Recreational fishing for Atlantic bluefin tuna in Norwegian waters : A detailed look at the fishing effort and economic value of this new fishery.

Master thesis
Flemming Versloot

Department of Biological Sciences

University of Bergen Norway

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Supervisors:

Karin Anna Pittman (University of Bergen), Keno Ferter (Institute of Marine Research), Leif Nøttestad (Institute of Marine Research/ University of Bergen).

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Abstract:

Recreational fishing is a popular hobby and ecosystem service around the world, yet the impact of recreational fishing on both fish populations and local economies is often overlooked. This thesis will look at the fishing effort and economic value of recreational fishing for Atlantic bluefin tuna (*Thunnus thynnus*), a fish species that has only recently returned to Norwegian waters. In 2020, recreational bluefin tuna anglers got a license to fish and were involved in a citizen-based science project in collaboration with the Institute of Marine Research in Norway. A total of 24 fishing teams took part in this project, in which they helped register valuable fishing data by maintaining a logbook of their bluefin tuna fishing trips. This data included the number of fishing trips, trip duration, fish caught, and fishing strategy used for fishing . The recreational fishermen also helped in tagging bluefin tuna for research purposes. As recreational fishing for bluefin tuna in Norway is relatively new, an economic off-site survey (online questionnaire) was run 6 months after the fishing season was over to estimate the economic value of this new fishery. This can highlight the importance of recreational bluefin tuna fishing for future fisheries management. Besides expenditures that the anglers were willing to make, the questionnaire also had several questions regarding efforts made by the fishermen to fish for bluefin tuna. A total of 19 bluefin tunas were caught by the recreational anglers in Norwegian waters in 2020, with 4 fish being the highest catch for an individual team. The 24 teams set out for 176 fishing trips, which lasted for a combined total of 1641 hours. The combined *Catch per unit effort* (CPUE) for the 2020 BFT season was 0.012 fish per hour. The most popular fishing strategy used by the fishermen was spreader-bars, which were used in 75% of all fishing trips. The minimum economic value of the 2020 recreational bluefin tuna fisheries was estimated at 6 952 167 NOK. This excludes the investment costs of buying a suitable fishing boat. When these investment costs are included the minimum economic value would be 41 261 167 NOK. Boat-owners spend considerably more money and effort on their hobby than non-boat owners. The recreational fishing for Atlantic bluefin tunas in Norwegian waters has expanded in 2021 both in terms of fishing quota and the amount of participating teams. The information in this thesis may be used as a valuable baseline for future studies on the recreational fishing for bluefin tunas in Norway.

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1. Introduction:

The Atlantic bluefin tuna (*Thunnus thynnus, hereafter BFT)* has returned to the waters of Northern Europe (MacKenzie *et al.,* 2018; Nøttestad, Boge & Ferter, 2020) . The factors that have led to this reappearance and the population origin of these individuals is presently unknown (MacKenzie *et al.,* 2018). Therefore, research has been performed in several Northern European countries in cooperation with ICCAT (*The International Commission for the Conservation of Atlantic Tunas*) (MacKenzie *et al.,* 2018*;* Maoileidigh *et al.,* 2018; Nøttestad, Boge & Ferter, 2020). In order to obtain BFTs for research and to catch as many fish as possible, scientists collaborated with recreational big game fishermen (Mackenzie *et al.,* 2018; Ferter *et al.,* 2018; Ferter *et al.,* 2020). The purpose of this thesis is to give an insight into the results of the catching and tagging effort by recreational fishermen in Norway in 2020. Furthermore, as recreational fishing for BFT can be an important ecosystem service, an economic survey was performed in 2020 that focused on effort and personal spending by the recreational fishermen to show the value of rod and reel fishing for BFT in Norwegian waters.

1.1 Background: The biology of the Atlantic bluefin tuna

1.1.1 Description:

The BFT is the largest species of tuna and is known as one of the largest teleost fish species (Fromentin & Powers, 2005). Its scientific name *Thunnus,* derives from the word ''tunny-fish'', which in turn derives from ''to rush/to dart''. *Thynnus* has a similar meaning, which is fitting for this fast swimming species (Block & Stevens, 2001). The BFT can reach weights of up to 700kg and can reach a length of around 3.2 meters (Cort *et al*., 2013). BFT can be recognized by its large conical head and mouth, the dark blue dorsal area and the grey ventral part. It can be distinguished from other tuna species by its relatively small pectoral fins (Fig. 1)(Block & Stevens. 2001). The BFT is one of the fastest fish species on the planet, reaching a maximum speed of around 70km/h, and it can maintain these speeds for a prolonged time period (Block & Stevens, 2001; Shadwick, Schiller & Fudge, 2013). BFT can be found at different depths, from surface waters to depths of over a 1000 meters (Block *et al*., 2001). BFT is a carnivore species, often described as an apex predator, although killer whales (*Orcinus orca*) are known to predate on BFT in the Strait of Gibraltar (Guinet *et al*., 2007; Esteban et al., 2001; Reglero *et al*., 2018). BFT is an opportunistic feeder, the diet of the juvenile fish consists of small zooplankton and piscivore larvae, including those of their own species, whereas the diet of adult fish largely consists of fish and invertebrates (Fromentin &

Powers, 2005; Uriarte *et al*., 2019). Adult BFTs typically hunt small schooling fish and often actively migrate to areas where prey is in abundance. Here they can be found hunting in large schools in pelagic waters (Newlands, 1997; Humston *et al.,* 2000).

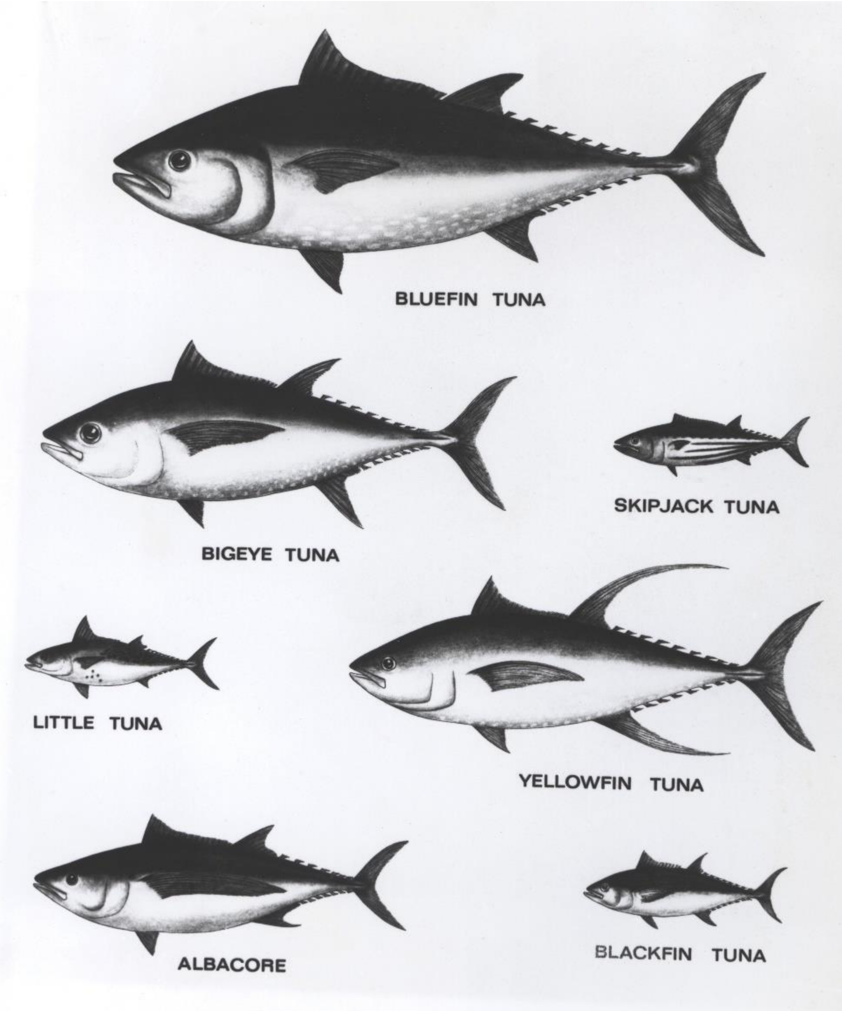

Figure: 1 Similar species of tuna and their morphological differences. The Atlantic bluefin tuna (Thunnus thynnus) is displayed on top and can be recognized by its large head and mouth and relatively small pectoral fins. Photo taken from NOAA Central Library Fisheries collection/public domain

1.1.2 Distribution:

BFTs have an extended geographical range and can be found throughout the entire Atlantic Ocean as well as the Mediterranean Sea, from Norway to South Africa and from Newfoundland to the South of Argentina (Fromentin & Powers, 2005). The species is known to have at least two different spawning grounds, so the BFT population is divided in to two subpopulations: the Western population, that spawns in the Gulf of Mexico and the Eastern population that spawns in the Mediterranean Sea (Rooker *et al*., 2007).

Fish from the Eastern and Western population do mix and are not entirely separated from each other. Besides the two known spawning grounds, other spawning grounds off the coast the eastern United States have been proposed (Richardson et al., 2016; Rypina *et al.,* 2021).

1.1.3 Endothermy

BFTs are regionally endothermic, meaning that they are partially warm-blooded (Dickson & Graham, 2004). BFT can conserve metabolically derived heat to maintain the temperature of the viscera, the slow twitch oxidative myotome muscle fibers, the eye and the brain. For this retainment of heat, the BFT uses red-blood vessels that act as counter-current heat exchangers (*Retia mirabilia*) interposed between the endothermic tissue and the gills (Dickson & Graham, 2004). This retainment of heat is energetically costly as it increases the metabolic rate (Block & Finnerty, 1994). Regional endothermy however comes with many advantages: It allows BFT to recover quicker from anaerobic burst (Stevens & Neill, 1978; Brill, 1996) and it grants the ability to maintain relatively stable tissue temperatures when encountering large changes in ambient water temperature (Dickson & Graham, 2004). BFT can maintain an internal temperature that can be up to 7 degrees above ambient water temperatures (Block *et al*., 2001). Endothermic tissues also allow BFT to easily migrate through different areas and allow BFT to comfortably vertically migrate through water columns (Block *et al*., 1993; Graham & Dickson 2000). It has also been hypothesized that endothermy in fish allows them to have an increased sustainable swimming speed as well as an increased sustainable swimming speed performance (Dickson & Graham, 2004).

This regional endothermy clearly give the BFT an advantage while hunting prey in cold waters, although it could become a disadvantage in subtropical waters due to ocean warming (Logan, Golet, & Lutcavage, 2014; Muhling et al., 2017). The increased metabolic rate causes proportionally higher oxygen demands in comparison to other tuna species (Block *et al.,* 2005; Teo et al., 2006). Thus warmer water temperatures may induce metabolic stress more quickly in BFT (Block *et al.,* 2005; Kitagawa *et al.,* 2006; Blank *et al.,* 2007).

One could also hypothesize that ocean warming could restructure the food web in colder waters as the advantage that the BFT has over its prey due to endothermy is decreased by warmer water temperatures (MacKenzie *et al.,* 2014).

1.1.4 Migration:

BFT is a highly migratory fish species and evidence of their migration's dates back to more than 3000 years ago (Fromentin & Powers, 2005; Pérez-Lloréns, 2019). BFTs seasonally migrate between feeding and spawning areas in the Atlantic Ocean (Fig.2)(Aranda *et al.,* 2013). BFTs migration patterns are largely dependent on size and age of the individuals in the school (Nøttestad, Boge & Ferter, 2020). Although BFT migration patterns have been well researched, part of the migratory behavior of BFT remains unknown (Richardson *et al*., 2016). The amount of mixing between the Eastern and Western populations is unclear, as well as the degree of natal homing (Rooker *et al*., 2008). What is known about the migratory paths of BFT has largely been discovered with the use of (satellite) tags (Hamre, 1959; Wilson *et al*., 2005; Aranda *et al., 2013*). In one of the first tagging studies, a BFT tagged off the Bahamas was recaptured of the Norwegian coasts less than 50 days later, proving the long migratory pathways that these fish are taking in rapid speed (Block & Stevens, 2001). Not all BFT individuals are long-distance migratory fish, as fish can be found on certain locations throughout the year such as in the Gulf of Lions in the Mediterranean Sea (Fromentin & Lopuszanski, 2014; Rouyer *et al.,* 2021).

Most of the performed studies look into the spawning migrations of BFT, for both the Eastern and the Western stock (Humston *et al.,* 2000; Block *et al*., 2001; Rooker *et al*., 2008; Aranda *et al.,* 2013). The Eastern BFT population gathers in the Mediterranean around mid-May to spawn (Reglero *et al*., 2018). This spawning behavior seems to be largely dependent on water temperature and can thus fluctuate, making both BFT subpopulations vulnerable to climate change (Block et al., 2005; Muhling *et al.,* 2011). Gonad data and the occurrence of larva and eggs indicate that the main spawning grounds in the Mediterranean can be found around the Balearic islands and of the coast of Sicily, although spawning in other areas of the Mediterranean does occur (Fromentin & Powers, 2005; Rooker *et al*., 2007; Aranda *et al.,* 2013; Reglero *et al.,* 2017).

The Western Atlantic stock is known to spawn earlier in the Gulf of Mexico, around March, when local water temperatures are similar to those in the Mediterranean in May (Druon et al., 2016). Mixing does take place between the two populations making it unclear to which extent natal homing occurs in BFT (Rooker et al., 2008; Rooker et al., 2014). Furthermore, evidence suggests that BFT may also spawn of the east coast of The United States in the Slope Sea, about two months later in the year than in the Gulf of Mexico (Richardson et al., 2016; Reglero *et al*., 2018; Rypina *et al.,* 2021).

Juvenile BFTs are often found in the vicinity of their spawning grounds in (sub)tropical waters as they have a low tolerance for low surface water temperatures (Druon et al., 2016). Juvenile BFT of the Eastern stock are found in the large parts of the Mediterranean as well as off the coast of Spain and Northern Africa (Druon et al., 2016; Arregui et al., 2018). Juvenile fish of the Western population are found in the Gulf of Mexico and its adjacent seas, and on the North-West Atlantic shelf (Druon et al., 2016).

