A catch-22 scenario in the Swedish food system

– A scientific examination of cyprinid fishing and its management possibilities in Sweden

Ett moment-22 scenario i Sveriges livsmedelssystem – en vetenskaplig undersökning av karpfiskeriet och dess förvaltningsmöjligheter i Sverige

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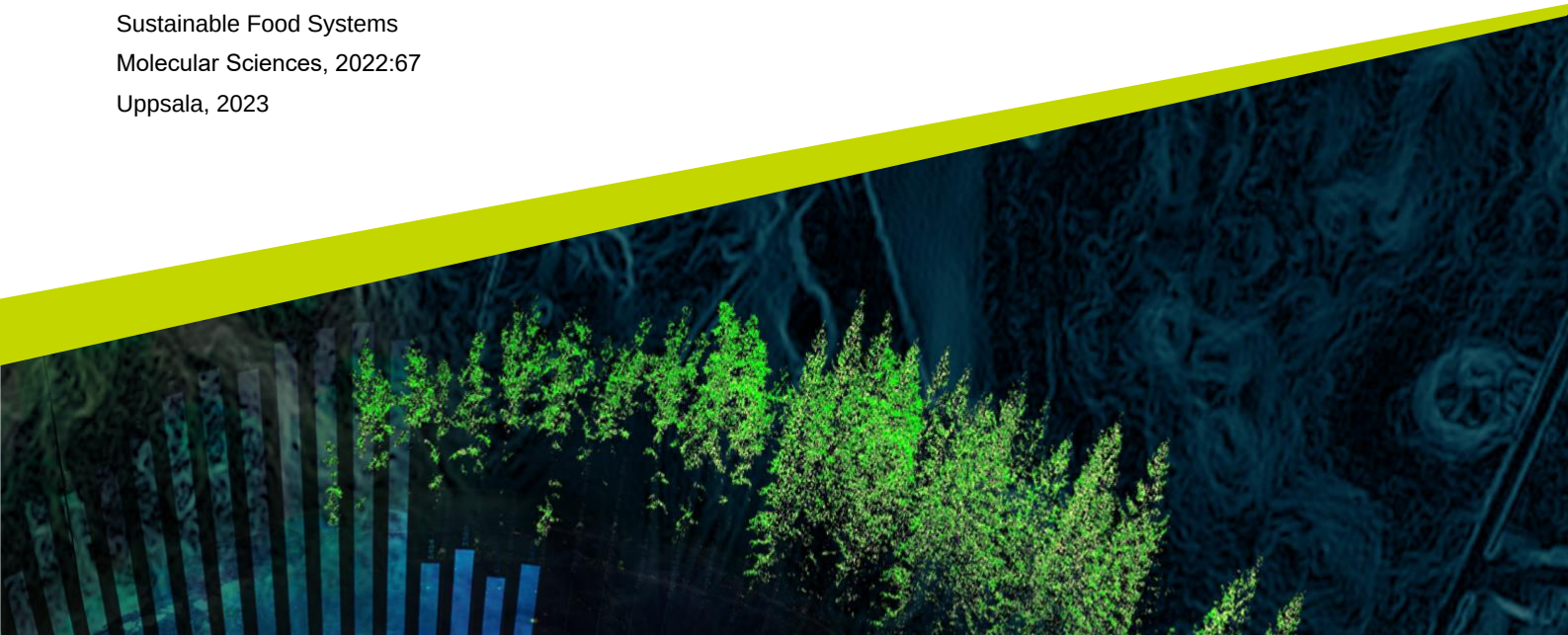

– a scientific examination of cyprinid fishing and its management possibilities in Sweden

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Abstract

Cyprinid fish like roach, bream and ide are natural resources in Sweden that were common and consumed in households up to the late 19th century. Due to societal changes during the industrialization cyprinids lost their domestic importance. Today we see an increasing demand for sustainable food sources. Cyprinid fishing has low carbon emissions and may possibly improve water quality in eutrophic waters and could be an interesting additional resource to the Swedish food supply chain. Cyprinid fish need to be managed in a sustainable way that will ensure long-term sustainability for the cyprinid stocks and complies with environmental goals and the Swedish Food Strategy goals of increasing domestic food production. In this thesis I have used catch reports and environmental data to estimate how much bream can be fished in the Swedish part of the Baltic Sea. I have participated in meetings with stakeholders in an ongoing project to increase cyprinid fishing in the Baltic Sea, conducted interviews with fishers active in the Bothnian bay and created self-completion questionnaire for employees at authorities working with cyprinid management. Through Thematic Analysis, Stakeholder Identification and with the use of the literature available I made a SWOT-analysis of the cyprinid fisheries in Sweden and discussed possible management scenarios for cyprinid fishing in Sweden. The results indicate that bream fishing in the Baltic Sea can increase to between 1894 - 13 637 tons. A possible way to manage cyprinid fisheries is to allow fishers to self-regulate or have fish-producing companies involved in management by having contracts with fishers. I also argue that viewing cyprinid fishing as a Complex Adaptive System (CAS) would allow better understanding of how to manage the resource. This paper implies that cyprinid fishing can increase in the Baltic Sea and that viewing cyprinid fishing as a Complex Adaptive System would supply managers with more tools and possibly make management more effective.

Keywords: Cyprinids, Swedish food supply chain, Sustainable fisheries management, Complex Adaptive System (CAS)

Sammanfattning

Karpfiskar som mört, braxen och id är naturresurser i Sverige som var vanliga och konsumerades i hushållen fram till slutet av 1800-talet. På grund av samhällsförändringar under industrialiseringen förlorade karpfiskarna sin inhemska betydelse. Idag ser vi en ökad efterfrågan på hållbara livsmedelskällor. Fiske av karpfiskar har låga koldioxidutsläpp och kan möjligen förbättra vattenkvaliteten i eutrofa vatten och skulle kunna vara en intressant ytterligare resurs i den svenska livsmedelskedjan. Karpfisket behöver förvaltas på ett hållbart sätt som säkerställer långsiktig hållbarhet för bestånden och som överensstämmer med miljömålen och den svenska livsmedelsstrategins mål att öka den inhemska livsmedelsproduktionen. I detta examensarbete har jag använt fångstrapporter och miljödata för att uppskatta hur mycket braxen som kan fiskas i den svenska delen av Östersjön. Jag har deltagit i möten med intressenter i ett pågående projekt för att öka karpfisket i Östersjön, genomfört intervjuer med fiskare som är verksamma i Bottenviken och skapat enkäter för anställda på myndigheter som arbetar med förvaltning av karpfisket. Genom tematisk analys, identifiering av intressenter och med hjälp av tillgänglig litteratur gjorde jag en SWOT-analys av karpfisket i Sverige och diskuterade möjliga förvaltningsscenarier för karpfisket i Sverige. Resultaten visar att fisket av braxen i Östersjön kan öka till mellan 1894 - 13 637 ton. Ett möjligt sätt att förvalta fisket av karpfiskar är att låta fiskarna självreglera eller att låta fiskproducerande företag delta i förvaltningen genom att ha kontrakt med fiskarna. Jag hävdar också att om man betraktar karpfisket som ett komplext adaptivt system kan man få en bättre förståelse för hur resursen ska förvaltas. Resultaten från undersökning innebär att fisket av braxen kan öka i Östersjön och att om man betraktar fisket av karpfiskar som ett komplext adaptivt system skulle förvaltarna få fler verktyg och eventuellt göra förvaltningen mer effektiv.

Nyckelord: Karpfiskar, Sveriges livsmedelssystem, hållbar fiskeriförvaltning, Komplexa Adaptiva System (CAS).

Table of contents

List of tables

List of figures

1. Introduction

With an increasing global population there is a need to increase food resources to feed the world's inhabitants. These food resources need to be produced sustainably so they can feed the current generations without compromising the food production for future generations. In Sweden develop and promoting domestic food sources is part of the National Food Strategy (Swedish Government 2016). A food source that has been utilized previously in Sweden and is consumed to a large extent in other parts of Europe is various species of cyprinid fishes (Fam. *Cyprinidae*)(Bninska 1991), like bream (*Abramis brama*), roach (*Rutilus rutilus*) and ide (*Leuciscus idus*). However, cyprinid fishes lost their domestic importance after the post-war period due to many factors, among them the invention of cooling systems, increased availability of marine fish species, and industrial reforms (Bonow and Svanberg 2013). Cyprinids have now become a less reputable fish, described as boney and having a muddy taste (Bonow and Svanberg 2013). Now consumers prefer marine species, which many are threatened because of overfishing and climate change while eutrophication and pollution make some marine fishes inedible (Walday et al 2008).

Cyprinids likely benefit from the current conditions of high nutrient levels and temperatures, and their populations have been left mostly undisturbed from fishing (Dahlin et al 2021). Cyprinids from the stocks in the Baltic Sea and the larger Swedish freshwater lakes are also safe for human consumption (Waldetoft and Karlsson 2020; Dahlin et al 2021). Reducing cyprinid populations through fishing could, besides being a food source, also improve water quality. Fishing cyprinids removes nutrients and reduces nutrient resuspension into the water column, thereby reducing eutrophication effects (Bernes et al. 2015). Cyprinid fishing could also contribute to improve income security for small-scale coastal fisheries (Länsstyrelsen Stockholm 2022). An awareness of the benefits of cyprinid fishing has prompted a comeback for these fish as human food. Two projects within Sweden have worked with increasing production and awareness of the benefits of cyprinid fishing, while another project has worked with developing recipes to make the fishes more desirable (Baltic Fish n.d. b; Länsstyrelsen Stockholm 2022; Högskolan Kristianstad 2022).

1.1. Purpose

In this study I will examine how Sweden has tried to integrate cyprinid fishing into the food supply system. This has entailed looking at projects that have aimed to use cyprinids and turn it into a desirable food commodity. It has also entailed locating and communicating with stakeholders who are affected or can affect cyprinid fishing, including: fishers, fish producers, authorities, and NGOs. I identified three questions that I will address to complement previous literature:

1) How much cyprinids can potentially be harvested in the Swedish Baltic Sea?

2) What are the incentives and limitations of cyprinid fishing for fishers and authorities? Is there incentive or motivation for fishers to increase cyprinid production?

3) How should cyprinid stocks be managed for a sustainable food production?

The first aim is to give a quantitative estimation of how much cyprinids can realistically be caught in the Swedish Baltic Sea. The second is to understand fishers' incentives and perception of cyprinid fishing as well as the authority's perspective. The third aim is to find what management model that could be suitable for cyprinid fisheries. Whether it be local, national, centrally regulated, or self-regulated to make suggestions of what an appropriate management approach might be. This report also aims to illustrate the strengths, weaknesses, threats, and opportunities for cyprinid fishing in the Swedish food supply chain.

2. Background

2.1. History of cyprinid fishes as food in Sweden

Historically cyprinids have been an important food source in Sweden, however, today the cyprinid fishes are almost non-existent in the Swedish food system (Bonow and Svanberg 2013). The consumption of fish in Sweden today is constituted primarily of marine and farmed fish, while the consumption of cyprinids such as bream (*Abramis brama)*, carp (*Cyprinus carpio)* and tench (*Tinca tinca*) are too low to make the official statistics of what Swedish citizens eat (Lind 2019). This differs from a 150 years ago, when cyprinid fishes were a more common household fish for the rural population (Bonow and Svanberg 2013).

During the pre-industrial period cyprinids were commonly consumed in Sweden due to its availability and that there was a general view that most fishes were edible (Bonow and Svanberg 2013. The consumed cyprinids included species such as asp (*Aspius aspius)*, bream, ide (*Leusiscus idus)*, and roach (*Rutilus rutilus*) (Bonow and Svanberg, 2013). A requisite for being allowed to fish cyprinid fish in freshwater bodies in pre-industrial Sweden was owning land, as fishing rights came with landownership. Therefore, it was common for landowning farmers to fish as a subsidiary income and for food (Bonow and Svanberg, 2013). It was mainly peasants that ate cyprinids, and the cyprinids were consumed fresh, but the fish were also conserved through drying, salting, or fermenting (Bonow and Svanberg, 2013). However, not only lower estates consumed cyprinids, prevalence of cyprinid fishes in cookbooks from the 18th and 19th century indicate that higher estates also consumed these fishes (Bonow and Svanberg, 2013). Cyprinids were also cultivated in ponds. In the 17th and 18th century it was not uncommon that country seats and clergy residences practiced aquaculture. In these aquaculture ponds primarily crucian carp (*Carassius carassius*) was cultivated because it managed winters well. The aquaculture was praised by both the state and scholars but decreased during the latter part of the 18th and beginning of 19th century. This was done because agriculture was given

precedence and ponds were drained and the land used was used for farming (Bonow and Svanberg, 2013).

