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 Zdenek Adamek

Annual counts over time of rainbow trout, *Oncorhynchus mykiss* (Actinopterygii: Salmoniformes: Salmonidae) catches in fishing grounds with respect to stocking events

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Background. The rainbow trout, *Oncorhynchus mykiss* (Walbaum, 1792), is a popular species for Czech recreational fishing, both on trout fishing grounds and even some designated as non-trout waters if they have sufficient environmental quality. Rainbow trout are usually stocked using a ‘put-and-take’ management approach, in which the majority of fish are caught and harvested during the fishing season.

Methods. Rainbow trout stocking and return data in anglers’ catches were analysed with respect to the time period between stocking and catch and evaluated the rates of return. Two differently managed types of fishing grounds were taken into account – the non-trout and trout grounds. The study was conducted on five fishing grounds (four rivers) in the Czech Republic.

Results. The data suggest that the average proportion of stocked rainbow trout caught during the first two weeks after release on non-trout fishing ground is 92.3 %, significantly ($P < 0.001$) higher than the 64.1 % taken from designated trout grounds. On the trout fishing grounds, rainbow trout tend to be caught more evenly throughout the fishing season. Mean total individual return rates ranged between 36.8 and 53.4 % in the non-trout fishing ground and between 29.8 and 68.4 % in the trout fishing ground. The respective weight return rates were 47.7–79.5% in the non-trout fishing ground and 34.4–75.3% in the trout fishing ground with no significant differences in individual ($P = 0.50$) and weight ($P = 0.19$) returns.

Conclusion. The vast majority of rainbow trout are caught and harvested shortly after being stocked. The proportion of stocked fish caught within two weeks of release in non-trout fishing grounds is significantly higher than in trout grounds. Stocked rainbow trout tend to be caught more evenly throughout the fishing season in trout fishing grounds due to lower angling pressure. Both individual and weight returns for the entire year (season) were similar in non-trout and trout areas.

Key words: non-trout fishing ground; ‘put and take’ fisheries management rate of return; recreational fisheries; stocking; trout fishing ground;

Introduction

The rainbow trout, *Oncorhynchus mykiss* (Walbaum, 1792), is a non-indigenous species in Europe with great economic importance both in terms of production fisheries and recreational fishing. It was introduced into the Czech Republic at the end of the 19th century (Stanković et al. 2015) and its annual aquacultural production in 2022 reached 438 tonnes, with 81 tonnes

caught by angling (MZe 2023). In Czech open waters, its occurrence is completely dependent on stocking as natural reproduction is highly unlikely (Stanković et al. 2015). This means that all fish removed during angling are already largely included in aquacultural production data.

The rainbow trout is a fairly tolerant species and, while it prefers conditions typical of the trout and grayling zones of fast-flowing rivers and streams or the colder still waters typically designated as trout fishing grounds by angling associations, it also tolerates flowing waters designated as non-trout fishing grounds if they meet its requirements, especially in terms of temperature and oxygen saturation. Consequently, the rainbow trout is a popular species for recreational fisheries (Cambray 2003). Its importance for recreational fishing is further enhanced by the fact that the requirements for stock fish can easily be met through existing production facilities (Fornshell 2002) and that it tolerates transport well, even over longer distances. In the Czech Republic, rainbow trout stocking in fishing grounds typically follows a “put-and-take” approach, whereby stocking rates are based on the assumption that anglers will catch and remove almost all the stocked fish shortly after stocking (Craig 2016).

As a result of the foraging reflexes acquired during intensive aquaculture, rainbow trout are relatively easy to catch immediately after release (Adamek et al. 2011). Consequently, the rate of return after stocking the Czech fishing grounds is assumed to be relatively high, though specific data are available rather sporadically. According to the catch statistics, rainbow trout are the third most commonly caught fish in the Czech Republic after common carp, *Cyprinus carpio* Linnaeus, 1758, and common bream, *Abramis brama*, Linnaeus, 1758. Between 2017 and 2022, the average annual catch of rainbow trout in designated fishing grounds of the Czech Anglers Union (<http://www.rybsvaz.cz>) and the Moravian Anglers Union (<https://mrs.mrsbrno.cz>) was 167,563 fish (73,488 kg), with an average individual weight of 0.44 kg.

Angling harvest of salmonid fishes and its efficiency with regard to stocking in Czech conditions is a not a frequent topic of ichthyological studies. The most of sporadically published data appeared in the “grey” literature (Adamek et al. 2011; Chalupa et al. 2014; Jurajda et al. 2023) with the only exception of the evaluation of long-term anglers’ harvest of grayling, *Thymallus thymallus* (Linnaeus, 1758), by Lyach and Remr (2020).

Data on the effectiveness of stocking rainbow trout for recreational fisheries tend to appear only in studies from North America (OBara and Eggleton 1995; Bettinger and Betolli 2002; Cassinelli and Meyer 2018) and Australia (Faragher and Gordon 1992), but these were conducted under conditions somewhat different from European waters (Champigneulle and Cachera 2003). The objective of the study was therefore to evaluate rainbow trout catches in Czech fishing grounds in relation to stocking events and rates of return on designated trout and non-trout fishing grounds to better understand their importance and role in recreational fisheries. In both types of fishing grounds, the rainbow trout are typically stocked using a ‘put-and-take’ management approach that supports efforts for their recapture throughout the fishing season.

Materials and Methods

The study was conducted on five fishing grounds (four rivers) in the Czech Republic (Fig. 1).



Fig. 1. Location of the surveyed fishing grounds in the Czech Republic

Fishing grounds

Data on rainbow trout stocking (dates, numbers and weight) and catches were obtained from the local angling associations managing the Svitava-1 non-trout fishing ground (years 2007, 2008 and 2019), the Blanice Vodňanská-4B trout fishing ground (2007 and 2008), the Hanácká Bystřice -3 and -4 trout fishing grounds (2019), and the Vsetínská Bečva-4P trout fishing ground (2020). It is common practice in these fishing grounds to regularly release rainbow trout every year in several stocking events according to compulsory stocking plan. For the purpose of the study, data from the periods 2007 – 2008 and 2019 – 2020 were randomly selected as the best documented.

Although Svitava-1 (hereafter Sv-1, 49°08'30.91"N, 16°37'41.74"E - 49°15'06.62"N, 16°40'13.91"E) is officially designated as a non-trout fishing ground, the water is relatively cold and its environmental conditions are suitable for rainbow trout, which enables its stocking. The majority of the fishing ground is located directly in the inner city of Brno with 400 thousand residents. The river immediately upstream is managed as a trout fishing ground, but the downstream migration of rainbow trout stocked here is highly unlikely due the weir barrier and the 1200 m stretch of stagnant up-weir zone. Moreover, the distance between the nearest rainbow trout release sites on these two fishing grounds is 11 km. The length of Sv-1 fishing ground is 16 km and rainbow trout were released at 3 - 4 sites. The stream width

varies between 7–10 m and discharge rates range from 1–4 m³.s⁻¹. Typologically (EU 2000), it has a large drainage area (1147 km²) in a medium altitude (195 – 236 m a.s.l.) with an average bed slope 2.9 ‰. Almost the entire river course in the fishing ground with 6 weirs is modified (often channelized) to various extent.

The fishing ground Blanice Vodňanská-4B (hereafter BV-4B, N 49°5.92235', E 14°3.90532' - N 49°3.11465', E 14°1.42823') is 8 km long with 8 sites of release. It has a width of 5–10 m and discharge rates of 1–3 m³.s⁻¹. The river upstream is a protected non-fishing section with no stocking of rainbow trout. Rainbow trout are stocked also in downstream fishing ground, but there is a 1.1-meter weir barrier on the border between the fishing grounds, preventing migration. The specified river section flows through a less populated area with several small settlements and 1700 residents. Typologically (EU 2000), it has a medium sized drainage area (861 km²) in a medium altitude (446 – 501 m a.s.l.) with an average bed slope 6.9 ‰. A total of 1.3 km of the river in the fishing ground with 5 weirs is modified (often channelized).

