Master's thesis

Cod Ranching in the Westfjords: A Political, Social, and Spatial Analysis

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Ísafjörður, February 2013

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45 ECTS thesis submitted in partial fulfilment of a Master of Resource Management degree in Coastal and Marine Management at the University Centre of the Westfjords, Suðurgata 12, 400 Ísafjörður, Iceland

Degree accredited by the University of Akureyri, Faculty of Business and Science, Borgir, 600 Akureyri, Iceland

Printing: University Centre of the Westfjords and Háskólaprent, February, 2013

Declaration

I hereby confirm that I am the sole author of this thesis and it is a product of my own academic research.

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Student‘s name

Abstract

This research aims to identify the legal, political, and social contexts necessary for the successful implementation of cod ranching projects in the Westfjords of Iceland. With the technical components tested and economic viability shown, cod ranching has been slow to develop mainly due to social and political obstacles. One such obstacle concerns the allocation of a large area of a fjord to an exclusive user, which could potentially displace fishing effort. Interviews with government agency personnel, municipal representatives, and fishermen are conducted and analyzed to determine the necesssary measures to be taken for cod ranching to become recognized as a legal, socially responsible method of harvesting wild cod. Spatial and statistical analyses based on historical catch data is conducted to determine potential ranching sites which can restrict commercial fishing without causing significant fishing displacement. The results of this study will serve as a cornerstone in the overall feasibility analysis of cod ranching and will provide researchers, entrepreneurs, and community leaders with valuable information on whether to, how to, and where to attempt a cod ranching project.

Dedicated to the people of Dravuni Village

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Acronyms

CPUE – Catch Per Unit Effort

DoF – Directorate of Fisheries (Fiskistofa)

EA – Environmental Asessment

ED – Exclusion Device

EEZ – Exclusive Economic Zone

EIA – Environmental Impact Assessment

FAD – Fish Aggregating Device

GHGE – Greenhouse Gas Emissions

GIS – Geographic Information Systems

IFF –Institute of Freshwater Fisheries

IMA – Icelandic Maritime Authority (Siglingastofnun)

MAST – Iceland Food and Veterinary Authority (Matvælastofnun)

MII – Ministry of Industries and Innovation (Atvinnuvega- og Nýsköpunarráðuneytið)

MPA – Marine Protected Area

MRI – Marine Research Institute (Hafrannsóknastofnunin)

MSP – Marine Spatial Plan

NPA – National Planning Agency (Skipulagsstofnun)

SEA – Strategic Environmental Assessment

TAC – Total Allowable Catch

TURF – Territorial User Rights in Fishing

WFG – Westfjords Fishing Grounds

Acknowledgements

This thesis was made possible by the collaboration and participation of many people in Iceland and the United States. The first extension of gratitude goes to my advisors Björn Björnsson and Gunnar Páll Eydal, who provided insightful, exhaustive, and timely advice throughout the duration of the project.

Secondly, I would like to thank those at the Iceland's Marine Research Institute, in particular Ólafur Arnar Ingólfsson, for the relentless efforts to provide me with the fishing data vital to my research. Dr. Laura Kracker with NOAA in Charleston, South Carolina, provided me with valuable assistance in the GIS portion of this research. Sigríður Norðmann provided thorough and valuable insight into the legal chapters. Special thanks to Vaxtarsamnings Vestfjarða for providing funding for this project, under the guidance of Shiran Þórisson.

I would like to acknowledge those at the University Centre of the Westfjords who assisted me through the thesis process, as well as during my course work; in particular Dagný Arnarsdóttir, Peter Weiss, and Albertína Friðbjörg Elíasdóttir.

The foundation of this work rests upon the cooperation of all the professionals who gave their time and valuable opinions through interviews. This includes: Benedikt Bjarnason, Ragnar Árnason, Ingimar Jóhannsson, Hrefna M. Karlsdóttir, Áslaug Eir Hólmgeirsdóttir, Sigmar Arnar Steingrímsson, Daniel Jacobsson, Elías Jónatansson, Ásthildur Sturludóttir, Hjalti Karlsson, Bjarni Jónsson, and Ólafur Árnason. Finally, I would like to thank the fishermen of the Westfjords; your names will remain anonymous, yet you are greatly appreciated for your contributions towards fisheries management in the Westfjords.

1 Introduction

Significant progress has been made in recent years conditioning cod to return to designated areas to be harvested (Björnsson, 2011). The practice, called "cod ranching," shows promise of being an efficient, profitable enterprise (Halldórsson, Björnsson, and Gunnlaugsson, 2012), has potentially less impact on the sea benthos than cod farming (S.A. Steingrímsson, personal communication, December 9, 2012; Ó. Árnason, personal communication, December 9, 2012) and is more selective – in terms of bycatch reduction – than capture-based trawling (Björnsson, 2011). However, the missing link to proclaim outright feasibility of cod ranching is the required political institutions necessary to initiate and oversee cod ranching. Cod ranching utilizes a management system that is undeveloped and lacking in precedence. At the forefront of the system is the allocation of a large coastal area to the designated "rancher," thus prohibiting all other commercial fishing. There is currently nothing in Iceland's planning, fishing, or environmental policy framework that addresses cod ranching directly, making the implementation and permitting process quite complicated. Furthermore, a lack of knowledge and/or trust concerning cod ranching on the part of coastal community stakeholders may deem the practice socially unacceptable at the regional and local levels. In an international online journal, Scott Lindell of the Marine Biological Laboratory in Woods Hole, Massachusetts, claimed "[Cod ranching]'s feasible, but it requires as much social engineering as it does anything to do with fish" (Cressey, 2011).

The research presented here is exactly that: a social engineering approach to show *how* cod ranching can be implemented and officially recognized and supported as a legitimate fishing method. This research does not aim to address the biological or technical concerns of ranching cod. Moreover, it is a study into the legal, political, and social feasibility of ranching cod; specifically in the Westfjords of Iceland. Interviews and discussions with national policy makers are conducted to reveal and, ideally, help navigate through the labyrinth of the permitting process for this unrecognized commercial fishing method. Interviews and discussions with fishermen, businessmen, and local politicians reveal the degree of acceptability of implementing cod ranching in a particular area, as well as the potential impacts cod ranching would have on local

stakeholders. Meanwhile, quantitative analyses using catch data in the Westfjords from 2007-2011 identify opportune areas to implement a ranching project; potential ranching sites that would cause the least amount of disruption to the fishing industry. This component is essentially an exercise in marine spatial planning, with the goal of reducing conflict in the already heavily-competed coastal areas of the Westfjords. By the end of this report the questions of *how?* and *where?,* as they relate to the political and socio-economic contexts of cod ranching, will be answered.

1.1 Cod Ranching: A Technical Explanation

Cod ranching is a novel harvesting method that operates at a level between capture-based fishing and aquaculture. The practice entails anthropogenic feeding of wild cod in a designated area that is restricted from commercial fishing. The theory is that wild cod will aggregate towards fixed feeding stations and will increase in biomass at a rate faster than they would naturally. The marketable cod are then captured using various methods and can either be placed in a net pen for further fattening or sold directly on the market. The method is early in the development stage; experiments in 1995-1996 in Stödvarfjördur and 2005-2006 in Arnarfjörður were conducted by the Marine Research Institute (MRI) and led by Björn Björnsson. Both experiments exhibited success on a technical scale (Björnsson, 2002; Björnsson, B. 2011). The aggregation, feeding, herding fidelities, and harvesting of the cod were all successful endeavors in these experiments. A follow-up economic feasibility study by Halldórsson, Björnsson, and Gunnlaugsson (2012) found cod ranching to be more profitable than fishing, grow-out cod farming, and full cycle farming.

The 2005-2006 experiment took place in the mid-section of Arnarfjörður in the Westfjords. Recent years had seen declines in shrimp numbers in that region, likely due to predation from increased numbers of cod and haddock within the fjords, which led to the initiation of the project. Researchers believed that by providing a feed of less economic value to the cod and haddock, shrimp numbers would rise and total biomass of cod and haddock would increase (H. Karlsson, personal communication, March 27, 2012). The project was funded and led by the MRI, with cooperation from Arnarfjörður-based fishermen. The project required an experimental operating permit, issued by the Ministry of Fisheries. The permit granted the MRI a 30 km^2 working area, of which all commercial fishing was prohibited. The prohibition of commercial

fishing within the allocated, or “ranched,” area is of vital importance to a successful ranching project. The ranching operation requires large investments into the fattening of these fish, and the taking of these man-fed fish by other fishermen would diminish the return to the rancher, making the endeavor economically unfeasible. Thus there would be no incentive to ranch cod in this manner if the right to harvest the ranched fish were available to all. This subject of spatial allocation will be a focal point for this paper.

From April 2005 to December 2006 wild cod were fed mostly a diet of frozen capelin, by mooring the frozen bags to buoys approximately 20-30 meters deep. Initial feedings consisted of an average of 9 tonnes (t) per month, dispersed five times per week and were increased to 27 t, dispersed twice per week by the end of August of 2005. Feeding decreased in autumn and winter due to decreased appetite of the cod, with less feeding than planned in the summer of 2006 due to difficulties obtaining feed. A total of 261.7 t of frozen fish (91% capelin and 9% herring) was dispersed through the 21-month experiment. Video cameras observed cod crowding around the feed bags soon after the bags were lowered, with the larger cod consistently crowding out the smaller cod for prime position to feed (*Figure 1*).

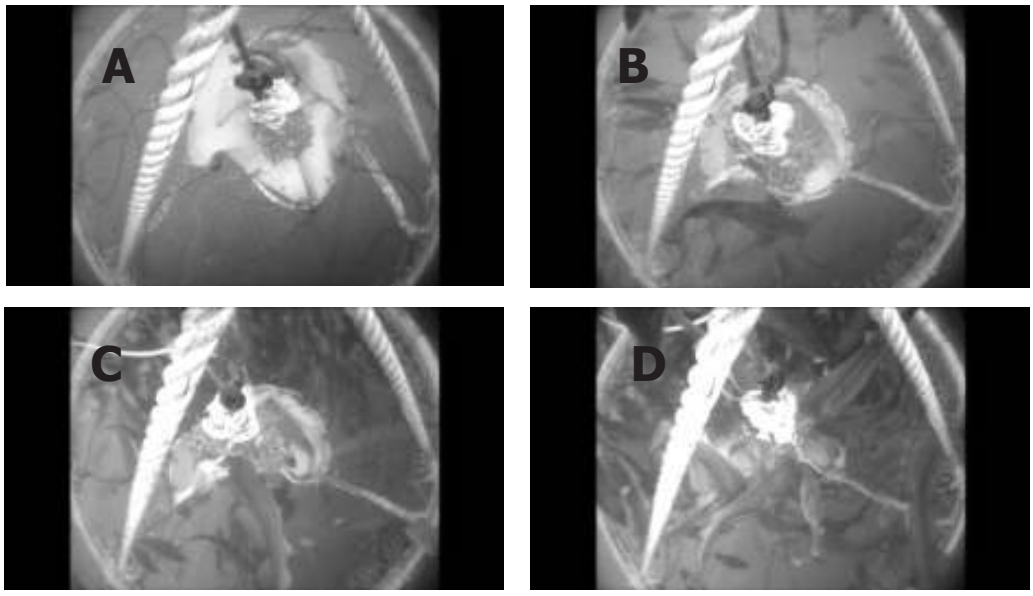


Figure 1: Harvesting aggregated cod with a lift net. a) Fishing begins - lift net void of fish; b) 18 seconds after "a" - fish begin to congregate; c) 33 seconds after "a" - feeding pack more dense; d) 50 seconds after “a” – net full of cod, mainly large and highly competitive specimens. Source: Still images taken from video provided by the MRI, Ísafjörður.

Cod were captured twice for tagging and measuring purposes; once in June 2005, and once in July 2006. Tagging demonstrated the fidelity of the cod to one of the four feeding stations (or herds), while measurements were taken to document the increase in biomass of the herds. Primary harvesting was accomplished with a lift net, with subsequent harvesting accomplished using a trawl and Danish seine. By November of 2006, tagged cod recaptured within the herds had grown an average of 490 g per month, compared with just 51 g per month for those recaptured outside of the herds. Concerning fidelity, Björnsson noted that "once cod have been conditioned to feed in a herd during summer they have a tendency to remain in that herd until autumn and those that leave a herd are more likely to join a nearby herd than a distant herd on the other side of the fjord" (Björnsson, 2011).

1.2 Classification of Cod Ranching: Aquaculture or Fishing?

To apply a legal framework or management recommendations, it is important to classify the activity taking place. Different regulations apply to different techniques of harvesting fish and other animals, and choosing the appropriate and applicable policies is important for its implementation and operation.

Table 1: The Aquaculture, ranching, and fishing index. Source: Anderson (2005).

Factor	Assigned degree for cod ranching	Score*
The degree of dependence on wild fish stock for brood stock and/or juveniles	All operations are dependent on wild brood stock or juveniles	1
The degree of dependence on a wild fish stock for feed	The dominant ingredient in the feed is derived from wild fish, organisms, or plants, which is provided by the manager or is available naturally	2
The degree of confinement	If the organism is completely unconfined prior to harvest	1
The degree of control of the environment/habitat	Habitat, pollution, and other factors influencing the organism are managed	2
The degree of harvest and	The timing of harvest and sale of the product are mostly controlled	4

market management	by the operator, but external factors, such as regulation, impose some restrictions

* A score of 1 is representative of a traditional fishery, graduating to a score of 5 which would represent closed-cycle aquaculture

Anderson (2005, pp. 239-243) puts forth an Aquaculture, Ranching, and Fishing (ARF) Index which quantifiably places a fishing operation within a particular management category. In the ARF Index, the value of five equally weighted factors assigns a score, in which one can categorize the activity. *Table 1* details the ARF Index and cod ranching's associated values.

Anderson describes a score of all 5's as being the model of a closed-cycle aquaculture operation, while all 1's would represent a traditional fishery. Cod ranching in this analysis would receive a score of 2. This score, according to Anderson, could be construed as "either ranching or range/habitat management." Of course this index does not consider all factors – such as assigning more weight to the manipulated aggregation – and does not have significant legal implications. However, it can be useful in determining the appropriate attention a manager should give to certain fisheries or aquaculture regulations.

1.3 Potential Impacts for Contextual Purposes

The introduction of a new harvesting technique will undoubtedly have impacts on the economic and social side of fishing communities, as well as environmental impacts. Exactly how cod ranching would impact societal attributes – economic, industrial, social, and environmental – perhaps could only be fully realized through a thorough environmental assessment (to be discussed below) and economic analysis. However, in order to identify the necessary frameworks for advancing cod ranching, it is important to identify potential impacts. Cod ranching's influence upon economic, social, and environmental sectors must be put into context.

1.3.1 Economic

Halldórsson et al. (2012) show how ranching cod "has the potential of decreasing the cost of fishing, improving growth rate and enhancing quota yield without the investments required in conventional farming."

Table 2 depicts cod ranching as having a higher net present value than all other modes of fish harvesting, indicating high returns of discounted cash flow, as well as generating the highest net operating profits. Cod ranching's relatively high degree of profitability is due in large to its utilization of cod's natural increases in biomass. There is no investment in the first stages of growth, as cod naturally predate on wild food.

Table 2: Economic scenarios for four methods of harvesting cod. Source: Adapted from Halldórsson et al., 2012)

	Ranching	On-growing	Full-cycle	Fishing
EBITDA* (€/yr)	199,992	123,411	-83,133	92,863
Net operating profits (€/yr)	149,635	86,147	-128,556	71,485
Profit margin	24.4	13.3	17.7	26.2
NPV** (€)	753,692	197,836	-95,157	532,425

* Earnings before interest, taxes, depreciation and amortization
** Net present value

This is not to indicate that cod ranching is void of economic risks. Halldórsson is quick to point out the risks and uncertainties involved, including: herd fidelity, market fluctuations in feed and cod prices, and recapture rates – concluding that a recapture rate of less than 75% could render the operation unviable (Halldórsson et al., 2012).

Near-shore cod, as catch data below will reveal, is not a priority catch for Icelandic fishermen. According to the fishermen interviewed for this research, this is because of the relatively small size of the near-shore specimens. Near-shore cod are perceived as undesirable and unmarketable (personal communications, multiple anonymous fishermen). Feeding these fish presents an economic opportunity by adding value to an otherwise underutilized resource. Cod ranching is a quota multiplier, in the same sense that cod farming (or fattening) is. A more detailed discussion on how cod ranching fits into the quota management system will be discussed below; yet in short, a rancher would receive greater biomass and edible flesh than the quota price that is paid. Additionally, a rancher can harvest large amounts of cod without spending the fuel required to go far out to sea. The savings in fuel over a two-year period of ranching could be quite substantial.

1.3.2 Impact on Fisheries

Ranching could have direct and indirect impacts on the fishing sectors in Iceland. The impact most relevant to this study is displacement of fishermen from cod ranching sites. The exclusive

use could displace vessels to further fishing grounds, at least for a portion of their catch. This issue is examined fully in Chapters 6 and 7.

The ranching experiment in Arnarfjörður was initially a response by the MRI to fishermen's complaints of decreasing shrimp populations. The cod feeding was instigated to decrease predation on shrimp and other prey, such as juvenile gadoids, a species with a higher commercial value than the capelin and herring used as feed (Björnsson et al., 2011b). Although biological studies have yet to document the impact on these prey populations in these experiments, common trophic level theory (Odum, 1969; Pauly et al., 1998) supports the notion that a population lower on the trophic level will increase if predation decreases. Therefore, in theory, cod ranching can enhance shrimp and gadoid populations, and thus their respective fisheries yield. Furthermore, assuming decreased mortality of cod that would likely result from the feeding, along with emigration to areas outside of the ranched area, other fishing vessels can increase the size and value of their catch (B. Björnsson, personal communication, August 28, 2012). Also, processing plants could benefit from an increased supply of cod (and perhaps the other species mentioned above) as would those contracted to transport feed to the ranched sites.

1.3.3 Social Impact

A strong devotion to traditional means of fish harvesting typical of a traditional fishing community could show resistance to a new cod fishing technique. This would perhaps create friction and even animosity within fishing circles. And at its worst, the introduction of a new method such as cod ranching could be disruptive to the fishing dynamics of a fishing town. The introduction of aquaculture into fishing communities has often been met with skepticism by fishermen (Clayton & Gordon, 1999). This, according to VanderZwaagand (2005) is due to the prospect of their losing access to marine space, aesthetic interferences, and lower prices for fish products. Gibbs (2009) explored what the main barriers of entry for aquaculture into a coastal community are, and determined that difficulties obtaining development approval, on account of local objection from stakeholders, was the major preventative factor. He showed how even towns equipped with the necessary infrastructure, natural conditions, and markets were poor choices for introducing aquaculture due to resistance to change on behalf of fishermen. This is an important consideration for potential cod ranchers. Fishermen interviewed for this research expressed similar skepticism of cod ranching, of which will be discussed further below. A proper

consultation process is vital to the successful implementation of cod ranching, and can help ameliorate the potential conflict as described above. This concept is a common thread through later parts of this paper.

Other social considerations and impacts include the potential change in labor dynamics in the fish harvesting industry, and how these changes in labor dynamics impact domestic life. Cod ranching, like cod farming, requires fewer employees. Two persons with a 200 t quota can effectively operate a cod ranching venture by working full time for six months (B. Björnsson, personal communication, November 13, 2012). This labor-efficient method of fish harvesting is undoubtedly safer than multi-day capture-based fishing, and could provide the added social benefits of more time devoted to family and community, as well as more leisure time for the fishermen.

1.3.4 Environmental Impact

Exactly how cod ranching would impact the marine environment is difficult to estimate. Discussions with environmental impact assessors follow later in this report, mainly in regards to the possibility of an Environmental Impact Assessment (EIA) for cod ranching. Yet a brief discussion on environmental benefits and consequences that cod ranching might induce is relevant here.

Bycatch: Ranching cod has the benefit of being relatively selective, in terms of catch composition (Hreinsson, 2012c). This is especially true when utilizing the lift net. FAO (2012a) associates the lift net with low bycatch, due to its selectivity and use of attraction and baiting. As larger, more aggressive cod out-compete smaller sizes and other species for the bait within the net, mortality for smaller cod and other species (resulting from capture) is minimal (Björnsson, 2011). As advancements in the field of fish behavior are made, the lift net could potentially be used to catch a greater percentage of the fish being ranched. This can be especially attractive to Westfjords fishermen in recent years who have complained of haddock bycatch (Jansen, 2013). Ranching cod with a lift net, as shown in *Table 3*, can be an effective solution to fishermen whose cod catch is limited due to their small haddock quota.

Table 3: The number and mean weight of cod and haddock caught within the different gear types for cod ranching. Source: adapted from Björnsson (2011).

Capture Gear	Cod (n)	Cod (mean weight)	Haddock (n)	Haddock (mean weight)
Lift Net	34,219	2.71 kg	0	-
Shrimp Trawl	85,148	1.36 kg	7,966	0.80 kg
Danish Seine	51,935	1.87 kg	74,153	1.03 kg

Benthic Disturbance: Ranching can be considered a method of extensive aquaculture (FAO, 1989), with low stock densities and the utilization of natural feed, and thus has the environmental implications of such. Benthic pollution would likely approach that of cod farming, yet be much less concentrated due to the large area utilized. The cod are not nearly as concentrated as those in sea cages, and one can thus expect the wastes to be more diluted and dispersed than farm wastes (S. Steingrímsson, personal communication, September 21, 2012). Concerning waste pollution, cod ranching vs. cod farming is comparable to free range chicken farms vs. caged chicken, with the associated benefits of low density farming and animal health ethics as those in free range farms. Also, minimized use of the trawling gear can decrease the environmental damage so often attributed to bottom trawling (Jones, 1992).

Ecological Impact: Cod ranching's impact on the variability of fish populations is not completely understood. Björnsson, who has led both cod ranching experiments, has noted a variety of potential ecological changes, including: alterations to vertical migration patterns when "food is falling from the sky," the attraction of predators (such as marine mammals) to the abundance of prey, and potential variances to cod population migration in and out of the fjords (Björnsson, 2001; Björnsson, 2011; B. Björnsson, personal communication, August, 2012). However, some positive ecological changes could be expected. As noted above, supplying feed to a predator can reduce predation on other species. Thus, shrimp, juvenile haddock, juvenile cod, and other prey of larger, adult cod could potentially increase in size and abundance.

The novelty of cod ranching means that little to no outside literature is available to help estimate major ecological changes specific to this technique. Perhaps the practice of "sea ranching" is most near to the methodologies used in the cod ranching experiments described here, in that it too seeks to enhance local populations of (commercially) valuable stocks. Sea ranching, as Liao (2003) describes it, is aimed at "recapturing releases or to promoting inter-breeding between

released and wild populations so that an enhanced self-sustaining population is produced." This is often accomplished through hatchery-raised juveniles, a method widely criticized for inducing negative genetic effects on wild populations (Araki and Schmid, 2010; Leikvoll, 2006; Moksness, 2004). Cod ranching is not intrusive upon genetic variance on wild populations as these methods are, as it seeks only to fatten wild cod. However, an important consideration needing further research is the impact that feeding wild populations would have on the behavior and overall fitness of the wild stocks. Careful monitoring and additional research could help determine whether anthropogenically-fed cod demonstrate decreased survival abilities.

Greenhouse Gas Emissions (GHGE): In Iceland in 2010, 1,625 domestic fishing vessels used 169 kilotons of oil (Statistics Iceland, 2012a). The use of fossil fuels by the fisheries sector contributed to 17% of GHGE in Iceland in 2007 (Ministry of Environment, 2009). Ranching, with most operations taking place near shore like many types of aquaculture, diminishes the need for long distance trips to harvest the catch, potentially saving 1000s of liters in fuel per vessel per year. More consideration of utilizing passive-gear types of fishing, such as in cod ranching, could help Iceland achieve GHGE reduction goals as set forth through the Kyoto Protocol. (Suuronen et al., 2012; Ministry of Environment [MOE], 2009). Consideration must be given to the capture and transport of feed used in cod ranching. Most of this feed is capelin and herring captured off the Eastern coast of Iceland, which would undoubtedly require fuel and energy to bring into the ranching operation. A full assessment of GHGE offsets was not carried out for this research, yet further evaluation of this component could help in planning efforts to determine the necessity of cod ranching or could be used in a complete Cost Benefit Analysis (CBA).