Larger BFTs (>25kg) have a better tolerance for low surface water temperatures and often migrate to open waters. These larger BFTs can be found in more colder regions, often migrating after prey species (Humston *et al.,* 2000; Druon et al., 2016; Nøttestad, Boge & Ferter, 2020). Historically, migrating BFT have been found as far north as northern Norway. Overexploitation in recent decades led to the disappearance of BFT in Norwegian waters, but a recent increase in population size possibly caused BFT to return to Norwegian waters in the 2013. Here, large (>200kg) individuals feed on schools of mackerel (*Scombrus scombrus*) and other schooling fish species (Arregui et al., 2018; Nøttestad, Boge & Ferter, 2020). Large specimens off the Western Atlantic stock undergo a similar migration, and can be found as far North as Newfoundland (Fromentin & Powers, 2005).

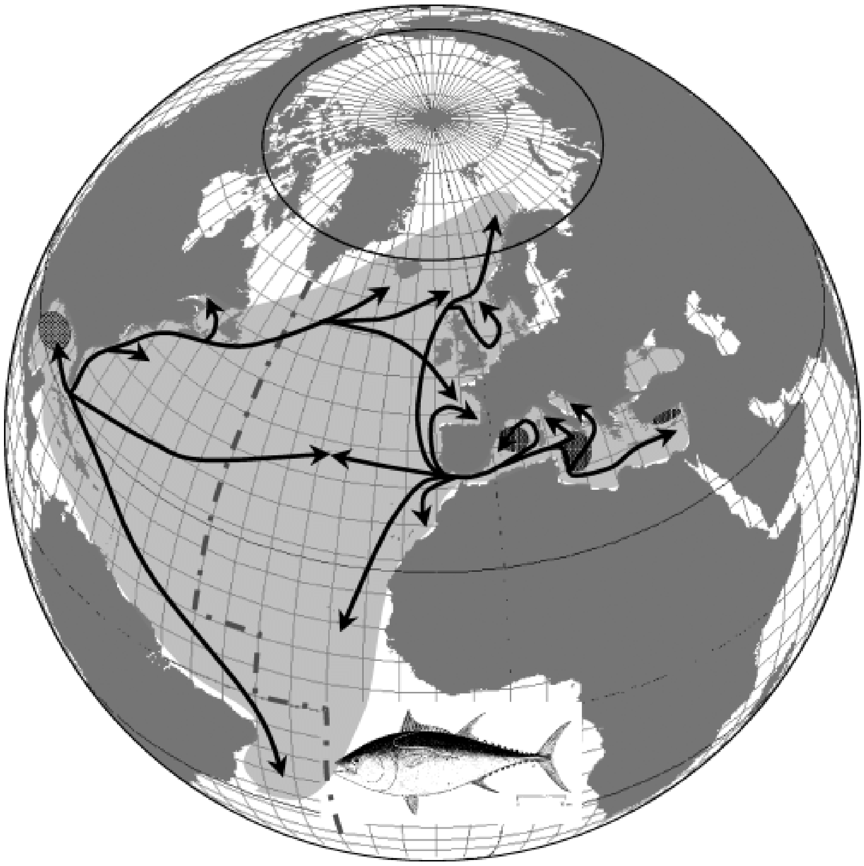

Figure: 2 Atlantic bluefin tuna (Thunnus thynnus) migration patterns. This figure shows the migration paths of the Atlantic bluefin tuna, with the dotted line marking the separation between the Eastern and Western stock. Spawning grounds that are well scientifically established in the Mediterranean and Golf of Mexico are marked in black. Figure taken from Fromentin & Powers (2005).

1.1.5 Status:

The population of BFT was once so dense that entire regions could live of the BFT catch, such as the Cádiz region in southern Spain (Pérez-Lloréns, 2019). However, at the start of the 20th century, the BFT populations were at the brink of collapse (Arregui et al., 2018). The cause of this strong decline in population size was believed to be primarily overfishing. The recent decline since the 1960's in the Eastern population seems to have been caused by high fishing pressure on juvenile fish, which limited recruitment to the spawning stock, as well as high levels of illegal fishing (Cort & Abaunza, 2015). Overexploitation, as well as mismanagement seem to have caused the rapid decline of the western population (Safina, 1993).

The overexploitation of BFT was being caused by increasing demands for human consumption (Furtado, 2020; Milatou, Dassenakis & Megalofonou, 2020). Prices for the protein and omega three fatty acid rich meat soared, and an individual fish could be sold for as much as $3 million on the Japanese market (Furtado, 2020; Milatou, Dassenakis & Megalofonou, 2020).

Strict fishing regulations in the last 15 years have led to a steady recovery of the Eastern population, which is showing a consistent growth in abundance for over a decade (Nøttestad, Boge & Ferter 2020). The Western population remains more fragile (ICCAT, 2020). Originally the International Commission for the Conservation of Atlantic Tunas (ICCAT), an intergovernmental organization, was established in 1969 in an effort to protect Atlantic Tuna populations (Straker, 2009). However, ICCAT was often criticized for ignoring their own scientists and having short term policies that favored fishermen over the conservation of the species (Straker, 2009; Webster, 2011; Belschner, 2015). In more recent years, ICCAT implemented stricter measurements and set lower quotas which supposedly led to the steady increase in the Eastern stock, as well as a slow recovery in the Western Stock (Furtado, 2020). The BFT was red-listed by the IUCN (International Union for the Conservation of Nature) with the status of Endangered until September 2021, when the status was updated to near threatened (IUCN, 2021). Thus, the rigorous measurements implemented in recent years by ICCAT seem to have paid off.

1.1.6 Commercial fishing for bluefin tuna in Norwegian waters:

Norway had one of the largest fisheries for BFT in the North Eastern Atlantic in the 1950's and 60's (Ferter *et al.* 2018; Boge, 2019). The annual landings of BFT were as high as 15 000 tons before they gradually disappeared from Norwegian waters and the fishery was no longer viable. The history of BFT fishing before the return of the BFTs to Norwegian waters in 2013 is best described in the master thesis by Boge (2019) and will thus not be described here. In 2007, after a recent increase in population size, ICCAT granted Norway its first BFT quota. The Norwegian authorities however, decided to not make use of this quota for conservation purposes. Commercial trial-fisheries for BFT in Norwegian waters started in 2014, when Norway first made use of its allocated quota of 30.97 tons. As commercial fishing quotas for BFT increased, so did the commercial fishing effort for BFT until the Norwegian Directorate of Fisheries released targeted annual quotas to commercial fishermen in 2016. In 2020, the year this research was performed, Norway had a commercial fishing quota of 311.95 tons (Lovdata, 2020).

1.2 Background: Recreational Fishing

1.2.1 Recreational Fishing; A general understanding of the hobby:

Recreational fishing is a popular hobby around the world with an estimated 220 million participants (Arlinghaus, Tillner & Bork, 2015). Fishing is defined as recreational, when it does not constitute the individuals primary source of nutrition and the fisherman has the financial capacity to substitute the fishing products by other products to meet nutritional needs (FAO, 2012). The term recreational fishing is rather broad and contains many different methods such as trapping, netting and spearfishing as well as angling (Arlinghaus & Cooke, 2008). Although catch and release fishing is becoming more and more common depending on fish species, the recreational fishing effort still harvests billions of fish every year (Cooke & Cowx, 2004; Arlinghaus et al., 2007; Brownscombe et al., 2019). This can sometimes lead to the overfishing of fish species affecting entire ecosystems, especially when the impacts of recreational fishing are not considered (Cooke & Cowx, 2004; Lewin, Arlinghaus & Mehner 2006; Hyder et al., 2018; Radford et al., 2018). However recreational fishing can also help with the conservation of fish species and ecosystems, either directly or through the economic benefits of recreational fishing (Granek *et al.,* 2008; Cowx, Arlinghaus & Cooke, 2010; Cooke *et al.,* 2013).

Angling is fishing with rod and reel (Mckean, Johnson & Taylor, 2014). It is popular throughout Europe for a diverse range of species in both fresh and saltwater ecosystems (Brownscombe et al., 2019). Catch and release (or *C&R*) can be common practice in sportfishing depending on species and, in some species such as in common carp (*Cyprinus carpio*), harvesting your catch is not socially tolerated in certain areas (Arlinghaus *et al.,* 2009; Lyach, 2020). The goal of angling can be catching large amounts of fish, often from the same species in a short time span, or hunting for large specimens of a specific fish species. This type of fishing is known as specimen or trophy fishing. These ''trophy-sized'' fish are often treated with care, weighed an measured and released after (Arlinghaus, Matsumura & Dieckmann. 2010; Dotson *et al.,* 2013; Ferter *et al.,* 2013; Shiffman *et al*., 2015). Angling has evolved over the years and many different specializations can be found. These specializations can often be categorized based on fish-species (such as fishermen that want to catch as many different fish species as possible or fishermen that specialize in fishing for only one species, such as carp-fishermen), or fishing method (such as flyfishing, jigging, trolling and casting). In addition to these groups there are also fishermen that find the catching part of the trip of lesser-importance and just go out to experience nature (Arlinghaus, 2006).

1.2.2 Big game fishing:

Big game fishing is a form of recreational fishing where the goal of the fishing trip is to actively pursue large fish species such as marlin *(Istiophoridae*) and tuna (*Scombridae)* (Vieira

& Antunes, 2017). Although big game fishing is a common term in the recreational fishing world, it is not scientifically defined and little has been written about the subject (Vieira & Antunes, 2017). The following part is therefore heavily opinionized by the author while trying to stick with the definition that can be found in the study by Vieira & Antunes (2017). As the goal of big game fishing is to pursue large fish species (50>KG) special fishing equipment and a certain level of expertise is needed. Besides marlins and tunas, other popular species include large sharks (*Selachii*), groupers (*Epinephelinae*) and tarpon (*Megalopidae*) (Pikitch, Camhi & Babcock. 2009; Vieira & Antunes, 2017; Martinez-Escauriaza *et al*., 2021).

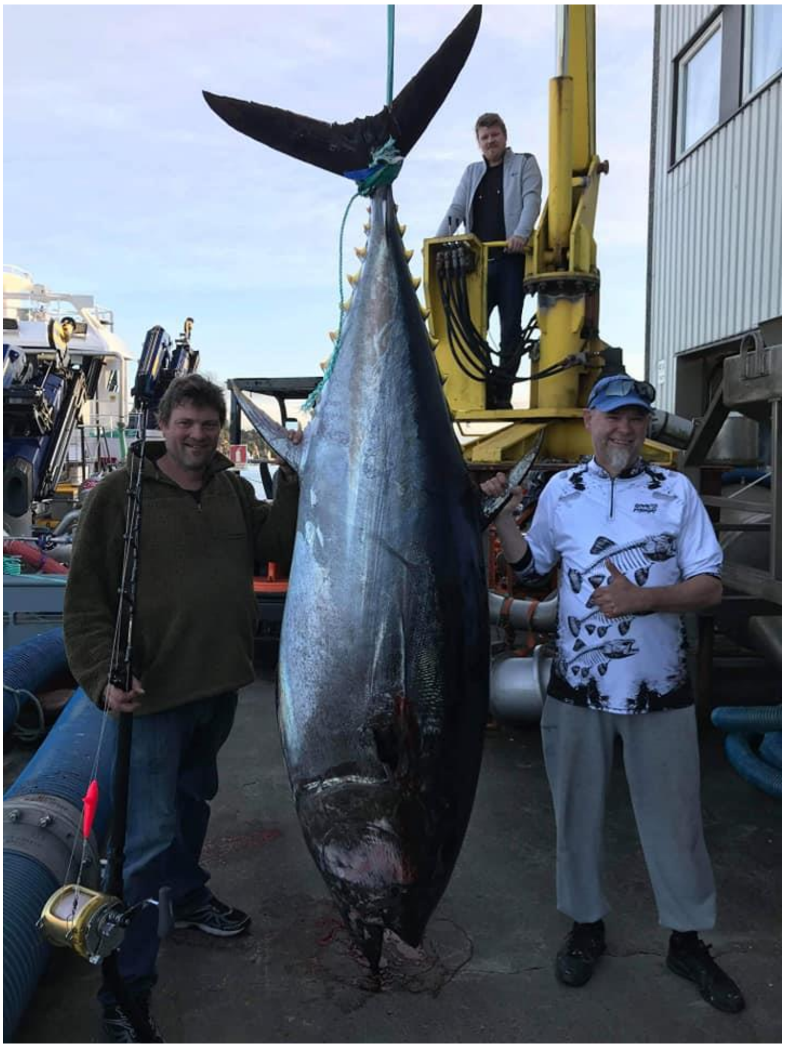

*Figure: 3 Big tunas, like this Atlantic bluefin tuna (*Thunnus Thynnus*) are popular fish for anglers to target. Photo from the 2020 Norwegian recreational BFT fisheries by Terje, E. Steinsland.*

All species of Bluefin tuna (*Thynnus, Orientalis & Maccoyii*) are popular big game fish in their respective domains (Fig 3). Catching a Bluefin tuna species is for many anglers a goal of its own (Bohnsack et al. 2002; Ezzy, Scarborough & Wallis, 2012; Deloitte, 2013). Bluefin tunas can put up long fights once hooked (Block, 2019). These long fights or drills as they are called in recreational fishing are often desired by the angler as they are for many the most exciting part of fishing (Arlinghaus, 2006). The long drills can however have implications on the fish's welfare (Arlinghaus *et al.,* 2009). Because bluefin tunas are mostly found in open waters and can put up such a long fight, recreational fishing for Bluefin tuna is normally done from specialized fishing boats or charters (Ezzy, Scarborough & Wallis, 2012; Deloitte, 2013).

