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Practical Guidelines for Recreational Anglers on Selective Fishing of Alien Species in Protected and Natura 2000 Areas

NATURA 2000

Life

FOND ZA ZAŠTITU OKOLIŠA I
ENERGETSKU UČINKOVITOST

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Contents

FOREWORD

The handbook *Practical Guidelines for Recreational Anglers on Selective Fishing of Alien Species in Protected and Natura 2000 Areas* was developed with the aim of providing clear and practical guidance to recreational anglers who fish in protected areas and Natura 2000 ecological network sites. The guidelines are intended to assist in the identification of alien species, their selective removal, and the proper handling of catches, while simultaneously reducing impacts on native species and their habitats.

The guidelines are primarily intended for recreational anglers, regardless of experience level – from beginners to experienced anglers wishing to further improve their knowledge. They are also intended for members of fishing associations, nature rangers, managers of protected areas, and all other stakeholders involved in the management and conservation of freshwater ecosystems. The content is adapted to field conditions and real fishing situations, without requiring prior expertise in biology or ecology, in order to be easily understandable and applicable in practice.

Although the guidelines were developed within the project area, their application is broader. They may be adapted and applied in other protected areas and Natura 2000 sites in the Republic of Croatia, while respecting legislation and in cooperation with the competent public institutions responsible for protected area management, recreational fishing associations, and other relevant stakeholders. This ensures that the implementation of selective fishing is aligned with local regulations and conservation objectives.

The document was prepared as part of the ReFresh Fish LIFE project, whose objective is to contribute to the conservation and restoration of freshwater ecosystems through reducing the negative impacts of alien and invasive alien species in protected areas and Natura 2000 sites, specifically within the areas of the Wider Area of Krka National Park (HR2000918), Čikola (HR2000919), Vrba (HR2001266), and the Srednji tok Cetine s Hrvatačkim and Sinjskim poljem (HR2001313). Although the species presented in this handbook are examples recorded in the Krka River basin, these species are widespread throughout Adriatic catchment watercourses and represent a broader conservation issue for freshwater ecosystems in this region. The guidelines represent one of the project tools for strengthening cooperation between experts and recreational anglers and for actively involving the fishing community in the implementation of nature conservation measures.

Recreational anglers play an important role in nature conservation because they are regularly present on water bodies, are familiar with local conditions, and are often the first to notice changes in fish communities. Through targeted removal of alien species, responsible handling of catches, and sharing basic catch data, anglers can directly contribute to the conservation of native fish species and the balance of aquatic ecosystems. These guidelines aim to encourage anglers not only to engage in fishing activities, but also to actively participate in the conservation of the waters they use and value.

INTRODUCTION

What Are Invasive Alien Species and How Do They Affect the Environment?

Based on its biodiversity, Croatia is considered one of the richest countries in Europe. More than 40,000 native species have been recorded in its terrestrial and aquatic ecosystems to date. Over long periods of time, these species have adapted to natural conditions and to other species, establishing a delicate ecological balance. Human activities, particularly those related to the use of natural resources, can seriously disrupt this balance, and one of the most significant pathways is the intentional or unintentional introduction of alien (non-native) species.

An alien (non-native) species is any species introduced outside its natural range through direct or indirect human activity. After being introduced into a new habitat, some species fail to survive, while others successfully adapt, reproduce, and spread without further human assistance. It is important to emphasize that not all alien species are necessarily harmful – for example, many agricultural crops such as potatoes and tomatoes were introduced from other parts of the world but do not pose a threat to the environment.

However, certain alien species in a new environment lack natural enemies, diseases, or predators that would otherwise limit their population size. Such species can spread rapidly, displace native species, and alter natural habitats. When an alien species becomes widespread and negatively affects biodiversity, ecosystem functioning, human health, or the economy, it is referred to as an invasive alien species (IAS).

The negative impacts of alien and invasive alien species may be numerous and include habitat degradation, predation on native species, competition for food and space, hybridisation and genetic pollution, transmission of parasites and pathogens, and changes in feeding niches. Due to their often greater adaptability, alien species can significantly alter habitat conditions, making them unfavourable for native species.

In the waters of the Republic of Croatia, two groups of alien species are distinguished. The first includes species that naturally occur outside Croatian territory, mainly introduced from parts of Asia and North America. The second group includes species naturally distributed in one part of Croatia but considered alien, and even invasive, in another part. Thus, certain freshwater fish species (such as northern pike, common perch, and tench) that are native to one Croatian river basin have been intentionally or accidentally translocated by humans into waters of another basin where they do not naturally occur.

Most alien fish species in Croatia, including translocated species, were introduced for recreational fishing purposes. In addition to intentional introductions, accidental introductions caused by improper fish handling, unauthorized stocking, or fish transfers between watercourses (e.g. contamination of stocking material with alien species) also represent a major part of the problem.

