Guidelines for Stocking Atlantic Salmon

NASCO has adopted the following Guidelines to assist with the sound management of wild Atlantic salmon, in accordance with the Precautionary Approach. A glossary is included at the end.

1. Introduction

In this document, the term '*stocking*' is defined as 'the deliberate release of Atlantic salmon into the wild at any stage of its life cycle for any purpose'. Stocking is typically undertaken for: population restoration; population recovery; fishery enhancement; creation of new populations and mitigation. Stocking programmes are undertaken to increase the number of salmon returning to a stream. However, an increasing body of scientific evidence concludes that many existing programmes do not achieve their desired objective and, in some circumstances, are likely to have a serious negative impact on any existing populations of wild Atlantic salmon. To mitigate the known risks of stocking practices, NASCO has adopted the following Guidelines for Stocking Atlantic Salmon. This is a revision of previously adopted guidelines.

2. Recognition of the Impacts of Stocking

Deleterious Impacts

The evidence generated from four decades of research into the impacts of stocking on Atlantic salmon populations has prompted the scientific consensus that: **where integrity (i.e. evolutionary and ecological naturalness) of the wild stock is a management priority, stocking should not be considered as a remediation measure**.

The empirical evidence shows that the risks associated with stocking often outweigh any perceived biological / ecological benefits. Risks associated with stocking have been well documented and largely result from the relaxation of natural selection and the impacts of domestication leading to maladaptation and reduced individual fitness. In some cases, stocking has been linked to declines in wild population productivity and reduced wild fish individual fitness. Stocking should only be considered as a last resort, for a finite period of time, where a population of wild Atlantic salmon is at risk of being lost or if the integrity of the wild population is not a management priority.

Beneficial Impacts

Despite the risks outlined above, there are some limited situations where stocking may be beneficial for wild salmon. Stocking may be beneficial where the wild Atlantic salmon population has been extirpated or is at immediate risk of extirpation. There is scientific evidence of stocking programmes achieving a level of success when used in combination with other restoration efforts. Additionally, there may be positive ecological benefits from stocking, for example, reintroduction of marine-derived nutrients into the freshwater environment where salmon have been lost.

Stocking may provide or facilitate benefits from a social, cultural and conservation perspective. Hatcheries and stocking activity may engage and educate the public on salmon management and conservation.

3. Considerations Prior to Stocking

To maximise resilience in salmonid populations in the face of rapid environmental change, such as climate change, it is vital to maintain the genetic diversity and complex life histories of wild populations by ensuring natural reproduction. There must be an emphasis on identifying and remedying the threats responsible for the initial population decline. Relevant restoration actions should address, wherever possible, those reasons on a river-by-river basis. Restoration of habitat quality, quantity and accessibility should often be the initial focus of any attempt to improve Atlantic salmon populations. Conservation and management interventions should consider wider ecosystem dynamics and address issues such as freshwater connectivity, water quality and habitat degradation.

4. Stocking Guidelines

When stocking is proposed, even in light of the precautionary approach stated above, the following guidelines are offered to minimise negative impacts:

I. Guidelines Relevant to all Stocking Programmes

A. In advance of any stocking

1. Research the relevant river system in respect to the history of salmon, past and present distribution, causes for declines and relevant ecological and sociological factors.
2. Identify the status of the stock.
3. If the stock is declining, identify and correct the cause(s) of the population decline (e.g. water quality, habitat, pollution, migratory barriers, fishing).
4. If the corrective measures referenced above are not possible in time to save the population, create a stocking proposal with clear objectives, including a definition of success for that proposal.
5. Discuss the proposed measures with the appropriate authorities to understand the process and secure the necessary permissions.
6. If hatchery stocking appears to be likely in the future, consider the creation of a gene bank prior to total population collapse so native genes can support eventual future stocking programmes.

B. Broodstock selection – to be considered when the use of broodstock is considered to be an acceptable option taking account of the known risks set out above

1. Use broodstock from the same continent of origin (Europe vs North America) as the receiving river.
2. Wherever possible, select broodstock from the river targeted to receive stocking, and, if not possible, the closest relevant broodstock source.
3. Use wild-origin (not hatchery-origin) fish, ensuring negligible negative impact to the wild spawning stock.
4. Select broodstock that are representative of the entire wild population (e.g. size, age, return timing, possible sub-populations from tributaries).
5. Implement a Broodstock Control Programme that screens potential broodstock for fish of aquaculture-origin and non-native strains (using both scale reading and genetic analysis) to reject the use of such fish.

