9-1-2016

Icelandic Fisheries: Scenario Planning for Climate Change

Tara Sorrels
Western Kentucky University, tara.sorrels760@topper.wku.edu

ICELANDIC FISHERIES: SCENARIO PLANNING FOR CLIMATE CHANGE

A Capstone Experience/Thesis Project

Presented in Partial Fulfillment of the Requirements for

The Degree Bachelor of Science in International Business with

Honors College Graduate Distinction at Western Kentucky University

By:

Tara Sorrels

*****

Western Kentucky University

2016

CE/T Committee:

Dr. Leslie North, Advisor

Dr. Joshua Hernsberger

Siera Bramschreiber

Approved By

_____

Advisor

Department of Geography & Geology

ABSTRACT

This study aimed to develop an understanding of how a scenario planning process could be used to assist businesses to adapt to climate change. The focus of this study was on the Icelandic fishing industry since Iceland is experiencing firsthand climate change impacts. Mitigation strategies are the main focus in climate change research, but this study focused on a possible adaptation method that requires changing management practices in order to reduce the impact of climate change on the economy. Tours of Icelandic fisheries and interviews with individuals within the Icelandic fishing industry were conducted to assess the current adaptive capacity of the industry. Three company profiles were created to represent fisheries at different levels of preparedness for climate change. Future climate scenarios were derived from data provided in the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report. The climate scenarios were used to make predictions about the future challenges or opportunities the company profiles would face. The findings of this study reflect that Iceland's fishing industry will continue to be greatly impacted by climate change, and the industry does not have a specific planning approach to climate change. The results from this study also suggest that the scenario planning process is a promising approach to complex issues with high levels of uncertainty like climate change, but a successful scenario planning process is difficult to achieve due to a lack of time and resources. This thesis provides a

starting point for large-scale scenario analysis and can be returned to fisheries management in Iceland to highlight both the resources needed to make the scenario processes effective and the benefit of using a scenario planning approach to climate change in the fishing industry.

Keywords: climate change, Iceland, fishing, adaptation, business strategy

Dedicated to Que Buenos, El Maz, and GADS

ACKNOWLEDGEMENTS

Thank you to Dr. North for your expertise, guidance and encouragement. This project would not have been possible without you. Thank you to Dr. Hernsberger for the enthusiasm and strategy expertise and for being willing to help on such short notice. Thank you to Stephanie Hammons not only for encouraging me to apply to the Honors College, but also for being an exceptional teacher, inspiration, and friend. Thank you to Dr. Strenecky for believing that I could do a CE/T project when I felt that I could not, and providing me with endless learning opportunities. Thank you to the Honors College for giving me a second family and a wonderful job. Thank you to DELO, Jarve, the Study Abroad office, the Gordon Ford College of Business, the Honors College, the Hershberg foundation, and FUSE for funding my study abroad experience and making this project possible.

I cannot express enough thanks to my parents for dealing with my consistent long-lasting absences from home to pursue this project and for supporting me in everything I have wanted to do my whole life. Thank you to my brother for being my campus map, guide, and advisor throughout my undergraduate career. Thank you to Austin Paulson for being my emotional support as well as my life's comic relief. Thank you to the friends who allowed me to be absent in order to pursue this project. Thank you

to Little Britches for providing puppy cuddles when this project got hard. Thank you to Coach Talley for helping me realize that I can always go further than I believe.

VITA

May 28, 1994…….....Born – Taylorsville, Kentucky

2012……Spencer County High School, Taylorsville, KY

PRESENTATIONS

September 25-26, 2015…...Kentucky Honors Roundtable at Eastern Kentucky University

FIELD OF STUDY

Major Field: International Business

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION AND BACKGROUND

Climate change is the most pressing and complex issue of today, and it is prompting action around the world. The Intergovernmental Panel on Climate Change (IPCC) released a new assessment report in 2014 on the observed and projected impacts of climate change. An agreement was reached at the 2015 Paris Climate Conference between 190 countries to legally limit emissions and keep global warming below 2˚C (Climate Action, 2015). Mitigation strategies, such as limits to emissions, are just one type of reaction to the changing climate. This study aimed to emphasize the need for more adaptation strategies that require a change in the way humans think of and perceive the issue of climate change. Iceland is heavily impacted by the changes in the climate and Icelanders are some of the many people on Earth reacting to these changes right now. The purpose of this study was to figure out how a scenario planning approach to climate change could be implemented into fisheries management in Iceland. Icelandic fisheries management can benefit from using a scenario planning approach when making strategic decisions, and this process would reduce the economic risk that climate change poses to the industry.