The watercourses of the Adriatic catchment are short and mutually isolated. Their characteristics often change depending on whether they flow calmly through karst fields or cut through deep canyons, creating waterfalls and lakes. They are rich in water during spring and autumn, while many dry out during summer. These highly specific habitat conditions, combined with geological history, make this area exceptionally rich in endemic fish and other freshwater organisms. According to recent data, approximately forty endemic fish species inhabit the Adriatic catchment area in Croatia. These species generally have very restricted distributions, often limited to a single watercourse and its tributaries. Due to the high degree of endemism, limited distribution of many species, and the natural absence of true predatory fish in native fish communities, the watercourses of the Adriatic catchment are extremely sensitive to the introduction of alien species. Such introductions represent one of the greatest threats to the conservation of their biodiversity. The introduction of predatory species such as northern pike and perch can lead to major changes in the composition and structure of fish communities and consequently disrupt entire freshwater ecosystems, including threatening the survival of local endemic species.

In the Krka River, the densest populations of invasive alien species include pumpkinseed, northern pike, perch, and black bullhead catfish. Their impacts on native fish are multiple: adult individuals of certain alien species (especially pike and perch) primarily feed on juveniles of native species, thereby reducing their success in reproduction. Alien species also compete for food and suitable habitats and alter community structure and habitat conditions. Alongside habitat degradation and destruction, overexploitation, pollution, and climate change, invasive alien species are among the leading causes of biodiversity loss globally as well as in Croatia. Therefore, reducing the impacts of invasive species through preventing their introduction into new areas, limiting their spread, and removing them wherever possible is considered a priority in nature conservation.

Selective Fishing

Selective fishing of alien and invasive alien freshwater fish species in natural habitats should be based on targeted and controlled removal, while strictly respecting legal regulations and preserving native species. Although the complete eradication of already established populations is often difficult to achieve, regular removal can significantly reduce their abundance and therefore negative impacts on native fish communities. Prevention of new introductions is equally important and includes prohibiting unauthorized fish stocking and translocations, educating and raising awareness among anglers, and surveillance.

Freshwater anglers use various fishing gear and techniques. In practice, hook-and-line fishing and lure fishing are most commonly used, while the use of nets is allowed only under special permits. For alien fish species removal targeted electrofishing by authorised personnel is also applied. In the management of alien and invasive alien species such as pumpkinseed, Prussian carp, or black bullhead catfish, targeted fishing throughout the year should be encouraged. Good fishing practice includes proper handling of catches, preventing fish from escaping back into the water, and a strict prohibition on transferring captured individuals to other water bodies. Particular attention should be on avoiding accidental catches and injuries to native species.

Systematic removal, combined with catch monitoring and cooperation between anglers and competent institutions, represents one of the key measures in controlling populations of alien freshwater fish species.

LEGAL FRAMEWORK

International Framework

Convention on Biological Diversity

The most important legal provision regarding invasive species within the Convention on Biological Diversity (CBD) is contained in Article 8, according to which Parties to the Convention are obliged to prevent the introduction of, control, or eradicate alien species that threaten ecosystems, habitats, or species.

Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)

The fundamental provision regarding invasive alien species in the Bern Convention is defined in Article 11, according to which Parties to the Convention are obliged to strictly control the introduction of non-native (alien) species.

EU Biodiversity Strategy for 2030

Invasive alien species are identified as one of the five main drivers of biodiversity loss. In the section defining concrete targets for 2030, invasive alien species are mentioned in the context of achieving the goal of reducing by 50% the number of Red List species threatened by invasive alien species.

Regulation (EU) No 1143/2014 on the Prevention and Management of the Introduction and Spread of Invasive Alien Species

Regulation (EU) No 1143/2014 on the prevention and management of the introduction and spread of invasive alien species entered into force on 1 January 2015. It establishes rules aimed at preventing and managing the introduction and spread of invasive alien species (IAS) within the European Union, with the objective of minimizing and mitigating their adverse impacts on biodiversity, ecosystems, human health, and the economy. The Regulation applies to IAS of Union concern and, among other measures, prescribes the establishment and regular updating of a list of such species, known as the Union List.

EU Member States are required to undertake measures aimed at preventing the unintentional introduction of IAS, ensuring their early detection and rapid eradication, and managing those species that are already widely spread within their territories.

National Framework

Nature Protection Strategy and Action Plan of the Republic of Croatia for the Period 2017–2025 (Official Gazette 72/17)

At the national level, the Nature Protection Strategy and Action Plan of the Republic of Croatia for the period 2017–2025 recognises the need to establish an effective management system for alien species, as well as the implementation of measures to prevent their introduction and

spread and to control invasive alien species in order to prevent the loss of biological and landscape diversity.

Act on the Prevention and Management of the Introduction and Spread of Alien and Invasive Alien Species (Official Gazette 15/18, 14/19)

In accordance with the Strategy and as a framework for implementing Regulation (EU) No 1143/2014, Croatia adopted the Act on the Prevention and Management of the Introduction and Spread of Alien and Invasive Alien Species in 2018.

Article 9(6) of the Act prescribes the adoption of regulations governing:

- the list of invasive alien species of national concern (the so-called black list),
- the white list, and
- the list of invasive alien species requiring enhanced regional cooperation.

The competent authority for implementing Regulation (EU) No 1143/2014 and the IAS Act in Croatia is the ministry responsible for nature protection, in cooperation with authorities responsible for customs supervision, agriculture, plant health, veterinary affairs, forestry, hunting, fisheries, and internal affairs.