Common methods for fishing for BFT are trolling with spreader-bars or using live bait such as mackerel (Ferter *et al.,* 2018; Tracey *et al.,* 2020). Other fishing strategies that can be used to target BFT are daisy chains, specialized lures and dead bait (Fig. 4) (Foster *et al.,* 2012 ; Ferter *et al.,* 2018).

If anglers fish for adult BFT, then the fishing boat needs to contain specialized fishing equipment. This includes heavy fishing equipment such as specialized rods and reels as a minimum, but it can include much more such as specialized fishing chairs and fishing belts. This specialized fishing equipment is often expensive and can costs several thousands of US dollars, making big game fishing for BFT an expensive hobby. Buying all of this expensive equipment is not necessary for all anglers as boats and equipment can be rented.

Fishing charters for bluefin tuna have become another popular option for fishing after bluefin tunas around many areas where the fishing is known to be excellent. Charter fishing has become a tourist industry of its own (Bohnsack et al., 2002; Ezzy, Scarborough & Wallis, 2012; Tracey *et al.,* 2020). This has led to certain areas becoming popular tourist destinations among anglers that otherwise would not have gotten the opportunity to fish for bluefin tuna (Ezzy, Scarborough & Wallis, 2012; Deloitte, 2013; Tracey *et al.,* 2020). These specialized charters often include a captain and crew with expertise on fishing for bluefin tuna, as well as all the necessary equipment. Boarding those charters is often expensive yet it remains popular as they often give an angler the best chance of catching their target species. However, charter fishing for bluefin tunas is controversial as ICCAT does not legally allow it. ICCAT only allows recreational fishing for bluefin tunas when the respective country has allocated a specific quota to recreational fishing. The rules specifically prohibit charter fishing for any species of bluefin tuna (ICCAT, 2018).

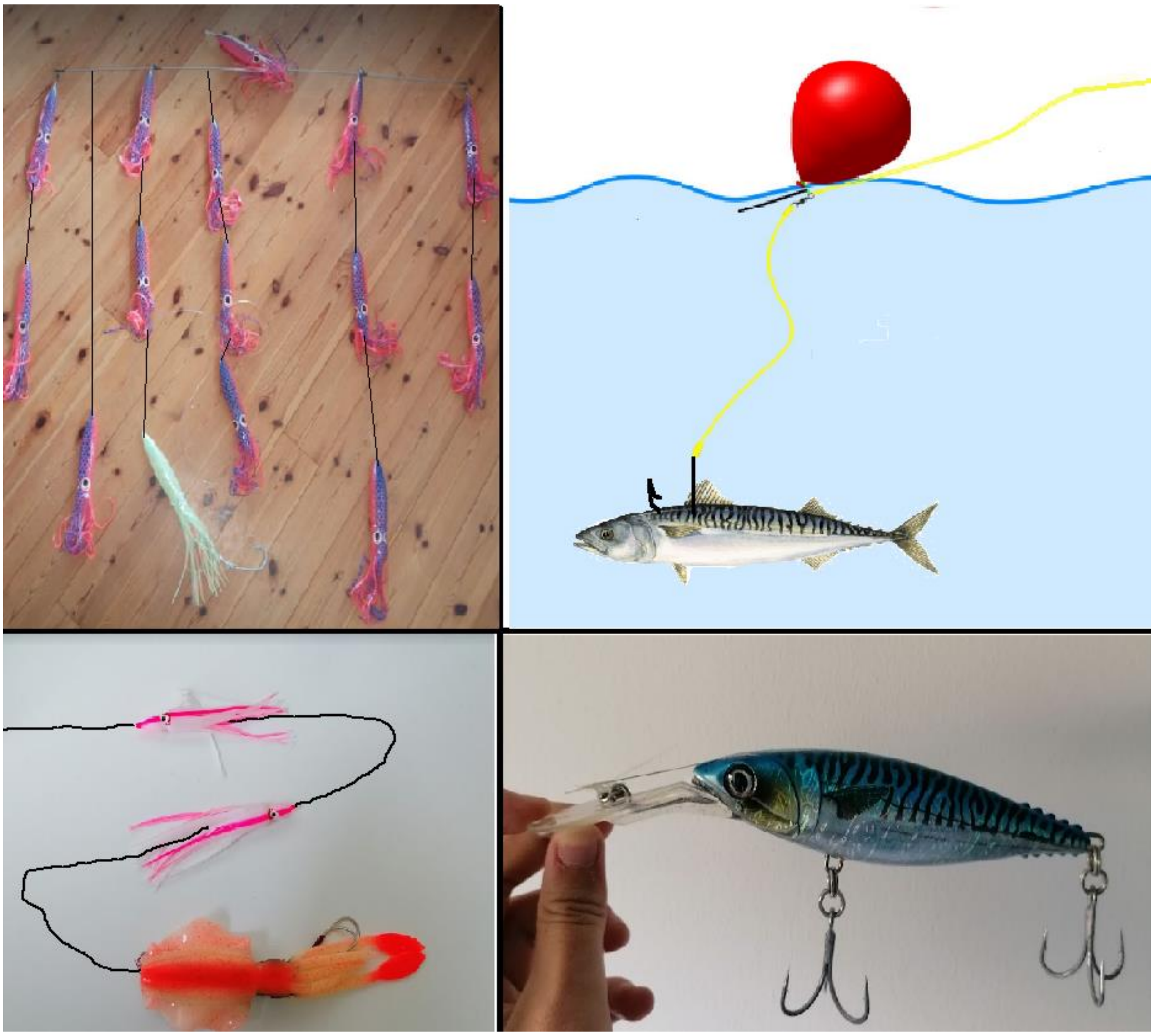

Figure: 4 Different types of baits and lures used for tuna fishing, with spreader-bars in the top left, live/deadbait fishing top right, daisy chains bottom left and a specialized lure bottom right. Pictures are taken by Keno Ferter & Flemming Versloot and then modified in paint. The live/deadbait figure was made in paint.

1.2.3 Recreational Fishing as an ecosystem service:

Recreational fishing is an important ecosystem service, providing many people with an outdoor activity that allows them to be in nature (Butler *et al.,* 2009; Villamagna, Mogollón & Angermeier, 2014). Ecosystem services can be best described as the benefits that people gain from ecosystems (Millennium Ecosystem Assessment, 2003). These benefits can be described and assessed in different ways in both ecologic and economic values (Farber, Costanza & Wilson, 2002). Fish provide value to ecosystem services as use or ''utilitarian'' and non-use or ''existence''. Recreational fishing mostly brings value as a utilitarian ecosystem service. This value can be measured in economic value through the expenditure of anglers and the economic activity generated by these expenditures in the economy on both macro (global) and local level (Williams *et al.,* 2020). The economic value can be identified as the monetary funds that a particular industry brings to the area where it is located (Toivonen *et al.,* 2015). These values are important for recreational fisheries as they can then help to establish the role of recreational fisheries in fisheries management (Terashima, Yamashita & Asano, 2020). They can also help visualize the importance of recreational fishing as an ecosystem service (Williams *et al.,* 2020; Maar *et al., in prep*). Furthermore, these expenses can give a valuable insight to the relevance the recreational fisheries might have on the local or regional economy (Deloitte, 2013; Williams *et al.,* 2020).

1.2.4 Survey methods:

There are two common methods that are usually implemented to estimate the economic value of recreational fishing, on-site and off-site surveys (van Poorten & Brydle, 2018). On-site surveys are surveys where the fishermen are contacted directly on-site and interviewed regarding the fisheries and expenditures. The disadvantages of these on-site surveys are that they are labor intensive, expensive, not suitable for all types of recreational fisheries and subject to their own set of biases such as avidity bias (van Poorten *et al.,* 2015). Off-site surveys, such as questionnaires, are surveys that are performed through the internet, phone or email. They have a broader reach and are relatively less expensive but are subjected to a wide set of biases such as: non-response, underreporting, recall and avidity bias (Thomson, 1991; Cooke et al., 2000; Jones & Pollock, 2012; Barret *et al.,* 2017; Gundelund *et al.,* 2020).

- A non-response bias occurs when the sum of the answers given by the responders is used to calculate values for the whole group. However, it might be unclear whether or not these non-responders would have had similar answers to the responders.
- Underreporting occurs when it is in the interest of the respondent to lower the values given. This can for instance be done to hide illegal activities such as fishermen exceeding their catch quota.
- Recall biases are mistakes in which the respondent is not able to recall what exactly occurred or was spent in detail. Thus the given answer might be incorrect as it was recalled incorrectly.
- Avidity bias is a bias in which the most active people of your total group respond to your survey with less “not active people” responding to your survey. This could lead to overestimation.

Questions in both on-site and off-site economical surveys are often categorized into different sectors of spending such as the direct money spent on the fishing equipment, boat fees and licenses and the indirect expenditures such as travel costs, overnight stays and food & drinks (Borch *et al.,* 2011; Deloitte, 2013; Terashima, Yamashita & Asano, 2020; Maar *et al., in prep*).

Economic evaluations of recreational fishing are currently lacking in many countries making it unclear how much money recreational fishing provides as an ecosystem service (Hyder *et al.,* 2018). Hyder *et al.* (2018) estimated the total value of the European marine recreational fishing sector at €5.89 billion euros annually.

Only a few published studies can be found on the potential economic value of recreational fishing for bluefin tunas. One of those is a local questionnaire based survey in Hatteras, North Carolina (Bohnsack et al., 2002). This study estimated the total value of recreational BFT fishing to more than 5 million for North Carolina alone. Recreational fishermen set out for a total of 1390 fishing trips for BFT, with the average fishermen spending $588 on a single fishing trip. Although outdated, this study highlights the importance of recreational BFT fishing as an ecosystem service for the local recreational fishermen. Furthermore, this study concludes with the suggestion that a community-based, C&R BFT fishing strategy could promote more local income from tuna fishing expenditures in comparison with other fishing strategies (Bohnsack et al., 2002).

Another study on the economic value of recreational bluefin tuna fishing has been performed by Deloitte (2013) in Portland, Australia (Deloitte, 2013). This study is one of several similar studies performed on Southern bluefin tuna (*Thunnus maccoyii)*. The results are relevant to discuss as the fisheries is very similar to BFT. This study performed in 2012 aimed to give insights into the Southern bluefin tuna's value to the regional economy and to fill in knowledge gaps in Southern bluefin tuna's fishery management. An interesting result was that 95% of the fishermen that went Southern bluefin tuna fishing in Portland were not actually from the area but traveled in 93.8% of the cases to Portland for the sole purpose of participating in this recreational fishery. The total value of Southern bluefin tuna fishing in Portland alone was estimated between $5.64 and $7.58 million dollars. This, again, highlights the importance of recreational bluefin tuna fishing as an ecosystem service on a local level (Deloitte, 2013).

1.2.5 Citizen based science:

Scientists do not only have an interest in knowing the expenditures that are being made in recreational fishing. There can also be an interest in getting to know other aspects of the fishing such as the amount of fish caught by fishermen and the effort that they are willing to make (Hyder *et al.,* 2018). One way for scientists to gain more insights in the effort and harvest of recreational fishing, which could contribute to better management, are projects based on citizen-based science (Gundelund *et al*., 2020). In citizen-based science projects, citizens are involved in science as researchers (Conrad & Hilchey, 2010). This can expand opportunities to learn for citizens, researchers and managers. Citizens can have or gain knowledge that is often inaccessible through traditional research methods (Kruger & Shannon, 2000). In recreational fishing, citizen-based science is increasingly used as a low-cost method to collect data (Gundelund *et al.,* 2020).

1.2.6 Recreational fishing in Norway:

Recreational fishing is an important ecosystem service in Norway (Hyder *et al.,* 2018; Selvaag *et al.,* 2021). Recreational fishing in both fresh and saltwater has been a legal right for local residents and a millennia-long tradition in Norway (*Norges Offentlige Utredninger [NOU],* 1999). According to the Norwegian hunting and fishing organization (NJFF), 50% of Norway's total population goes fishing at least once a year (NJFF, 2018). According to the study by *Hyder et al.* (2018), about 1.3 million, 33%, of Norway's total population participates in recreational fishing at sea, which is the highest percentage of recreational marine fishers in Europe. This study estimated that these 1.3 million fishermen spend an annual 210 million euros on their hobby. This estimate is however based on Denmark expenditures, which underpins the importance of future studies to the value of recreational fishing in Norway.

Not only is recreational fishing important to the citizens of Norway, it is also an important ecosystem service for tourists (Vølstad *et al.,* 2011). Norway is a popular traveling destination for anglers worldwide. A study by *Borch et al.* (2011) found that the sea-fishing tourism industry in Norway alone is worth 56,3 million euros, generating a total tourism income of 84.1 million euros (Borch *et al.,* 2011).

Recreational sea fishing in Norway is currently subject to few regulations as no fishing license is required and no bag limits are in effect (Vølstad *et al.,* 2011). The rules that do apply are a simple set of regulations for both citizens and tourist anglers (Fiskerideriktoratet, 2021; Selvaag *et al*., 2021). There are two rules that are relevant to discuss in regards to BFT fishing in Norway. The first one is that fishing with live-bait in Norwegian waters is illegal, thus this popular method for fishing for BFT cannot be used. The second important rule is that it is illegal to fish for BFT in Norwegian waters without permission of the Directorate of Fisheries.

1.3 Fishing for Atlantic bluefin tunas with rod and reel in Northern Europe:

The return of the BFT in large quantities in the seas of Northern Europe quickly gained a lot of scientific attention (MacKenzie *et al.,* 2018*;* Maoileidigh *et al.,* 2018; Boge, 2019; Nøttestad, Boge & Ferter, 2020). Studies into the origins of these BFTs and how possible ecosystem variables and fishing affects the distribution and migration behavior, were deemed necessary (MacKenzie *et al.,* 2018). This led to the first ICCAT fish & tagging program of BFTs in North-Western Europe in September 2017 in the Skagerrak by Denmark and Sweden. BFTs are most often sighted in Northern European waters during late summer/early autumn, which makes the months of August and September the best for fishing (Mackenzie *et al.,* 2018; Ferter *et al.,* 2018; Boge, 2019). In the tagging programs by ICCAT, fish are preferably caught by methods that cause minimum harm and have a low mortality (Cort *et al.,* 2010). One of these low mortality strategies for bluefin tunas is rod and reel fishing which has a post-release mortality of about 3.4% (Stokesbury *et al.,* 2011). Moreover, rod and reel fishing requires no physical contact with the BFT the besides hooking it during the capture process (Ferter *et al.,* 2018).

