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Darah Gibson, Kyrstn Zylich and Dirk Zeller

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Email: d.gibson@fisheries.ubc.ca

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Darah Gibson, Kyrstn Zylich and Dirk Zeller

Sea Around Us, Fisheries Centre, University of British Columbia,
2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada

d.gibson@fisheries.ubc.ca; k.zylich@fisheries.ubc.ca; d.zeller@fisheries.ubc.ca

ABSTRACT

Catch from the Faeroe Islands within their Exclusive Economic Zone (EEZ) equivalent waters from 1950-2010 are preliminarily reconstructed. Data which are officially reported to the International Council for the Exploration of the Seas (ICES) is publically available and we use this as a 'reporting' baseline for the reconstruction. Data and information on components not included in official reported data are sourced from ICES working group reports, peer-reviewed literature, grey literature and local experts. The unreported catch is represented by non-commercial subsistence and recreational fisheries as well as commercial discards. Our preliminary reconstructed catch is 1.04 times the ICES baseline landings. The reconstructed catch increases from an average of 42,000 t·year^{-1} (1950-1960) to 331,000 t·year^{-1} between 2000 and 2010, with a peak of 442,000 t in 2003. Blue whiting (*Micromesistius poutassou*) comprises the largest proportion (21%) of the reconstructed catch; however, almost all of the catch occurs in the 2000s. Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and saithe (*Pollachius virens*) are the three most important species and they comprise 44% of the reconstructed catch collectively. These species remain prominent over the whole time series. The discrepancy between the ICES reported baseline and our reconstructed catch is mainly due to our estimates of discards, which account for 3% of the reconstructed catch. The Faeroe Islands have an enforced discard ban as of 1994, however there is still discarding that occurs and likely consists of juvenile target species. The Faeroe Islands have an effective system of management; however, to remain completely transparent, they should provide estimates of discards.

INTRODUCTION

The Faeroe Islands are a small group of islands in the north-east Atlantic Ocean north of the United Kingdom and south of Iceland. The Faeroes have a total land area of 1,400 km^2 with around 270,000 km^2 Exclusive Economic Zone (EEZ) equivalent waters, of which around 24,000 km^2 are shelf waters (FAO 2005). With such an expansive shelf area in relation to land area, fisheries are an obvious industry for these small islands. The harsh climate, with very little protection from winds and rains make these islands unfavourable for many forms of livestock and agriculture. Fish remain the single most important resource to the Faeroe Islands, accounting for 95% of exports and 44.5% of the gross domestic product (GDP) (Zeller and Freire 2002; Edvardsson *et al.* 2011).

The Faeroe Islands did not always have autonomy over their most valuable resource. Historically, they are part of the Kingdom of Demark and only received home rule in 1948 (Hannesson 1996). The Faeroe Islands maintained control of their fisheries only within a 3 nm zone until 1959 (Reinert 2001b). During this time, there was substantial foreign fishing presence on the Faeroe Bank and Faeroe Shelf (Reinert 2001b). Throughout the 1960s and 1970s, the Faeroe Islands began to gain more control over their shelf with an expanding EEZ. The EEZ was finally fixed at 200 nm in 1977 and Faeroese vessels could begin to take a majority of the catch from their waters (Reinert 2001b). At this time, there were no management measures to prevent by-catch in demersal fisheries, only standard management measures such as closures and minimum mesh size (Johnsen and Eliasen 2011).

In 1987, the Faeroe Islands introduced the first licensing system (ICES 2013) as a major management decision in the Faeroes. The Faeroe Islands are not part of the European Union (EU), therefore, they do not conform to the Common Fisheries Policy (CFP) and instead, negotiate their own trade agreements with the rest of Europe (Anon. 2008). A collapse in demersal stocks in the early 1990s led the Faeroe Islands to set their own Total Allowable Catch (TAC) quotas for demersal fisheries, independently from those set by the EU's CFP (Reinert 2001b; Zeller and Freire 2002; Jakupsstovu *et al.* 2007; Johnsen and Eliasen 2011; ICES 2013). There was also a discard ban enforced at this time; both regulations were met with opposition by the fishing industry in the Faeroe Islands (Jakupsstovu *et al.* 2007; Hoydal *et al.* 2010). When the TAC quota system was enforced, substantial discarding and misreporting in the Faeroese fisheries occurred as well (Zeller and Freire 2002; Jakupsstovu *et al.* 2007; Hoydal *et al.* 2010; ICES 2013), however there are no quantitative records for discarded by-catch (E. Magnussen, pers. comm.).