Ordinance on the Black and White Lists of Alien Species (Official Gazette 13/2024)

The Ordinance regulates which alien species are permitted and which represent a risk in Croatia, as well as the manner in which they are managed. In addition to general provisions, the Ordinance contains:

1. The Black List – a list of invasive alien species that cause or may cause damage to biodiversity, human health, or the economy, for which prohibitions and control measures are introduced;
2. The White List – a list of alien species permitted for cultivation and marketing because they do not represent a significant ecological risk, provided that cultivation takes place under controlled conditions;
3. Criteria for including species on the black or white list (e.g. invasiveness, harmful impacts, spread potential);
4. Procedures for periodic review and updating of the lists based on new scientific knowledge.

Freshwater Fisheries Act (Official Gazette 63/19)

Articles 3(1)(7), 3(1)(53), 9(2)(8), 51(1)(3), and 38(2) explicitly prohibit fishing in fishing waters using alien and invasive fish species (live or dead) as bait, while selective fishing aimed at reducing populations of alien fish species is permitted.

According to Article 25(6) of the IAS Act, any individual or legal entity that, due to the nature of their work or for other reasons, detects the occurrence of an invasive alien species of Union

concern or a species of concern in Croatia is obliged to immediately notify the competent nature protection inspector or the ministry responsible for nature protection.

Pursuant to the permit issued by the Ministry of Environmental Protection and Green Transition (CLASS: UP/I-352-02/25-09/249, REG. NO.: 517-06-2-1-25-2) on 14 November 2025, the removal of invasive and alien fish species in protected areas is authorised within the framework of the LIFE – ReFresh Fish LIFE project. For recreational anglers, this permit is valid subject to compliance with the following conditions:

- Catching invasive alien fish species using fishing rods is permitted;
- Only artificial lures may be used during fishing activities;
- Fishing may only be carried out during daylight hours (from dawn to dusk);
- Captured invasive fish species must be removed and disposed of safely;
- Groundbaiting (pre-baiting) prior to fishing is prohibited;
- Fishing is not permitted on travertine (tufa) barriers;
- It is necessary to keep catch records during fishing activities;
- Equipment must be cleaned, dried, and disinfected before and after use between different water bodies, in accordance with good practice measures aimed at preventing the spread of diseases and other organisms associated with aquatic habitats.

INVASIVE FISH SPECIES OF THE WIDER KRKA RIVER BASIN

NORTHERN PIKE – *Esox lucius* Linnaeus, 1758

Distribution

Northern pike is native to continental European watercourses. In Croatia, it naturally occurs in rivers and lakes of the Danube basin. In the Adriatic basin, it is considered an invasive species and has been recorded in the Mirna, Lika, Gacka, Krka, and Cetina rivers, the Čikola estuary, the Neretva River, Vransko jezero on Cres Island, Vransko jezero near Biograd, Prološko Lake, and smaller lakes in the hinterland of Zadar. Pike can be found throughout the Krka River, although it is more common in impounded sections, especially downstream of Roški Slap, in Lake Brljan, Visovac Lake, and Carigradska Draga.

Appearance

The body of the northern pike is elongated and slightly laterally compressed. The front part of the body features a pointed head with large elongated jaws full of sharp teeth. The large eyes are positioned high on the head. The dorsal and anal fins are located near the large forked caudal fin at the rear part of the body. Body colouration and patterns vary depending on habitat conditions. The typical green or black back, light green flanks with white stripes or spots, and white belly may be absent in clear waters without vegetation, where pike become lighter in colour.

Lifestyle

The typical habitat of the northern pike includes lakes and slow-flowing lowland rivers, especially natural side channels and oxbow lakes with weak current and abundant aquatic vegetation. Pike is an ambush predator that primarily relies on vision while hunting, although it also has a highly developed sense of smell and may occasionally feed as a scavenger. Its diet mainly consists of smaller fish, and cannibalism has also been recorded. The spawning period lasts from January to April, when water temperatures rise above 5 °C. Spawning itself lasts only two or three days and takes place in shallow areas with dense aquatic vegetation onto which the eggs are laid.

Impact on Native Fauna

Northern pike has a direct negative impact on native fish communities through predation. Since true predatory fish are naturally absent from Adriatic basin watercourses, the introduction of this species results in a decline in native fish populations.

Recommended Fishing Method

As a typical ambush predator, northern pike is best targeted near shelters such as water lilies, reeds, submerged branches, and tree roots where it hides while waiting for prey. Fishing with artificial lures is effective throughout the year, although success is usually greater during autumn months. Trolling is also highly effective in lakes. The use of a steel leader is strongly recommended to prevent the fish from biting through the fishing line or braided line with its sharp teeth. The best times of day for pike fishing are dawn and dusk.

PERCH – *Perca fluviatilis* Linnaeus, 1766

Distribution

Perch is distributed throughout Europe and western Asia. In Croatia, it is a native and widespread species in the Danube basin, while in the Adriatic basin it is considered an alien species introduced into the Lika and Gacka rivers, Prološko Blato, the Vrljika and Krka rivers, the Čikola estuary, as well as waters in Istria. Perch is a common species in the Krka River and can be found in greater abundance in Visovac Lake, Lake Brljan, and Carigradska Draga. It has also been recorded at the mouth of the Čikola River within Krka National Park.