1.4 From Experimental to Practical Application

Up to now, cod ranching, as practiced above, has only been carried out as government funded research projects. Although the method is not perfected (J. Þórðarson, personal communication, September 12, 2012), one could argue that the experiments have demonstrated results sufficient to satisfy, or at least garner interest from, many participants in the fishing industry. In order to advance the effectiveness and our understanding of cod ranching, support and participation cannot depend solely on the MRI; their funds are limited and diversified. At some point, if cod ranching is accepted as a legitimate technique to harvest cod, the private sector would need to become participatory. However, being new and relatively unknown (even in many fisheries

management circles), questions of how one could go about implementing a private – or semi-private – cod ranching practice have yet to be answered. This paper explores these questions and attempts to answer them, so that cod ranching can progress from an experimental phase to an applied fisheries management technique.

1.5 Research Aims

Having provided a background on cod ranching, this report will now provide a political, social, and spatial framework for cod ranching. In order to do this, three specific research questions were proposed at the outset of this project. These are questions of which the answers to, the author believes, will reveal the most socially responsible approach to implementing cod ranching into the fisheries management of the Westfjords. The three reesearch questions that are asked, and subsequently answered, include:

1. What existing legislation provides a framework for implementing cod ranching into Iceland's resource management plans?
2. What policies must be considered and applied for cod ranching to become a feasible commercial activity?
3. Considering socio-economic factors, where is the most viable location in the Westfjords for a cod ranching operation?

1.6 Limitations

The most limiting factor to this research was translation issues, both from English to Icelandic and Icelandic to English. This was most limiting during the fisheries interviews segment; some interviews were cancelled and some were rearranged with a translator due to communication issues. Information at times was unable to be sufficiently communicated, leading to abandoned thoughts or ideas that could have provided the interviewer or the interviewee with better information. Much of the literature used for research, primarily Icelandic legislation, was in Icelandic. In cases where literature was not legally or professionally translated, translation software was used and often led to dubious results. In some cases this required translation assistance from willing Icelandic people.

Time and weather was a limiting factor while gathering data in Iceland. The majority of the data used here was obtained within a three month period in the Westfjords. Working under this deadline led to small time frame windows of opportunity in many cases. There were multiple cases where interviews were cancelled due to weather-related transportation issues. A field trip to the Southern Westfjords to interview fishermen in Bíldudalur, Patreksfjörður, and Tálknafjörður was cut short by three days due to blizzard conditions. The result was less subjects interviewed than planned in Patreksfjörður, and Tálknafjörður fishermen being completely excluded from the data. Time also affected the scope of coverage to be analyzed in the fish catch analyses portion of this research. Had there been more time to conduct this analysis, fish catch data in other regions such as Jökulfirðir, around Hornstrandir, and smaller fjords lining the southern boundary of Ísafjarðardjúp would have been assessed.

1.7 Structure and Contents

This thesis uses a "topic-based thesis" format (Paltridge, 2002); it is comprised of multiple sub-topics under the overarching major topic. Each chapter therefore has its own divisions of case reviews, data collection, and analysis, and each topic, or chapter, assists in shedding light on a socially responsible approach to cod ranching.

Chapter 2 explains the methodology used for this study. Chapter 3 is a review of the existing legal material that may be used to establish a legal framework for cod ranching. Chapter 4 details current permitting and licensing pathways for aquaculture, and a proposed permitting and licensing pathway for cod ranching. Chapter 5 will discuss some political issues regarding cod ranching; these include the applicability of the ITQ system, resource economics, and coastal jurisdiction. Chapters 6 and 7 use original research to determine the social acceptability of cod ranching at potential ranching sites in the Westfjords. Chapter 6 reveals answers from fishermen and other stakeholders to understand their perception of cod ranching, their degree of acceptance of the practice, and how it may impact them and their fishing practices. Chapter 7 uses catch data from the MRI to show fishing effort within the fjords of the Westfjords. Using GIS software, spatial analyses is conducted to determine which fjords would have the least negative impact on current fishing efforts. Chapter 8 and 9 conclude this thesis; Chapter 8 highlights the conclusions

drawn from each chapter, while Chapter 9 is a discussion on relevant considerations and potential areas of future resesarch.

2 Methodology

There are three major segments to this research; legal and policy analyses, qualitative assessment of fishermen's attitudes, and quantitative research documenting catch data in the Westfjords. The methods for data collection and analyses for each component is described below.

2.1 Legal and Policy Research

2.1.1 Legal Texts

Existing literature – including scientific papers, legal documents, national regulatory acts and local statues – provides a backdrop for cod ranching's present standing and legal status. Legal documents were mostly found through Alþingi's online legal repository, found at http://www.althingi.is/vefur/lagasafn.html. Most legislation had accompanying English translations, assumed to be recognized as legal translations due to the source being a government website. However, some texts were translated unofficially through Google Translate and with assistance from native Icelandic speakers. Subjective interpretation is therefore used; these translations would perhaps not be recognized as legal translations and should be treated as such.

Because this research applies a muli-discipline approach, with legal matters being one of many components, the research for this section was not exhaustive. Not every act or regulation was analyzed and it is therefore probable that other legal texts can be applied to cod ranching. The laws presented in this thesis were selected through consultation thesis advisors and with some of the professionals listed in *Table 4*. The texts have been determined to be the most relevant and applicable to the implementation of cod ranching.

2.1.2 Selection of Interviewees

A series of semi-structured interviews (the first of two in this thesis) were conducted to subjects with significant involvement or influence in fields of fisheries, environment, planning, and municipal governance (*Table 4*). Subjects were identified through assistance with advisors, former professors, and professionals in the Ísafjörður community. It was established that each professional has extensive knowledge of a field that can help answer questions regarding this research.

Table 4: Interview subjects for legal and policy chapters

Name	Organization	Position	Date	Location
Hjalti Karlsson	MRI - Ísafjörður	Fisheries Scientist	March 27, 2012	Ísafjörður
Ragnar Árnason	University of Iceland	Fisheries Economist	April 25, 2012	Reykjavik – via telephone
Bjarni Jonsson	Association of Coastal Landowners	Member	Aug. 20, 2012	Reykjavik – via telephone
Benedikt Bjarnason	DoF	Ísafjörður Branch Director	Aug. 22, 2012	Ísafjörður
Daniel Jacobsson	Municipality of Ísafjarðarbær	Mayor	Sept. 6, 2012	Ísafjörður
Ásthildur Sturludóttir	Municipality of Vesturbyggð	Mayor	Sept. 12, 2012	Bildudalur
Ólafur Árnason	EFLA Verkfræðistofa	Environmental Assessment Advisor	Sept. 21, 2012	Reykjavik
Sigmar Arnar Steingrímsson	NPA	EIA Director	Sept. 21, 2012	Reykjavik
Elías Jónatansson	Municipality of Bolungarvik	Mayor	Oct. 1, 2012	Bolungarvik
Áslaug Eir Hólmgeirsdóttir	DoF	Head of Aquaculture	Oct. 9, 2012	Reykjavik
Ingimar Jóhannsson	MII	Director	Oct. 11, 2012	Reykjavik
Hrefna M. Karlsdóttir	MII	Special Advisor	Oct. 11, 2012	Reykjavik

2.1.3 Implementation of Interviews

Subjects were initially contacted either by email or telephone to be requested for interviews. All interviews were conducted in an office setting at the subjects' place of work, except for two interviews which were conducted over the phone. Respondents were asked permission to be

recorded with a digital audio recording device, in which all subjects complied with. The interviews were conducted in what Kvale & Brinkman (2008) describe as an exploratory, open-question format, to allow unconfined discourse and flexibility within the direction of the interviews. Interviews ranged from 20 minutes to one hour. The questions were tailored for each individual, as each subject had a different role in relation to the implentation of cod ranching. The one uniform set of questions that was used was for the three mayors, which can be seen in Appendix I. Responses were transcribed using F4 Audio transcription program.

2.2 Qualitative Analyses: Fishermen

This segment was conducted through a second set of interiews that aimed to answer fisheries-related topics (as opposed to the legal-related topics discussed above). The interviewer aimed to address major themes that would best reflect attitudes towards cod ranching. Analyses of these attitudes show the constraints and potential impacts that cod ranching may incite if attempted in the Westfjords. These themes include: 1) The frequency of use and importance of the fjords by Westfjords fishermen; 2) current spatial conflicts between fishermen and fish farms; 3) opinions concerning the potential prohibition of fishing within a cod ranching site; and 4) general attitudes fishermen have towards the prospect of cod ranching in the Westfjords. As in the methodology presented in section 2.1, these themes were addressed in an exploratory, open-question format to allow for flexibility (Kvale & Brinkmann, 2008). Due to the differences in fishing locations, gear types, and exposure to cod ranching, some questions were specifically tailored for each fisherman. For example, questions for Arnarfjörður fishermen were geared towards how they were impacted during the previous experiment, while questions for Ísafjarðardjúp fishermen focused on current use of the fjords, to assess how they might be impacted. A sample questionnaire can be found in Appendix II.

2.2.1 Selection of Fishermen

Fishermen were selected from towns throughout the Westfjords. The selection was mainly based on referrals from community members or other fishermen. The towns – Ísafjörður, Bolungarvík, Þingeyri, Bíldudalur, and Patreksfjörður – were selected due to their viability of being associated with future cod ranching projects, and their proximity to Ísafjörður, the homebase of the interviewer. The respective fjords surrounding these towns are utilized in different ways. There are differences in geophysical, political, and social differences from town to town, as well as

differences in fishing effort and fishing management. Although some of these differences are reflected through the subjects' responses, an exploration of these contextual factors is not within the scope of this paper. Therefore a basic understanding of the geopolitical structure in the Westfjords may yield a deeper comprehension of the responses. Important to note is that the ranching experiment of 2005-2006 took place in Arnarfjörður, a fjord closest in proximity to Bíldudalur and Patreksfjörður. Although all but one of the interviewees had at least heard of the past cod ranching experiments, the fishermen from these towns were more familiar with it – its aims, methods, and results – and were impacted in one way or another. For this reason, the base port of each interviewee should be noted when reading a response. Another consideration is the type of gear and target species associated with each fisherman. Cod ranching would impact fishermen in different ways, depending on where they fish, what they fish, and how they fish. This will be fully discussed in Chapter 6. *Table 5* provides background details on the subjects interviewed for this chapter.

Table 5: Background information on fishermen interviewed

Respondent	Base Port	Gear Used	Target Species	Date of Interview
A	Ísafjörður	Trawl	Shrimp	Aug. 22, 2012
B	Ísafjörður	Seine	Cod	Aug. 30, 2012
C	Flateyri	Trawl, Seine	Cod, haddock, shrimp	Aug. 31, 2012
D	Bolungarvík	Longline	Cod, haddock, wolffish	Aug. 17, 2012
E	Þingeyri	Longline	Cod, haddock, wolffish	Sept. 10, 2012
F	Þingeyri	Longline	Cod	Sept. 10, 2012
G	Bíldudalur	Trawl	Shrimp	Sept. 11, 2012
H	Bíldudalur	Trawl	Shrimp	Sept. 11, 2012
I	Patreksfjörður	Longline	Cod, haddock wolffish	Sept. 12, 2012
J	Patreksfjörður	Longline	Cod	Sept. 12, 2012

2.2.2 Implementation of Interviews

Although most fishermen were first contacted by phone for an interview request, some were found on docks or at ports of their respective landing sites. In this case they were approached and the interviewer explained the subject matter and purpose of the study, and then asked for an interview. Fishermen were asked permission to be recorded, in which all subjects complied. It was explained to fishermen that they would maintain anonymity. Most interviews were approximately 15-20 mins. The F4 transcription software program was again used to transcribe the recordings.

2.3 Quantitative Analyses: Catch Data

The quantitative analyses presented in Chapter 7 of this text are based primarily on fishing effort data collected by the MRI. Fishermen are required to submit a log of fishing trips which document, among other things, the type of gear used, species composition, weight of catch, and location of each haul (Ó.A. Ingólfsson, personal communication, July 18, 2012). It is this information that I received and utilized, through contractual agreement dictating the extent of use. Names of fishing vessels were scrambled to preserve confidentiality. This data was processed and organized using Microsoft Excel spreadsheets.

One of the major purposes of this study was to determine the importance of fishing grounds within the Westfjords relative to overall catch. Therefore, data was retrieved from fishing vessels recording hauls from within the Westfjords. The scope of total fishing effort locations was limited to a predefined area, being called the Westfjords fishing grounds, to reduce working with unnecessary data. This area is defined as being within Iceland's exclusive economic zone (EEZ), with an eastern limit of 20° 6' W (north of the Skagi Peninsula) and a southern limit of 65° 54' S (west of the Snæfellsnes Peninsula).

Three major fjord regions were selected to serve as case studies: Önundarfjörður, Arnarfjörður, and Ísafjarðardjúp. These fjords were selected based on: 1) their feasibility to serve as a potential cod ranch site, 2) the variety of sizes represented, and 3) the potential impact on the fishing industry for these particular areas. One can define the boundaries of these fjords based on multiple perspectives, i.e. administrative, geographic, ecological, or maritime delineations (G.P. Eydal, personal communication, December 21, 2012). For this study I chose a geographic

delineation, by drawing a straight line between opposing landforms on either end of the respective fjords' mouth. *Table 6* displays the coordinates of the boundary lines for the mouth of each fjord:

Table 6: Coordinates used to define the case study fjords

Region	Coordinates of fjord mouth boundary
Önundarfjörður	23° 45' 44" W, 66° 04' 12" N to 23° 39' 45" W, 66° 06' 52" N
Arnarfjörður	24° 05' 06" W, 65° 48' 23 N to 23° 50' 30" W, 65° 54 37 N
Ísafjarðardjúp	23° 26' 12" W, 66° 11' 50" N to 22° 58' 18" W, 66° 13' 53" N

One limitation to note was that of catch data accuracy. In obtaining data from the MRI, it was noticed that some coordinate inputs for fish catches were in improbable or impossible locations. For example, there were some reported catches of groundfish by trawlers within the fjords (which is illegal). In consulting with the MRI it was determined that these were more likely the result of poor record keeping on part of the fishermen than it was that illegal fishing was taking place (due to the improbability of a large trawler fishing close to shore unnoticed). There were also some catches taking place onshore; again, assumed to be poor record keeping. It was decided to exclude this data for this research.

The geographic information software (GIS) program ArcMap 10.0 by Esri was used to process and display the figures in Chapter 7. Under the recommendation of GIS consultants in Reykjavik, data was processed using the geographic coordinate system ISN_2004 (H. Guðmundsdóttir, personal communication, December 7, 2012). For the spatial analyses steps, the data was transformed into the projected coordinate system World_Equidistant_Cylindrical, due to the systems' capabilities to preserve relative distances (Arc 9.2 Desktop Help, 2012).

Densities were calculated using the point density spatial analyst tool in ArcMap 10. A degree of subjectivity is required when conducting spatial analyses in ArcGIS. The various combinations of cell outputs, neighborhood sizes (search radiuses), and color ramp details create near endless possibilities of presentations on the map. The specifications used in this section were chosen after consultation with GIS professionals (L. Kracker, personal communication, November 9,

2012), case study reviews (Smith et al., 2007; Ornsby et al., 2004), and personal judgment based on trial and error efforts. Specifications used in the calculations of *Figure 5(a-d)* include an output cell size of 500x500 meters and a neighborhood size of two km, meaning the color ramps display a density of kg of fish caught per km² within a two km search radius. The two km radius was chosen because of its presentation properties; *Figure 5(a-d)* is meant to show general trends of fishing in the Westfjords, and a one kilometer radius displays data too acute to allow for patterns to be easily detected by the reader. Specifications used in the calculations of *Figure 6*, *7*, *8*, and *9* include an output cell size of 500x500 m and a neighborhood size of one km, meaning the color ramps display a density of kgs of fish caught per km² within a one km search radius. These figures are meant to show more detail and accuracy in fish catch locations, justifying the use of a one km search radius. Break values, or uniform intervals, are established at .5, 1, 2.5, 5, 10, 25, 50, 75, and 100% of the area density for each map. This method displays uniform intervals so that the reader can determine how dense each area is relative to other areas (e.g. areas symbolized with dark red cells represent areas among the 75-100 percentile of highest densities). These percentiles are displayed in the legend as "relative percentile ranking."

3 Existing legal material relevant for cod ranching[1]

In this section, a thorough overview of current legal material – as they are applicable to ranching cod – will be discussed. The material researched included national acts and regulations, and local ordinances. Relevant material will be identified and discussed as to how the rule could impact the implementation and/or management of a cod ranching project. Information gathered here could be used to help provide a legal recognition of cod ranching.

To date, cod ranching is not legally recognized as a fishing activity. No acts, regulations, nor fisheries management plans address the idea of anthropogenically herding fish for harvesting purposes. If cod ranching is proven to be an advantageous form of fishing, it must first be legally recognized and addressed before operations at the commercial level can begin (H.Á. Grétarsson, personal communication, May, 2012). *Table 7* shows national acts with articles that could be relevant in forming a legal foundation for cod ranching.

Table 7: Relevant acts and regulations for cod ranching

Act, Number/Year	Governing Agency	Relevant Subjects
Fisheries Management Act, No. 116/2006	Ministry of Industries and Innovation	Fishing rights; TAC and quotas; regional development; fishing fees
Icelandic Fishing Operations Act, No. 79/1997	Ministry of Industries and Innovation	Technological, temporal and spatial restrictions; area closures
Act Concerning the Treatment of Commercial Marine Stocks, No. 57/1996	Ministry of Industries and Innovation	Monitoring and weighing of commercial species
Act on Hunting and Fishing	Ministry of Industries and	Implementation of fees and

[1] The legal research for this thesis was undertaken between June and August of 2012. Some legal amendments or temporary provisions have been made between the time of research and the time of publication. The reader is advised to make considerations for these time-appropriate amendments.

Charges, No. 74/2012	Innovation	rent charges on fishing activities
Aquaculture Act, No. 71/2008	Ministry of Industries and Innovation	Sustainable utilization; sensitive areas; farmers' monitoring responsibilities
Aquaculture Regulation, No. 401/2012	Ministry of Industries and Innovation	Specific operating rules and guidelines
Aquaculture Regulation, No. 736/2009	Ministry of Industries and Innovation	Allocation of quota for fish farming
Act on Shellfish Culture, No. 90/2011	Ministry of Industries and Innovation	Management of marine areas harvested using spatial requirements
Health and Pollution Act, No. 7/1998	Ministry for the Environment and Natural Resources	Responsibilities of monitoring, testing, and pollution prevention; license to pollute
Planning Act, 123/2010	Ministry for the Environment and Natural Resources	Structures and changes to the appearance of the environment
Act on Seabed Ownership, No. 73/1990	Ministry of Industries and Innovation	Coastal Jurisdiction
Strategic Environmental Assessment Act, No. 105/2006	Ministry for the Environment and Natural Resources	Sustainability of new programs and plans
Environmental Impact Assessment Act, No. 106/2000	Ministry for the Environment and Natural Resources	Consideration for and categorization of an EIA
Nature Conservation Act, No. 44/1999	Ministry for the Environment and Natural Resources	Conservation of sensitive habitats and ecosystems

3.1 Fisheries Management Act, No. 116/2006

All fishing related activities in Iceland must abide by the Fisheries Management Act, No. 116/2006. The act is supervised by the Ministry of Industries and Innovation (MII), with the Directorate of Fisheries (DoF) having a significant regulatory role. Because cod ranchers would be harvesting wild fish stocks, many components of the act are relevant for the practice, including the following:

> *Chapter I, Article 1:* "The exploitable marine stocks of the Icelandic fishing banks are the common property of the Icelandic nation... The allocation of harvest rights provided for by this Act neither endows individual parties with the right of ownership nor irrevocable control over harvest rights."

This provision is often the pillar for critics of the Individual Transferrable Quota (ITQ) system (Auth, 2011; Gylfason & Weitzman, 2002; Pálsson and Helgason, 1995;). In essence the article proclaims all exploitable fish to be owned by all Icelandic people, and that the ITQ system does not grant fisherman ownership over the fish, only a revocable right to harvest them. Cod ranching would be no different in this regard. A rancher would not have ownership over the fish being ranched. However, the rancher, by obtaining the necessary permits as discussed below, would have the exclusive right to fish within the allocated area. This is similar to other marine based industries with temporary spatial leases (i.e. aquaculture, oil extraction, and mining).

> *Chapter I, Article 3*: "Catch caught for purposes of research by or for the Marine Research Institute shall not be included in the TAC... catch caught for scientific research by other parties shall be partially or totally excluded from the TAC."

The reference to science-based fishing is important for the future growth of cod ranching. Cod ranching is likely to need more trials to gather more data and perfect its methodology. A collaborative effort by the MRI and a commercial fishing vessel is perhaps the most feasible and effective next step in the process. Therefore, it will be important to determine and monitor who are participating, the degree of participation, and the benefactors of the harvests, to ensure the catches are justly applied to the TAC record.

> *Chapter II, Article 4:* "No one may pursue commercial fishing in Icelandic waters without having a general fishing permit."

In cod ranching, both the general fishing permit and the necessary aquaculture permits and aquaculture quota will be needed (H. Karlsdóttir, personal communication, October 11, 2012).

> *Chapter II, Article 10:* "Each fishing year the Minister shall have available harvest rights amounting to up to 12,000 tonnes of ungutted demersal species, which he may use... for regional support, in consultation with the Regional Development Institute, through allocations:
>
> > a) to smaller communities which are facing difficulties due to downturns in fisheries and which are dependent upon demersal fishing or processing;
> > b) to communities which have suffered unexpected cutbacks in the total catch quotas of fishing vessels operating from and landing their catch in the communities in question, which has had a substantial impact on the employment situation in these communities.

This article could be attractive to communities seeking government assistance in the form of fish harvesting rights. Cod ranching could be an attractive allocation of this regional support quota to areas in the Westfjords and other outer regions that are experiencing difficulties in fishing operations due to a lack of quota.

> *Chapter V, Article 22*: "The Directorate of Fisheries shall levy the fishing fee. Vessel owners shall pay a fishing fee for each cod-equivalent kilogramme of allocated harvest rights or landed catch of individual species, as determined pursuant to Article 21. The fee paid by individual vessels, however, may never be less than ISK 5,000."

Harvesting fee regulations will also be applied to cod ranching. However, because of the allocation of exclusive use of marine space, it is likely, or at least suggested, that the fee amount be calculated differently for cod ranchers. A more thorough discussion will follow in Chapter 5.

3.2 Icelandic Fishing Operations Act, No. 79/1997

This Act is primarily concerned with specific gear, time, and spatial restrictions for commercial fisheries. Cod ranching must comply with all the same regulations that other coastal fisheries must follow, and perhaps to a stricter regiment considering all fishing will take place near the coast, where many species reside in the early parts of their life cycles. To identify all fishing restrictions set forth in this act is not within the scope of this paper, yet some regulations are important to illuminate. Withholding exceptions made for shrimp

vessels and experimental purposes, trawling within 12 miles from the mouth of the fjords is prohibited year round (Article V). Also, only vessels under 42 ft and with a power index of less than 2,500 may fish using Danish seine net gear within the fjords. These rules play an important role in spatial planning for ranching. One further stipulation to note in this Act is Article 11, which gives the DoF authority to shut down an area for population conservation reasons, as they see fit. It is therefore important for ranchers to be knowledgeable of the various marine species populations within the ranched area so that they are aware of the potential for conservation measures to be put in place, which could impact operations.

3.3 Act Concerning the Treatment of Commercial Marine Stocks, No. 57/2006

Weighing the catches of cod ranching is an important component of its management. Ranchers will require special attention when harvesting, because of the stocks having been fed. Most grow-out aquaculture weighing requirements are covered in aquaculture regulations. However, because cod ranching is harvesting wild populations, ranchers would also need to adhere to Act 57 on the Treatment of Commercial Marine Stocks. This act is mainly concerned with post-harvest operations as expressed in Article 3.

> *Article 3:* The Directorate of Fisheries shall monitor the composition of catches of the fishing fleet, in order to have always available the most accurate information on the composition of vessels' catches according to the size and type of the vessel, the type and construction of fishing gear, fishing areas and times of fishing.

The monitoring of harvesting cod from ranching sites will require unique consideration. The DoF will play a role in determining what proportion of the catch is value-added by the rancher, and thus not included in the quota. A thorough explanation is offered in Chapter 5; suffice it to say, communication and cooperation between the ranchers and the DoF is integral.