Catches were typically high during spawning season which facilitated the relatively high consumption of cyprinids, during which large amounts could be caught (Bonow and Svanberg, 2013). Svärdson (1965) writes about the "bream stand" which is a spot in a lake where the bream would gather during the cold months and if fished during the winter, high catches could be landed. Catches with seine nets could exceed 6000 kg (Svärdson 1965). Cyprinids were also sold at town markets (Bonow and Svanberg, 2013). To conclude, in pre-industrial Sweden cyprinid fish was a common food source.

Many factors contributed to the change in fish consumption patterns during the 20th century. During the 19th century the workload for farmers increased, leaving less time for subsidiary fishing including cyprinid fisheries. Simultaneously, the agricultural sector's efficiency increased which meant higher costs for investments within agriculture resulting to poorer landowners having to sell their land and losing their fishing rights (Bonow and Svanberg, 2013). Another contributing factor to the reduction of freshwater fishing was pollution from the growing industries which affected water quality and spawning areas (Bonow and Svanberg, 2013). This pollution reduced the stock sizes of cyprinids (Bonow and Svanberg, 2013). So, less time to fish, losing fishing rights and pollution were factors that contributed to changing patterns of cyprinid fishing.

During the second half of the 19th century the industrialization flamed these changes further. Cyprinid fishes still had some prevalence in the Swedish household's diet, especially in the northern part of the country (Bonow and Svanberg, 2013). However, it was demanded less and less, and cyprinid went from human food to animal fodder and started being used as poultry and pig fodder. Roach became commonly used as bait within the growing cray fisheries (Bonow and Svanberg, 2013). So, slowly the cyprinids were removed from the dinner table. Bream, crucian carp, Eurasian carp and tench diverge slightly and were desired food fish for longer than ide and roach. Svärdson (1965) writes about bream from Lake Ringsjön which was a coveted bream brand, that produced the best and biggest bream, fetching high prices until the 1960s. During the latter part of the 19th century to the middle of the 20th century cultivating cyprinids in ponds became more common too. The primary cultivated species were Eurasian carp (*Cyprinus carpio*), tench and crucian carp. At this time aquaculture was driven as enterprises and were facilitated with new developments that made transportation of live fishes possible (Bonow and Svanberg, 2013). The industrialization came with large social and cultural changes, leading to people leaving the countryside while new methods in the food processing system meant

that new types of products became available: such as diary, charcuteries, and canned products (Bonow and Svanberg, 2013). These changes brought by industrialization and logistics affected dietary preferences and cyprinids become less and less favorable.

Alongside the processes of industrialization and urbanization, a more specialized fishing fleet developed, which meant that less fish was caught from freshwater lakes in general, and that fewer cyprinid fish were caught (Bonow and Svanberg, 2013). New cooling techniques allowed icing of fish and, later refrigerators, meant that marine fish species could be transported longer. These marine species were in higher demand than cyprinid fishes and other freshwater species (Bonow and Svanberg, 2013). The marine species were more expensive for the consumer and brought a larger income to the fisheries than inland fishes. The changes of availability appear to have changed the perception of cyprinid fishes too. Bonow and Svanberg (2013) found numerous historical accounts from the 1920-1970s calling cyprinid fishes, especially bream, a "junkfish" and too boney to eat. So, in conclusion, the industrialization spurred social and cultural changes that lead to cyprinid fishes being consumed less in Sweden.

2.2. Cyprinids as an expanding food source

Despite its diminished use the cyprinid fishes could have an interesting role to play in the Swedish food system. In the National Swedish Food Strategy as formulated by the Swedish Government in 2016, one of the aims is to be more self-sustaining with food production and processing (Swedish Government 2016). However, today the majority of the seafood consumed is imported, in 2019 about 75 % of the seafood consumed was imported (Hornborg et al, 2021). Of the 100 most consumed seafood species in Sweden today, no common native cyprinid fish such as bream, ide, and roach are listed (Ziegler and Bergman 2017). To reach the goal of the Swedish Food Strategy exploring the potential for increasing consumption of cyprinid fishes is interesting as these resources could increase domestic food production.

Another goal in the Swedish Food Strategy is to make Swedish food production climate neutral. Hornborg and Främberg (2020) conducted a Life Cycle Assessment (LCA) on freshwater cyprinids in Sweden and found that for fish caught in pound nets, stationary fishing traps fixed to the lakebed, 1 kg of edible fish product had an average carbon footprint of 0.77 kg eCO_2. The carbon footprint for cyprinids, caught in pound nets, can be compared to 1 kg edible Swedish produced beef and 1 kg edible Norwegian salmon which have a carbon

footprint of 28 kg eCO_2 and 6.1 kg eCO_2, respectively (RISE Climate Database 2020).

A prerequisite for using cyprinid fishes as a food source is that they are safe for human consumption. Studies have examined the toxicants concentration of cyprinid fishes in the Baltic Sea and inland lakes. Dahlin et al. (2021) concluded that based on current regulations of the Swedish Food Agency (Livsmedelsverket) and EU, consuming cyprinid fishes once a week does not represent a health risk. However, it was concluded that each fishing site should be monitored and checked as contaminant levels varied between the sampling sites (Dahlin et al. 2021). Some sampling sites contained higher levels of Perflourinated alkylated substances (PFAS) and other contaminants, therefore cyprinid fishes should not be consumed more than once a week (Dahlin et al. 2021). Waldetoft and Karlsson (2020) examined bream in freshwater lakes Mälaren, Vänern and Södra Bergundasjön and concluded that bream from these lakes is suitable for human consumption. So, consuming cyprinids from the Baltic Sea and freshwater lakes does not entail a dangerous exposure to toxins.

2.3. Cyprinids in the Swedish food system today

In Sweden there are at least two recent projects aimed at processing food products of cyprinid fish. The "Baltic Fish" is a collaborative project between fishers, a fish-processing company, NGOs, Universities. Two Swedish authorities (the Swedish Agency of Marine and Water Management and Regional County boards) take part in the project as experts and observers (Baltic Fish n.d.). This project started 2019 and is still ongoing. The goal of Baltic Fish is to establish a sustainable fishery of bream and ide and in the process reduce eutrophication in the Baltic Sea. The fishing in this project occurs primarily in the Bothnian Bay, in the north of Sweden, but also on Gotland and at the coast of Västervik. For the fishers working in the Bothnian Bay there are regulations governing where fishing gears are allowed to be used to not interfere with the migration route of wild salmon (FIFS 2004:36). For the Baltic Fish Project exemptions from these restrictions were made, on the pretext that the fishing contributes to scientific research (FIFS 2004:36). The volume of cyprinids caught under this project has grown over the years, in 2019, when the project started, the catches of bream were 13 tons and in 2021 the bream catches had risen to 29 tons.

Another project; "Resursfisk" started in 2019 as a collaboration between fishers in the Lakes Mälaren and Vänern, Axfoundation, food processors, and the Stockholm County board. The aim of this project was to incorporate the cyprinid fishes, caught as by-catch from pikeperch fisheries, into the Swedish food system

(Länsstyrelsen Stockholm 2022). During the fishing of pikeperch in the lakes of Mälaren and Vänern the by-catches can be as large as 50 % of the total catch, whereof bream constitutes about 75 % (Länsstyrelsen Stockholm 2022). The two projects are collaborating, and information is shared between the stakeholders.

Besides these two projects there is, to my knowledge, no other structured effort to fish, process and sell cyprinids products at a larger scale in Sweden.

Both the Baltic Fish project and Resursfisk have been engaged in promoting edible cyprinids products. As outlined above cyprinids fish species are, today, not the most reputable fish in Sweden, and this affects consumers' willingness to buy cyprinid products (Bonow and Svanberg 2013). To change the perspective and promote the use of this resource, a gastronomic project was undertaken called "*Dags för brax*" or "*Time for Bream*" (Högskolan Kristianstad et al 2021). In this project an expert tasting panel were tasked with sampling and characterizing the flavors of steamed unseasoned bream and chefs were invited to create dishes with minced bream. The expert tasting panels verdict was that bream had a taste of mud and staleness (Högskolan Kristianstad 2021). Not discouraged by these characteristics the chefs produced recipes that were described as tasty. Within the Resursfisk project, tasting tests were also conducted of bream and in their study bream from freshwater lakes was described as having similar taste to perch, whereas Baltic Sea bream had overtones of mud (Länsstyrelsen Stockholm 2022). Resursfisk also tested a minced bream dish at a Swedish school where kids between the ages 6-16 tried the dish. The tests concluded that kids between 6-7 were positive toward the dish whereas kids between the age of 10-16 had other preset preferences (Länsstyrelsen Stockholm 2022). Therefore, it could perhaps be said that bream may not come as a culinary experience served by itself, but with the right knowledge it can be made into a dish that is more than edible.

Labels and Certifications are important as consumer guides and can help consumers make choices that reflect their ethic values when making decisions on what products to buy. Currently cyprinids fish products caught in Sweden have no consumer labels. However, one of the consumer guides for fish; the WWF *Fish guide*, (a guide that orients consumers to make sustainable food choices) have evaluated bream. The WWF *Fish guide* labels products from red, yellow to green. Red indicates that consumers should avoid the product, yellow that consumers should be careful with the product and be aware that they can have detrimental effect on the environment and green indicates that the product is safe from an environmental perspective (WWFa n.d.). The evaluation for wild caught fish is based on three criteria: 1) how the stocks are faring, 2) if the management and monitoring is effective and 3) how the fishing effects the ecosystem, including how the gear and bycatch affect the ecosystem (WWFa n.d.). Currently, the fish

guide gives bream products for the Baltic Coast a yellow label, while bream fished in the inland freshwater lakes is given a green label (WWFb n.d). One of the reasons for the Baltic Sea bream attaining the yellow label could be because of how the species is management and monitored. This is something that will be discussed in the following sections of this report.

2.4. Eutrophication

The Baltic Sea is currently eutrophic, mainly due to the influx of nutrients from agriculture, sewage, and industry. This results in an increase in algal bloom (Cyanobacteria), turbid waters, and oxygen deficient waters (Bernes et al. 2015; Dahlin et al. 2021; Smith 2003). The external influx of nutrients has been reduced in the Baltic Sea since the 1980s (HELCOM 2018). However, despite a reduction of nutrient input, the Baltic Sea is still regarded as being in a eutrophic state, because of the nutrients still in the water column and recirculation from bottom sediments (HELCOM 2018). There are signs of links between eutrophication and cyprinid abundance in the Baltic Sea, and abundance of cyprinids is generally higher in eutrophic area (Olin et al. 2002; Bergström et al. 2019). To what degree cyprinids contributes to eutrophic symptoms in the Baltic Sea is not known. In freshwater lakes there are examples of Cyprinids keep lakes in eutrophic state due to their resuspension of sedimented nutrients and their feeding on herbivores (mollusks and crustaceans) that result in exaggerated eutrophic symptoms (Bernes et al 2015).

To counteract the effects of the eutrophication, a strong reduction or even total exclusion of the cyprinid fish stock by fishing, so called fish-biomanipulation, can be and has been tried in some lakes. Biomanipulation works by removing planktivorous and benthivorous (bottom-dwelling vertebrates) fish species that cause suspension of sediment into the water column, thus providing nutrients to phytoplankton, which in turn, causes turbidity in the lakes. Turbidity is a disadvantage for macrophytes because it limits the light that reaches the bottom. The loss of macrophytes changes the dynamic of the ecosystem as certain species are dependent on the availability of macrophytes (Bernes et al. 2015). Cyprinid fishes also feed on zooplankton that in turn feed on phytoplankton. If there is an excess of cyprinid fishes, they can reduce the abundance of zooplankton that otherwise would mitigate the effects of turbidity caused by the increase of phytoplankton. Removing cyprinids also removes nutrients bound in their biomass, mitigating the effect of eutrophication (Bernes et al. 2015). To get the best effects of biomanipulation, as much planktivorous fish as possible should be removed (Bernes et al. 2015).