Appearance

The average body length ranges between 15 and 30 cm, with females usually larger than males. Perch has a high, slightly laterally compressed body covered with rough ctenoid scales. The back is dark green, fading into greenish-yellow on the flanks, while the belly is pale yellow. The most distinctive characteristic of perch is the presence of 5–8 dark vertical bands along the sides of the body, sometimes forming a “Y” shape. It has two dorsal fins: the first contains spines, while the second contains soft rays. The pelvic, anal, and caudal fins are often reddish, the pectoral fins yellowish, and the dorsal fins greyish-green.

Lifestyle

Perch inhabits a wide variety of freshwater habitats. It feeds mainly at dawn and dusk and consumes almost anything it can swallow, including smaller fish, while cannibalism has also been observed. Males reach sexual maturity between their first and second year of life, while females mature between their second and fourth year. Spawning takes place in spring. During spawning, females deposit adhesive eggs on aquatic vegetation and stones. Larvae hatch after 1–8 days, depending on water temperature.

Impact on Native Fauna

Perch has a direct negative impact on native fish communities through predation. Since natural predatory fish are absent from Adriatic catchment watercourses, the introduction of perch leads to declines in native fish populations. In addition, perch often becomes the dominant species in watercourses where it has been introduced and negatively affects not only fish communities but also aquatic invertebrate communities on which it feeds.

Recommended Fishing Method

Perch most commonly inhabits deeper parts of water bodies with heterogeneous bottoms, such as transitions between gravel, sand, and rocks, submerged structures, or the edges of deeper pits. Fishing is most commonly carried out using small artificial lures. During autumn, perch gather in larger schools, making it possible to achieve high catch rates in a short period of time. Perch can be caught using various techniques, including float fishing and bottom fishing, depending on water depth and local conditions.

GRASS CARP – *Ctenopharyngodon idella* (Valenciennes, 1844)

Distribution

Grass carp is an alien species in Europe, introduced for aquaculture purposes from East Asia (Amur River basin). In Croatia, it occurs in fish ponds and in the middle and lower reaches of rivers within the Danube basin, as well as in certain reservoirs of the Adriatic basin. Grass carp is a rare species in the Krka River and appears only sporadically. To date, it has been recorded in Lake Brljan.

Appearance

Grass carp is the only representative of its genus. It can grow up to 150 cm in length and weigh up to 45 kg, although individuals are usually between 30 and 60 cm long. Its body is elongated and spindle-shaped, with a large, broad head and subterminal mouth. The body is covered with large scales with dark outer edges. The back is dark green, the flanks greenish, and the belly pale greenish. The dorsal and caudal fins are somewhat darker than the remaining fins. Inexperienced anglers may confuse it with the chub.

Lifestyle

Although there are indications that grass carp has fully acclimatised and naturally reproduces in large rivers such as the Danube, it is unknown whether it reproduces in natural waters in Croatia. Sexual maturity is reached between 7 and 10 years of age. Juveniles feed on aquatic invertebrates and plankton, but adults switch entirely to plant-based food, primarily aquatic vegetation, making the species a typical herbivore. Due to this feeding habit, grass carp has

frequently been introduced into standing waters for biomanipulation purposes, namely to reduce the amount of aquatic vegetation.

Impact on Native Fauna

The introduction of grass carp into natural habitats causes significant changes in aquatic vegetation, phytoplankton, and invertebrate communities. Consumption of aquatic plants directly affects the reproduction of phytophilous fish species and reduces shelter availability for juvenile fish. Introduced for biological control of aquatic vegetation, grass carp has in some areas completely eliminated vegetation, disrupting food webs in affected habitats. By disturbing sediment during feeding and removing vegetation, nutrient concentrations in the water column increase, resulting in eutrophication, reduced dissolved oxygen levels, and algal blooms.

Recommended Fishing Method

Grass carp usually inhabits calmer sections of water bodies and nearshore zones rich in vegetation. Common baits include plant-based products such as maize, wheat grains, peas, or boilies with plant flavours. Fishing is typically carried out using bottom-fishing techniques, often with feeders and groundbait used to attract fish to the fishing location. Grass carp often occurs in smaller groups, and several individuals may be caught at well-baited sites. The species is most active during warmer months, especially from spring to autumn. Within project areas covered by this project, only artificial lures are permitted.

TENCH – *Tinca tinca* (Linnaeus, 1758)

Distribution

Tench is distributed throughout Europe and has also been introduced into North America and Australia. In Croatia, it is a native species in rivers and standing waters of the Danube basin. In the Adriatic basin it is considered an alien species and occurs in the Lika, Gacka, Krka, Čikola estuary, Neretva, Mirna, and Pazinčica rivers, as well as Lake Vrana on Cres Island, and numerous ponds and wells throughout the Dalmatian hinterland. In the Krka River, tench has been recorded in Carigradska Draga, Visovačko Lake, and near Roški Slap.

Appearance

The body of the tench is robust, stocky, and laterally compressed, with a short and broad caudal peduncle. The head is triangular with small eyes. Both lips are thickened, and each corner of the mouth bears a short barbel. In males, the pelvic fins are significantly larger and longer than in females and, when folded, cover the anal opening. The fins are dark green, brown, or black, while the body is generally black or dark green on the back, golden-yellow or olive-green on the flanks, and yellowish on the belly. The body is covered with small elongated scales embedded deeply in the skin and coated with a thick protective mucus layer.