The trout fishing ground Hanácká Bystřice-3 (hereafter HB-3, 49°39'15.305"N, 17°24'38.20"E - 49°44'48.57"N, 17°26'14.758"E) is 15 km long with 5 sites of release and Hanácká Bystřice-4 (hereafter HB-4, 49°44'48.57"N, 17°26'14.76"E - 49°50'2.84"N, 17°24'2.67"E) has 16 km with 5 sites of release. The grounds are located on headwater with a width of 4–7 m and discharge rates of 0.5–1 m³.s⁻¹. Rainbow trout stocking is performed also in the downstream fishing ground, but upstream fish migration is impossible due to the 1-meter weir barrier between the fishing grounds. The entire 31 km long river section of both fishing grounds is located in a sparsely populated area with a few settlements and a total of 9 thousand inhabitants. Typologically (EU 2000), it has a medium sized drainage area (266 km²) in a medium altitude (382 – 608 m a.s.l.) with an average bed slope 7.5 ‰. The river in the fishing grounds flows in a natural bed with minor modifications around two weirs and in the intravillages of settlements.

The Vsetínská Bečva-4P (hereafter VB-4P, 49°19'32.14"N, 18°9'46.821"E - 49°23'50.37"N, 18°23'53.46"E) fishing ground is 20 km long with 20 sites of release. It is a headwater with a width of 8–12 m and discharge rates of 1–4 m³.s⁻¹. Rainbow trout are stocked also in the downstream fishing ground, but upstream fish migration is impossible due to 2.7-meter weir barrier. The section of the river with the fishing ground flows through several settlements with a total of 10 thousand inhabitants. Typologically (EU 2000), it has a medium sized drainage area (734 km²) in a medium altitude (425 – 590 m a.s.l.) with an average bed slope 8.3 ‰. The main (lower) part of the stream in the fishing ground with 9 weirs is ecologically modified against floods in a length of 16 km.

Data analysis

The counts of rainbow trout caught during the year/season were evaluated on the basis of compulsory entries made in yearly fishing permits by the anglers, later provided by the local angling associations managing the respective fishing ground. The fishing pressure (number of visits) on a specific fishing ground could not be analysed from the records in the permits, because the permits are valid for the entire region representing tens of thousands of anglers and several dozens of fishing grounds, and these data cannot be appropriately extracted from them. The number of catches therefore corresponds only to the data from the permits of appropriate association managing the fishing ground (hereinafter referred to as 'local permits'), while the data on total return rates was obtained by summarizing the records from all permits issued for the grounds of the entire region. The vast majority of them were valid

for the whole year, while short-time (monthly, weekly and/or daily) permits were applied only very sporadically and were therefore not taken into account.

Rainbow trout catches were evaluated over two time periods – (a) within two weeks post-stocking and (b) during the rest of year (non-trout grounds) or fishing season (trout grounds). The first and second week post-stocking periods were empirically chosen as the time frame for concentrated fishing of stocked rainbow trout, especially in the non-trout grounds. This period could not be specifically assessed on the basis of the records in fishing permits there, as it is not possible to specify what was the target fish of the anglers recording the fishing trip on non-trout ground (it may not always be rainbow trout). According to experience, the interest in rainbow trout fishing in the non-trout fishing grounds continuously decreases within two weeks post-stocking, and later on, anglers only occasionally choose the bait and method of fishing for rainbow trout.

Rate of return was determined as the number/weight of caught (and harvested) fish as a proportion of the total number/weight of stocked fish, using the sum of fish caught for the year evaluated. The data for this purpose were obtained from all permit holders, including those from other angling associations in the region.

We used generalised linear mixed models (GLMM, binomial distribution) to test differences in proportion of trouts captured within the first two weeks (out of all captured trouts), using the fishing ground-year category (nested within fishing ground category) as a random factor. Observation-level random effects were also introduced to the model to mitigate effect of overdispersion.

Results

Svitava-1 non-trout fishing ground

In 2007, a total of 2,300 rainbow trout (770 kg) were stocked on three separate dates (June 13, August 28 and September 1). Of these, 1,170 trout (368 kg) were subsequently caught and harvested, corresponding to an individual rate of return of 50.9 %, or 47.8 % by weight (Table 1), with an average individual weight of 335 g at release and 315 g when caught. In all, 94.7 % of rainbow trout catches on local permits in 2007 occurred in the two-week post-release period, with further 5.3 % of fish caught outside the period directly related to stocking (Fig. 2, Table 2).

Table 1. Rate of return (%) of stocked rainbow trout at each fishing ground on all valid permits

Note: Sv-1 = Svitava-1; BV-4B = Blanice Vodňanská-4B; HB-3 = Hanácká Bystřice-3; HB-4 = Hanácká Bystřice-4; VB-4P = Vsetínská Bečva-4P; NT = non-trout fishing ground; T = trout fishing ground; n = number of fish, \bar{x} = mean individual weight, N/A = data not available

| Fishing ground | Year | Stocked | | | Caught | | | Rate of return (%) | |
|----------------|------|---------|------|-------------|--------|-----|-------------|--------------------|--------|
| | | n | kg | \bar{x} g | n | kg | \bar{x} g | individual | weight |
| Sv-1 NT | 2007 | 2300 | 770 | 335 | 1170 | 368 | 315 | 50.9 | 47.8 |
| | 2008 | 2990 | 1100 | 368 | 1297 | 525 | 405 | 36.8 | 47.7 |

| | | | | | | | | | |
|---------|------|------|-----|-----|------|-----|-----|------|------|
| | 2019 | 1909 | 600 | 314 | 1019 | 477 | 468 | 53.4 | 79.5 |
| BV-4B T | 2007 | 400 | 130 | 325 | 171 | 57 | 333 | 42.8 | 43.8 |
| | 2008 | 370 | 150 | 405 | 253 | 113 | 447 | 68.4 | 75.3 |
| HB-3 T | 2019 | N/A | 192 | N/A | 212 | 76 | 358 | N/A | 39.6 |
| HB-4 T | 2019 | N/A | 105 | N/A | 117 | 40 | 342 | N/A | 38.1 |
| VB-4P T | 2020 | 798 | 337 | 422 | 238 | 116 | 487 | 29.8 | 34.4 |

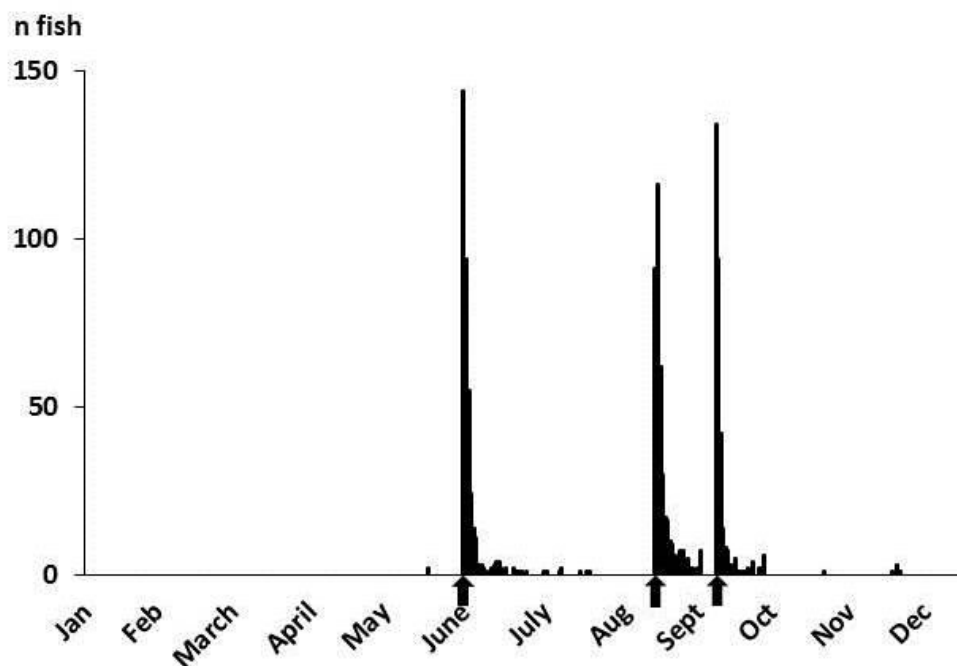


Figure 2. Numbers of rainbow trout caught at the Svitava-1 non-trout fishing ground in 2007. Note: The arrows indicate the dates of stocking