3.4 Hunting and Fishing Charges Act, No. 74/2012

This Act concerns the imposition of fees and rent extraction from commercial fishing activities. The Act lists specific calculations which are fishing type and time specific, of which will not be included in this work, yet could be revelatory in computing exact fees for cod ranchers. Noteworthy sections of the Act include:

> Article 2: Which states that fishing fees are imposed in order to meet the costs of the state for research, control, monitoring and management of fisheries and to ensure that the nation as a whole shares in the profitable exploitation of marine resources.
>
> Article 4: Which states that a fishing fee committee shall conduct continuing reviews of activities and may gather information and process data to calculate rent for activities other than those provided for in this Act, such by species, fishing form or type of quotas, and make recommendations to the Minister of changes in laws, regulations or service if it is warranted.

Article 2 justifies the collection of fees by explaining what it is they fund: primarily research and monitoring. The Act stresses that for the state to continue to monitor the countries' shared natural resources, the profiting extractors are the ones to pay for these services.

Article 4 allows for special consideration (and thus perhaps special rent calculations) for activities that are not provided for in the Act. This would be the case for cod ranching; the MII would likely need to be consulted for establishment of proper rent collection protocol.

3.5 Aquaculture Act, No. 71/2008

In 2008, the Ministry of Fisheries passed a new law regarding the administration of the aquaculture industry. The main purpose of this Act "is to promote the profitability and competitiveness of the aquaculture industry within the framework of sustainable development," as well as to "build up industrial activity in the countryside" (MRI, 2012). With these principles guiding the creation of the act, cod ranching adequately fits into this framework.

The articles in this act primarily stress the Ministries' priority of sustainability and ecological integrity when practicing commercial aquaculture. If cod ranching is perceived as an environmental threat, it will likely not become integrated into Iceland's fisheries management structure; its adoption as a legal form of aquaculture or legal form of fishing will likely be jeapordized. Article 6 is notable in that particular areas or fjords may be considered more vulnerable to an experimental fishing technique, and hence may not be the most opportune places to try cod ranching until the methods and effectiveness are further advanced. Potential ranchers should also be aware of the possible financial burden of expensive environmental studies and assessments, paid by the rancher as noted in Article 9.

Chapter I, Article 1: Which states that actions should always be taken to minimize disturbance to the ecology of wild stocks and so that their sustainable utilization is not compromised.

Chapter II, Article 5: Which states that the agency (MII) can assign "aquaculture zones" along the coast. The agency must obtain the opinion of the Environment, Fisheries, Food, aquaculture Federation, National Federation of Hunting, IFF, MRI, and the local authorities before doing so.

Chapter II, Article 6: Which states that the Ministry of Industries and Innovation may, upon review [with other agencies], limit or prohibit certain farming methods in individual fjords, bays or areas that are considered particularly vulnerable to harm from farming methods.

Chapter III, Article 9: Which states that the agency may require a study at the farmer's own expense if the proposed operation of fish farms includes the increased risk of fish diseases or whether negative ecological effects can occur.

The first, third, and fourth of these articles pass a degree of environmental responsibility, and liability, to potential aquaculturists. It would be important for a potential cod rancher to realize these liabilities, and perhaps have the financial backing prepared for unexpected consequences. Although disease breakouts are unlikely, the potential for other negative ecological consequences must be considered as a financial liability, albeit small, until further research is carried out. The exercising of Article 5 in Chapter II by the MII would greatly benefit potential cod ranchers. This law would help the rancher to secure the exclusive rights to harvest the ranched cod, and would make fishing within these boundaries illegal.

3.6 Aquaculture Regulation, No. 401/2012

This provision provides specific operating regulations as they relate to traditional off-shore aquaculture farms. Again, these articles do not address cod ranching, yet they can be used to establish a framework for cod ranching. Some noteworthy regulations include the following:

Chapter II, Article 3: Which states that the minimum distance between pens shall be 5 km. Pending further consultation, the MII may authorize shorter or longer distances between farms. After the end of each slaughter period, the operating area shall rest for 90 days, and that a larger area will rest for a longer period if necessary.

Chapter III, Article 9: Which states that operations must begin within 24 months of licensing.

The justification for Article 3 is to minimize the concentration of pens in a given area. Carrying capacities of the fjords for a given amount of nutrients and pollutants help determine the total input load, thus determining the density and distances of pens in a given fjord. The 5 km buffer zone between netpens is primarily to limit the spread of diseases and parasites such as salmon lice, of which cod is an unlikely vector of (Watson, Fast, & Johnson, 2008). Whether this regulation would apply to a cod ranching site would need special consideration from the appropriate authority.

The main justification for Article 9 is so that multiple, large near shore areas are not sitting idly in the control of one company or user. This would be especially relevant for applying to a cod ranching framework, because of the large amount of space required. If a large, valuable portion of the sea is allocated for a use and excludes other uses, it would be appropriate that operations begin shortly after the granting of the license.

> *Chapter IV, Article 14:* Which regulates the demarcation of aquaculture sites. It states that floating structures in the sea, as well as the boundaries of the farms, shall be marked and visible with yellow signs, lights, and reflectors. Coordinates of farms should then be submitted to the Icelandic Maritime Administration and Coast Guard. Furthermore, it states that unauthorized persons are not permitted to fish or sail within 200 meters of the farms.

Marking the complete parameter for the ranched area would be difficult, expensive, and obstructive. One would however need floating marks at individual feeding stations, which are permanent, floating buoys. This regulation notes the involvement of the Coast Guard, who would undoubtedly be a key player in the regulatory components of ranching. Concerning the last sentence of the article, the 200 meter buffer zone would only apply to fishing. It would be politically and socially unacceptable to restrict passage through the entire area being ranched. However, certain activities may need to be restricted around the feeding stations.

> *Chapter VIII, Article 26 and 27:* Which gives the Directorate of Fisheries the authority to supervise and record all information in regards to production.

As mentioned in the Act Concerning the Treatment of Marine Stocks, the DoF will be directly involved in the monitoring aspects of cod ranching, and will ensure that data is collected accurately and obiding within quota regulations.

3.7 Aquaculture Regulation, No. 736/2009

This regulation can serve as the basis for quota allocation for cod ranching. The rule authorizes, in Article 1, that "in fishing years 2009/2010 through 2014/2015 the Ministry of Fisheries and Agriculture [currently the Ministry of Industries and Innovation] can specially allocate annual quotas amounting to 500 tonnes of ungutted cod, which to the experimental rearing of cod." The regulation does not stipulate the exact terms or definitions of "experimental rearing of cod," nor does it address the feeding of wild cod for future harvesting. However, representatives at the MII confirmed that this would be the most likely method for allocating quota for cod ranching (H. Karlsdóttir, personal communication, October 11, 2012). Even commercial cod ranching would be operating under experimental contexts; just as commercial cod farms currently obtain experimental quotas in exchange for data sharing with the MRI.

3.8 Act on Shellfish Culture, No. 90/2011

This Act is worthy of consideration based on the fact that shellfish harvesting has particular spatial requirements, similar to that of cod ranching.

> Chapter II, Article 5: Which states that the fisheries minister may oversee the planning, preparation and custody of a database of regionalization of crop areas… Before deciding such regionalization is taken, the Minister seeks reviews of the MII, MRI, ICG, IMA, the Environment Agency, local authorities and others as need.
>
> Chapter III, Article 7: Which requires that the license shall contain information about the location, methods of cultivation and the species license applies. The license shall be restricted to limited areas... If the planned activities under the application of the applicant are carried out within *netlög* region (within 115 meters from the low water mark), application be accompanied by an agreement with the owner of the property.

The articles provide little framework for the legal requirements needed for spatial allocation. Nothing in the Act considers socio-economic conditions (such as fishing effort) before determining areas for shellfish cultivation. If such considerations are to be made, it would perhaps come through consultation with other agencies, as mentioned in Chapter II, Article 5. This article considers the demarcation of shellfish areas. This would be beneficial for establishing cod ranching regulations.

Concerning licensing, Article 7's main focus is on environmental considerations, and placing minimal emphasis on the location of the site in regards to impact on other operations. It only

addresses that if the cultivated area falls within the *netlög*, or netting limits (see Chapter 5.4 on coastal jurisdiction), permission must be granted from coastal landowners. If any operation of cod ranching was to take place so near to shore, it would likely follow the same procedure.

3.9 Health and Pollution Act, No. 7/1998

This act ensures that commercial projects do not pose environmental health risks to the public.

> *Chapter I, Article 2:* Which states that this act applies to any businesses or developments in land, airspace, or territorial waters.
>
> *Chapter I, Article 3:* Which states that businesses or developments that could potentially have unwanted and harmful effects on public health or ecosystem disruption must, with the best available technology, provide testing which involves the analysis of samples for surveillance. Businesses must show regular testing, surveillance, monitoring, and preventative action in the field of health and pollution prevention. Monitoring means systematic and repeated registration of individual variable factors in the environment.
>
> *Chapter I, Article 5:* Any business which may result in the contamination must have a valid license polluters license and may not begin operating related activities if authorization has not been released. Regulation 769/1999 sets forth the guidelines for the prevention of water pollution, while Regulation 804/1999 concerns water pollution caused by nitrogen from agriculture.
>
> *Chapter I, Article 6:* Which mandates that any operation involving production at sea which could lead to pollution at sea or on the seabed within the EEZ and continental shelf must apply for polluters licensing. The Environment Agency shall seek the opinions of the Marine Research Institute, National Energy Authority and others as necessary.

Noteworthy is Article 3, stating that a potentially harmful activity should undergo testing, surveillance, and monitoring with the *best available technology*. And as the definition of monitoring goes here, ranchers need to show repeated registration of the environmental variances. In the case of cod ranching, this primarily concerns changes in benthic sedimentation composition, due to large densities of cod and the associated feed and waste that would drift to the sea floor. Also, articles 5 and 6 show that a rancher would need a polluters permit due to the input of feed.

3.10 Planning Act, No. 123/2010

This Act is noteworthy for the special reason that it does *not* apply: the Planning Act is applicable only up to 115 meters beyond the low tide line. Because the operations of cod

ranching would likely take place outside of this jurisdiction, this Act has little application to cod ranching. Some municipalities would like to see planning and jurisdiction coverage extend beyond this line (Fjórðungssamband Vestfirðinga, Teiknistofan Eik and University Centre of the Westfjords, 2012; E. Jónatansson, personal communication, October 1, 2012; D. Jacobsson, personal communication, September 6, 2012). This issue will be discussed in greater detail in Chapter 5. The only potential land planning issue in regards to cod ranching would be in the case that production required the construction of buildings with freezers and storage compartments. In this case, particular articles in this Act specifying permitting and fees for development projects would then so apply.

3.11 The Nature Conservation Act, No. 44/1999

Primarily concerned with maintaining the integrity of the ecosystem and the natural resources of Iceland, adherence to this Act would ensure that critical habitats or ecosystems are not jeopardized. As denoted in Chapter II, Article 6, they are authorized to deliver opinions on proposed projects and activities. Given the novelty of cod ranching, they would likely be inclined to do so.

3.12 The Strategic Environmental Assessment Act, No. 105/2006

A SEA aims to promote sustainability "by evaluating environmental consequences of proposed policy, plan, or programme initiatives" (Sadler & Verheem, 1996). Specifically, Iceland's SEA Act assesses whether certain plans and programs are likely to result in a significant impact on the environment. This is expressed in the following:

> *Article 1*: Which states that the objective of this Act is to promote sustainable development and reduce negative environmental impact and to ensure that the planning process takes into account environmental considerations.

An assessment of how cod ranching specifically would impact the environment would be assessed in an EIA. However, marine spatial plans and various programs of which cod ranching may be adapted into would follow the requirements of a full Environmental Assessment (EA), as required under the SEA Act. As indicated in Article 3 of this Act, the NPA is the authority to determine the necessity of such a plan or program undergoing an EA.

3.13 The Environmental Assessment Act, No. 106/2000

Before implementation, a prospective cod rancher would need to consider the Environmental Impact Assessment Act of 2000. Exactly how cod ranching fits into the EIA framework is not yet established. Yet listed here are components of the Act which should be considered.

Projects listed in Annex I "shall always be subject to an EIA." Projects listed in Annex II, as described in Article 6, are subject to an EIA "when they could have significant environmental effects due to their scope, nature or location." Provision *G* under annex II includes "intensive fish farming, where the annual production is 200 t or more and waste water empties into the ocean." Thereby, if a fish farm produces more than 200 t, they would be summoned to a review by the NPA, who would then determine whether the environmental effects would be significant enough to require an EIA. One could argue that because cod ranching is not "intensive" it would not fall in annex II, although this could be subject to interpretation. Assuming cod ranching per se is not included in either annex, one must consider Article 7 which states that the NPA may make provisions for other projects not listed in either annex to be subject to an assessment "if it is deemed clear that such a project could result in significant environmental impact." In the section below discussions with policy makers and planners yield clues as to how the approach towards an EIA for cod ranching can be established.

4 Permits and licensing required for cod ranching

To be attractive to potential ranching entrepreneurs, a thorough understanding of the required licenses and permitting processes must be understood. Cod ranching has not been developed enough to receive the attention required by fisheries management agencies in order to formulate a permitting process. Furthermore, the application for typical offshore grow-out farms is a multi-step process involving multiple agencies. Yet recent efforts to streamline the application process have simplified what was once deemed a "complicated" process (Jónsson, 2000). As a director at the MII said, the permitting process for cod ranching could be "a long process… it could be tricky" (I. Jóhannsson, personal communication, October 11, 2012).

Nonetheless, proper permitting would be necessary before ranching could begin on a commercial level. This section attempts to provide a direction and basic framework for how that process would be administered. By first examining the permitting process for typical offshore aquaculture we will see the existing legal framework for as comparable of an activity that exists. Comparisons to other similar ranching projects and their utilization of EIAs will then be analyzed. Then, discussions with government agencies and policy makers cast a light on what further efforts need to be considered.

4.1 Case Studies in Permitting

Although the method of cod ranching – as carried out in the experiments described above – is not known to be practiced elsewhere, similar fishing practices and their permitting processes associated with each are worthy to explore. The aggregation of fish for harvesting purposes using fish aggregating devices (FADs) is similar to ranching in that they both: are passive forms of fishing, target fish behavior, and are relatively selective in catch composition. The practice has been carried-out commercially since at least the 1950s (Dagorn, Holland, Restrepo & Moreno, 2011). Dagorn et al. describe them as being "primarily used in small-scale coastal, semi artisanal and sport fisheries, whereas open ocean drifting FADs are used by industrial purse seine

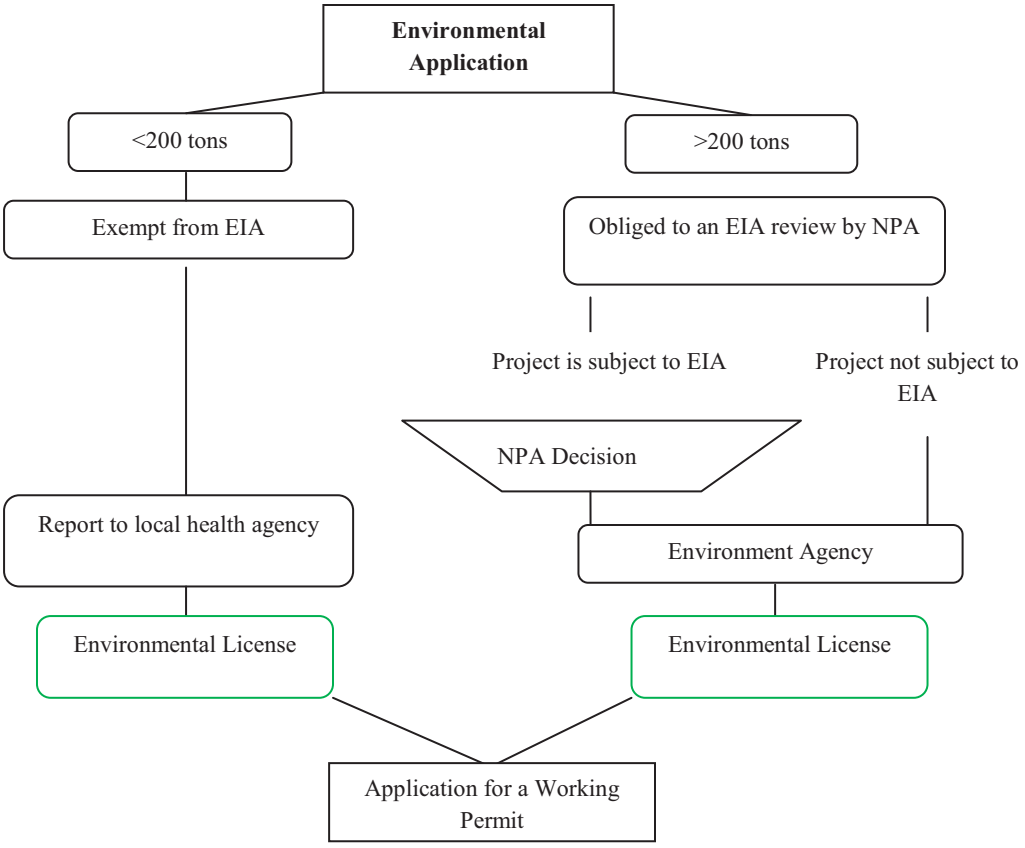
fisheries." These "small-scale, semi artisanal" fisheries using FADs are numerous around south eastern Asia yet there seems to be no legal material recognizing their use (Cayre, 1990; author's personal experience), meaning – at least for small scale FAD ranching – licenses are not typically required. Concerning large scale use, tuna fishers in general are not required by any legislative body to register their use of FADs (Dagorn et al., 2011). This is probably due to the large amount of tuna that are caught outside of EEZs, meaning fewer authoritative bodies to oversee the implementation of such a requirement.

Norway has long been involved with different forms of ranching, with a nation-wide ranching program beginning officially in 1990. This program operated under the principle that "those who sow have the right to harvest" (Moksness, 2004). By 1997 they realized that there was "no existing management basis to establish exclusive harvesting rights for fish" (Leikvoll, 2007). The Sea Ranching Act of 2000 provided licenses that granted "exclusive right to harvest the species in question for a geographic area." So far, however, only licenses have been given for the ranching of sedentary species such as lobster and oysters. There are obvious biological reasons for this, such as difficulties controlling a highly migratory species; yet Leikvoll (2007) cited social factors as being a reason for the slow development of licensing: "[Fishermen] feared that sea ranching would confiscate large areas that would exclude traditional fishing activities." To the best of the author's knowledge, EIAs are not required to ranch fish or shellfish in Norway.

There are many examples of ranching, extensive aquaculture, and fishing operations that authorize licenses to fish or farm based on an exclusive right to harvest a given area. These are commonly known as Territorial User Rights in Fishing (TURFs) (Christy, 1982). TURFs are marine areas that are managed based on spatial considerations, with fishing licenses – or entry to the fishery – controlled by a decentralized, regional authority (Villena & Chávez, 2005; Christy, 1982). In most cases of TURFs, it is the fishermen themselves, usually in a unionized or co-operative form, who manage the permitting process and determine who is allowed entry. Japan has the oldest and most established TURF system, with Chile, Fiji, Alaska, and the New England region of the US having experimented with various levels and degrees of success (Akimichi, 1984; Cancino, Uchida, and Wilen, 2007; Criddle, Herrmann, and Greenberg, 2001; Holland, 2004).

4.2 Current Aquaculture Permit Process

Iceland has seen significant growth in aquaculture in recent years. By the end of 2010, forty operational permits were in effect. By August of 2011 an additional 27 permits had been issued with more expected (Fiskistofa, 2011); 4,700 t of fish were estimated to be raised in Icelandic fish farms in 2012 (Fjórðungssamband Vestfirðinga, Teiknistofan Eik, and University Centre of the Westfjords, 2012). Although the permitting process may not be perfected, it has been continuously adjusted and fine-tuned over the years to become what it is today. *Figure 2* details the main components of aquaculture permitting in Iceland. The aquaculture process is principally a two part process, with part one being the determination of an EIA, and part two being an application for an operations permit.



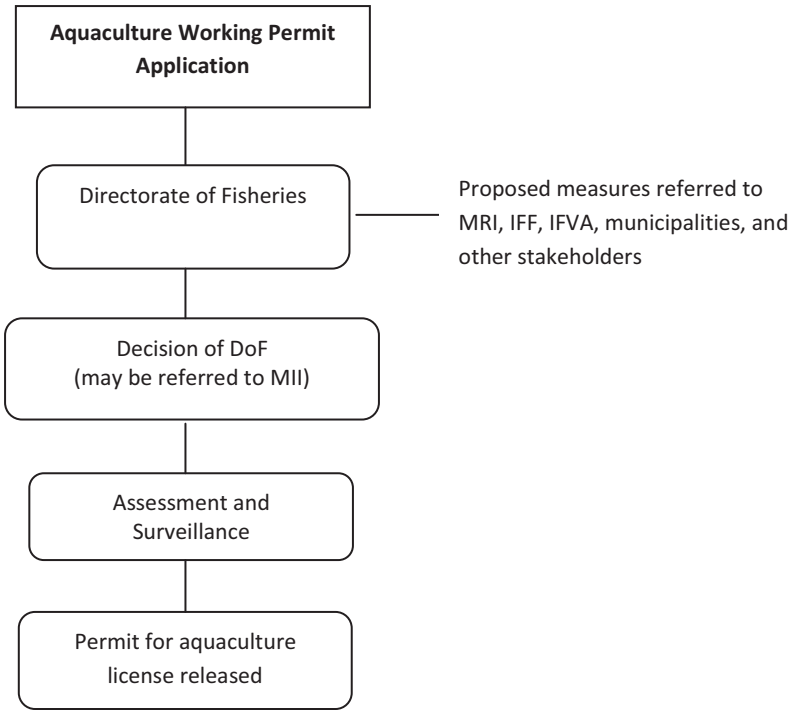


Figure 2: The aquaculture permitting process in Iceland. Source: Adapted from Fiskistofa (2011).

4.3 Environmental Licensing and Environmental Assessments

The Strategic Environmental Assessment Act No. 105/2006 requires an Environmental Assessment (EA) to assess the sustainability of plans and programs. The purpose of such an assessment is "to ensure that points-of-view on environmental protection and sustainable development are properly taken into account and that the plan's, and the proposed developments', effects on the environment are properly assessed as part of the triple bottom line: nature, society and economy" (Fjórðungssamband Vestfirðinga, Teiknistofan Eik and University Centre of the Westfjords, 2010). It is likely that Iceland will begin implementing Marine Spatial Plans (MSPs) in coastal regions in the near future. A formal MSP is being finalized for Arnarfjörður and other such plans are proposed for the whole Westfjords in the next 2-3 years (Fjórðungssamband Vestfirðinga, Teiknistofan Eik and University Centre of the Westfjords, 2012). If cod ranching were taking place in an area conducting an MSP, it would then be appropriate to apply an SEA. However, as long as it is operating as an experimental fishing project with supervision from the MRI, the most likely method for assessment to be used is that of an EIA, as determined by the EIA Act 106/2000, and explained below.

As shown at the top of *Figure 2*, fish farms intending to carry the capacity of less than 200 t of fish are exempt from having an environmental impact assessment carried out. An overwhelming number of fish farmers, perhaps in recognition of this threshold, have their operations fall into this category (Fiskistofa, 2011). These companies then apply to the local Health Inspection Authorities for an environmental license. Production exceeding 200 t requires companies to report to the NPA, who then determines whether the project should undergo an EIA. From this stage, an environmental license is issued by the Environment Agency, pending the EIA. Considering the advantage of economies of scale, it would be more effective if ranchers were capable of, or at least legally entitled to, harvesting greater than 200 t. In Björnsson's 2006 experiment, 171 t of cod and 82 t of haddock were harvested. It is at least worth considering that cod ranching may utilize greater than 200 t, and thus may undergo a screening for an EIA.

According to Steingrímsson at the NPA (personal communication, September 21, 2012), as it stands the EIA Act is not applicable to cod ranching, as there is nothing in text referring to it. However, the NPA says that it would be necessary for someone interested in ranching to fill out a project description so that the NPA can carry out a screening. Based on that project description authorities with the NPA would decide whether the particular cod ranching project would need to undergo an EIA. According to Steingrímsson, the major components of the project description would include:

- Summary / Project description
- Background information on the project participants
- Exact location of the project
- Description of inputs
- Expected production capacity

From there, according to Steingrímsson, the NPA would use protocol typical with that of EIA screening for cod farms – with slightly different considerations:

> They would be very similar issues as they are in aquaculture… mainly concerning the working area: carrying capacity of the fjords, the current systems, the depth, the amount of feed you are putting into it, the dilution area. …Apart from disease, because you are actually using wild stock. So I don't think that would be an issue.