Lifestyle

The natural habitat of tench includes lakes and slow-flowing lowland rivers, as well as side channels and oxbow lakes with weak current and abundant aquatic vegetation. It tolerates low oxygen concentrations well and can inhabit waters unsuitable for many other fish species. Tench is an omnivorous species feeding on aquatic invertebrates, detritus, and aquatic plants. Reproduction begins when water temperatures exceed 19 °C. Spawning takes place in shallow areas with dense aquatic vegetation and little or no current. After hatching, larvae and juveniles remain among dense aquatic vegetation.

Impact on Native Fauna

Through competition for food, tench may negatively affect native fish species by reducing the abundance of invertebrates and other prey resources available to native fish.

Recommended Fishing Method

Tench is most commonly found in nearshore areas with calm water, aquatic vegetation, and muddy bottoms. Common baits include maize, dough, boilies with plant flavours, or natural baits such as earthworms. Fishing is usually carried out using bottom-fishing techniques, often with feeders or standard bottom rigs, while groundbait is used to attract fish to the fishing location. Tench often occurs in small groups, allowing multiple catches at properly baited sites. It is most active during the warmer part of the year, especially from spring to autumn. Fishing is usually more successful during stable weather conditions and light winds, while sudden weather changes can reduce activity. Within project areas covered by this project, only artificial lures are permitted.

TOPMOUTH GUDGEON– *Pseudorasbora parva* (Temminck & Schlegel, 1846)

Distribution

Topmouth gudgeon is naturally distributed in East Asia, from the Amur River basin to the Zhujiang River. It was first introduced into Europe around 1960 in Romania, and subsequently spread to Russia and Ukraine together with grass carp (*Ctenopharyngodon idella*). Since then, it has rapidly expanded throughout Europe. In Croatia, it is very common in the Danube basin, occurring in nearly all watercourses, and is also present in the Adriatic basin. In the Krka River, topmouth gudgeon is a common species and has been recorded near Roški Slap, in Lake Brljan, and at Carigradska Draga.

Appearance

Topmouth gudgeon is a small fish, usually 5–8 cm in length. Its body is slightly laterally compressed, and the head is relatively small compared to the rest of the body. The body colour is silvery with somewhat darker dorsal surfaces. During the spawning season, a dark stripe may appear along the middle of the flanks.

Lifestyle

Topmouth gudgeon is an extremely resilient fish inhabiting all types of freshwater habitats and some brackish waters. It prefers slow-flowing waters, canals, lakes, and springs. Its diet consists mainly of small aquatic invertebrates such as crustaceans and aquatic insects. It is a short-lived species that rarely survives longer than three years. Sexual maturity is reached during

the first year of life. Spawning occurs multiple times within a single season, from March to June. After fertilisation, males guard the eggs until the larvae hatch.

Impact on Native Fauna

In suitable habitats, topmouth gudgeon can establish extremely abundant populations that compete with native species for food and habitat, especially with larvae and smaller fish. It also feeds on the eggs and larvae of native species, thereby reducing their populations.

Recommended Fishing Method

The species is best caught using small nets. Catching it with hook-and-line gear is difficult.

GIBEL CARP – *Carassius gibelio* (Bloch, 1782)

Distribution

GibeL carp is an invasive alien species in Europe. Its native range is China, particularly the Amur River basin. In Croatia, it is distributed throughout almost all rivers and standing waters of both the Danube and Adriatic basins. In the Krka River, the species appears sporadically and has so far been recorded at Carigradska Draga.

Appearance

GibeL carp has a relatively high and laterally compressed body. The head lacks scales and barbels around the mouth. The body colour is generally silver-brown or dark grey. The dorsal fin is long, and the last unbranched dorsal-fin ray is strongly serrated. During spawning, males develop breeding tubercles on the head, flanks, and pectoral fins.

Lifestyle

GibeL carp is a limnophilic species inhabiting nearly all freshwater habitats, including ponds, marshes, lakes, reservoirs, fish ponds, and the middle and lower reaches of lowland rivers rich in aquatic vegetation. It is also common in floodplains of large lowland rivers. The species tolerates environmental fluctuations extremely well, especially low oxygen concentrations, changes in water levels, and pollution. Sexual maturity is reached at three or four years of age (or one to two years in southern Europe). Spawning occurs in shallow and warm waters with bottoms covered by aquatic vegetation or roots and usually begins in spring when water temperatures exceed 14 °C. Females lay adhesive eggs on aquatic vegetation or other submerged plant material. The strong invasive potential of GibeL carp lies in its ability to reproduce asexually through gynogenesis. In this process, sperm from other related cyprinid species (such as common carp, nase, or chub) can trigger egg development. In nature, Prussian carp may live up to ten years.

Impact on Native Fauna

Through its feeding behaviour, which involves frequent disturbance of bottom sediments, GibeL carp alters habitat structure and increases water turbidity, contributing to declines in native fish populations. Predation also negatively affects native species.