Table 2. Rainbow trout catches after stocking events in percentage of fish caught on local permits

Note: Sv-1 = Svitava-1; BV-4B = Blanice Vodňanská-4B; HB-3 = Hanácká Bystřice-3; HB-4 = Hanácká Bystřice-4; VB-4P = Vsetínská Bečva-4P; n = number of fish; NT = non-trout fishing ground; T = trout fishing ground

| Fishing ground | Date of stocking | Fish stocked (n) | Caught in 1st week (n) | Caught in 2nd week (n) | Caught later (n) | Caught in 1st week (%) | Caught in 2nd week (%) | Caught later (%) |
|----------------|------------------|------------------|------------------------|------------------------|------------------|------------------------|------------------------|------------------|
| Sv-1 NT | June 13, 2007 | 800 | 345 | 15 | 22 | 90.3 | 3.9 | 5.8 |

| | | | | | | | | |
|---------|-------------------|-------------|------------|------------|------------|-------------|-------------|-------------|
| | Aug 28, 2007 | 900 | 342 | 41 | 14 | 86.2 | 10.3 | 3.5 |
| | Sept 21, 2007 | 600 | 302 | 14 | 23 | 89.1 | 4.1 | 6.8 |
| | <i>2007 total</i> | <i>2300</i> | <i>989</i> | <i>70</i> | <i>59</i> | <i>88.5</i> | <i>6.2</i> | <i>5.3</i> |
| Sv-1 NT | Apr 4, 2008 | 606 | 248 | 39 | 107 | 62.9 | 9.9 | 27.2 |
| | June 18, 2008 | 1111 | 311 | 23 | 30 | 85.4 | 6.3 | 8.3 |
| | Sept 3, 2008 | 606 | 273 | 39 | 33 | 79.1 | 11.3 | 9.6 |
| | Oct 24, 2008 | 667 | 142 | 19 | 7 | 84.5 | 11.3 | 4.2 |
| | <i>2008 total</i> | <i>2990</i> | <i>974</i> | <i>120</i> | <i>177</i> | <i>76.6</i> | <i>9.5</i> | <i>13.9</i> |
| Sv-1 NT | Oct 10, 2019 | 909 | 211 | 15 | 8 | 90.2 | 6.4 | 3.4 |
| | Nov 11, 2009 | 1000 | 147 | 64 | 40 | 58.6 | 25.5 | 15.9 |
| | <i>2019 total</i> | <i>1909</i> | <i>358</i> | <i>79</i> | <i>48</i> | <i>73.8</i> | <i>16.3</i> | <i>9.9</i> |
| BV-4B T | Apr 12, 2007 | 100 | 22 | 7 | 20 | 44.9 | 14.3 | 40.8 |
| | July 15, 2007 | 300 | 36 | 20 | 66 | 29.5 | 16.4 | 54.1 |
| | <i>2007 total</i> | <i>400</i> | <i>58</i> | <i>27</i> | <i>86</i> | <i>33.9</i> | <i>15.8</i> | <i>50.3</i> |
| BV-4B T | Apr 13, 2008 | 170 | 81 | 9 | 43 | 60.9 | 6.8 | 32.3 |
| | Aug 13, 2008 | 200 | 57 | 30 | 33 | 47.5 | 25.0 | 27.5 |
| | <i>2008 total</i> | <i>370</i> | <i>138</i> | <i>39</i> | <i>76</i> | <i>54.6</i> | <i>15.4</i> | <i>30.0</i> |
| HB-3 T | Apr 15, 2019 | N/A | 42 | 15 | 23 | 52.5 | 18.8 | 28.7 |
| | June 15, 2019 | N/A | 10 | 14 | 35 | 17.0 | 23.7 | 59.3 |
| | Aug 14, 2019 | N/A | 13 | 11 | 4 | 46.4 | 39.3 | 14.3 |
| | Nov 6, 2019 | N/A | 15 | 20 | 10 | 33.3 | 44.5 | 22.2 |
| | <i>2019 total</i> | <i>N/A</i> | <i>80</i> | <i>60</i> | <i>72</i> | <i>37.7</i> | <i>28.3</i> | <i>34.0</i> |
| HB-4 T | Apr 15, 2019 | N/A | 5 | 1 | 15 | 23.8 | 4.8 | 71.4 |
| | June 15, 2019 | N/A | 16 | 9 | 20 | 35.6 | 20.0 | 44.4 |
| | Aug 14, 2019 | N/A | 12 | 18 | 21 | 23.5 | 35.3 | 41.2 |
| | <i>2019 total</i> | <i>N/A</i> | <i>33</i> | <i>28</i> | <i>56</i> | <i>28.2</i> | <i>23.9</i> | <i>47.9</i> |
| VB-4P T | Apr 15, 2020 | 248 | 31 | 6 | 4 | 75.6 | 14.6 | 9.8 |
| | May 16, 2020 | 110 | 46 | 7 | 57 | 41.8 | 6.4 | 51.8 |
| | Oct 21, 2020 | 440 | 48 | 15 | 21 | 57.1 | 17.9 | 25.0 |
| | <i>2020 total</i> | <i>798</i> | <i>126</i> | <i>28</i> | <i>81</i> | <i>53.2</i> | <i>11.9</i> | <i>34.9</i> |

In 2008, a further 2,990 trout (1100 kg) were stocked on four separate dates (April 16, June 18, September 3 and October 24). A total of 1,297 trout (525 kg) were subsequently caught and harvested, representing a rate of individual return of 36.8 %, or 47.7 % by weight (Table 1), with an average individual weight of 368 g at release and 405 g when caught. In all, 86.1

% of rainbow trout catches on local permits in 2008 occurred within the two-week post-release period, with further 13.9 % caught outside the period directly related to stocking (Fig. 3, Table 2).

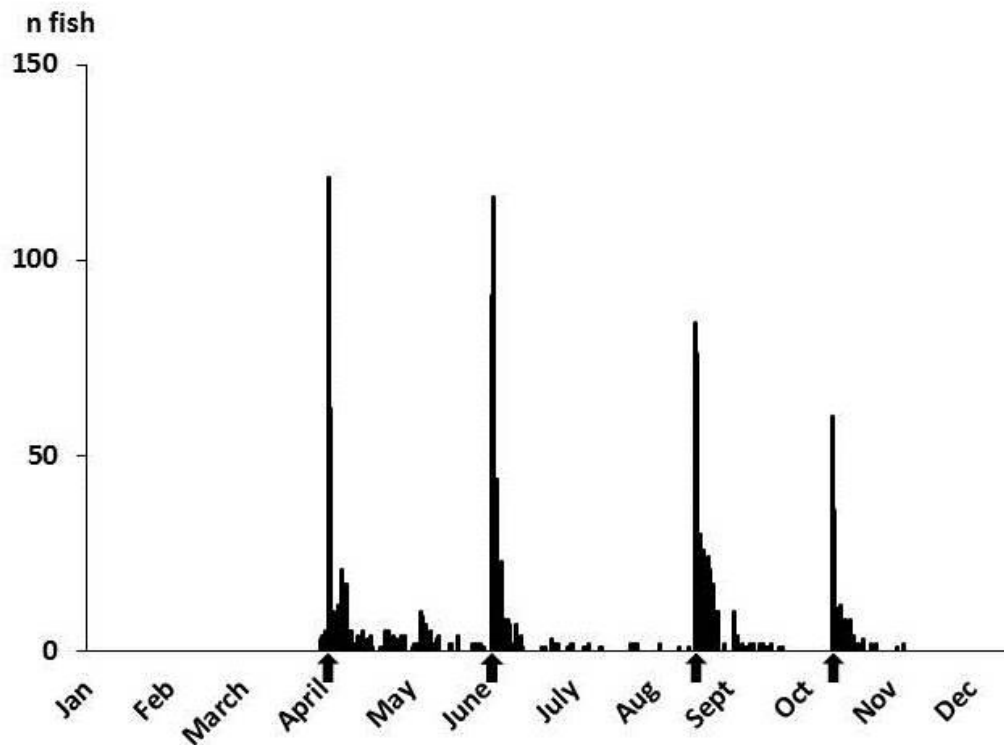


Figure 3. Numbers of rainbow trout caught at the Svitava-1 non-trout fishing ground in 2008.
 Note: The arrows indicate the dates of stocking

In 2019, 1,909 trout (600 kg) were stocked on two dates (October 10 and November 4). A total of 1,019 trout (477 kg) were subsequently caught and harvested, representing a rate of individual return of 53.4 %, or 79.5 % by weight (Table 1), with an average individual weight of 314 g at release and 468 g when caught. In all, 90.1 % of trout catches on local permits in 2019 occurred within two weeks post-stocking, with further 9.9 % caught outside the period directly related to the release (Fig. 4, Table 2).

