Title: Revisiting Size Selective Mortality in Young Fish: Do Small Teleosts Really Pay a Cost?

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Abstract

Small juvenile and larval teleosts are typically more susceptible to starvation and predation, so the largest individuals tend to survive. However, most support for this 'bigger is better' hypothesis is experimental and does not account for the variation in food availability, competition, and other conditions that alter how starvation and predation affect small fish. To assess how natural populations experience size-selective mortality, we reviewed the past 30 years of literature on the subject while compiling 76 effect sizes of longitudinal survival data, which evaluates selection against size classes, to test for evidence that 'bigger is better'. Our meta-analysis shows that the effect of body size on survival is consistently weak across species, populations, times, and locations. We discuss several reasons why larger young teleosts may not have a distinct survival advantage. We argue that they: 1) may be more profitable or noticeable to predators, 2) are unable to outgrow all their predators, and 3) require more resources, increasing their predator exposure out of necessity to forage. We recommend that mortality not be treated as constant across young teleost size classes, as different ecological conditions may favour smaller, larger, or neither size class. We suggest that the relationship between metabolic scope and mortality, geographic gradients in the importance of predation and starvation, and the interactive effects of alternative sources of mortality with predation and starvation in warming oceans are underexplored and could change how we think about the relationship between young teleost size and survival. Investigating these drivers will be important as temperatures rapidly rise, altering growth in wild fish.

Introduction

Vulnerability to predation and starvation—the primary sources of mortality among larval and juvenile teleost fish—is influenced by an individual's size (e.g., Garvey et al., 2004; Holmes & McCormick, 2010; van Deurs et al., 2011). Larger individuals are thought to face less predation risk because their size makes it harder for predators to capture and consume them (Juanes & Conover, 1994; Sogard, 1997). Larger fish are also more resistant to starvation as they tend to have more mass-specific stored energy and lower mass-specific metabolic rates (Auer et al., 2015). The idea that larger larval and juvenile fish are more likely to survive is the basis for the 'bigger is better' hypothesis. This hypothesis has been widely accepted in the literature for decades and forms the fundamental framework for understanding fish ecology (Bailey, 1984; Bailey & Batty, 1983; Bailey & Yen, 1983; Sogard, 1997).

While the 'bigger is better' hypothesis is influential in fish ecology, the relationship between size and survival is complex. Which prey sizes are most vulnerable to predation depends on which predators are present and their sizes relative to the prey (Juanes & Conover, 1994; Scharf et al., 1998). Behavioural dynamics among conspecifics can leave larger fish more vulnerable to predation and starvation (Polyakov et al., 2022; Reinhardt, 1999). Predators may target larger fish during shoaling because they are more noticeable (Polyakov et al., 2022). Importantly, ecological conditions can change seasonally and interannually, which previous studies note alter when size-selective mortality occurs and in what direction (Bath et al., 2024; Peres et al., 2022).

To understand the evidence for both sides of the size-selective mortality argument, we review evidence for and against the 'bigger is better' hypothesis, focusing on the two primary

sources of mortality for young teleosts: starvation and predation (Gjøsæter et al., 2016; Sogard, 1997). First, we introduce the foundational ideas behind the hypothesis that led to widespread acceptance. We then synthesize longitudinal survivor data from studies of natural populations to test whether bigger fish enjoy lower rates of starvation and predation. Next, we review factors that influence the risk of predation and starvation, explaining why the 'bigger is better' hypothesis might hold in some cases and not in others. Our work builds on a foundational review by Sogard (1997), incorporating findings from recent studies to provide a contemporary consensus from the literature. Finally, we offer a perspective on areas of future research that would lead to our better understanding of the factors shaping early-life fish mortality and when the ‘bigger is better’ hypothesis applies.

1. Why is bigger better?

At the time of Sogard’s (1997) review of size-selective mortality in juvenile teleosts, evidence favoured the ‘bigger is better’ hypothesis. Here we discuss the ecological mechanisms for this pattern in larval and juvenile (hereafter, young) teleosts, which fall into two major categories: the metabolic efficiency of larger fish and their capacity for accessing and storing energy, which reduces their susceptibility to starvation, and the related behavioural and morphological adaptations that help them avoid predation.

Larger teleosts are more resilient to starvation than smaller ones because of physical advantages that help them store and access more energy. Endogenous energy storage scales with body size while mass-specific metabolic rate declines, allowing larger teleosts to store more energy while needing to forage relatively less (Biro et al., 2021; Brown et al., 2004; Shuter & Post, 1990). This means that during food shortages, larger teleosts can meet up to 80% of their metabolic needs from stored energy (Heintz & Vollenweider, 2010), leading to higher survival

rates than smaller fish, approaching nearly 100% in some cases (Biro et al., 2021; Blom et al., 1994; Byström et al., 2006; Finstad et al., 2004; Geissinger et al., 2021; Pangle et al., 2005, 2011; Trexler et al., 1992). In contrast, smaller teleosts, with their high mass-specific metabolisms and limited energy reserves (Biro et al., 2021), lose body mass during long periods of low food availability because they lack sufficient endogenous stores (Fishelson, 1997; Heintz & Vollenweider, 2010; van Deurs et al., 2011).

Morphologically, body size improves foraging capacity in teleosts because gape limitations (i.e., how wide a fish can open its mouth) scale positively with size. Larger fish can consume a relatively wider range of prey sizes (Gaeta et al., 2018; Higgins et al., 2018; Pessanha & Araújo, 2014). Therefore, they are more likely to consume energetically profitable intermediate-size prey. Larger teleosts relative to others in the same development stages can also shift to more profitable prey guilds sooner, moving, for example, from invertebrates to other fish (Scharf et al., 2009). Improved diet quality during this transition reduces the need for teleosts to forage frequently, which lowers predation risk and increases energy gains, facilitating further growth. Additionally, the largest teleosts physically dominate others in their cohort and monopolize food sources, enhancing their growth rates and energy reserves (Beaugrand & Beaugrand, 1991; Naman et al., 2019; Reed et al., 2019; Whiteman & Côté, 2004).

The physiological and morphological advantages that help larger teleosts avoid starvation also translate into safer behavioural strategies that help them avoid predation. For example, lower mass-specific metabolic rates enable larger fish to reduce their foraging effort and avoid places where their predators are likely to hunt, choosing instead to remain in safer places with fewer resources (Garvey et al., 2004; Jonas & Wahl, 1998; Reinhardt & Healey, 1999; Sewall et al., 2019). In contrast, smaller teleosts store relatively less energy and use it less efficiently,

95 forcing them to forage more often and in areas where predators are more likely to target them
96 (Catano et al., 2016; Garvey et al., 2004; Heintz & Vollenweider, 2010; Naman et al., 2019; Pratt
97 & Fox, 2002; Reinhardt & Healey, 1999; Sbragaglia et al., 2021). By physically dominating
98 smaller teleosts, larger teleosts also control the resources in areas with fewer predators, further
99 reducing their predation risk (Naman et al., 2019).

100 In addition to avoiding predation behaviourally, large teleosts are also harder to consume,
101 making them less profitable prey. The largest teleosts can be inaccessible prey for other teleosts
102 because they outgrow the maximum mouth width or 'gape limit' of predatory fish (Mihalitsis &
103 Bellwood, 2017). Predatory fish and those from other guilds—including birds and
104 invertebrates—also avoid eating larger prey due to longer handling times, which lower net
105 energy gain and increase the risk of injury (Lucas et al., 2021; Lundvall et al., 1999; Mukherjee
106 & Heithaus, 2013; Scharf et al., 1998; Taylor, 2003; Taylor & Collie, 2003; Tucker et al., 2016).

107 While there is good theoretical and experimental evidence for 'bigger is better', natural
108 populations face ecological dynamics, such as fluctuating predation pressure and food
109 availability, that can alter the benefits of size across time and space. Yet, studies in natural
110 populations typically test size-selective mortality in only a few species, at ecologically similar
111 sites, and over short timeframes (e.g., Pangle et al., 2011; Raventos & Macpherson, 2005;
112 Takasuka et al., 2016). These studies also employ a variety of non-standardized methods that are
113 difficult to compare directly (Sogard, 1997). As a result, we still lack a consensus understanding
114 of how size affects survival in young teleost fish.

2. Meta-analysis of 'bigger is better'

To improve our general understanding of size-selective mortality, we conducted a meta-analysis to assess size-selective mortality in survivor analysis studies, focusing on young teleosts. Survivor analysis, an established method to test for size-selective mortality in natural fish populations (Sogard, 1997), looks for relationships between survival and phenotypic traits. Longitudinal sampling compares the trait distributions between surviving individuals and an initial sample of young teleosts (Figure 1). If survivors differ phenotypically from the initial sample of young teleosts, we assume that selection for that trait led to non-random mortality. In size-selective mortality studies, size is the focal trait in the survivor analysis. A single group of young teleosts is measured at two points in time, and support for 'bigger is better' is concluded if the average length of surviving individuals is greater than the original sample (Figure 1).