One dimension that sets ranching apart from farming is the lack of boundary parameters (for the fish stock). Whereas net pens are physical structures with a well-defined working area, ranching does not confine the fish, leaving room for interpretation as to where one might monitor benthic impacts. However, Steingrímsson claims "I think it would be on the area where you're actually operating the feeding. Whether it extends from that… I don't think so." EIA specialist Ólafur Árnason (personal communication, September 21, 2012) supported this notion: "These location[s] where you're always feeding them… that's going to be the core, central area. You would be able to locate where most of the activities would go on and concentrate the [EIA] efforts there."

An EIA, as specified by the EIA Act No. 106/2000, should also include a social component, in which "the co-operation of stakeholders and concerned parties" are fully considered. Steingrímsson recognizes this: "I think the key factor here is that you come to some kind of consensus with the local populations as to where you have it before you bring it up here. If they are against it, I don't see how you can go ahead." Cooperation with the fishing industry is a vital part of the EIA process for these types of projects. Cases of appeals – both by the private sector and the public – concerning the location and impacts of fish farms in the Westfjords have been growing in recent years (B. Bjarnason, personal communication, August 22, 2012; K. Jóakimsson, personal communication, September 17, 2012). The sixth chapter of this report is a social examination of fishing industry's attitudes towards a proposed cod ranching venture, and will examine these impacts in more detail.

4.4 Operating Permit

Assuming the EIA process is complete, a company would then apply for an operating permit through the DoF. *Table 8* details the information needed from an aquaculture producer to obtain a license.

Table 8: Information to be provided to the Directorate of Fisheries to obtain an aquaculture license. Source: Adapted from the Directorate of Fisheries

I. General Information	• Type of license (new, renewal, or change in operation • General information (name, business information, contact details) • Information on farm ownership
II. Farm Specification	• Number of net pens, size and diameter of net pens, water depth at locations) • Other farm specifics (such as potential for other species harvesting within the cage)
III. Description of Operations and Rearing methods	• Land-based, sea-based, seabed-based, labor and time considerations • Information on other technologies to be used (holding tanks, pots, etc.) • GPS Coordinates of farm location
IV. Description of Environmental Hazards	• Water Source (running/pumped, fresh/salt) • Water Runoff (from farm in liters per second, into sea and into freshwater)
V. Type of Aquaculture	• Species (salmon, charr, cod, haddock, trout, etc…) • Production purpose (fish to eat, direct to market, out-growing, research, angling, etc…) • Permitted output: tonnage or quantity of each species
VI. Information Related to EIA Act 106/2000	• Screening • Professional knowledge of applicants
VII. Additional Materials to be Enclosed with Application	• Operating license • Plan for financing infrastructure and other equipment • The monthly operating budget for the first two years • Confirmation of auditing (above estimates are correct given the assumptions) • Illustration of the position (location on maps) • Schedule of regular inspection and maintenance • Permits for construction, if applicable • Certificate for the use of land, water and sea

This information, however, is not fully sufficient for a company or individual interested in ranching. Most of these components, especially items II-IV, are inapplicable to the operations of cod ranching. Potential ranchers would therefore require special attention and consideration to be offered an operating permit. Discussions with personnel at the DoF and the MII offer some insight into the process that would be required to obtain the necessary permit.

According to authorities in the aquaculture department of the DoF, a person or company interested in cod ranching should apply for an operating permit with the MII. This is due to the fact that:

> "I suppose we would point them in the direction of the Ministry... today there is nothing in our [the Directorates'] laws or regulations that says ranching is a possibility and that you can get an area which is going to be a whole fjord or half a fjord or whatever… and there is nothing in the laws that would secure that the cod would be left alone from other fishermen" (Á.E. Hólmgeirsdóttir, personal communication, October 9, 2012).

Hólmgeirsdóttir is thus deferring responsibilities of this matter to the MII. The Ministry, overseeing the Directorates' operations, handles all experimental licensing. Directorate authorities pointed out that it was the Ministry who granted the operating license for the cod ranching experiment in 2005. They said that in the hypothetical situation that one is ranching not as an experiment but for economic gain the applicant should go to the Ministry. The authorities also pointed out that the DoF is operating under a new legal framework than 2005 (Aquaculture Regulation 401/2012, to be specific) and that the new framework must be taken in consideration.

Hrefna Karlsdóttir and Ingimar Jóhannsson, representing the MII, offered insight into how they would handle an applicant interested in cod ranching. In general, the MII representatives made it clear that because cod ranching is not in the legal framework, the application process would be complicated: "it would take some time because there's a lot of things to look into. It's quite a process" (H. Karlsdóttir and I. Jóhannsson, personal communication, October 11, 2012). Each application would need to be considered *ad hoc* and taken "step by step," as explained below in 4.5. It must be clarified that the MII does not have the authority to issue a commercial ranching license without it operating as an MRI-led experiment (S. Norðmann, personal communication,

January 16, 2013). This is mainly due to the lack of legislation related to the spatial requirements and resource rents related to ranching (see Chapter 5).

4.5 Recommendations for Obtaining an Operating Permit for Cod Ranching

Questions from the MII and DoF about the nature of cod ranching – its technical components – made clear that the technique of cod ranching, as exercised in the experiments, are not well known among the agencies. One conclusion to be drawn after meeting with Fiskistofa and MII representatives is that for cod ranching to be implemented among the current legal framework, knowledge of prior ranching experiments' results must be disseminated. However, recommendations to potential cod ranchers, as demonstrated in *Figure 3* and based on advice from the MII, present a protocol that could be followed if one were interested in ranching cod. This is the protocol to be followed with the following assumptions: the environmental permit has been issued, and the MII has been authorized by the appropriate legislation to issue ranching permits for commercial ranching.

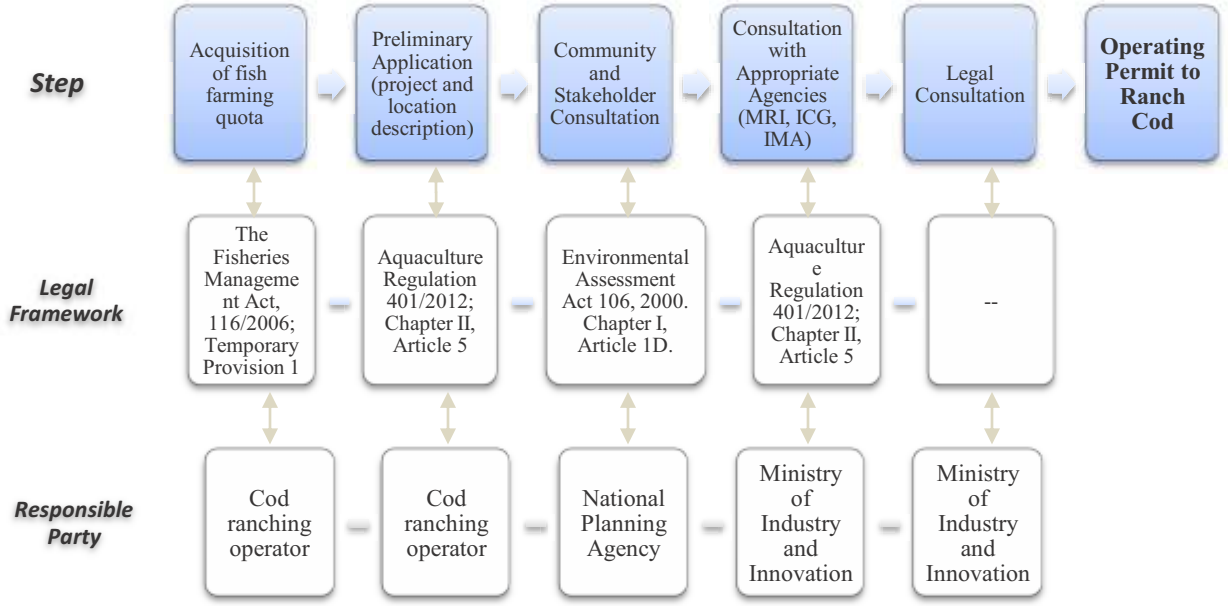


Figure 3: Proposed hierarchal process for obtaining an operating permit for cod ranching, and accompanying legal frameworks for each step.

The first and most basic step is for the applicant to obtain the necessary quota. There are a couple different options for determining the proper method for allocating quota of this nature, yet the most economically attractive option would be to acquire fish farming quota by applying to the MII. MII then suggests sending in a preliminary application. This is similar to the suggestion made by Steingrímsson at the NPA, which asks for basic information for authorities to review to help them determine what protocol to use. This preliminary application would be approximately two pages, detailing exactly how the operation would be carried out. MII would also like as much information as possible concerning the location of the area to be ranched (H. Karlsdóttir, personal communication, October 12, 2011). This would likely need to include coordinates of the ranched area, a physical description and imagery of the area, documentation of historic fishing activity in the area, and other uses of the area. Information and analyses presented in Chapter 7 of this thesis can potentially be used for this purpose.

After a review of the project description, the MII would then address community members in the municipality of the fjord being ranched. Karlsdóttir said: "We would have to talk to local fisherman in the area, because you can't just close a big area without talking to them. Some of these areas also have mining… I would imagine there would be consultation with those [as well]." It is vital that this consultation is the first step in the process. As Gibbs (2009) explains, one of the major reasons of failure for aquaculture entry is objection from local stakeholders. When there is significant objection, complaints can be directed to a recently formed Complaint Committee on environmental and resource issues. This committee operates according to the Act on Environmental Complaints, No. 130/2011. All decisions in application processes made by Regional Authorities, Environmental Agency of Iceland, National Planning Agency and Directorate of Fisheries can be indicted to this committee. According to Sigríður Norðmann, a legal advisor with the MII, "They [decision making institutions] can no longer be indicted to individual ministries, institutes or other committees prior to the act nr. 131/2011" (personal communication, January 16, 2013). With this act most other acts that can influence the environment were affected and a special desicion making committee at a high goverment level. The MII would then consult other agencies, just as they would for typical aquaculture permitting shown in *Figure 2*. Agencies likely to be consulted include the MRI, the Coast Guard, and the Icelandic Maritime Authority (IMA). Finally, MII would seek legal consultation. Lawyers would review the case to make sure the project abides by fisheries, maritime, and property laws (among others), and that no individual rights are being infringed upon. This would almost certainly be a

legal analysis of how cod ranching would impact fishing effort. Following this step, assuming authorities are satisfied with all results, a permit could then be issued.

5 Politics and management issues concerning cod ranching

There are issues of cod ranching that lack managerial precedence at various levels of governance. For example, exactly how cod ranching will fit into Iceland's ITQ system must be clarified, as the system differs from both traditional cod fishing and on-growing of captured cod. Whether or not ranching gains approval for practice by a private entity will likely depend on the system of resource economics that would take effect: how are cod ranching quotas allocated? should cod ranchers be charged resource rent for the exclusive use of marine space? If so, how much, and to whom shall it be paid?

5.1 The ITQ System and Cod Ranching

Iceland's ITQ system has been an ever-evolving managerial process, with its formal initiation taking place in 1984 to help regulate demersal fisheries. Currently, all commercial vessels wishing to fish must possess a quota, or dividend, of the Total Allowable Catch (TAC). The quotas are permanent, perfectly divisible, and subject only to a small ownership cost, which covers regulatory expenses (Árnason, 1993; Matthíasson, 1997). The major assumption of the ITQ model was that "by establishing private property rights to fish resources it is possible to create an incentive to harvest the resources in a way which secures long term sustainability" (Eythórsson, 1996). It is within this spirit of fishing efficiency that cod ranching arises and follows.

The system was designed for capture-based fishing, yet with the advent of offshore grow-out pens, quotas are now used to capture smaller cod to be transferred to larger pens for fattening. Temporary Provision 1 of the Fisheries Management Act No. 116 (2006) allocates 500 t of ungutted cod towards on-growing experiments. It is through this system that most cod farmers obtain quota for operating their grow-out farms. In exchange for the free quota, farmers are expected to work with the MRI to collect data, communicate knowledge, and publish results concerning the grow-out operations (Gunnarsson, 2008). The quota for this program is allocated at the time of capture. The feed is an input, or cost incurred by the fish farmer. The final weight

of the slaughtered fish, minus the weight at the time of quota allocation, is value-added which is a benefit gained by the farmer.

According to representatives at the MII, cod ranching qualifies for this program and should seek quota allocation of this sort to operate with (H. Karlsdóttir, personal communication, October 11, 2012). The fish being fed in a cod ranching operation are wild and free ranging, yet the same quota-purchasing protocol would likely follow suit. They would hold quota for the natural fish stock, feed/fatten the stock, and reap the benefits of the added value. Fisheries economist Ragnar Árnason (personal communication, April 25, 2012) supported this, saying value-added should not be calculated into the quota value for ranching cod, and that "the price should only consider the normal natural stock, then they should buy quotas for that volume, and then increase the weight of the fish afterwards." The difficult part is determining the weight of the natural stock to allocate towards quota. With typical grow-out operations, small fish are captured and their weight is taken and reported to the DoF. The DoF sometimes monitors this process, but often relies on the captain's calculations (B. Bjarnason, personal communication, Aug. 22, 2012). A cod rancher cannot know which wild fish he will be feeding and catching and would thus have to rely on sampling. Tagging and periodic sampling will determine weight gained by the wild fish, which in turn indicates the value added by the farmer. This operation will undoubtedly need monitoring by the DoF or a third party. This monitoring can be funded by resource rent paid by the ranchers, as discussed below.

5.2 Resource Rent and Cod Ranching

It has been considered that cod ranching will require a resource rent to be paid (B. Björnsson, personal communication, August 28, 2012; R. Árnason, personal communication, April 25, 2012). The main justification for this idea is the large amount of marine space that is being utilized in an exclusive manner. To help determine appropriate applications of resource economics, insight can be gathered from past case studies, as well as opinions from fishermen in the area.

Fisheries managers and economists point to the efficiency of fishing rights as justification for generating resource rents (Eythórsson, 1996; Árnason, 1993). Resource rent in fisheries is payment for harvesting fish, typically from a commons area (Gordon, 1954). Act 74/2012 on Hunting and Fishing Charges states that resource rent is calculated based on income arising from

employment-based natural resource management in excess of operating costs so that "the nation as a whole shares in the profitable exploitation of marine resources." According to FAO (2005), "the purpose would be to promote an equitable distribution of a 'surplus' income that some consider in principle to belong to all members of the community." Among these definitions and considerations, extracting rent from a cod ranching operator appears justifiable and worthy of consideration.

A first consideration is that of opportunity cost on behalf of the fish to-be-ranched. Cod ranchers will be foregoing the opportunity to harvest the wild cod for marketing purposes when they begin the ranching operation. By capturing and slaughtering the fish initially (and foregoing the ranching), fishermen would only be paying a rent equal to the price of a quota lease on the quota market, as well as the applicable fishing fees (T. Matthíasson, personal communication, February 6, 2013). To properly assess the potential realized benefits for ranching cod, a determination of this opportunity cost would be necessary.

As mentioned, ranching would require exclusive use to the column of sea below a predefined area, along with the food resources within this column. It is therefore worthwhile to examine what legislation could be cited for determining rent for such a practice. Icelandic Regulation No. 290/2012 on seabed ownership denotes that resource rent should be paid for utilization of seabed materials, but does not address exclusive utilization of the sea surface or water column. For aquaculture, fish farmers must pay annual fees which cover monitoring expenses, yet these fees are not necessarily tied to the leasing of marine space (Aquaculture Regulation 401/2012, Chapter X, Article 29). As mentioned before, the Fisheries Management Act No. 116/2006 proclaims all exploitable fish to be owned by all Icelandic people. Although the Act does not address rent specifics, it provides an argument for rent extraction for fish harvesting base on its labelling of fish as a "common good." Rent is currently extracted in the form of a fishing fee, pursuant of Chapter V, Article 21 of this act which states: "Vessel owners shall pay a fishing fee for each cod-equivalent kilogramme of allocated harvest rights or landed catch of individual species." Without precedence of extracting rent based on territorial use of the sea, this would be the most relevant legislative framework on which to impose rent extraction from cod ranchers, considering the harvested resource is "owned by all Icelandic people." The exclusive use of a large marine space – and the potential disruption to fishing operations that exclusion may cause –

is adequate argumentation to impose fees higher than those incurred through traditional means of fishing.

Yet consideration must be given to Iceland‘s ITQ system and how the combination of these two rights-based fishing methods may overlap concerning rent extraction. In a non-quota system, fishermen accustomed to fishing within the ranched grounds would potentially be more impacted by the restricted access; they have not yet purchased their right to fish, and they thus face uncertanties not only of where they will fish, but how much they will catch. The place-based ban would likely only have negative consequences from a financial perspective. Quota-based fishermen, on the other hand, have already been allocated their share to fish, and the major variable thus lies in where to catch their share. The displacement may or may not impact his operations financially; if it proves to be too costly, he could then choose to sell his quota share (T. Matthíasson, personal communication, February 6, 2013). Quota-based fishermen are thus marginally impacted by the exclusive rights ban relative to non-quota based fishermen.

A fee collection, based on Chapter V, Article 21 of the 2006 Fisheries Act and specified in the 2012 Act on Fishing and Hunting Charges is the framework of which to collect rent from potential cod ranchers. This fee is based on the value of catch of the preceding year (minus certain costs such as fuel and salary). Yet for cod ranching, an additional charge accounting for the opportunity cost to fishermen who are excluded from the ranching site would be necessary. As there is currently no other economic valuation method of to-be-ranched sites, fishing opportunity cost is most appropriate. Exactly how much should be extracted would be a calculation based primarily on the economic yield of fish catch from the area to be ranched, which can be based on information provided in Chapter 7.

5.3 Compensation from Cod Ranchers to Westfjords Fishermen

One scenario is to provide direct compensation to fishermen who regularly fish within the area being ranched. Research for this study revealed no historical cases of compensating fishermen for declaring exclusive uses of a marine area in Iceland; international cases are relatively few (discussed below). Some scenarios involving compensation due to declines in shrimp have led to compensation in recent years (B. Bjarnason, personal communication, August 22, 2012). However, this differs from compensation arising from intentional displacement. The latter exists

to provide economic assistance to the industry in times of biological uncertainty. Intentional displacement involves issues of social equity and market forces; the two offer vast differences in their rationale to compensate. All considered, none of the fishermen interviewed for this thesis had any experience with having been compensated due to lost opportunities.

One burgeoning industry with precedence of fishing compensation is the construction of wind farms over valuable fishing grounds (Perry & Smith, 2012). Yet the most common global situation is that of the creation of Marine Protected Areas (MPAs) in prime fishing territory. The Great Barrier Reef in Australia, Glacier Bay Marine Park in Alaska, the Papahanaumokuakea Marine Park near Hawaii, and offshore from Tasmania are all places where fishermen are compensated due to displacement by a marine park (Llewellyn, 2007; Sen, 2010). Although the function of the reserved area differs from that of a cod ranching site, the exclusivity function and its resulting impact on fishing effort is exactly the same.

Sen (2010) developed a framework for "scenarios and options when planning spatial commercial fishing closures" *(Table 9)*. Although his framework addresses MPAs specifically, the model can be applied to that of cod ranching.

According to Sen's model, a high proportion of catch from an overfished area would result in maximum payout to fishermen; monetary compensation, new management measures, and adjustment assistance would be the necessary actions to follow. On the opposite end of the spectrum, a low proportion of catch from an underfished fishery would result in no compensation measure taking place. Specifically how a particular cod ranching operation would fit in to Sen's model would depend on exact coordinates of the proposed site, which at the time of writing, no commercial proposals had taken place. Yet by obtaining and applying catch data from a specific area to this model one can determine what degree of compensation measures would be required.

Table 9: Suggested compensation/assistance outcomes for different displaced effort. Source: adapted from Sen (2010)

Proportion of catch from MPA		A	B	C
	High	Time bound adjustment assistance	Targeted buyout of effort Adjustment assistance	Effort buyout Fisheries management measures Adjustment assistance

	Low	No compensation	Targeted buyout	Effort buyout Fisheries management measures Adjustment assistance
		D	E	F
		Underfished	Fully Fished	Overfished
Fishery status				

There are arguments as to why compensation should not be a consideration. One relates to the first article in the Fisheries Management Act, which proclaims all exploitable fish stocks are common property of the Icelandic people. Therefore, paying select individuals would undermine the notion that all citizens have a stake in the fish resources. Another argument could be that of the value added to commercial fishing stocks, such as shrimp, gadedoids, and cod and haddock that stray from the feeding sites. Cod ranching in this case would be transmitting a positive externality to the fisheries sector, and would not be indebted to compensation. A final argument would be of the application of free market principles; if the ranching site was fairly auctioned, everyone would have access to purchase the exclusive rights to ranch or harvest.

A hypothetical scenario of being compensated due to displacement by a cod ranching operation was proposed to fishermen around the Westfjords. Subjects were asked the question, "How would you respond to the prospect of receiving compensation if you were restricted from fishing within *fjord X* (the most nearby fjord respective to each fisherman)?" Those with an opinion on the matter were recorded and their answers are transcribed in

Table 10.

Table 10: Westfjord fishermen's responses to the idea of compensation

Respondent	**Response**
A	No, because the shrimps are giving lots of work here in the area when they are fishing the shrimps. Not just for the fisherman but for the factories, year round. So I think it would not be easy to do that.

B That's bullshit. Come on. The ocean is 70% of the earth. You can just pick a place without impact.

D I don't know. It's a difficult question. Especially if you ask me about the area here. Like I said, these fishing grounds here are like two or three percent of our fishing on the year. We use the bad weather days. So it [cod ranching] wouldn't have a lot of impact for us.

E I don't know. I don't think that would be an issue here [in Þingeyri]. But it might be in Ísafjörðurjup or in Arnarfjörður or something… Its strange to think of paying compensation to people catching fish that nobody owns... that the state owns... for the right to catch it. But of course if the fishing limits would go far out to the sea, it might cost more oil or whatever and less opportunity to catch. So somewhere there's a line you know, where this concept must not cross. But I think we're far away from that here anyway.

G Yeah, if they want to do that... I would be happy.

J I don't think that is necessary.

Of the six respondents who had an opinion, five neglected the idea of compensation. Respondents *A* and *B*'s answers can be construed as a rejection of the idea of cod ranching in general, while *J* can possibly be interpreted as the same; *A* on the grounds that ranching would adversely affect the shrimp fishermen (which is not the case), and *B* on the grounds that potential cod ranchers should be able to find areas to operate that would not impact fishermen. *D* simply sees no need for compensation if such a scenario arises, while *E* maintains a suspicion that such an exclusive right to harvest is unnecessary and unfeasible. *G* is the only respondent open to the proposal. One can conclude that the idea of compensation evokes suspicion on behalf of resource users; it perhaps represents a notion of "buying out" fishing resources – perhaps enticing a loss of control over resource management – a notion not very welcoming to small fleet fishermen in rural environments, as documented in ITQ impact-related research (Auth, 2012; Benediktsson & Karlsdóttir, 2011).

5.4 Coastal Jurisdiction

Many coastal citizens in the Westfjords proclaim strong connections to the coastal zone and entitlement to its resources, usually citing historical reasons (Auth, 2012; D. Jacobsson, personal communication, September 6, 2012; undisclosed fisherman, personal communication, August 12,

2012; Fjórðungssamband Vestfirðinga, Teiknistofan Eik & University Centre of the Westfjords, 2012). Ideally (from a regional perspective), communities and municipalities from the surrounding ranched fjord would reap the economic benefits through some entitlement to the rent collected by the DoF. However, this is unlikely to take place due to the legal idea of *netlög***,** a historical hunting concept from the Icelandic text Jónsbók of 1281 (B. Jonsson, personal communication, August 20, 2012). The concept, which was adapted into the 1849 Directive of Hunting in Iceland, was initially installed to allow coastal dwellers the rights to harvest resources up to 115 meters from the low-tide mark (Alþingi, 2012). The modern version of the law now provides municipalities with management responsibilities, planning duties, and the rights to access resources within this 115 meter limit (Fjórðungssamband Vestfirðinga, Teiknistofan Eik & University Centre of the Westfjords, 2012). (However, it must be noted that all coastal activities are subject to the regulations set out by authorities administrating particular coastal activities). Beyond the 115 meter mark, however, no legislation entitles any group to an exclusive right to use or harvest resources; the only allocated jurisdiction of this area is to that of the country of Iceland, as declared in Act 41/1979, the Law on Territorial Waters, Exclusive Economic Zone and Continental Shelf.

