A call for a paradigm shift: Assumed-to-be premature migrants actually yield good returns

Animals with complex life cycles often display plasticity in the timing of transitions across life stages. The brown trout, *Salmo trutta*, highlights such phenotypic plasticity with its alternative migratory tactics. Downstream migration of smolts exemplifies one of the many ways in which brown trout display plasticity. The timing of this migration is assumed to be in the spring, although recent evidence suggests an autumn migration is also present. While the proximate and ultimate causes for this autumn migration remain unclear, it was hypothesised that leaving in the autumn may have short-term benefits (e.g., lower competition) but that these individuals are maladapted to life at sea and yield poor adult returns. To test this hypothesis, 1370 wild juvenile brown trout from a Danish stream were tagged with PIT tags. Individuals were then divided into autumn and spring migrants depending on the timing of their outmigration to saltwater, and their return to freshwater was followed. Inconsistent with the hypothesis that autumn migrants yield poor returns, our findings suggest that autumn migrants yield similar return rates to spring migrants, with no observed differences in length, mass and condition upon tagging, nor in average time spent at sea. Our findings suggest that autumn migrants may not be maladapted to marine environments in a way that affects their survival, and call for a paradigm shift in the current description of the brown trout lifecycle.
rates documented for the species in marine environments. After a variable period of residency close to the river mouths, the fish moved through the fjord within a short window of time at gradually increasing speeds (mean: 1.1 km d\(^{-1}\) in the fjord compartment they entered, mean: 43.4 km d\(^{-1}\) in the final fjord compartment before reaching the sea). We found no statistically significant differences between exit timing, migration behaviour (speed and time) and survival of fish from the 2 river systems. The results suggest that migrating quickly through the dangerous fjord system and exiting at a specific time is important to succeed in the area. Our results distinguish themselves from those obtained in similar studies of sea trout elsewhere and provide new insights on factors influencing survival and migration behaviour of salmonids.

**Cortisol predicts migration timing and success in both Atlantic salmon and sea trout kels**

Kelts – individuals of anadromous fish species which have successfully spawned and may return to sea to repeat the cycle – are perhaps the least studied life stage of iteroparous fish species. To date, our understanding of what makes them successful in their return migration to sea is limited. We investigated the relationship between three physiological parameters (baseline cortisol, baseline glucose and low molecular weight antioxidants) and the timing and success of Atlantic salmon (Salmo salar) and sea trout (Salmo trutta) kelt migration. To do so, we combined blood samples obtained within 3 minutes of capture and acoustic telemetry to track 66 salmon and 72 sea trout as they migrated out of rivers, into fjords and out at sea. We show that baseline cortisol may be a good predictor of migration success. Individuals with high baseline cortisol levels exited the river earlier but were less likely to successfully reach the sea. Similar relationships were not observed with glucose or antioxidants. We provide the first evidence to support the role of physiological status in migration success in Atlantic salmon and sea trout kels. Our findings contribute to our understanding of the relationship between physiology and fitness in wild animals. Further, we suggest that migration timing is a trade-off between stress and readiness to migrate.
From endangered to sustainable: Multi-faceted management in rivers and coasts improves Atlantic salmon (Salmo salar) populations in Denmark

The status of Atlantic salmon, Salmo salar L., over the last decades has been of concern across its entire distribution area. Its anadromous nature exposes the species to human pressures in both freshwater and marine environments, and over long periods, thus exacerbating its decline. Given its value within the food industry, the recreational angling community as well as culturally, the status of Atlantic salmon is regarded as a matter of national and international conservation interest, providing great incentive for its management. The literature currently lacks specific examples of successful and unsuccessful management strategies and practices for Atlantic salmon populations at a broader scale. To address this, the present article describes how the multi-faceted management approach taken for Danish Atlantic salmon, which included changes in legislation, stocking practices, habitat restoration, population genetics and barrier removals, successfully rehabilitated salmon populations in four major Danish rivers. Specific recommendations are provided for the successful management of Atlantic salmon elsewhere.