Methods

In our literature search, we used the search terms 'size selective mortality' and 'bigger is better', as these terms are common keywords in survival analysis studies. First, we systematically searched the Web of Science core collection on February 12th, 2024. Then, we searched for papers on the Dryad data repository on April 15th, 2024, employing an application programming interface in Python. Search details are in S1 Methods.

We selected studies based on several requirements. First, we included studies focused on our two target life history stages of young teleost—larval or juvenile. To facilitate our effect size calculations—i.e., the direction and magnitude of effect standardized across studies—we only included studies that measured the mean length of an initially sampled cohort of fish, i.e., the 'original,' and the back-calculated mean length of a surviving group of fish using the otoliths

(Figure 1). Additionally, we only included studies that reported sample size for the original and survivor groups and a measure of variation for each group. We placed no constraints on the years that papers were published.

To calculate the effect size across studies, we used ‘C*ohen’s d’*, i.e., the standardized mean difference between the survivor and original groups (Harrer et al., 2021). We calculated effect sizes so that negative values indicated selection against smaller young teleosts and positive values indicated selection against larger individuals. When studies compared multiple survivor groups with a single original group, we considered them separate effect sizes. We considered comparisons in different years, locations, and from different species as separate effect sizes, even when they came from the same studies.

Our initial search returned 829 publications. After screening the publications by journal, title, and abstract (S1 Methods), we found 10 studies were suitable for our meta-analysis (Figure 2). From these studies, we could extract 76 effect sizes representing 16,264 individual fish. The effect sizes represent 10 species from 6 orders of teleosts, including Salmoniformes, Blenniiformes, Clupeiformes, Labriformes, Perciformes and Gobiiformes (Table S3). The phylogeny covers species that are anadromous, freshwater, and marine. Larval teleosts represent 79% of the effect sizes and juvenile life stages, 21% (Table S4). The effect sizes are from the northern hemisphere only, but their geographic locations span broadly east and west of the prime meridian (Figure 3). The studies also represent several life events, including marine migration, metamorphosis, overwintering, post-hatching, post-settlement, and young of the year (Table S3).

To estimate true effect sizes for studies and the pooled effect between studies, we fit a Bayesian, intercept-only mixed-effects model using the package ‘brms’ (Bürkner, 2017) in R (R

Core Team 2023), specifying study ID as the random effect. We used an intercept-only model because we are only interested in the relationship between body size and survival.

Results

Our meta-analysis, including 16,264 individuals across 10 studies, showed a weak effect of size on survival. The pooled effect size across studies was -0.056 (95% CI: -0.14 to 0.035; Figure 4). The probability that the pooled effect size is less than 0 was 90% (Figure S1). This means that the pooled effect size has a 90% probability of being negative, weakly supporting greater survival for larger fish. Except for one study, the credible intervals of all effect sizes crossed zero, which indicates a similarly weak relationship between body size and survival in young teleost fish regardless of year, location, or species.

A single study, Macpherson & Raventos (2005), accounted for 47% of all effect sizes in our meta-analysis. The effect size from this study was the largest (-0.20), with the only confidence interval not crossing zero (95% CI: -0.31 to -0.077; Figure 4; Table S2). To ensure our results were not biased by this large study, which included multiple species, years, and locations (S1 Methods), we excluded the study and re-ran the model. Its removal increased the pooled effect size from -0.056 (95% CI: -0.14 to 0.035) to –0.022 (95% CI: -0.61 to 0.027; Figure 5), and the probability of the pooled effect size being less than 0 decreased to 76%, but the pooled effect size did not change direction. This means the weak relationship we found between body size and survival persisted across the other less influential studies.

Despite a consistently weak relationship between size and survival in our meta-analysis, given the large spread in true effect sizes across studies, our results also suggest that the exact strength of selection against smaller fish still depends on the time, location, and species being

181 tested (Table S1). This finding supports similar observations from Sogard (1997), indicating that
182 bigger is not always better, and hinting that factors other than size could help explain the
183 additional variation in survival among young teleosts.

184 *3. Why is bigger not always better?*

185 Although many studies report that larger fish experience higher survival rates, this is not
186 always the case in natural populations because predator-prey relationships are complex. Under
187 optimal foraging, fish predators should select prey sizes that maximize net energy gain (Charnov,
188 1976; Sogard, 1997; Werner & Hall, 1974; Werner & Mittelbach, 1981). However, which prey
189 sizes maximize energy gain also depend on predator traits. When young teleosts face diverse
190 predators under natural conditions, predation pressure should be distributed more evenly across
191 size classes, leading to no clear size advantage (Figure 6A). Additionally, young teleosts,
192 regardless of size, are willing to risk predation to access the resources they need when growing
193 (Catano et al., 2016; Naman et al., 2019; Sbragaglia et al., 2021).

194 Prey vulnerability to predation shifts over time and across locations based on predator
195 traits. Predator capture success and preferences often follow a dome-shaped distribution of prey
196 sizes that depends on the predator's size (Cowan et al., 1996; Sigler et al., 2009). Thus, size-
197 selective morality is not dependent on the size of the young teleost relative to others but on
198 predator size preferences (i.e., optimal foraging; Charnov, 1976; Scharf et al., 1998, 2009; Sigler
199 et al., 2009; Taylor, 2003). This means prey species might face selection against smaller or larger
200 individuals or no size-selective mortality at all, depending on which predators are present (e.g.,
201 Holmes & McCormick, 2006, 2010; Figure 6A). As young teleosts grow, their value to predators
202 also changes, so selection patterns can change over time (Figure 6B). For example, predators

203 removed the largest damselfish (*Pomacentrus amboinensis*) on their initial settlement, but
204 predation shifted to target the smallest individuals one month later (Meekan et al., 2010).

205 Young teleosts face multiple predators, each of which influences the advantages of
206 different sizes. For larger individuals to consistently benefit from reduced predation risk, most
207 predators would need to prefer smaller prey. However, under natural conditions, co-occurring
208 predators often specialize on different prey sizes (Holmes & McCormick, 2010; Figure 6A).
209 When predators are removed experimentally, the survival advantage shifts toward prey sizes
210 favoured by the removed predator (McCormick & Hoey, 2004), highlighting that the survival
211 advantage of large young teleosts is highly dependent on the predator pool.

212 Young teleost fish can outgrow their predators, but they may be unable to do so when the
213 predator's preferred size window encompasses the entire size distribution of its prey (Robert et
214 al., 2010; Figure 6C). Some predators have adapted to grow synchronously with the prey species
215 they consume, ensuring their prey remains within an optimal size range for consumption (e.g.,
216 Persson & Bronmark, 2002; Figure 6D).

217 Some stages of development are energetically expensive, changing the relationship
218 between size and foraging risk. While energy stores usually scale with size, at earlier life stages,
219 fish devote more energy to growth, reducing energy storage, and resulting in larger young teleost
220 fish with lower energy stores (Abookire et al., 2024; Biro et al., 2005; Schultz & Conover, 1997;
221 Sewall et al., 2019). Transitioning from the larval to juvenile stage can be energetically
222 expensive, requiring as much as half of a fish's energy reserves (Nursall & Turner, 1985;
223 Youson, 1988). These developmental changes mean that young teleosts in the early juvenile
224 stage can often have lower lipid levels than smaller individuals that are in the late larval stage.
225 Individuals with few energy stores are at risk of starvation, and as a result, they are often more

willing to risk predation while foraging (Dall et al., 2004). As a result of this risk-taking behaviour, predators may opportunistically select larger prey instead of smaller ones (McCormick & Hoey, 2004).

Some of the collective strategies young teleosts use to lower their predation risk may increase risk to the largest individuals in the group. Shoaling behaviour, for example, lowers individual risk if all individuals in the group are similar in size. However, individuals larger than the average shoal member attract predators, increasing their mortality rates (Polyakov et al., 2022). Also, individual behavioural traits like boldness, which determine risk-taking in fish, often increase with size (Brown et al., 2007). This means larger young teleosts might be more willing to accept risk while foraging, resulting in greater predation of larger individuals (Biro et al., 2005; Stamps, 2007).

While larger young teleosts typically dominate access to resources, which helps them survive resource limitations, they may be more vulnerable to starvation when under predation risk. Larger fish use dominance behaviours to monopolize resources, as their greater standard metabolic rates (Metcalfe et al., 2015; Reid et al., 2012; Yamamoto et al., 1998) require them to consume more energy. However, the presence of predators suppresses these dominance behaviours in larger fish, reducing their food intake relative to their mass and increasing their risk of starvation (Cutts et al., 2002; Johnsson, 1993; Metcalfe et al., 2015; Naman et al., 2019). Also, suppressing dominance behaviours raises predation risk to larger individuals, as they may resort to riskier foraging behaviours than smaller individuals to meet their energy needs for growth (Johnsson, 1993; Metcalfe et al., 2015).