Recommended Fishing Method

GibeL carp can be successfully caught using various fishing techniques, usually in calmer waters and nearshore zones. Common baits include earthworms, maggots, and sweetcorn. Fishing can be carried out using float fishing or bottom-fishing techniques with feeders containing groundbait to attract fish. Since GibeL carp often forms groups, large catches may be achieved at properly baited locations. The species is most active during warmer parts of the year, especially in spring and summer. Within project areas covered by this project, only artificial lures are permitted.

COMMON CARP – *Cyprinus carpio* Linnaeus, 1758

Distribution

Common carp inhabits much of Asia and was probably introduced into Europe during Roman times and the Middle Ages. In Croatia, common carp is native to most rivers and standing waters of the Danube basin. In the Adriatic basin, it is considered an alien species and has been recorded in the Mirna, Lika, Krka, Cetina, Vrljika, and Neretva river basins, as well as in Vrana Lake near Biograd and Prološko Lake. In the Krka River, it occurs sporadically in Lake Brljan and has also been recorded in the Šarena Lakes near Knin. The species can also be found in numerous ponds and wells throughout the Dalmatian hinterland. It has been recorded in Gabelino Lake near Umljanovići, which may connect with the Čikola River during periods of high water, allowing further spread. Additional records exist from Miloševo and Stipančevo lakes.

Appearance

Several morphotypes of common carp exist, differing in body depth, degree of lateral compression, and scale coverage. Individuals inhabiting flowing waters are usually elongated and fully scaled, whereas cultivated forms commonly found in ponds and lakes have deeper bodies with few or no scales. The mouth is adapted for bottom feeding, and the upper lip bears two short barbels. The dorsal fin is long, while the first ray of both the dorsal and anal fins is hardened and serrated. Body colour varies depending on habitat, ranging from grey to brown on the back, yellowish-brown on the flanks, and pale yellow or white on the belly.

Lifestyle

Common carp inhabits lakes and slow-flowing lowland rivers, preferring habitats with abundant aquatic vegetation and soft substrates. It tolerates pollution and low oxygen concentrations relatively well. While searching for food, carp disturbs muddy or sandy bottoms, damaging aquatic plant root systems and increasing water turbidity. It is an omnivorous species feeding mainly on invertebrates (crustaceans, molluscs, larvae, etc.) and plant material. Males reach sexual maturity between 3 and 5 years of age, females between 4 and 6 years. Spawning occurs from May to June when water temperatures exceed 18 °C. Females deposit adhesive eggs on aquatic vegetation in shallow lake zones or floodplain areas of rivers, after which males fertilise them. Natural floodplain areas are especially important as nursery habitats for juveniles.

Impact on Native Fauna

Through its feeding behaviour involving sediment disturbance, common carp alters habitat structure and increases water turbidity, contributing to declines in native fish species. In addition to impacts on fauna, carp also negatively affects certain aquatic plant and algal communities.

Recommended Fishing Method

Common carp can be successfully caught using various techniques, most commonly in calm and deeper waters as well as nearshore zones with gently sloping bottoms. Common baits

include sweetcorn, dough, boilies, and natural baits such as earthworms. Fishing is generally carried out using bottom-fishing techniques, often with feeders or standard carp rigs, while groundbait is used to attract fish to the fishing site. Carp frequently gathers at feeding areas, and regular moderate baiting may improve fishing success. The species is most active during the warmer part of the year, especially from late spring to autumn. Within project areas covered by this project, only artificial lures are permitted.

BLACK BULLHEAD – *Ameiurus melas* (Rafinesque, 1820)

Distribution

Black bullhead originates from North America and was introduced into Europe during the nineteenth century. In Croatia, it occurs in numerous rivers, canals, ponds, and reservoirs in both the Danube and Adriatic basins. In the Krka River basin, black bullhead is considered one of the most problematic invasive alien fish species and is particularly abundant in lentic and slow-flowing habitats.

Appearance

Black bullhead has a stocky body with smooth skin lacking scales. Adults usually measure between 20 and 35 cm in length, although larger individuals may occur. The head is broad and flattened, with a large mouth surrounded by four pairs of barbels used for orientation and food detection. The body colour is generally dark brown to black on the back and lighter on the belly. The dorsal and pectoral fins contain strong serrated spines capable of inflicting painful injuries.

Lifestyle

Black bullhead is an extremely tolerant species capable of surviving in waters with low oxygen concentrations, elevated temperatures, and high levels of pollution. It inhabits lakes, ponds, canals, reservoirs, and slow-flowing rivers with muddy bottoms. The species is omnivorous and opportunistic, feeding on aquatic invertebrates, fish eggs, small fish, detritus, and plant

material. Spawning usually takes place in late spring and early summer. Both parents guard eggs and juveniles.

Impact on Native Fauna

Black bullhead negatively affects native fish communities through predation on eggs and juvenile fish, competition for food and habitat, and disturbance of bottom sediments during feeding. High population densities may significantly alter aquatic ecosystem structure and reduce native biodiversity.

Recommended Fishing Method

Black bullhead is commonly caught using bottom-fishing techniques with natural baits such as earthworms, fish pieces, or dough-based baits. The species is particularly active during warmer months and at dusk or during nighttime hours. It inhabits muddy bottoms and deeper slow-flowing sections where multiple individuals may often be caught at the same location.