Overlooked aspects of the Salmo salar and Salmo trutta lifecycles

The salmonid lifecycle has been studied for over a 100 years. Our literature search indicated that the Atlantic salmon (Salmo salar) and brown trout (Salmo trutta) are among the most studied of fish species. By reviewing both their anadromous and non-anadromous lifecycles, we show that there is a growing body of evidence of considerable variation in many aspects of their lifecycle. However, variation in migration patterns and life history strategies are still poorly studied and not well understood, such as juvenile autumn migration, repeat spawning, marine migrations, straying and homing.

Growing evidence supports a group of downstream autumn migrants in both species, which may represent as much as 25–40% of the spring class. Some males and females mature sexually as parr very early in life. They probably contribute to genetic variation and stability to populations in a changing environment and are likely very common in many rivers, but rarely considered. Information on marine migrations have been restricted by available methods, and particularly for brown trout, this may have resulted in underestimating straying and long-distance migrations. Repeat spawning is another understudied aspect of the salmonid life history but should be viewed as an opportunity to understand ecological and evolutionary dynamics. We conclude that both brown trout and Atlantic salmon appear to have aspects of their lifecycle overlooked, and that the description of their lifecycle should acknowledge the variation we observe in natural systems as well as the flexibility between strategies.
Sea trout behaviour in the Limfjord - a fascinating display of the adaptability of the species?
Almost all surviving acoustically tagged sea trout smolts and kelts left a Danish fjord system using a similar 120 km long route. They also left with the highest recorded progression speed ever reported for sea trout in the literature. The repeatability of the behaviour and the geographical history of the Limfjord suggest that the sea trout are adapted to the specific conditions found in the area.

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Another paradigm lost? Autumn downstream migration of juvenile brown trout: Evidence for a presmolt migration

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Almost all surviving acoustically tagged sea trout smolts and kelts left a Danish fjord system using a similar 120 km long route. They also left with the highest recorded progression speed ever reported for sea trout in the literature. The repeatability of the behaviour and the geographical history of the Limfjord suggest that the sea trout are adapted to the specific conditions found in the area.

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Comparison of vegetable shortening and cocoa butter as vehicles for cortisol manipulation in Salmo trutta

This study demonstrates that vegetable shortening and cocoa butter are two effective vehicles for intraperitoneal cortisol implants in juvenile teleosts, specifically brown trout Salmo trutta, residing in north temperate freshwater environments. Each vehicle showed a different pattern of cortisol elevation. Vegetable shortening was found to be a more suitable vehicle for long-term cortisol elevation [elevated at 3, 6 and 9 days post treatment (dpt)], while cocoa butter may be better suited for short-term cortisol elevation (only elevated at 3 dpt). Additionally, plasma cortisol levels were higher with cortisol–vegetable shortening than with cortisol–cocoa butter implants. Plasma glucose levels were elevated 6 and 9 dpt for fishes injected with cortisol–vegetable shortening, but did not change relative to controls and shams in cortisol–cocoa butter fishes. In conclusion, vegetable shortening and cocoa butter are both viable techniques for cortisol manipulation in fishes in temperate climates, providing researchers with different options depending on study objectives.

Getting cozy in freshwater: assumed-to-be brackish pike are not so brackish after all

Pike (Esox lucius) occupy coastal streams and rivers of the Baltic Sea, where they attain large sizes (>5 kg). These large sizes are perhaps due to the fact that they can tolerate relatively high salinities and can thus forage in the nearby more productive brackish environments. In an attempt to quantify the extent to which pike utilise brackish environments, and to provide some insight into the underlying causes for brackish water migrations, we tagged 30 pike from a western Baltic river with acoustic transmitters and were able to track 21 individuals for 1 year. Based on experienced from local anglers, this population was assumed to be brackish in nature, where individuals underwent freshwater migrations to spawn. Our findings however suggest that the smallest and most active individuals make short exits into brackish waters and do so on rare occasions. Our results further indicate that neither sex nor size is related to activity level. We suggest that these patterns reflect two distinct behaviours—active and passive—and that large pike can be supported by the food availability in the river, without the need to venture into coastal zones, thus defying the conventional view that Baltic pike are all
Moving beyond fitting fish into equations: Progressing the fish passage debate in the Anthropocene

Realization of the importance of fish passage for migratory species has led to the development of innovative and creative solutions ('fishways') to mitigate the effects of artificial barriers in freshwater systems in the last few decades. In many instances, however, the first move has been to attempt to engineer a solution to the problem, thus attempting to 'fit fish into an equation'. These fishways are often derived from designs targeting salmonids in the Northern Hemisphere. They are rarely adequate, even for these strong-swimming fish, and certainly appear to be unsuitable for most other species, not least for those of tropical regions.