6. Ensure broodstock collection methods minimise damage and stress to help reduce the risk of subsequent disease and mortality. It is imperative that broodstock are held in secure, disease-free facilities and frequently treated with approved and effective chemicals to avoid the loss and deterioration of broodstock prior to maturation and stripping.

C. Broodstock mating

1. Consult with geneticists and maintain consultations to ensure that genetic risks are mitigated on an ongoing basis.
2. Use all available broodstock in mating if considered to be healthy and disease free.
3. The sex ratio of the contributing broodstock should be equal.
4. The contribution of each broodfish to the mating scheme should be equal (e.g. no pooled milt which may result in sperm competition).
5. Consider the use of factorial paired crossings to increase phenotypic diversity and minimize the impact of immature broodstock.
6. Adjust the number of broodstock to the size of the existing wild population to avoid reducing the population's effective population size; achieve a Ne / N ratio as close to 2.0 as possible.
7. Employ non-random mating (supported wherever possible by a database of previously genotyped broodstock) to avoid mating of closely related individuals and to increase genotypic diversity.

D. Culture of progeny

1. Maintain pathogen-free conditions.
2. Constantly minimise mortality, which can promote artificial selection of the survivors.
3. For fry, parr and pre-smolts:
    a. Manipulate fish density to reduce antagonistic behaviour, maintain good fin condition, etc.
    b. Increase water velocity to maintain good physical conditioning.
    c. Explore ways of mimicking natural conditions (e.g. substrate, overhead cover, light patterns and photoperiod, and methods of introducing food and possibly introducing natural food) to acclimate the fish to a more natural state that will expedite their transition to the wild.

E. Release of fish

1. Release the youngest possible life stage (i.e. eggs or unfed fry) to minimise hatchery exposure and artificial selection.
2. Avoid release of smolts, which have the longest hatchery residence and also have the highest tendency to stray and enter a non-targeted river that supports wild salmon with a natural genome.
3. Release relevant life-stages into suitable habitat and synchronise releases with appropriate river conditions that mimic the occurrence of the same life stages of wild salmon (e.g. date, water temperature, flows).
4. Avoid releasing fry or parr into areas that are already being utilised by wild salmon.

5. Do not release any life-stage into the wild that has tested positive to known salmon pathogens.
6. Minimise stress during the release stage.

F. Assessment

1. Implement an appropriate monitoring programme that will assess levels of success relative to the stated objectives and support adaptive management.

II. Guidelines for Specific Types of Stocking Programmes

(All guidance listed in section I pertains to all categories listed below)

A. Restoration

This type of programme seeks to re-establish a run of Atlantic salmon in a stream in which the native populations have been lost and there are no extant runs of salmon.

1. Use archived genes if a gene bank has been previously established.
2. Choose a broodstock from the geographically closest wild salmon river that is ecologically similar to the river under restoration.
3. Consider using broodstock from multiple sources as a means to increase the founding population's genetic diversity on which natural selection can act.
4. Specialist genetic advice is needed for the entire programme to guide not only the establishment of the founding population but to guide managers on a broodstock plan and subsequent mating schemes.
5. Use returning adults as broodstock and cease importation of outside sources of fish as soon as the programme can become self-supporting.
6. Once the stock is self-sufficient and genetic viability is secured, cease hatchery operations.

B. Recovery

This type of programme seeks to rebuild stocks of wild salmon that still exist in a stream but are present in low numbers, considered under threat of extirpation and the runs are far below the Conservation Limit of the home streams.

1. Use archived genes if a gene bank has been previously established.
2. Use a broodstock derived from the recovery river, using criteria listed in section 4.I.B.
3. Specialist genetic advice is needed for the entire programme to guide a broodstock management plan and mating schemes.
4. Consider a programme that captures wild-origin parr or smolts and raises them in a hatchery to adult stage as a broodstock supplement to sea-return adults, seeking to minimise the time spent in captivity.
5. Terminate hatchery operations when Recovery Plan goals have been met and allow natural reproduction to continue to rebuild the population.