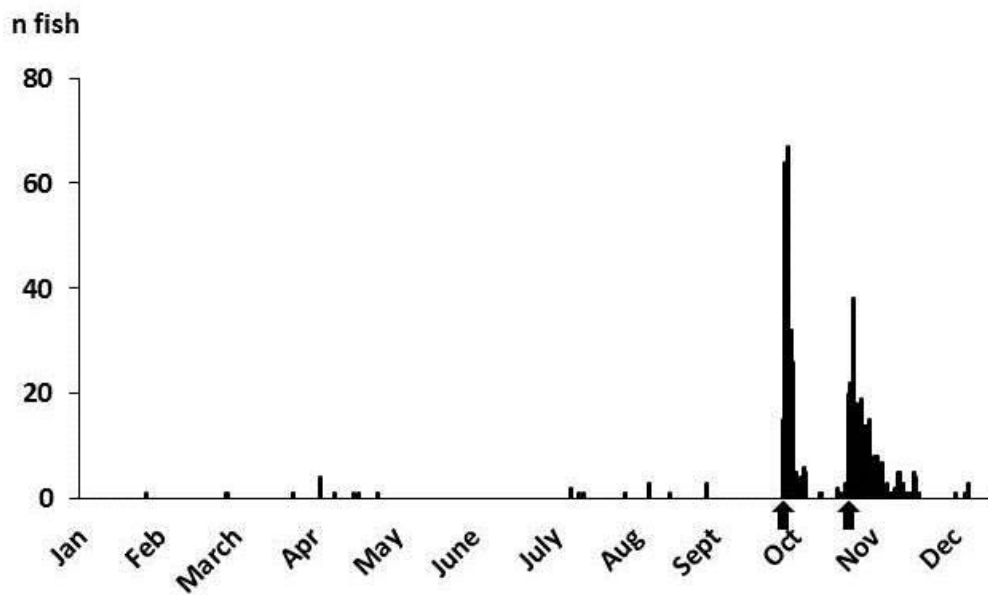


Figure 4. Numbers of rainbow trout caught at the Svitava-1 non-trout fishing ground in 2019.
Note: The arrows indicate the dates of stocking

Blanice Vodňanská-4B trout fishing ground

In 2007, 400 trout (130 kg) were stocked on two dates (April 12 and July 15). Altogether, 171 trout (57 kg) were subsequently caught and harvested, representing a rate of individual return of 42.8 %, or 43.8 % by weight (Table 1), with an average individual weight of 325 g at release and 333 g when caught. In all, 49.7 % of trout catches in 2007 occurred in the two-week post-release period, with further 50.3 % caught outside the period directly related to release (Fig. 5, Table 2).

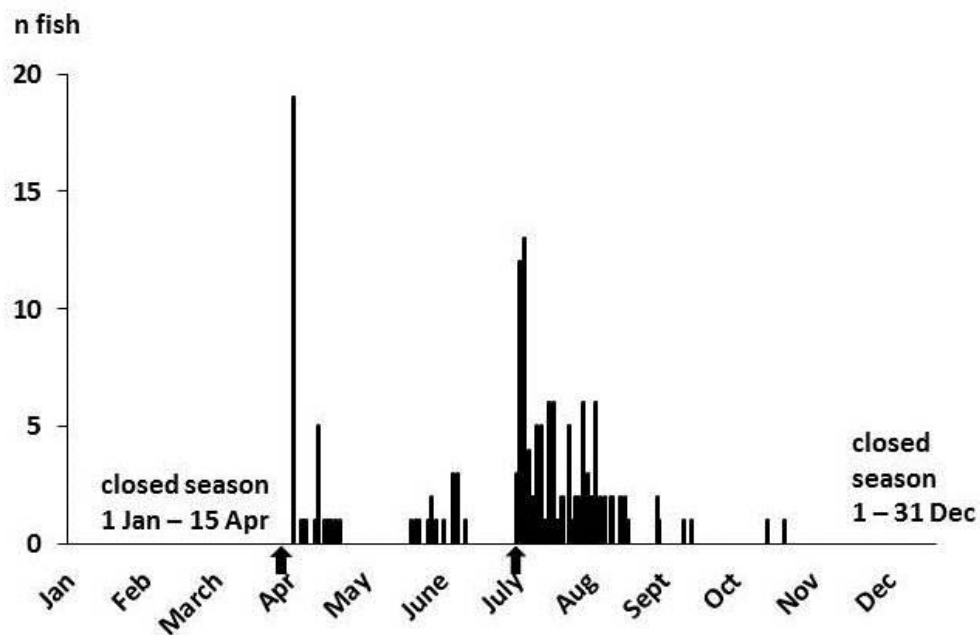


Figure 5. Numbers of rainbow trout caught at the Blanice Vodňanská-4B trout fishing ground in 2007.

Note: The arrows indicate the dates of stocking

In 2008, 370 trout (150 kg) were stocked on two dates (April 13 and August 13), of which 253 (113 kg) were subsequently caught and harvested, representing a rate of individual return of 68.4 %, or 75.3 % by weight (Table 1), with an average individual weight of 405 g at release and 447 g when caught. In all, 70.0 % of the trout catches in 2008 occurred in two weeks post-stocking, with further 30.0 % caught outside the period directly related to stocking (Fig. 6, Table 2).

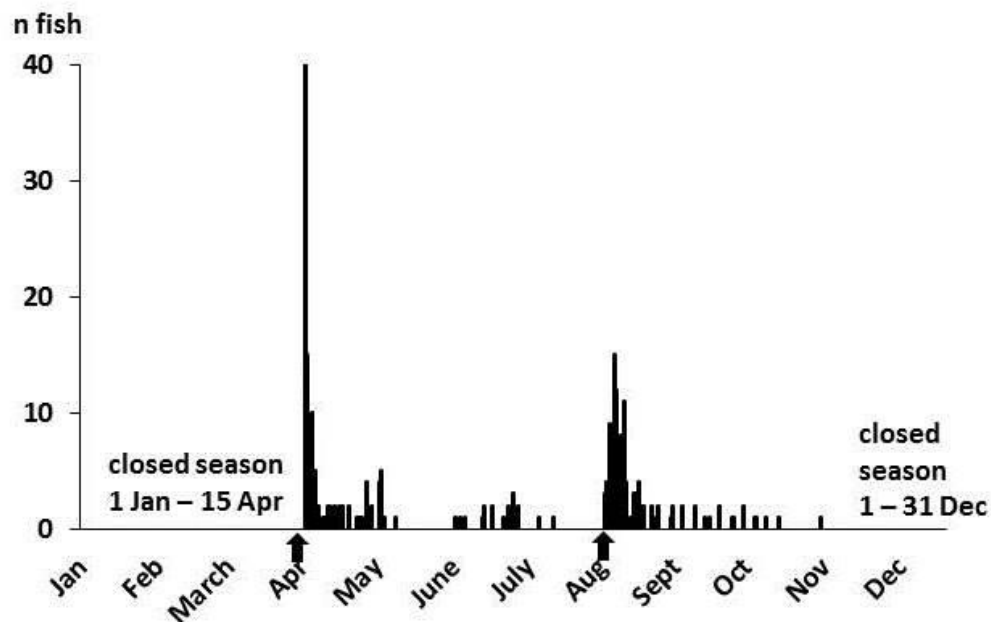


Figure 6. Numbers of rainbow trout caught at the Blanice Vodňanská-4B trout fishing ground in 2008.