Fishway design criteria do not adequately account for natural variation among individuals, populations and species. Moreover, engineered solutions cannot reinstate the natural habitat and geomorphological properties of the river, objectives that have been largely ignored.

This article discusses the most prominent issues with the current management and conservation of freshwater ecosystems as it pertains to fish passage. It is not intended as a review on fish passage, but rather a perspective on the issues related to fishways, as seen by practitioners.
N-acetylcysteine manipulation fails to elicit an increase in glutathione in a teleost model

Levels of oxidative stress can be affected by a range of compounds including toxins and pharmaceuticals. Antioxidants are important protective compounds which counteract the damaging effects of oxidative stress. Glutathione (GSH) is one of the main antioxidants for many organisms and can be synthesized from administered N-acetylcysteine (NAC). NAC has therefore often been used in a wide range of taxa to manipulate levels of GSH. Our objective was to validate this approach in a wild temperate teleost fish model, the brown trout (Salmo trutta). We used intracoelomic injections of NAC in saline and vegetable shortening, at two different concentrations (100 and 400 mg/kg), with the appropriate controls and shams, under controlled laboratory settings. We found that NAC failed to elicit an increase in GSH over three time periods and concluded that NAC is not an effective method to enhance GSH levels in teleost fish using the concentrations and vehicles tested here. We emphasize the importance of validation studies across all new species/taxa when possible and suggest that more investigation is required with regard to NAC manipulation in fish if this approach is to be used.

River connectivity reestablished: effects and implications of six weir removals on brown trout smolt migration

Today's river systems have been extensively modified, requiring us to rethink how we approach the management of these important ecosystems. We evaluated the effects of removing 6 weirs in River Villestrup (Jutland, Denmark) on the smolt run of brown trout (Salmo trutta) over the course of 12 years. During 5 of these years, we evaluated the number, size, and timing of smolts during their downstream migration. We found an increase in smolt output following the weir removals, along with a decrease in average length and indications of an earlier peak migration. Our results suggest that barrier removal has led to an increase in spawning success by adults, fry survival, recruitment, and smolt migration success. Weir removal is therefore a viable management approach to restore connectivity in freshwater streams and rivers, which promotes the passage of smolts as they migrate to marine environment.
Testing three common stocking methods: Differences in smolt size, migration rate and timing of two strains of stocked Atlantic salmon (Salmo salar)
The influence of three common stocking practices for two strains (Åtran and Burrishoole) of hatchery-reared Atlantic salmon, Salmo salar, on smolt size, migration probability and migration timing were investigated in situ. Using a common
garden experiment, fish from these populations were released as fry, half-year olds and one-year olds. Our results indicate that fish released at the fry and half-year stage produce smaller smolts, and migrate later in the year than their counterparts released at one-year of age, for both the Åtran and the Burrishoole populations. While fry had the lowest probability of migration, half-year old releases had greater migration rates than one-year olds of the same strain. Additionally, Åtran fish tended to migrate earlier in the year than Burrishoole fish of the same age. Our findings highlight the variability that exists among individuals and populations due to inherited factors, and emphasize the importance of considering age of fish and time spent in the hatchery when stocking populations in the wild to maximize smolt output.

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Toads are plastic, it's fantastic! Or is it?