In the tagging programs from ICCAT, three different types of tags are used: the conventional or spaghetti tag, the archival tag and the pop-up satellite tag (Cort *et al.,* 2010). These tags are used to obtain information about the BFTs movements, migrations, stock structure, growth, population size, mortality, schooling behavior and physiology. The conventional tag is the smallest tag that is the easiest to insert into the fish, it is also the most commonly used tag by ICCAT (Cort *et al.,* 2010). The conventional tag has a serial number and an address for returning the tag if the fish is found or caught again. The information of the conventional tag can be used to study population size and migration.

In **2017**, neither Denmark nor Sweden had a commercial catch quota for BFT. Thus, special permission to catch BFT in order to study them was requested and granted by ICCAT to Sweden and Denmark to catch and tag BFTs by rod and reel fishing for them in the Skagerrak (MacKenzie *et al.,* 2018). Voluntary anglers with experience in big game fishing and the necessary equipment were recruited in both Sweden and Denmark to help the scientists maximize their catching effort (MacKenzie *et al.,* 2018). The big game fishers and scientists would set out to go fishing for BFT on the Skagerrak in September of 2017. Incidental mortality of BFTs in this project was covered by ICCAT's research mortality allowance. It was the first time that BFTs were targeted with rod and reel since the return of the BFTs to Northern European waters. In total, 18 BFTs were tagged in the combined effort of the Danish and the Swedish fishing teams (MacKenzie *et al.,* 2018).

In **2018,** three more ICCAT tagging programs for BFTs started up in North-Western Europe: one in Ireland in the Celtic Sea, one in the waters around the UK and one in Norway in the Norwegian Sea (Ferter *et al.,* 2018; Maoileidigh *et al.,* 2018; ThunnusUK, 2019). In all of these programs, the rod and reel fishing was used as the fishing method. Following the Danish and Swedish example, the Norwegian Institute of Marine Research (IMR) collaborated with nine selected recreational BFT fishing teams to catch their BFTs. It was the first time since the return of the BFTs to Norwegian waters that BFTs were target with rod and reel. The fishing teams were involved in this as citizen-scientists in an effort to tag as many BFTs as possible. Besides tagging, samples of the caught BFT were also taken to further investigate the origin of these BFTs. Unfortunately, due to bad weather in the months of August and September, only 2 BFTs were caught and tagged in Norway in 2018.

In **2019** all of the BFT research programs continued (Maoiléidigh *et al.,* 2019; ThunnusUK 2019; Fiskepleje 2020, Ferter *et al.,* 2020). In Norway, one ton of the national BFT quota was allocated for rod and reel fishing by the Norwegian Ministry of Trade, Industry and Fisheries. This quota was used to cover incidental mortality (fish that would accidentally die) during the tagging program. It was the first time rod and reel fishing for BFT had a quota in Norway. A total of four teams of recreational fishermen caught and tagged BFT in Norwegian waters. The recreational fishermen were given the responsibility to tag BFT with conventional tags without the assistance of scientists. The tags from ICCAT were redistributed by the Norwegian Directorate of Fisheries to the anglers. Information on how to handle and tag a BFT with a conventional tag was demonstrated in a meeting organized by IMR. Four BFTs would be tagged in the rod and reel fishing effort of 2019.

1.3.1 Recreational fishing for Atlantic bluefin tuna in Norwegian waters in 2020:

In 2020 the efforts of tagging BFT in Norwegian waters continued. The quota of the recreational BFT fishing increased to six tons, of which one ton was used for incidental mortality during tagging. The other five tons were allocated for harvesting by the Department of Fisheries based on management advice. This increase of available quota allowed more anglers to participate. A total of 215 recreational fishermen were given permission to go BFT fishing. A total of 24 teams were given a license. 20 of these teams would participate in the catch and tagging effort. Every fishing team that participated in the program was allowed to harvest, but not sell, one BFT from which a meat sample was taken for further scientific studies. It was the first time that recreational fishermen were allowed to take home a BFT in Norway in recent times. Overall, the teams fished from harbors between Frederikstad (Viken) along the entire coast to as far north as the island of Frøya (Trøndelag). The fishing for BFT mainly occurred from August to November. Besides the tagging of BFT with conventional tags, the recreational fishermen were required to maintain a logbook about their fishing trips. The fishermen were also asked to participate in a questionnaire regarding the efforts and expenditures that they made in order to fish for BFT in 2020.

1.3.2 Aim of this study:

The aim of this study is to give an overview of the recreational BFT fishing season in 2020. To give a valuable insight into the citizen-based tagging effort by the recreational BFT fishermen of Norway as well as the economic value of the fishing that was generated through their expenditures in order to fish for BFT. This economic value will give an indication of the value of recreational BFT fishing in Norway as an ecosystem service. This oversight will be given through analysis of logbook data and through the results of a questionnaire which was handed out to the fishermen about six months after the recreational BFT fishing season (off-site survey). This questionnaire contained questions about expenditures and effort that were made by the anglers in order to fish for BFTs. It was hypothesized that boat ownership would be an important predictor in both economic expenditures and effort made in order to fish for BFT. Therefore it was decided to compare the results from the ‘’boat-owners’’ with those of the “non-boat owners”. Furthermore it was hypothesized that spending more money on fishing equipment or spending more money in all categories would lead to catching more BFTs for both boat-owners and non-boat owners. The data discussed in this thesis contributes to the knowledge-based management of BFT fisheries management in Norway.

2. Materials & Methods

2.1 The fishing logbook:

Recreational BFT anglers that were fishing in 2020 in Norway were required to maintain a fishing logbook. This logbook was set-up and created by the Directorate of Fisheries, and the goal was to create a citizens-science database for the BFT recreational fisheries. An example of the questions asked (translated to English) in the logbook can be found in the **appendix (table 3).** When the season ended, the logbook data from each of the 24 BFT fishing teams was emailed by the fishermen to the Directorate of Fisheries.

The logbook contained valuable information that can be categorized in three sub-groups: location and time, observatory data and fishing data. Location and time were important to be able to see how many hours were used per fishing trip and from which harbor the fishermen set-off. This data can for instance be used to compare fishing success between different locations. Observational data included the location where BFTs were spotted in Norwegian waters and an estimate of how many BFTs the fishermen thought they had observed. These estimates are often hard to make as not all BFTs will breach the surface at the same time, but can give valuable information about BFT. The tracking of these observatory data aimed to gain more insight into the BFT's whereabouts in the Norwegian sea, which could further help understand migration behavior (Boge, 2019; Nøttestad, Boge & Ferter, 2020). Data regarding BFT observations will be shown in this thesis, but they have been assessed and studied by Erling Boge from IMR and are not the author's work. The analysis of the meat-sampling will not be discussed in this thesis as this is part of Sigurd Øyan's thesis (*In prep.)*.

The focus for this thesis will be on the fishing data which includes: the amount of rods used per fishing trip, bait types used per fishing trip, amount of fish hooked and brought to the boat per fishing trip and amount of fish tagged and dispatched. This data was used to calculate catch per unit effort and to compare the success between different fishing teams and fishing strategies used, as well as the hook/catch ratio.

Besides the tagging and maintaining of a logbook, the recreational BFT anglers were invited to participate in an off-site survey set-up by the author of this thesis regarding their efforts and expenditures in order to be able to fish for BFT in 2020. This survey became available in the spring of 2021. This off-site survey was set-up, as the economic value of recreational BFT fishing in Norway had not been assessed before. In recent years Danish researchers from the university of Copenhagen did a similar economic evaluation on the estimated value of the recreational BFT fishing in Denmark (Maar *et al. in prep*). It was thus decided that a similar economic evaluation would be done in Norway, as this would make comparison between the economic values of BFT fishing in these Scandinavian countries easily comparable. The combined data of the logbook and the off-site survey will be used in this thesis, to give an insight into the effort and expenditures made in the 2020 recreational BFT fishing season.

2.2 Analysis of logbook data:

After the 2020 BFT fishing season ended, all the logbook data was combined into one excel sheet by the Directorate of Fisheries. This main file was then checked and verified by the author of this thesis, concluding with a talk with the captain of the respective fishing team if necessary. The data was then organized accordingly, so that calculations such as the *Catch per unit effort, Time to catch one fish, Hook/catch ratio* and the bait preferences could easily be calculated. It is important to mention that the amount of rods used per fishing trip was not used in the calculations, as it is unclear how many hours were actually fished per fishing trip, nor for how many hours the given amount of fishing rods were used for fishing. The amount of rods used per fishing trip thus had no effect on the overall calculations. All calculations were made in Microsoft Excel.

The *Catch per unit effort* or CPUE is a standard calculation and an indirect measure of the abundance of the target species if the fishing method remains constant. The CPUE for the recreational BFT fishing in Norway can be used as a valuable baseline. The CPUE was calculated for the 11 teams that caught at least one fish by dividing the number of fish caught by the total trip time of the team. The total CPUE for 2020 of all 24 fishing teams was also calculated, in which the total trip time of the teams that caught zero BFT was included.

The *Time to catch one fish* calculation was calculated for each team that caught a fish by dividing the team's total trip time by the number of fish caught. This was also calculated for all the teams combined. This indicator can be used in recreational fishing for comparison between anglers or regions. The *hook/catch ratio* was calculated by dividing the total amount of successful catches (fish hauled into the boat) divided by the number of bites (times a fish was hooked including fish the fish that were lost). This was calculated for the total fishing effort and per team. The objective of this calculation is to give an indication of the difficulty of successfully catching a BFT versus hooking one. Figures of the data were then made in R-studio (version 1.4.1717) to visualize the data.

2.3 Economic evaluation of the survey data:

The decision to look at the economic value that the BFT recreational fishing would have for Norway was made in early 2021, making an on-site survey regarding the 2020 season was impossible. Therefore, the only option to get a proper indication of the total value of the BFT fishing in 2020 was to use an off-site digital survey. Through collaboration with Danish scientists, it was decided that the Danish questionnaire made by PhD student Kristian Maar for assessing the value of the recreational BFT fishing in Denmark would be used for calculating the value of the recreational BFT fishing in Norway as well (Maar *et al., in prep*), to be able to compare results between the two countries easily.

The Danish Questionnaire was made ready for use in Norway and translated to Bokmål by the author of this thesis for use on the Norwegian fishermen. The questionnaire had a broad set of questions to give a clear perspective on the efforts made by the recreational anglers, such as the hours spend in preparation in order to fish for BFT or kilometers driven in connection to BFT fishing and expenditures like expenditures made on fishing equipment and gasoline used for the boat. Besides the efforts and spending on fishing, questions about gender, age and distances traveled in connection with BFT fishing were also asked. Some questions regarding personal information in the Danish questionnaire were removed from the Norwegian one as the Norwegian questionnaire needed to be anonymous. The decision to make the Norwegian questionnaire anonymous was made as the process of getting permission for handling personal data would take too much time and it was unclear if it would be approved. Other questions in the Danish questionnaire that were specific to Denmark were adjusted so that they would be appropriate for Norway (e.g. questions about fishing in the Skagerrak were replaced by questions about fishing in the Norwegian sea). Overall, an effort was made to adjust the questionnaire to an absolute minimum. Two extra question were added: 1, ''Did you have permission to fish for BFT in 2020?'', was added to ensure that nobody outside of our target audience would fill in our survey. 2, ''Would you have used the same amount of money on BFT fishing if the chances of catching a BFT were smaller?'', was added to get an indication on the motivation for the fishermen to actually catch a BFT versus being able to fish for them. The end result was an economic survey consisting of 38 questions **(appendix, table 4)**.

In order to make the questionnaire publicly accessible, it was uploaded and created in Typeform by the author of this thesis. Typeform is an easy accessible online questionnaire website (www.typeform.com). A Typeform questionnaire creates a unique ID for all respondents answering in the questionnaire and will thus allow the owner of the questionnaire to check for potential double reporting. An effort was made to give the questionnaire a capturing design to motivate the target audience to answer the questions. The questionnaire was completely anonymous and was made available to the recreational BFT fishermen on the 17th of March 2021 through a link sent by SMS. 200 out of 215 recreational BFT fishermen that were given a permit were registered with their phone number at the Norwegian Directorate of Fisheries, which made the sending of this SMS possible. A message in a private Facebook group (Størjefiske 2020) that was setup for collaboration between BFT fishing teams in Norway was published on the 2nd of March by Dr. Keno Ferter from IMR. On the 17th of March a message with a direct link to the questionnaire was posted in the Facebook group ''Størjefiske 2020''. A reminder was posted on the 7th of April, thanking the fishermen that took the time to fill in the survey and making them aware that the survey would close within ten days. The questionnaire which saw no increase of participants after the 11th of April was closed on the 17th of April 2021.

2.4 Questionnaire Analysis:

A total of 94 participants filled in the survey, which all had a unique web ID. Eight of the respondents answered that they did not have permission to fish for BFT in 2020. Therefore, these eight were automatically excluded from partaking in the questionnaire any further. Another nine fishermen that filled in the questionnaire were removed from the total sample size because they did not fish for BFT in Norwegian waters in 2020. Some questions were left open by participants which led to a fluctuating amount of answers per question. This left us with a total usable dataset of 77 participants (N=77) and 2675 responses. In order to make the best possible estimate available, a total of 10 individual responses out of the total of 2675 were not used and removed from further calculations.

The economic value of the BFT fisheries in 2020 was calculated through the expenditures (costs) that the fishermen made in order to fish for BFT (*cost=value*). This value is given in NOK. The expenditures and efforts made by "boat-owners" (n=32) were compared with "non-boat owners" (n=45). The category ''boat-owners'' included both full owners and part owners of one boat. Answers regarding the effort with different units (such as hours, days and kilometers) were calculated separately and visualized using a table displaying the totals, averages and standard errors. The calculations for this table were done on Excel while the table was made in R-studio (version 1.4.1717).