Note: The arrows indicate the dates of stocking

Hanácká Bystřice-3 trout fishing ground

In 2019, 192 kg of rainbow trout (number of individuals not specified in the data provided) were stocked at Hanácká Bystřice-3 on five separate dates (March 29, April 15, June 15, August 14 and November 6), of which 190 trout (76 kg) were subsequently caught and harvested, giving an estimated rate of return by weight of 39.6 % (Table 1), with an average individual weight of 358 g when caught. In all, 66.0 % of trout in 2019 were caught on local permits within two weeks of stocking, with further 34.0 % caught outside the period directly related to the release (Fig. 7, Table 2).

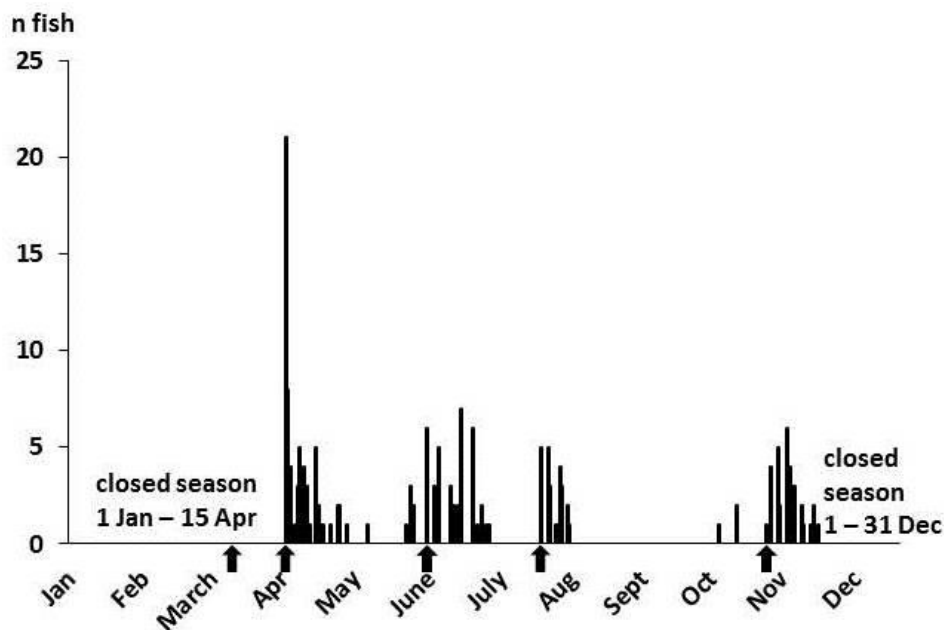


Figure 7. Numbers of rainbow trout caught at the Hanácká Bystřice-3 trout fishing ground in 2019.

Note: The arrows indicate the dates of stocking

Hanácká Bystřice-4 trout fishing ground

In 2019, a total of 170 kg of rainbow trout (number of individuals not specified in the data provided) were stocked on four separate dates (March 29, April 15, June 15 and August 14), of which 105 fish (40 kg) were subsequently caught and harvested, giving an estimated rate of return by weight of 38.1 % (Table 1), with an average individual weight of 342 g when caught. In all, 52.1 % of trout in 2020 were caught on local permits within two weeks of stocking, with further 47.9 % caught outside the period directly related to the release (Fig. 8, Table 2).

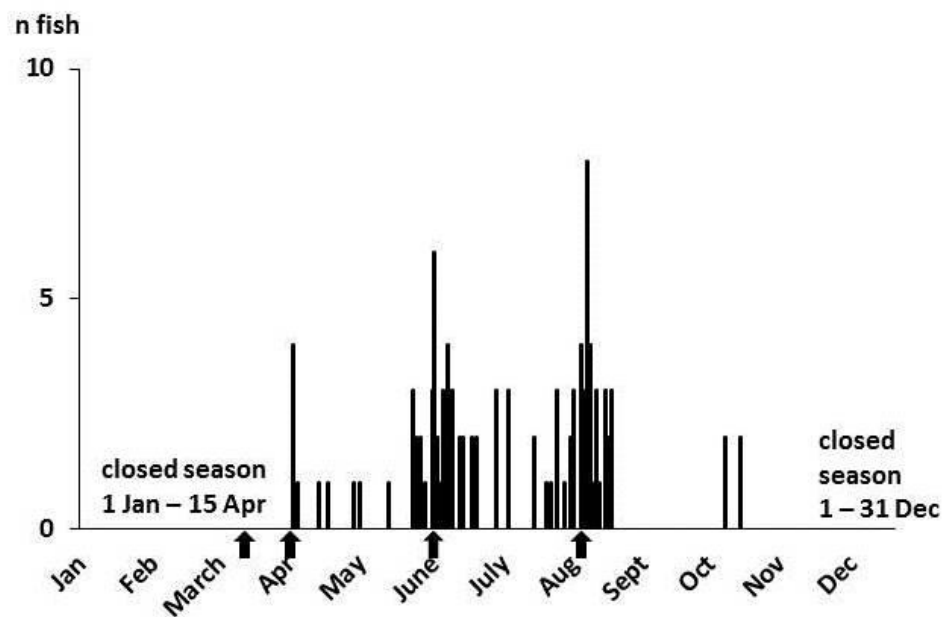


Figure 8. Numbers of rainbow trout caught at the Hanácká Bystřice-4 trout fishing ground in 2019.

Note: The arrows indicate the dates of stocking

Vsetínská Bečva-4P trout fishing ground

In 2020, 798 rainbow trout (337 kg) were stocked on four dates (April 15, May 16, October 8 and October 21). In total, 238 fish (116 kg) were subsequently caught and harvested, representing a rate of individual return of 29.8 %, or 34.4 % by weight (Table 1), with an average individual weight of 422 g at release and 487 g when caught. In all, 65.1 % of trout in 2020 were caught on local permits within two weeks of stocking, with further 34.9 % caught outside the period directly related to the release (Fig. 9, Table 2).

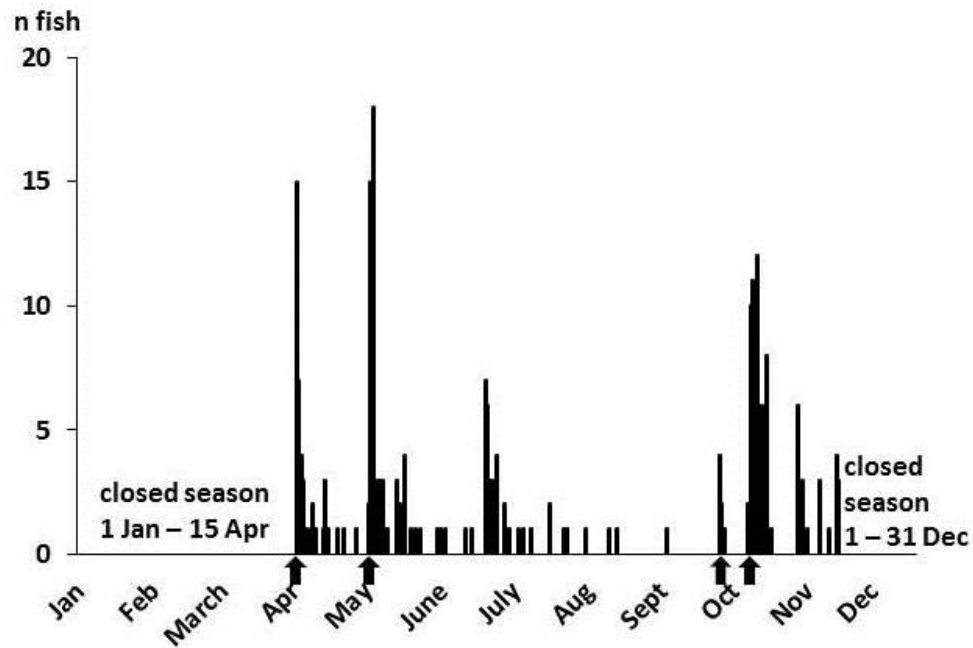


Figure 9. Numbers of rainbow trout caught at the Vsetínská Bečva-4P trout fishing ground in 2020.

Note: The arrows indicate the dates of stocking

Overall, the non-trout ground showed a significantly higher proportion of stocked trout caught during the first two weeks (92.3 % on average) compared to trout grounds (64.1%; GLMM, $n=23$, $P < 0.001$, Fig. 10).