In order to deal with the issues of discarding and misreporting in mixed fisheries, the Faeroese government worked with the industry to change the TAC quotas to a 'Fishing Days System' in which management is on the basis of effort (Reinert 2001b; Zeller and Freire 2002; Jakupsstovu *et al.* 2007; Edvardsson *et al.* 2011; Johnsen and Eliasen 2011). The discard ban is still incorporated into the new effort-based management system; however, it is not always strictly enforced and does not prevent high-grading (Reinert 2001a; Johnsen and Eliasen 2011). It is required for fishers to report a catch with more than 30% juvenile cod, saithe and haddock (Anon. 2008), and the area being fished will be closed immediately for 1-2 weeks (Reinert 2001b).

The Faeroe Islands' fisheries mostly consist of large-scale commercial fishing by larger trawlers and small-scale commercial fishing using open boats and smaller vessels. Commercial trawlers with 400HP or greater are banned within a 12 nm zone around the islands (Reinert 2001b). The islands have a small population, with an average of 60% residing in rural locations[1]. There is certainly a dependence on fish as a resource beyond commercial fisheries and the economy. Many crew members take home a portion of the undersized catch after it has been hung out to dry on deck as a traditional meal for their families (Reinert 2001a). In addition to this non-commercial catch, there are a few tourists that participate in sea angling trips (M. Bástein, pers. comm.).

The Faeroe Islands have a relatively progressive management system compared to the EU. The Faeroe Islands' ability to maintain control over their most valuable resource is a large part of the reason for them to remain independent from the EU and the CFP. The dependence on fish as a resource has forced the government to work with many in the industry to create effective management measures. Fish are important to the lives of the Faeroese and the government maintains an image of sustainability and transparency with their citizens. However, a discard ban does not necessarily equate to zero discards and some measure or estimate of these discards should be accounted for by the government.

METHODS

Landings

Faeroe Islands landings data are acquired through the International Council for the Exploration of the Sea (ICES) public database[2]. The data span 1950-2010 and are used as a reporting baseline for the reconstruction. In order to account for catch from only EEZ equivalent waters, we include catch from ICES management division II a, IV a, V b 1 and V b 2 (Figure 1). The 200 nm EEZ (Figure 1) was established in 1977, which grew from 3 nm starting in 1903 (Kopela 2013; E. Magnussen pers. comm.) to

[1] World Bank: http://databank.worldbank.org/data/ (Accessed April 8, 2014)
[2] ICES: http://www.ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx (Accessed February 10, 2014)

6 nm in 1955 and again to 12 nm in 1964 (E. Magnussen pers. comm.). We treat the 200 nm EEZ as the EEZ equivalent waters back to 1950.

The Faeroe Islands' EEZ overlaps with a portion of the IV a management area. We use the spatial proportion of IV a within EEZ equivalent water from the total IV a area and apply that proportion to all landings from IV a. This simplifying assumption is made to prevent over-representing catch.

For some taxa, there are values reported as 'ICES Area (not specified)'. Most of this catch is reported for the years 1950-1951, 1973 and 2000. There is also catch reported in area V b (not specified) until 1965, it is separated into the Faeroe Plateau (V b1) and the Faeroe Bank (V b2) (ICES 2013). These landings, as well as others from non-specified management areas (i.e., II a not specified) are distributed into specific management areas within the EEZ equivalent waters using spatial proportions of surrounding years as a simplifying assumption.

