with the Senior Fisheries Technical Specialist on a risk-based approach, consistent with the scale of potential impact of the scheme.

For third parties, monitoring or some other form of scheme evaluation is strongly recommended and may be a condition of the fish movement permit scheme (expected to replace removal and introduction consents from 2011).

Table 2.1 Summary of criteria and requirements for proposed stocking programmes from locally sourced broodstock

| Reason for stocking | Stocking programme | |
|---|--------------------|-------------|
| | Agency | Third Party |
| Restoration | ✓ | ✓ |
| Mitigation | ✓ | ✓ |
| Enhancement | X | ✓ |
| Investigation | ✓ | ✓ |
| Historic statutory / legal agreement | ✓ | ✓ |
| Requirements | | |
| Removal Consent | ** | ✓* |
| Salmonid Stocking Plan | ✓ | ✓ |
| ▪ Options appraisal | ✓ | ✓ |
| ▪ Demonstration of cost-benefit | ✓ | (✓) |
| ▪ Rearing regime | ✓ | ✓ |
| ▪ Consideration of genetic impacts | ✓ | ✓ |
| ▪ Consideration of conservation impacts | ✓ | ✓ |
| ▪ Monitoring programme | ✓ | (✓) |
| Generic byelaw and S30 consent requirements | ✓ | ✓ |
| Section 30 stocking consent | ** | ✓ |

✓ = Required

(✓) = optional but recommended

X = not applicable

* = Removal consent is not required for external applications if the broodstock is removed legally by rod and line

** = although we are not required to issue ourselves a removal or S30 consent, we must record any removal or stocking that we undertake on LFMD.

Best practice guidelines for the use of local broodstock and suitable rearing regimes

The following management practices reflect the best available science and expert knowledge and will help minimise the risks and increase the likelihood of success of local broodstock schemes. However, due to the varied nature of our salmonid populations, both between and within rivers, some of the following guidelines cannot be specific. Therefore, each river should be considered on a case by case basis, taking into account the relevant local information.

As with any form of stocking, local broodstock schemes deal with the symptoms of underproduction, rather than the causes. Therefore, it is likely that supportive breeding to assist the recovery of a population is only justified when:

- a. the scheme results in higher lifetime fitness (survival + spawning success) of the captive bred fish in comparison to that of the wild bred fish,
 - b. there are identifiable bottlenecks (such as impacted spawning or nursery habitat), which the scheme can bypass, and
 - c. there are efforts concurrent to the broodstock scheme, to alleviate the bottlenecks in a sustainable manner.
-

Broodstock

Naturally produced broodstock

Broodstock must be **naturally produced** within the river system into which their offspring will be stocked. Hatchery offspring should not be used as broodstock. This is to reduce the risk of inbreeding and avoid multi-generation domestication impacts occurring in the hatchery.

In cases where current supplementation programmes stock non-local strain fish (such as farmed trout or salmon from another catchment) and these fish are not readily distinguished from local salmonids, there should be a gap of at least one generation between the end of supplementation and the initiation of the local broodstock scheme. This is to reduce the risk of using non-local fish as broodstock and to safeguard against outbreeding depression.

Source of local broodstock

Ideally, the selection of local broodstock should be based on genetic information of the structure of the fish population in a river system. In the absence of genetic data, phenotypic and life history characteristics (such as colour, maximum size, age, timing of migration, location of spawning) can be used to identify different stocks within a catchment.

Where no such information is available, broodstock should be obtained from the same spawning location that would naturally provide the recruitment to the area being stocked.

In cases where distinct stocks exist within a catchment (such as isolated trout populations in tributaries or above barriers, spring and autumn salmon runs or other variable life histories) “local” will refer to a particular stock. In larger rivers there may be significant genetic differences within the catchment and this should also be considered in any breeding programme. The maximum extent of the definition of ‘local broodstock’ is within the same river system (catchment). Each situation will need to be assessed on a river-by-river basis and local advice sought.

In reintroductions of extinct populations where no stock currently exists, broodstock should be from the nearest available river, where the stock is considered to be stable and could support the removal of broodstock. The donor stock should preferably have similar geo-physical characteristics and be similar to that believed to have existed in the receiving river.

In the rare cases where this is not possible, then another indigenous (British Isles) source may be used, but strong preference should be for rivers as close to the receiving water as possible. Second generation hatchery-reared fish must not be used as broodstock, in order to avoid inbreeding (with the possible exception of circumstances where stock/run restoration is starting from zero wild stocks, and hence having no potential adverse impacts on existing wild stocks).