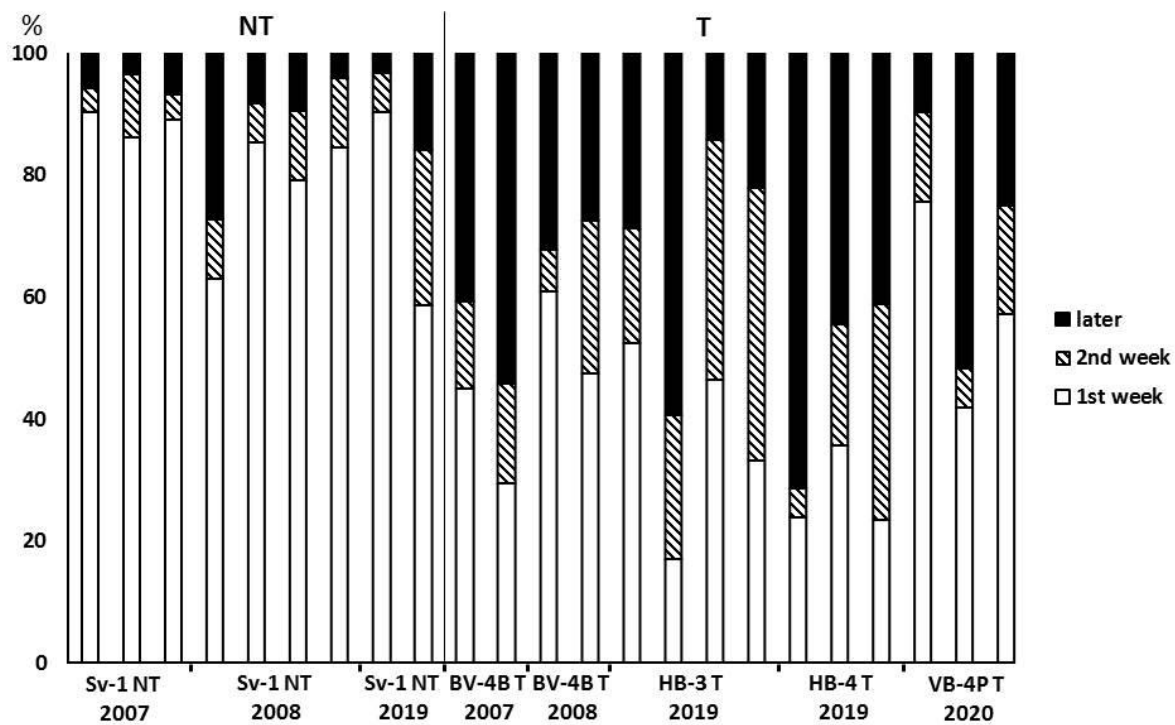


Fig. 10. Proportional share of fish caught following individual stocking events (on local permits only)

Note: Sv-1 = Svitava-1; BV-4B = Blanice Vodňanská-4B; HB-3 = Hanácká Bystřice-3; HB-4 = Hanácká Bystřice-4; VB-4P = Vsetínská Bečva-4P; NT = non-trout fishing ground; T = trout fishing ground

Discussion

Our analysis confirms that the majority of rainbow trout catches fall in the period shortly after stocking. The actual fishing effort at each site is very likely to depend primarily on how well anglers are informed about the date of release, the weather and hydrological conditions on those days and the timing of release (i.e. beginning of the season, weekend, public holiday). The opening of the season in trout fishing grounds was associated with higher catches as can be seen especially in the grounds BV-4B (Fig. 5 and 6) and HB-3 (Fig. 7). The periods of days off and public holidays can also be particularly important as Chalupa et al. (2014) found that fishing trips to trout fishing grounds on the River Opava were twice as frequent on weekends as weekdays. Surprisingly, the availability of fishing ground (density of population including anglers) in the vicinity of the fishing ground was not reflected in the return rates which were comparable regardless of population density per 1 km of the fishing ground (Table 3).

Table 3. Abiotic determinants of the studied fishing grounds

Note: * average values; ** km of a fishing ground; Note: Sv-1 = Svitava-1; BV-4B = Blanice Vodňanská-4B; HB-3 = Hanácká Bystřice-3; HB-4 = Hanácká Bystřice-4; VB-4P = Vsetínská Bečva-4P; N/A not available

| determinant | unit | Sv-1 | BV-4B | HB-3-4 | VB-4P |
|-------------------------|---------------------------------|-----------|-----------|-----------|---------|
| inhabitants | n/km** | 25000 | 213 | 290 | 500 |
| sites of release | n/10 km** | 2 | 10 | 3 | 10 |
| stocking events/year | | 2-4 | 2 | 4-5 | 4 |
| discharge* | m ³ .s ⁻¹ | 1-4 | 0.5-3 | 0.5-1 | 0.5-3 |
| river slope | ‰ | 2.5 | 6.9 | 7.5 | 8.3 |
| river width* | m | 7-10 | 5-10 | 4-7 | 8-12 |
| watershed | km ² | 1147 | 861 | 266 | 734 |
| altitude* | m a.s.l. | 195-236 | 446-501 | 382-608 | 425-590 |
| channelization | % | 100 | 15 | 5 | 80 |
| individual return rate* | % | 36.8-53.4 | 42.8-68.4 | N/A | 29.8 |
| weight return rate* | % | 47.7-79.5 | 43.8-75,3 | 38.1-39.6 | 34.4 |

The rules for angling on trout and non-trout grounds are different, which undoubtedly affects the effectiveness of fishing and the counts of rainbow trout catches over time. The bag limit of three salmonid fish per day is obligatory to both types of fishing grounds, but the most significant difference is the limit of three one-day trips per week and the ban on the use of natural baits on the trout grounds, while on the non-trout grounds there is no limit to the week number of trips or the type of baits. Moreover, the fishing season on trout grounds runs only from April 16 till November 30, while whole-year angling is allowed on non-trout fishing grounds.

As can be seen from the graphic presentations (Fig. 2 - 9), rainbow trout catches from individual stocking events dropped to zero in the days preceding the next release with only sporadic exceptions (Sv-1 in April 2008 and November 2019; Fig. 3 and 4). This proves that the vast majority of stocked fish were caught in the inter-stocking periods and the possible contribution of previously stocked fish to the catch after the next stocking event is negligible. Interestingly, while 72.8 – 96.6 % of the rainbow trout catches occurred within two weeks of release at the Sv-1 non-trout fishing ground, however, a significantly lower percentage were caught over the same period in trout grounds (28.6 – 90.2 %; $P < 0.01$, Table 2). Chalupa et al. (2014) also recorded a significant increase in fishing pressure immediately after stocking in trout fishing grounds on the Opava River. Consequently, the vast majority of stocked trout at non-trout fishing ground Sv-1 were caught shortly after release, with relatively few fish (3.4 – 27.2 %) being caught thereafter (Fig. 10). In comparison, the counts of rainbow trout caught in trout fishing grounds through the year (actually during the fishing season) were relatively even (Fig. 10), partly due to reduced fishing pressure (i.e. fewer licensed anglers) and the added restrictions in place when fishing for trout (i.e. only specific fishing methods allowed, such as fly fishing or spinning with artificial lures). As a result, the proportion of fish caught outside the two-week post-stocking period was significantly higher ($P < 0.01$) in trout fishing grounds, ranging from 9.8 to 71.4 % (Table 2). In reality, this proportion was mostly between 30 and 50% (Fig. 10).

In the non-trout fishing ground, the concentration of catches almost exclusively in the short two-week period after stocking raises the question of whether stocking should be spread over more dates and more locations. Although it can be assumed that this would lead to a wider spread of catches throughout the year, it is difficult to judge whether it would also lead to higher return rates. As shown in Table 3, the number of stocking sites and stocking events does not appear to be reflected in return rates suggesting that other factors such as current weather and hydrological conditions and timing of release play a significant role. E.g., in BV-4B, where rainbow trout were released twice a year at one site per 1 km, the return rates were the highest (42.8-68.4 %), while in VB-4P with stocking four times a year at the same frequency of sites, the return was the lowest (29.8 %).