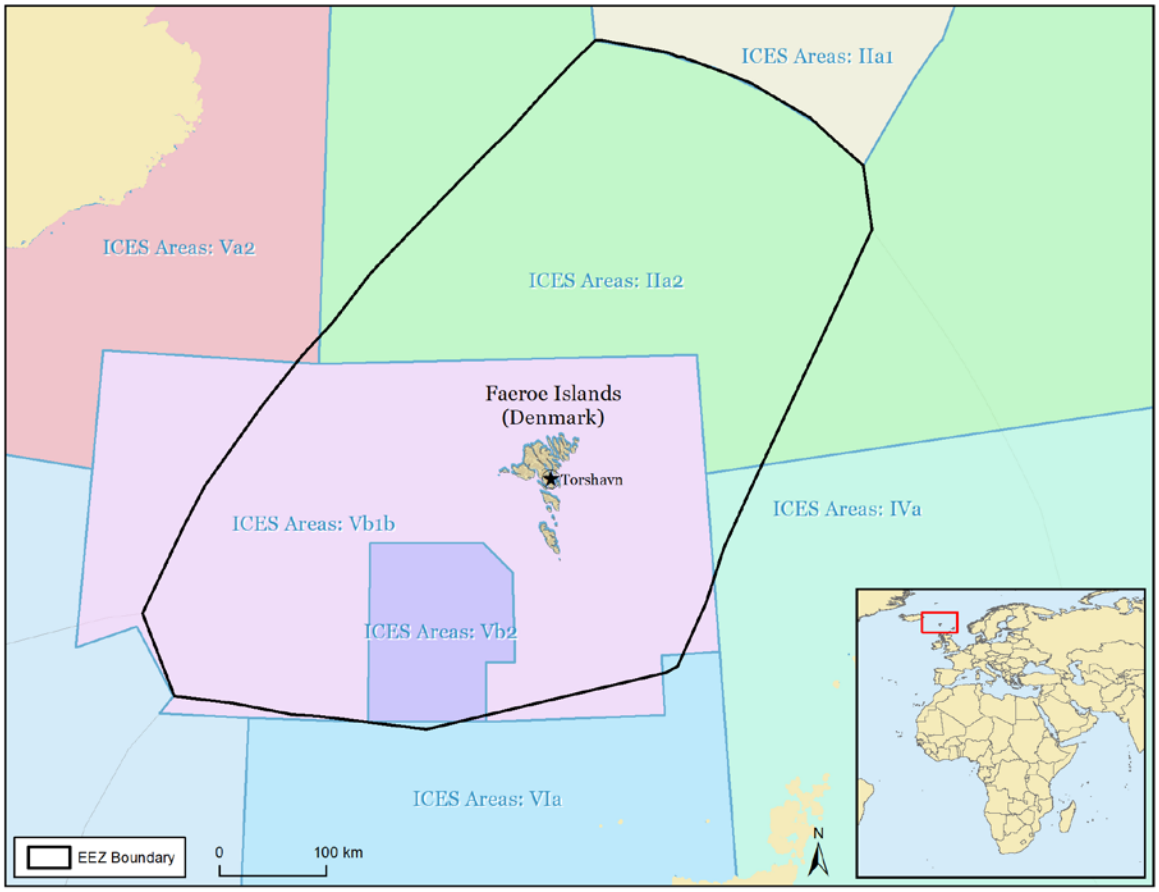

Figure 1. The Faeroe Islands EEZ waters and corresponding ICES management areas (1977 – 2010).

Subsistence and recreational fisheries

Fishing for personal use is common place in the Faeroe Islands; however there are no records of amounts taken home. We use *per capita* subsistence rates from the reconstruction of Iceland (Valtýsson *in press*) and derive subsistence catch for the Faeroes using population data from Populstat[3] and Worldbank[4].

[3] Populstat http://www.populstat.info/ (Accessed April 8, 2014)

Subsistence catch mostly consists of individuals using personal boats or crew members taking home some undersized fish for their families (Reinert 2001a).

The Faeroe Islands have a small population and there is not a great deal of tourism. There is likely an overlap of recreational and subsistence catches, in terms of definition, in rural areas over the investigated time series. The Faeroe Islands do not require a license for recreational or subsistence fishing and there is no data collection program for these non-commercial fisheries (E. Magnussen, pers. comm.).

We allocate 70% Atlantic cod (*Gadus morhua*), 15% haddock (*Melanogrammus aeglefinus*), 10% saithe (*Pollachius virens*) and 5% other species to all non-commercial catch (both recreational and subsistence). Due to the importance of demersal fisheries in the Faeroe Islands, much of the subsistence and recreational catch likely consists of demersal targets. The catch of other species (5%) likely consists of flatfishes (European plaice, common dab, etc.), other cod-fishes (whiting, ling and pollock), wolfish, sharks and rays, angler, mackerel and herring.[5]

Our estimate of recreational catch is a fraction of the estimated subsistence catch over time. It is estimated that in 1950, 100% of the non-commercial catch was for subsistence purposes and by 2010; it represents 80% of the non-commercial catch. 20% of the non-commercial catch is designated as recreational in 2010. Proportions of subsistence and recreational catch are interpolated from 1950-2010.