The Questions regarding expenditures were combined into three different categories; “Boat related costs”, “Fishing equipment costs” and “Other costs in relationship to BFT fishing in 2020”. Each category is described below and the question numbers are added so that they can be looked up in the **Appendix (table 4)**.

The boat related costs category (**Q24**+**Q25**+**Q26**+**Q27**) is a combination of the answers given on questions of the questionnaire regarding the cost on the fishing boat used for BFT fishing. These exclude the value of the boat (**Q5)** yet include: maintenance costs, gasoline for the boat while fishing for BFT, boat equipment needed for BFT fishing and rental of harbor place.

The fishing equipment costs category (**Q22+Q23**) is a combination of two questions of the questionnaire regarding fishing equipment. This includes the costs of rods, reels, line, hooks lures and equipment such as fighting belts.

The other costs in relationship to BFT fishing in 2020 category (**Q28+Q29+Q30+Q31+Q32+Q33+Q34+Q35)** involves questions regarding costs on: transport, such as gasoline for the car, boat transport costs, ferries, parking, car rental and bridges; costs on other equipment needed for BFT fishing such as clothes, gloves, sunglasses, camera and binoculars; the cost for overnight stays in connection to BFT fishing; the cost of souvenirs and goods such as team jerseys, keys, trophies and flags in connection to BFT fishing; and the cost on other expenditures that are not specified in this questionnaire.

For each of the three categories of costs, a box-plot was made in R-studio comparing the expenditures made by boat-owners vs non-boat owners. A Welch t-test was run for each boxplot to calculate the significance of the differences in expenditures between boat-owners and non-boat owners. The answers given to **Q5** in the questionnaire regarding the total value of the BFT fishing boat, including trailer, fishing equipment needed for BFT fishing, electronics and other equipment are not used in the boat related cost category. The reason for this is that the boats are not exclusively used for BFT fishing and the costs are therefore not costs that are exclusively made for BFT fishing. Boats are however crucial for the BFT fishing and thus the expenditures will be used as “boat investment costs’’ in calculations. These costs that are not exclusively made for BFT fishing, were also not used for calculations in the Danish study (Maar *et al. in prep*).

For the calculations of the economic value (**Q22:Q35)** that are exclusively made for BFT fishing, all of the costs made exclusively for BFT fishing of the respondents (n=77) were added up in Excel. These were then compared to the expenditures by boat-owners and non-boat owners, to make sure no mistakes were made in either of the calculations. In order to include boat investment costs in these calculations, the other costs (**Q27: Q35)** made by boat owners (n=32) that were not included in the question regarding boat investment, were added up to the boat investment costs **(Q5)**, and then the total costs **(Q22: Q35)** by non-boat owners (n=45) was added.

2.5 Analysis of expenditures in relation to catches:

The amount of money spent per caught BFT was calculated by dividing the number of fish caught by the total costs **(Q22:Q35)** spent for BFT fishing. Furthermore, a calculation was performed to see if spending more money on fishing equipment or spending more money in all categories would lead to catching more BFT for both boat-owners and non-boat owners. Figures were made in R studio to visualize this relationship between expenditure and amount of fish caught for both fishing equipment and total cost. The significance of both of these calculations was calculated with an ANCOVA for boat-owners and non-boat owners.

3. Results:

3.1 Logbook data results:

3.1.1 BFT observations made by the recreational fishermen:

In 2020, the recreational fishers made a total of 700 BFT observations. This is a conservative estimate made by Erling Boge. The observed BFT were usually seen by the fishermen while they were hunting mackerel. For a map of the BFT observations of 2020 see figure 5:

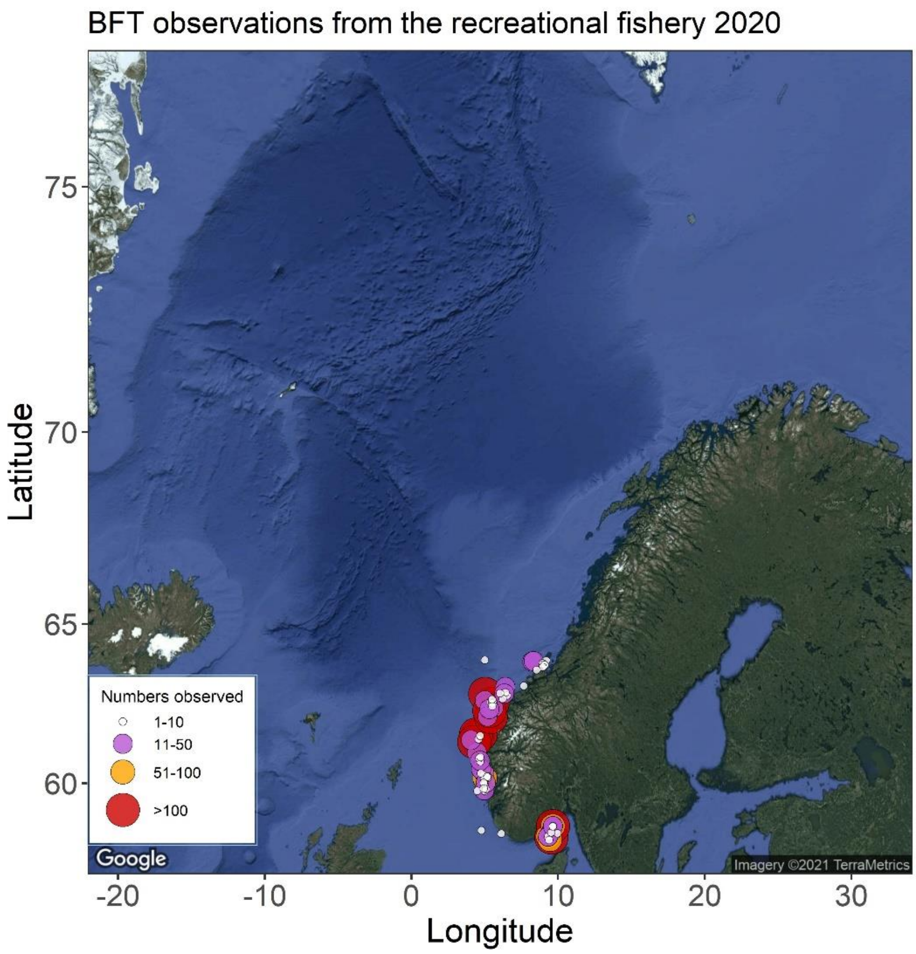

Figure: 5 A map of all the observations made by the recreational anglers that had permission to fish for Atlantic bluefin tuna (Thunnus thynnus) in 2020. The size of the dots indicate the number of tuna observed in a certain area. This figure, and the research performed to on observational bluefin tuna data was performed by Erling Boge.

3.1.2 Fishing results in 2020:

In 2020, the recreational BFT fishing teams set out for a total of 176 attempts to fish for BFT in Norwegian waters, combining for a total fishing time of 1641 hours. The team with the most fishing attempts went out 18 times, while the team with the least fishing attempts fished for BFT once. On average, the teams would go out and fish for BFT 7.33 ± 0.96 times. The team that spent most hours targeting for BFT had a trip time of 159.5 hours, while the team that fished the least only fished for 5 hours. On average, teams fished for BFT for 68.3 ± 0.36 hours. The average fishing trip lasted 9.2 ± 0.01 hours in 2020.

In 2020, the recreational fishing teams got 51 hook-ups which led to the landing of 19 BFTs while the remaining fish managed the escape. This leads to an overall catch ratio of 37.25%. 11 of the 24 teams fishing for BFT managed to catch at least one fish, while 13 teams caught no fish. The highest number of fish caught by a single team was 4 fish. This results in the teams catching 0.79 ± 0.25 BFTs in 2020 on average. 9 of the 19 fish caught by the recreational fishermen were harvested for consumption (47%), while the other 10 BFT's (53%) were tagged and released. On average 3.7 ± 0.09 rods per team were used by the fishermen per fishing session.

3.1.3 Catch per unit effort & time to catch one fish:

When the combined total trip time of all teams (n=24) is used as unit of effort, then the combined catch per unit effort (CPUE) in 2020 was 0.012. The team with best CPUE of 0.056 fish per unit effort fished for 72 hours and caught 4 BFTs. The large difference between overall CPUE and highest team can be explained by the many fishing teams that did not catch a single fish (n=13).

The total time to catch one fish for all fishing teams (n=24) is about 86 hours. The team that needed the least amount of time only needed 18 hours per fish, while the team that needed the most time and caught BFT needed 116 hours per fish. The 13 teams that did not manage to catch a BFT in 2020 fished for a combined 711 hours divided over 67 fishing trips. Overall there was large variation between fishing teams during the 2020 fishing season. Table 1 ranks all the teams based upon catching the most fish followed by the catch per unit effort (CPUE), followed by time fished (from low to high).

Table 1: Table of all Atlantic bluefin tuna (Thunnus thynnus) fishing teams that participated in the recreational fishing in Norway in 2020. The teams are ranked on amount of fish caught, followed by CPUE, followed by time fished (trip time) from lowest to highest. Team names are anonymized for privacy. .

Rank:	Team:	Fish Caught:	Fishing trips:	Hours Fished:	CPUE:
1	Team A	4	12	72 Hours	0,056
2	Team B	4	11	100 Hours	0,04
3	Team C	3	10	111 Hours	0,027
4	Team D	1	3	29 Hours	0,034
5	Team E	1	6	39 Hours	0,026
6	Team F	1	7	63 Hours	0,016
7	Team G	1	8	79 Hours	0,013
8	Team H	1	9	91 Hours	0,011
9	Team I	1	9	102 Hours	0,0098
10	Team J	1	12	105 Hours	0,0095
11	Team K	1	18	116 Hours	0,0086
12	Team L	0	1	5 Hours	N/A
13	Team M	0	1	8 Hours	N/A
14	Team N	0	1	12 Hours	N/A
15	Team O	0	2	16 Hours	N/A
16	Team P	0	3	28 Hours	N/A
17	Team Q	0	3	29 Hours	N/A
18	Team R	0	3	32 Hours	N/A
19	Team S	0	6	54 Hours	N/A
20	Team T	0	6	74 Hours	N/A
21	Team U	0	9	88 Hours	N/A
22	Team V	0	12	113 Hours	N/A
23	Team W	0	8	118 Hours	N/A
24	Team X	0	16	160 Hours	N/A

3.1.4 Fishing strategies:

All of the 19 BFT that were caught in 2020 were caught on spreader-bars.

The following chart highlights the amount of times different types of fishing strategies have been used in 2020 during all fishing trips (n=176) (fig 6). The most popular fishing method in 2020 was with spreader-bars, followed by other strategies such as specifically designed tuna lures. It is important to mention that many boats used multiple rods at the same time while targeting BFT and that often multiple strategies were implemented at the same time. Most teams used similar amounts of rods.

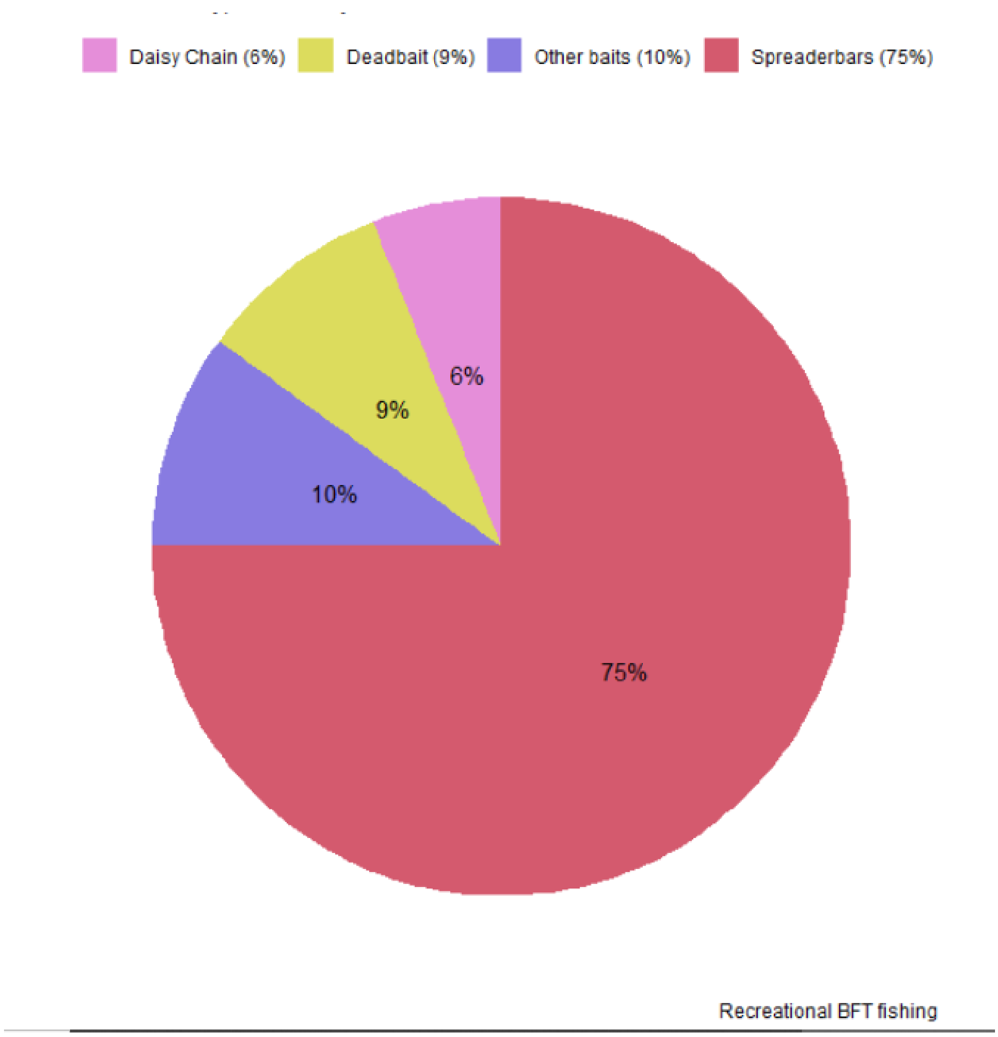

Figure 6: Pie chart of fishing strategies used in the recreational fishing in Norway for Atlantic bluefin tuna (Thunnus thynnus) according to the logbook data during all trips (N=176) in 2020. Spreader-bars was the most used fishing strategy in 2020, followed by other strategies such as lures, dead bait and daisy chain.