This is the theoretical idea of biomanipulation. In practice, there is evidence of biomanipulation being successful in some lakes. Bernes et al. (2015) reviewed studies of biomanipulation in freshwater inland lakes and found that biomanipulation can be effective in lakes regardless of its size. However, biomanipulation was more efficient in smaller lakes, partly attributed to the fact that it is easier to remove a larger proportion of benthivores and planktivorous fish in a smaller lake. The authors found that the effects of biomanipulation are not permanent, but generally effects of biomanipulation are discernable 3 years after an intervention (Bernes et al. 2015). So, for freshwater bodies, biomanipulation should be considered as at least a short-term method for mitigating an eutrophic state.

In the Baltic Sea and coastal areas in general, fewer studies have been made about the effects of biomanipulations of cyprinid fish and what the effect on eutrophication might be. However, fishing for cyprinids still directly removes nutrients from the system. Mäkinen (2008) calculated the amount of nutrients in wet weight cyprinids where the average factor for phosphorus (P) was 0.86 % and 1.73 % for nitrogen (N). This means that removing 100 kg cyprinids would amount to a removal of 0.86 kg P and 1.73 kg of N. Mäkinen (2008) estimated the biomass of cyprinids was typically 78 – 172 kg per hectare in the Archipelago Sea. In a pilot project, Sandström (2011) suggested that removing 20 kg P ha^{-1} $year^{-1}$ was reasonable from Östhammarsfjärden in Sweden by targeting cyprinids. The author also found that reducing cyprinids was a cost-efficient way to remove P compared to sewage treatment (Sandström 2011). Therefore, fishing cyprinids could be one way to mitigate eutrophication effects along the Swedish coast in the Baltic Sea.

2.5. Management and directives

The following section contains an overview of the intergovernmental (mainly EU) regulations, the national goals, policies, and rules presently applied in natural resource management in Sweden and how these are implemented in fishery management planning.

2.5.1. The Swedish Food Strategy

The Swedish Food Strategy (SFS) is a government strategy outlining the main goals and actions for making the food supply chains more competitive and to increase Swedish domestic food production (Swedish Government 2016). The Strategy and its action programs are governed by EU's overall goals EU 2020 (Jordbruksverket 2021). This implies that beside increasing production and value,

the SFS should emphasizes the importance of producing food without exerting an environmental toll through a more resource efficient production (Swedish Government 2016).

The Marine and Fisheries Program (MFP) is one of the strategic action tools of the SFS. This Program outlines the strategies for growth within the fishery sector, to increase the competitiveness of small- and medium-scale businesses, to protect the environment and sustainable use of resources, and to promote employment (Jordbruksverket 2021). According to the SFS the government sees an opportunity of increasing demand for domestic fish products, with marketing and product development, as consumers generally prefer preprocessed fish products (Swedish Government 2016).

At the national level, the SFS needs to take regard to environmental management goals for fishing, including sustainable use of specific stocks, natural ecosystem functioning, stability and resilience, and social and economic sustainability (Fiskeriverket 2010). Therefore, when management plans for fish species are created the main point is to ensure that environmental goals are reached and that detrimental environmental effects are avoided.

2.5.2. Fisheries management framework

In Swedish administration, the management of fisheries are guided by intergovernmental directives (EU), national laws and policies, and national environmental goals formulated based on the national environmental legislation. The intergovernmental directives include: the Habitats Directive, which is an EU-directive to ensures the conservation of threatened animals, plants, and habitats, usually not applicable for exploited fish species (Council Directive EU 1992). The Common Fisheries Policy (CFP), which is a set of rules to guide EU members in managing fisheries sustainably (European Commission 2015). The Marine Strategy Framework Directive (MSFD), which purpose is to achieve or maintain good environmental marine status in European oceans and coordinated in the Baltic Sea by the Baltic Sea Action plan (SFS 2010:1341; HELCOM 2018 b). The three Swedish environmental goals, as formulated based on the environmental code, that affect fisheries management are "*Balanced seas and a living archipelago and coast, living lakes and streams"*, and "*A rich plant and wildlife"* (Fiskeriverket 2010). These directives, policies, and goals guide authorities in managing fisheries and must be regarded when considering management for cyprinid fishing.

2.6. National cyprinid management plan

The management structure of cyprinids species differs from fish species that falls under international decided quotas, such as herring (*Clupea harengus*), sprat (*Sprattus sprattus*) or cod (*Gadus morhua*). The fishing of Cyprinid species is entirely managed by Swedish national authorities, whereas herring, sprat and cod are managed through transnational channels and agencies such as the International Council for Explorations of the Sea (ICES) (Sundblad et al. 2020). The reason for this is that the cyprinid species that occur in many smaller populations in inland lakes and coastal areas. Most cyprinid fish occur in Swedish waters and do not move to international or other countries' waters. Therefore, they are regulated at a national level by the Swedish Agency for Marine and Water management (SwAM) (Sundblad et al. 2020). Besides SwAM, county administrative boards assist in fisheries management (FIFS 2004:36).

The purpose of the national fisheries management goals in Sweden is to ensure long-term sustainable usage of fish and shellfish resources. To enable this, specific quantitative goals are established (Östman et al 2016). These quantitative goals can be divided into three categories:

i) Yield goals

ii) Abundance or biomass goals

iii) Size and age distribution goals

The yield goals define how much should be fished from each stock, while the abundance or biomass goals establish how much of the stock should remain after fishing. The size and age distribution goals are goals about how the demographic (age-size) structure of the stock or population should be (Östman et al 2016). Yield goals aims to optimize yield from fishing, either economic yield or catch yield, which include Maximum Sustainable Yield (MSY) and Maximum Economic Sustainable Yield (MSEY). MSY can be explained as the theoretical maximal annual catch that can be taken from a stock and still maintain the stock at a biomass and abundance level where production is highest (Jennings et al 2001). MSEY is like MSY but also accounts for the costs of fishing, with MSEY goals stocks can be kept at a higher level than MSY to make the catch per effort higher, making each effort more lucrative (Östman et al 2016). Yield goals requires data on the fishing mortality (*F*) and spawning stock biomass (*B*), which is not available to make quantitative yield goals for most stocks within the Swedish national fisheries management.

The abundance or biomass goals are similar to yield goals in that they aim to preserve stocks at a certain biomass or abundance interval. However, the method

varies, and abundance and biomass goals can be used for stocks that lack detailed data on fishing mortality or how spawning stock biomass affects reproduction (Östman et al 2016). Abundance or biomass goals uses abundance indexes over time and can set reference levels or minimum levels of catches. For example, if there is a time series of cyprinid catches the averaged catch from the last two years can be quoted against the average of the previous three years catches and give an indication if the biomass is increasing or decreasing (Sundblad et al 2020). This approach is useful for managing stocks where data to make MSY calculations is not available.

Size and age distribution can indicate how a stock is doing. Generally, if a stock is overfished older and larger individuals will be rare in the population and be composed of young, smaller individuals (Froese et al 2008). Therefore, size and age distribution goals aim to have all age and size classes within the population, which could indicate the demographic structure is natural. These types of goals require information on the life history traits of the studied species and population, because without knowledge on which age and size individuals reach, setting up goals will be difficult (Östman et al 2016).

Which goals and data that is available will also affect which type of regulation can be used in fisheries management. For stocks with large amounts of available data, it is possible to make quotas of total allowable catches and try to keep the biomass at a high level, which require a lot of data. For abundance or biomass goals, there might not be enough data to make quota estimates. This is typical for small national fisheries. Instead of quotas, regulations can be aimed at regulating fishing effort, for example, through having a limit on number of days fishers can fish, number of gears, or which gears are allowed to be used. To achieve size and distribution goals, regulation can have maximum or minimums lengths that is allowed to be fished, which can be achieved through increasing requirements on mesh sizes or selection panels. (Östman et al 2016)

Besides these goals Sweden has started to shift toward an ecosystem approach within natural resource management, with origins from the Convention on Biological Diversity (CBD) (Naturvårdsverket 2020). The ecosystem approach has to some extent affected fisheries management with directives to preserve natural population structures (Naturvårdsverket 2020). Therefore, quantitative goals including size and age distribution goals are compatible with an ecosystem approach.

At present there is no established management plan for cyprinid fish in Sweden. However, establishing a specific management plan for cyprinids could be a way of ensuring increased long-term sustainable usage (Östman et al 2016). A management plan should be guided by quantitative management targets and

indicators for assessments to ensure that these goals are reached. Hence, there is a need for establishment of quantitative management targets and indicators (Östman et al 2016).

Sundblad et al (2020) investigated which quantitative indicators and management targets may be appropriate for stock assessments of one cyprinid species: bream. The authors found that bream is a species with large regional variation in abundance and life-histories. To develop a set of general indicators, more data on length and age needs to be collected. Based on the available data the authors could exemplify several quantitative indicators suitable for cyprinid fisheries depending on available data. For example, biomass or abundance indicators, and size distribution indicators (Sundblad et al 2020). These indicators should be applied locally and adapted to available local data.

2.7. Complex Adaptive Systems

Managing cyprinid fishing could follow the conventional approach of top-down regulation, where a centralized authority uses available information to make models or assessments and regulate the fishery accordingly. According to Österblom et al (2011) this conventional approach has not been appropriate to reach the ecological, social, and economic management goals. They highlight the importance of stakeholder inclusion and promote a regionalization (decentralization) of the management (Österblom et al 2011). Mahon et al (2008) propose viewing fishery systems as Complex Adaptive System (CAS), which is described as a system with the ability to self-organize or adapt without external interference (Mahon et al 2008). With this approach managers should look at ways to enable stakeholders within the system to self-organize and adapt to new situations. Mahon et al (2008) think of this approach as balancing regulations with enabling inputs. Where regulations are laws, enforcements, and surveillance, and enabling inputs are building institutions that create transparency, inclusion, and empowerment of stakeholder (Mahon et al 2008). McCay et al (2014) studied a cooperatively managed fishery along the Pacific coast and concluded that because of strong enabling institutions such as transparent and democratic decision-making, knowledge sharing and internal and external vigilance this fishery was adaptive to environmental, social, and economic perturbations. Considering cyprinid fishery within a CAS would move fisheries management away from highly regulating fisheries and allow for a bottom-up management.

3. Methodology

To answer my research questions, I used a mix of quantitative and qualitative methods. I have referred to cyprinid fisheries as an entirety, but for my research, focus has been on bream. This is because bream is the most fished cyprinid is Sweden and most research has been dedicated to bream.

3.1. Estimates of bream landings in the Swedish Baltic Sea

To get a coarse but realistic idea of how much bream could be fished at the Swedish coast of the Baltic Sea I scaled up registered landings from different waterbodies with the area of respective environments. The estimates are based on relatively few areas with observed landings and should therefore be considered as rough estimates. The data gathered is based on fishery dependent data, this means that the data is collected by fisheries, and not through environmental monitoring, and based on the landings fishers reported by fishers (Sundblad et al. 2020). Here I use landings as a proxy of bream abundance as abundance estimates are lacking and landings provide a realistic estimate of how much breams that can be landed from an area during a year.

The estimations are based on catch and landing reports from fishers working along the Baltic Sea coast in the Bothnian bay, on the east coast of Gotland and one in Västervik. In total I had access to catch reports from ten water bodies. From the catch reports I compiled how much cyprinids (bream, ide, and roach) each fisher had caught during March-June in 2021. I choose to only include data from March-June because this is the time where most fishers are likely to conduct cyprinid fishing. I then compiled the available coordinates to find which waterbody the fishers had been fishing in.

Next, I downloaded modelled environmental data for each waterbody from the Swedish Meteorologic and Hydrological Institute (SMHI https://www.smhi.se/data/hydrologi/vattenwebb). This data included modelled information about each waterbody and included environmental variables: temperature, salinity, total nitrogen (N) and phosphorous (P) per m^3, chlorophyll A per m^3, water turnover days, oxygen saturation in O_2 /m^3, and Secchi depth. I

wanted to see if any of these factors showed any correlations with cyprinid landings. Environmental data for the bodies of water is only available up to 2019, so to get better representation over the values for each factor I averaged the values between 2017 to 2019. I could then test if there were any correlations between the environmental factors and cyprinid landings. To do this I used the correlation function in Excel. The correlations coefficient gave an indication of which environmental factors were most associated with cyprinid landings.