C. Creation of new runs

This type of programme seeks to create a run of Atlantic salmon in a stream that has never hosted a run of wild salmon. This is typically pursued when a fishway is built around a natural barrier that blocked access to critical upstream habitat.

1. Conduct ecological assessments to determine if the introduction of non-native Atlantic salmon will have unintended consequences for native biodiversity.
2. Follow the guidance outlined in section 4.I. that is relevant to all stocking programmes.
3. Follow the guidance outlined in section 4.II.A. since it also involves stocking a river with no salmon.

D. Mitigation

This type of programme uses the stocking of hatchery salmon as compensation for negative impacts of anthropogenic activities such as dam building and discrete natural / industrial events.

1. Identify and remedy the core issue responsible for the negative impact (see section 3).
2. Careful assessment of the risks and benefits of such a proposed mitigation stocking is needed prior to accepting such a settlement.
3. Proponents should follow the general guidance in section 4.I. but also the relevant guidance in the relevant listed subsections.

E. Fishery enhancement

This type of programme refers to stocking for the purpose of augmenting the production of wild populations with the intent of increasing commercial and / or recreational harvest or recreational angling opportunity. In this instance, stocking would not be considered a conservation measure and NASCO strongly recommends that this type of stocking should not be undertaken where integrity (i.e. evolutionary and ecological naturalness) of the wild stock is a management priority.

1. Alternatives to increasing the harvest or recreational opportunities should be considered and implemented before embarking on a hatchery stocking scheme.
2. For the most part, fishery enhancement stocking is conducted in streams which already have salmon runs. Therefore, if stocking is pursued, guidance in sections 4.I., 4.II.B. and 4.II.D. should be followed.
3. Measures should be undertaken to identify and remove hatchery stock in order to eliminate any spawning of hatchery stock with wild stock.
4. This type of stocking should only be used as a short-term measure.
5. Monitoring should be conducted and if deleterious impacts are observed, stocking should be terminated.

F. Ranching

This type of programme seeks to stock fish (typically smolts) with the sole purpose of harvesting all of the adults when they return to the river to spawn. Ranching normally uses a trap that collects adults and, in some cases, sorts wild and sea-ranched adults. Such programmes are often but not always developed for rivers with no existing wild salmon populations.

1. Stocking guidance in section 4.I. should be followed.
2. Effective imprinting of smolts must be done to minimise subsequent straying of returning adults to adjacent catchments.
3. If the river supports a wild salmon population, a trap should be located downstream of suitable spawning habitat and all returning adult salmon must be trapped and sorted.

Ranched salmon can be removed for harvest and wild salmon can be released and allowed to proceed upstream.

4. In catchments with wild salmon, ranched smolts should be marked / tagged to allow clear identification of ranched individuals when they arrive at a trap.
5. Monitor the incidence of escapees into the catchment and assess the impact of escapees on the wild salmon population in the catchment.
6. Monitor adjacent catchments that support wild salmon for strayed ranched salmon and if straying is documented, its impact to wild salmon should be assessed.
7. If deleterious impacts to wild salmon are documented in either the natal or adjacent catchments, stocking should be terminated.

5. Overview of New Approaches and Alternatives to Stocking of Atlantic Salmon

The use of hatcheries has been largely unchanged for over 100 years. In this section, new and emerging approaches that may minimise the risks of traditional hatchery practices or provide alternatives to hatchery rearing are identified. NASCO recognises that the techniques described below are novel and potential risks and benefits should be assessed through further scientific research.

- **Smolt-to-adult supplementation (SAS):** this approach seeks to overcome low rates of smolt-to-adult survival by capturing migrating smolts to be captive-reared until maturity. Adult salmon are subsequently released into the environment where they can spawn naturally. SAS may reduce risks by avoiding captive-rearing at early life-stages, and by facilitating natural mate selection. However, SAS may also reduce marine adaptation and result in negative carry-over effects on wild fitness.
- **Novel rearing environments and regiments:** seeking alternatives to the hatchery environment for the production of stocked Atlantic salmon has begun to be explored as a means to reduce risks associated with traditional hatchery environments. For example, adapting marine net pens to grow wild-origin smolt has been used experimentally to stock Atlantic salmon for recovery purposes.
- **Enrichments to the hatchery environment**: this technique involves the addition of physical complexity to traditional hatchery environments. Enriching the hatchery environment may help to reduce risks associated with growing salmon in captivity; i.e. more wild-like rearing conditions may result in more ‘wild-like’ fish. Enriching the hatchery environment can have positive outcomes for captively reared Atlantic salmon, however, it does not eliminate the impacts of time spent in captivity.
- **Translocation of fry:** this approach moves wild fry from sites of higher to lower density with the aim of decreasing local density-dependent mortality, and potentially increasing subsequent overall fry abundance within a catchment. In an experimental translocation, fry were shown to colonise their new catchment areas successfully, and to have higher survival rates when compared to hatchery-origin fry. Understanding of population processes points to a need for careful site-specific analysis and risk assessment prior to the application of this approach.

