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Annual catch of rainbow trout, *Oncorhynchus mykiss* (Actinopterygii, Salmoniformes, Salmonidae), in fishing grounds in the Czech Republic, related to stocking

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Abstract

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. Rainbow trout stocking and return data in anglers' catches were analyzed with respect to the time period between stocking and catch and the rates of return were evaluated. 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 within 2007–2020. 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-related ($P = 0.19$) returns. 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 and legal restrictions (artificial flies and lures only). Both individual and weight returns for the entire year (season) were similar in non-trout and trout areas.

Keywords

fishing grounds, put-and-take fisheries management, rate of return, recreational fishing, stocking

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, of which 81 tonnes are caught by anglers (Anonymous 2023). In Czech open

waters, its occurrence is completely dependent on stocking as natural reproduction is highly unlikely (Stanković et al. 2015). Therefore, according to the Czech Government Regulation No. 145/2022 (Anonymous 2022), permission for the deliberate spread of an alien species is not required for the stocking of rainbow trout, with the exception of national reserves, national parks, and areas protected by the Nature and Landscape Protection Act No. 114/1992 (Anonymous 1992).

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 stagnant waters typically designated as trout fishing grounds, 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 harvest 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 mean 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 the mean 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. Most of the sporadically published data appeared in the "grey" literature (Adamek et al. 2011; Chalupa et al. 2014; Jurajda et al. 2023) with the only exception being 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 (O'Bara 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), the basic characteristics of which are given in Table 1.

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

Table 1. Abiotic determinants of the studied fishing grounds in the Czech Republic within 2007–2020.

Determinant	Sv-1	BV-4B	HB-3-4	VB-4P
Inhabitants [ind. · km^{-1}]	25000	213	290	500
Sites of release [ind. · 10 km^{-1}]	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 ASL]	195–236	446–501	382–608	425–590
Channelization [%]	100	15	5	80
Numerical return rate [%]	36.8–53.4	42.8–68.4	—	29.8
Weight-related return rate [%]	47.7–79.5	43.8–75,3	38.1–39.6	34.4

Sv-1 = Svitava-1, BV-4B = Blanice Vodňanská-4B, HB-3 = Hanácká Bystřice-3, HB-4 = Hanácká Bystřice-4, VB-4P = Vsetínská Bečva-4P. km relates to the length of a fishing ground.

Figure 1. Location of the surveyed fishing grounds in the Czech Republic within 2007–2020.

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 appropriately 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. Common carp (*Cyprinus carpio*) is the most common fish in harvested anglers' catches, followed by rainbow trout and rheophilic fish species, such as nase, *Chondrostoma nasus* (Linnaeus, 1758), and chub, *Squalius cephalus* Linnaeus, 1758. Overall, the fish assemblage is very rich, consisting of approximately 20–25 species, although most of them are not the anglers' target fish. 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 $m^3 \cdot s^{-1}$. Typologically (Anonymous 2000), it has a large drainage area (1147 km^2) in a medium altitude (195–236 m ASL) with the mean bed slope 2.9‰. Almost the entire river course in the fishing ground with 6 weirs is modified (often channelized) to various extents.