The next step was to apply this information of how landings relate to environmental conditions to scale up the results to all waterbodies along the coast of the Swedish Baltic Sea. Indicating how much cyprinids could potentially be landed in each waterbody. By using the values acquired in the previous process to categorize each body of water as either having 'zero', 'low', 'medium', or 'high' landings depending on its environmental condition (Table 1). All areas of zero landing were assumed to provide 0 kg of cyprinids, low = 0.5 tons, medium = 2 tons, high = 5 tons of cyprinids every year. The environmental condition for each category is available in Table 1. Since cyprinid fishing is only conducted to depths down to 5 meters, data from all deeper areas was discarded. In the final step I estimated the total area of waterbodies along the Swedish coast for each of the four different categories from the SMHI modelled data. This gives the total area of water bodies of different categories, but no landing estimates. To convert area to landings I needed to know how many fishing gears can be placed per unit area without negatively affecting each other. Based on the actual position of fishing gears the shortest distance between two gears was 750 m which would correspond to 1.8 gears per km^2 ($1/0.75^2$), which is unrealistic high but could be seen as a maximum, whereas 2 kilometers between gears could be seen as more realistic corresponding to 0.25 gears per km^2 as a lower estimate.

3.2. Qualitative data on stakeholders' perception on cyprinid fisheries

I collected qualitative data from different sources using three different methods: Observation, semi-structured interviews, and a self-completion questionnaire.

3.2.1. Observation

During my research I attended an online meeting with stakeholders, as an observer, regarding the management of cyprinid fishing in the Baltic Sea along the Swedish coast. The stakeholders attending the meeting were a mix of actors and stakeholders: there were fishers, a business that fish and process fish into food

products, representatives from county administrative boards, representatives from the scientific community from Swedish Agricultural University (SLU), representatives from an NGO (Race for the Baltic) and representatives from the Swedish Agency of Marine and Water Management (SwAM). The observation was carried out with the intent to gain an idea of what stakeholders were involved in the Baltic Fish project and their different interests. The observation followed Bryman's (2012) description of a "minimally participating observer" as I tried to alter the meeting as little as possible with my presence. Practically this meant asking few questions and mostly listening and taking notes to not alter the dynamics between the stakeholders. At the start of the meeting, I was introduced to the participants and the reason why I was observing was explained. Ethically this was important because if I was not fully transparent about my work then participants could say things that they would later regret (Bryman 2012). So, I was participating as little as possible to not interfere with the meeting and I was fully transparent with my research intentions for ethical reasons.

During the meeting I took notes to remember as much as possible, I was not able to record the meeting and therefore I prioritized writing down my impressions from the meeting as soon as possible. I did this to reduce the risk of convoluting the information from the meeting with information gathered from other sources. Directly after the meeting I went through the meeting notes and summarized what had been said.

I was invited to the meeting by my supervisor who has been a part of the Baltic Fish project. Therefore, my supervisor was, during the meeting, categorized as a stakeholder (researcher) and treated as such during the meeting. To keep the data objective, or at least subjective from my experience, I tried to keep inputs from my supervisor regarding the meeting limited to grammatic and linguistic inputs to avoid altering my own perceptions with that of my supervisors'.

3.2.2. Semi-structured interviews

I used semi-structured interviews to get an understanding of fishers' drives for fishing cyprinids and how to increase production. Semi-structured interviews are a qualitative method that gives the interviewer freedom in the interview. The interviewer has pre-written questions in an *interview guide* that guides the interviewer in topics. However, unlike structured interviews the interviewer can depart from the questionnaire and ask unprepared questions (Bryman 2012). Semi-structured interviews allow the interviewee to reply in their own words, which can improve the understanding of the interviewee's references, experience of the situation or progress that is being asked about (Bryman 2012).

Selecting which individuals to interview and to be included in the sampling was a straightforward process. The fishers interviewed represent the total population of fishers involved in the "Baltic Fish" project operating along the coast of the county of Norrbotten that were not directly employed by Guldhaven Pelagiska AB, the company buying and processing bream. To capture other possible interview candidates, I tried creating a "Snowball sampling" as described by Bryman (2012), where at the end of each interview I asked the interviewees if there was someone else that could be relevant to interview for the subject. However, this approach was unsuccessful and no other interview candidates were found.

Four fishers were interviewed, and three out of four interviews were conducted face to face, at a location of the interviewees choosing, all interviews were recorded after getting permission from the interviewees. To make the fishers more comfortable and relaxed during the interview the fishers could choose location of interview. However, letting the interviewee choose the location meant that the location may have been less than ideal for an interview. For example, one interview was conducted in a café and background noise made it difficult to hear everything that was being said, both during the interview and the recording. Despite those difficulties, conducting the interview in a less than ideal setting was better than not having the interview at all. With the help of the recording and notes taken the interview still were possible to analyze. One interview was conducted over the telephone without visual, which meant that body language could not be interpreted. This was not necessarily negative. Bryman (2012) argues that conducting interviews over the telephone is better than conducting no interview at all. All interviews were transcribed and only what I deemed relevant for the thesis was included. For example, even though the fishers were specifically asked about cyprinid fishes, they sometimes left the topic over an enthusiasm about talking about other fishes.

3.2.3. Self-completion questionnaire

I created an online self-completion questionnaire and invited authorities to respond. I did this to get a qualitative response from authorities that work with management of bream. I decided to limit the questionnaire to four questions so that respondents would not think it too tiresome to reply to all of them (Bryman 2012). One reason I choose to have open questions instead of having closed questions was that the replies would be easier to compare to the results from the semi-structured interviews with the fishers. Another reason was to allow respondents to reply in their own words, which let them reply more creatively and possibly giving answers which I did not contemplate before. Open questions

allowed me as a researcher to explore areas which I had limited knowledge (Bryman 2012).

I invited six respondents at various authorities to reply to the questionnaire. The respondents I invited to reply were working at SwAM and the County administrative boards. I knew that these authorities had worked with bream fishing management, therefore the sampling was targeted (Bryman 2012). The invitation to reply to the questionnaire were sent through my supervisor so that the respondents working at Swedish authorities were not sent a link from an unknown party. Out of the six that were asked to reply to the self-completion questionnaire four replied.

3.3. Qualitative research analysis

I analyzed the information gathered through qualitative research using stakeholder interest identification and thematic analysis. I used stakeholder interest identification for the information gathered during the observation and conducted thematic analysis on the interview from the fishers and the self-completion questionnaire.

3.3.1. Stakeholder interest identification

I used the notes and information gathered from the observation to map out the stakeholders and their interests. I did this based on what information I gathered from the meeting, interviews, and survey resulting, not in a complete stakeholder analysis, but a shallow analysis of participants interests. The analysis followed a developmental stakeholder analysis, where I followed the pragmatic approach described by Lindenberg (1981, see Brugha & Varvazovszky 2000), which entails asking “Who wants what, When, and how?”. This is a straightforward way of discerning both participants and their interests.

3.3.2. Thematic Analysis of interview with fishers

To interpret the semi-structured interviews with the fishers I analyzed the responses and categorized the replies using Thematic Analysis. Thematic Analysis is a method for interpreting qualitative research data. The method entails reading the gathered material thoroughly and trying to see themes in interviewees replies (Bryman 2012). The themes chosen should help answer the research question, or hypothesis. So, when I was reading and rereading the transcribed interviews, I continuously thought about the replies in themes in relation to fishers’ incentives and if the volume of cyprinids that are fished could be doubled.

After I had read the interviews thoroughly, I decided that I should categorize the replies through the same themes from that I constructed the questionnaire. The themes in the questionnaire were: economy, market, environment, and management. “Economy” and “Market” may not seem to be very distinctive themes, so to clarify “Economy” concerns internal workings of the fishers’ companies, this includes investments, transport, volume fished, time spent on fishing and profit from fishing cyprinids was placed in the economy theme. Whereas the market theme relates to external workings such as demand for their products. The theme “Environment” regards the fisher’s perception of how cyprinid fishing has affected the marine environment, how the cyprinid fish stocks have changed over time, and how the environment may have changed the cyprinid stocks. Lastly, the theme “Management” relates to how fishers have perceived the management of cyprinid fishing.

To create an overview of the results from the thematic analysis I created a matrix. The point of the matrix was to identify positive and negative outlooks depending on the answer was positively or negatively indicative for an increase of cyprinid fishing from the fisher’s viewpoint. However, not every reply could be said to be directly positive or negative and some points were given a neutral value. Notably, each statement should not be regarded equal to other statements, but each statement should be evaluated independently. For example, a positively indicative statement such as “fishers have a short travel distance to fish for cyprinids and therefore fuel costs are low” is hard to equate with the negatively indicative statement “none of the fishers can sell any of the caught cyprinids”. So, the statements are gathered to be discussed rather than give a direct indication if the volume cyprinids fished can be increased or not.

3.3.3. Thematic analysis of self-completion questionnaire

To find and present the relevant data from the self-completion questionnaire I conducted a thematic analysis. The thematic analysis was like the thematic analysis on the interviews with the fishers, but for this thematic analysis I categorized the answers in different themes. I categorized the answers in four themes, which I named: Authorities roll, biological risks, beneficial environmental effects and regulating cyprinid fishing. The themes followed the topics of the questions in the self-completion questionnaire (Appendix 2). Within the theme “authorities roll” I placed answers which in some way answered what roll authorities played in the management and development in cyprinid fishing. In the theme “biological risks” I placed replies that shows which biological risks the respondents associate with cyprinid fishing. In the theme “beneficial environmental effects” I placed replies that gave an indication of how respondents view possible beneficial environmental effects of cyprinid fishing. Lastly, in the

theme “regulating cyprinid fishing” I placed respondents’ ideas of which measures could be used to regulate cyprinid fishing. Like the thematic analysis for the interview with the fishers, I created a matrix to categorize the replies and then summarized the answers in a table.

3.4. SWOT-analysis

Finally, I did a SWOT-analysis to evaluate cyprinids expansion into the food system. SWOT analysis, or Strength, Weakness, Opportunities and Threats - analyses is a tool used to develop strategic actions for a company or organization, based on the inner strengths and weaknesses of the unit and the opportunities and threats in the environment in which the company or organization operates (Coman and Ronen 2008). So, strengths and weaknesses are internal forces, and opportunities and threats are external forces. Internal forces are related to factors such as: people, products, skills, performance, reputation, infrastructure, etc. Internal forces are usually in the present (BusinessBalls 2022). External forces are dependent on factors such as: markets, audience, seasonality, competition, politics, trends, etc. External forces tend to be in the future (BusinessBalls 2022). One of strengths with the SWOT analysis method, and why this method was chosen in this paper, is because it is a flexible tool that is not limited to be used only in market scenarios and is adaptable to many scenarios (Coman and Ronen 2008).

I applied the classic methodology and created a 2x2 matrix grid with internal and external, and negative and positives as dimensions (BusinessBalls 2022). Within each grid I also had three themes, these themes were created to facilitate understanding what type of Strength, Weakness, Opportunity, or Threat I was referring to. The themes were 1) Environment, 2) Economy and Market, 3) Management. I choose these themes because they have been relevant for this study.

4. Results

4.1. Landings estimation

Bream stock estimations, landings, had the highest correlation coefficient (*r*) with total nitrogen, total amount of chlorophyll – α and turnover days (Figure 1-3). The *r*-coefficient was equal to 0.63, 0.79, and 0.90 respectively. Based on the relationship between landings and environmental classes different landing categories were created (Table 1). When extrapolated with the different environmental classes in the Baltic Sea the total estimated landings were somewhere between 1894 – 13 637 tons per year. The difference in landings depends partly on how close the gears are modelled to be to each other. The main bulk, 1 200-8 800 tons of the potential landings were from 'Medium' catch areas as they were most prevalent environmental class (Table 1). From 'High' landing areas, assumed to be most profitable, 394 – 2839 ton per year were estimated.