Life stage

The choice of the appropriate life stage for broodstock will be largely dependent on the numbers of naturally produced fish available and the ease with which these can be distinguished from stocked or hatchery fish. Where naturally produced and stocked adults cannot be easily distinguished (such as by physical or chemical tagging or genetics) then broodstock should be sourced from immature parr that are then reared to maturity.

However, the longer the fish spend under a hatchery environment, the more domesticated they become with direct implications on the fitness of their progeny. Therefore, wild, mature salmonids should always be preferred as broodstock.

Selection of broodstock

Broodstock should **not** be selected in order to enhance a particular component of a stock. Selecting for a favourite trait (such as large size, early maturation and so on) can lead to inbreeding and loss of genetic variation, since only a component of the population is amplified by the scheme. Spawners should be randomly collected from each component of the stock (resident trout, sea trout, mature parr, grilse, multi sea winter salmon), in proportions that reflect the natural population or run.

It is well documented that salmon and trout mature male parr can be responsible for up to one third of fertilisations in the wild, with their more concentrated and highly motile sperm and therefore represent an important component of stock diversity. Equally, sea and brown trout regularly interbreed.

Out of season rod and line broodstock collection

There is a general presumption against the taking of broodstock after the end of the rod fishing season. However, this decision will be taken locally, on a river by river basis and will consider a number of issues.

For instance, ease of capturing suitable broodstock by other methods, timing of the end of the rod season in relation to the run, river association and angler participation in catch and release within the rod season and contribution of these groups to other salmonid conservation initiatives. If this practice is approved locally, the area team must be prepared to justify their decision.

Number of broodstock taken and progeny released

The number of progeny released should always be limited to the available (spare) habitat capacity. Exceeding the carrying capacity of the environment for any life stage is likely to be counterproductive and result in density dependent effects (such as increased mortality and reduced growth) for both the hatchery and the wild fish.

Consequently, the number of broodstock fish taken should be a direct function of the number of offspring required. However, in order to avoid inbreeding and loss of genetic variation in a stock, there are also very important genetic conditions to be met.

In any stock, the number of adults breeding successfully will be far less than the total number of fish (that is the census population, N). This reduced number of individuals which contribute genes equally to the next generation is known as the **effective population size** (N_e) and for salmonids it is on average one third of N. N_e is what determines gene transmission to the next generation and it should be maintained high, for a population not to become inbred.

N_e depends on:

- number of individuals breeding successfully;
- ratio of males and females (50 males x 50 females = N_e 100; 75 males x 25 females = N_e 75; 99 males x 1 female = N_e 4);
- families of unequal size contributing to the next generation (creates gene bias);
- fluctuating population size over generations (N_e = harmonic mean).

In supportive breeding it is the N_e of the hatchery + the N_e of the wild population which needs to be maintained high. This overall N_e is determined by:

- N_e of the hatchery component;
 - N_e of the wild component;
 - the relative lifetime success of the hatchery versus the wild produced fish.
-

Ideally, the minimum number of pairs should be determined based on the above information. However, in practice this may not be feasible. We have therefore sought expert opinion, reviewed the available scientific literature and drawn on Finnish and Danish guidance, to conclude that:

Local broodstock schemes with a minimum of 25 pairs as broodstock and adhering to the best practice guidelines in this document, should adequately safeguard most stocks from population genetic risks.

The UK have signed up to the NASCO guidelines (the Williamsburg Resolution). NASCO recommends a minimum of 50 pairs of salmon should be used in hatcheries, although recognises that this number may not always be appropriate and specialist advice should be sought in order to minimise genetic impacts in resultant generations. The NASCO recommended number of pairs is more relevant for maintaining the genetic diversity of a closed hatchery population (that is no or very little broodstock renewal), hence it is not applicable for local broodstock schemes, where new broodstock is obtained every year.

The lower than the NASCO recommended broodstock number is also compensated for, in part, by introducing the requirement for factorial mating.

Full factorial mating involves all broodstock males being crossed with all broodstock females. Partial factorial mating involves undertaking this for a proportion of the broodstock. Factorial mating increases the effective number of breeders thereby acting to maximise the genetic diversity of the progeny. Factorial mating also reflects a situation more similar to the wild where females and males may spawn multiple times and with multiple partners.

| We will only consent schemes which: | |
|--|---|
| 1 | give rise to less than 1% of any component of a salmonid stock, since we believe that the risks involved in such small interventions are negligible. |
| | or |
| 2 | give rise to more than 1% of any introduced component of the stock where the habitat is below carrying capacity as a result of an identifiable bottleneck to reproduction and natural survival. |
| | and |
| | a) use a minimum broodstock size of 25 pairs.* |
| | and |
| | b) follow best practice as it appears in Part 3 of this document |
| | * in restoration schemes, when 25 pairs make up more than 1/3 of the total stock, a smaller number of broodstock will be acceptable. |

It is important to note that for rivers where salmonids are a Designated Feature of a National or European designated site, Natural England will need to be consulted on the number of broodstock to be taken.