Climate Change

Climate change is one of the most threatening phenomena humans have experienced. The concept of climate change has been debated time after time around the world. The United States Environmental Protection Agency (EPA) defines climate change as "any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among others, that occur over several decades or longer" (EPA, 2016). The term climate is not to be confused with weather which is the day to day changes in the atmosphere. The IPCC AR 5 reports on observations of the global average temperature increasing over the last 100 years (2013). The report also states that "[c]limate change, whether driven by natural or human forcing can lead to changes in the likelihood of the occurrence or strength of extreme weather and climate events or both (Cubasch et al., 2014, p. 121).

Global warming and climate change are sometimes misconceived to be synonymous, however, an important distinction to make is that global warming is the current trend of the climate changes that are apparent today, and warming is not the only trend that can occur (Kennedy & Lindsey, 2015). Another common misunderstanding is the assumption that climate change is a natural phenomenon on which humans have no impact. The assertion that climate change is a natural occurrence is true, however, what is not natural is the rate at which the change is happening (EPA, 2016). Climate records show that the amount of Co_2 in the atmosphere correlates with the increase in temperatures and both increased during the industrial revolution. The quick increase in Co_2 emissions during the 19th century due to human behavior caused a relatively fast

increase in average global temperature. The dangerous rate of temperature increase is at the fault of human activity (IPCC, 2007).

In the Oxford Handbook of Climate Change, Steffen states that "[p]erhaps no other problem-environmental or otherwise facing society requires such a strong interdisciplinary knowledge base to tackle; research to support effective policy-making and other actions must cut across the full range of natural sciences, social sciences, (including economics), and humanities" (p.21, 2013). As mentioned before, human activity contributes to the changing climate. Industry is a large contributor and businesses will need to be able to withstand changes in the climate if they wish to succeed. Takacs emphasized that managers have become more commonly engaged with climate change issues, but climate change has not been implemented into the business school classroom (2013). Further, Linnenluecke found that climate change adaptation in business is rare and many individuals within business management do not understand the threats climate change poses to their company (2015). These findings support Steffen's statement by showcasing that it is difficult for a discipline outside of science to understand climate change.

Climate Change and the Ocean

Climate change has a critical influence on the ocean, and the resultant changes can alter the marine ecosystem and cause potentially severe consequences for the economy (Pörtner et al., 2014) by reducing profitability of fisheries. Specifically, climate change can lead to increases in sea surface temperature, ocean acidification, and ocean circulation variability.

Approximately 93 percent of the warmth from increased CO_2 emissions between 1971 and 2010—from anthropogenic means—can be found in the ocean (Hoegh-Guldbert et al., 2014). This absorption of CO_2 causes the sea surface temperature to increase (Hoegh-Guldbertet al., 2014), thus disrupting the ocean ecosystems. As cited in an article in *Proceedings: Biological Sciences* in 2009, changes in ocean temperatures can cause a shift within the marine food web by disrupting nutrients and causing species migration (Kirby & Beaugand, 2009). Species can evolve or adapt to the changing environment, but the rate at which the temperatures have been changing is much faster, and the adaptive capacities of many species may be lacking (Chevin et al., 2010).

The increasingly CO_2 in the ocean results in a decrease in the pH levels of the water (Pörtner et al., 2014), which can also be considered ocean acidification (Hoegh-Guldbert et al., 2014). A study on the impacts of warming on marine organisms found that there are "reductions in survival, calcification, growth, development, and abundance in response to ocean acidification across a broad range of marine organisms" (Kroeker et al., 2013, p. 1890). For example, Pteropods are a common source of food for many fish; yet, ocean acidification can reduce the population of the species by making the mollusks' shells soft. With a reduction in the quantity of Pteropods, an important segment of the ocean food web is altered. (Pörtner et al., 2014).