6. Indigenous Knowledge and Perspectives

NASCO has acknowledged that the incorporation of Indigenous knowledge into its discussions and policies regarding Atlantic salmon will allow each country to make better informed conservation decisions in their borders. Where stocking occurs in the context of Indigenous People’s livelihood, land, and rights, an approach that considers both section 4.I. ‘Guidelines relevant to all Stocking Programmes', as well as Indigenous People's connections to, and experience with, Atlantic salmon, should be considered.

Glossary

Artificial selection – an evolutionary process in which humans consciously or unconsciously select for or against particular features in organisms – for example, by choosing which individual salmon to breed from one generation to the next or by raising salmon in an environment different from the natural environment from which it originated.

Broodstock – a group of mature individuals used in aquaculture / hatcheries for breeding purposes. Broodstock can be a population of salmon maintained in captivity as a source of progeny used in stocking.

Density-dependent mortality – mortality of an animal influenced by the population density of that animal. Changes in the birth and death rate of a population as a result of changes in population density; usually in the form of increased mortality rate as density increases.

Effective population size – the number of individuals that effectively participate in producing the next generation. Generally, the effective size of a population is considerably less than the census size and is calculated by this formula: $Ne=(4*Nm*Nf)/(Nm+Nf)$; where:

- **Ne** = effective population size
- **Nm** = the number of breeding males
- **Nf** = the number of breeding females

Often, a geneticist is consulted to calculate the effective population size of a salmon population.

Epigenetic – an adjective that describes changes, especially heritable changes, in the characteristics of a cell or organism that result from altered gene expression or other effects not involving changes to the DNA sequence itself.

Extirpation – the termination of a species (or stock or subspecies) in a geographic area, although it may still exist elsewhere.

Factorial paired crossings – typically involves dividing the milt from each male and eggs from each female into multiple sub-samples so that each female is mated with more than one male and vice versa. A schematic example is shown below.

males ⇨ / females ⇩	A	B
1	Mating 1A	Mating 1B
2	Mating 2A	Mating 2B

Gene bank – an archived collection of tissue from a stock, or stocks, of salmon. Typically, the gene bank is cryopreserved samples of milt from targeted salmon populations. They can be thawed and used in the future to culture future individuals as part of a recovery or restoration program.

Genetic introgression – the incorporation of novel genes or alleles from one group of fish (e.g. hatchery-origin salmon) into the gene pool of a second, distinct group of fish (e.g. wild-origin salmon) via mating.

Genetic diversity – the biological variation of genes that occurs within species or a local population of the species. High levels of genetic diversity (many different genes) are considered favorable to help the species to adapt to changing conditions such as climate change. Low levels of genetic diversity (fewer different genes) can lead to fish with reduced fertility and resilience in the wild.

Genome – the complete set of genetic information in a species or local population of a species.

Genotyped broodstock – a laboratory process in which an individual salmon's DNA is analysed for specific nucleotides, alleles or bases to determine whether certain variants are present. This will produce a profile that is unique to the individual fish and can be used to identify the fish in the future and determine how closely related one individual broodstock is to another.

Natural selection – the evolutionary process through which populations of wild organisms adapt and change. Individuals in a population are naturally variable, meaning that they are all different in some ways. This variation means that some individuals have traits better suited to the natural environment than others and those traits allow them to survive at a higher rate than other individuals.

Ne / N ratio – the ratio of the effective population size with the census population size. Often, a geneticist is consulted to calculate this ratio of a salmon population. See also 'effective population size' above.

Phenotypes – the observable physical properties of an organism; these include the organism's appearance, development, and behaviour. These could include the size and colouration of a salmon.