At present, there is little or no information available on the behaviour of rainbow trout after stocking; however, our data on rate of return indicate that less than half of stocked trout, an identical 47.0 % on average in both non-trout and trout fishing grounds (Table 1), are ever caught, suggesting that a high proportion of fish probably migrate away from the stocking site, with unknown outcomes. According to Bettinger and Bettoli (2002), the stocked rainbow trout dispersed rapidly and nearly all (93%) of those fish died quickly or emigrated by rapid, long-range movements. Undoubtedly, some losses will certainly occur soon after stocking due to the stress of transport and subsequent release, while some fish will almost certainly be taken by fish-eating predators. Furthermore, there will often be a percentage 'lost' to illegal fishing (i.e. unlicensed fishing and/or unregistered removals, including removal of more than the three fish allowed per day). On the other hand, a number of rainbow trout, albeit a minority, are released back after being caught by the angler, potentially leading to some post-catch mortality. Actually, the re-releasing of landed rainbow trout (as a non-indigenous species) is not very common in Czech anglers' practice, but it is widely practiced for native brown trout (*Salmo trutta* Linnaeus, 1758).

Although angling is generally thought to result in lower stress responses than those incurred during transportation (Wedekind and Schreckenbach 2003), a review by Muoneke and Childress (1994) suggests that post-catch mortality is significantly lower when using artificial lures (1–10 %) or flies (5.2–20 %) than with baited hooks (34.5–95 %). Similarly, Taylor and White (1992), Lewin et al. (2006) and Arlinghaus et al. (2007) all documented lower mortality in re-released rainbow trout when fished for with artificial flies and lures. Thus, it is possible that post-catching mortality will be higher on the non-trout fishing ground, where the use of baited barbed hooks is permitted, than on the trout grounds where restrictions require the use of artificial lures and flies with barbless hooks only. The mandatory use of barbless hooks on trout fishing grounds may also have led to lower capture efficiency compared to barbed hooks on non-trout grounds, as shown by Bloom (2013), who demonstrated that anglers using barbless flies landed proportionally less trout than when they used barbed flies.

Though the data from our trout fishing grounds show that catches were spread more evenly over the entire fishing season, the return rates (29.8–68.4 %) were somewhat comparable with those at the non-trout ground (36.8-53.4 %; $P = 0.40$; Table 1). Also the weight return rates on trout fishing grounds (34.4–75.3 %) were comparable to those from the non-trout ground (47.7–79.5 %; $P = 0.19$; Table 1). While these figures were considered rather low, they are somewhat higher than those reported for other Czech trout fishing grounds in the Moravian-Silesian region in 2019 (25 to 55 %; Jurajda et al. 2023) and the River Opava in 2013 (26 to 36 %; Chalupa et al. 2014).

However, compared to the data on return rates reported in the literature, the return percentage of rainbow trout from the studied fishing grounds, reaching approximately 30 – 60 %, is rather higher. The reported return rates achieved from North American rivers and lakes are significantly lower. As shown by OBara and Eggleton (1995) from the Clinch River below Norris Dam in Tennessee, they averaged 23 % and ranged from 13 to 29 % over the 4 years of their study. Similarly, the first-year angler return rates across four study years averaged 23% and ranged from 0% to 76% for individual stocking events in Idaho impoundments (Cassinelli and Meyer 2018) and the annual exploitation rate for rainbow trout in Lake Eucumbene (New South Wales, Australia) was 26.7% (Faragher and Gordon 1992). The approximately half return rates from these waters compared to our data is undoubtedly fundamentally influenced by the area of the studied lakes and the size of the rivers, which affects the catchability of stocked fish. Data in Tab. 3 indeed indicate that the lowest average return was in VB-4P ground with a stream width of 8 - 12 m compared to the smaller streams of the other fishing grounds. On the other hand, however, the low weight return from the smallest stream of the HB-3-4 grounds shows that other factors, such as e.g. fishing pressure are also undoubtedly involved.

The average individual weight of rainbow trout caught and reported by anglers was usually higher than that at release, with the difference being particularly evident in catches from the Sv-1 non-trout fishing ground in 2019 (314 g stocked against 468 g caught). Since the vast majority of fish were caught shortly after release, this suggests that the weights reported by anglers may be slightly overstated and may not always correspond with reality. Indeed, many anglers do not bother to report the actual weight but instead provide an indicative one based on a table provided in the appendix to their fishing regulations booklet, which is probably slightly overestimating catch weight, or the angler's own estimate is 'subjectively distorted'. The erroneous anglers' lower estimate was probably also the reason for the lower individual weight of 315 g of the fish caught compared with the average weight of 335 g when released in Sv-1 in 2007 (Table 1).

Despite the generally higher individual weight at catch on trout fishing grounds, the weight return rate was generally slightly lower than that on the non-trout fishing ground (Table 1). It is very likely that the higher individual weights recorded at trout fishing grounds were due to the longer time interval between release and catch compared to the non-trout ground, during which the fish were able to grow and gain weight. Indeed, Adamek et al. (2011) and Jurajda et al. (2023) showed that stocked rainbow trout are able to ingest various food components immediately after release, though many of them (wood particles, stones, plant buds, leaves, etc.) have no nutritional value and are apparently taken reflexively when carried by the water current. On the other hand, the feeding habits of rainbow trout stocked from intensive aquaculture farms do not correspond completely with those of salmonid fish in their natural environment, though the ability to react to food organisms (drift, zoobenthos) and prey (fish) remains similar. Teixeira and Cortes (2006), for example, showed that, while both stocked and wild brown trout ingested natural food items, there were significant differences in their dietary preferences. Importantly, differences in diet preferences may also be indicated indirectly from the time distribution of catches after stocking, i.e. a larger percentage caught sooner after stocking in the Sv-1 non-trout ground, where many of the stocked trout were caught on hooks baited with bread, which resembles the feed they were given at the aquaculture facilities (Adamek et al. 2011). At the trout fishing grounds, the use of such 'organic' baits is prohibited, with only barbless flies and lures allowed, potentially lowering the catch rate. This limitation, together with reduced fishing pressure from the lower numbers

of anglers on trout grounds, most likely explains the spread of catches over a longer post-stocking period and the slightly lower rates of return at trout fishing grounds.

Conclusions

The vast majority of rainbow trout are caught and harvested shortly after stocking. Our data indicate that the proportion of stocked fish caught within two weeks of release averaged 88.6 % of the total catch in non-trout fishing grounds, which is significantly higher ($P < 0.01$) than the 63.6 % taken from designated trout grounds. On the other hand, the stocked rainbow trout tend to be caught more evenly throughout the fishing season on trout fishing grounds due to lower angling pressure (lower numbers of anglers owing a trout permit) and legal restrictions of fishing methods (barbless artificial lures and flies only). The rates of return over the whole year (season) were, however, rather comparable and ranged between 36.8 and 53.4 % on non-trout ground and between 29.8 and 68.4 % on trout grounds. Similarly, the weight returns were 47.7 – 79.5 % on non-trout ground and 34.4 – 75.3 % on trout grounds.