The CO_2 emissions responsible for an increase in sea surface temperature and ocean acidification also impact ocean circulations. As explained by Carl Wunsch in a 2002 *Science Magazine* article, the movement of temperature and salt is driven by thermohaline circulation which is the mass circulation of the ocean driven by wind and tidal forcing (Wunsch, 2002). The region-specific circulation in the North Atlantic—the

Atlantic Meridional Overturning Circulation (AMOC)—alters Earth's climate as it moves heat northward (Kuhlbrodt et al., 2007; Marini & Frankignoul, 2013). Studies of the AMOC show variances that correlate with the Atlantic Multidecadal Oscillation (AMO) (Marini & Frankignoul, 2013). The AMO is "the multidecadal SST [sea surface temperature] variability observed in the North Atlantic" (Marini & Frankignoul, 2013, p. 607).

Scenario Planning

Scenario planning is a type of strategic planning process that is used in a multitude of ways to look at multiple variations of the future. This approach is a way of looking at the future and asking the question, what would we do in that situation? Or, how can we avoid that situation? Scenario planning is a tool that is well suited for problems with high uncertainty and long timelines (Wack, 1985a; Wack, 1985b; Schoemaker, 1995; Chermack, 2015; Phadnis, 2015;). Scenario planning is not to be confused with forecasting, in which previous events are used to project a single future event quantitatively (Wack, 1985a; Kloss, 1999). Scenario planning is a much more imaginative process that requires analysis of external variables with a wide variety of stakeholders and planning members to be successful (Wack, 1985a; Kloss, 1999).

One of the earliest individuals to combine forecasting techniques with a scenario planning approach was Herman Kahn (Wack, 1985a; Kloss, 1999). In Herman Kahn's *The year 2000* the author noted that the most important aspect to studying the future is to find trends that are likely to continue in the long-term and think about those trends in relation to the problem at hand (Kahn, 1967). Kahn discusses how this type of approach can alter peoples' thinking and promote change within a system. In the same publication,

Kahn goes on to complete quantitative scenarios and forecasts of gross national product per capita with a focus primarily on macroeconomics and international policy, but his studies have prompted experimentation of scenarios in many different sectors (Kahn, 1967).

One of the most frequently cited scenario planning success stories is about a company, Shell Oil, who translated Kahn's scenario approach into corporate planning and avoided the oil crisis in 1973 (Wack, 1985a). Shell Oil had planners who presented analysis of the global business environment, which they then used to project what was likely to happen to the oil market (Wack, 1985a; Schoemaker, 1995; Kloss, 1999; Peterson, 2003; Chermack et al., 2015; Phadnis et al., 2015). Wack reports that because of the scenario planning process, Shell was able to sell off its extra oil after the beginning of the Iran-Iraq war before prices collapsed (1985a)

Scenario construction processes are widely known throughout the literature to include any number of the following steps: define the scope of the analysis, identify the major stakeholders, identify basic trends, identify key uncertainties, construct initial scenario themes, check for consistency and plausibility, develop learning scenarios, identify research needs, develop quantitative models, and evolve toward decision scenarios (Schoemaker, 1995). These methods help to narrow the focus of the problem being analyzed, and provide guidance to learn more about the possibilities and uncertainties of the outcomes, and then develop scenarios based on what has been discovered throughout the process.

Wack (1985b) states that the key problem with scenario planning is getting the manager or decision maker to understand that the issues being discussed are important to

them. Bartholomew's (2007) study of 80 difference scenario-planning projects found that many planners went into the scenario planning process with an agenda already set on what they were wanting to get out of the scenario process. Bartholomew (2007) also found that possible reasons for a lack of successful projects is the lack of public participation, political investment, and authority.