Although previous experiments and field work have suggested larger young teleosts have higher survival rates, the relationship between body size and survival is less clear under natural

249 conditions. The vulnerability of different size classes to predation varies depending on the
250 predator size and the composition of the predator community. Additionally, larger young teleosts
251 remain susceptible to starvation, as energy storage is not always proportional to size, and
252 dominance hierarchies break down under high predation pressure. These dynamics in natural
253 predator-prey communities likely explain the absence of a strong size-selective mortality signal
254 we observed in our meta-analysis.

255 Literature gaps

256 In the previous section, we outlined several ecological contexts in which predation
257 patterns in young teleost fish might not be size selective. Predicting when these ecological
258 contexts might arise will require uncovering the relationship between size, metabolism, and
259 dominance in fish, mapping geographic patterns of size-selective mortality in response to the
260 environment, and considering the additive effects of mortality sources other than starvation and
261 predation. In this section, we describe three future directions for research in these key areas.
262 Studying them should improve our overall knowledge of fish ecology and population dynamics,
263 particularly as the climate warms.

264 *Gap 1—The link between metabolic scope and size-selective mortality*

265 Metabolic scope, which typically increases with size, is thought to influence size-
266 selective mortality in young teleosts (Clarke & Johnston, 1999; Jerde et al., 2019). This is
267 because metabolic scope can determine access to resources, vulnerability to predation, and
268 ultimately survival (Killen et al., 2006; Naya & Bozinovic, 2012). However, it is unclear whether
269 these factors are actually determined by metabolic scope or resting and maximum metabolic
270 rates. Because metabolic scope is the difference between resting and maximum metabolic rates,

individuals with the same metabolic scopes may still differ greatly in their metabolic profiles (Norin & Malte, 2012).

Resting and maximum metabolic rates may be the key drivers of size-selective mortality for several reasons. First, having a higher resting metabolic rate can mean a greater energy demand, which is often considered the driver of dominance and risk-taking behaviours in young teleosts that affect mortality (e.g., Auer et al., 2015; Cutts et al., 2002). Furthermore, regardless of metabolic scope, maximum metabolic rate can restrict the behaviours young teleosts use to acquire energy. Thus, to understand how size affects survival, we need to know the extent to which behavioural differences related to specific metabolic profiles drive mortality in young teleosts. These studies will be best carried out under natural conditions where predators are present (Reinhardt, 1999) and food patches and habitats are complex (Reid et al., 2012), providing a realistic picture of how metabolic scope relates to behaviour and size-selective mortality.

Gap 2—Geographic gradients

The relationship between size and survival likely operates on a latitudinal gradient. At higher latitudes, survival in young teleosts is influenced by shorter growing seasons and periods of low food availability (Shuter & Post, 1990). Their size and lipid amount often increase with latitude (Knouft, 2004; Saunders & Tarling, 2018; Schultz & Conover, 1997), as reaching a size with adequate energy stores can reduce the risk of starvation and minimize foraging-related predation (Garvey et al., 2004; Jonas & Wahl, 1998; Sewall et al., 2019; van Deurs et al., 2011). This means that size-selective mortality due to starvation might be more important for young teleosts at higher latitudes. Conversely, young teleosts at lower latitudes should be less prone to starvation due to higher resource availability but may face greater predation risk from a more

diverse predator pool. When multiple predators are present in a diverse predator pool, predator selection across the size-frequency distribution of prey could cause stabilizing selection on size, where greater size does not increase survival.

Distinguishing the most influential source of mortality—predation or starvation—is crucial for understanding how and when size should influence population dynamics. While some models assume constant mortality across size classes (e.g., Froese et al., 2008), this assumption may not hold across environmental gradients. Testing for size-selective mortality across latitudes, where predator communities and resource availability vary, could reveal whether this assumption is consistent. This is especially important since climate change will likely continue to alter size-selective mortality in young teleosts.

Gap 3—Additive and interactive effects

Our review focused on two sources of mortality in young teleosts: predation and starvation. However, other equally important sources can compound mortality risk, sometimes with additive effects for larger individuals. For example, parasites often affect smaller fish disproportionately (e.g., Smith et al., 2022; Tucker et al., 2002). However, larger individuals can develop higher parasite loads over time because of their larger surface areas for infection, and underdeveloped immunocompetence, which they trade off for faster growth rates (Bartuseviciute et al., 2022). Additionally, temperature can compound foraging risk for smaller fish by elevating their metabolic demand (Pink & Abrahams, 2016) and increasing predator activity.

The future impact of climate warming on size-selective mortality through interactive and additive factors will be a key area of future study. The transmission and biodiversity of aquatic parasites in warmer waters are highly uncertain (Lõhmus & Björklund, 2015). Also, the

shrinkage of body size in fish caused by global temperature increases will have important and complex effects on size-selective mortality (Daufresne et al., 2009; Deutsch et al., 2022; Forster et al., 2012). For example, while temperature could shift size-selective mortality distributions, fish predators are also reaching smaller sizes under higher global temperatures, which will relieve some predation pressure (Eskuche-Keith et al., 2024). Thus, exploring the mechanisms by which additive and interactive sources of mortality, like parasites and temperature, interact with size-selective mortality from predation and starvation, in both experimental and natural settings, will help anticipate and explain unexpected relationships between size and mortality in young teleosts.

Conclusion

We provide evidence that, as a young teleost, being bigger may hold only a weak advantage in the face of mortality. Assumptions of the 'bigger is better' hypothesis, while well supported experimentally, are limited by complex interactions under natural conditions. In environments where predators prefer different-sized prey, all sizes of young teleost may be vulnerable. However, as climate change alters community composition and maximum growth, the relationship between size and vulnerability is likely to change. We suggest that future longitudinal studies under natural conditions consider how latitude, metabolic physiology, and additive effects might change the relationship between size and mortality for young teleosts. This understanding will help anticipate mortality patterns under new conditions caused by the changing climate.

References

Abookire, A. A., Copeman, L. A., Litzow, M. A., & Laurel, B. J. (2024). Seasonal shift in energy allocation from somatic growth to lipid storage and the link between pre-winter condition and overwintering potential in juvenile Pacific cod. *ICES Journal of Marine Science*, *81*(4), 710–723. https://doi.org/10.1093/icesjms/fsae023

Auer, S. K., Salin, K., Rudolf, A. M., Anderson, G. J., & Metcalfe, N. B. (2015). The optimal combination of standard metabolic rate and aerobic scope for somatic growth depends on food availability. *Functional Ecology*, *29*(4), 479–486. https://doi.org/10.1111/1365-2435.12396

Bailey, K. M. (1984). Comparison of laboratory rates of predation of five species of marine fish larvae by three planktonic invertebrates: Effects of larval size on vulnerability. *Marine Biology*, *79*(3), 303–309. https://doi.org/10.1007/BF00393262

Bailey, K. M., & Batty, R. S. (1983). A laboratory study of predation by Aurelia aurita on larval herring (Clupea harengus): Experimental observations compared with model predictions. *Marine Biology*, *72*(3), 295–301. https://doi.org/10.1007/BF00396835

Bailey, K. M., & Yen, J. (1983). Predation by a carnivorous marine copepod, Euchaeta elongata Esterly, on eggs and larvae of the Pacific hake, Merluccius productus. *Journal of Plankton Research*, *5*(1), 71–82. https://doi.org/10.1093/plankt/5.1.71

Bartuseviciute, V., Diaz Pauli, B., Salvanes, A. G. V., & Heino, M. (2022). Size-selective harvesting affects the immunocompetence of guppies exposed to the parasite Gyrodactylus. *Proceedings of the Royal Society B: Biological Sciences*, *289*(1981), 20220534. https://doi.org/10.1098/rspb.2022.0534

Bath, D. R., Gregory, R. S., Snelgrove, P. V., & Geissinger, E. A. (2024). Low predator and conspecific density lead to larger juveniles. *Canadian Journal of Fisheries and Aquatic Sciences*. https://doi.org/10.1139/cjfas-2023-0344

Beaugrand, J., & Beaugrand, M. (1991). Prior residency and the stability of dominance relationships in pairs of green swordtail fish *Xiphophorus helleri* (Pisces, Poeciliidae). *Behavioural Processes*, *24*(3), 169–175. https://doi.org/10.1016/0376-6357(91)90072-8

Biro, P. A., Post, J. R., & Abrahams, M. V. (2005). Ontogeny of energy allocation reveals selective pressure promoting risk-taking behaviour in young fish cohorts. *Proceedings of the Royal Society B: Biological Sciences*, *272*(1571), 1443–1448. https://doi.org/10.1098/rspb.2005.3096

Biro, P. A., Post, J. R., & Beckmann, C. (2021). Autumn lipid reserves, overwinter lipid depletion, and high winter mortality of rainbow trout in experimental lakes. *Canadian*