PUMPKINSEED – *Lepomis gibbosus* (Linnaeus, 1758)

Distribution

Pumpkinseed is native to North America, where it naturally inhabits the eastern parts of the United States and southern Canada. It was introduced into Europe in the late nineteenth century and has since spread rapidly across numerous freshwater ecosystems. In Croatia, it is widely distributed in both the Danube and Adriatic basins. In the Krka River basin, pumpkinseed is among the most abundant invasive alien fish species and is particularly common in slower-flowing sections, lakes, canals, and areas with abundant aquatic vegetation.

Appearance

Pumpkinseed is a small but highly recognizable fish with a laterally compressed and relatively tall body. Adults usually range between 10 and 20 cm in length. The body colour is highly variable and often very vivid, with greenish, yellow, orange, and bluish patterns. The species is characterised by dark opercular flaps edged with red or orange coloration. During the breeding season, males become especially brightly coloured.

Lifestyle

Pumpkinseed inhabits warm, slow-flowing or stagnant waters rich in aquatic vegetation. It is highly adaptable and tolerates a broad range of environmental conditions. The species feeds on aquatic invertebrates, insect larvae, molluscs, crustaceans, fish eggs, and occasionally small fish. Sexual maturity is usually reached during the second year of life. Spawning takes place from late spring to summer when males construct circular nests in shallow water. Males guard both eggs and larvae aggressively until juveniles become independent.

Impact on Native Fauna

Pumpkinseed has multiple negative impacts on native fish and aquatic communities. Through predation on eggs, larvae, and juvenile fish, it reduces reproductive success of native species. It also competes intensely for food and habitat with smaller native fish species and amphibians. In habitats where pumpkinseed populations become abundant, substantial alterations in aquatic invertebrate communities may occur.

Recommended Fishing Method

Pumpkinseed can be caught relatively easily using small hooks and lightweight tackle. Small artificial lures, soft plastics, or natural baits are effective. The species is commonly found near vegetation, submerged structures, and shallow warm areas. Due to its aggressive feeding behaviour, catches are often frequent and numerous.

EASTERN MOSQUITOFISH - *Gambusia holbrooki* Girard, 1859

Distribution

The eastern mosquitofish is an invasive alien species in Europe. It originates from North America and was introduced to Europe at the beginning of the 20th century. It was introduced from Italy to Istria in 1924 with the aim of controlling malaria-carrying mosquitoes. Today, it is widespread throughout the Adriatic river basin and is also present in Lake Savica in Zagreb (Danube basin).

Appearance

The eastern mosquitofish is a small fish. Males are about 3 cm long, while females reach about 5 cm. Their bodies are greyish in colour and may display yellow-green-blue iridescence. The fins are almost transparent, while the dorsal and caudal fins have several rows of black spots. The abdomen is rounded. The head is pointed, with a small upward-facing mouth. Females have a black spot on their body.

Lifestyle

Eastern mosquitofish can be found in standing and slow-flowing waters. They prefer areas with dense aquatic vegetation. They inhabit the upper layers of the water, where they feed on insects and aquatic invertebrates. They reach sexual maturity after only 4–6 weeks, and because the spawning season is very long — from April to October — three generations can be produced within a single year. They do not lay eggs; instead, females give birth to live young, producing 40 to 60 offspring per brood. The gestation period lasts 3–4 weeks. The number of offspring is affected by temperature, with higher temperatures reducing fecundity, and it is also influenced

by the age of the female. Males are often sexually aggressive during the spawning period, so females form shoals to protect themselves.

Impact on native fauna

In areas where eastern mosquitofish are abundant, competition for food and habitat with native species occurs, primarily because of their highly aggressive feeding behaviour. They cause a decline in native invertebrate populations. They also attack and bite the fins of other fish, exposing them to disease. Due to their negative impact on native species, mosquitofish are considered among the 100 most dangerous invasive alien species in the world.

Recommended Fishing Method

This species can be caught using aquarium nets and other small-mesh nets.

WHAT DATA NEEDS TO BE COLLECTED?

Systematic collection of data on the removal of alien and invasive alien freshwater fish species is essential for assessing the effectiveness of selective removal carried out by recreational anglers. The collected data will provide insight into the abundance and population structure of alien species, as well as an assessment of the impact of removal efforts on reducing their populations.

For every caught alien or invasive alien fish species described in this manual, it is necessary to record basic information related to the catch and the fishing conditions. For each species, the following should be recorded:

- length in centimetres,
- weight in grams,
- date and time of capture,
- exact or approximate fishing location,
- total number of individuals caught,
- fishing gear used,
- any additional notes (e.g. condition of the fish, etc.).

All of the above data should be entered into the designated table provided in the appendix of this manual. It is recommended that anglers collect completed forms throughout the week and submit them at the end of each week to the responsible nature ranger or ranger service. Regular and accurate record-keeping represents an important contribution to the effective monitoring of alien fish populations.

HOW SHOULD CAUGHT FISH BE HANDLED?

Caught alien and invasive alien fish species must be handled responsibly and in accordance with applicable legal regulations. Captured individuals must not be returned to the water or transferred to other water bodies, as this further promotes their spread and increases pressure on native species.

It is recommended that fish be humanely euthanised immediately after capture and disposed of in the prescribed manner. In cases where permitted, the catch may be used for personal consumption, while fish remains must not be discarded into nature or watercourses.