The fishing ground Blanice Vodňanská-4B (hereafter BV-4B, 49°5.92235′N, 14°3.90532′E–49°3.11465′N, 14°1.42823′E) is 8 km long with 8 sites of release. It has a width of 5–10 m and discharge rates of 1–3 $m^3 \cdot s^{-1}$. Fish community consists of salmonids (rainbow trout and brown trout *Salmo trutta* Linnaeus, 1758) and perch (*Perca fluviatilis* Linnaeus, 1758) with occasional occurrence of grayling and cyprinids such as chub, roach, *Rutilus rutilus* (Linnaeus, 1758) and common minnow, *Phoxinus phoxinus* Linnaeus, 1758. 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-m 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 (Anonymous 2000), it has a medium-sized drainage area (861 km^2) in a medium altitude (446–501 m ASL) with the mean bed slope of 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 $m^3 \cdot s^{-1}$. The dominant fish species in both fishing grounds is brown trout, followed by rainbow trout, chub and abundant alpine bullhead, *Alpinocottus poecilopus* (Heckel, 1836), common minnow and stone loach, *Barbatula barbatula* Linnaeus, 1758. Rainbow trout stocking is performed also in the downstream fishing ground, but upstream fish migration is impossible due to the 1-m 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 (Anonymous 2000), it has a medium sized drainage area (266 km^2) in a medium altitude (382–608 m ASL) with the mean bed slope of 7.5‰. The river in the fishing grounds flows in a natural bed with minor modifications around two weirs and in in the urban areas 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 $m^3 \cdot s^{-1}$. The fish assemblage is dominated by brown trout with occasional occurrences of rainbow trout, chub, grayling, alpine bullhead, common minnow, gudgeon, *Gobio gobio* (Linnaeus, 1758) and spirlin, *Alburnoides bipunctatus* (Bloch, 1782). Rainbow trout are stocked also in the downstream fishing ground, but upstream fish migration is quite limited due to 2.7-m weir barrier provided with fish ladder. The section of the river with the fishing ground flows through several settlements with a total of 10 thousand inhabitants. Typologically (Anonymous 2000), it has a medium sized drainage area (734 km^2) in a medium altitude (425–590 m ASL) with the mean 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 analyzed from the records in the permits, because the permits are valid for the entire regions representing tens of thousands of anglers and several dozens of fishing grounds, and these data cannot be appropriately extracted from them.

The system of permit validity in Czech fishing grounds is so specific that it makes it impossible to evaluate the angling pressure in individual fishing grounds based on all daily records. Fishing permits are valid for entire regions, although they are issued by local associations (clubs) entrusted with the management of one or more fishing grounds. These associations collect the records (including all fishing grounds in the region visited by an

angler—a member of the respective association) after the end of the fishing season/year and provide the relevant information to the regional office, which is responsible for their summarization and further processing. The records of rainbow trout catches in a given fishing ground on a daily basis (hundreds to lower thousands of records) are therefore available only at the level of members of the relevant association, while the summary of catches (several tens of thousands of records) was available at the regional office, but without the possibility to daily evaluation for individual fishing grounds.

The number of catches therefore corresponds only to the data from the permits of appropriate association managing the given fishing ground (hereinafter referred to as "local permits"), while the data on the total return rates in a specific fishing ground was obtained by summarizing the records from all permits issued for the region.

Rainbow trout catches were evaluated over two time periods:

- within two weeks post-stocking and
- during the rest of year (non-trout grounds) or fishing season (trout grounds).

The first and second week of 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 (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 generalized linear mixed models (GLMM, binomial distribution, Harrison 2014) to test differences in proportion of trout captured within the first two weeks (out of all captured trout), 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 2300 rainbow trout (770 kg) were stocked on three separate dates (13 June, 28 August, and 1 September). Of these, 1170 trout (368 kg) were subsequently caught and harvested, corresponding to an individual rate of return of 50.9%, or 47.8% by weight (Table 2), with the mean 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. 2A, Table 3).

In 2008, a further 2990 rainbow trout (1100 kg) were stocked on four separate dates (16 April, 18 June, 3 September, and 24 October). A total of 1297 trout (525 kg) were subsequently caught and harvested, representing a rate of individual return of 36.8%, or 47.7% by weight (Table 2), with the mean 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. 2B, Table 3).

In 2019, 1909 rainbow trout (600 kg) were stocked on two dates (10 October and 4 November). A total of 1019 trout (477 kg) were subsequently caught and harvested, representing a numerical rate of individual return of 53.4%, or 79.5% by weight (Table 2), with the mean 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 a further 9.9% caught outside the period directly related to the release (Fig. 2C, Table 3).