Although scenario planning has showed to be most beneficial in its strategic planning use within corporations, this approach can be used for a variety of planning entities (Schoemaker, 1995). Scenario planning has been used by crisis management teams to develop crisis management options by analyzing worst case scenarios and brainstorming possible preventions and reactions to the scenarios (Barton, 1991). This approach has also been used in areas such as land-use transportation (Bartholomew, 2007), nonprofit associations (Kloss, 1999), investments in infrastructure (Phadnis et al., 2015), and inter-organizational strategizing (Bowman, 2016). Thus, scenario planning holds promise as being a suitable tool to prepare for future climate changes, but, to date, there have been limited attempts in this regard.

Scenario Planning and Climate Change

Scenario planning holds promise for being a sensible method for climate change adaptation management, but scenario planning for climate change adaptation has rarely been pursued. The limited previous research on scenario planning for climate change adaptation has revealed three primary trends in the methodology of scenario planning as well as three trends in the benefits resulting from the scenario processes. The trends in methodology consist of the necessity of locally-scaled scenarios (Carlsen et al., 2013; Rickards et al., 2014a; Rickards et al., 2014b), stakeholder and public participation

(Karvetski et al., 2011; Carlsen et al., 2013; Rickards et al., 2014a), and different frameworks in management styles (Lawler, 2009; Johnson and Welch, 2010; Rickards et al., 2014b; Jones et al., 2015). The common benefits found in the literature to performing scenario planning for climate change adaptation include making the complexities of climate impacts comprehensible to management (Carlsen et al., 2013; Hansen, 2013; Rickards et al., 2014a), assisting in the analysis of the long-view implications of management decisions (Hansen, 2013; Rickards et al., 2014a; SRES: IPCC, 2000), and providing a learning experience for participating members (Caves et al., 2013; Rickards et al., 2014b). Overall, successful scenario constructions and analyses have been completed, but very few instances where adaptations were implemented after the scenario process are documented.

Commonalities exist with regard to how to construct scenarios for climate change adaptations. For example, Carlsen et al. (2013) offer a step-by-step guide on how to construct downscaled scenarios through stakeholder engagement. Stakeholder involvement was also emphasized by Karvetski et al. (2011), Rickards et al. (2014a), and Rickards et al. (2014b), stating that participation from the planning body is essential to make the scenario process more likely to achieve adaptive action. In contrast, Jones et al. (2015) modified the Alternative Future Scenarios for Marine Ecosystems scenarios and used them to assess the profitability of fisheries under those scenarios by performing sensitivity and cost-benefit analyses. Rather than stakeholder engagement, the authors concluded, fisheries need to create adaptive capacity and diversify the business in order to minimize the impact of the projected lower profitability. Similarly, Lawler (2009) suggests that large-scale issues such as climate change make changes to the management

strategy a necessity. Johnson and Welch (2010) found that the impacts of climate change are increasing variability in a way that requires fisheries management to develop a more flexible type of management. Similarly, Rickards et al. (2014b) found that the uncertainty and variability of the issue of climate change creates a need to use methods such as scenario planning as alternatives to the common decision-making tools such as cost-benefit analysis. This finding suggests that management must be willing to use new and diverse methods that differ from quantitative measurements.

A well-documented common benefit resulting from the scenario processes is making the complexities of global climate impacts comprehensible to management. Rickards et al. (2015) cite that scenarios for climate change create an opportunity for management to view the complexities of the future in a more serious and less 'imaginative' way (p. 596). Furthermore, Carlsen et al. (2013) suggest that scenarios not only make complicated issues intelligible, but also emphasize what the stakeholders view as relevant. In other words, scenarios help take large complex concepts and provide a focused and relevant perspective for the scenario users. This benefit was also shown by Hansen (2013) while exploring climate change challenges in river basin planning. He found that scenarios made complex coastal dynamics into more comprehensible information that could be used to make decisions. Hansen (2013) also found that scenarios helped managers see the long-term view and get away from the comfort of blinded short-term analysis; scenario planning for climate change can often assist in analysis of the long-view implications of management decisions, which is important for a long-term issue that requires immediate attention like climate change. Rickards et al. (2014b) reports success in assessment of the long-view and states that scenario planning