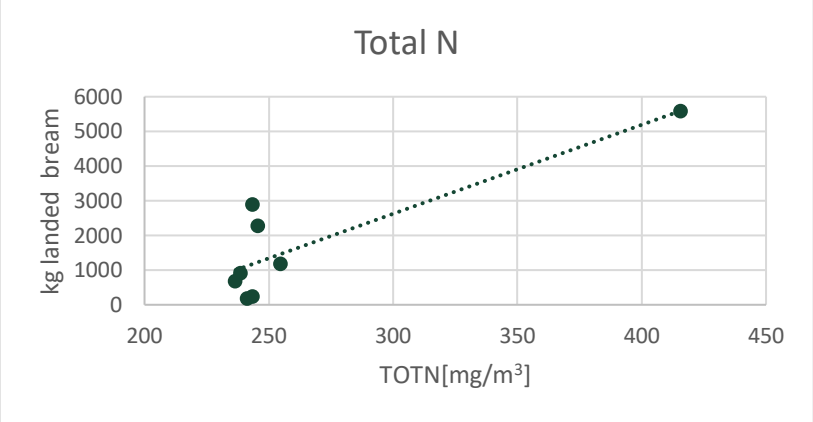

Figure 1. Each reported landed amount of bream shown to how much total nitrogen was in the waterbody in which the bream was caught.

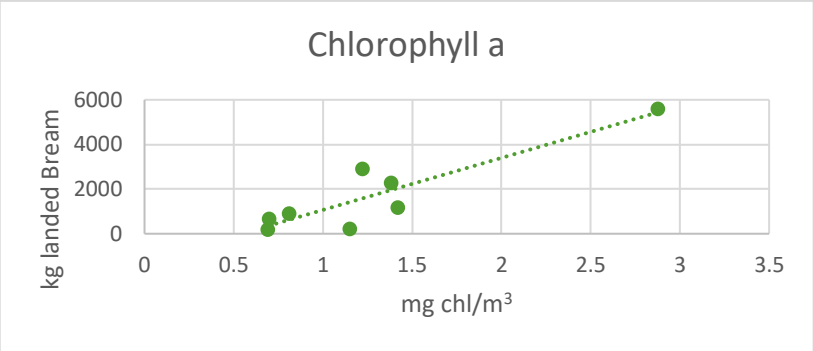

Figure 2. Each reported landed amount of bream shown to how much Chl-a was in the waterbody in which the bream was caught.

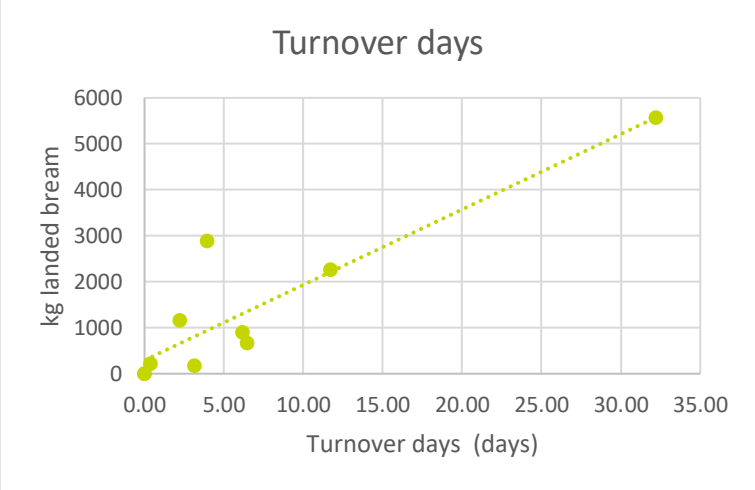

Figure 3. Each reported landed amount of bream shown to turnover days was in the waterbody in which the bream was caught. Turnover days is the number of days it takes for water to circulate in the waterbody.

Table 1. Environmental conditions for different categories of estimated landings of cyprinids. If estimated Turnover of water was < 2 days, water was considered as Zero landings, and if Tot N > 243, chl-A > 2 and Turnover > 14 days, water was considered as high landing area. For low and medium landing areas different combinations of environmental variables (i.e. case a., b. c.) could result in the same category. For example, if Turnover was 2-14 days it was considered as a low landing area if either Tot N < 243 mg/m3 (a.) or Chl-a < 1.2 mg/m3 (b.).

Categories	**Tot N [mg/m^3]**	**ChlA [mg chlA/m^3]**	**Turnover days**	**Landings of cyprinid ton/year**	**Total area (km2)**	**Cumulative landings 0,75 km between traps (ton/year)**	**Cumulative landings 2 km between traps (ton/year)**
Zero	-	-	<2	0	3558.23	0	0
Low				0.5			
a.	>243	<1.2	2-14		1850	1664	231
b.	<243	>1.2	2-14		346	312	43
Medium				2			
a.	>243	1.2-2	2-14		2111	7599	1055
b.	>243	<2	>14		326	1172	162
c.	<243	>2	>14		14	50	7
High	>243	>2	>14	5	315	2839	394
Total	-	-	-	-	1113	13 637	1894

4.2. Results from qualitative research

4.2.1. Stakeholder meeting

The aim of the meeting was to discuss a viable management strategy for primarily bream, but to some extent other cyprinids too. The motivation to construct a management strategy were multiple, but the primary objective was to ensure sustainable usage of a generally unfished species. The different stakeholders and their interests are summarized in Table 2.

Table 2. The different stakeholders who participated in a zoom meeting about the management of bream and their interest as I perceived them.

Stakeholder	**Interests**
Fishers	• No expressed interest
Guldhaven Pelagiska AB	• Management plan, to have the possibility of getting a better market value of bream products.
SwAM (Swedish Agency for Marine and Water Management)	• Sustainable fishing. • Management plan if bream becomes threatened.
Race for the Baltic (RFTB), a NGO	• Management plan to ensure sustainable fishing • Social sustainability
SLU (Scientific community)	• Finding indicators to be used for stock assessment. • Management plan with goals to preserve natural size distributions.
County administrative boards	• Sustainable fishing. • Does not want bream fishing to interfere or threaten other species, such as salmon or trout.

Fishers were mainly quiet during the meeting. Therefore, their interests will be presented later, with the results from the interviews.

Guldhaven Pelagiska AB saw benefits of having a management plan. The reason was that a management plan could be beneficial for creating surplus value for bream products. Guldhaven Pelagiska AB talked about the consumer guide for fish WWF *Fish guide.* They were worried that the consumer guide had given bream products from the Baltic Sea a yellow label instead of green. During the meeting it was said that one motivation for the yellow label was a lack of management plan for bream. Guldhaven Pelagiska AB said that it would therefore be good to have a management plan.

SwAM were an active participant during the meeting. Their objective as an authority is to ensure long-term sustainable usage of resources. They said that they are the authority that makes decisions and creates management plans if necessary. During the meeting they said that they are not likely to create a management plan for bream or other cyprinid fishing, because the available data indicate that there is no need for a management plan.

Race for the Baltic (RFTB) is the driver of the Baltic Fish project to promote more fishing of bream and cyprinids in the Baltic Sea. During the meeting RFTB expressed that they wanted to push this project forward and increase consumption of cyprinids partly with the help of a management plan. They explained that they saw cyprinid fishery as having beneficial effects for the environment and the small-scale fishing industry. It was further explained that the beneficial effects from cyprinid fishing were twofold: 1) the removal of nutrients with fishing, which could negate effects of eutrophication and 2) creating employment opportunities locally as well as giving fishers another source of income. Race for the Baltic was concerned with having a management plan that ensured both the advantageous consumer label and long-term sustainable production.

SLU were interested in evaluating stock status and finding indicators that can be used for a sustainable management plan. During the meeting they presented what was currently known about bream stocks using data from 2019-2021 in the Baltic Sea and from this data suggested 2 indicators: 1) size distribution and 2) catch per unit effort (CPUE). They were interested in having a management plan that regulated fishing so that natural size distributions would not change because of fishing pressure. SLU is also interested in research about environmental effects of bream and said, at a later occasion, that if studies show that it has beneficial environmental effects to remove large bream individuals then these should be allowed to be removed.

The County administrative board of Norrbotten expressed that they were concerned with bream fishing affecting other species in the area, such as salmon or trout. They said that they want sustainable fishing to occur and that reporting landings is important.

There seemed to be agreement between most stakeholders that they were dealing with a unique situation. The bream stocks did not currently need to be managed, because there were no indications of stocks being in risk of depletion or losing their natural populations structure due to fishing. A management plan could benefit small businesses as it could make cyprinid products easier to market if a management plan would change bream being labelled green instead of yellow on WWF *Fish guide*. Implementing a management plan could help to proactively ensure long-term sustainable usage of bream. During the meeting multiple stakeholders referred to the situation as a "catch-22" because of the paradoxicality of the situation: a management plan would be beneficial for many stakeholders and for the long-term sustainability of bream stocks, while the authorities with jurisdiction to create a management plan do not have the mandate to enforce a management plan without indication that the stocks are at risk.

4.2.2. Results from interviews with fishers

Identity of Fishers

The interviewed fishers are all based in Norrbotten and fish along the coast in the northern part of the Baltic Sea. From the interviews I gathered that the fishers all have worked with fishing, either as a hobby or as professionally, for at least 20 years and all of them identify as professional fishers. Despite all fishers working as professional fishers all of them have secondary or other occupations too. One of them mentions that as small-scale coastal fishers this is natural and their work changes with seasons. Regarding cyprinid fishing they have all fished cyprinids for 3 years and the fishing primarily occurs between May to middle of June. During this fishing period they use between 3-to-5m pound nets, and their average catch is around one ton of cyprinids per trap. After midsummer the fishers target other non-cyprinid species.

Economy

Within the Economy theme, most of the statements were positively indicative of an increase of cyprinid fishing (Table 3). Positive statements from the fishers included that, 1) For the volume fished today, no investment for gear was needed for any of the fishers. 2) The necessary distance that the fishers needed to travel is short, reducing the expenses of fuel. 3) The fishers were positive toward cyprinid

fishing because it provides them with an additional source of income. 4) Most fishers appeared to be prepared to invest to increase cyprinid fishing. Statements from the interviews that was indicative that cyprinid fishing would not increase included that the earnings from selling cyprinids are low, meaning that they would target other species when possible. One fisher also expressed that they would fish more cyprinids if the bycatch of perch could be landed.

Market

The Market theme contained the fewest statements (Table 3). The statements from the fishers that was positively indicative of an increase of cyprinid fishing were two things: 1) The project "Baltic Fish" has created a way for fishers to sell cyprinids for human consumption. 2) Besides selling cyprinids for human consumption two fishers said they sell cyprinids as cray fish bait too. Information gathered that was negatively indicative of an increasing cyprinid fishing were also two things: 1) One fisher has tried selling cyprinids directly to private costumers without success and another said that they have not tried because cyprinids are not popular among Swedish consumers. 2) Two fishers voiced their concerned that the market will disappear if the Baltic Fish project is stopped.

Environment

From environmental aspect the fishers' statements were mostly positively indicative of an increase of cyprinid fishers (Table 3). 1) Three fishers said there has been an increase in abundance and prevalence of cyprinid fish during their lifetime. 2) Three fishers say that the cyprinid stocks appear unaffected by the last three years of fishing. 3) Two fishers say that bycatch can easily be thrown back. 4) One fisher said that the selection grid is effective and lets small individuals escape. Negatively indicative data came from one fisher that said that marine environment is currently in bad health.

Management

Within the management theme the statements were rather neutral or descriptive than positively or negatively indicative (Table 3). Statements from the fishers included: 1) Two fishers said that having a management plan for cyprinid fishing is unnecessary because of the low amounts being fished and that they are understanding toward the Swedish Agency for Marine and Water management for not wanting to implement or create a management plan. 2) Two fishers are optimistic of self-regulation, and one fisher said that it works well in small-scale coastal fishing because overfishing would destroy their own livelihood. 3) One fisher said that informal structures are already in place that regulate fishing,

another fisher said that natural regulations limits fishing, such as ice during the winter or other resource pulses that are prevalent throughout the year. 4) All fishers said the bureaucratic work was difficult and obtaining exemptions was difficult and that county administrative board in Norrbotten prioritized sport fishing. 5) Two fishers said that they do not understand why they are not allowed to land the perch caught as bycatch in the cyprinid traps, when they are allowed to fish for perch in different traps close by. One negative statement was that one fisher said that there is a power imbalance between the actors of the Baltic Fish project. The fisher explained that a lot is expected from the fishers, and little is given in return.