Table 2. Rate of return (%) of stocked rainbow trout at each fishing ground on all valid permits in the Czech Republic within 2007–2020.

Fishing ground	Year	Stocked			Caught			Rate of return [%]	
		n	W_T [g]	W_I [g]	*n*	W_T [g]	W_I [g]	Numerical	Weight related
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	—	192	—	212	76	358	—	39.6
HB-4 T	2019	—	105	—	117	40	342	—	38.1
VB-4P T	2020	798	337	422	238	116	487	29.8	34.4

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, W_T = total weight of fish, W_I = mean individual weight of fish.

Blanice Vodňanská-4B trout fishing ground. In 2007, 400 rainbow trout (130 kg) were stocked on two dates (12 April and 15 July). 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 2), with the mean 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. 2D, Table 3).

In 2008, 370 rainbow trout (150 kg) were stocked on two dates (13 April and 13 August), 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 2), with the mean 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. 3A, Table 3).

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 (29 March, 15 April, 15 June, 14 August, and 6 November), of which 190 trout (76 kg) were subsequently caught and harvested, giving an estimated rate of return by weight of 39.6% (Table 2), with the mean 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 a further 34.0% caught outside the period directly related to the release (Fig. 3B, Table 3).

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 (29 March, 15 April, 15 June, and 14 August), of which 105 fish (40 kg) were subsequently caught and harvested, giving an estimated rate of return by weight of 38.1% (Table 2), with the mean 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. 3C, Table 3).

Table 3. Rainbow trout catches after stocking events in percentage of fish caught on local permits in the Czech Republic within 2007–2020.

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	13 Jun 2007	800	345	15	22	90.3	3.9	5.8
	28 Aug 2007	900	342	41	14	86.2	10.3	3.5
	21 Sep 2007	600	302	14	23	89.1	4.1	6.8
	2007 total	**2300**	**989**	**70**	**59**	**88.5**	**6.2**	**5.3**
Sv-1 NT	4 Apr 2008	606	248	39	107	62.9	9.9	27.2
	18 Jun 2008	1111	311	23	30	85.4	6.3	8.3
	3 Sep 2008	606	273	39	33	79.1	11.3	9.6
	24 Oct 2008	667	142	19	7	84.5	11.3	4.2
	2008 total	**2990**	**974**	**120**	**177**	**76.6**	**9.5**	**13.9**
Sv-1 NT	10 Oct 2019	909	211	15	8	90.2	6.4	3.4
	11 Nov 2009	1000	147	64	40	58.6	25.5	15.9
	2019 total	**1909**	**358**	**79**	**48**	**73.8**	**16.3**	**9.9**
BV-4B T	12 Apr 2007	100	22	7	20	44.9	14.3	40.8
	15 Jul 2007	300	36	20	66	29.5	16.4	54.1
	2007 total	**400**	**58**	**27**	**86**	**33.9**	**15.8**	**50.3**
BV-4B T	13 Apr 2008	170	81	9	43	60.9	6.8	32.3
	13 Aug 2008	200	57	30	33	47.5	25.0	27.5
	2008 total	**370**	**138**	**39**	**76**	**54.6**	**15.4**	**30.0**
HB-3 T	15 Apr 2019	N/A	42	15	23	52.5	18.8	28.7
	15 Jun 2019	N/A	10	14	35	17.0	23.7	59.3
	14 Aug 2019	N/A	13	11	4	46.4	39.3	14.3
	6 Nov 2019	N/A	15	20	10	33.3	44.5	22.2
	2019 total	**N/A**	**80**	**60**	**72**	**37.7**	**28.3**	**34.0**
HB-4 T	15 Apr 2019	N/A	5	1	15	23.8	4.8	71.4
	15 Jun 2019	N/A	16	9	20	35.6	20.0	44.4
	14 Aug 2019	N/A	12	18	21	23.5	35.3	41.2
	2019 total	**N/A**	**33**	**28**	**56**	**28.2**	**23.9**	**47.9**
VB-4P T	15 Apr 2020	248	31	6	4	75.6	14.6	9.8
	16 May 2020	110	46	7	57	41.8	6.4	51.8
	21 Oct 2020	440	48	15	21	57.1	17.9	25.0
	2020 total	**798**	**126**	**28**	**81**	**53.2**	**11.9**	**34.9**

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.