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30 years of data reveal dramatic increase in abundance of brown trout following the removal of a small hydropower dam

Humans and freshwater ecosystems have a long history of cohabitation. Today, nearly all major rivers of the world have an in-stream structure which changes water flow, substrate composition, vegetation, and fish assemblage composition. The realization of these effects and their subsequent impacts on population sustainability and conservation has led to a collective effort aimed to find ways to mitigate these impacts. Barrier removal has recently received greater interest as a potential solution to restore river connectivity, and reestablish high quality habitats, suitable for feeding, refuge and spawning of fish. In the present study, we present thirty years of data from electrofishing surveys obtained at two sites, both prior to and following the removal of a small-scale hydropower dam in Central Jutland, Denmark. We demonstrate that the dam removal has led to a dramatic increase in trout density, especially in young of the year. Surprisingly, we found that this increase was not just upstream of the barrier, where the ponded zone previously was, but also downstream of the barrier, despite little changes in habitat in that area. These findings suggest that barrier removal may be the soundest conservation option to reinstate fish population productivity.

A comparative and evolutionary approach to oxidative stress in fish: A review

Oxidative stress results from an imbalance between the production of reactive oxygen species and the antioxidants defences, in favour of the former. In recent years, the association between oxidative processes, environmental change and life histories has received much attention. However, most studies have focused on avian and mammalian taxonomic groups, with less attention given to fish, despite their ecological and socio-economic relevance. Here we present a review of the extrinsic and intrinsic factors that influence oxidative processes in fish, using a comparative and evolutionary approach. We demonstrate that oxidative stress plays a key role in shaping fish’s responses to environmental change as well as life history strategies. We focus on representative examples to compare and contrast how levels of oxidative stress respond to changes in temperature, salinity and oxygen availability. Furthermore, we describe how emerging threats (i.e., pollution) affect oxidative stress parameters in fish. Oxidative stress indicators are increasingly being used as biomarkers to understand the mechanisms of various human-induced stressors, but also to understand the physiological consequences of how animals are distributed in space and time and influenced by different life stages. Despite the expansion of the field of ecological oxidative stress, we are only beginning to understand the complex ways in which oxidative stress may interact with both extrinsic and intrinsic factors in fish. We conclude with a research agenda for oxidative research on fish and note that there is need for further research particularly in the area of life history strategies and ecological implications of oxidative status, as this type of research has the potential to help us understand patterns and dynamics relevant to fish conservation.
Adaptive management in the context of barriers in European freshwater ecosystems

Many natural habitats have been modified to accommodate for the presence of humans and their needs. Infrastructures such as hydroelectric dams, weirs, culverts and bridges are now a common occurrence in streams and rivers across the world. As a result, freshwater ecosystems have been altered extensively, affecting both biological and geomorphological components of the habitats. Many fish species rely on these freshwater ecosystems to complete their lifecycles, and the presence of barriers has been shown to reduce their ability to migrate and sustain healthy populations. In the long run, barriers may have severe repercussions on population densities and dynamics of aquatic animal species. There is currently an urgent need to address these issues with adequate conservation approaches. Adaptive management provides a relevant approach to managing barriers in freshwater ecosystems as it addresses the uncertainties of dealing with natural systems, and accommodates for future unexpected events, though this approach may not be suitable in all instances. A literature search on this subject yielded virtually no output. Hence, we propose a step-by-step guide for implementing adaptive management, which could be used to manage freshwater barriers.

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Conservation physiology can inform threat assessment and recovery planning processes for threatened species

Conservation physiology has emerged as a discipline with many success stories. Yet, it is unclear how conservation physiology is currently integrated into the activities of bodies such as the IUCN and other agencies/organizations/bodies which undertake international, national, or regional species threat assessments and work with partners to develop recovery plans. Here we argue that conservation physiology has much to offer for the threat assessment process and outline the ways in which this can be operationalized. For instance, conservation physiology is effective at revealing causal relationships and mechanisms that explain observed patterns (e.g., population declines). Identifying the causes of population declines is a necessary precursor to reverse or mitigate such threats. Conservation physiology can also identify complex interactions and support modeling activities that consider emerging threats. When a population or species is deemed "threatened" and recovery plans are needed, physiology can be used to predict how organisms will respond to the conservation intervention and future threats. For example, if a recovery plan was focused on translocation, understanding how to safely translocate organisms would be necessary, as would ensuring that the recipient habitat provides the necessary environmental characteristics to meet the fundamental physiological needs/tolerances of that organism. Our hope is that this paper will clarify ways in which physiological data can play an important role in the conservation activities of bodies like the IUCN that are engaged in threat assessment and recovery of endangered organisms. Although we focus on activities at the international scale, these same concepts are relevant and applicable to national and regional bodies.
Does coastal light pollution alter the nocturnal behavior and blood physiology of juvenile bonefish (Albula vulpes)?