Discards

The Faeroe Islands are not a member of the European Union (EU) and as a result, they do not follow the EU CFP management scheme (Anon. 2008). From 1950-1986, the Faeroes managed fisheries based on traditional regulations in the form of area closures and minimum mesh size (Johnsen and Eliasen 2011). In 1987, a licensing scheme came into effect and dramatic decreases in cod and haddock in the early 1990s (Zeller and Reinert 2004) prompted a need for a change in management. In 1994, the Professional Fisheries Act of 1994 introduced single species Total Allowable Catch (TAC) quotas as well as a discard ban (Eliasen *et al.* 2009; Hopkins *et al.* 2013). With a TAC system, the discard ban isn't effective, as there remains an incentive to high-grade (Eliasen *et al.* 2009) or misreport catches to make the quotas. During this management regime, it was known that there was a significant amount of discarding as well as misreporting occurring (Hopkins *et al.* 2013). In efforts to control illegal practices, the Faeroes switched to an effort based quota in 1996, which would minimize incentive to discard (Reinert 2001b; Jakupsstovu *et al.* 2007; Anon. 2008; Johnsen and Eliasen 2011). In theory, the discard ban should be effective, but may not be as effective as intended in practice (Johnsen and Eliasen 2011). There are no tonnage records of discarded fish in the Faeroe Islands, even though fish may be discarded if they are commercially important and undersized, damaged or non-commercial (Reinert 2001a).

There are however, accounts of misreporting and discarding and we need to account for this catch. Iceland and Norway also have a discard ban in place; however, they manage fisheries on a TAC quota system. We choose to use Icelandic discard rates from Valtýsson (*in press*), for the major targeted species in the Faeroe Islands (Table 1). We apply Icelandic discard rates (Valtýsson *in press*) to all major reported commercial species that comprise 1% or more of the total reported catch. For example, the discard rate of cod indicates that for every tonne of Atlantic cod landed, 0.055 t of Atlantic cod are discarded (Table 1). These rates were applied from 1950-1993, and are then increased by 20% from 1994-1996. This increase is to account for the introduction of the TAC system and the concurrent increase in discarding (Hopkins *et al.* 2013). Icelandic discard rates are again used from 1997-2000 as a result of the introduction of the effort quota system (Reinert 2001a; Jakupsstovu *et al.* 2007; Anon. 2008; Johnsen and Eliasen 2011).

[4] Worldbank http://databank.worldbank.org/data/views/reports/tableview.aspx# (Accessed April 8, 2014)
[5] Magni Blástein http://fishingwithblastein.com/index.html (Accessed April 16, 2014)

Relatively little discarding is thought to occur at present (E. Magnussen, pers. comm.), but the exact percentage or amount is unknown, so we have chosen an anchor point for 2010 that is 10% of the Icelandic discard rates to remain conservative. Rates between 2000 and 2010 are linearly interpolated. Discard rates are then applied to reported landings of corresponding taxa to provide a complete discard estimate.

Table 1. Discard rate anchor points (tonnes discarded per tonne landed) for major commercial taxa (Valtýsson *in press*).

Taxon	Discard rate
Blue whiting	0.015
Saithe	0.055
Atlantic cod	0.055
Atlantic herring	0.020
Haddock	0.055
Norway pout	0.020
Golden redfish	0.055
Argentines	0.055
Capelin	0.020
Atlantic mackerel	0.020
Tusk	0.055
Ling	0.055

Results

Reported landings

Over 80% of Faeroese reported landings come from ICES management area Vb which covers the Faeroe Bank and the Faeroe Plateau fishing grounds (Figure 2a). Faeroese EEZ equivalent waters also include parts of management areas IIa2 and portions of IVa, VIa, and Va2. We choose to only include the proportion of IVa that falls within the EEZ and we consider landings from the VIa and Va2 portions of the EEZ to be negligible.

Blue whiting (*Micromesistius poutassou*) comprises the largest proportion (approximately 21%) of reported landings (Figure 2b). Most of this catch is landed between 2000-2010 and is nearly exclusive used for reduction into fishmeal and fish oil (Reinert 2001b). The sudden increase in catch of blue whiting is the result of an increase in stock over this period (E. Magnussen, pers. comm.), and likely also the result of climate change driven distribution changes (Cheung *et al.* 2009).

Demersal fishes (i.e., Atlantic cod, haddock and saithe) are the most economically important fisheries in the Faeroe Islands (Zeller and Reinert 2004). Atlantic cod, saithe and haddock comprise nearly 43% of the total reported catch (Figure 2b).

Faeroese catch increases from 55,000 t in 1950 to 277,000t in 2010 (Figure 2a). There is a peak of approximately 196,000 t in 1985, followed by a decline in catch to 125,000 t in 1994. Demersal fisheries and specifically, Atlantic cod crashed in the mid-1990s (Vestergaard 1995; Eliasen *et al.* 2009). Catch reaches another peak of 431,000 t in 2003, which is followed by a decline to 2010 (Figure 2a).