Table 3.1

Summary of how we will manage local broodstock status in relation to its potential*.

| Type of scheme | Under utilised ** | Fully utilised ** |
|----------------|---|--|
| Restoration | Scheme involves <1% of any stock life stage or 25 pairs broodstock and best practise, unless 25 pairs > than 1/3 of stock | No stocking from local broodstock scheme |
| Mitigation | Size of scheme as set out in legal agreement | No stocking from local broodstock scheme |
| Enhancement | Not Applicable; see definition of Enhancement stocking | No stocking from local broodstock scheme *** |
| Investigation | Any size scheme possible, but with full scientific justification and assessment of risks | |
| Historic | As specified in agreement | |

*Status, as established by FCS2, juvenile/population surveys, HABSCORE or other suitable method.

**For migratory salmonids, this refers to juvenile density and juvenile habitat availability; for brown trout, this refers to density of life stage or habitat that is the bottleneck.

***The only exception is for migratory salmonids when smolts are stocked, since evidence suggests density dependent mortality is rare in the marine environment.

Retention of broodstock

Broodstock should ideally be obtained from the wild close to spawning time each year and not be retained at the hatchery for spawning in subsequent years (kelt reconditioning). This will minimise any domestication effects and reduce the risk of inbreeding and loss of genetic diversity (which would otherwise arise if year-on-year offspring from the same broodstock swamped the wild population).

Also the progeny of the broodstock scheme should not be used as broodstock in subsequent years, since they are more likely to be siblings. Sibling crosses can result in inbreeding and loss of genetic diversity. Consequently, all released local broodstock scheme progeny should be easily identifiable.

Hatchery practice and rearing regime

Spawning time

When stripping the broodstock, it is important to adhere to the spawning time of the naturally produced fish.

For example, salmon in Southern chalk-streams typically spawn late, from late December through to late January. Hatchery practices can easily select for earlier spawning, which would potentially be to the detriment of naturally produced chalk-stream populations.

Broodstock are unlikely to all mature at the same time, therefore it is important to strip fish throughout the range of natural maturation times. It is best practice not to select only the first maturing fish and not to strip only on one day when sufficient fish are ripe.

Mating protocols

In the wild, sibling recognition and sexual selection processes have evolved to avoid inbreeding and ensure optimum fitness. On the other hand, mating in the hatchery is forced and biased. Therefore, to reduce the risk of loss of genetic diversity, males and females should be crossed in a manner as similar as possible to the wild, where a female may cut several redds and each redd can be fertilised by several males.

Milt from different males should never be mixed, since sperm competition will result in one or few males fertilising most of the eggs. Full factorial crossings (each male fertilising a portion of eggs from each female) will produce the most families. However, full factorial crossing may not be possible since not all the broodstock will mature simultaneously.

Partial factorial crossings are a more realistic option and 3x3 should be a minimum, as studies have demonstrated this number to maximise benefit whilst being practical. For factorial crossings, mix the eggs from all females and then split them into as many batches as the number of males.

Alternatively, split the eggs of each female into as many batches as the number of males and fertilise each batch with one male.

When less than the required 25 males or females are available then the following factorial mating system should be used in order to minimise the loss of genetic variation:

| | | | | | | | | | | |
|---------------|----|----|----|----|----|----|----|----|----|--|
| Rarest gender | | | | | | | | | | |
| 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | |
| 26 | 27 | 29 | 31 | 33 | 37 | 41 | 47 | 57 | 75 | |
| Other gender | | | | | | | | | | |

Survival in the hatchery and family size

It is important that the eggs and juveniles in the hatchery have a high survival rate. This reduces any selective effects due to the artificial hatchery environment.

Making sure that each family contributes the same number of spawning adults (equalising family sizes) has genetic and fitness benefits (that is halves the rate of inbreeding, domestication and genetic drift). However, culling at the hatchery is not recommended, since it is impossible to predict the survival and spawning success of each family after stocking.

Time in the hatchery

There is evidence that the longer salmonids spend in a hatchery environment, the more domesticated they become. Domestication can cause a substantial loss of fitness (reduced survival and reproductive success). Therefore, it is recommended that fish are reared and kept at a hatchery for the minimum amount of time required to overcome the identified bottlenecks to natural production.