3.2 Questionnaire results:

3.2.1 Non-economic survey results:

All participants from the questionnaire data (N=77) identified as male (100%), being 20 to 71 years old (Average age of 46 years old ± 1.24). The average yearly income before tax of our respondents (N=55) was 768 063 ± 75 017 NOK in 2020. Despite the fact that only 19 BFTs were caught in 2020, 75% of all respondents (N=77) state that they would spend similar amounts of money on tuna fishing and equipment if the chances of catching a BFT would be even lower than they were in 2020. All of the respondents (N=77) fished exclusively for BFT during their fishing trips.

27.3% of the respondents (N=77) state they ate in restaurants and similar places more often in connection to BFT fishing. The respondents (N=77) slept for a total of 259 nights outside of their own homes in connection to BFT fishing. 86.5% of these overnight stays was solely because of the fishing for BFT. Other answers of the respondents regarding non-economic results and effort can be found in table 2**, s**uch as the total kilometers driven in connection to BFT fishing (40 249 KM), total amount of days fished (588 days), total amount of days that fishermen intended to go fishing but it was not possible because of bad weather (1210 days), total amount of overnight stays outside of your own home in connection to BFT fishing (259 nights), the total preparation time for BFT fishing (Time needed to equip the boat and rods to go fishing) (6887 hours) and the total amount of nautical miles traveled (34 015 NM) in relation to BFT fishing:

Table 2: A summary of the non-economic survey results of the questionnaire on the efforts made by Norwegian anglers that were targeting Atlantic bluefin tuna (Thunnus thynnus), divided by boat ownership, with boat owners (n=32) on the left and non-boat owners (n=45) on the right. The survey question can be found in the first column. The total, average and standard error can be found in the next columns.

	Boat owners:			Non-boat owners:		
Question:	**Total:**	**Average:**	**SE:**	**Total:**	**Average:**	**SE:**
How many km did you drive in your car in connection to BFT fishing in 2020? **Q8**	13260	428	102.6	26989	613	149.9
How many days have you been out and fished specifically for BFT in 2020? **Q10**	325	10	1	263	6	0.6
How many days were you not able to fish for BFT because of the weather, lack of crew etc. in 2020? **Q11**	723	23	4.3	487	11	1.8
How many nights did you spend outside of your own home in the vicinity of your departure harbor in connection with BFT fishing in 2020? **Q15**	115	3.6	0.8	144	3.2	0.7
How many hours did you spend on preparation and transport in connection to BFT fishing besides fishing and traveltime in 2020? **Q18**	4085	132	26.6	2802	62	22.1
Circa how many nautical miles did you travel in total in connection with BFT fishing in 2020? **Q20**	22505	703	88.1	11510	295	42.5

3.2.2 Economic survey results:

3.2.2.1 Boat related costs:

For the recreational BFT fishing season of 2020, the total boat expenditures of our respondents are 2 774 550 NOK. These expenditures include boat maintenance (859 450 NOK), gasoline (525 700 NOK), boat equipment bought in relation to BFT fishing (1 327 500 NOK) and the use of harbor facilities (61 900 NOK). Boat owners (n=32) spend 90.7% of the total expenditures with non-boat owners (n=44) only spending 9.7% of the total expenditures. The differences between expenditures between boat owners and non-boat owners on boat costs is significant (p=1.061e-05). A box-plot of the comparison in expenditures between boat owners and non-boat owners is displayed in figure 7.

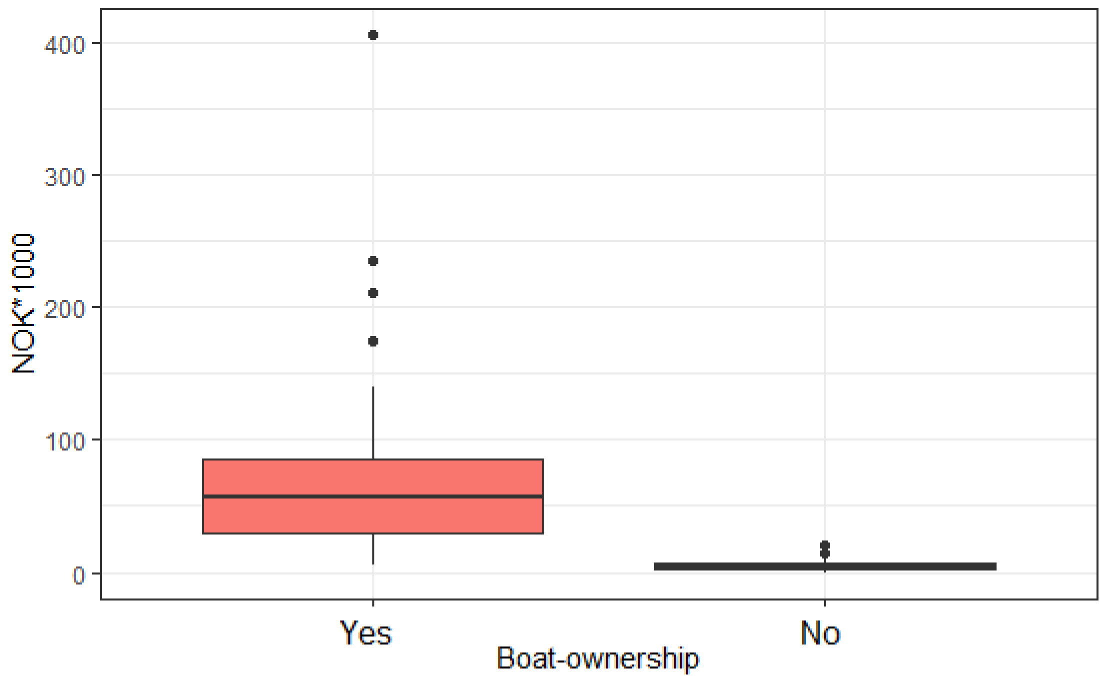

Figure 7: A box plot showing the difference in expenditures between boat owners (n=32) and non-boat owners (n=44) on boat related costs in Norway in 2020 according to the questionnaire. Values are in NOK and divided by 1000. The x-axis displays boat-ownership, with Yes being boat-owners and No being non-boat owners. The Y-axis displays the amount of money spend and needs to be multiplied by a 1000 to gain the original value. Boat owners spend significantly (p=1.061e-05) more (mean=80.1±14.4) then none-boat owners (mean=4.8±0.64).

3.2.2.2 Fishing equipment costs:

For the recreational BFT fishing in Norway, a total of 3 432 500 NOK was spent on fishing equipment in relation to BFT fishing in 2020. These include costs for rod and reel (2 532 500 NOK) and costs for other fishing equipment such as lines, hooks, leaders, spreader-bars fighting belts etc. (900 000 NOK). Boat owners (n=32) spend 72.5% of the total budget, with non-boat owners (n=45) spending the remaining 27.5%. The differences between expenditures between boat owners and non-boat owners on boat costs is significant (p= 8.053e-06). A box-plot of the comparison in expenditures between boat owners and non-boat owners on fishing equipment is displayed in figure 8.

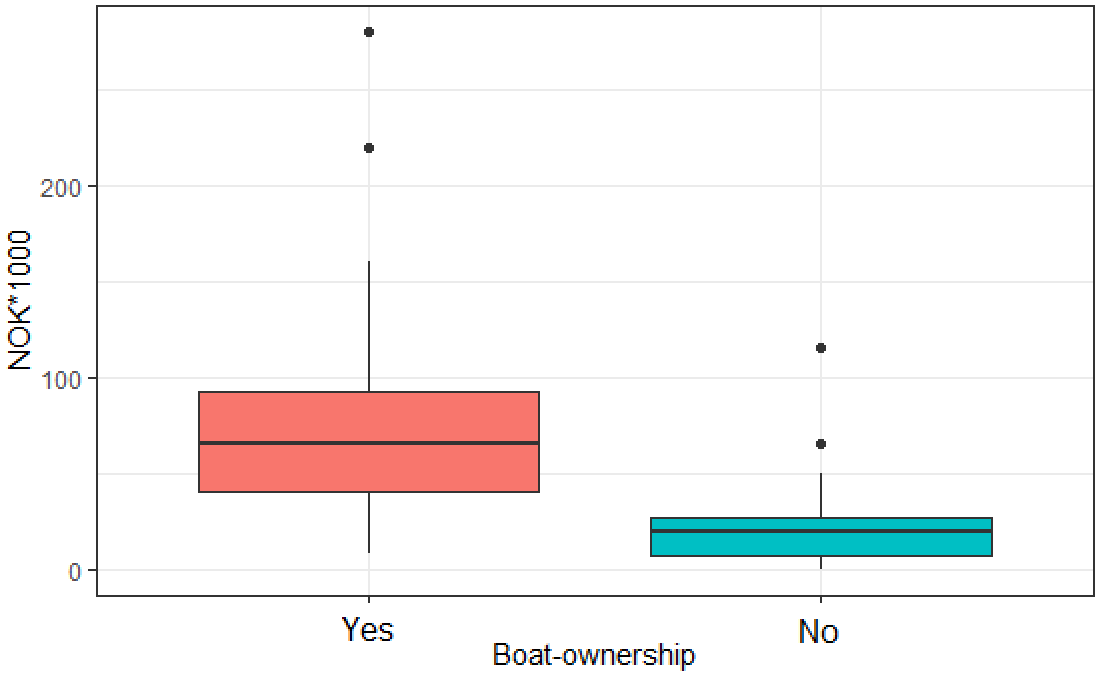

Figure 8: Box plot showing the difference in expenditures between boat owners (n=32) and non-boat owners (n=45) on fishing equipment in Norway in 2020 according to the questionnaire. Values are in NOK and divided by 1000. The x-axis displays boat-ownership, with Yes being boat-owners and No being non-boat owners. The Y-axis displays the amount of money spend and needs to be multiplied by a 1000 to gain the original value. Boat owners spend significantly (p= 8.053e-06) more (mean=77.7±10.49) then none-boat owners (mean=21±2.99).

3.2.2.3 Other costs made in relationship to BFT fishing in 2020:

A total of 745 117 NOK was spent in the other costs category. These costs include transport (180 960 NOK), other equipment (303 200 NOK), overnight stays (84 657 NOK), drinks in the pub (27 400 NOK), souvenirs and other goods such as team jerseys, key chains, trophies and flags (58 100 NOK) and other expenditures that were not covered in the questionnaire (90 800 NOK). Boat owners (n=32) spend 67.8% of these other costs, with non-boat owners (n=43) spending the remaining 32.2%. The differences between expenditures between boat owners and non-boat owners on boat costs is significant (p= 0.0496). A box-plot of the comparison in expenditures between boat owners and non-boat owners on these other costs is displayed in figure 9.

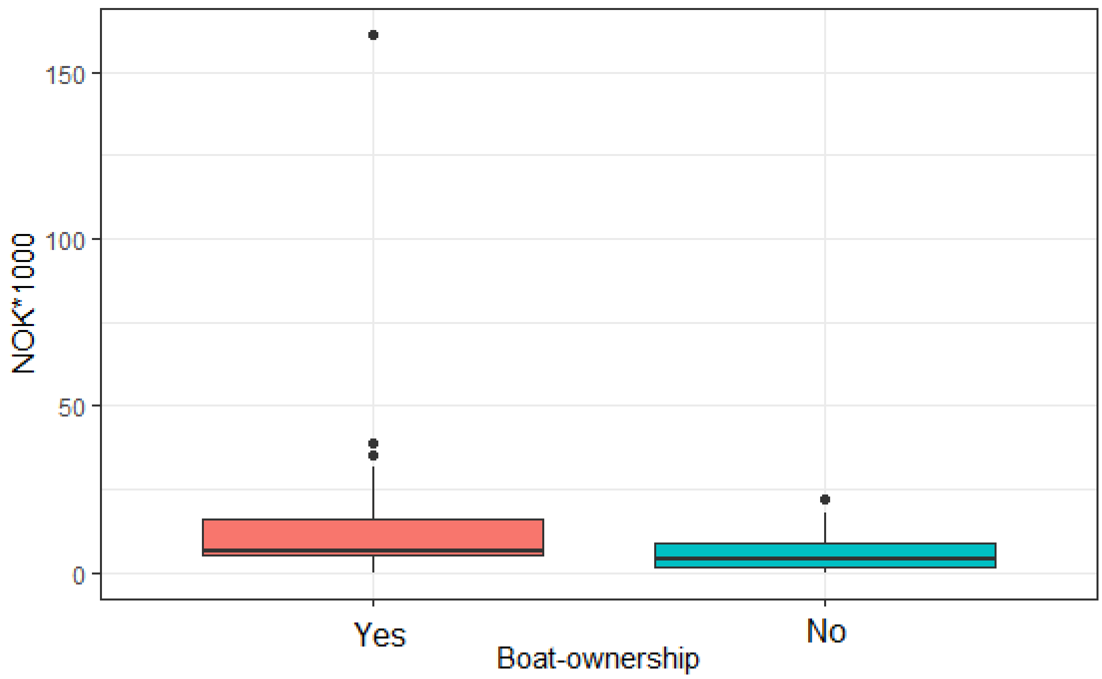

Figure 9: Box plot showing the difference in expenditures between boat owners (n=32) and non-boat owners (n=43) on other costs on other costs in Norway in 2020 according to the questionnaire. Values are in NOK and divided by 1000. The x-axis displays boat-ownership, with Yes being boat-owners and No being non-boat owners. The Y-axis displays the amount of money spend and needs to be multiplied by a 1000 to gain the original value. Boat owners spend significantly (p= 0.0496) more (mean=15.8±5.0) then none-boat owners (mean=5.5±0.78).