helps “to sketch out the future situations that near-term decisions need to be able to accommodate or track” (p. 648). One intergovernmental body, the IPCC, realized this notion and created the SRES scenarios with the intention that policymakers would use them to gain “long-term context for near term analysis” (2000, p. 11). Along with the view of the long-term comes a learning effect. Rickards et al. (2014b) found that scenario planning raises awareness of future trends and impacts of climate change and develops a shared understanding between disciplines (2014b). Further, scenario planning for climate change adaptation provides an opportunity to raise awareness among stakeholders of climate change impacts. Caves et al. (2013) expressed lessons learned in theoretical frameworks for addressing complex issues like climate change.

Providing a learning activity to raise awareness and creating a comprehensive version of climate impacts are possibly the biggest successes of scenario planning for climate change adaptation, but there is a predominant lack of implementation from management after scenarios are analyzed. Reasons for this lack of implementation were examined by Cairns et al. (2013), who noticed stakeholders with power to implement adaptations had other agendas or were uninterested, and those who were interested had less resources and less power. Rickards et al. (2014b) found other reasons for the lack of action and assess that the environment of adaptation—especially within policymaking—is limited by politics and expectations of certainty. Perhaps the concept of embracing uncertainty is not enough and does not yet persuade decision makers to move forward with potentially costly adaptations.

The literature seems to conclude that scenario planning is an adequate tool for preparing for the uncertain futures that climate change presents and can help management

gain a better understanding of the scientific complexities of the issue. However, scenario planning is lacking in practice of climate change adaptation due to lack of resources, time, cooperation, and knowhow. The reasons behind the lack of cooperation and priority in regard to climate change adaptation are uncertain.