Journal of Fisheries and Aquatic Sciences, *78*(6), 738–743. https://doi.org/10.1139/cjfas-2020-0276

Blom, G., Svåsand, T., Jørstad, K. E., Otterå, H., Paulsen, O. I., & Holm, J. C. (1994). Comparative Survival and Growth of Two Strains of Atlantic Cod (Gadus morhua) through the Early Life Stages in a Marine Pond. *Canadian Journal of Fisheries and Aquatic Sciences*, *51*(5), 1012–1023. https://doi.org/10.1139/f94-101

Brown, C., Jones, F., & Braithwaite, V. A. (2007). Correlation between boldness and body mass in natural populations of the poeciliid Brachyrhaphis episcopi. *Journal of Fish Biology*, *71*(6), 1590–1601. https://doi.org/10.1111/j.1095-8649.2007.01627.x

Brown, J. H., Gillooly, J. F., Allen, A. P., Savage, V. M., & West, G. B. (2004). Toward a Metabolic Theory of Ecology. *Ecology*, *85*(7), 1771–1789. https://doi.org/10.1890/03-9000

Bürkner, P.-C. (2017). brms: An R Package for Bayesian Multilevel Models Using Stan. *Journal of Statistical Software*, *80*, 1–28. https://doi.org/10.18637/jss.v080.i01

Byström, P., Andersson, J., Kiessling, A., & Eriksson, L.-O. (2006). Size and temperature dependent foraging capacities and metabolism: Consequences for winter starvation mortality in fish. *Oikos*, *115*(1), 43–52. https://doi.org/10.1111/j.2006.0030-1299.15014.x

Catano, L. B., Rojas, M. C., Malossi, R. J., Peters, J. R., Heithaus, M. R., Fourqurean, J. W., & Burkepile, D. E. (2016). Reefscapes of fear: Predation risk and reef hetero-geneity interact to shape herbivore foraging behaviour. *Journal of Animal Ecology*, *85*(1), 146–156. https://doi.org/10.1111/1365-2656.12440

Charnov, E. L. (1976). Optimal foraging, the marginal value theorem. *Theoretical Population Biology*, *9*(2), 129–136. https://doi.org/10.1016/0040-5809(76)90040-x

Claiborne, A. M., Fisher, J. P., Hayes, S. A., & Emmett, R. L. (2011). Size at Release, Size-Selective Mortality, and Age of Maturity of Willamette River Hatchery Yearling Chinook Salmon. *Transactions of the American Fisheries Society*, *140*(4), 1135–1144. https://doi.org/10.1080/00028487.2011.607050

Clarke, A., & Johnston, N. M. (1999). Scaling of metabolic rate with body mass and temperature in teleost fish. *Journal of Animal Ecology*, *68*(5), 893–905. https://doi.org/10.1046/j.1365-2656.1999.00337.x

Cowan, J. H., Jr, Houde, E. D., & Rose, K. A. (1996). Size-dependent vulnerability of marine fish larvae to predation: An individual-based numerical experiment. *ICES Journal of Marine Science*, *53*(1), 23–37. https://doi.org/10.1006/jmsc.1996.0003

Cutts, C. J., Metcalfe, N. B., & Taylor, A. C. (2002). Juvenile Atlantic Salmon (Salmo salar) with relatively high standard metabolic rates have small metabolic scopes. *Functional Ecology*, *16*(1), 73–78. https://doi.org/10.1046/j.0269-8463.2001.00603.x

Dall, S. R. X., Houston, A. I., & McNamara, J. M. (2004). The behavioural ecology of personality: Consistent individual differences from an adaptive perspective. *Ecology Letters*, *7*(8), 734–739. https://doi.org/10.1111/j.1461-0248.2004.00618.x

Daufresne, M., Lengfellner, K., & Sommer, U. (2009). Global warming benefits the small in aquatic ecosystems. *Proceedings of the National Academy of Sciences*, *106*(31), 12788–12793. https://doi.org/10.1073/pnas.0902080106

Deutsch, C., Penn, J. L., Verberk, W. C. E. P., Inomura, K., Endress, M.-G., & Payne, J. L. (2022). Impact of warming on aquatic body sizes explained by metabolic scaling from microbes to macrofauna. *Proceedings of the National Academy of Sciences*, *119*(28), e2201345119. https://doi.org/10.1073/pnas.2201345119

Eskuche-Keith, P., Hill, S. L., López-López, L., Rosenbaum, B., Saunders, R. A., Tarling, G. A., & O'Gorman, E. J. (2024). Temperature alters the predator-prey size relationships and size-selectivity of Southern Ocean fish. *Nature Communications*, *15*(1), 3979. https://doi.org/10.1038/s41467-024-48279-0

Finstad, A. G., Ugedal, O., Forseth, T., & Næsje, T. F. (2004). Energy-related juvenile winter mortality in a northern population of Atlantic salmon (Salmo salar). *Canadian Journal of Fisheries and Aquatic Sciences*, *61*(12), 2358–2368. https://doi.org/10.1139/f04-213

Fishelson, L. (1997). Experiments and observations on food consumption, growth and starvation in Dendrochirus brachypterus and Pterois volitans (Pteroinae, Scorpaenidae). *Environmental Biology of Fishes*, *50*(4), 391–403. https://doi.org/10.1023/A:1007331304122

Forster, J., Hirst, A. G., & Atkinson, D. (2012). Warming-induced reductions in body size are greater in aquatic than terrestrial species. *Proceedings of the National Academy of Sciences*, *109*(47), 19310–19314. https://doi.org/10.1073/pnas.1210460109

Froese, R., Stern-Pirlot, A., Winker, H., & Gascuel, D. (2008). Size matters: How single-species management can contribute to ecosystem-based fisheries management. *Fisheries Research*, *92*(2), 231–241. https://doi.org/10.1016/j.fishres.2008.01.005

Gaeta, J. W., Ahrenstorff, T. D., Diana, J. S., Fetzer, W. W., Jones, T. S., Lawson, Z. J., McInerny, M. C., Jr, V. J. S., & Zanden, M. J. V. (2018). Go big or … don't? A field-based diet evaluation of freshwater piscivore and prey fish size relationships. *PLOS ONE*, *13*(3), e0194092. https://doi.org/10.1371/journal.pone.0194092

Garvey, J. E., Ostrand, K. G., & Wahl, D. H. (2004). Energetics, Predation, and Ration Affect Size-Dependent Growth and Mortality of Fish During Winter. *Ecology*, *85*(10), 2860–2871. https://doi.org/10.1890/03-0329

Geissinger, E. A., Gregory, R. S., Laurel, B. J., & Snelgrove, P. V. R. (2021). Food and initial size influence overwinter survival and condition of a juvenile marine fish (age-0 Atlantic cod). *Canadian Journal of Fisheries and Aquatic Sciences*, *78*(4), 472–482. https://doi.org/10.1139/cjfas-2020-0142

Gjøsæter, H., Hallfredsson, E. H., Mikkelsen, N., Bogstad, B., & Pedersen, T. (2016). Predation on early life stages is decisive for year-class strength in the Barents Sea capelin (Mallotus villosus) stock. *ICES Journal of Marine Science*, *73*(2), 182–195. https://doi.org/10.1093/icesjms/fsv177

Good, S. P., Dodson, J. J., Meekan, M. G., & Ryan, D. A. (2001). Annual variation in size-selective mortality of Atlantic salmon (Salmo salar) fry. *Canadian Journal of Fisheries and Aquatic Sciences*, *58*(6), 1187–1195. https://doi.org/10.1139/f01-069

Harrer, M., Cuijpers, P., Furukawa, T., & Ebert, D. (2021). *Doing Meta-Analysis with R: A Hands-On Guide*. Chapman and Hall/CRC. https://doi.org/10.1201/9781003107347

Heintz, R. A., & Vollenweider, J. J. (2010). Influence of size on the sources of energy consumed by overwintering walleye pollock (*Theragra chalcogramma*). *Journal of Experimental Marine Biology and Ecology*, *393*(1), 43–50. https://doi.org/10.1016/j.jembe.2010.06.030

Higgins, B. A., Law, C. J., & Mehta, R. S. (2018). Eat whole and less often: Ontogenetic shift reveals size specialization on kelp bass by the California moray eel, Gymnothorax mordax. *Oecologia*, *188*(3), 875–887. https://doi.org/10.1007/s00442-018-4260-x

Holmes, T. H., & McCormick, M. (2006). Location influences size-selective predation on newly settled reef fish. *Marine Ecology Progress Series*, *317*, 203–209. https://doi.org/10.3354/meps317203

Holmes, T. H., & McCormick, M. I. (2010). Size-selectivity of predatory reef fish on juvenile prey. *Marine Ecology Progress Series*, *399*, 273–283. https://doi.org/10.3354/meps08337