The significance of this concept for cod ranching (as well as offshore fish farming of all kinds), is that coastal municipalities have very little influence over whether it should take place, where it should take place, or how it should take place. And, perhaps most importantly, they lack any entitlement to rent created from offshore resource extraction. In theory, ownership of fish farms or cod ranching operations can be from outside the Westfjords, with profits derived from extraction of Westfjords resources flowing outside of the region. This has created concern for at least one fishermen interviewed:

> I think whenever you are creating a new business in those sensitive communities here, the benefit of the people should be number one... the social responsibility of those companies who are coming or investors who are willing to do it. The owners of a factory with 1/4th the population working there, if it comes from elsewhere, the ownership, the profit goes somewhere else. So it all goes away. Its like being a colony in a way (Fisherman Respondent F, personal communication, September 10, 2012).

Similar opinions were expressed in the Arnarfjörður MSP initiative (Fjórðungssamband Vestfirðinga, Teiknistofan Eik & University Centre of the Westfjords, 2012).

Cod ranching would be taking place in waters controlled by the national government, and the state would thus be the benefactors of the taxes and fees collected. This is despite community leaders‘ pleas for increased inheritance of coastal resource taxes on behalf of coastal communities: “It would be good for the coastal people to get this fee because they would use it at the site,” said the head of a coastal landowners association (B. Jonsson, personal communication, Aug. 20, 2012). Of the three mayors interviewed for this thesis, two agreed that their respective communities would benefit from having greater influence on activities taking place beyond the 115 meter mark. Bolungarvík mayor Elías Jónatansson said, “That's the way it should be I think. We should control more of our own coastal areas and what's close by” (personal communication, October 1, 2012). Greater jurisdiction would assume greater management responsibilities, yet more revenue from taxes and fees incurred from activities such as aquaculture and cod ranching would perhaps encourage research and support improved management and monitoring.

6 Qualitative assessments of fishermen's attitudes towards cod ranching

This chapter reveals the results of interviews given to fishermen in the Westfjords. These open-ended questions followed a general format, divided into the themes addressed below. Information on respondents can be found in *Table 5* in Chapter 2, and a sample questionnaire can be found in Appendix II.

6.1 Use of the Fjords

Understanding the extent of use of the fjords by fishermen is important before determining whether the fjord is an adequate site for a cod ranching project. Of course the exact extent of fjord use is quantifiable. Fishing effort coordinates are collected by the MRI continuously, and some of this data is presented in Chapter 7. Yet this section focuses on the attachment that fishermen have with these fjords, and how much value they place on the right to use these areas for fishing.

First, it is important to recognize that coastal fishing, especially within the fjords, has stricter regulations than offshore fishing. Temporal, spatial, and gear restrictions are often put in place to prevent the degradation of sensitive marine areas (Icelandic Fishing Operations Act, No. 79/1997). Under this act, trawling is not allowed within the fjords (except for shrimp), and seine nets are only allowed with special permission from the DoF. Shrimp trawling was banned in Ísafjarðardjúp from 2004-2010 and in Arnarfjörður from 2006-2007. Yet in 2011 eight boats in Ísafjarðardjúp and four boats in Arnarfjörður caught a combined 792 t of shrimp within the fjords (data provided by the MRI).

In general, most longliners seem to associate fishing within the fjords as a last resort; they only fish there when constrained by time and weather. Five of the six longliners interviewed did not fish inside the fjords if the weather was good. The main reason for this is because they perceive the fish to be of poor quality; small, inferior marketability, and sometimes laden with parasites. Respondent E claimed: "In general we go outside the fjords. Because you get bigger fish that pay better and also you get rid of the worms that are usually in the fjords and you also get fish that

are brown from the seaweed so the skin gets brown. Inshore means a lot of worms and the processors are not so keen on it." A manager at a fish processing plant in Bíldudalur validated these claims: "We don't like the coastal fish so much because it takes a bit more time to inspect… special lamps to detect the worms and more time separating" (personal communication, anonymous, September 11, 2012). Meanwhile some simply blame a lack of fish inside the fjords: "For some reason - I don't know why - there are no cod inside these fjords. Usually we don't have any fish here in Ísafjörðurjup. The last – I don't know how many years – the cod go there [the mouth of the fjord] and just stop there and go out again" (Respondent A).

Two of the respondents were contracted by fishing companies to catch juvenile cod or small cod to place in netpens for further fattening, a growing practice in Ísafjarðardjúp. They both preferred fishing areas just outside of the fjords for this purpose: "Adalvik, in Hornstrandir… That's the best area for fish, the small cod there. So for the cod you catch for the netpens, you never fish inside Ísafjarðardjúp," said Respondent C.

The current ITQ management system could also explain a lesser dependence on the fjords. The system, which aims to promote efficiency, is perceived to have decreased the amount of small boats using the fjord through the consolidation of quota into fewer hands: "There are some long liners and seiners but... they sometimes fish here in fjords. Those kinds of fishing boats are always getting fewer and fewer" (Respondent H); "Flateyri… they don't have any more quota. Maybe it's a good place to put a boat now" (Respondent F). All the longliners agreed that haddock have now been flooding into the fjords, yet most do not have the sufficient quota to fish haddock, nor to fish cod where haddock might be due to the risk of catching them as bycatch.

One could also associate fishing within the fjords as more of a recreational practice: "We always have some individuals that plan to catch a lot in the fjords. And those are maybe not in it for serious business. More for sport, or, how to say... they don't take their job very seriously" (Respondent E). Iceland's annual summer coastal fishing is an example of a more recreational form of fishing. Each summer the MII allocates a certain amount of quota to be shared by small vessels, with last year having had 760 boats obtain a temporary license to share 8,600 tons of cod equivalents (Iceland Review, 2012). "In this sort of system you might go in fjords, just to make something out of this instead of nothing, because you lose it otherwise," said Respondent E. If an area is indeed being used primarily for recreational fishing, this should perhaps be taken in consideration if determining whether the area can be allocated for cod ranching.

6.2 Current Conflicts between Fishing and Farming within the Fjords

To predict whether or not cod ranching would create conflict between fishermen and those ranching the cod, it is useful to determine whether there are current conflicts between fishermen and fish farming. Subjects were asked their opinions on fish farms in the fjords and whether they are disruptive to fishing operations. Of the ten respondents, one thought that fish farming is a problem, two thought that it was not a problem at all, while the other seven believed that there are not currently any problems, but could foresee potential problems at its current rate of growth.

Respondent J, a longliner from Patreksfjörður, was the only interviewee with a definitive "no": "They are close to shore. And we can also go around it. If you lay down a line, and you got one here and one there, and we know its okay to go here, then you can do that." Respondent F meanwhile responded with a cautious no: "No issue. But [it] depends on the occupation, you know. If it was to be all over, and you had to sail out like this [zigzag motion], then maybe yes. But in small quantities I suppose its okay." Although neither expressed an explicit conflict with fish farms, both respondents commented on having their navigation affected, referring to potential impact. Yet both are implying that making small adjustments to steering around the pens is not a problem.

The strongest opinion on this matter came from Respondent H:

> "Now there are these large salmon cages. And we have nothing to say about it. They just put their factories over the shrimp areas and Hafro or nobody doesn't say anything. We have worries about that because you can have a license to harvest up to 200 tons - 199 - and you don't have to get any permit for that. And today there are 25 licenses like that in the fjord. But they are not being used. They just want the space. They are just handing out licenses. It doesn't matter if we have been using the area for 100 years to fish shrimps they just put it wherever."

This fisherman appears more threatened by future spatial allocation than he is aggravated by the farms' impact on fishing effort. He views it as a threat to traditional practices. These issues – the large tracts of spatial allocation and a shift from traditional practices – are the two derivatives of cod ranching most likely to provoke resistance from fishermen. "[Fishing] takes time and is hard. It always has been like this. If it is not, everyone does it," said respondent F.

The other respondents were in general okay with the current presence of the net pens, yet were suspicious about future growth:

> Not [concerned] now because all the pens are inside the fjords. We are not fishing in these fjords. But now they are talking about having pens inside Ísafjörðurjup and having salmon. But I know there are a lot of shrimping boats - they are not very happy about it. And few of them are thinking about very good places. A few people are trying to stop that right now (Respondent A).

Respondent C said: "They are going to put farms in Ísafjarðardjúp , where we are trawling with the shrimp trawler. And that's not good. Yeah I'm upset about it. It takes a lot of space for one pen." And respondent G: "It could be [a problem], but its not now. Not yet. You never know, if it's going to be bigger and they need more space, it could be a problem."

Clearly the fishermen are concerned and feel the productivity of their fishing operations could be jeopardized. A representative from Hraðfrystihúsið - Gunnvör Ltd, a large fishing company in the Westfjords, confirmed that they are expanding in coverage: "We are trying to extend our aquaculture operations and the sites for the pens in the area. It's still creating conflict in the area" (K. Jóakimsson, personal communication, September 17, 2012). The amount of complaints that have been filed in recent years has been enough for the MII to appoint a new committee to work on this issued. They handle complaints from people not happy about the distribution of aquaculture licenses, and "have been drowning in cases" (Á.E. Hólmgeirsdóttir, personal communication, October 9, 2012). The difference between the netpens and a cod ranching site is that the netpens present a physical obstacle, while ranching is more of an operational obstacle.

These issues of conflict must be discussed transparently in regional stakeholders meetings if a new type of aquaculture is going to gain entry into a community. According to these fishermen, this is not the current trend in regards to the rise in fish farms in the Westfjords. Giving a voice to fishermen and municipalities will be vital to minimizing potential conflict if a cod ranching project is proposed.

6.3 On Being Prohibited from Fishing within a Cod Ranching Site

Fishermen were proposed a hypothetical scenario in which a large marine area was allocated to ranch cod, thus making commercial fishing within the area prohibited. The fishermen were asked whether they or other fishermen would oppose such a project "in their own backyard," and how they believe it would impact their fishing operations. The responses are organized into two geographic categories: Ísafjarðardjúp fishermen and Arnarfjörður fishermen. The reason for this is that fishermen from Arnarfjörður already adhered to this prohibition in the 2005-2006 experiment, and thus offer different perceptions on the situation. Worthy to note here is that the interviewer did not use this time to clarify who would or would not be excluded (e.g. shrimp trawlers), but only collected data on opinions and perceptions as they were.

6.3.1 Ísafjarðardjúp Fishermen

In general, fishermen expressed negative attitudes towards the possibility of having a large tract of marine area set off limits to fishermen. Many cited the shrimp industry as having the most at stake inside the fjords:

> Respondent A: [Doing both ranching and fishing] is not possible. I think they would never be allowed to do that because not just the trawlers, there are the line boats and the seines… because they need so much area to do this. The boat fishing with the line, they are only fishing in the fjords when it is bad weather outside. But we have other boats here like the shrimp and the seine… When we were fishing the shrimp we fished all around Ísafjarðardjúp, all the Jökulfirðir, and all the fjords. So I think we are not very happy if someone say we are going to take 1/3 of the area for cod farming.

> Respondent B: [Ranching in Ísafjarðardjúp]… that's a big problem. Because it's a big shrimp area. They catch a lot of shrimp there in the fall and the longliners use this area when there's bad weather… So why can't you just pick a place that's not affected. Like in here [points to Jökulfirðir]. Okay, shut this down. Shut this place down and do it here. There is fish in here. And this is a small area [pointing to Mjóifjörður] so it would not affect so much, and you say from here to here we aren't allowed to fish inside this. That will be okay.

By illustrating with his hands, Respondent B was showing places that could be used for ranching that would not displace fishing effort. He was mainly pointing to the smaller fjords of Ísafjörður, Mjóifjörður, and Skötulfjörður. Although from a displacement perspective these fjords would be most minimal, these fjords would not be ideal site candidates due to the low abundance of quality cod and the high potential for organic pollution.

Respondent D was concerned for haddock in his catches: "If they were doing it where we normally fish haddock… no I wouldn't like that."

The only respondent from this region who did not think the fish ban would pose a problem was E: "I'm not sure. I think maybe those who do it for sport [would oppose it]. But I don't think that professional fisherman would have anything against it, because we do go anywhere much further out. Depends on the fjords I suppose."

The thought that the shrimp industry would be negatively affected by cod ranching is misconstrued and demonstrates the lack of awareness of the practice among fishermen. The exclusion of shrimpers in the ranching area is a very important consideration. Shrimpers are now required by regulation to use exclusion devices (EDs) for their trawls (B. Bjarnason, personal communication, August 22, 2012). These EDs would not capture cod and other large demersal fish. Shrimp trawls would therefore not be banned from ranching sites. Of the two greatest concerns among fishermen, the impact on shrimp trawlers and the impact on seiners, the impact on seiners is the most legitimate threat.

All respondents were relatively hesitant with answers to this question. Obviously more precise information would need to be given to have precise sentiments reflected; exactly where, when, and who would be prohibited? Of course these details cannot be provided until a serious proposal is made to proceed with an effort to ranch cod. Nonetheless, the responses by these fishermen in general represent a high degree of consternation concerning the proposition of areas in Ísafjarðardjúp being banned from commercial fishing. Biological and social considerations will need to be appropriately weighted to find an adequate ranching site.

6.3.2 Arnarfjörður Fishermen

The fishermen from this region were all active during the 2005-2006 experiments, and were thus prohibited from fishing in the designated ranching area. These responses detail their thoughts on

that ban, and how they would respond in the case of another experiment taking place in Arnarfjörður.

> Respondent G: It was a little bit of a problem. We had more boats with the Danish seine. But now we don't have these boats so I don't know if it would be a problem now. Inside Arnarfjörður the usual fishing like cod and haddock is less. But there are now three boats fishing shrimp in the winter time. So maybe that can be a problem. Will closing an area be a problem? Not if they have a cooperation. If they just talk to everyone. It depends where they will close.

An important point brought up here is the changing dynamics of the fishing industry in Iceland. Population shifts, species shifts, changes in regulations and climate all lead to consistent uncertainties in what is actually happening in and around the fjords. This makes the decision of where and when to ranch especially spatially and temporarily sensitive; perhaps more so than other forms of harvesting cod, since ranching has so many socio-political considerations. The second important point by Respondent G is that of social cooperation. This is a reoccurring theme throughout the interviews, as well as this thesis. Cod ranching can only be executed though extensive cooperation with all stakeholders.

Respondent H said: "[Danish seiners] were complaining about the place it was put because maybe in September, October they often fish haddock. So they were complaining about that - there was no *problem*." The emphasis on "problem," detected in his diction, implied that people complained, but there was no conflict. There of course are grey areas between "complaints" and "problems" and this subject would need to be monitored. Complaints can be mitigated and appeased through mutual agreements. Problems might jeopardize the entire operation. Respondent H continued: "I think the shrimpers would not like it. They would say you can do it any other place because this is the only place we can fish shrimps and we would not want the fish to stay like it did. Maybe not a problem but we would prefer it take place more out in the fjords, not as close to the shrimp areas as they were last time." Again, misconceptions arise concerning the impact on shrimp trawling.

Respondent I, who was adamantly opposed to the ranching experiments in general (claiming them to be unfeasible and uneconomic), said this about whether another ban would be a problem for local fishermen: "Yeah, big problem. And I really don't see the reason why they should do it.

Because if they really want to fish the fish there's much cheaper and better ways to do it instead of this." When asked if he had seen publications on the results of the experiment, the respondent said he had not, that he had just heard that all the cod had left the fjord and were not harvested. As noted in Chapter 5, dissemination of the results of past experiments is necessary for clarity and transparency purposes. The more knowledge about exactly how cod can be ranched, and its associated costs, the more informed decisions other stakeholders will make.

Respondent J also showed disapproval of being banned from fishing within the fjord: "If you try to do the thing like they tried to do in Arnarfjörður... well, you are not going to be very popular if you try to close down these fjords for that. Definitely. Because then we know we cannot use it. But… it depends where it is in the fjord. If it is inside deep then there probably won't be a problem." Again the respondent stresses the importance of where in the fjord it would be located. A successful bid for a cod ranching permit would not hinge only on which fjord to ranch, but also where in the fjord it would operate.

6.4 General Opinions on Cod Ranching

Some interviewees shared general thoughts on the subject of cod ranching. Opinions were offered on the techniques and feasibility of ranching cod, as well as advice for where one could/should ranch cod. And some fishermen offered commentary on social responsibility.

6.4.1 Feasibility of Cod Ranching

Respondent A doubted the economic efficiency of capturing so much prey fish for feed: "If you are going to feed all the cod and haddock that are in the fjords so they don't eat the shrimp I think you are going to need thousands and thousands of tons of food for them. So I think it's not possible. If you fish small fish just to give them to eat it's not possible. I don't think so." Respondent H's concerns were based around changing the behavior of cod migrating in and out of the fjord: "Usually the cod goes out of the fjord in February. And there's no cod in the fjord in February, March, April, May, and in beginning of June they start to come in again. And we had worries that if you were feeding it, all year, we would start some problem where the cod would not go to feed… Maybe the cod who had food all year, they would never leave. It would change the behavior." Meanwhile, Respondent I from Patreksfjörður questioned the motif behind the 2005-2006 experiments:

> [It's a way of] manipulating the system trying to do something new and trying to get quota for it. [One] gets free research quota for this. Anybody would participate in something like this if you could get free quota for it. If they are catching them, it's fine. But they haven't been doing that. When they were doing it they were just monitoring it and stuff like that. From my opinion, if you are going to harvest cod, and keep it and feed it, then what they used was not a good system... What they were doing was using nets on the boat. If they're going to kill the fish then yeah, that's fine. But if you're going to carry on making it larger and feeding it in the sea then that's not the way to do it.

These technical doubts over cod ranching are for the most part discrepancies with the methodology of cod ranching. They fortify the fact that more knowledge needs to be shared concerning the reasons for, methodologies of, and results of cod ranching. With cod ranching being in its infancy, there is certainly room for adjustments and improvements in the methodology. One consideration is for those interested in ranching to consult with fishermen from a particular area to exchange ideas on the methodology. Information exchange of this sort can help clarify purposes, improve transparency, and generate new ideas concerning harvesting methods. Furthermore, the establishment of a legal framework for cod ranching, shifting the efforts as much from the public sector to the private sector, and placing the burden of liability and reward on the rancher will all help rectify the political "manipulation" problem.

6.4.2 Where (not) to ranch

Many respondents believe that cod ranching would not be a problem from a socio-political standpoint if the ranched site were located inside some of the smaller fjords: "In the small fjord, I think there would be no problem to have the farm for cod there, inside the fjord" (Respondent A). Respondent C said: "Some of the fjords are not used. I'm working in Önundarfjörður, where Flateyri is. Here is very good fjord for this [cod ranching]. I think Önundarfjörður and Dýrafjörður are very good areas for this. Not Arnarfjörður because… Arnarfjörður *was* good for this but when you have shrimp then the cod will come in the same area and he will eat the shrimp too." And Respondent B commented that as long as the ranching site was out of the way of high areas of fishing traffic, then fishermen would honor a license to ranch and there would be no issues of poaching:

> If you are doing something and you have some license for it, then they don't come and take it away from you. If someone started this in Mjóifjörður or something, if somebody started this in one of the fjords here, in Seydisfjörður there is big fish farming here, if somebody started in Hestfjörður or somewhere… the longlines would not come and try to catch the fish.

However, Respondent D from Þingeyri had a different opinion. He believes that the people will follow the fish:

> I don't think it would be a problem for us here. I can tell you when the problem starts. For example take this place here [Ísafjörður fjord]. Nobody fishes here. Ever. No long line goes here. Then they start working here. And there's going to be a lot of cod here. Then its going to be a conflict. Because then the other people want to come here and fish because now the cod are here... After you start and get the fish there, then they start coming. Then the problem begins.

Certainly opinions will vary as to how fishermen in different parts of the Westfjords would respond to having an area closed off. The common thread of sentiment seen through most of these interviews is that fishermen are fine with cod ranching taking place in underutilized fjords. The larger marine areas of Ísafjarðardjúp and Arnarfjörður seem to touch a nerve; fishermen display a discomforting, nervous look when talking about closing sections of these areas. One can draw the conclusion that obtaining a working permit to ranch cod in Arnarfjörður or Ísafjarðardjúp may not be impossible, but it will face a lot of resistance.

6.4.3 The importance of local involvement

The thought that "people will follow the fish" is worth considering. No matter where cod ranching takes place, fishermen will likely be tempted to poach within the ranch site, or fish just outside of the established parameters. Certain measures taken in implementation and enforcement can help mitigate the poaching. Respondent I claimed that due to the fact cod ranchers were getting free quota in the 2005-2006 experiment, "other guys would just turn off the lights and put a line around it and fish this area." Respondent J confirmed the poaching: "Some of the fishermen, they just went out into the field. The line was here. And the dark came and they just went there and fished there. That's just the way it was."

There are technical measures one could take to help minimize poaching: in the 2005-2006 experiments, researchers expanded the no-catch zone by 1.5 km to prevent small boats from sneaking in and out (Björnsson, 2011). Increasing surveillance, through video or motion detectors is an option, albeit expensive one. Nevertheless, a certain level of social distrust will inevitably lead to greater temptation to poach. This in turn makes monitoring and enforcement more difficult and expensive. One of the solutions to this potential problem can be found in the theory of community-based fishing groups (Rieser, 1997; Kurien, 2004), which states that local ownership and management leads to greater trust towards fishing operations, thus leading to less, cheaper, self-imposed surveillance. In other words, a cod rancher who is a resident of the nearby area being ranched will perhaps have greater success in avoiding poaching than would an "outsider." Perhaps locals like to see other locals utilizing, and be successful at utilizing, the nearby resources. Respondent I supported this theory with some discourse on social responsibility… "It's so important that the locals benefit from it. In some cases, especially when it comes to fish farming, its foreign companies who are utilizing the fjords. So I think whenever you are creating a new business in those sensitive communities here, the benefit of the people should be number one."

7 Fish Catch Data Analyses

Fishing carries great economic importance in the Westfjords: in 2011 45,592 tonnes of fish were landed in the Westfjords, an area with a population of only 7,056 (Statistics Iceland, 2012b; Statistics Iceland, 2012c). Between 29-40% of the population is employed in fisheries, making it the most fisheries-dependent region in the country (Auth, 2012; Bjarnason, 2012). With such reliance on the resource, one can assume that placing fishing restrictions on valuable fishing grounds (as cod ranching would incur) would meet with friction from members within the fishing sector. This section aims to show the most viable locations to implement cod ranching in the Westfjords, based on current fishing effort, so that this friction is minimal or negligent. As mentioned above, the large amount of ocean space required to ranch cod is perhaps the greatest hindrance to it's implementation. By showing where fishermen are currently catching fish – and more importantly, where they are not – better decisions can be made concerning potential cod ranching sites that would least interfere with fishing effort.

Specifically, the analyses here will focus on the fjords of Önundarfjörður, Arnarfjörður, and Ísafjarðardjúp. Spatial analyses portraying the density of caught fish in these regions are broken down by gear, species, and season. Accompanying statistical results quantify the findings to further our understanding of coastal fishing in the Westfjords; the most socially responsible cod ranching sites are thus identified.

7.1 An Overview of Fish Catches in the Westfjords

The data presented in this section gives an overview of where fish are being caught in the Westfjords, broken down by gear type. *Figure 4* shows the extent of coverage for the data presented, which is the area defined by the author to be the Westfjords Fishing Grounds (WFG).