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Effects of Cortisol on Short and Long Term Diet and Morphology
Glucocorticoids such as cortisol are released during stressful events. However, many of the effects of cortisol on animals in the wild are still poorly documented. We evaluated the effects of artificially elevated cortisol on diet and morphology over the short term (2 weeks) and long term (4 months) using a wild population of juvenile semi-anadromous brown trout (Salmo trutta) in Denmark. We caught, tagged and manipulated juvenile fish while in their natal freshwater streams in the fall. Manipulations consisted of an exogenous intracoelomic injection of cortisol suspended in vegetable shortening (designed to mimic an extreme physiological challenge), a sham group (injection of vegetable shortening) and a control group (tagged only). We then recaptured fish 2 weeks later and again after 4 months. We assessed diet using stable isotopes from plasma (short term) and scales (long term), and morphology using geometric morphometrics. Cortisol affected carbon stable isotope signatures but had minimal effects on nitrogen isotopes and morphology. Irrespective of treatment, carbon and nitrogen stable isotope values increased over time. This study shows that cortisol can have both short and long term effects on individuals in the wild.

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Policy development and management decisions should be based upon the best available evidence. In recent years, approaches to evidence synthesis, originating in the medical realm (such as systematic reviews), have been applied to conservation to promote evidence-based conservation and environmental management. Systematic reviews involve a critical appraisal of evidence, but studies that lack the necessary rigour (e.g. experimental, technical and analytical aspects) to justify their conclusions are typically excluded from systematic reviews or down-weighted in terms of their influence. One of the strengths of conservation physiology is the reliance on experimental approaches that help to more clearly establish cause-and-effect relationships. Indeed, experimental biology and ecology have much to offer in terms of building the evidence base that is needed to inform policy and management options related to pressing issues such as enacting endangered species recovery plans or evaluating the effectiveness of conservation interventions. Here, we identify a number of pitfalls that can prevent experimental findings from being relevant to conservation or would lead to their exclusion or down-weighting during critical appraisal in a systematic review. We conclude that conservation physiology is well positioned to support evidence-based conservation, provided that experimental designs are robust and that conservation physiologists understand the nuances associated with informing decision-making processes so that they can be more relevant.

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If and when: Intrinsic differences and environmental stressors influence migration in brown trout (Salmo trutta)
Partial migration is a common phenomenon, yet the causes of individual differences in migratory propensity are not well understood. We examined factors that potentially influence timing of migration and migratory propensity in a wild population of juvenile brown trout (Salmo trutta) by combining experimental manipulations with passive integrated transponder telemetry. Individuals were subjected to one of six manipulations: three designed to mimic natural stressors (temperature increase, food deprivation, and chase by a simulated predator), an injection of exogenous cortisol designed
to mimic an extreme physiological challenge, a sham injection, and a control group. By measuring length and mass of 923 individuals prior to manipulation and by monitoring tagged individuals as they left the stream months later, we assessed whether pre-existing differences influenced migratory tendency and timing of migration, and whether our manipulations affected growth, condition, and timing of migration. We found that pre-existing differences predicted migration, with smaller individuals and individuals in poor condition having a higher propensity to migrate. Exogenous cortisol manipulation had the largest negative effect on growth and condition, and resulted in an earlier migration date. Additionally, low-growth individuals within the temperature and food deprivation treatments migrated earlier. By demonstrating that both pre-existing differences in organism state and additional stressors can affect whether and when individuals migrate, we highlight the importance of understanding individual differences in partial migration. These effects may carry over to influence migration success and affect the evolutionary dynamics of sub-populations experiencing different levels of stress, which is particularly relevant in a changing world.