Honda, K., Shirai, K., Komatsu, S., & Saito, T. (2020). Sea-entry conditions of juvenile chum salmon Oncorhynchus keta that improve post-sea-entry survival: A case study of the 2012 brood-year stock released from the Kushiro River, eastern Hokkaido, Japan. *Fisheries Science*, *86*(5), 783–792. https://doi.org/10.1007/s12562-020-01442-0

Jerde, C. L., Kraskura, K., Eliason, E. J., Csik, S. R., Stier, A. C., & Taper, M. L. (2019). Strong Evidence for an Intraspecific Metabolic Scaling Coefficient Near 0.89 in Fish. *Frontiers in Physiology*, *10*, 1166. https://doi.org/10.3389/fphys.2019.01166

Johnsson, J. I. (1993). Big and brave: Size selection affects foraging under risk of predation in juvenile rainbow trout, Oncorhynchus mykiss. *Animal Behaviour*, *45*(6), 1219–1225. https://doi.org/10.1006/anbe.1993.1143

Johnston, P., Bergeron, N. E., & Dodson, J. J. (2005). Assessment of winter size-selective mortality of young-of-the-year Atlantic salmon (Salmo salar) using otolith microstructure analysis. *Ecology of Freshwater Fish*, *14*(2), 168–176. https://doi.org/10.1111/j.1600-0633.2005.00089.x

Jonas, J. L., & Wahl, D. H. (1998). Relative Importance of Direct and Indirect Effects of Starvation for Young Walleyes. *Transactions of the American Fisheries Society*, *127*(2), 192–205. https://doi.org/10.1577/1548-8659(1998)127<0192:RIODAI>2.0.CO;2

Juanes, F., & Conover, D. O. (1994). Piscivory and prey size selection in youngof-the-year bluefish: Predator preference or size-dependent capture success? *Marine Ecology Progress Series*, *114*, 59–69.

Killen, S. S., Costa, I., Brown, J. A., & Gamperl, A. K. (2006). Little left in the tank: Metabolic scaling in marine teleosts and its implications for aerobic scope. *Proceedings of the Royal Society B: Biological Sciences*, *274*(1608), 431–438. https://doi.org/10.1098/rspb.2006.3741

Knouft, J. H. (2004). Latitudinal variation in the shape of the species body size distribution: An analysis using freshwater fishes. *Oecologia*, *139*(3), 408–417. https://doi.org/10.1007/s00442-004-1510-x

Lõhmus, M., & Björklund, M. (2015). Climate change: What will it do to fish—parasite interactions? *Biological Journal of the Linnean Society*, *116*(2), 397–411. https://doi.org/10.1111/bij.12584

Lucas, J., Ros, A., Gugele, S., Dunst, J., Geist, J., & Brinker, A. (2021). The hunter and the hunted-A 3D analysis of predator-prey interactions between three-spined sticklebacks (Gasterosteus aculeatus) and larvae of different prey fishes. *PLoS ONE*, *16*(8), e0256427–e0256427. https://doi.org/10.1371/journal.pone.0256427

Lundvall, D., Svanbäck, R., Persson, L., & Byström, P. (1999). Size-dependent predation in piscivores: Interactions between predator foraging and prey avoidance abilities. *Canadian Journal of Fisheries and Aquatic Sciences*, *56*(7), 1285–1292. https://doi.org/10.1139/f99-058

Macpherson, E., & Raventos, N. (2005). Settlement patterns and post-settlement survival in two Mediterranean littoral fishes: Influences of early-life traits and environmental variables. *Marine Biology*, *148*(1), 167–177. https://doi.org/10.1007/s00227-005-0059-5

McCormick, M. I., & Hoey, A. S. (2004). Larval growth history determines juvenile growth and survival in a tropical marine fish. *Oikos*, *106*(2), 225–242. https://doi.org/10.1111/j.0030-1299.2004.13131.x

Meekan, M. G., von Kuerthy, C., McCormick, M. I., & Radford, B. (2010). Behavioural mediation of the costs and benefits of fast growth in a marine fish. *Animal Behaviour*, *79*(4), 803–809. https://doi.org/10.1016/j.anbehav.2009.12.002

Metcalfe, N. B., Van Leeuwen, T. E., & Killen, S. S. (2015). Does individual variation in metabolic phenotype predict fish behaviour and performance? *Journal of Fish Biology*, *88*(1), 298–321. https://doi.org/10.1111/jfb.12699

Mihalitsis, M., & Bellwood, D. R. (2017). A morphological and functional basis for maximum prey size in piscivorous fishes. *PLoS ONE*, *12*(9), e0184679. https://doi.org/10.1371/journal.pone.0184679

Mukherjee, S., & Heithaus, M. R. (2013). Dangerous prey and daring predators: A review. *Biological Reviews*, *88*(3), 550–563. https://doi.org/10.1111/brv.12014

Naman, S. M., Ueda, R., & Sato, T. (2019). Predation risk and resource abundance mediate foraging behaviour and intraspecific resource partitioning among consumers in dominance hierarchies. *Oikos*, *128*(7), 1005–1014. https://doi.org/10.1111/oik.05954

Naya, D., & Bozinovic, F. (2012). Metabolic scope of fish species increases with distributional range. *Evolutionary Ecology Research*. https://www.semanticscholar.org/paper/Metabolic-scope-of-fish-species-increases-with-Naya-Bozinovic/ab51f29020c98c57f5a3e35dc18b0ce6bdbb3701

Norin, T., & Malte, H. (2012). Intraspecific Variation in Aerobic Metabolic Rate of Fish: Relations with Organ Size and Enzyme Activity in Brown Trout. *Physiological & Biochemical Zoology*, *85*(6), 645–656. https://doi.org/10.1086/665982

Nursall, J., & Turner, L. (1985). The liver supports metamorphosis in the Caribbean reef blenniid. *Proc 5th Int. Coral Reef Symp.*, *5*, 457–462.

Pangle, K. L., Sutton, T. M., Kinnunen, R. E., & Hoff, M. H. (2005). Effects of Body Size, Condition, and Lipid Content on the Survival of Juvenile Lake Herring During Rapid Cooling Events. *Journal of Great Lakes Research*, *31*(3), 360–366. https://doi.org/10.1016/S0380-1330(05)70266-5

Pangle, K. L., Sutton, T. M., Kinnunen, R. E., & Hoff, M. H. (2011). Overwinter Survival of Juvenile Lake Herring in Relation to Body Size, Physiological Condition, Energy Stores, and Food Ration. *Transactions of the American Fisheries Society*, *133*(5), 1235–1246. https://doi.org/10.1577/T03-127.1

Peres, H. A., Robert, D., Mainguy, J., & Sirois, P. (2022). Interannual variability in size-selective winter mortality of young-of-the-year striped bass. *ICES Journal of Marine Science*, *79*(5), 1614–1623.

Persson, A., & Bronmark, C. (2002). Foraging Capacity and Resource Synchronization in an Ontogenetic Diet Switcher, Pikeperch (Stizostedion Lucioperca). *Ecology*, *83*(11), 3014–3022. https://doi.org/10.2307/3071838

Pessanha, A. L. M., & Araújo, F. G. (2014). Shifts of the feeding niche along the size dimension of three juvenile fish species in a tidal mudflat in southeastern Brazil. *Marine Biology*, *161*(3), 543–550. https://doi.org/10.1007/s00227-013-2356-8

Pink, M., & Abrahams, M. V. (2016). Temperature and its impact on predation risk within aquatic ecosystems. *Canadian Journal of Fisheries and Aquatic Sciences*, *73*(6), 869–876. https://doi.org/10.1139/cjfas-2015-0302

Polyakov, A. Y., Quinn, T. P., Myers, K. W., & Berdahl, A. M. (2022). Group size affects predation risk and foraging success in Pacific salmon at sea. *Science Advances*, *8*(26), eabm7548. https://doi.org/10.1126/sciadv.abm7548

Post, J. R., & Prankevicius, A. B. (1987). Size-Selective Mortality in Young-of-the-Year Yellow Perch (Perca flavescens): Evidence from Otolith Microstructure. *Canadian Journal of Fisheries and Aquatic Sciences*, *44*(11), 1840–1847. https://doi.org/10.1139/f87-228

Pratt, T. C., & Fox, M. G. (2002). Influence of Predation Risk on the Overwinter Mortality and Energetic Relationships of Young-of-Year Walleyes. *Transactions of the American Fisheries Society*, *131*(5), 885–898. https://doi.org/10.1577/1548-8659(2002)131<0885:IOPROT>2.0.CO;2

Raventos, N., & Macpherson, E. (2005). Effect of pelagic larval growth and size-at-hatching on post-settlement survivorship in two temperate labrid fish of the genus Symphodus. *Marine Ecology Progress Series*, *285*, 205–211. https://doi.org/10.3354/meps285205