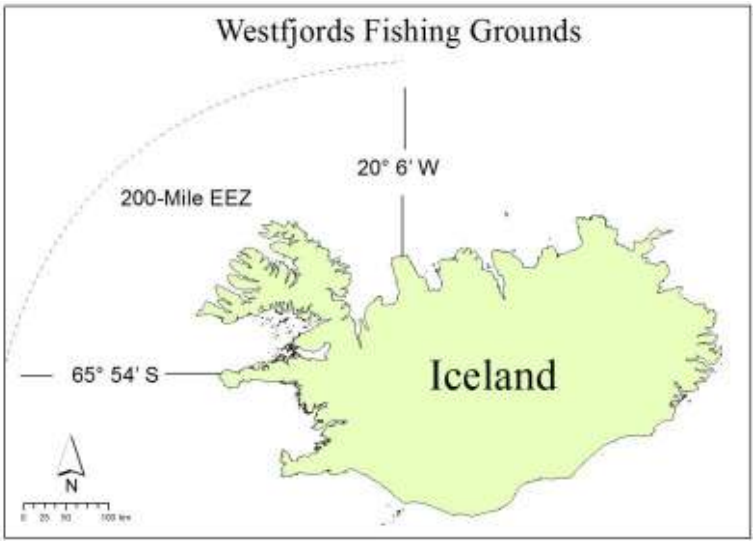
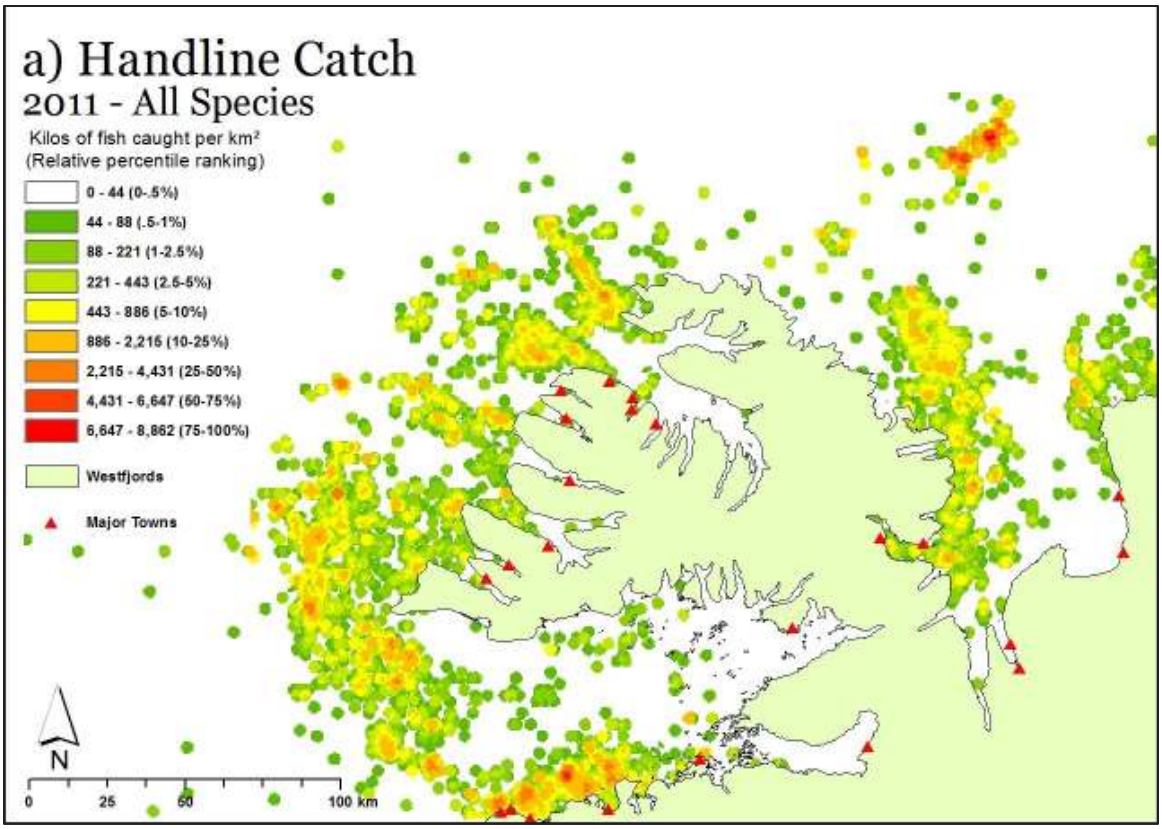
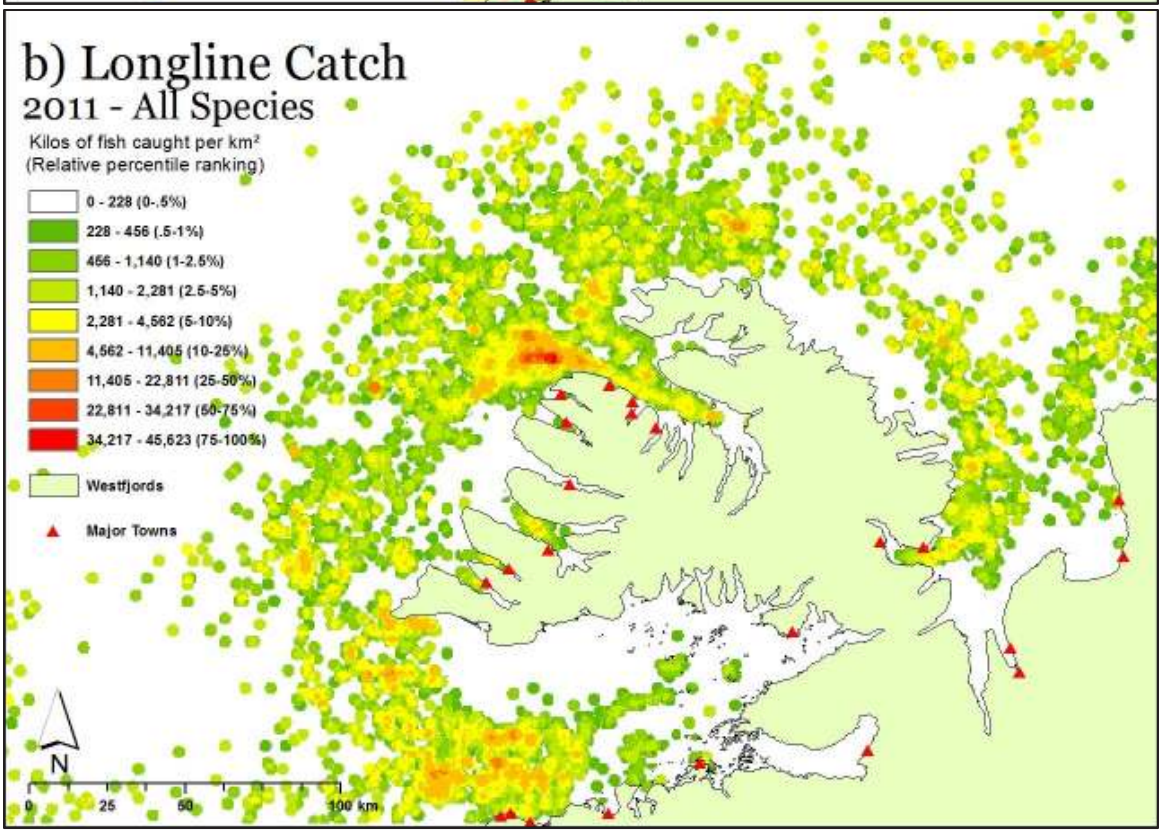


Figure 4: Spatial coverage of catch data (Map authored by Graham Gaines)

Figure 5(a-d) displays the density of caught fish in 2011, separated by gear types. The color ramp indicates which percentile a given square kilometer lies within the whole Westfjords area. The handline catch map *(a)* displays an even sprawl of high concentration patches, with most catches occurring within 100 kilometers of the shoreline. Longline catches *(b)* are more dense, with a high concentration of catches coming just outside of Ísafjarðardjúp. There is also significantly higher densities within the study sites of Önundarfjörður, Arnarfjörður, and Ísafjarðardjúp. Seine catches *(c)* are sparse and segmented area to area. Besides a high concentration just north of the Snæfellsnes Peninsula, the three fjord study sites contain significant catch areas, with Arnarfjörður containing some areas in the 5-10 percentiles. Finally, trawl catches *(d)* are highly concentrated and distant from the shoreline. There is a clear delineation of catches at the 12 nautical mile mark from shore, at which trawling inside of this limit is prohibited by Icelandic Fishing Operations Act, No. 79/1997. The only trawl catches displayed close to shore are those of shrimp boats, who are exempt from this law.


a) Handline Catch
2011 - All Species
Kilos of fish caught per km²
(Relative percentile ranking)
0 - 44 (0-.5%)
44 - 88 (.5-1%)
88 - 221 (1-2.5%)
221 - 443 (2.5-5%)
443 - 886 (5-10%)
886 - 2,215 (10-25%)
2,215 - 4,431 (25-50%)
4,431 - 6,647 (50-75%)
6,647 - 8,862 (75-100%)
Westfjords
Major Towns
N
0
25
50
100 km


b) Longline Catch
2011 - All Species
Kilos of fish caught per km²
(Relative percentile ranking)
0 - 228 (0-.5%)
228 - 456 (.5-1%)
456 - 1,140 (1-2.5%)
1,140 - 2,281 (2.5-5%)
2,281 - 4,562 (5-10%)
4,562 - 11,405 (10-25%)
11,405 - 22,811 (25-50%)
22,811 - 34,217 (50-75%)
34,217 - 45,623 (75-100%)
Westfjords
Major Towns
N
0
25
50
100 km

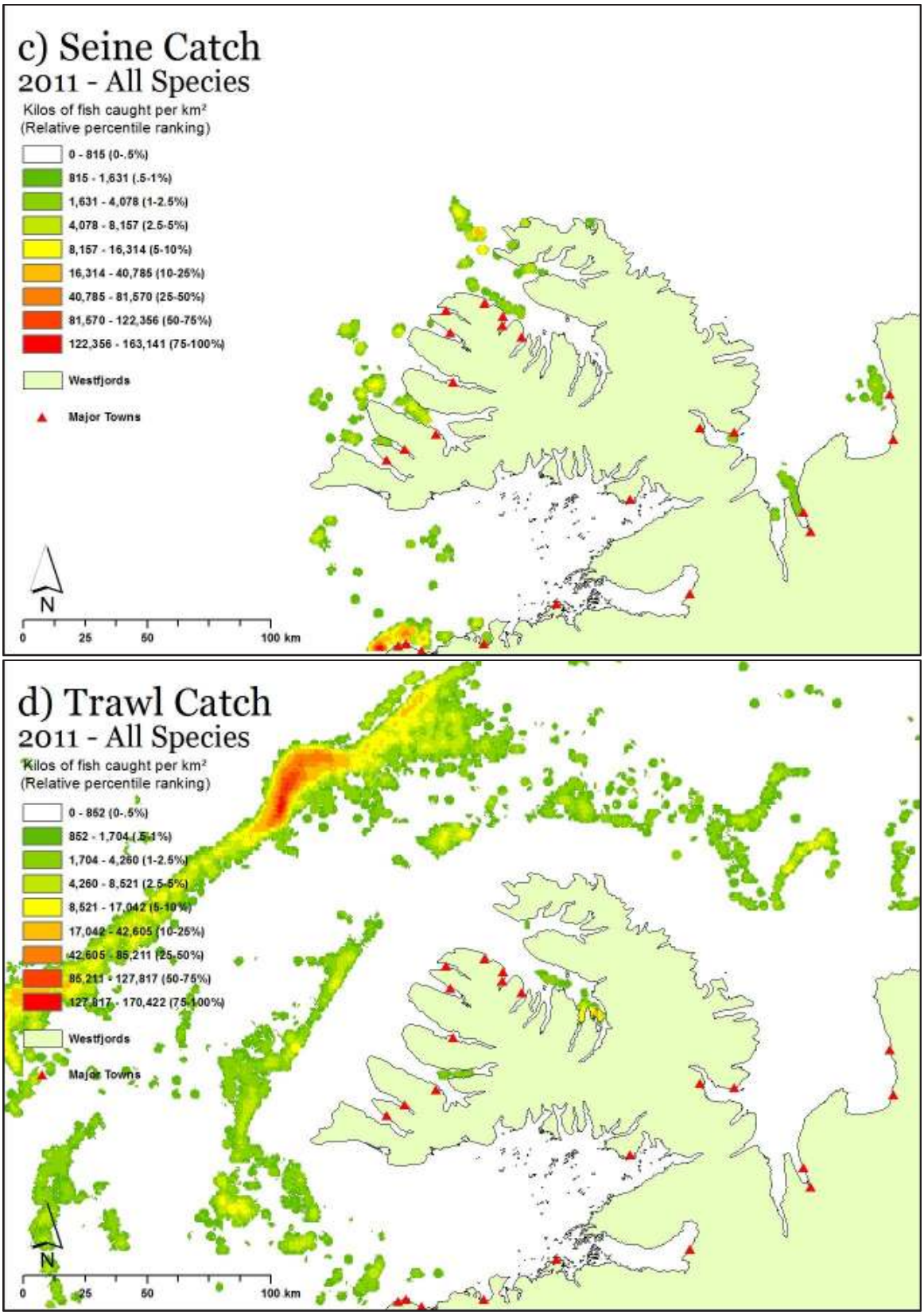


Figure 5(a-d): Density of fish catches around the Westfjords by gear type. (Map authored by Graham Gaines; data provided by the MRI.)

The total catch of all four gears combined is quantified in *Table 11*. The table shows how significant each of the three fjord study sites are to fishing in the Westfjords as a whole, as a percentage of total catch. With 1.44% of the total catch, Ísafjarðardjúp is the most heavily fished of the three fjords. Following is Arnarfjörður with 0.55% and Önundarfjörður with 0.03% of the overall catch.

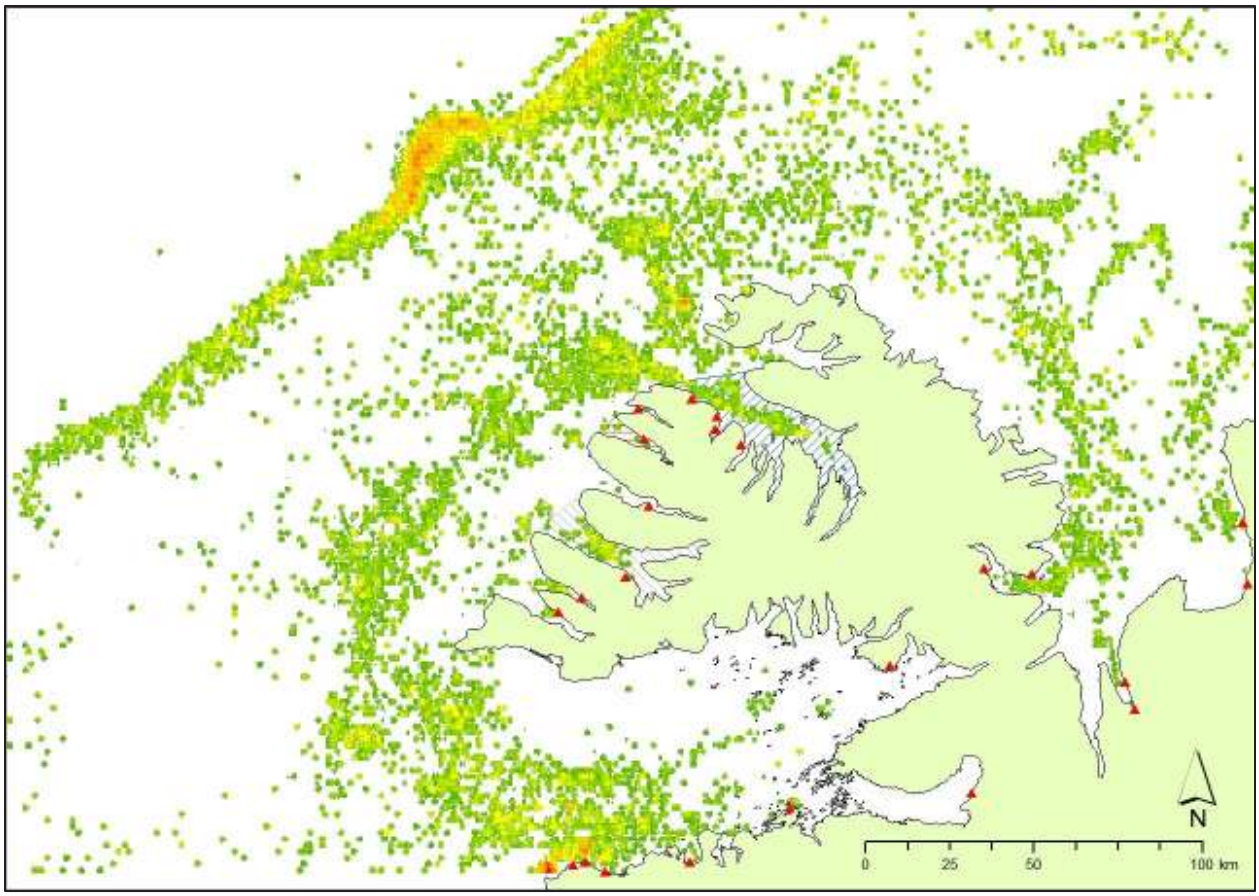
Table 11: Importance of fjords for fishermen; total catch by gear and fjord in 2011

	Önundarfjörður	Arnarfjörður	Ísafjarðardjúp	Westfjords
Handline (t)	6.2	49.4	31.1	5,998.8
Longline (t)	31.6	206.2	928.2	40,159.6
Seine (t)	12.8	406.1	250.0	9,203.8
Trawl (t)	0.00	147.7	895.3	90,764.6
Total Catch (t)	50.6	809.4	2,104.6	146,126.8
Percent of Westfjords catch	0.03	0.55	1.44	100

7.2 Cod and Haddock Fishing in the Westfjords

Because cod ranching aggregates both cod and haddock, it is useful to isolate high density areas of catch for these species from all other commercial species. We can thus recognize areas with a high potential of resistance from cod and haddock fishermen. Temporal variables are also useful to analyze, considering cod ranching has been suggested to take place between the months_of April-October. Therefore, cod and haddock catches from April 1 to October 31 present the most relevant data when considering potential cod ranching sites. *Figure 6* and *Figure 7* both show wide-angle views of the Westfjords, with *Figure 6* showing total cod and haddock catches for 2011 and *Figure 7* showing cod and haddock catches between April 1 and October 31 of 2011.

In *Figure 6*, the highest density area is approximately 100 km NNW from the Westfjords mainland. The only other areas within the 50-100 percentiles are just north of the Snæfellsnes Peninsula. However, color ramps within both Arnarfjörður and Ísafjarðardjúp reveal significant cod and haddock catching activity. *Figure 7* reveals that during the April to October time period, a slight increase in cod and haddock catches takes place closer to shore. Areas just at the mouth of Ísafjarðardjúp show densities between the 10-50 percentiles, with one area just outside the mouth in the 75-100 percentile.



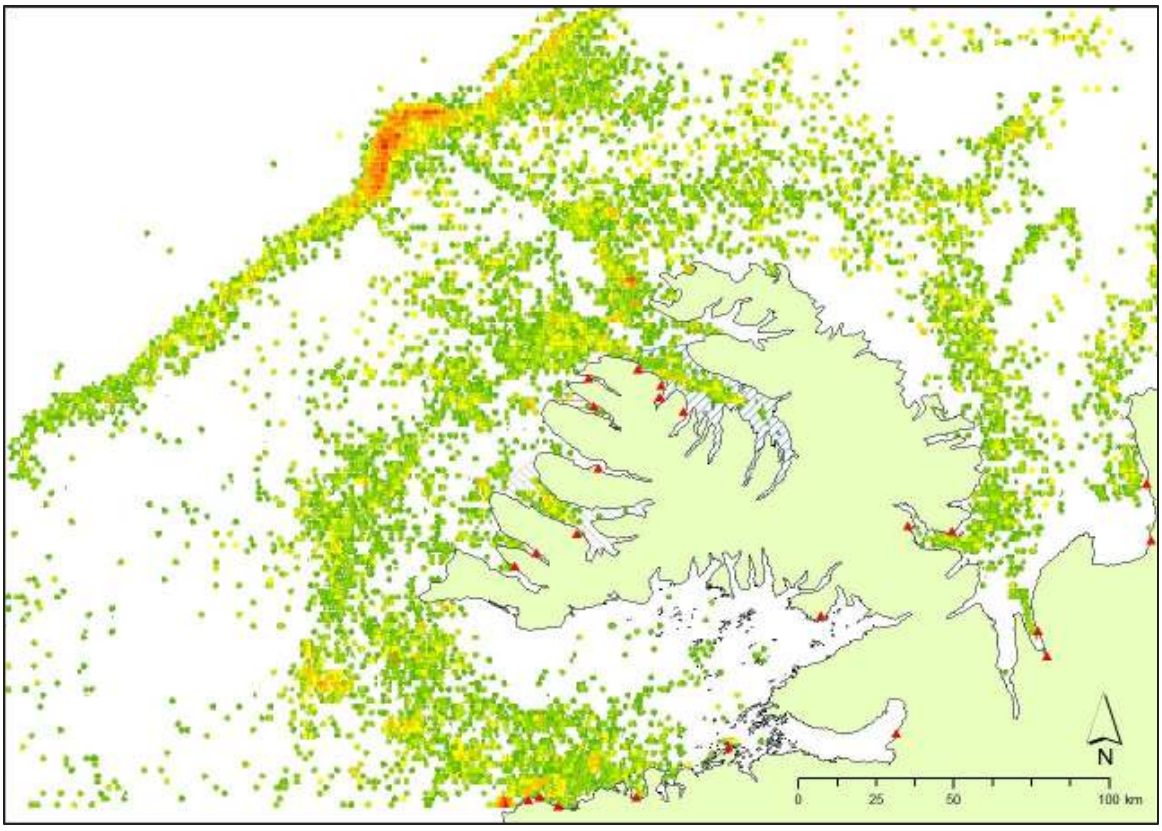
Kilos of fish caught per km²
(relative percentile ranking)

- 0 - 1,172 (0-.5%)
- 1,172 - 2,344 (.5-1%)
- 2,344 - 5,860 (1-2.5%)
- 5,860 - 11,720 (2.5-5%)
- 11,720 - 23,441 (5-10%)
- 23,441 - 58,604 (10-25%)
- 58,604 - 117,208 (25-50%)
- 117,208 - 175,812 (50-75%)
- 175,812 - 234,416 (75-100%)

Legend

- Önundarfjörður
- Arnarfjörður
- Ísafjarðardjúp
- Westfjords
- Towns

Figure 6: Cod and haddock catches in the Westfjords in 2011 (Map authored by Graham Gaines; data provided by the MRI)



Kilos of fish caught per km²
(relative percentile ranking)

- 0 - 410 (0-.5%)
- 410 - 821 (.5-1%)
- 821 - 2,053 (1-2.5%)
- 2,053 - 4,106 (2.5-5%)
- 4,106 - 8,212 (5-10%)
- 8,212 - 20,531 (10-25%)
- 20,531 - 41,063 (25-50%)
- 41,063 - 61,595 (50-75%)
- 61,595 - 82,127 (75-100%)

Legend

- Önundarfjörður
- Arnarfjörður
- Ísafjarðardjúp
- Westfjords
- Towns

Figure 7: Cod and haddock catches in the Westfjords between April 1 and October 31, 2011. (Map authored by Graham Gaines; data provided by the MRI)

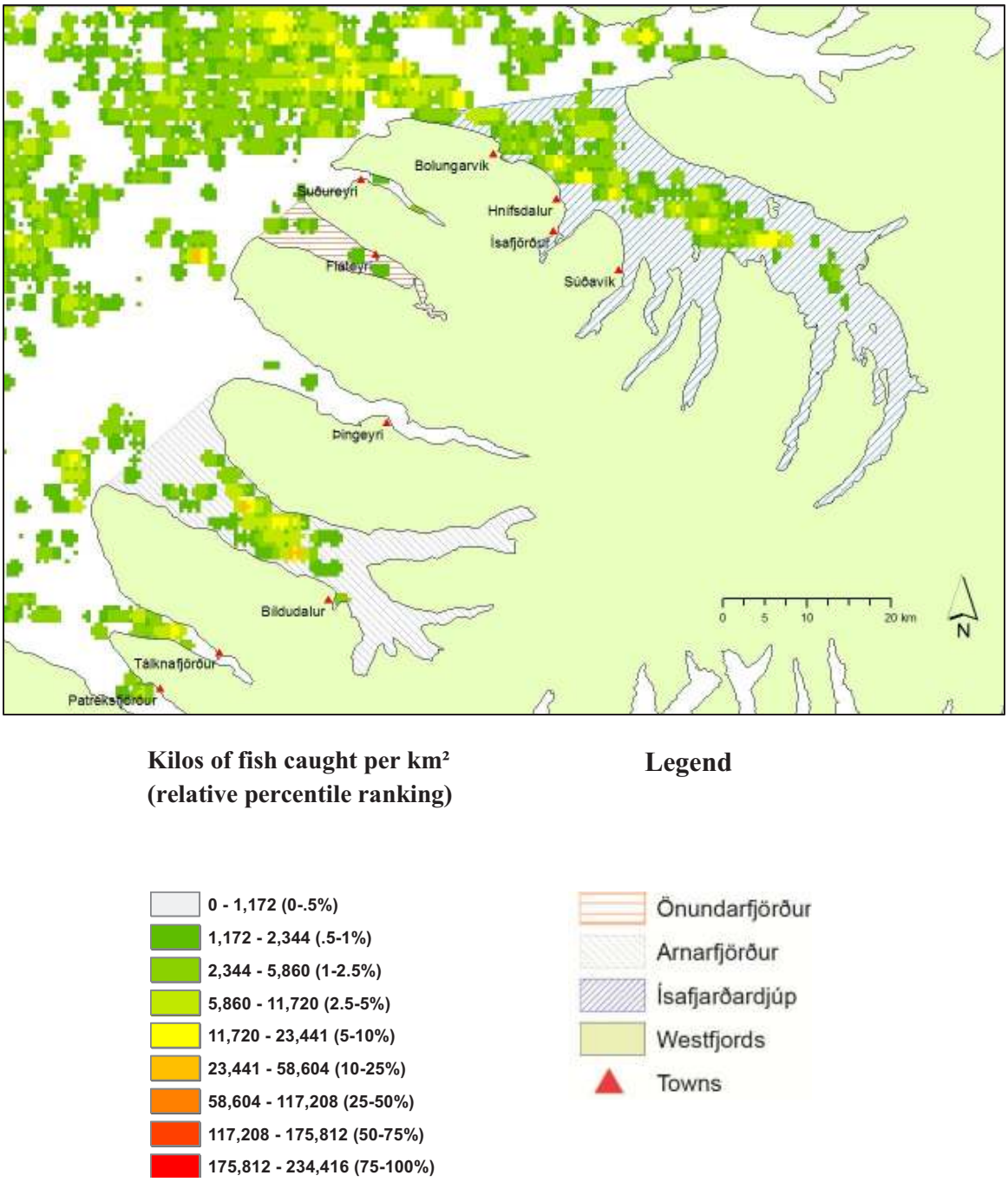


Figure 8: Cod and haddock catches within the case study fjords in 2011 (Map authored by Graham Gaines; data provided by the MRI)