4.2.3. Results from self-completion questionnaire

Authorities roll

The respondents had written what different authorities' roll were regarding cyprinid fishing (Table 4). Respondents said that SwAM had final say over regulations over fisheries and fishing, including when, how, and where fishing can be conducted. It was also written that SwAM have national responsibility to ensure sustainable usage of water and marine resources. Respondents replied that County administrative boards can support in development projects such as the Baltic Fish project, issue exemptions to allow fishing under certain conditions, such as allowing fishing with stationary gear for research purposes before the 17th of June. The county administrative board also evaluates and assesses fishers' applications for exemptions.

Biological risks

Respondents answered that they saw several biological risks associated with cyprinid fishing (Table 4). The respondents wrote that there was a risk of overfishing cyprinids, that there is a risk associated with not knowing enough about cyprinids movements patterns and which factors affect recruitment. Respondents also wrote that there is a risk of fishing a species where MSY is not known and a risk that fishing cyprinids at MSY might affect other species in the ecosystem. Respondents replied that there was a risk of harming other species as they could be caught as bycatch and that other species could be affected in unforeseen ways by cyprinid fishing.

Beneficial environmental effects

Within the theme beneficial environmental effects answers that showcased respondents view of how cyprinid fishing could have positive environmental

effects were place (Table 4). The responses varied. One respondent wrote that they were skeptical that cyprinid fishing had positive effects on eutrophication. One respondent wrote that if there were beneficial effects with cyprinid fishing then cyprinid fishing could at times be allowed to exceed MSY, but this should be assessed case-by-case by appropriate authorities. One respondent wrote that even if there are beneficial environmental effects of fishing cyprinids and these effects are amplified if the fishing occurs over MSY this could have negative effects for fishers' economy and might not be socially justified.

Regulating cyprinid fishing

Respondents were asked to suggest regulations that could be appropriate to apply to cyprinid fisheries in case regulations become necessary (i.e., if stock depletion becomes apparent). The respondents wrote that appropriate regulations could be to limit number of licenses, customize gear and have gear restrictions, for example limit cyprinid fishing to fyke nets and trap (Table 4). Suggested regulations also included regulations on where fishers are allowed to fish for cyprinids. There were also other suggestions that were not regulations, these suggestions were aimed at higher management goals and referenced current national goals. These suggestions included that fisheries management should always be ecosystem based and that cyprinid fishing should be reserved for small-scale fisheries.

4.3. SWOT-analysis

Table 3. summarizes my SWOT-analysis of cyprinids fishing integration in the Swedish food supply chain, based on my collected data from interviews, self-completion questionnaires and literature on the subject (Appendix 1, 2).

Table 3. SWOT – analysis of cyprinid fishing integration in the Swedish food supply chain

Strengths	**Weaknesses**
Environment Low bycatch Bycatch can be released Selection panels for targeting wanted individuals only Stocks currently non-threatened Product with low CO_2 eq emissions May reduce eutrophication effects in eutrophic freshwater lakes and potentially in eutrophic bays in the Baltic Sea. Economy & Market Logistics from fishing to processing and selling are already in place, no need for costly investments in infrastructure. Company structure that can manage landings and sell fish products exists Low investments in fishing gear to get started Extra source of income for small-scale fishers Relatively low costs to conduct cyprinid fishing Management Self-regulation possible among fishers in the Bothnian bay, which may inhibit overfishing. Low risk of overfishing cyprinids in freshwater lakes because of low prices for cyprinid catches Low risk of overfishing cyprinids in the Bothnian bay because of regulations aimed at protecting salmon and trout	Environment Uncertainty about beneficial environmental effects of cyprinid fishing in the Baltic Sea i.e., fishing does not reduce eutrophication Economy & Market Cyprinids not reputable among Swedish consumers Relatively expensive consumer product Project based fishing Relatively low income for fishers Management Regulation FIFS2004:36 requires cyprinid fishing is conducted with an exemption for research in the Bothnian bay No or little initiative for SwAM to create a management plan before stocks at risk Difficult to manage because bream stocks are local, making wider stock assessments costly and only locally relevant
Opportunities	**Threats**
Environment Reduce eutrophication Economy & Market Mixed fishing, so fishers can land caught perch, increasing profit from fishing Cyprinid fish products can be marketed as sustainable Management Learn how to create a management plan before stocks are at risk Including cyprinid fishes in the Swedish food supply chain contributes with another income for small-scale fishers and can be a resource for future generations.	Environment Cyprinids have a slow growth rate and are therefore vulnerable to overfishing Economy & Market Problems with getting cyprinids caught in the Baltic Sea with “ green light” labelling from WWF *Fish guide* Few places that sell cyprinid fish products High competition from other species. Management Regulations for fisheries inhibit fishing for cyprinids in certain areas Bream in the Baltic Sea does not have “ green light” from WWF *Fish guide*

5. Discussion

The results from the stock estimations indicate that cyprinid fishing, on a national scale from the Baltic Sea, can increase up to between 1894-13 637 tons depending on how gears are placed (Table 1), compared to 30 tons 2021. The result from the qualitative research shows that the Baltic Fish project has gathered a range of stakeholders who have converging views that increasing cyprinid fishing is good but diverge in their view of what management actions need to be taken (Table 3). The fishers in the Bothnian bay are mostly positive toward cyprinid fishing as this has provided them with a new source of income which has required few investments. However, they are less satisfied with the fisheries management and the power structure in the Baltic Fish project which could indicate that management should review how stakeholders are included (Österblom et al 201; Table 3). The self-completion questionnaire showed that authorities working with management of cyprinid fishing are concerned that cyprinid fishing could lead to overfishing, that the fishing could affect the ecosystem in unforeseen ways for example, fishing could affect cyprinid movement patterns. The authorities are somewhat skeptical that cyprinid fishing could have positive environmental effects in the Baltic Sea, such as mitigate eutrophication, however, they say that such effects should be considered case by case. They also have ideas of what regulations could be used if there is indication of overfishing of cyprinids, which correlates to the suggested regulations proposed by the scientific literature (Östman et al 2016).

5.1. Catch estimations and contributions to the Swedish food system

The catch estimates are interesting from the perspective of Swedish seafood consumption and the Swedish Food Strategy (SFS). Since most of the seafood consumed in Sweden is imported and the recommendation is to increase seafood consumption per capita, it is interesting to see how much bream could be landed from the Baltic Sea and contribute to the Swedish food system. The estimates indicated that landings from the Baltic Sea could be increased from 29 tons per year to at least around 2 000 tons per year. This is a huge increase, but

comparatively it is not surprising that catches can be increased. In Finland commercial annual bream catches have exceeded 100 tons since 2011 in the Archipelago Sea (Lappalainen et al 2019). Considering the goals of the SFS are to increase domestic production the Swedish government should continue to invest in bream fishing to become more self-sustaining and increase domestic production (Swedish Government 2016). Bream also had a relatively low carbon impact, (RISE Climate Database 2020; Hornborg Främberg 2020) therefore increasing bream production could be seen as adhering to SFS environmental goals.

The estimations could also be compared to other seafoods consumed in Sweden. Only between 40-45 % of wet weight bream can be used for human consumption (the rest is entrails and head) (Länsstyrelsen Stockholm 2022). This means that if fishing gears are placed as close as possible to each other (within 750 m), the edible product from the catch would amount to 5 728 tons per year. This is close to the amount of saithe (*Pollachius virens*) consumed in Sweden, at 5 565 tons per year (Zeigler and Bergman 2017). If cyprinid fishing increases, but only to the extent where gears are placed 2 km within one another, the processed minced bream from the Baltic Sea could provide 795 tons of edible product per year to the Swedish food system. This is close to the amount of char (*Salvenius* sp.) consumed in Sweden (Zeigler and Bergman 2017). If the Baltic Fish project and Resursfisk contribute to this increased production of domestic fish product, this would be considered a success from the SFS.

5.2. Fishers' incentives, authorities' view, and the market of cyprinids

If around 800 tons of edible bream can be produced for the Swedish supply chain annually and the SFS has goals to increase domestic production, why is Sweden not fishing more cyprinids? To understand this, it is important to understand the fishers' incentives, the authority's perspective of cyprinid fishing and the market for cyprinid products.

5.2.1. Fishers' incentives

The fishers had a few different incentives to fish for cyprinids. Firstly, all interviewed fishers expressed a strong will to fish. This incentive could be the strongest incentive for fishing to increase, or at least, continue. This is because cyprinid fishing enables the fishers to spend more time with their profession. Fishers' desire to fish could therefore be considered a social incentive to continue or increase cyprinid fishing.

Secondly, cyprinid fishing has so far required low investments in gear, however, if the volume is to be increased most fishers will need to invest in more gears. This could become costly depending on the requirements of the gear. For example, if only one type of gear is allowed to be used for cyprinid fishing and this gear is costly then this increases the threshold to invest. Furthermore, if the gear is only adequate to be used for cyprinid fishing and is not suitable for fishing other species, which is typical in the coastal small-scale enterprises in the Bothnian bay, this would further discourage fishers to invest in gears for cyprinid production. Östman et al (2016) write that regulating gear is a tool in fisheries management, especially if the quantitative indicators are based on abundance or biomass indices, or size or length distribution population structures. There are other regulations that could be enforced that are less costly for the fishers than limiting fishing to one gear. For example, selection panels or limiting fishing effort (Östman et al 2016). Therefore, if gear regulations are deemed necessary the regulations should consider fishers expenses, as certain gear regulation could discourage fishers from increasing cyprinid production. This is only relevant if the aim is to increase cyprinid production, which at times will not be relevant.

Thirdly, cyprinid fishing contributes to the fisher's income, but the income is dependent on the Baltic Fish retail revenues. One of the Marine Fisheries Program's (MFP) purposes is to promote local development and the Baltic Fish project could be seen as on the way to success in this regard, as it has developed the local fisheries in the Bothnian Bay and along the coast in the Baltic Sea (Jordbruksverket 2021). Despite the contemporary success, the development of cyprinid fishing faces future challenges. To continue with fishing a profit needs to be secured for the fishing to be sustainable long-term. From the fishers statements the outlook was somewhat positive for cyprinid fishing to increase, as cyprinid fishing provides an additional income. However, as stated by all fishers, without Baltic Fish there would be little income for cyprinids and at best cyprinid could be sold as baitfish (Table 3). Therefore, the income from cyprinid fishing is contingent on the Baltic Fish project continuation and success, as it is only through the channels and the help of Baltic Fish project that the fishers have a revenue for cyprinids. This may affect fishers' willingness to invest in cyprinid fishing as currently the long-term stability of the income from cyprinids is precarious. Therefore, to achieve the purpose of the MFP and continue development of local fisheries the Baltic Fish project should continue to the point where fishers profit from cyprinid fishing is more secure.

Lastly, fishers are incentivized through management. When interviewed, the fishers' mentioned difficulties with the current management. One difficulty fisher mentioned is that there are administrative difficulties when applying for permits, which is recognized within the MFP as a weakness (Jordbruksverket 2021).

Measures are being taken to reduce these weaknesses and could therefore be expected to be resolved. Another difficulty mentioned by the fishers is the regulation on bycatch, which currently says that landing bycatch is prohibited in Norrbotten (FIFS 2004:36). Resolving this issue might be more difficult. Since the MFP and the SFS want to promote domestic production, it could be of interest to change this regulation (Jordbruksverket 2021; Swedish Government 2016). However, this would require more knowledge on how the landing of bycatch affects the ecosystem since Sweden has taken to applying an ecosystem approach to fisheries management (Naturvårdsverket 2020). Hence, the issue of bycatch should be studied more before regulation can be changed. During the interviews one fisher also mentioned there is a difference in power in the Baltic Fish project and that they perceived that their interests as fishers were not entirely considered (Table 3). This is important to highlight as studies have shown the importance of including all stakeholders in fisheries management decisions (Österblom et al 2011). Therefore, going forward in the Baltic Fish project reviewing the institutions and ensuring inclusion will be of importance for the project's success. So, management difficulties recognized by the fishers are to a large extent issue that fisheries management is aware of, and is partly dealing with, while other issues need more research and internal reviewing.