Reed, C., Branconi, R., Majoris, J., Johnson, C., & Buston, P. (2019). Competitive growth in a social fish. *Biology Letters*, *15*(2), 20180737. https://doi.org/10.1098/rsbl.2018.0737

Reid, D., Armstrong, J. D., & Metcalfe, N. B. (2012). The performance advantage of a high resting metabolic rate in juvenile salmon is habitat dependent. *Journal of Animal Ecology*, *81*(4), 868–875. https://doi.org/10.1111/j.1365-2656.2012.01969.x

Reinhardt, U. G. (1999). Predation risk breaks size-dependent dominance in juvenile coho salmon (Oncorhynchus kisutch) and provides growth opportunities for risk-prone individuals. *Canadian Journal of Fisheries and Aquatic Sciences*, *56*(7), 1206–1212. https://doi.org/10.1139/f99-064

Reinhardt, U. G., & Healey, M. C. (1999). Season- and size-dependent risk taking in juvenile coho salmon: Experimental evaluation of asset protection. *Animal Behaviour*, *57*(4), 923–933. https://doi.org/10.1006/anbe.1998.1051

Robert, D., Takasuka, A., Nakatsuka, S., Kubota, H., Oozeki, Y., Nishida, H., & Fortier, L. (2010). Predation dynamics of mackerel on larval and juvenile anchovy: Is capture success linked to prey condition? *Fisheries Science*, *76*(2), 183–188. https://doi.org/10.1007/s12562-009-0205-y

Samhouri, J. F., Steele, M. A., & Forrester, G. E. (2009). Inter-cohort competition drives density dependence and selective mortality in a marine fish. *Ecology*, *90*(4), 1009–1020. https://doi.org/10.1890/07-1161.1

Saunders, R. A., & Tarling, G. A. (2018). Southern Ocean Mesopelagic Fish Comply with Bergmann's Rule. *The American Naturalist*, *191*(3), 343–351. https://doi.org/10.1086/695767

Sbragaglia, V., López-Olmeda, J. F., Frigato, E., Bertolucci, C., & Arlinghaus, R. (2021). Size-selective mortality induces evolutionary changes in group risk-taking behaviour and the circadian system in a fish. *Journal of Animal Ecology*, *90*(2), 387–403. https://doi.org/10.1111/1365-2656.13372

Scharf, F. S., Buckel, J. A., & Juanes, F. (2009). Contrasting patterns of resource utilization between juvenile estuarine predators: The influence of relative prey size and foraging ability on the ontogeny of piscivory. *Canadian Journal of Fisheries and Aquatic Sciences*, *66*(5), 790–801. https://doi.org/10.1139/F09-030

Scharf, F. S., Buckel, J. A., Juanes, F., & Conover, D. O. (1998). Predation by juvenile piscivorous bluefish (Pomatomus saltatrix): The influence of prey to predator size ratio and prey type on predator capture success and prey profitability. *Canadian Journal of Fisheries and Aquatic Sciences*, *55*(7), 1695–1703.

Schultz, E. T., & Conover, D. O. (1997). Latitudinal differences in somatic energy storage: Adaptive responses to seasonality in an estuarine fish (Atherinidae: Menidia menidia). *Oecologia*, *109*(4), 516–529. https://doi.org/10.1007/s004420050112

Sewall, F., Norcross, B., Vollenweider, J., & Heintz, R. (2019). Growth, energy storage, and feeding patterns reveal winter mortality risks for juvenile Pacific herring in Prince William Sound, Alaska, USA. *Marine Ecology Progress Series*, *623*, 195–208. https://doi.org/10.3354/meps13013

Shuter, B. J., & Post, J. R. (1990). Climate, Population Viability, and the Zoogeography of Temperate Fishes—Shuter—1990—Transactions of the American Fisheries Society—Wiley Online Library. *Transactions of the American Fisheries Society*, *119*(2), 314–336. https://doi.org/10.1577/1548-8659(1990)119<0314:CPVATZ>2.3.CO;2

Sigler, M., Tollit, D., Vollenweider, J., Thedinga, J., Csepp, D., Womble, J., Wong, M., Rehberg, M., & Trites, A. (2009). Steller sea lion foraging response to seasonal changes in prey availability. *Marine Ecology Progress Series*, *388*, 243–261. https://doi.org/10.3354/meps08144

Smith, A. J., Adams, M. B., Crosbie, P. B. B., Nowak, B. F., & Bridle, A. R. (2022). Size-dependent resistance to amoebic gill disease in naïve Atlantic salmon (Salmo salar). *Fish & Shellfish Immunology*, *122*, 437–445. https://doi.org/10.1016/j.fsi.2022.02.035

Sogard, S. M. (1997). Size-Selective Mortality in the Juvenile Stage of Teleost Fishes: A Review. *Bulletin of Marine Science*, *60*(3), 1129–1157.

Stamps, J. A. (2007). Growth-mortality tradeoffs and 'personality traits' in animals. *Ecology Letters*, *10*(5), 355–363. https://doi.org/10.1111/j.1461-0248.2007.01034.x

Takasuka, A., Aoki, I., & Mitani, I. (2004). Three synergistic growth-related mechanisms in the short-term survival of larval Japanese anchovy Engraulis japonicus in Sagami Bay. *Marine Ecology Progress Series*, *270*, 217–228. https://doi.org/10.3354/meps270217

Takasuka, A., Sakai, A., & Aoki, I. (2016). Dynamics of growth-based survival mechanisms in Japanese anchovy (Engraulis japonicus) larvae. *Canadian Journal of Fisheries and Aquatic Sciences*, *74*(6), 812–823. https://doi.org/10.1139/cjfas-2016-0120

Taylor, D. (2003). Size-dependent predation on post-settlement winter flounder Pseudopleuronectes americanus by sand shrimp Crangon septemspinosa. *Marine Ecology Progress Series*, *263*, 197–215. https://doi.org/10.3354/meps263197

Taylor, D. L., & Collie, J. S. (2003). Effect of temperature on the functional response and foraging behavior of the sand shrimp Crangon septemspinosa preying on juvenile winter flounder Pseudopleuronectes americanus. *Marine Ecology Progress Series*, *263*, 217–234. https://doi.org/10.3354/meps263217

Trexler, J. C., Travis, J., & McManus, M. (1992). Effects of Habitat and Body Size on Mortality Rates of Poecilia Latipinna. *Ecology*, *73*(6), 2224–2236. https://doi.org/10.2307/1941470

Tucker, C. S., Sommerville, C., & Wootten, R. (2002). Does size really matter? Effects of fish surface area on the settlement and initial survival of Lepeophtheirus salmonis, an ectoparasite of Atlantic salmon Salmo salar. *Diseases of Aquatic Organisms*, *49*(2), 145–152. https://doi.org/10.3354/dao049145

Tucker, S., Mark Hipfner, J., & Trudel, M. (2016). Size- and condition-dependent predation: A seabird disproportionately targets substandard individual juvenile salmon. *Ecology*, *97*(2), 461–471. https://doi.org/10.1890/15-0564.1

van Deurs, M., Hartvig, M., & Steffensen, J. F. (2011). Critical threshold size for overwintering sandeels (Ammodytes marinus). *Marine Biology*, *158*(12), 2755–2764. https://doi.org/10.1007/s00227-011-1774-8

Werner, E. E., & Hall, D. J. (1974). Optimal Foraging and the Size Selection of Prey by the Bluegill Sunfish (Lepomis Macrochirus). *Ecology*, *55*(5), 1042–1052. https://doi.org/10.2307/1940354

Werner, E. E., & Mittelbach, G. (1981). Optimal foraging: Field tests of diet choice and habitat switching. *Integrative and Comparative Biology*, *21*, 813–829. https://doi.org/10.1093/ICB/21.4.813

Whiteman, E. A., & Côté, I. M. (2004). Dominance hierarchies in group-living cleaning gobies: Causes and foraging consequences. *Animal Behaviour*, *67*(2), 239–247. https://doi.org/10.1016/j.anbehav.2003.04.006

Yamamoto, T., Ueda, H., & Higashi, S. (1998). Correlation among dominance status, metabolic rate and otolith size in masu salmon. *Journal of Fish Biology*, *52*(2), 281–290. https://doi.org/10.1111/j.1095-8649.1998.tb00799.x

Youson, H. (1988). First metamorphosis. In *Fish physiology* (pp. 135–196).