3.2.3 Total cost made by respondents in 2020:

The combined costs (boat costs, fishing equipment costs, other costs in relationship to BFT fishing in 2020) that are made exclusively for BFT fishing in 2020 of all our respondents (n=77) ads up to a total of 6 952 167 NOK. Boat owners (n=32) spend 79.9% of the total budget with an average spending of 173 611 ± 1293.7 NOK per boat owner. Non-boat owners (n=45) spend 20.1% of the total budget with an average spending of 31 205 ± 255.2 NOK per non-boat owner.

The total boat investment costs of our respondents (cost that are not exclusively made for BFT fishing) combine for a total of 38 100 000 NOK. When these investment costs are considered, then the total cost exclusively made for BFT fishing + Boat investment costs would be 41 261 167 NOK.

3.2.4 Does spending more money increase your chances of catching a BFT?

In 2020, the recreational fishing teams (n=24) caught a total of 19 fish. This means that the costs made per caught BFT in 2020 are 365 904 NOK per fish. Spending more money on fishing equipment did not result in catching more BFT for boat-owners (p=0.864) or non-boat owners (p=0.36). Spending more money on all the cost categories combined did also not lead to an increase in caught BFT for both boat-owners (p=0.979) and non-boat owners (p=0.245). A more detailed look regarding expenditures for both fishing equipment and the total costs can be found in Figures 10 and 11:

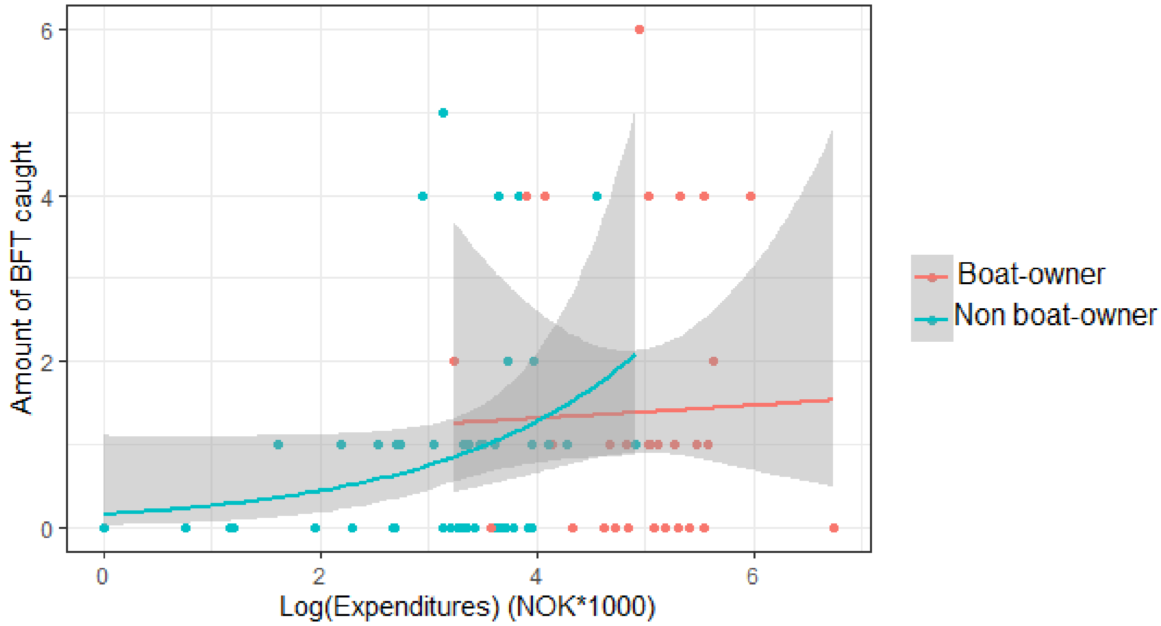

Figure 10: The amount of money spend on fishing equipment for Atlantic bluefin tuna (Thunnus thynnus) in Norway in 2020 did not lead to catching more tuna for both boat-owners (n=32)(red dots and line) (p=0.864) and non-boat owners (n=45) (blue dots and line)(p=0.36). The X-axis shows the log of the expenditures divided by 1000 (the original value is a 1000 times higher). The Y-axis shows the number of Bluefin Tuna (Thunnus thynnus) caught.

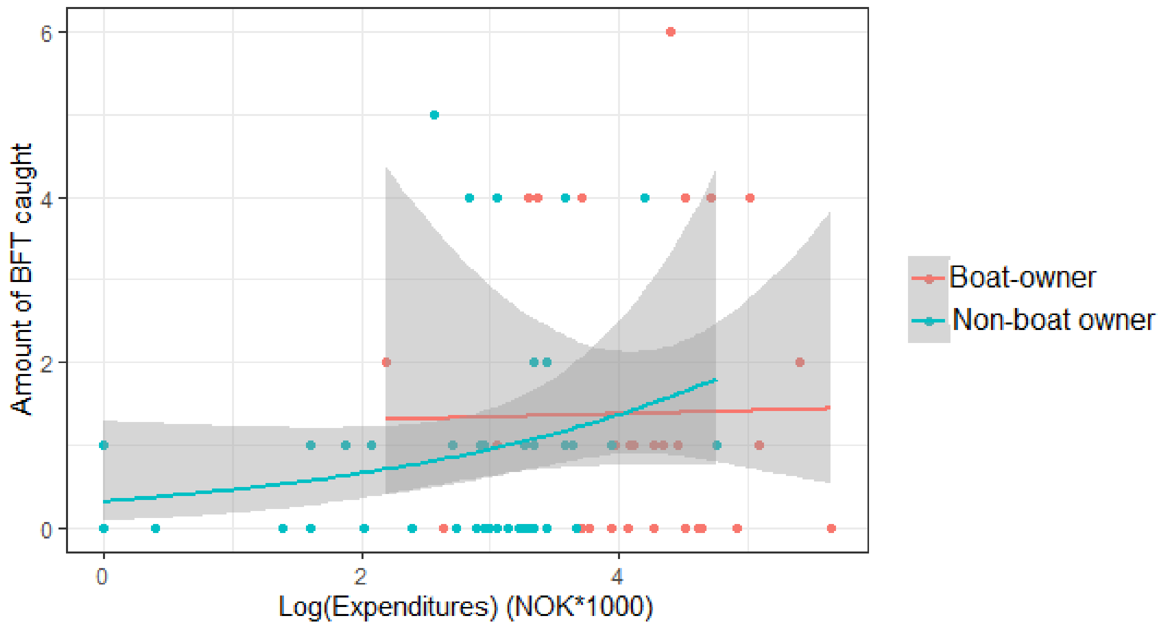

Figure 11: The amount of money spend in total for fishing Atlantic bluefin tuna (Thunnus thynnus) in Norway in 2020 did not lead to catching more tuna for both boat-owners (n=32) (red dots and line) (p=0.979) and non-boat owners (n=45) (blue dots and line)(p=0.245). The X-axis shows the log of the expenditures divided by 1000 (the original value is a 1000 times higher). The Y-axis shows the number of Bluefin Tuna (Thunnus thynnus) caught.

4. Discussion

4.1 The recreational BFT fishing season of 2020:

The collaboration between the fishing teams and scientists from IMR has been an effective citizen-based science project in 2020. The project brought valuable observational data which can help with studying the migration patterns of BFTs foraging in Norwegian waters and help with more effective BFT fisheries management and/or conservation efforts in the future. Furthermore, the successful tagging of ten BFTs by the recreational fishermen contributes to establishing better population estimates and can give further insights into BFT migration in Norwegian waters. The actual fishing data gave an insight into how BFTs were caught and which fishing strategies were preferred by the fishermen and which of these was most effective for catching BFT. Together with the economic survey data it clearly showed the large effort in time and money that the recreational fishermen were willing to use in the hope of catching their target fish.

Besides the things that went well in this project, there are a few things that could need improvement for the future studies on the recreational fishing for BFT. Regarding the logbook data, more effort should be placed on the recreational fishermen handing in complete logbooks, as contacting the fishermen at a later moment to collect the data led to incomplete data due to loss of memory. This responsibility lies both on the fishermen and IMR, who can both start verifying the data once it becomes clear that the BFT fishing season is over in early autumn. The logbook itself should also be extended:

- A question about how many different individual people are on board per fishing session can be a valuable addition. This could help with estimating expenditures per angler per fishing trip, something that was not possible this year.
- A question about actual fishing time should be added, as in this study the CPUE and time to catch one fish are based on total trip time instead of actual fishing time.
- A question about which fishing method/bait caught or hooked the fish should be added as well. With only 19 fish being caught in 2020, it was easy to find out at a later point which fishing strategy was used to catch the fish. The number of fish caught could increase in the future, making it harder to find this out. This data could help improve the recreational fishing in the future, making it more effective.
- A question should be added about catch location of the BFT, in 2020 recreational fishermen were only required to write down the coordinates of the location where

the fish was tagged, thus no location data was available in 2020 on the fish that were dispatched. This location data could help in the future to explain the differences between teams catches.

4.2 Fishing strategies:

Recreational anglers in 2020 showed a very clear preference for fishing with spreader-bars, which were used in almost all fishing trips, sometimes in combination with other fishing strategies (n=176). All of the BFTs (n=19) caught in 2020 were caught on spreader-bars. On only eight fishing trips of the 176 did fishermen not use spreader-bars on one of the used fishing rods. A possible explanation for this clear preference of spreader-bars by the recreational angler is that both spreader-bars and live-baits are popular methods for BFT fishing in general and that live-bait fishing is illegal in Norway (Ferter *et al.,* 2018; Tracey *et al.,* 2020), thus leaving spreader-bars as the best option available. Another explanation would be that the fishermen communicated about catching success with spreader-bars, as most recreational fishermen knew each other and openly shared information on spotted BFT, catches and fishing strategy used. However, the logbook data does not show an increase of the use of spreader-bars by teams over time thus making this explanation unlikely.

4.3 Tagging:

10 of the 19 BFTs have been successfully tagged by the recreational fishermen with conventional tags in 2020. One of the fish was transferred to a research vessel used by scientist of IMR to fish for BFT and also received a satellite tag. Besides the 19 fish caught by the recreational fishermen, another five BFTs were caught by the research vessel of IMR. Four of these fish were equipped with a satellite tag as well and one fish was dispatched. This makes the total catch of rod and reel fishermen in 2020 24 BFT (N=24)(100%) from which 14 were tagged and released after capture (58%).

In 2018 and 2019, a combined total of six fish were tagged in the Norwegian waters with nine teams of recreational anglers helping in the tagging effort of 2018 and four teams helping in the tagging effort. It thus seems that having more recreational tagging teams leads to a large increase in the amount of fish tagged. Although other factors, such as the amount of days fishing for BFT was possible due to the weather in all of these years also plays an important factor in the tagging success.

4.4 Off-site survey results:

4.4.1 Argumentation for the removal of datapoints:

10 out of the total of 2675 answers on the questionnaire were removed from further analysis. The argumentation for the removal these values is that they were deemed unlikely and were most likely a typo or the question was misunderstood by the participants. Five datapoints where removed from the question regarding the amount of time spent fishing for BFT on an average day in 2020, as these five datapoints exceeded 24hours, and it thus seems likely that the question was misunderstood. Three datapoints where removed from the question regarding the distance traveled in nautical miles in relationship to BFT fishing. One of these datapoints has the value of 100 000 NM, which is a likely a typo, as it would be 2.5 times the distance of traveling the earth at the equator. The other two removed datapoints are zero. These datapoints are removed as it can be said with certainty that no one fished from shore for BFT in 2020 and thus a boat must have been used in the process. Two more datapoints where removed from the question regarding distance traveled by car, these distances (8400km and 15 000km) are more than ten times the average, and considering the fact that the shortest car distance from Kristiansand to Kirkenes would be 2150 km, this would mean that the person traveling 8400km has traveled pretty much the equivalent of the country of Norway almost four times in his car.

4.4.2 Estimated value of the recreational BFT fishing in Norway :

In 2020, a total of 215 people had a permit to fish recreationally for BFT in Norwegian waters in 2020. However, it is unclear how many of the fishermen actually went out to fish for BFT in 2020. It is highly unlikely that all of the 215 people that signed up for BFT fishing actually went out to try in 2020, and it is likely that the most active participants in the fishing are also the ones that filled in this questionnaire. It is therefore hard to make estimates based on the total of 215 people as these will most likely exaggerate the actual value of this beginning sector due to avidity bias.

Therefore, the most reliable value estimate would be estimating the minimum value on an macro-economic level of what this recreational fishing is worth, by simply taking the total of our 77 survey participants. One argument for doing this is that we know that 24 fishing boats went out in 2020 and that 32 people that filled in the survey are a full or a shared owner of a boat. This is likely a large part of the boat owners total sample size.

The total minimum value of the recreational BFT fishing in 2020 in Norway is therefore estimated to be at 6 952 167 NOK, with an average spending of 173 611 ± 1293.7 NOK for boat owners and an average spending of 31 205 ± 255.2 NOK for non-boat owners.
It is unclear how much of the money spent has been spent directly in Norway, as the survey did not give insights as to where the expenditures were made. Nonetheless, it seems likely that a large proportion of these costs have been made in Norway but that certain expenditures, for example on specific lures like spreader-bars that are currently not available in Norway, have been made abroad. If boat investments costs are included in the calculation of the total economic value of the recreational BFT fishing in Norway in 2020, then the total minimum value would be 41 261 167 NOK.

4.5 Potential for Bias:

Recreational fishing surveys have a possibility for bias such as nonresponse, underreporting, recall and avidity bias (Thomson, 1991; Cooke et al., 2000; Jones & Pollock, 2012; Gundelund *et al.,* 2020). The chances of these biases in the logbook-data of the 2020 recreational season is however unlikely as there was only a very limited amount of BFT caught, that were either dispatched or tagged. Recall bias is however possible for both amount of fishing trips taken, fishing strategy and amount of hours fished per trip, this would thus have an impact on the CPUE and the amount of hours fished and the fishing strategies that were used in 2020.