Vsetínská Bečva-4P trout fishing ground. In 2020, 798 rainbow trout (337 kg) were stocked on four dates (15 April, 16 May, 8 October, and 21 October). 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 2), with the mean 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 a further 34.9% caught outside the period directly related to the release (Fig. 3D, Table 3).

Overall, the non-trout ground showed a significantly higher proportion of stocked trout caught during the first two weeks post-stocking (92.3% on average) compared to trout grounds (64.1%; GLMM, $n = 23$, $P < 0.001$, Fig. 4).

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. 2D, 3A) and HB-3 (Fig. 3B). 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 Opava River 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 1).

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 weekly number of trips or the type of baits. Moreover, the fishing season on trout grounds runs only from 16 April till 30 November, while whole-year angling is allowed on non-trout fishing grounds.

As can be seen from the graphic presentations (Figs. 2A–3D), 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; Figs. 3, 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, a significantly lower percentage were caught over the same period in trout grounds (28.6%–90.2%; $P < 0.01$, Table 3). 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. 4). In comparison, the counts of rainbow trout caught in trout fishing grounds through

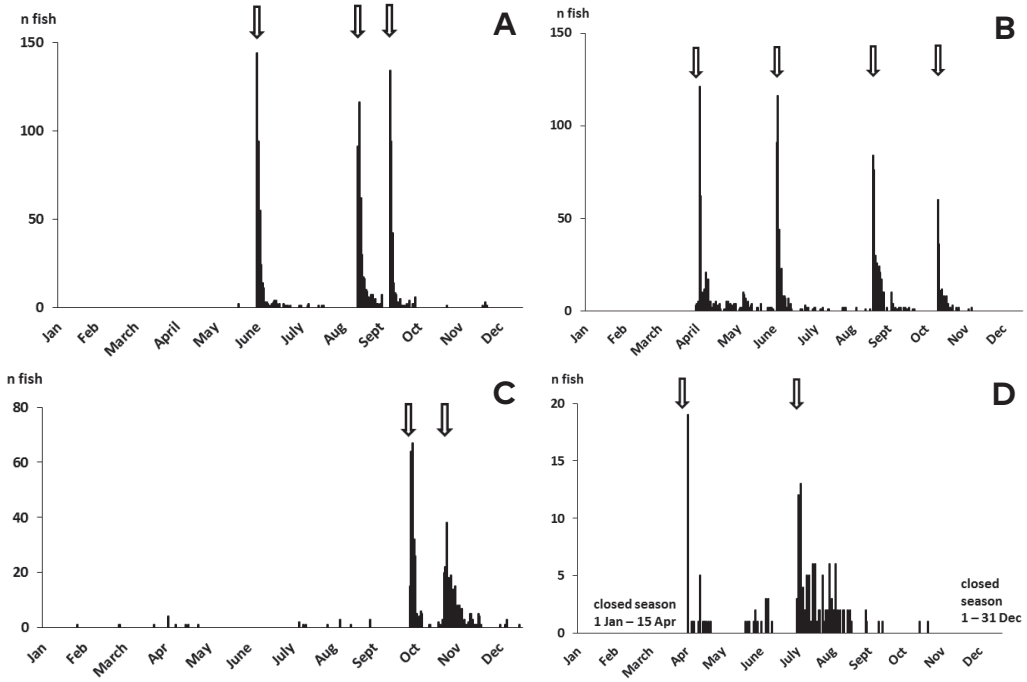

Figure 2. Numbers of rainbow trout caught at the Svitava-1 non-trout fishing ground (in 2007: **A**), (in 2008: **B**), (in 2019: **C**) and caught at the Blanice Vodňanská-4B trout fishing ground (in 2007 **D**) in the Czech Republic. Note: The arrows indicate the dates of stocking.