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Making touch choices: Picking the appropriate conservation decision-making tool
Conservation practitioners face complex challenges due to resource limitations, biological and socioeconomic trade-offs, involvement of diverse interest groups, and data deficiencies. To help address these challenges, there are a growing number of frameworks for systematic decision making. Three prominent frameworks are structured decision making, systematic conservation prioritization, and systematic reviews. These frameworks have numerous conceptual linkages, and offer rigorous and transparent solutions to conservation problems. However, they differ in their assumptions and applicability. Here, we provide guidance on how to choose among these frameworks for solving conservation problems, and how to identify less rigorous techniques when time or data availability limit options. Each framework emphasizes the need for proper problem consideration and formulation, and includes steps for monitoring and evaluation. We recommend clear and documented problem formulation, adopting structured decision-making processes, and archiving results in a global database to support conservation professionals in making evidence-based decisions in the future.

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Morphological, physiological and dietary covariation in migratory and resident adult brown trout (Salmo trutta)

The causes and consequences of trait relationships within and among the categories of physiology, morphology, and life-history remain poorly studied. Few studies cross the boundaries of these categories, and recent reviews have pointed out not only the dearth of evidence for among-category correlations but that trait relationships may change depending on the ecological conditions a population faces. We examined changes in mean values and correlations between traits in a partially migrant population of brown trout when migrant sea-run and resident stream forms were breeding sympatrically. Within each sex and life-history strategy group, we used carbon and nitrogen stable isotopes to assess trophic level and habitat use; assessed morphology which reflects swimming and foraging ability; measured circulating cortisol as it is released in response to stressors and is involved in the transition from salt to freshwater; and determined oxidative status by measuring oxidative stress and antioxidants. We found that sea-run trout were larger and had higher values of stable isotopes, cortisol and oxidative stress compared to residents. Most groups showed some correlations between morphology and diet, indicating individual resource specialization was occurring, and we found consistent correlations between morphology and cortisol. Additionally, relationships differed between the sexes (cortisol and oxidative status were related in females but not males) and between life-history strategies (habitat use was related to oxidative status in male sea-run trout but not in either sex of residents). The differing patterns of covariation between the two life-history strategies and between the sexes suggest that the relationships among phenotypic traits are subjected to different selection pressures, illustrating the importance of integrating multiple phenotypic measures across different trait categories and contrasting life-history strategies.

Nutritional physiology of wildlife in a changing world

Over the last century, humans have modified landscapes, generated pollution and provided opportunities for exotic species to invade areas where they did not evolve. In addition, humans now interact with animals in a growing number of ways (e.g. ecotourism). As a result, the quality (i.e. nutrient composition) and quantity (i.e. food abundance) of dietary items consumed by wildlife have, in many cases, changed. We present representative examples of the extent to which vertebrate foraging behaviour, food availability (quantity and quality) and digestive physiology have been modified due to human-induced environmental changes and human activities. We find that these effects can be quite extensive, especially as a result of pollution and human-provisioned food sources (despite good intentions). We also discuss the role of nutrition in conservation practices, from the perspective of both in situ and ex situ conservation. Though we find that the changes in the nutritional ecology and physiology of wildlife due to human alterations are typically negative and largely involve impacts on foraging behaviour and food availability, the extent to which these will affect the fitness of organisms and result in evolutionary changes is not clearly understood, and requires further investigation.
Oxidative stress and partial migration in brown trout (Salmo trutta)

During migration, animals are typically limited by their endogenous energetic resources which must be allocated to the physiological costs associated with locomotion, as well as avoiding and/or compensating for oxidative stress. To date, there have been few attempts to understand the role of oxidative status in migration biology, particularly in fish. Semi-anadromous brown trout (Salmo trutta, Linnaeus 1758) exhibit partial migration, where some individuals smoltify and migrate to sea, and others become stream residents, providing us with an excellent model to investigate the link between oxidative stress and migration. Using the brown trout, we obtained blood samples from juveniles from a coastal stream in Denmark in the fall prior to peak seaward migration which occurs in the spring, and assayed for antioxidant capacity (oxygen radical absorbance capacity) and oxidative stress levels (ratio of oxidized to reduced glutathione). We found that individuals that migrated had higher antioxidant capacity than residents and that future migration date was negatively correlated with both antioxidant capacity and body length in the fall. This study provides the first evidence that oxidative status is associated with migration strategy and timing, months in advance of the actual migration, and provides insight into the role of oxidative status in animal migration.
Right whale poo: the key to conserving an endangered species?