From the interview with fishers, it appears as though their incentives to fish cyprinids have to do with self-identity, gear regulation, the income provided by fishing cyprinids and the fisheries management. With the incentives mostly pointing towards an increase in production.

5.2.2. Authorities perspective of cyprinid fishing

The authorities I have been in contact with during my research have been County administrative boards and Swedish Agency for Marine and Water Management (SwAM). These authorities are tasked with resource management. From the observation and self-completion questionnaire their main interest is to increase the production of cyprinids while ensuring the ecosystem is not damaged and resources are not overused. Unsurprisingly, this coincides with their mandate (Sundblad et al 2020).

During the observation SwAM was the only stakeholder that considered a national management plan unnecessary for bream or other cyprinids (during the interviews with fishers they agreed with SwAM that there is no need for a management plan). This was also recognized as a weakness in the SWOT-analysis. The reason for this was that they saw no need for a management plan for bream because the current data does not show it to be in risk of being overused (Table 2; SLU Artdatabanken 2020). The lack of a management plan may impede bream from

obtaining a green label from WWF *Fish guide*, which has as a condition of having effective management and monitoring to obtain a green light (WWFa n.d.). This in turn might have made the selling of cyprinid products more difficult, especially if they want to market cyprinids as sustainable.

From the self-completion questionnaire, I gathered that the authorities were concerned about biological risks of cyprinid fishing, including how it could potentially affect the entire ecosystem (Table 4). Their view was that more data needed to be gathered to ensure long-term sustainable use, which coincides with values of the Convention on Biological Diversity (CBD) Naturvårdverket 2020). The county administrative board had strict conditions for issuing exemptions for gear placement to fishers, this could be explained through their adherence to the CBD and their fear of overfishing occurring and other species being harmed in the fishing (Table 4). This could be seen as a limitation on production, but also as a measure to carefully manage cyprinid fish and the ecosystem.

In the self-completion questionnaire, the authorities were asked to suggest regulatory measures in case cyprinid stocks become overexploited (Table 4). The suggestions correlate with Östmans' et al (2016) suggestions for regulating fisheries at the national scale. The suggested measures mentioned by the authorities were limiting number of licenses and customizing gear. These are measures that limit fishing effort and maintain size and age structure, respectively, and are appropriate based on the available data (Östman et al 2016; Sundblad et al 2020). This indicates that the authorities can be trusted to enforce appropriate regulations if stock assessments indicate that either overfishing is occurring, or fishing is affecting size and age distribution within stocks.

From the authority's perspective it appears as though cyprinid fishing is managed appropriately given the available data and various goals and directive. Because the authorities are acting according to the CBD and are careful with giving exemptions the stocks could be said to be managed carefully. Simultaneously, this could appear to be impeding the sales of cyprinids by not creating a management plan, which is identified as a threat in the SWOT-analysis.

5.2.3. Market

The market and demand for cyprinids is important to consider when trying to understand why more cyprinid products are not being produced. A weakness identified in the SWOT-analysis was the reputation of cyprinid fish. The historical context of cyprinid consumption can explain this reputation. The cyprinid fishes gradually disappeared from the dinner tables in Sweden during the industrial revolution and made its exit as an undesirable food fish (Bonow and Svanberg

2013). Regaining a reputation as a desirable food fish does not come easily, especially with today's market supply with a wide variety of fish. During the interviews with the fishers, they said that their direct consumers were unwilling to buy fresh cyprinids because of its reputation. Bonow and Svanberg (2013) suggest that cyprinid fish could be popularized for human consumption through sport fishers and influences of other cultures. If cyprinids can be popularized through sport fishers' associations should therefore be investigated further. Projects such as "*time for bream"* are a great way to start creating recognition for cyprinids as an edible product, and this type of initiative could be extended to become yearly competitions or brought to festivals to create a familiarity to cyprinids (Högskolan Kristianstad et al 2021). So, promoting the taste of cyprinid products should be intertwined when marketing cyprinids.

The SWOT-analysis identified two other explanatory factors that affect consumers' willingness to buy cyprinid products: 1) price, and 2) sustainability. The first, price, has not been investigated thoroughly in this paper, but interviews have indicated that it is a relatively expensive product. This supports Länsstyrelsen Stockholm (2022) findings, they investigated how the price of bream products could affect which market segment were more likely to buy bream products. Their conclusion was that bream products are relatively expensive compared to other similar fish products, but that the bream products were desirable for restaurateurs because the production was local, and from sustainably fished stocks (Länsstyrelsen Stockholm 2022). Their study was on bream products from the big freshwater lakes Mälaren and Hjälmaren. For bream products from the Baltic Sea the price is somewhat cheaper because the producers buy cyprinids for less[1]. However, the processed product is still relatively expensive compared to similar products made of cod and salmon. The bream products are marketed as sustainable but do not have the same labels as bream and cyprinid products from the freshwater lakes.

Secondly, cyprinid fishing is arguably sustainable, it results in low carbon emissions (RISE Climate Database 2020), fishing cyprinids potentially contribute to reduce eutrophication (Bernes et al 2015), and they are not currently fished in a way that risks stock collapse (this should be investigated). However, for this to be of relevance it needs to be communicated to the consumer. For cyprinids from the freshwater lakes the fishers and fish mongers can rely on the WWF *fish* guide, since the fish guide has given them a green light. Cyprinid fish products from the Baltic Sea have not been given a green label by the WWF *Fish guide*, but a

[1] Emma Gabrielsson, Head of sustainability, Guldhaven Pelagiska AB, email 2022-05-10.

yellow light, which encourages consumer to be careful with this product (WWF n.d. b). Therefore, it may lose some of its consumer appeal. It appeared to be of relevance because the labelling was a major discussion point during the bream meeting. Both RFTB and Guldhaven wanted to ensure this labelling. So, being sustainable and being marketed as sustainable are two different things and have different value, without being able to show ensure consumers of sustainability, the product loses some of its appeal.

So, the historical context that cyprinids have a bad reputation, are relatively expensive and fishers and retailers have not found a good way to show consumers that the product is sustainable, contributes to the understanding of why more cyprinids are not being produced for the Swedish food system.

5.3. Management plan suggestion

Here I will discuss how a management plan for cyprinid fishing could look, based on the research in this paper. Writing a complete management plan is out of scope for this study, so this discussion will be limited to quantitative management goals and which stakeholder can be responsible for data collection, monitoring and implementing regulations. The suggestions for the management plan will be based on the goals of having sustainable fishery and increasing food production.

To begin with quantitative management goals, the data availability will limit which goals are possible to set. For the Baltic Fish project and local fishing in the Baltic Sea reasonable quantitative management goals would be targets based on abundance indices and size distribution as these can be made from catch reports and measuring catches (Sundblad et al 2020). These quantitative goals have the benefit of being relatively easily applicable for local populations and having both abundance and size goals would mean that stock status will be monitored as well as stock health.

Data collection is necessary to follow quantitative targets and without data collection following set goals is impossible. In the Baltic Fish project data collection already occurs through the fishers catch reports and has been successful so far. Österblom et al (2011) suggest fishers' participation in research funding, though the authors suggest funding research instead of directly participating. This could be a goal for management, that the revenue from the fishing could finance data collection. Given the current circumstances this could be hard to implement as some fishers already do not feel fully compensated for having to spend extra time on administrative tasks (Table 3.) So, going forward data collection should remain as is until another constellation is possible to finance.

Monitoring could be handled as in the Baltic Fish project, where the fish producers or receiver (Guldhaven AB in the Baltic Fish case) with the assistance of county administrative boards. The fish producer could handle monitoring through only accepting catches under certain circumstance, i.e., bycatch must be discarded, or nets must have escape hatches. The county administrative board's role would be to control landings, so the fishers adhere to catch limitations. Ideally this would lead to a positive interaction between fishers and authorities with trust and respect increasing overtime.

Implementing regulation could be handled by SwAM with the help of county administrative boards. A benefit of having a centralized authority manage regulation is that they have the resources to make researched decisions based on available data and can account for all national and intergovernmental goals.

Another possible way to handle monitoring and deciding upon who implements regulations is to have the fishers manage this themselves. Inspired by McCay et al (2014) reviewed case where fishers monitored each other and ensured overfishing did not occur through implementing regulation. Fishers have an incentive to discourage overfishing when there is close to private access of a stock, as likely for bream, as they are beneficiaries of healthy stocks as the stocks provide them with a future income. McCay et al (2014) emphasized education on the benefits of healthy stocks for members as understanding why compliance to fishing limitations increased the will to adhere to fishing limitations. Practically, incentivizing self-monitoring and regulation could be achieved through having a strong professional fishers' organization which interacts regularly with each other and authorities. Since informal institutions may already be occurring (Table 3), making them formal might not require much work and should be researched.

5.4. Complex Adaptive system perspective

Here I will argue that treating the cyprinid fishing in the Baltic Sea as a Complex Adaptive System (CAS) would be better for the sustainable management of cyprinid fisheries. A benefit of viewing the fisheries as a CAS is that instead of applying regulation to fisheries as the key management action, management also entails enabling self-organization among stakeholders (Mahon et al 2008). In the Baltic Fish project enabling can to some extent be seen, fishing was facilitated by the county administrative board which gave exemptions to the fishers. Another form of enabling seen in the project is the involvement the scientific community through SLU, which have examined stock status and contributed to the allowance of exemptions (FIFS 2004:36). These enabling actions can then be evaluated and depending on their success, more enabling actions could follow. Another benefit

of viewing cyprinid fishing as a CAS system is that regulations are not seen as a hindrance but depending on the situation are necessary (Mahon et al 2008). For the Baltic Fish project this means the regulations suggested by authorities can be evaluated in similar ways as the enabling actions. The flexibility in the CAS approach is what makes it better for management.

The opposite of viewing cyprinid fishing as a CAS system is to view cyprinid fishing as predictable and controllable given enough data (Mahon et al 2008). This is the conventional view of fisheries management and has resulted in complex data driven models that have been useful in managing fisheries (Jennings et al 2001). Mahon et al (2008) writes that the opposite view focuses on regulations to manage fisheries to increase predictability and therefore fails to consider that complex social structure also affects fisheries. In the self-completion questionnaire authorities suggest regulating actions such as regulating gear type, number of limitations and regulating which positions are allowed to be fished upon (Table 4). The authorities also suggest enabling actions, such having an eco-system perspective and maintaining the fisheries to small-scale fisheries. Therefore, it has more explanatory value to view cyprinid fishing as a CAS as the authorities are acting as they have that view already.

Viewing cyprinid fishing as a CAS can also guide management, as there are frameworks based on examples to guide managers. I would interject that more important than zealously following lessons from past evaluations is to constantly evaluate what works to sustainably manage the cyprinid fisheries. For example, McCay et al (2014) write that transparency in a democratic decision-making process and vigilance among stakeholders is important for a decentralized management to function. In the Baltic Fish project, RFTB and Guldhaven AB have themselves set conditions on the fishers, which the fishers must follow to be allowed to sell their cyprinids. Currently this function has been beneficial for RFTB, Guldhaven AB and the fishers as cyprinid landings and sales has increased. So, rather than trying to alter the cyprinid fishing system to fit CAS frameworks, the systems functions should be evaluated before they are changed.

5.5. Study limitations

Within this research there have been limitations both within the quantitative and the qualitative research. Within the quantitative research the generalizability of the results is limited by a small sample size, only eleven catch reports and information from ten waterbodies were used to give an indication of how many cyprinids could be landed from the Baltic Sea. Furthermore, the data is fisheries dependent, which could create an uncertainty in stock assessment as the entire

population is not targeted. Therefore, future research should include data from more waterbodies and use data that is fisheries independent. There are also other ways of making stock estimations of unmonitored fish, that are more costly, but perhaps more accurate. For example, Setälä et al (2012) made cyprinid biomass estimations using echo sonar and sampled from shoals they found with the echo sonar. Using this method, the authors could get a high resolution of how much and which fish moved in the water (Setälä et al 2012). Having the extensive resources to conduct cyprinid biomass estimations with echo sonar and net sampling would of course have given a better idea of how much cyprinids could be fished along the Swedish Baltic Sea coast but would be very costly. The extrapolation method of actual catches used in this study has given an indication of how much bream can be fished and can be a springboard for further research. For example, the estimations are only extended to breams, with current data it is possible to make similar estimations for both roach and ide.