the year (actually during the fishing season) were relatively even (Fig. 4), partly due to reduced fishing pressure (i.e., fewer licensed anglers) and the added restrictions in place when fishing for salmonids (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 3). In reality, this proportion was mostly between 30% and 50% (Fig. 4).

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 1, 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 behavior 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 2), 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 hatchery rainbow trout dispersed rapidly from the stocking site 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.

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–

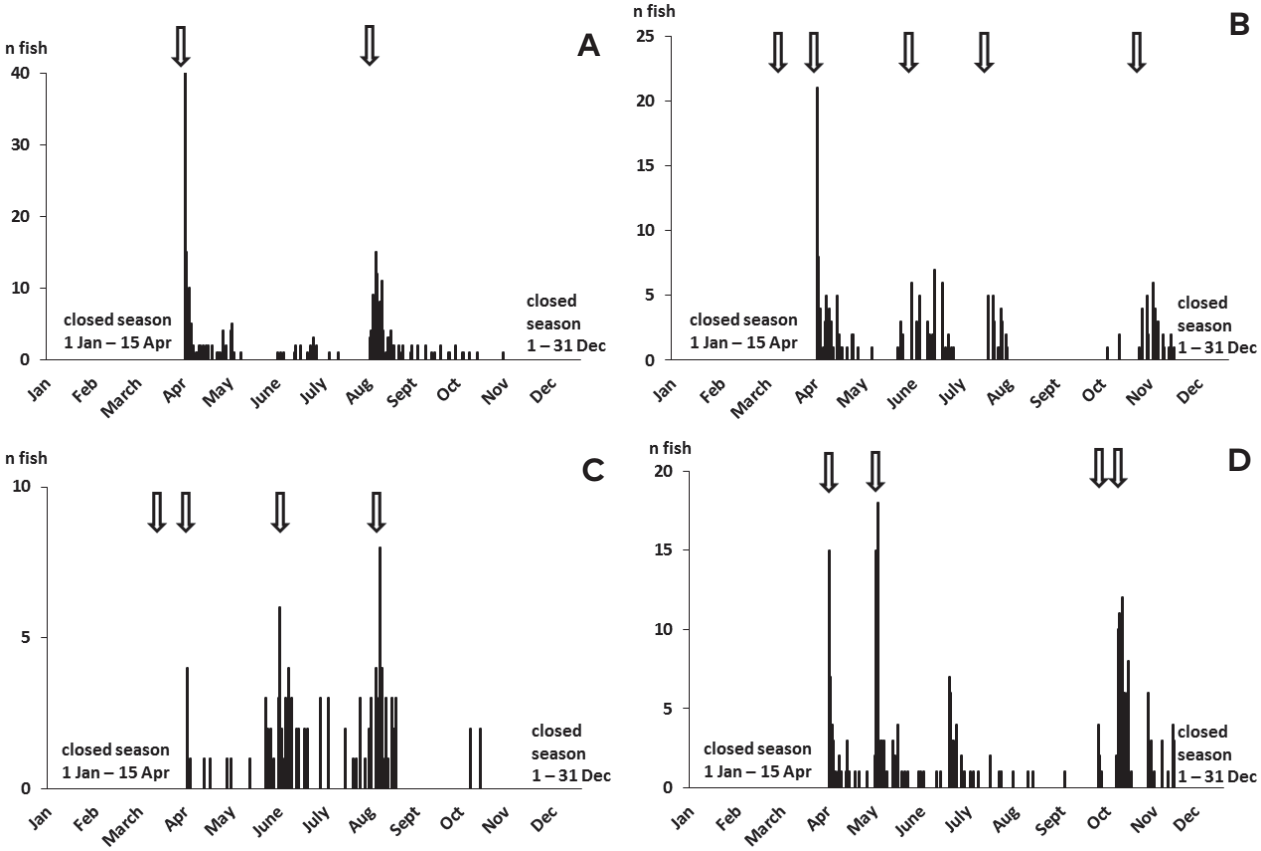

Figure 3. Numbers of rainbow trout caught at the Blanice Vodňanská-4B trout fishing ground in in 2008 (**A**), the Hanácká Bystřice-3 trout fishing ground in 2019, (**B, C**), and the Vsetínská Bečva-4P trout fishing ground in 2020 (**D**) in the Czech Republic. Note: The arrows indicate the dates of stocking.

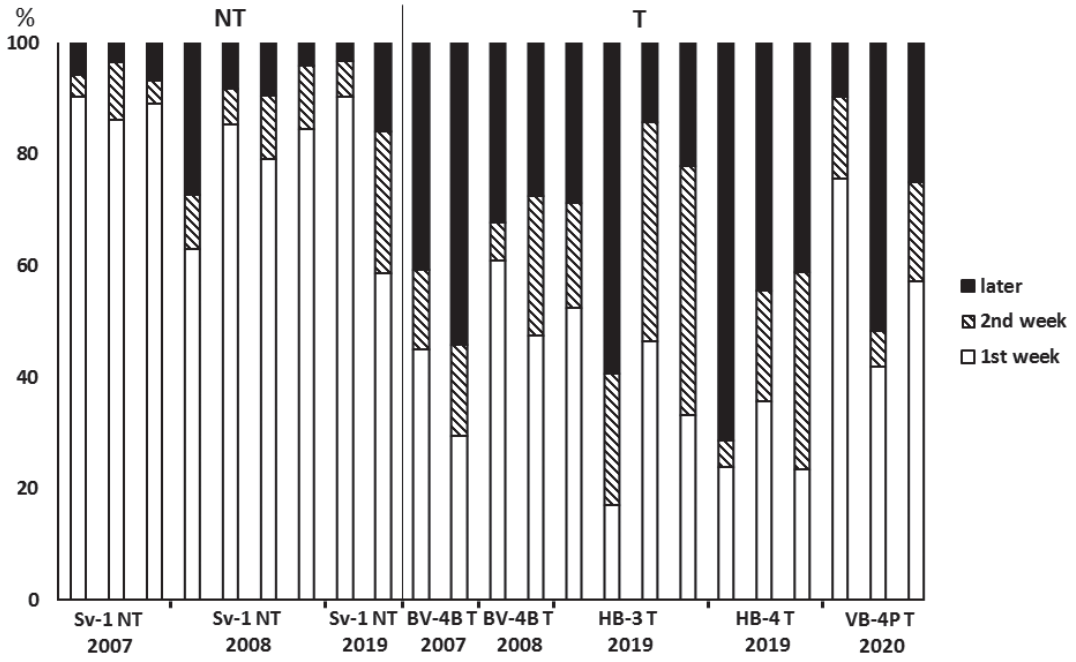

Figure 4. Proportional share of fish caught following individual stocking events (on local permits only) the Czech Republic within 2007–2020. Note: Sv-1 = Svitava-1; BV-4B = Blanice Vodňanská-4B; HB-3 = Hanácká Bystřice-3; HB-4 = Hanácká Bystřice-4; VB-4P = Vsetínská Bečva-4P; NT = non-trout fishing ground; T = trout fishing ground.

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 2). 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 2). 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%–55%; Jurajda et al. 2023) and the Opava River in 2013 (26%–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 O'Bara 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 Table 1 indeed indicate that the lowest mean 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 mean 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 mean weight of 335 g when released in Sv-1 in 2007 (Table 2).

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 2). 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 post-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 in 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.

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