Author contributions

Zdeněk Adámek - conceptualization, methodology, formal analysis, investigation, resources, data curation, validation, writing - original draft, writing - review and editing, supervision; Luděk Šlapanský - investigation, resources, data curation; Pavel Jurajda – project administration, writing - review and editing, funding acquisition

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References

- Adamek Z, Blaszcok R, Ctrnact P (2011) Rates of return and feeding habits of farmed rainbow trout after their release into angling grounds. In: *Toward Resilient Recreational Fisheries*, Berlin: 36.
- Arlinghaus R, Cooke SJ, Lyman J, Policansky D, Schwab A, Suski C, Sutton SG, Thorstad EB (2007) Understanding the complexity of catch-and-release in recreational fishing: An integrative synthesis of global knowledge from historical, ethical, social, and biological perspectives. *Reviews in Fisheries Science*, 15: 75–167. DOI: [org/10.1080/10641260601149432](https://doi.org/10.1080/10641260601149432)
- Bettinger JM, Betolli PW (2002) Fate, dispersal, and persistence of recently stocked and resident rainbow trout in a Tennessee tailwater. *North American Journal of Fisheries Management*, 22: 425-432. DOI: [10.1577/1548-8675\(2002\)0222.0.CO;2](https://doi.org/10.1577/1548-8675(2002)0222.0.CO;2)
- Bloom RK (2013) Capture efficiency of barbed versus barbless artificial flies for trout. *North American Journal of Fisheries Management*, 33:493-498. DOI: [10.1080/02755947.2013.769920](https://doi.org/10.1080/02755947.2013.769920)
- Cambray JA (2003) Impact on indigenous species biodiversity caused by the globalisation of alien recreational freshwater fisheries. *Hydrobiologia*, 500: 217–230. DOI: [org/10.1023/A:1024648719995](https://doi.org/10.1023/A:1024648719995)

- Cassinelli JD, Meyer KA (2018) Factors influencing return-to-creel of hatchery catchable-sized Rainbow Trout stocked in Idaho lentic waters. *Fisheries Research*, 204: 316-323. DOI: [org/10.1016/j.fishres.2018.03.005](https://doi.org/10.1016/j.fishres.2018.03.005)
- Chalupa P, Spurný P, Grmela J (2014) Management pstruhových revírů řeky Opavy [Salmonid fisheries management of the Opava river]. In: Kopp R. (ed.): 65 let výuky rybářství na Mendelově Univerzitě v Brně: 134–139 (in Czech).
- Champigneulle A, Cachera S (2003) Efficiency of one year old trout (*Salmo trutta* L. and *Oncorhynchus mykiss* W.) stocking for professional netting and recreational fishing in boats in Lake Bourget. *Bulletin Francais de la Peche et de la Pisciculture*, 369: 1-16. DOI: [org/10.1051/kmae:2003019](https://doi.org/10.1051/kmae:2003019)
- Craig J.F. (2016) *Freshwater Fisheries Ecology*, 1st Edition. John Wiley & Sons Ltd, 899 pp. DOI: [10.1002/9781118394380](https://doi.org/10.1002/9781118394380)
- EU (2000) Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for community action in the field of water policy, *Official Journal of European Communities*, L 327: 1-72.
- Faragher RA, Gordon GNG (1992) Comparative exploitation by recreational anglers of brown trout, *Salmo trutta* L., and rainbow-trout, *Oncorhynchus mykiss* (Walbaum), in Lake Eucumbene, New South Wales. *Australian Journal of Marine and Freshwater Research*, 43: 835-845. DOI: [10.1071/MF9920835](https://doi.org/10.1071/MF9920835)
- Fornshell G (2002) Rainbow trout - challenges and solutions. *Reviews in Fisheries Science*, 10(3&4): 545–557. DOI: [.org/10.1080/20026491051785](https://doi.org/10.1080/20026491051785)
<https://mrs.mrsbrno.cz>
<http://www.rybsvaz.cz>
- Jurajda P, Šlapanský L, Adámek Z, Hnilička M, Janáč M, Jurajdová Z, Mendel J, Marešová E, Halačka K (2023) Stav lososovitých ryb na revírech MSÚS ČRS. [Status of salmonid fish in fishing grounds of Moravian-Silesian Territorial Association of the Czech Anglers Union]. *IVB AS CR Brno*, 24 p. (in Czech).
- Lewin W-C, Arlinghaus R, Mehner T (2006) Documented and potential biological impacts of recreational fishing: Insights for management and conservation. *Reviews in Fisheries Science*, 14:305–306. DOI: [org/10.1080/10641260600886455](https://doi.org/10.1080/10641260600886455)
- Lyach R, Remr J (2020) Does harvest of the European grayling, *Thymallus thymallus* (Actinopterygii: Salmoniformes: Salmonidae), change over time with different intensity of fish stocking and fishing effort? *Acta Ichthyologica et Piscatoria*, 50: 53–62. DOI: [10.3750/AIEP/02643](https://doi.org/10.3750/AIEP/02643)
- Muoneke MI, Childress WM (1994) Hooking mortality: A review for recreational fisheries. *Reviews in Fisheries Science*, 2(2): 123–156. DOI: [10.1080/10641269409388555](https://doi.org/10.1080/10641269409388555)
- MZe (2023) Situační a výhledová zpráva. Ryby. [Situation and outlook report. Fish.]. Ministry of Agriculture of the Czech Republic, Prague, 46 p. (in Czech).
- OBara CJ, Eggleton MA (1995) Evaluation of 3 small-scale, put-and –take rainbow trout fisheries in Tennessee. In: Eversole A.G. (Ed.): *Proceedings of the Forty-Ninth Annual Conference - Southeastern Association of Fish and Wildlife Agencies*: 78-87.
- Stanković D, Crivelli AJ, Snoj A (2015) Rainbow trout in Europe: introduction, naturalization and impact. *Reviews in Fisheries Science and Aquaculture*, 23: 39–71. DOI: [10.1080/23308249.2015.1024825](https://doi.org/10.1080/23308249.2015.1024825)
- Taylor MJ, White KR, 1992: A meta-analysis of hooking mortality in non-anadromous trout. *North American Journal of Fisheries Management*, 12:760–767. DOI: [10.1577/1548-8675\(1992\)012<0760:AMAOHM>2.3.CO;2](https://doi.org/10.1577/1548-8675(1992)012<0760:AMAOHM>2.3.CO;2)
- Teixeira A, Cortes RMV (2006) Diet of stocked and wild trout, *Salmo trutta*: Is there competition for resources? *Folia Zoologica*, 55: 61–73. DOI: hdl.handle.net/10198/985

Wedekind H, Schreckenbach K (2003) Investigations on the effect of angling on stress response in rainbow trout. *Bulletin of the European Association of Fish Pathologists*, 23(5):235–240.

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Table 1. Rate of return (%) of stocked rainbow trout at each fishing ground on all valid permits

Note: Sv-1 = Svitava-1; BV-4B = Blanice Vodňanská-4B; HB-3 = Hanácká Bystřice-3; HB-4 = Hanácká Bystřice-4; VB-4P = Vsetínská Bečva-4P; NT = non-trout fishing ground; T = trout fishing ground; n = number of fish, \bar{x} = mean individual weight, N/A = data not available

Table 2. Rainbow trout catches after stocking events in percentage of fish caught on local permits

Note: Note: Sv-1 = Svitava-1; BV-4B = Blanice Vodňanská-4B; HB-3 = Hanácká Bystřice-3; HB-4 = Hanácká Bystřice-4; VB-4P = Vsetínská Bečva-4P; n = number of fish; NT = non-trout fishing ground; T = trout fishing ground

Table 3. Abiotic determinants of the studied fishing grounds

Note: * average values; ** km of a fishing ground; Note: Sv-1 = Svitava-1; BV-4B = Blanice Vodňanská-4B; HB-3 = Hanácká Bystřice-3; HB-4 = Hanácká Bystřice-4; VB-4P = Vsetínská Bečva-4P; N/A not available

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Note: The arrows indicate the dates of stocking

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Note: The arrows indicate the dates of stocking

Figure 4. Numbers of rainbow trout caught at the Svitava-1 non-trout fishing ground in 2019.

Note: The arrows indicate the dates of stocking

Figure 5. Numbers of rainbow trout caught at the Blanice Vodňanská-4B trout fishing ground in 2007.

Note: The arrows indicate the dates of stocking

Figure 6. Numbers of rainbow trout caught at the Blanice Vodňanská-4B trout fishing ground in 2008.

Note: The arrows indicate the dates of stocking

Figure 7. Numbers of rainbow trout caught at the Hanácká Bystřice-3 trout fishing ground in 2019.

Note: The arrows indicate the dates of stocking

Figure 8. Numbers of rainbow trout caught at the Hanácká Bystřice-4 trout fishing ground in 2019.

Note: The arrows indicate the dates of stocking

Figure 9. Numbers of rainbow trout caught at the Vsetínská Bečva-4P trout fishing ground in 2020.

Note: The arrows indicate the dates of stocking

Figure 10. Proportional share of fish caught following individual stocking events (on local permits only)

Note: Sv-1 = Svitava-1; BV-4B = Blanice Vodňanská-4B; HB-3 = Hanácká Bystřice-3; HB-4 = Hanácká Bystřice-4; VB-4P = Vsetínská Bečva-4P; NT = non-trout fishing ground; T = trout fishing ground