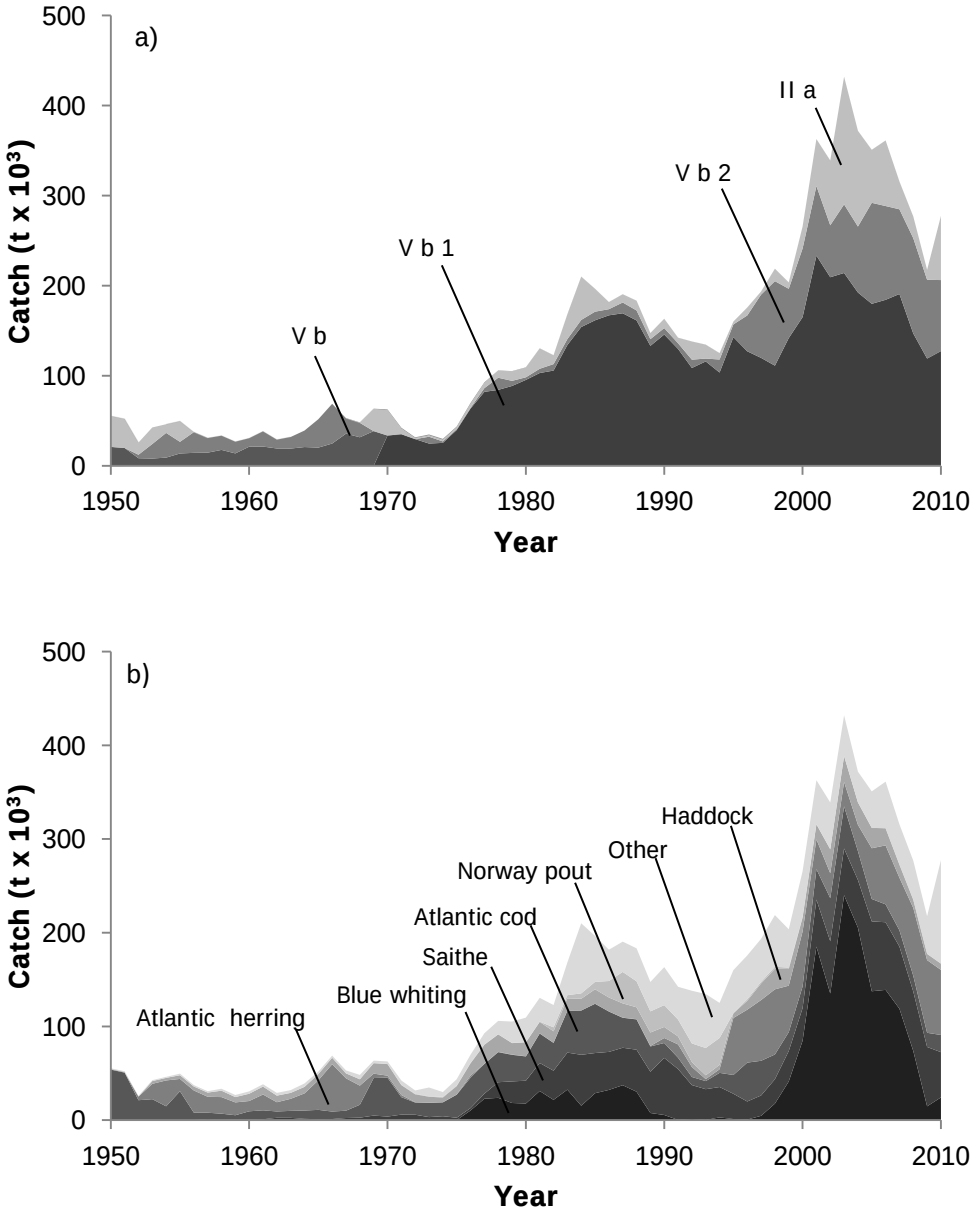

Figure 2. Reported landings in Faeroe Islands EEZ equivalent waters from 1950-2010 by a) ICES management areas - note that a proportion of IVa catch is included; and b) major commercial taxa.

Discards

Demersal fisheries are economically the most important fishery in the Faeroe Islands (Zeller and Reinert 2004), and are targeted for human consumption. Therefore, Atlantic cod, saithe and haddock are likely discarded if undersized or damaged, and comprise the largest proportions (68%) of estimated discards (Figure 3). The two peaks in discards in the mid 1980s and mid 1990s to mid 2000s (Figure 3) represent peaks in landings during those times (Figure 2b). Pelagic fisheries for blue whiting and Atlantic herring (*Clupea harengus*) are the other main source of discards in the Faeroe Islands.