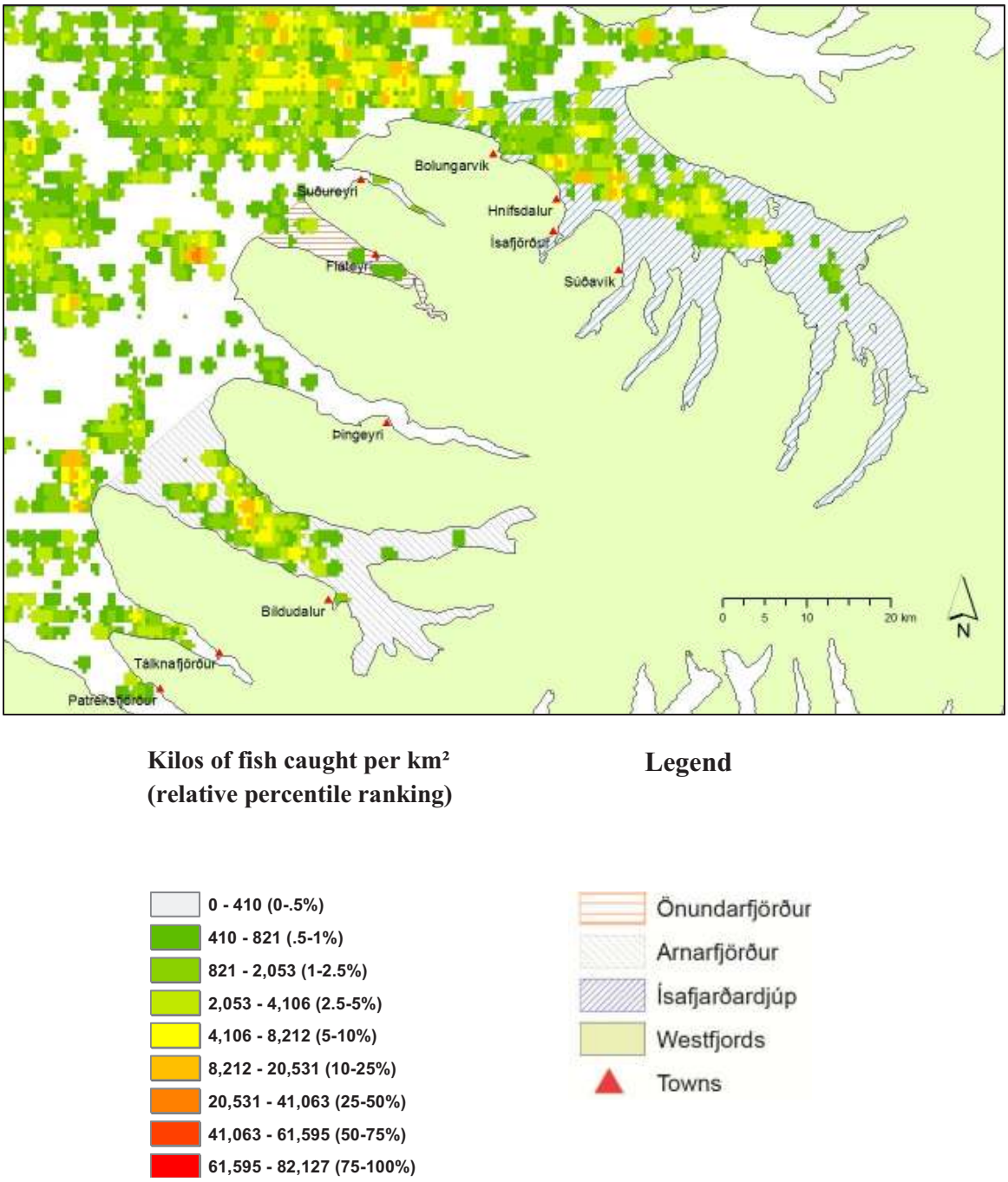


Figure 9: Cod and haddock catches within the case study fjords, April-October, 2011. (Map authored by Graham Gaines;data provided by MRI.)

Figure 8 and *Figure 9* project the same data as *Figure 6* and *Figure 7* respectively, yet with greater detail so that activity within the three case study fjords can be analyzed. One can see in *Figure 8* that Önundarfjörður, Arnarfjörður, and Ísafjarðardjúp are fished for cod and haddock

mostly in the centers of the fjords. However, the relative densities are low, with no area in Ísafjarðardjúp or Önundarfjörður placing above the 10 percentile. Arnarfjörður is also relatively low, yet some swatches of oranges show areas in the 10-25 percentile.

Figure 9 shows that the three case study fjords are more heavily fished during the prime cod ranching months of April through October. Multiple swatches in the 10-25 percentile range appear in Ísafjarðardjúp. Some areas at the mouth of Önundarfjörður show greater densities, and Arnarfjörður has slight increases throughout its color ramp.

The data presented in the above figures is quantified below in *Table 12*. One can see that gadoid catch compositions are still low for each fjord relative to gadoid catches throughout the WFG. However, the data shows that each fjord places greater importance to these fjord in the months April-October than they do relative to year round fishing. The row "April-October catch projected" shows how much cod and haddock would be caught in the fjord during these months if year round percentages were applied; the row "April-October catch observed" displays the actual amount caught. The importance of these months for fishermen can therefore be determined by viewing how much more fish were caught than projected during these times, as indicated by the rows "Higher than projected." The greatest relative use during the cod ranching months is in Önundarfjörður, where 10.3 t more were caught than projected, or 58.2% more than year round catch composition. 324 t, or 20.4% more fish were caught in Arnarfjörður than projected, while 76.2 t, or 15.5% more fish were caught than projected in Ísafjarðardjúp.

Table 12: Cod and haddock catch in the Westfjords Fishing Grounds in all of 2011 and during ranching season (April-October) of 2011

	Önundarfjörður	Arnarfjörður	Ísafjarðardjúp	WFG
Annual catch (t)	50.2	643.5	1,171.6	84,202.2
Annual catch (% of WFG)	0.05	0.76	1.39	-
April-Oct. catch projected (t)	17.7	268.9	491.8	-
April-Oct. catch observed (t)	28.0	324.0	568.0	35,381.9
April-Oct.catch (% of WFG)	0.07	0.91	1.60	-
Higher than projected (t)	10.3	55.1	76.2	-
Higher than projected (%)	58.2	20.4	15.5	-

7.3 Fjord Dependency by Fjord Fishermen

Up to this point, the data processed for analyses in this chapter has shown fish catches by all boat hauls in the Westfjords fishing region. This section, however, examines only fishermen who have fished at least once in the fjords of Önundarfjörður, Arnarfjörður, and/or Ísafjarðardjúp. The objective is to isolate fishermen who depend on the fjords for at least a portion of their catch from all other fishermen, and determine statistically how much they depend on these fjords respectively.

Fish catches from each of the three fjords, arranged by gear type, is shown in *Table 13*. Trawl vessels have been left out due to the fact that only shrimp trawls are allowed inside the fjords, and as determined earlier, cod ranching would not exclude shrimp trawlers. To accommodate historical trends and include more data, fish catches from the past five years (2007-2011) have been included.

Table 13: Dependency on fjords; catch by fishermen with at least one haul from Önundarfjörður, Arnarfjörður, or Ísafjarðardjúp, 2007-2011

	Handline	Longline	Seine	Total
Önundarfjörður				
Catch (t)	2.8	168.1	343.5	514.4
Portion of gear total (%)	0.05	0.14	0.96	0.32
Vessels (n)	6	16	7	29
Arnarfjörður				
Catch (t)	72.4	832.9	2,688.0	3,593.3
Portion of gear total (%)	1.20	0.71	7.54	2.26
Vessels (n)	29	25	17	71
Ísafjarðardjúp				
Catch (t)	143.3	5,959.5	3,224.1	9,326.9
Portion of gear total (%)	2.38	5.08	9.05	5.80
Vessels (n)	71	66	17	154
Total catch (t) by fjord users	6,023.2	117,142.6	35,611.7	158,777.5

As one might expect, the dependency upon the fjords are much higher for those fishermen who have fished at least once within one of the fjords when compared with overall fjord dependency presented in *Table 11*. Ísafjarðardjúp has the greatest dependency, with 5.8% of fish being

caught within the fjord. Arnarfjörður is next with 2.26% caught within the fjord, followed by Önundarfjörður with 0.32% dependency.

Among the different gear types, seine fishermen are most dependent on fjord use. 9.05% of fish caught by fjord-dependent seiners are caught within Ísafjarðardjúp, while 7.54% are caught in Arnarfjörður and 0.96% in Önundarfjörður. Longlining is most important in Ísafjarðardjúp, with 5.08% being caught there, and less than 1% caught in both Arnarfjörður and Önundarfjörður. Handlining is minimal in all fjords, with Ísafjarðardjúp having the highest dependency with 2.3%.

7.4 Dependency among Individual Vessels

One final important exercise is to examine dependency upon fjords by individual vessels. This will show how many boats use the fjords to a particular degree. We can interpret these results to know how many boats' operations would be severely impacted if displaced by cod ranching. Complete processed data showing individual boat use can be found in Appendix III.

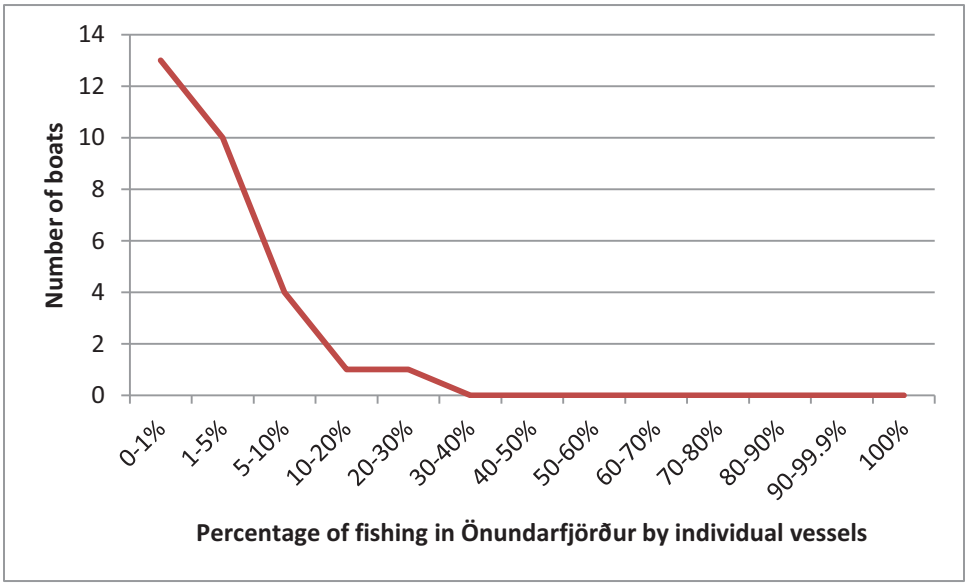


Figure 10: Distribution of fishing dependency in Önundarfjörður

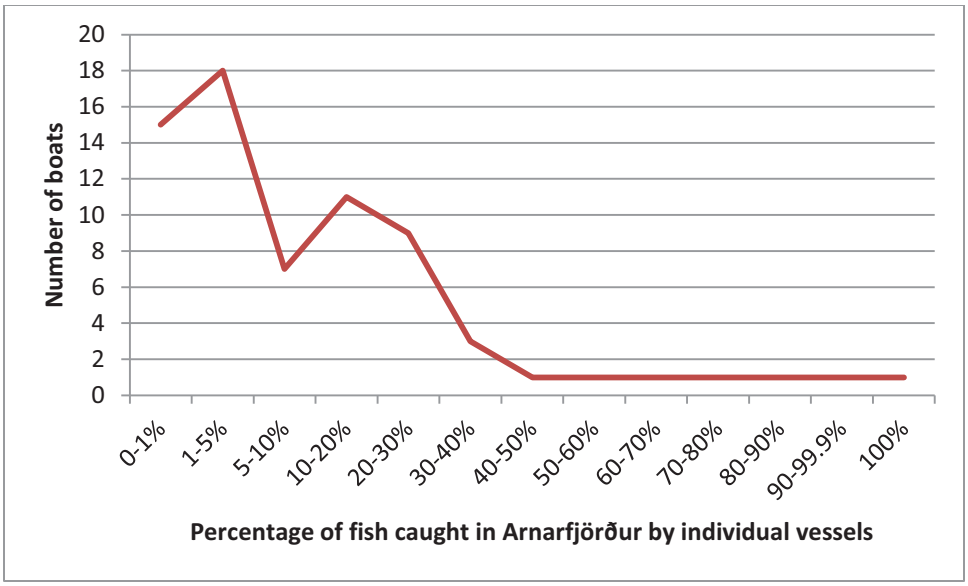


Figure 11: Distribution of fishing dependency in Arnarfjörður

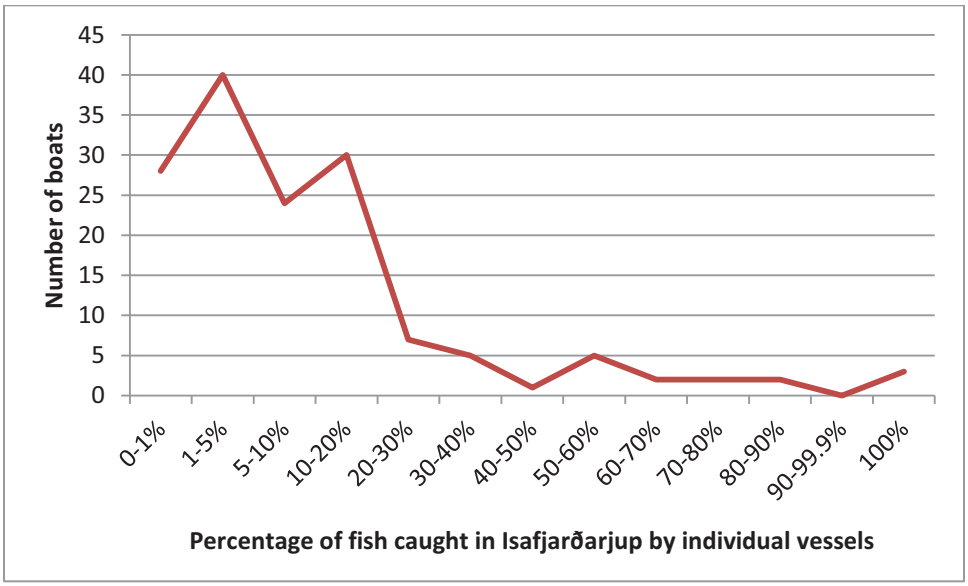


Figure 12: Distribution of fishing dependency in Ísafjarðardjúp

In *Figure 10*, one can see that boats that have fished in Önundarfjörður mostly obtain less than 1% of their total catch from within the fjord. Out of 29, zero boats caught more than 28% of their total catch inside the fjord.

Figure 11 shows that of the 71 boats that fished in Arnarfjörður between 2007-2011, 18 of them caught less than 5% of their total catch from within the fjord. 11 of the boats caught between 10-

20% of their catch within the fjord. Following this, there was one boat representing each category of 40-50, 50-60, 60-70, 70- 80, 80-90, 90-99.9, and 100% dependency.

Ísafjarðardjúp boats, as demonstrated in *Figure 12*, follow a similar plotting trend as that of Arnarfjörður boats, with the greatest number falling in the 1-5% category (40 of the 154 boats). The categories from 40-50% to the 89-90% each had between two to five boats fishing that respective amount from within the fjord. Zero boats obtained 90-99.9% of their catch within Ísafjarðardjúp, yet three boats obtained 100% of their catch within the fjord. Important to note however, is that the average catch for those three boats was 2.1 t, well below the 60.6 t average for all boats fishing inside the fjord.

8 Conclusions

8.1 Existing legislation relevant for cod ranching

Ranching cod by way of anthropogenic feeding within an exclusive marine area is not recognized by Icelandic law as a method to harvest fish. At this moment, however, experiments for the purposes of advancing aquaculture and fisheries science are encouraged and even subsidized. Therefore, if cod ranching is to take place without legal amendments being made, it will need to do so within an experimental context, through cooperation with the MRI and the DoF. For cod ranching to be carried out as a purely private enterprise, it will need further legal recognition and regulations to be administered. The framework for cod ranching can be established from existing legislation. However, unique considerations not yet found in current legislation, such as the exclusive allocation of marine areas for fishing purposes, would then have to be applied.

Much of the framework can be established by considering fishing and aquaculture legislation. Fish harvesting rights and limitations found in the Fisheries Management Act (No. 116/2006) also provides the foundation for cod ranching rights and limitations. A framework is found for gear restrictions, post-harvest handling requirements, and basic fishing fees, which cod ranching must abide, under various marine-related Acts. Cod ranching soundly follows the principles of the Aquaculture Act (No. 71/2008) which promote profitability and sustainability. Many of the articles set out in various aquaculture regulations are applicable to cod ranching, such as DoF monitoring duties, idle site stipulations, and structure demarcation, to name a few. Some articles such as the demarcation of boundaries of the site and buffer zones between sites will require unique consideration. There is a sound framework for environmental considerations found in current legislation, most appicably the Health and Pollution Act (No. 7/1998), the Nature Conservation Act (No. 44/1999), SEA Act (No. 105/2006) and the EIA Act (No. 106/2000).

The major element of ranching cod that is unique and unfounded within current legislation is the exclusive right to fish demersal species within a given area. An analyses of legislation devoted to marine activities with similar marine space allocation pretense, such as those for fish farms,

shellfish culturing, and seabed mining, provide very little framework which can be applied to cod ranching. Avoiding interference with marine traffic, usually assessed through coordination with the IMA and Coast Guard, is the primary consideration for determining acceptability of site placement for these activities (apart from environmental considerations). According to these Acts, leases and fees are not determined based upon economic valuation of the marine area being used (eg., based on fishing effort). Based on qualitative and quantitative data collected in latter parts of this research, implementing cod ranching without a system of economic valuation of the ranching site would be considered unacceptable. Therefore, for cod ranching to operate commercially, new regulations that consider exclusive use of marine space for fishing must be established.

8.2 Permits and licensing required for cod ranching

Just as other mariculture operations, cod ranching projects aiming to harvest >200 tons would be subject to a review by the NPA to determine whether it should undergo a thorough EIA. The focal point of this review would be the potential of benthic pollution below the feeding areas. With ranch sites being larger and less densely populated than typical fish cages, benthic pollution is likely to have less harmful an impact. Combined with the unlikelihood of disease spread and genetic pollution, it is probable that a cod ranch project would not undergo a full EIA.

Because cod ranching is not legally recognized, no protocol for obtaining an operating permit has been established. Yet by following a protocol similar to that of cod farming (with some minor deviations) authorities confirmed that obtaining an operating permit would be feasible, albeit time-consuming and complicated. The major steps in doing so would include: the acquisition of aquaculture quota, a thorough examination of the project and location description (including biological and physical characteristics), consulting with stakeholders, consulting with relevant agencies, and legal consultation.

8.3 Political considerations for cod ranching

The ITQ system will be applied similar to how it is in grow-out cod farming. The initial, natural weight of the cod determines the quota allotment. This will be determined by sampling and tagging at the beginning of the operation to determine a mean weight. Weight gained via

anthropogenic feeding is value-added by the rancher. These operations will require monitoring by the DoF or a third party observer.

The ITQ system makes Iceland a particularly favorable environment to ranch cod, as fishermen are less likely to be negatively impacted when already allocated a catch share. A resource rent would best be established by determining the economic value of the marine area to be ranched; the most significant determinant for such a value is the yield from fishing operations within the potential site. Data showing densities of catches and degree of boat dependency can be used to quantify resource rent. However, direct compensation towards displaced fishermen is perhaps not the best method for dispersing rent collection. The system appears to be an unattractive option; most likely due to fishermen perceiving this action as "buying out" the fisheries and a loss of fishing rights. Perhaps more feasible and socially acceptable is by increasing fishing fees in a way proportional to the value of the area being ranched.

One final political consideration is that of limits to jurisdiction, and thus resource rent derivatives, from offshore activities. Westfjords communities do not have an inherited right to any profit surplus or resource rent derived from resources harvested beyond 115 meters from the low tide line. This is a significant cause for distrust, tension, and conflict concerning commercial operations offshore and decreases potential benefits cod ranching could bring to the Westfjords region.

8.4 Qualitative assessment of fishermens' attitudes towards cod ranching

A low degree of attachment to and reliance upon fishing within the fjords was expressed by the fishermen interviewed in this study. Most cited the poor quality of the fish as the primary reason, and associated fishing close to shore with bad weather days. There is perhaps a greater appreciation for the fjords among recreational fishermen and those without commercial quota.

There is high precedence of conflict between fishing and fish farming operations in the Westfjords, both in Arnarfjörður and Ísafjarðardjúp. Most of the fishermen had either experienced some degree of disruption to operations due to fish farms or expressed apprehension that increases in fish farming operations would impact future fishing operations. In general, most fishermen do not describe the current situation as a problem, but foresee it as a potential problem

at its current rate of growth. Both fishermen and personnel in fisheries management agencies noted recent incidences likely to involve legal action.

When asked their perceptions of cod ranching and how it might impact their operations, most fishermen from Ísafjarðardjúp believed shrimp trawlers would be most impacted, unknowing that shrimp trawling would not be prohibited from operating within a ranch site. Fishermen near to Arnarfjörður expressed suspicion as to how cod ranching would impact seine fishermen. Most of these fishermen were present for the 2005-2006 experiment, and experienced the prohibition from fishing within the fjord. In general, most fishermen considered it to be a minor nuisance. Two, however, were adamant that cod ranching in Arnarfjörður was a bad idea, and indicated that the system for experimental quota was abused. There was also some misunderstanding as to the results of the past experiment, which likely affected the opinions of some of these fishermen. Results indicate that cod ranching is not well understood by many, and greater dissemination of its technique and potential impacts would lead to better informed, transparent decision making.

Concerning the placement of potential ranch sites, fishermen either hinted or openly expressed that "smaller is better." Many of the smaller, minor fjords were specifically suggested as being adequate. Fishermen generally agreed that cod ranching would be fine taking place in any fjord underutilized by boats. It was suggested that by trying to ranch cod in an area of high activity, poachers would be tempted. Some of the Arnarfjörður fishermen were familiar with boats poaching cod during the 2005-2006 experiments. One of the reasons for poaching can be explained through fishermens' sentiments towards the importance of community-based operations. Having local owners and operators of a cod ranch site would not only enhance regional economic growth but would also provide higher levels of trust among resource users, perhaps decreasing poaching and surveillance costs.

8.5 Analyses of catch data from three case study fjords

From a general statistical standpoint, fish catch within the fjords is marginal for the commercial fishing sector. However, certain sectors and variables within the fishing industry lend greater importance to these regions than others. For example, on a random summer day with the threat of bad weather looming off the coast, Ísafjarðardjúp becomes highly valued by recreational handliners. Meanwhile a large bottom trawler, who is an immensely greater economic player than the recreational handliner, probably places little to no value on the fishing grounds in

Ísafjarðardjúp. This goes to say that economic values of fish catches are not the only factor in determining where to cod ranch. Also important is determining what types of fisher groups are fishing where, to what extent will their normal fishing operations be impacted, and how likely are they to oppose cod ranching.