Rearing environment

Where possible, the hatchery environment, whether for the holding of adults prior to maturation, the rearing of trout parr for broodstock, or the rearing of juveniles for release, should be as similar as possible to the river environment, particularly with respect to water temperature, water quality and pH.

For example, salmonids to be released into a chalk-stream should be reared in a hatchery fed by a chalk-stream; salmonids to be released into a limestone stream should be reared in a limestone fed facility and so on.

Water temperature is a particularly important factor in the rearing environment, as it controls the rate of development of eggs and alevins. If a higher temperature prevails in the hatchery then the eggs will hatch and the alevins will emerge earlier than in the wild. If fry are to be released at the unfed stage, then an advancement of development through a higher temperature, or a delay in development through a lower temperature could be critical to survival. If fish are to be released at later life stages, then the prevailing water temperature may be less critical.

Less domestication and better survival post release could be achieved if efforts are made to naturalise the captive environment. Fish should be reared in densities as low as practically possible. The holding facilities should be enriched to include natural refuge areas (such as stones, tree roots) and predator conditioning.

Food items should be offered in a variety of ways to simulate invertebrate drift and not consistently from above, at set times. All of the above are known to improve fish condition and stimulate natural behaviours.

Incubator boxes

Stream-side egg incubator boxes are a popular method of overcoming egg survival bottlenecks, particularly in rivers where gravels are infiltrated by silts. In an incubator, layers of fertilised eggs are placed in clean gravel and bathed in water flow siphoned from the river, usually via a filter to reduce the amount of fines entering the box.

The eggs in the incubator develop under natural conditions and the swim-up fry as they emerge are free to swim out of the box to establish territories. It is therefore extremely important that the incubator is placed within large underutilised areas of juvenile habitat since a medium size box can be seeded with 5,000-10,000 eggs.

Alternatively, the swim up fry can be collected and distributed to suitable locations, to avoid very high density dependent mortalities from competition between fry, displacement and predation. Manual dispersal also helps to avoid swamping an area with a large number of fry from a small number of families.

In comparison to hatcheries, incubator boxes are low maintenance, low cost and cause little or no domestication, unless the broodstock has been kept for long periods at a hatchery. However, in most cases they do not negate the use of a hatchery, since the broodstock will need to be maintained until mature and the required factorial crossings are carried out. Therefore, these best practise guidelines are also applicable to incubator box schemes.

**Time,
location, age
and density at
release**

In order to maximise survival of the juveniles, they should be released at the right time of the year, in suitable habitat and in appropriate densities. The emergence of salmonid fry from gravels has evolved to coincide with favourable conditions in spring.

Early release (for example, as a result of higher than the wild incubation temperature in the hatchery) is likely to be followed by heavy mortalities, as the fragile fry are unable to shelter from spates or find enough food in the cold waters to sustain them.

Natural emergence is during the night and although in some cases it is not practical or safe to release fish in the dark, that might be a solution to high losses from predation when stocking out.

It is not uncommon for juvenile salmonids (trout in particular) to be released where the adults are expected to be caught. However, in many rivers the spawning and juvenile habitat can be located several kilometres upstream of where the angling interests are, usually in small tributaries. Releasing juveniles in adult habitat (such as fast runs and deep pools) should be avoided, since it can result in high mortalities.

Choose shallow riffles, small tributaries and areas with substantial in-stream and marginal cover (such as overhanging vegetation, tree roots, undercut banks, cobbles and boulders), where niches are not already occupied by wild fish, even if such habitat is outside the reach controlled by those carrying out the scheme. As the juveniles grow they will emigrate downstream to establish adult territories where there is suitable, unoccupied habitat.

The age and size at release will also affect subsequent survival rates both of the hatchery and wild fish. Avoid releasing large, later stage hatchery juveniles into habitat occupied by smaller, wild individuals, since they are likely to out compete the wild fish.

The larger the released fish are, the more likely they are to survive. However, in order to avoid domestication and allow for natural selection, the time in the hatchery should be limited to the minimum required to overcome the bottlenecks to natural production.

In order to avoid mixing stocks, the release location must be within the extent of the range of the stock that the broodstock belongs to. Salmonids are territorial and will compete for space.

It is best to release moderate numbers of fry or parr in each location, to avoid inter specific competition and displacement. In fact it is advisable to only release as many fish as there is spare carrying capacity for. The carrying capacity of any one stream depends on its productivity, the available juvenile habitat and the number of wild fish that are already present. In oligotrophic rivers or those with little habitat the carrying capacity might be as low as one to two juveniles per metre square.

Decisions on any of the above should be based on local expert knowledge and assessment. After all, the success of an entire scheme can be compromised by something as simple as releasing the fry a couple of weeks too early or in a suboptimum location.

Related documents

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