Abstract
1. The majority of rivers around Europe have been modified in one way or another, and no longer have an original, continuous flow from source to outlet. The presence of weirs and dams has altered habitats, thus affecting the wildlife that lives within them. This is especially true for migrating rheophilic fish species, which, in addition to safe passage, depend on gradient and fast-flowing waters for reproductive success and early development.
2. Thus far, research has focused on investigating the impacts of weirs and dams on fish passage, with less attention paid to the loss of habitat entrained by such infrastructure. The loss of rheophilic habitat is particularly important in lowland streams, where gradient is limited, and dams and weirs can be constructed with less effort.
3. Denmark is considered a typical lowland country, where the landscape around streams and rivers has been modified by agriculture and other human activities for centuries, leaving management practitioners wondering how much change is acceptable to maintain sustainable fish populations and fisheries practices.
4. With examples from Denmark, this paper attempts to conceptualize the loss in habitat as a result of barriers in lowland streams and rivers, and the repercussions that such alterations may have on rheophilic fish populations. Furthermore, the need for management to address habitat loss and its related consequences concurrently with the improvement of fish passage is emphasized.

Bibliographical note
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Shining a light on the loss of rheophilic fish habitat in lowland rivers as a forgotten consequence of barriers and its implications for management

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Short-term and long-term effects of transient exogenous cortisol manipulation on oxidative stress in juvenile brown trout

In the wild, animals are exposed to a growing number of stressors with increasing frequency and intensity, as a result of human activities and human-induced environmental change. To fully understand how wild organisms are affected by stressors, it is crucial to understand the physiology that underlies an organism's response to a stressor. Prolonged levels of elevated glucocorticoids are associated with a state of chronic stress and decreased fitness. Exogenous glucocorticoid manipulation reduces an individual's ability to forage, avoid predators and grow, thereby limiting the resources available for physiological functions like defence against oxidative stress. Using brown trout (Salmo trutta), we evaluated the short-term (2 weeks) and long-term (4 months over winter) effects of exogenous cortisol manipulations (versus relevant shams and controls) on the oxidative status of wild juveniles. Cortisol caused an increase in glutathione over a 2 week period and appeared to reduce glutathione over winter. Cortisol treatment did not affect oxidative stress levels or low molecular weight antioxidants. Cortisol caused a significant decrease in growth rates but did not affect predation risk. Over-winter survival in the stream was associated with low levels of oxidative stress and glutathione. Thus, oxidative stress may be a mechanism by which elevated cortisol causes negative physiological effects.
Sublethal consequences of urban life for wild vertebrates

Urbanization is modifying previously pristine natural habitats and creating "new" ecosystems for wildlife. As a result, some animals now use habitat fragments or have colonized urban areas. Such animals are exposed to novel stimuli that they have not been exposed to in their evolutionary history: Some species have adapted to the challenges they face- a phenomenon known as synurbanization-while others have not. Here we present a review of the sublethal consequences of life in the city for wild vertebrates, and demonstrate that urban animals face an almost completely different set of physiological and behavioural challenges compared to their rural counterparts. We focus on the negative fitness-related impacts of urbanization, but also identify instances where there are benefits to wildlife. The effects of urbanization appear to be both species- and context-dependent, suggesting that although the field of urban ecology is far from nascent, we are still just beginning to understand how the intricacies of biodiversity on our planet are affected by our presence.

The effects of global warming and ocean acidification on marine ectotherms: a meta-analysis

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Investigating the effects of barriers on fish in European streams and rivers
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