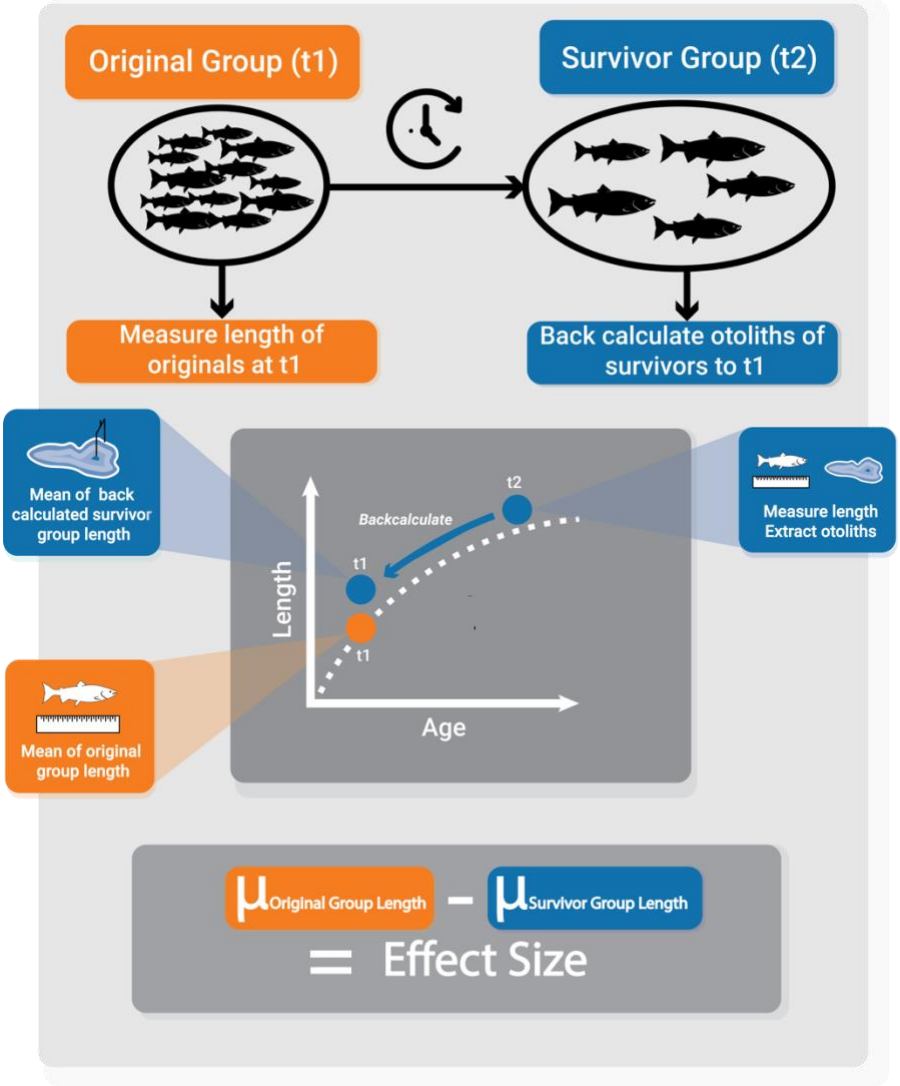

Figure 1. Schematic of effect size calculations derived from survival analysis. The original group represents the first capture at time 1 (t1), and the survivor group represents the individuals that survived to a later capture at time 2 (t2). The length of individuals in the original group and their mean length at t1 are measured. Mean and individual lengths of the survivor group at t2 are derived from extracted otoliths using the known relationship between otolith and somatic growth. The effect size is calculated by subtracting the mean lengths of the original group ($\mu_{\text{survivor group length}}$) from the survivor group ($\mu_{\text{original group length}}$).

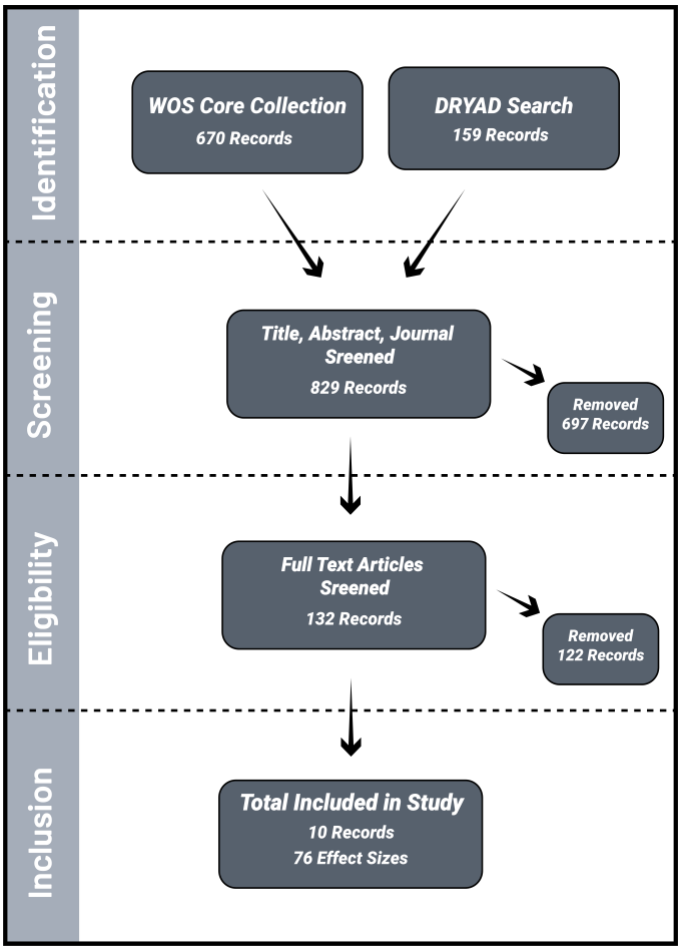

Figure 2. PRISMA diagram outlining our criteria for study inclusion in the meta-analysis. In the identification stage, we searched the Web of Science Core Collection and DRYAD data repository for studies matching the keyword terms ‘size selective mortality’ and ‘bigger is better’. We screened all publications at the abstract stage based on life history stage, method, and required data (‘screening’), and eliminated all studies not matching our criteria after a full-text reading (‘eligibility’). We included studies from which we could calculate at least one effect size (‘inclusion’).

Figure 3. Map showing the sampling locations of studies included in the meta-analysis. Each coloured point is a different study, several of which represent multiple effect sizes. The map is displayed using unprojected geographic coordinates (WGS 84, EPSG:4326), with longitude and latitude in decimal degrees. 1. Claiborne et al., 2011; 2. Post & Prankevicius, 1987; 3. Good et al., 2001; 4. Johnston et al., 2005; 5. Samhouri et al., 2009; 6. Raventos & Macpherson, 2005; 6. Macpherson & Raventos, 2005; 7. Takasuka et al., 2004; 7. Takasuka et al., 2016 ; 8. Honda et al., 2020.