Within the qualitative research there are some constraints. The methodology for analyzing the interviews and self-completion questionnaire were based on subjective interpretation. This could mean the results are hard to replicate with the given data. However, how the data was interpreted is clearly explained and could therefore be used as guide for anyone trying to replicate the conclusions drawn from the qualitative data gathered from the interviews and self-completion questionnaire. Future research should establish fishers' perspective through quantifiable self-completion questionnaire to try and establish how included fishers' feel within fisheries management, both within cyprinid fishing and fisheries management in general.

6. Conclusion

This study has shown that cyprinid fishing can increase to between 795 and 5 728 tons of edible bream product per year that could be added to the Swedish food system from the Baltic Sea. It has also shown that fishers are incentivized to increase cyprinid fishing because it provides them with an additional income and need few new investments. However, the income is small in relation to other endeavors and there is a precariousness of cyprinid fishing because in the Bothnian bay as it is project based. The authorities are acting according to their mandate and established directives, they also do not see a need for a management plan, which might impede the development of cyprinid fishing through excluded from labelling systems. The historical context of why cyprinids stopped being consumed in Sweden explains its current less positive reputation. Projects that work with promoting cyprinids as edible, for example, through cooking competitions could create a better reputation for cyprinids. The management of cyprinids could be viewed as a CAS system to better understand the system and increase the tools that managers can utilize. This might make management more effective.

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Popular science summary

Cyprinid fisheries in Sweden – a “catch-22”?

With an increasing global population there is a need to find new sustainable food sources that can feed people all over the world, now and in the future. In Sweden, the government is in search of increasing sustainable domestic food sources, and cyprinid fish might just fit the bill. Cyprinid fish like roach, bream and ide are natural resources in Sweden that were common and consumed in households up to the late 19th century but due to societal changes during the industrialization cyprinids became less commonly consumed. The production of edible cyprinid products emits low amounts of greenhouse gases and fishing for cyprinids can also potentially improve water quality. Today a resurgence of this commodity has occurred, and multiple projects have been undertaken to increase cyprinid fishing in Sweden.

It is therefore interesting to estimate how much cyprinid fish could contribute to the Swedish food supply chain. To estimate how much cyprinid fishing can occur I have used data from fishers on how much bream, a type of cyprinid fish, has been caught from different fishing locations. For these fishing locations, there was data on different environmental factors, for example, how much nitrogen and phosphorous there was in the water. I could combine this data and see which environmental factors had a connection with large catches. The next step was to screen all relevant waterbodies along the Swedish Baltic Sea coast to see how much bream could be expected to be caught. With this method it was estimated that it is possible to catch at least 2 000 tons of bream in Sweden. The annual edible product from 2 000 tons would be on par with the amount of char (*Salvenius sp*) that is annually consumed in Sweden.

If cyprinid fishing is to increase, then the fishing needs to be managed in a sustainable way that will ensure that this resource will not become overexploited and that the fishing does not affect the environment in other ways. Only through sustainably managed fisheries can cyprinid fish contribute to the Swedish food supply chain in the long run. Therefore, it is important to consider how these fish should be managed. To get an understanding of what type of management could

suit cyprinid fisheries I got in touch with fishers, authorities, parts of the scientific community and other stakeholders to get their perspective of the situation.

Regarding management, the stakeholders was in contact with all had relevant input that aided in understanding how management of cyprinids could be handled. Anecdotally, when I attended a meeting about the management of bream, there was a discussion about creating a management plan. Among the stakeholders there was a will to create a management plan because this could improve the prospects of managing bream sustainably, and it could help retailers because a management plan could contribute to getting bream labelled as sustainable. However, the authority that could create an official management plan did not think it necessary because bream is currently not a threatened species. This prompted many at the meeting to call the situation a "catch-22" because to manage bream sustainably a management plan is necessary, but because it is not necessary now, the authorities cannot create one.

To sustainably manage cyprinid fisheries some preconditions need to be met. Firstly, data about the stocks must be gathered so the managers know if the stocks are being overfished. Secondly, someone needs to monitor the fishers so that they are not overfishing and are reporting what they are landing. Lastly, in case there is evidence of overfishing then someone needs to take measures to ensure overfishing either stops or never occurs to begin with. After talking with the fishers, county administrative boards, fish retailers, the Swedish Agency for Marine and Water Management (SwAM) and parts of the scientific communities I got the impression that management could be set up to be self-regulated by the different stakeholders. Fishers could contribute with data collection, the fish retailers and county administrative boards could monitor the fishers and SwAM could contribute with measures that prevents overfishing. Also, management measures should not only focus on implementing laws that limit fishing but also focus on enabling stakeholders to be a part of management. That way one stakeholders' interest does not jeopardize the cyprinid stocks or the other stakeholders' interests.

In conclusion, if Sweden is looking for new sustainable food sources, cyprinid fish are a viable option. However, to ensure that the resource is not overexploited having a management plan that satisfies and enables affected stakeholders will aid in ensuring that the resource remains sustainable and can feed a growing population, now and in the future.

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Appendix 1

Intervjuguide – fiskare

(Interview guide – fishers)

Intro:

Hur skulle du beskriva din sysselsättning?

(How would you describe your occupation?)

Hur länge har du jobbat som yrkesfiskare?

(How long have you been working as a professional fisher?)

Har länge har du fiskat karpfiskar?

(How long have you been fishing for cyprinids?)

Ekonomi:

(Economy)

Hur mycket fiskar du?

(How much do you fish?)

På vilka platser fiskar du?

(On which locations do you fish?)

Hur och till vilka säljer du brax/id? (rensad,färsk, brygga, transporterad)

(How and to who do you sell bream/ide? (gutted, fresh, jetty, transported))

Vad betyder brax/id fisket i förhållande till dina övriga inkomster?

(What does bream/ide fishing mean i relation to your other incomes?)

Hur mycket behövde du investera för att börja fiska efter braxen?

(How much did you need to invest to start fishing for bream?)

Är det en lönsam syssla eller är det en sekundär verksamhet som ni gör när ni har tid?

(Is it a profitable occupation or is it a secondary business that you do on your spare time?)

Skulle ni vilja öka volym och tid ni lägger på karpfiske?

(Would you like to increase the volume and time you spend on cyprinid fishing?)

Marknad:

(Market)

Vilken betydelse har Baltic Fish projektet med RFTB haft för ditt fiske?

(What has the Baltic Fish project with RFTB meant for you fishing?)

Finns det möjligheter att förbättra din lönsamhet? (pris, logistik, förvaring, förädling)

(Are there opportunities to improve your profit? (price, logistics, storage, processing))

Finns det utrymme att öka marknaden? (vad skulle behövas)

(Is there room on the market to expand? (What would be needed))

Miljö:

(Environment)

Har ni sett någon förändring i bestånden, ökning eller minskning? (senaste åren, senaste decenniet)

(Have you seen a change in the stocks, increase or decrease? (The last years, the last decade))

Har du sett om karpfisket påverkar miljön?

(Have you seen if cyprinid fishing has affected the environment?)

Hur viktigt tycker du det är att förbättra havsmiljön?

(How important do you think it is to improve the marine environment?)

Vad tror du ökat karpfiske skulle ha för påverkan på miljön?

(How do you think increased cyprinid fishing could affect the environment?)

Förvaltning och myndigheternas roll:

(Management and authorities roles)

Vad ser ni för stöd och begränsningar från myndigheterna? (lst, kommun, HaV)

(What kind of support and limitations have you seen from authorities? (County administrative boards, municipalities, SwAM))

Hur har detta förändrats över tid?

(How has this changed over time?)

Behövs karpfiskbestånd övervakas, och i så fall hur? (Vem, skala, indikatorer)

(Do cyprinid stocks need to be monitored, and how could they be monitored? (Who, scale, indicators))

Kan det behövas regleringar av karpfiske? Vid behov vilka typer av regleringar skulle kunna vara lämpliga (tids/flyktöppningar)?

(Could there be a need for regulation of cyprinid fishing? At need, which types of regulations could be appropriate (time/selection panels)?)

Hur kan ansvar fördelas för att förvalta karpfisket?

(How can responsibilities be divided to manage cyprinid fishing?)

Avslutning:

(Outro)

Har ni något mer att tilläga?

(Do you have anything more to add?)

Finns det någon annan ni tycker jag borde intervjua som är relevant för ämnet?

(Is there anyone else that you think I should interview who is relevant for the subject?)

Table 4. Shows summary of my thematic analysis from the interviews with cyprinid fishers in the North of Sweden. The matrix shows statements that I have interpreted as positive (+), negative (-), or neutral (/) if whether they indicate that cyprinid fishing can increase in volume.

Economy	*Market*	*Environment*	*Management*
+ No investment for new gear + Short travel distances + Additional income + Plans to increase gears - Low profit - Bycatch cannot be landed	+ The Baltic Fish project a way to sell cyprinids for human consumption + Cyprinids sold as crayfish bait - No direct sales upon landing - Project based fishing	+ Increased abundance of cyprinids + Fishing has not affected cyprinid stocks + Bycatch easily managed + Selection grid is effective - Ecosystems unbalanced	/ Management not necessary because of the low amounts fished / Self-regulation an option for fishers / Environmental and informal social structure regulate fishing / Administrative difficulties obtaining exemptions / Regulations on landings by-catch - Power difference in Baltic Fish project and fishers in a disadvantageous position

Appendix 2

Self-completion questionnaire

1. Vilken roll har er myndighet och vad kan ni göra i utvecklandet av ett hållbart karpfiske?

(Which role does your authority have and what can you do in the development of a sustainable cyprinid fishery?)

2. Vilka biologiska risker ser ni som troliga med ett ökat karpfiske? Till exempel, ser ni risk för ett överfiske (mer än ”MSY”, även om det är okänt/osäkert), stora bifångster av andra mer känsliga arter, eller ett ”fishing-down-the-food-web” som förhindrar återhämtning av ekosystem?

(Which biological risks do you consider probable with an increased cyprinid fishing? For example, do you see a risk for overfishing (more than “MSY”, even if this is unkown/uncertain), large bycatch of more sensitive species, or a “fishing-down-the-food-web” which inhibits the recovery of the ecosystem?)

3. Anser ni att man kan eller bör ta hänsyn till eventuella positiva miljöaspekter av karpfisket (minskad övergödning, för mycket karpfisk i fisksamhällen) i förvaltningen? Det vill säga tillåta dispenser eller tillstånd även om det finns risk att det fiskas mer än ”MSY”.

(Do you consider that possible beneficial environmental aspects (reduced eutrophication, too many cyprinids in the fish communities) could or should be considered in management? That is allow exemptions or permits even if there is a risk of fishing above “MSY”.)

4. Vilka typer av regleringar ser ni främst vara lämpliga vid behov för att reglera karpfiske? Till exempel tidsbegränsningar, antal licenser/dispenser eller redskapbegränsningar som flyktöppningar/maskstorlekar.

(Which types of regulations do you consider to be appropriate in case there is a need to regulate the cyprinid fishery? For example, time limitations, number of licenses/exemptions or gear limitation such as selection panels/mesh size.)

Table 5. Respondents at authorities replies to a self-completion questionnaire about cyprinid fishing categorized into 4 different themes: 1) Authorities role in managing cyprinid fishing. 2) Biological risks associated with the current cyprinid fishing. 3) Authorities view of beneficial environmental effects of cyprinid fishing. 4) Authorities' suggestions on how to regulate cyprinid fishing.

Authorities roll	*Biological risks*	*Beneficial environmental effects*	*Regulating cyprinid fishing*
SwAM decides regulations SwAM have national responsibility to ensure sustainable usage of water and marine resources County administrative can support or participate in projects County administrative boards can issue local exemptions County administrative boards evaluate and assess fishers' applications for exemptions	Overfishing. Factors affecting recruitment unknown Fishing at MSY can affect the ecosystem MSY unknown Bycatches Food-web effects	Skepticism toward cyprinid fishing having beneficial effects for eutrophication. Case-by-case assessment and evaluation should be conducted. Achieving beneficial effects on environment could be in contradiction to economic sustainability.	Number of licenses Customized gear Ecosystem based perspective Maintain a small-scale fishery Gear restrictions: Fyke nets or traps Monitoring by coast guard and only allow gear that could be easily checked. Regulate positions, number of fishers and have time limitations.