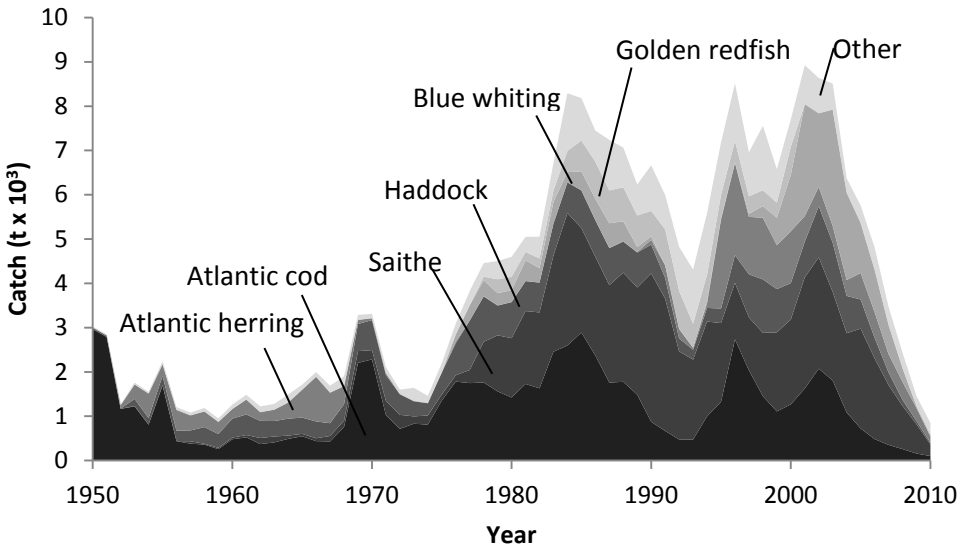

Figure 3. Estimated discards by major taxa within Faeroese EEZ equivalent waters (1950-2010).

Subsistence and recreational catches

The subsistence catch in the Faeroes increases from 680 t in 1950 to nearly 900 t in 2010 (Figure 4). This is a reflection of an increase in population over time. Much of this catch comes from people taking out their individual boats for a trip or fishing crew taking dried fish home for self- and family-consumption (Reinert 2001a). We have also estimated recreational catch as an increasing proportion of the subsistence catch over time (Figure 4). There is likely an overlap of the intention of subsistence and recreational catch in the Faeroe Islands, which is why we chose to take recreational catch out of the subsistence estimate. While tourism in the Faeroe Islands isn't significant, there are some fishing trip operators, which operate most of the year (M. Blástein, pers. comm.).

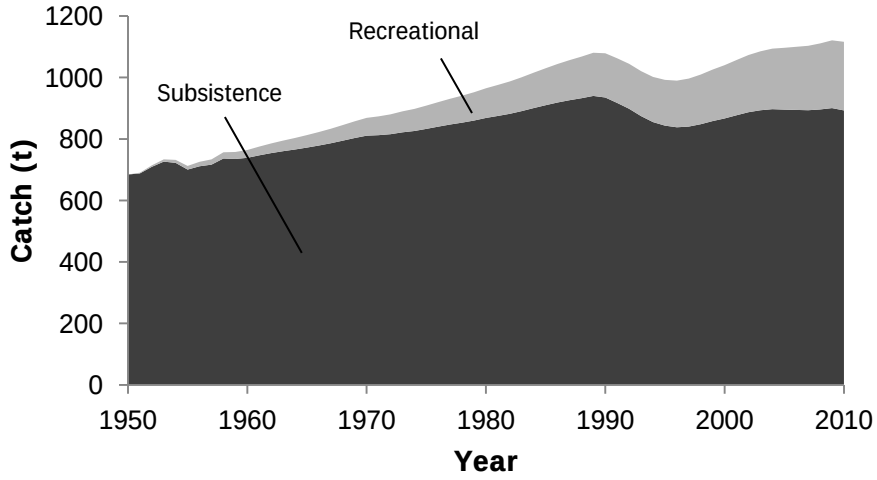

Figure 4. Preliminary estimate of recreational and subsistence catch in the Faeroe Islands 1950-2010

Total catch

Our preliminary estimate of reconstructed total Faeroese catch from 1950-2010 in the Faeroe EEZ equivalent waters increases from 59,000 t in 1950 to nearly 280,000 t in 2010 (Figure 5a) and is 1.04 times the officially reported catch. Faeroese catch remains relatively steady and small until the mid 1970s (Figure 5a) and begins to incline steeply with the introduction of the 200 nm EEZ in 1977 (Reinert 2001b; ICES 2013). This 200 nm EEZ gave the Faeroes more opportunity to fish as well as an opportunity for export of fish products to the foreign countries that used to fish there.