In the economic survey, there may be an incentive for the anglers to over-report on costs made, in the hope that this will give the BFT recreational fishing a stronger foothold in management. Some of the costs made by anglers indeed seem to be well above average such as an individual spending 85 000 NOK on gasoline for the boat, more than 10 times the average, while traveling a similar distance in nautical miles. This, however, can also be recall bias as the questionnaire was run about 6 months after the fishing occurred. Another example of potential recall bias is that some fishermen claimed to have been on-board of ships while more than 4 BFTs where caught. On the other hand, this can also be true as the fishermen might have joined different fishing teams in the 2020 season. In order to decrease the chances of recall bias, it is recommended to run the next economic survey right after the fishing season closes.

Underreporting on the economic survey seems less likely as there is no real incentive to underreport. The questionnaire did not ask about anything in which it is beneficial for the respondent to underreport (such as potential illegal activities). Avidity and non-response bias have been avoided in this thesis by only using the values given by our respondents.

4.6 Comparison with similar studies:

The study by *Bohnsack et al.,* (2002) estimated the total value of the already established recreational BFT fisheries in North Carolina at 5 million USD. The second study that we can use for comparison is the study from Deloitte (2013), which estimated the minimum value of their established recreational Southern bluefin tuna fisheries in Portland in 2012 at 5.6 million dollars.

When converted to USD dollars (13-9-2021), the recreational spending by our respondents on BFT fishing is worth $804 287 dollars. This lower overall value of the recreational sector in Norway in comparison to both of these studies can be explained by the fact that our study did not estimate the costs of all fishermen. Furthermore the other two recreational sectors are well established, and have been around for longer and are thus likely bigger. For example, a total of 1390 individual trips where taken in the study by *Bohnsack et al.,* when taking the average amount of fishermen on board a ship (4) and multiply this by the amount of trips (176) the total amount of individual trips in Norway would just be 704, about half as much. It is unclear how many fishing trips were taken in the study by Deloitte. The lower spending by Norwegian anglers in comparison to the other two studies can also be explained by the fact that all fishing in Norway takes places on private boats, while the other studies have day anglers that pay a fee to fish from a charter boat. These charter fees makes up a large sum of the total spending in both of these studies. There are currently no companies offering charter boats to go out in Norwegian waters to fish for BFT as this is currently not possible due to the tight rules regarding the recreational BFT fishing such as a ban on charter fishing for BFT.

4.7 Importance of recreational fishing in fisheries management and science:

The effects and values of recreational fisheries have largely been overlooked, especially within Europe (Hyder *et al.,* 2018; Brownscombe *et al.,* 2019). It is however important to include recreational fishing into fisheries management as it can reduce the capacity of fishing stocks to their maximum sustainable yield (Hyder *et al.,* 2014). Moreover, knowing the economic value of a recreational fisheries can help with establishing its importance as an ecosystem service. The European commission recognized the importance of collecting data on recreational fishing for member states for selected fish species, including BFT (EU, 2001).

Despite the EU data collection requirements many Europe countries were slow with initially setting up suitable survey methods (Hyder *et al.,* 2018).

Research on the economic value of recreational fishing as ecosystem service is equally important, as it can motivate governments to imply policy to support recreational fishing and protect species. An example of this is the recreational fisheries on bonefish (*Albula vulpes*), whose economic value lead to an nearly entire protected C&R only recreational fishery, as well as bonefish habitat protection in the Bahama's (Danylchuk et al., 2008; Fedler, 2013; Sherman et al., 2018). Establishing the value of recreational fishing can also help with prioritizing resource use and can for example help with setting up Marine Protected Environments (MPA's) in which in some cases, C&R fishing is allowed (Cooke *et al.,* 2006).

By analyzing the logbook data and running an economic survey among the recreational BFT fishermen of 2020, this thesis has aimed to increase the knowledge on the importance that recreational fishing might have, as an ecosystem service, in Norway.

4.8 Future expenditures and increase of the sector:

In 2021, the Norwegian Ministry of Trade, Industry and Fisheries increased the BFT quota for the recreational fisheries to six tons for harvest and four tons for tagging and C&R after the 2020 season. A total of 40 teams are allowed to go out BFT fishing in 2021. This is a 66% increase in teams and it is likely that more teams will join in the years to come. This increase in teams will increase the total value of the recreational BFT sector significantly as every team would have to invest in its own boat and fishing equipment. However, one could easily assume that the amounts of teams fishing for BFT in Norwegian waters at some point will reach its peak and that during this time, the yearly expenditures will drop.

The most expensive costs of BFT fishing such as boat and fishing equipment can be considered longtime investments, that would only need replacement after several years of use. It is thus likely that the boat costs, as well as the BFT fishing equipment costs, will slowly decrease over time. Furthermore, a market will establish itself for 2nd hand equipment which will decrease expenditures for starters in this expensive hobby. However, some costs are likely to be similar every year such as boat maintenance and harbor berth, fishing equipment such as lines and bait, gasoline for car and boat. It is also likely that as experience for BFT fishing grows among the fishermen in Norway, different boats will be bought that seem better suited for the hobby and other methods might be tried that seem more successful. It is therefore hard to say how much the total value of this sector would be worth in the future, but it is very likely to be higher than it was in 2020. The key factor of this recreational fisheries to be successful in Norway, and the most important factor that will decide how many teams can or will eventually sign up for BFT fishing, is eventually the political decision of how much quota is allocated to the recreational fisheries.

4.9 The potential of Norway as a big game fishing destination:

Norway is already a popular destination for many tourist anglers for saltwater fishing (Borch *et al.,* 2011). Now with the return of the BFT to Norwegian waters, one could hypothesize the potential of Norway as a big game fishing destination. Recreational fishing for BFT can be a lucrative business model (Bohnsack *et al.,* 2002; Deloitte, 2013). The key element for this to happen would be the allowance of charter fishing for BFT in Norwegian waters by ICCAT (ICCAT, 2018). One could hypothesize that the likeliness of this ban being lifted has increased now that the BFT is no longer considered threatened (IUCN, 2021)**.**

If charter fishing for BFT does become legal then the average large size BFTs can lure in many tourist anglers to Norway. This could further increase the value of recreational BFT fishing as tourist not only spend capital on fishing, but also on travel related costs such as food, transportation and shelter. Small businesses can arise at places were BFT fishing is found to be excellent, boosting local economies. It is hard to estimate how much money this could potentially generate with the recreational BFT fishing currently being in its infancy. Nevertheless, similar spending as those found in the study by people traveling to Portland in the study by Deloitte. (2013) of $508 dollars to go fishing on a charter boat can be expected. Besides the current ban on charter fishing, there are a few other factors that could potentially limit the potential of Norway as a big game fishing destination besides the current regulations. First of all, the limited timeframe in which BFT can be caught in Norwegian waters, which is currently only being late-summer/early autumn. In this limited time-frame, bad weather could significantly halt the number of days that can actually be utilized for fishing for BFT. The respondents (n=77) of our economic survey were halted from fishing and other conditions in 2020 for a total of 1210 days. Thus, tourist anglers must be willing to take a risk knowing that bad weather might halt the possibility of catching a BFT completely. This is however also the case for tourist anglers currently coming to Norway to fish for other species and this does not seem to be halting them.

5. Conclusion:

The author of this thesis has tried to give the best possible overview of the recreational BFT fishing season of 2020 with the data that was available. The recreational fishermen have brought in valuable information as citizen-scientist during 2020. The logbook data gave an insight in the BFT observations, fishing strategies used for them in Norwegian waters, the amount of fished hooked and caught and tagging data that can be used in the future. The questionnaire gave an insight into the economic value of this new fisheries of Norway and what the money was spent on. With the amount fishing teams expanding in 2021, it is likely that the economic value of the recreational BFT fishing will increase in the next years. This is especially true if charter fishing is allowed in Norway. Regarding the hypotheses that were made regarding the spending, it can be concluded that boat-owners indeed spend more time and effort in their hobby then non-boat owners. When looking at the expenditures, this was found to be significant in the three different spending categories. Spending more money however, does not lead to a significant increase in your chances of catching a BFT in 2020. Thus, the hypothesis that spending more money on fishing equipment or on all categories combined would lead to catching more BFT has been found to be incorrect.

The fact that boat owners seem to be spending more effort and money in their fishing effort seems to be logical, as they also have invested the money in buying a boat. If you own a boat that is suitable for BFT fishing, it is likely that you would also spend the money that is needed to go out and fish for BFT. If you on the other hand are not a boat owner, it is more likely that you spend less money since you can use the equipment that is already available on the boat. The fact that spending more money did not result in catching more BFT can be attributed to the low number of fish being caught, as the total amount of fish caught in 2020 was only 19 fish. This, although there are other explanations, like the location of fishing, also plays an important role in catch success. The data on catch location in 2020 was however limited to only 9 tagged fish which gave little information in 2020. It would be interesting to recalculate this in future years, to see if the amount of money spend would have a positive impact on the amount of BFT caught or if the fishing location plays a bigger role in catching success.

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7. Appendix:

7.1 Example of logbook questions:

Table 3: An example of the questions asked in the logbook to the recreational anglers that fished for Atlantic bluefin tuna (Thunnus thynnus) in 2020:

1	Timestamp
2	Name of the team
3	Date of fishing trip
4	Name of the harbor departure
5	Starting time of the fishing
6	Name of the harbor arrival
7	End time of the fishing
8	Amount of observations from BFT during the day
9	Amount of single observations of BFT during the day
10	Bait type that was used
11	Amount of rods that was used
12	Amount of bites
13	Amount of fish brought into the boat
14	Amount of fish tagged
15	Amount of fish released
16	Amount of fish kept (dispatched)
17	Other commentary
18	Amount of observations of Porbeagle shark

7.2 Questionnaire questions:

Table 4: The 38 questions that were asked in the questionnaire to the recreational anglers that fished for Atlantic bluefin tuna (Thunnus thynnus) in 2020. The first column displays the question number.

Question number:	**Question:**	**Question type**
Q1	Did you have permission to go BFT fishing in 2020?	Yes/No
Q2	How old are you?	Value (age)
Q3	Sex	Male/Female
Q4	Are you owner or part owner from a boat?	Yes/No
Q5	If you are the owner or part owner of a boat, what is the total value of the boat, including trailer, fishing	Value (NOK)

	equipment for BFT, electronics and other equipment?	
Q6	How big is your share of the boat in %	Value (%)
Q7	Did you fish for BFT in Norwegian waters in 2020?	Yes/No
Q8	How many km did you drive in your car in connection to BFT fishing in 2020	Value (KM)
Q9	How many BFTs were caught when you were on board in 2020?	Value (amount of fish)
Q10	How many days have you been out and fished specifically for BFT in 2020?	Value (days)
Q11	How many days were you not able to fish for BFT because of the weather, lack of crew etc. in 2020?	Value (days)
Q12	How many fishers (including captain) were on board on average per trip in 2020?	Value (people)
Q13	Did you also fish for other species while you were fishing for BFT in 2020?	Yes/No
Q14	If so, how many days in total have you fished purposefully for species other than BFT?	Value (days)
Q15	How many nights did you spend outside of your own home in the vicinity of your departure harbor in connection with BFT fishing in 2020?	Value (nights)
Q16	Were there other formalities for your stay in and around the harbor in connection with BFT fishing in 2020?	Yes/No
Q17	If there have been other purposes, what proportion of your visit to the area did you spend on these other purposes? Type in %.	Value (%)
Q18	How many hours did you spend on preparation and transport in connection to	Value (hours)

	BFT fishing besides fishing and traveltime in 2020?	
Q19	How many hours did you fish with your team per average fishing day, including travel time by boat for BFT in 2020?	Value (hours)
Q20	Circa how many nautical miles did you travel in total in connection with BFT fishing in 2020?	Value (NM)
Q21	Did you eat out in restaurants and similar places more in this period than if you not have gone fishing for BFT in 2020?	Yes/No
Q22	How much money did you spend on fishing equipment such as rods and reels in connection to BFT fishing in 2020?	Value (NOK)
Q23	Other equipment such as line, hooks, leaders, spreader-bars, figthing belts etc. in connection to BFT fishing in 2020?	Value (NOK)
Q24	The maintance of the boat (excluding gasoline and equipment), insurance, motor and service in connection to BFT fishing in 2020?	Value (NOK)
Q25	Gasoline for the boat in connection to BFT fishing?	Value (NOK)
Q26	Boatequipment such as electronics, rodholders, downriggers, fightings chairs etc. in connection to BFT fishing in 2020?	Value (NOK)
Q27	The rental of the harborplace, harborfacilities and boatramps in connection to BFT fishing in 2020?	Value (NOK)
Q28	Other equipment, such as clothes, gloves, sunglasses, camera, binoculairs etc in connection to BFT fishing in 2020?	Value (NOK)
Q29	Gasoline for the car that was used in connection to BFT fishing in 2020?	Value (NOK)

Q30	Other transportcosts, such as bridges, ferries, boat-transport, parking, car rental etc. in connection to BFT fishing in 2020?	Value (NOK)
Q31	Public transportation in connection to BFT fishing in 2020?	Value (NOK)
Q32	Overnight stays in connection to BFT fishing in 2020?	Value (NOK)
Q33	Souvenirs and goods such as team jerseys, keychains, trophies and flags in connection to BFT fishing in 2020?	Value (NOK)
Q34	Drinks in the pub in the vicinity of the harbor in connection to BFT fishing in 2020?	Value (NOK)
Q35	Other expenditures in connection to BFT fishing in 2020?	Value (NOK)
Q36	Annual income before tax (voluntary)	Value (NOK)
Q37	Had you spent the same amount of money on BFT fishing if the chance of catching a BFT had been smaller than in 2020?	Yes/No
Q38	If you have any comments, feel free to leave a comment below:	Open text