8.5.1 Önundarfjörður

The smallest of the three fjords (70.2 km²), Önundarfjörður also hosts the fewest fishermen and provided the fewest fish in weight of the three fjords, with 50.6 t caught in 2011. Compared to the other fjords, Önundarfjörður has the highest April-October fishing dependency; 58% more fish were caught during this time period than what would be projected using year-round data. From 2007-2011, seine fishermen were the most dependent on the fjord; seven seiners caught 343.5 t, compared with 16 longliners catching 168.1 t and six handline vessels catching 2.8 t.

It is possible that cod ranching could be of some disturbance to seine operations in the area during cod ranching months; however, it can also be argued that the lack of individual boat dependency shows that the area is not of significant value for any one vessel. When examining individual boat dependency on the fjord between 2007 and 2011, only two vessels caught more than 7% of their total catch within the fjord: "Oddgerður," a longliner, caught approximately 28% of his 21 t inside the fjord; and Dýrmundur, a handliner, caught just under 12% of his 12 t inside the fjord. It is thus adequate to say that Önundarfjörður lacks any true dependency on its fishing grounds. The impact of restrictions on fishing within this fjord would likely be negligible.

8.5.2 Arnarfjörður

Arnarfjörður represents the medium-size case study area (388 km²); 809 t of fish were caught in the fjord in 2011. The area experienced a 20.4% higher catch rate than projected between April-October. Perhaps the most important fishery inside the fjord is the shrimp fishery, which as mentioned before would not be excluded by cod ranching. Seine fishermen have quite a dependency on the fjord; seventeen seiners caught 2,688 t from 2007-2011. In comparison 24 longliners caught 833 t and 29 handliners caught 72 t in the same period.

Within this same data set, one longliner with 42 t of catch caught nearly 80% of his catch within the fjord. Other than that boat, no other longliner with at least 20 t of catch over the five year span caught more than 30% from within the fjord. Four seiners, however, demonstrate significant

dependency on the fjord: “Bjartey” caught 92% of its 9 tons within the fjord; “Thormar” caught nearly 75% of its 648 t within the fjord; “Adda” caught 34% of its 1,786 t within the fjord; and “Ida” caught 33% of its 623 t within the fjord. In regards to cod ranching, a fishing ban would have the heaviest impact on a handful of seining ships. Displacement of these boats would likely lead to resistance and a moderately negative economic impact.

8.5.3 Ísafjarðardjúp

Ísafjarðardjúp is by far the largest of the three fjords (751 km^2), as well as the most heavily fished of the three fjords, with 2,058 tons of fish in the year 2011. It is also the fjord most depended on from a relativity perspective, with Ísafjarðardjúp fishermen catching close to 6% of their overall catch within the fjord. The 15.6% greater reliance on fishing from April-October means that the area is slightly more important for Westfjords fishing during cod ranching months than it is year round, yet less than the other two case study fjords. That this will lead to greater resistance towards cod ranching is not a certainty, but should be taken in consideration.

From 2007-2011, 64 longliners caught 5,959 t, 17 seiners caught 3,224 t, and 70 handliners caught 143 t. Cod ranching would impact seining operations the most, considering 9% of fjord-using seiners get their catch within the fjord. But longlining in Ísafjarðardjúp is also significant, with >5% of fjord-using longliners‘ catch coming from inside the fjord (the other case study fjords had <1% by comparison). Results from indivual boat dependency shows that Ísafjarðardjúp has the most boats of the three sites with high levels of dependency: seven boats (three seiners, four longliners) with catches in excess of 55 t over the five year sampling period caught more than half of their weight inside the fjord. Displacement for these seven boats would likely have significant negative impact on their operations. One can expect moderate negative impact on some of the longlining and seining fleet as well.

9 Discussion

Cod ranching has the promising potential to alleviate some of the most serious flaws in modern commercial fishing; most notably by decreasing bycatch and energy use. However, due to its unique spatial requirements uncommon to Iceland's fisheries management, there exists uncertainty and skepticism as to where and how it should be implemented. Some fishermen believe that exclusion from fishing grounds is an infringement upon rights and the practice is thus not worth pursuing. Iceland's historical connection to fishing makes it an especially difficult place to try allocating territorial rights to fishing. Therefore, identifying a proper place to ranch cod, and initiating it in a socially sensitive manner, is crucial to its success; poaching occurred in past experiments due to a lack of approval and cooperation. Absolute appeasement of a fishing community is unrealistic. However, the greater the support behind the project, the faster it can be implemented, the less likely the area is to be poached, and the easier to monitor it will be. Catch statistics should be the main factor in determining socially acceptable places to ranch cod, and data presented in this paper can serve as a road map for that decision-making process.

Yet another major consideration for this topic is the increasing demand for use of marine space, especially in Ísafjarðardjúp and Arnarfjörður. Applications for aquaculture net pens have risen drastically in recent years in these areas, which have already led to various degrees of conflict. Summers are bringing increased whale watching and fishing tourism, as well as cruise ship traffic. There are also increased recreational opportunities, with new sea kayaking operations and plans for recreational diving scheduled to take place in Ísafjarðardjúp in 2013 (RÚV, 2012). The multiple industrial and social uses of Arnarfjörður have led to the draft of Iceland's first marine spatial plan (although this plan is currently non-legally binding). Municipalities are realizing greater and greater economic opportunities for these coastal areas. Therefore, convincing regional authorities, fishermen, and other coastal resource stakeholders in these regions that ranching cod is an efficient use of space will likely require further trials. By improving the methodologies (and results) in areas with minimal maritime traffic and commercial activity, cod ranching can become a more established, reputable fishing method. Önundarfjörður presents a good opportunity to do so. Fjords socio-economically similar to Önundarfjörður (such as the narrower fjords along the southern parameter of Ísafjarðardjúp: Skötufjörður, Mjóifjörður and

Ísafjörður) fit the socio-economic requirements for cod ranching. However, biological and geographical hindrances exclude many of these regions from being good candidates for ranching cod. These fjords lack suitable fish stocks, have geographical features that make the fjords pollution-prone, and have minimal infrastructure/processing facilities nearby. Cod ranching takes advantage of areas populated by plenty of half-grown fish yet minimal full/commercial size fish. The greater the biomass and fish catch, the greater the opposition to fisheries exclusion will be, thus resulting in a need for higher resource rent. These biological and socio-economic considerations are what make the Westfjords in general a suitable region to ranch cod. Deciding on the most appropriate place within the Westfjords to ranch will require an appropriate, carefully weighted consideration of each factor.

It seems clear that near-future attempts to ranch cod will only be considered by the MII if done so for experimental purposes, with support and participation from the MRI. However, if communities are to realize the benefits from cod ranching, the method must eventually be adopted by the private sector. The MII has stated that implementing cod ranching commercially would be difficult, complicated, and time consuming, but not impossible. A cod rancher can minimize these difficulties, complications, and time issues by being proactive with the communities' stakeholders at the ranching site, and by showing documentative proof of interaction and agreements with those stakeholders.

Crucial to the process is proper community consultation. Initiating this consultative process before the mandatory consultations required by the NPA and MII will facilitate the permitting stage and solidify the degree of community support. This should be a multi-step process, involving dissemination of knowledge and forums for discussion and feedback. Awareness of the technical aspects of cod ranching, including logistical, biological, and spatial requirements, must be known. Gear and spatial restrictions must be clarified among fisheries circles before the permitting process begins. By doing this, cod ranchers and fjord fishermen can come to agreements – in writing, preferably – as to where the best location could be to be ranched. Terms of compensation (if any) from resulting fluctuations of commercially valuable stocks can be discussed and agreed upon at this stage as well. Consultation can also be economically advantageous for cod ranchers by helping to avoid unecessary disruptions or changes in operations, as well as legal costs, that may arise from opposition later in time. Regional marine spatial plans (MSPs) are one method for formalizing this process. MSPs can facilitate

cooperation between cod ranchers and stakeholders, and help to integrate cod ranching with other nearshore or offshore activities, leading to greater compatability between coastal zone activities. In short, a potential cod rancher must be proactive in working with stakeholders until sufficient support is realized before proceeding with any permitting processes.

In addition, strategic planning for such a novel exercise must occur at all levels of management. Besides basic business operating plans, ranching operators should develop research, monitoring, and environmental contingency plans. It would be beneficial for municipal plans to account for any allocation of marine territory for specific uses, yet until planning jurisdiction is extended beyond 115 meters, this is unlikely to happen. However, any exersises in marine spatial planning should consider accounting for any allocation of large tracts of marine territory.

With increasing research and interest in spatially-based fisheries management, governments should consider leasing options for tracts of marine space for fishing purposes. There are increasing efforts in methods to homestead fishing grounds, by controlling environmental variables such as feed availability and fish behavior. The combination of fish behavior-based harvesting with TURFs can help in the reduction of overfishing and bycatch problems. Yet this will require proper socio-economic oversight, specifically in the execution of resource economics. Economic valuation of nearshore waters could be useful, especially for marine spatial planning efforts. Marine spatial plans, using data such as that presented in Chapter 7 of this thesis to valuate marine areas, could then conduct cost-benefit analyses for cod ranching and other activities requiring large tracts of ocean space.

There are significant opportunities for further research on this topic. First, a complete determination of the socio-economic impacts cod ranching may have would need a proper economic analysis. This could involve attaching economic values to the fish catch data, thereby assigning valuation to the marine areas. This could lead to greater insight into compensation measures, resource rent or fishing fees that would apply to cod ranching. Secondly, the coverage of spatial analyses documenting catch data could be expanded. This study focused on three regions representative of a particular fjord size; analyses of other areas in the Westfjords would be fruitful in completing the feasibility of implementing cod ranching. Regions such as Jökulfirðir, around Hornstrandir, and smaller fjords lining the southern boundary of Ísafjarðardjúp could yield interesting results. This coverage can be expanded even greater to assess how cod ranching might impact fisheries in other parts of Iceland; there are many

advantages for ranching cod in the Westfjords, yet the method is not limited only to this region. Broadening the scope even further, any country attempting projects or programs which require exclusive rights to harvest fish in a particular area can benefit from applying the methods used in this research; advancing studies in this field is by no means limited to Iceland. Finally, there is room for expanding upon the legal and social aspects of this research. A thorough examination into the legal aspects of marine space allocation would be practical and beneficial for a variety of agencies, organizations, and businesses.

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Appendix I: Interview Questions for Mayors

I.

Do you notice conflict between national and local governments concerning coastal resource use?

What is the general attitude of the locals when it comes to national involvement in the way coastal resources are utilized?

Do you think greater control/management of resources in the fjord on behalf of the coastal communities could improve rural/coastal communities in Iceland?

Is there any movement towards making this happen?

II.

Do you notice increasing tension/pressure between resource users of the fjord (growing aquaculture, shrimping, and tourism sectors for example).

What is your role and interaction with the fisheries sector?

What are some common complains or issues with fisherman in this region? Is there much conflict between fisherman and other coastal users?

How are fisherman organized and represented in this area?

Is there a protocol or forum for fisherman to voice complaints concerning local issues?

III.

Concerning an experimental fisheries project such as cod ranching, what would be your role or influence as mayor, if any? Or the role of the local government in general?

Would you like to be involved in the decision making process for something like this?

Would you support cod ranching?

Appendix II: Interview Questions for Fishermen

General information:

- Name:

- Type of boat:

- Type of gear:

- Employees:

- Catch for 2011 in tons:

1. How often do you fish in the fjords?

2. How would you describe the quality of the fish you catch in the fjords?

3. Within the fjords, do you have favorite locations that you return to, or fish in a particular place on a consistent basis?

4. Would you describe yourself as dependent on any particular site within the fjords? What is the degree of fidelity?

5. Do you think fishermen are territorial within the fjords? More or less so than in open water?

6. Cod ranching would require forbidding of commercial fishing within a designated area inside the fjords. What are your general thoughts on this?

7. In some severe displacement scenarios, a form of compensation is offered – to cover additional fuel and labor charges. If you were displaced, do you think some form of compensation is necessary?

8. Would you be in favor of such a project being carried out in Ísafjörðurjup/Arnarfjordur?

9. Do you feel you have any influence concerning activities taking place near to your fishing grounds?

10. How do you express your concern for fisheries related issues at the local level?

Appendix III: Fjord Dependency by Boat

*Gear types: 1 = handline, 2 = longline, 3 = seine

a) Arnarfjörður

Boat	*Total (kg)*	*Arnarfjörður*	*Percent*	*Gear**	*Boat*	*Total (kg)*	*Arnarfjörður*	*Percent*	*Gear*
Ingisol	600	600	100.00%	1	Magný	825587	43235	5.24%	2
Bjartey	8290	7665	92.46%	3	Brá	17367	890	5.12%	1
Arny	38111	30700	80.55%	2	Steinthor	4238	200	4.72%	1
Thormar	588370	439008	74.61%	3	Brá	54582	2570	4.71%	2
Yrr	20197	13656	67.61%	2	Magngeir	33766	1540	4.56%	1
Leonhard	8355	4938	59.10%	1	Holmbjorg	12261	530	4.32%	1
Kornelíus	37345	15321	41.03%	1	Alfsol	15610	580	3.72%	1
Elsý	10150	3480	34.29%	1	Fjalar	2358720	82350	3.49%	2
Adda	1620591	552149	34.07%	3	Freyviður	2931836	98301	3.35%	3
Ida	565983	189745	33.52%	3	Linda	2167680	66202	3.05%	3
Leonóra	24880	7190	28.90%	1	Bjargþór	28682	776	2.71%	1
Karin	63003	18100	28.73%	2	Barbára	236819	6320	2.67%	2
Alexa	8150	2300	28.22%	1	Gudvardu	25367	670	2.64%	1
Arveig	12975	3505	27.01%	1	Engilbjartur	38820	975	2.51%	1
Sakarías	4440	1070	24.10%	1	Minný	1222807	30230	2.47%	2
Arnfríður	62818	13922	22.16%	2	Vemundur	82511	1500	1.82%	2
Gunnlaugur	1851878	402842	21.75%	2	Hallrun	54360	900	1.66%	1
Lýður	2440471	510788	20.93%	3	Sigurást	2425020	27503	1.13%	3
Thorir	33879	7050	20.81%	1	Steinfinnur	182934	2066	1.13%	3
Sumarliði	1375079	245854	17.88%	3	Yr	270390	2700	1.00%	2
Gunnveig	26120	4500	17.23%	1	Borgþóra	2482563	22800	0.92%	2
Adalheidur	9544	1535	16.08%	1	Baldur	24764	190	0.77%	1
Hjörný	12260	1890	15.42%	1	Elli	3236467	24189	0.75%	3
Hlöður	307488	45407	14.77%	2	Vörður	88285	635	0.72%	2
Húnn	3210076	469653	14.63%	3	Benóný	1841780	13050	0.71%	3
Hjálmgerður	72951	9420	12.91%	2	Petrina	87341	600	0.69%	1
Nýbjörg	30440	3730	12.25%	1	Svafar	1447300	8390	0.58%	3
Yrja	270392	32810	12.13%	3	Asgrimur	2713777	8560	0.32%	2
Stjarna	15323	1808	11.80%	1	Henning	3110762	8725	0.28%	2
Baeringur	24311	2450	10.08%	1	Palmfridu	201528	450	0.22%	1
Sigurdrifa	7994	774	9.68%	1	Margrét	1931869	3500	0.18%	2
Skúli	575318	46550	8.09%	2	Eyveig	234162	400	0.17%	1
Krummi	199733	11500	5.76%	2	Hjördís	1650744	2215	0.13%	2

Jana	360290	20100	5.58%	2	Haflína	13333405	5313	0.04%	2
Svava	27692	1540	5.56%	1	Magga	1704228	419	0.02%	3
					Hermóður	1978978	239	0.01%	3

b) Ísafjarðardjúp

Boat	*Total (kg)*	*Ísafjarðardjúp*	*Percent*	*Gear*	*Boat*	*Total (kg)*	*Ísafjarðardjúp*	*Percent*	*Gear*
Sigurmon	2450	2450	100.00%	1	Maren	37018	2370	6.40%	1
Svangeir	2300	2300	100.00%	2	Herthrudur	16840	1050	6.24%	1
Thorhalla	1459	1459	100.00%	1	Karli	8199	500	6.10%	1
Thorveig	1500	1265	84.33%	1	Audbjorg	52052	3078	5.91%	1
Astros	59989	50500	84.18%	2	Maídís	18290	1050	5.74%	1
Elimar	66882	52297	78.19%	2	Kári	127758	7105	5.56%	2
Brá	54582	39787	72.89%	2	Valgerður	110470	5760	5.21%	1
Cecilia	181418	125634	69.25%	2	Cecilia	137662	6645	4.83%	1
Telma	13715	9065	66.10%	1	Grímar	60080	2770	4.61%	1
Gauthildur	126549	73434	58.03%	2	Ingey	1069248	48670	4.55%	2
Orlaugur	177148	93471	52.76%	3	Snæbrá	130111	5900	4.53%	2
Svafar	1447300	745998	51.54%	3	Samúel	117693	5250	4.46%	2
Hunbjorg	2570	1300	50.58%	1	Signý	37891	1667	4.40%	1
Sæmann	809373	408087	50.42%	3	Thorhaddu	27844	1214	4.36%	1
Sverrir	282563	140190	49.61%	2	Elna	1141060	49575	4.34%	2
Kaprasíus	550978	202147	36.69%	2	Mey	41360	1700	4.11%	2
Elíana	453102	165203	36.46%	2	Markús	15708	638	4.06%	1
Maren	243064	88170	36.27%	2	Alisa	41620	1550	3.72%	1
Lýður	2440471	823823	33.76%	3	Ashildur	7103	260	3.66%	1
Garpur	46111	14725	31.93%	2	Alida	22100	750	3.39%	1
Ian	90556	26316	29.06%	2	Armenía	20875	699	3.35%	1
Thea	10140	2941	29.00%	1	Nadia	22631	756	3.34%	1
Fura	32329	9076	28.07%	1	Olgeir	18930	600	3.17%	1
Loðmundur	1277964	349072	27.31%	2	Bergrós	99887	3110	3.11%	1
Ida	565983	146225	25.84%	3	Sveina	25930	800	3.09%	1
Hróðólfur	29681	7552	25.44%	3	Sigurást	2425020	72988	3.01%	3
Eyvör	500	125	25.00%	2	Snæþór	55426	1620	2.92%	1
Thorolfur	1150058	231846	20.16%	2	Leonóra	24880	690	2.77%	1
Elsabet	26041	5190	19.93%	1	Domaldi	10880	300	2.76%	1
Stirnir	1037220	206575	19.92%	2	Bjargþór	28682	774	2.70%	1
Romeo	11554	2254	19.51%	1	Lini	28000	750	2.68%	1
Katrín	7780	1450	18.64%	2	Linda	2167680	55165	2.54%	3
Elias	17340	3118	17.98%	1	Ruth	111144	2740	2.47%	3
Adda	1620591	289207	17.85%	3	Garpur	83739	2035	2.43%	1
Armenía	92125	16380	17.78%	2	Dagbjörg	56010	1350	2.41%	1
Gabríel	59971	9840	16.41%	2	Eylaugur	47560	1050	2.21%	1

Steinvör	36291	5918	16.31%	2	Arsael	1187611	25578	2.15%	2
Sigurdor	12218	1870	15.31%	1	Kodran	81588	1600	1.96%	1
Dýri	1789003	271204	15.16%	2	Arnlaug	41594	780	1.88%	1
Björn	405294	61127	15.08%	2	Bentína	90921	1650	1.81%	1
Safír	3594874	536681	14.93%	2	Osa	45615	750	1.64%	1
Randíður	9847	1418	14.40%	2	Petrina	87341	1425	1.63%	1
Valgerður	2255249	309405	13.72%	2	Melrós	23435	335	1.43%	1
Brynjar	6212825	847456	13.64%	2	Guðsteinn	1477040	20528	1.39%	2
Ebeneser	1445450	196628	13.60%	2	Paley	29960	400	1.34%	1
Sigurhans	13410	1750	13.05%	1	Miriam	55621	724	1.30%	1
Karles	2752780	348598	12.66%	2	Henning	3110762	36311	1.17%	2
Kristmann	255535	32345	12.66%	2	Gunnberg	165616	1650	1.00%	2
Húnn	3210076	403222	12.56%	3	Arnfinnur	15352	150	0.98%	1
Geir	177417	21713	12.24%	2	Gunnsteinn	34840	335	0.96%	2
Jara	21992	2551	11.60%	1	Minný	1222807	11630	0.95%	2
Betúel	695276	79975	11.50%	2	Betsy	854157	8080	0.95%	2
Sævör	6043207	671449	11.11%	2	Drifa	25451	240	0.94%	1
Arnberg	60750	6690	11.01%	2	Benóný	1841780	16427	0.89%	3
Patrekur	130932	14223	10.86%	3	Asgrimur	2713777	20189	0.74%	2
Kiddý	21230	2300	10.83%	1	Austar	24574	170	0.69%	1
Solvor	1178386	124569	10.57%	2	Julie	29279	200	0.68%	1
Palmey	27820	2940	10.57%	1	Mia	18762	120	0.64%	1
Dýrmundur	10717	1107	10.33%	1	Hallvör	302739	1900	0.63%	3
Mattea	37495	3635	9.69%	1	Friðfinnur	1936629	10663	0.55%	3
Sumarliði	1375079	126547	9.20%	3	Máney	239071	1180	0.49%	1
Eylaugur	1529065	138021	9.03%	2	Oddgerður	39853	165	0.41%	1
Sia	214893	18820	8.76%	1	Steinvör	75451	300	0.40%	1
Borgný	764748	65262	8.53%	2	Adríel	2357545	8935	0.38%	2
Sveinberg	10829	900	8.31%	1	Brestir	578803	2125	0.37%	2
Otkell	15350	1250	8.14%	1	Kakali	55927	200	0.36%	1
Betuel	26672	2125	7.97%	1	Tjörvi	82660	250	0.30%	1
Hlöður	307488	24174	7.86%	2	Snorri	2153737	5625	0.26%	2
Veiga	473110	36670	7.75%	2	Selja	1879868	4800	0.26%	2
Ketilfríður	9240	700	7.58%	1	Vilmar	3738350	6063	0.16%	2
Asi	667277	50385	7.55%	2	Danival	1554611	2500	0.16%	2
Gunnberg	66240	4950	7.47%	1	Thorgnyr	2342049	3000	0.13%	2
Geirfinnur	443596	31200	7.03%	2	Kolur	2237297	2800	0.13%	2
Mörður	30803	2120	6.88%	1	Elli	3236467	3840	0.12%	3
Oddhildur	41893	2850	6.80%	1	Ingilaug	11445724	13125	0.11%	2
Arinbjörg	11800	800	6.78%	1	Magga	1704228	1391	0.08%	3
Sylvía	126107	8132	6.45%	2	Haflína	13333405	2925	0.02%	2

c) Önundarfjörður

Boat	*Total (kg)*	*Önundarfjörður*	*Percent*	*gear*	*Boat*	*Total (kg)*	*Önundarfjörður*	*Percent*	*Gear*
Oddgerður	19395	5400	27.84%	2	Adda	1620591	27900	1.72%	3
Dýrmundur	10717	1250	11.66%	1	Hlöður	307488	3386	1.10%	2
Húnn	3210076	224338	6.99%	3	Sæmann	809373	7213	0.89%	3
Magnfríður	43137	2770	6.42%	2	Sveinbjörg	44830	300	0.67%	1
Nikólína	19589	1252	6.39%	2	Minný	1222807	6478	0.53%	2
Hjálmgerður	72951	3727	5.11%	2	Ingey	1069248	5575	0.52%	2
Friðrún	431232	18304	4.24%	2	Elna	1141060	5910	0.52%	2
Hektor	160763	6740	4.19%	2	Henning	3110762	15674	0.50%	2
Guðsteinn	1477040	42828	2.90%	2	Asgrimur	2713777	11985	0.44%	2
Petur	35388	1000	2.83%	1	Orlaugur	177148	658	0.37%	3
Svafar	1447300	37864	2.62%	3	Otkell	15350	50	0.33%	1
Betsy	854157	18475	2.16%	2	Hlöður	74040	200	0.27%	1
Betúel	695276	14890	2.14%	2	Thorgnyr	2342049	4716	0.20%	2
Lýður	2440471	42445	1.74%	3	Elli	3236467	3125	0.10%	3
					Magngeir	33766	20	0.06%	1