Faeroese fisheries are mixed gear targeting various pelagic, demersal and deep-water species (Reinert 2001a, 2001b; ICES 2013). The majority of catch falls in the industrial sector (Figure 5a) due to the frequent use of trawling gear in demersal and pelagic fisheries (Reinert 2001a, 2001b; Martin 2012; ICES 2013). There are still a number of 'open boats' which use long-lines to target demersal species and usually operate part-time (Reinert 2001a, 2001b; ICES 2013). Catch from these vessels is classified as artisanal small-scale commercial catch for our reconstructions purposes (Figure 5a).

Demersal catch represented by Atlantic cod, saithe and haddock comprise the largest portion (43%) of the estimated total catch (Figure 5b). Blue whiting represents the largest portion (21%) of total estimated catch for a single species (Figure 5b). The blue whiting catch suddenly peaks in the mid 2000s but, then sharply declines to 2010 (Figure 5b).

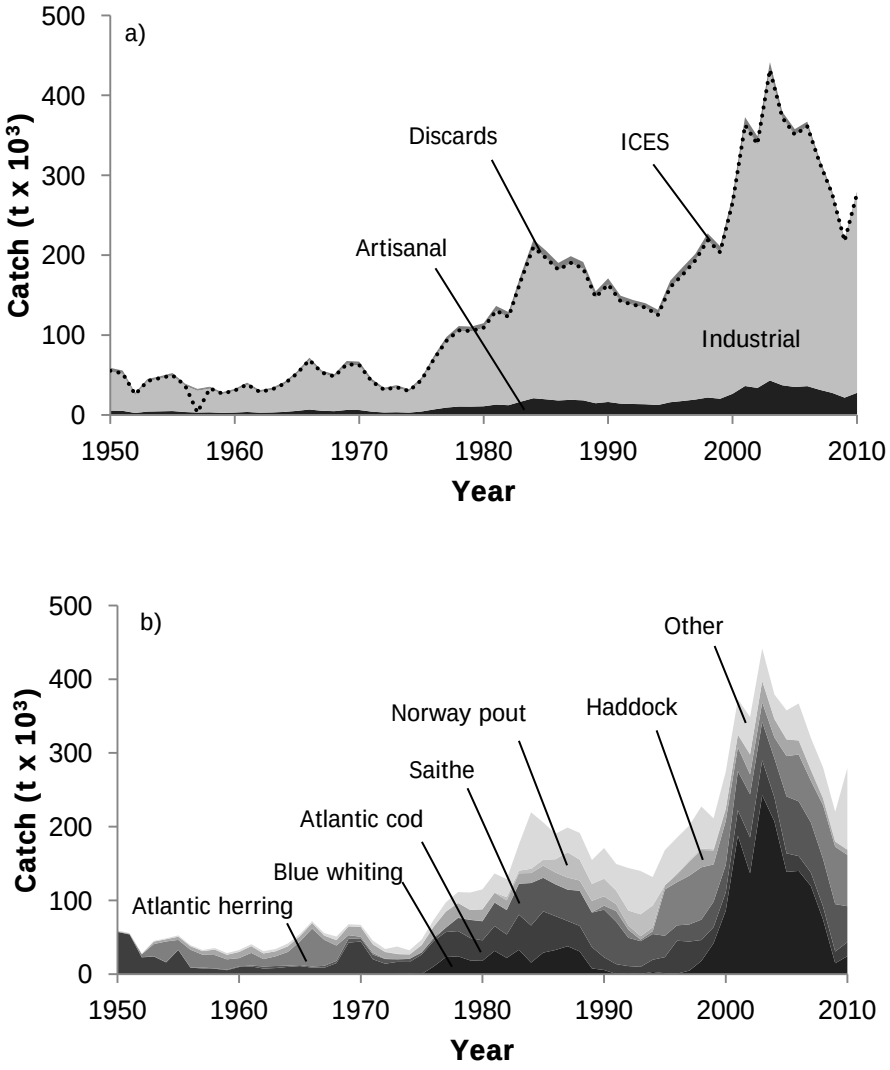

Figure 5. Preliminary reconstruction of Faeroese catches within EEZ equivalent waters from 1950-2010 by a) sectors – note that subsistence and recreational catches are included but too small to show. The dotted black line represents the ICES reported baseline; and b) major taxonomic group.