In the event of a large catch, the fish may be left with the responsible nature ranger, who will arrange for its disposal and delivery to zoo staff, where the fish will be used as animal feed.

KOME SE OBRATITI ZA DODATNE SAVJETE U NEDOUMICI OKO STRANIH VRSTA U PROJEKTNIM PODRUČJIMA?

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ADDITIONAL INFORMATION ON ALIEN AND INVASIVE ALIEN SPECIES

More information about what invasive alien species are, an overview of the legal framework, recommendations for responsible behaviour, and prevention of the introduction of alien species into nature can be found in numerous printed publications and online sources.

Additional information on invasive alien species in Croatia can be found on the website "Invasive Species", available at Invazivne vrste (HAOP)

There are also printed manuals and brochures in the Croatian language (which are also available in PDF format):

- Mihinjač, T., Boršić, I., Kutleša, P., Ješovnik, A., Cigrovski Mustafić, M., Slivar, S. (2020). *Invazivne strane vrste*. Ministarstvo zaštite okoliša i energetike. Zagreb, 24 str.
- Mihinjač, T., Sučić, I., Špelić, I., Vucić, M., Ješovnik, A. (2019). *Strane vrste slatkovodnih riba u Hrvatskoj*. Ministarstvo okoliša i energetike Republike Hrvatske; Udruga Hyla, Zagreb. 105 str.

In addition to the above-mentioned sources, more information can also be found in documents such as the Code of Good Practice, the Manual for Identification and Handling of Invasive Alien Species, Monitoring Programmes for Topmouth Gudgeon and Pumpkinseed Sunfish, and Action Plans on the unintentional introduction of invasive alien species. All of the listed manuals are available in PDF format at Educational materials (Invazivne vrste portal).

In addition, a mobile application called Invazivne vrste u Hrvatskoj has been developed. It is intended for the general public and allows citizens to report sightings of alien and invasive alien species they encounter in nature.

The app is free of charge and available for both iOS and Android devices.

GLOSSARY

Native (autochthonous) species = a species that naturally occurs in a particular area.

Alien (allochthonous) species = a species introduced outside its natural range through direct or indirect human activity.

Invasive alien species = an alien species that successfully spreads in a new environment and has a negative impact on biodiversity, ecosystems, human health, or the economy.

Translocated species = a species naturally distributed within the Republic of Croatia, but moved by human activity into water bodies where it would not naturally occur.

Stocking (fish release) = the deliberate introduction of fish into water bodies, usually for sport fishing or commercial purposes, which must be carried out in accordance with legal regulations.

Unintentional introduction = the accidental introduction of a species, usually due to improper handling of fish or equipment, or illegal transfer between water bodies.

Translocation = the movement of fish from one water body to another, which can lead to the spread of alien or translocated species.

Biodiversity = the variety of living organisms in a given area, including species diversity, genetic diversity, and ecosystem diversity.

Removal (culling) = the extraction of fish from the natural environment through fishing or other permitted methods, often as a management measure for alien and invasive alien species.

Prevention of introduction = measures aimed at preventing the introduction of new alien or invasive alien species.

REFERENCES

- Regulation (EU) No 1143/2014 of the European Parliament and of the Council on the prevention and management of the introduction and spread of invasive alien species.
- Act on the Prevention and Management of the Introduction and Spread of Alien and Invasive Alien Species (Official Gazette 15/18, 14/19).
- Freshwater Fisheries Act (Official Gazette 63/19).
- Nature Protection Strategy and Action Plan of the Republic of Croatia for the period 2017–2025.
- Convention on Biological Diversity.
- Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention).
- Scientific and professional literature related to freshwater fish fauna and invasive alien species in Croatia.

APPENDIX 1 – Example form for recording catches of alien and invasive alien fish species intended for recreational anglers

Obrazac za evidenciju ulova stranih i invazivnih vrsta riba	Ime i prezime rekreativnog ribolovca:	

VRSTA	DUŽINA RIBE	MASA RIBE	DATUM	VRIJEME	LOKACIJA	BROJ ULOVLJENOG	KORIŠTEN RIBOLOVNI ALAT	KOMENTARI

APPENDIX 2 – Example of a completed form for recording catches of alien and invasive alien fish species intended for recreational anglers

Obrazac za evidenciju ulova stranih i invazivnih vrsta riba

Ime i prezime rekreativnog ribolovca: ANTE ANTIĆ

VRSTA	DUŽINA RIBE	MASA RIBE	DATUM	VRIJEME	LOKACIJA	BROJ ULOVLJENOG	KORIŠTEN RIBOLOVNI ALAT	KOMENTARI
ŠTUKA	66	1,5	19.5.2026	8:15	VISOVAČKO JEZERO	1	VARALICA	
GRGEČ	40	0,8	19.5.2026.	10:05	VISOVAČKO JEZERO	1	VARALICA	
GRGEČ	42	0,8	19.5.2026.	10:15	VISOVAČKO JEZERO	1	VARALICA	
LINJAK	14	0,3	19.5.2026.	14:45	VISOVAČKO JEZERO	1	VARALICA	
GRGEČ	31	0,6	19.5.2026.	16:00	VISOVAČKO JEZERO	1	VARALICA	