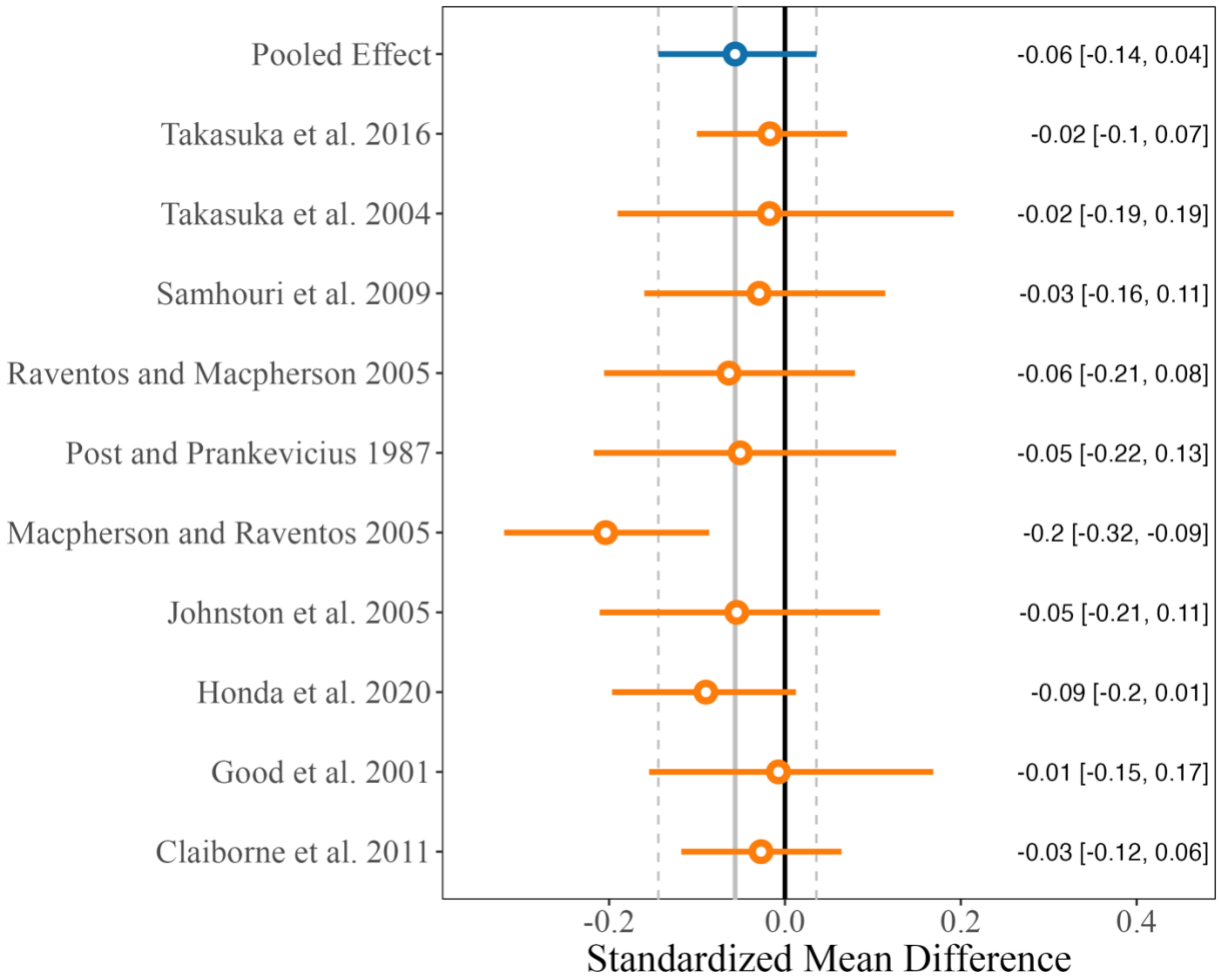

Figure 4. Forest plot of study true effect sizes and the pooled effect size of survivor analyses where a negative effect size indicates larger individuals had greater survival. Length of lines denote the upper and lower 95% credible interval. The effect size is annotated on the right-hand side with the 95% credible interval in square brackets. The grey solid line represents the true pooled effect size, and the dashed grey lines represent the 95% credible interval of the pooled effect size.

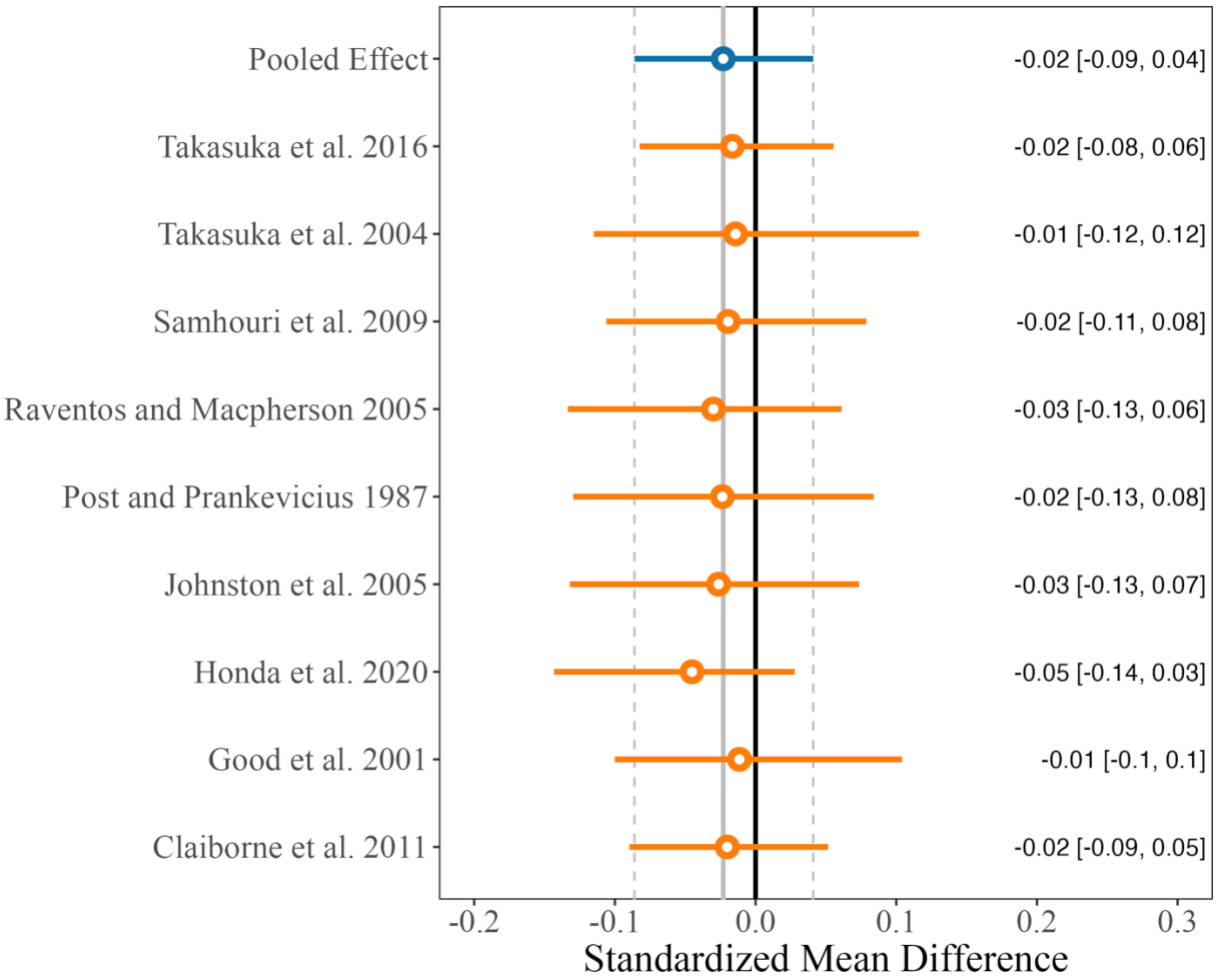

Figure 5. Forest plot of the sensitivity analysis containing study true effect sizes and the pooled effect size of survivor analyses with the largest study removed. Negative effect sizes indicate larger individuals had greater survival. Length of lines denote the upper and lower 95% credible interval. The effect size is annotated on the right-hand side with the 95% credible interval in square brackets. The solid grey represents the pooled effect size and the dashed grey lines represent the pooled effect size's 95% credible interval.

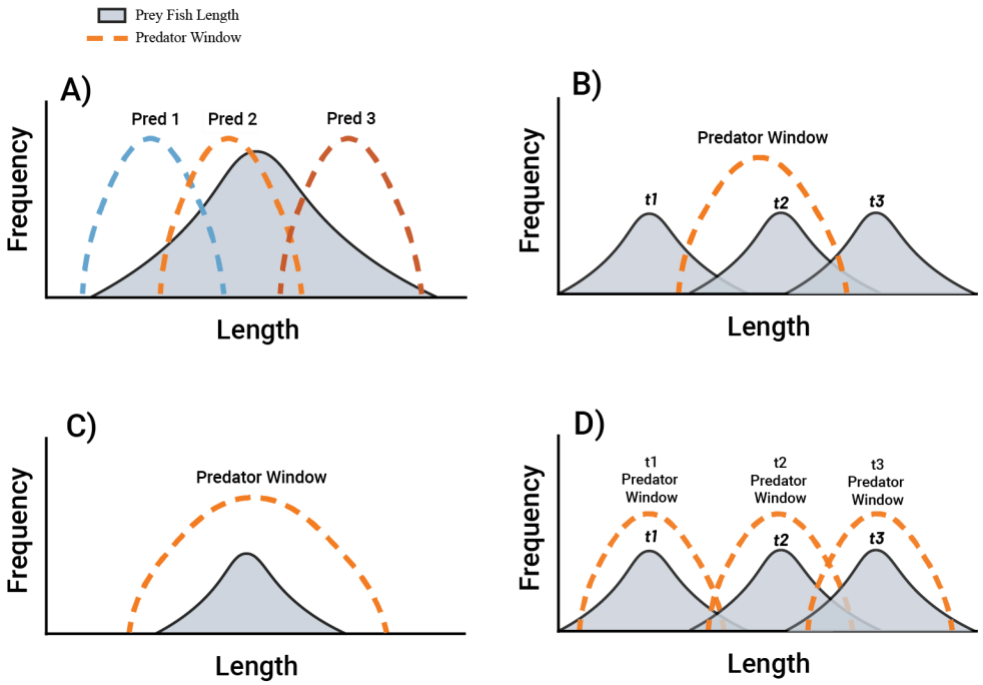

Figure 6. Conceptual figure showing the relationship between young teleost size and survival under different predation contexts. Orange, blue, and red dotted lines represent a predator's consumption window for a particular prey size frequency distribution (grey). **A)** Shows how the presence of multiple predators could cause stabilizing selection by selecting prey across the size frequency distribution. **B)** Indicates how a fish growing over time (t1 to t3) could move through a predator window, changing the direction of size-selective mortality over time. **C)** Displays how a predator could encompass an entire size frequency distribution of prey, and **D)** demonstrates how a predator could synchronize growth rates with a prey, in both cases eliminating size-selective mortality.