DISCUSSION

Over the investigated time series, the Faeroe Islands have gone through a great deal of change and development. Fish resources are very important for the Faeroe Islands. The preliminary reconstruction of total marine catches in the Faeroe Islands from 1950-2010 is approximately 1.04 times the reported baseline provided by ICES within EEZ equivalent waters. Faeroese reconstructed total catch increases from 59,000 t in 1950 to 280,000 t in 2010.

Fish products currently comprise 94% of all exports (Edvardsson *et al.* 2011; Hopkins *et al.* 2013), which demonstrates the islands' dependence on fish. The Faeroe Islands must its fisheries on a sustainable basis for continuing economic stability. Past management by minimum mesh size, closures, etc. created deteriorating stocks by the mid 1980s (Eigaard *et al.* 2011) and in combination with years of poor

recruitment and high rates of fishing mortality there was a collapse of demersal stocks in the early 1990s (Jakupsstovu *et al.* 2007; Edvardsson *et al.* 2011). Many European countries were dealing with similar stock conditions at this time and were managed by EU quotas.

The Faeroe Islands chose to not abide by the TAC quotas recommended by the EU (Anon. 2008), and instead fish based on an effort quota system of total days fished as of 1996 (Jakupsstovu *et al.* 2007; Eigaard *et al.* 2011; Johnsen and Eliasen 2011). Effort quotas, in addition to a discard ban are the main aspects of Faeroese management; however, there are additional measures such as minimum mesh size, closures, etc. One of the negative aspect of effort-based management is that it does not account for technology creep, which is one possible factor for why effort-based management has not significantly increased stocks from the decline in the 1990s (Eigaard *et al.* 2011). However, modeling by Zeller and Reinert (2004) suggests that the effort-based management system used in the Faeroe islands may be effective for the mixed demersal fisheries.

One of the strengths of effort-based management is the reduction of the incentive to discard (Reinert 2001a; Jakupsstovu *et al.* 2007; Anon. 2008; Hoydal *et al.* 2010; Johnsen and Eliasen 2011). The Faeroe Islands also employ a discard ban that requires fishers to land non-commercial catch and report when catch is comprised of 30% juvenile cod, saithe and haddock (Jakupsstovu *et al.* 2007). The Faeroe Islands have one of the most effective methods of dealing with discards in Europe as a result of their independence from the TAC quota system. We have estimated a tonnage of Faeroese discards for the entire time series, even over the course of the discard ban, using Icelandic discard rates as a proxy. Iceland and Norway also implement a discard ban; however, unlike the Faeroes, they record discard data. We recognize that our estimate may be a misrepresentation, but, by reducing the Icelandic discard rates, it should be a conservative one. We suggest that regular and comprehensive data on actual discarding in Faeroes fisheries be obtained in the future.

In addition to discards, there is unreported catch in the form of recreational and subsistence catches. The Faeroe Islands do not have much tourism. There are some charter vessels in larger cities and towns throughout the islands (M. Blástein, pers. comm.). These charter vessels target a variety of areas and species, which allow them to remain active all year. There is no licensing program (E. Magnussen, pers. comm.) or data collection program for recreational or subsistence fisheries in the Faeroe Islands. This presents a challenge for estimating tonnages of recreational and subsistence catches. We use Iceland's *per capita* subsistence rates applied to the Faeroe Islands population for total subsistence and recreational catch. This may be a misrepresentation of subsistence catch, however Iceland and the Faeroe Islands have similar dietary habits, and hence we assume that both have similar subsistence rates. The Faeroe Islands have a much higher rural population proportion than Iceland, which suggests that our estimate is likely on the conservative side. No non-commercial catch is recorded in the official landings in the Faeroe Islands (Reinert 2001a). We suggest that estimates of country-wide non-commercial catches be obtained on a regular basis, and that these are to be included in annual data reporting.

The Faeroe Islands are dependent on fish stocks for consumption as well as economic stability. Only commercial catch is reported to the government and further reported to bodies such as ICES and the Food and Agriculture Organization of the United Nations. The government may believe that discarded and non-commercial catch is negligible, but there should still be efforts for data collection and estimation. The Faeroe Islands are vulnerable to the changing climate (Cheung *et al.* 2011), which highlights the importance of accurate stock assessments. If the Faeroe Islands can practice thorough data collection, the country will ultimately provide more accurate stock assessments for their most valuable resource. Due to the lack of data, we have provided a preliminary reconstruction, and would like to encourage further data collection and analysis by local experts.

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