CHAPTER 2

STUDY AREA

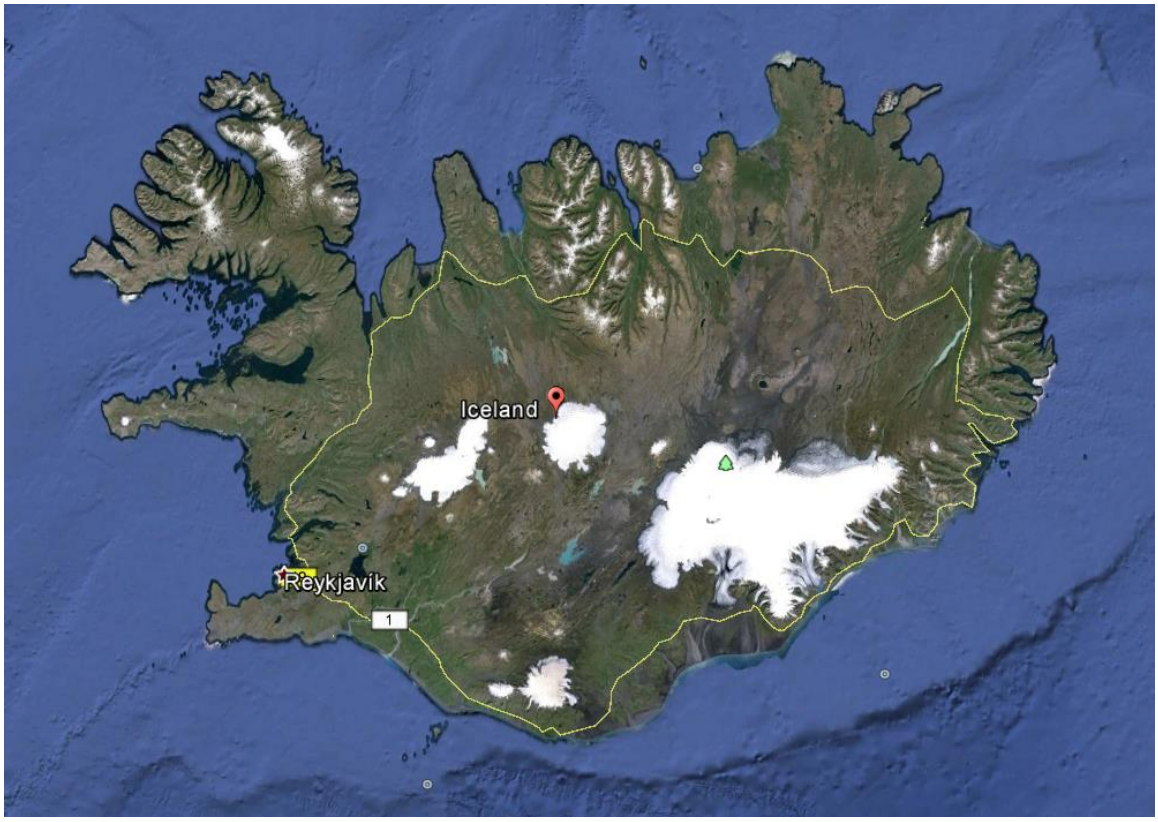

Figure 1. Iceland. *Source: Google Earth.*

This study is an analysis of the projected impacts to the fishing industry in Iceland. Iceland is an island located in the North Atlantic, which borders the Arctic region. The CIA World Factbook reports that the country is roughly the size of Kentucky, 103,000 km^2, but has a population of approximately 331,918 people (2016). The CIA also reports that 94% of the population is descendant from Norse and Celts, and only 6% of the population is of foreign origin (2016). As of 2015, the total population had a 1.01 males/female ratio (CIA, 2016).

While Iceland is commonly thought to be fully covered in ice, the country has a rather temperate climate; this is, in part, due to the Gulf Stream, which brings warmer temperatures northward towards Iceland. Temperatures average 32°F in February and 50°F in August (Icelandic Met Office, 2012). On the ice caps Vatnajökull and Mýrdalsjökull, the precipitation is the greatest with approximately maximum annual precipitation of more than 4,000 mm (Einarsson, 1984). Precipitation can vary greatly across a small landscape with different regions of Reykjavik, the capital city, obtaining different values of precipitation (Einarsson, 1984).

Iceland has an abundance of volcanic activity, as well as glaciers and waterfalls, and the mainland is one of the youngest on Earth (Promote Iceland, n.d). The North American plate and the Eurasian plate join to form the Mid-Atlantic Ridge which surfaces right through Iceland creating some of the most active volcanoes in the world (U.S. Geological Survey, 2011). Iceland is home to the largest glacier in Europe—the Vatnajökull—which covers about 8000 km^2 (Ingólfsson, 2008). The country has waterfalls all over the landscape, with new ones forming as glaciers melt (Gunnarsdóttir, n.d.). The water in Iceland is reported to be pure enough for humans to drink directly from the source.

Collectively, the physical landscape of Iceland makes the island a great tourist location. In fact, although Iceland's economy primarily has been historically comprised of the fishing industry, tourism now accounts for more foreign exchange income than fisheries (Óladóttir, 2015). The GDP growth rate for the nation in 2014 was approximately 2% (Statistics Iceland, 2015), while the purchasing power per capita growth in 2014 was approximately 4% (Statistics Iceland, 2015). Iceland has been

growing towards manufacturing in the past decade within the software production, biotechnology.

Fishing Industry

Even with the growth of the Icelandic economy into other sectors, the fishing industry still accounts for 40% of export earnings and more than 12% of GDP (CIA, 2016). A negative impact on the fishing industry could be detrimental to the economy. Approximately 5% of the work force is employed with the fishing industry (CIA, 2016). The largest fishing fleet in Iceland has 400 tonnes of cargo capacity worth of ships and is located in the Westfjords (Statistics Iceland, 2014).

As cited by Knutsson and Gestsson, there are three sectors of Icelandic fishing industry: catching, processing, and exporting. The fish can be processed in six different ways: frozen, salted, fresh, dried, meal and oil, and canned (2006). Iceland's largest export in marine products is frozen (Statistics Iceland, 2014). Fishery management in Iceland depends heavily on three activities: research, policy, and implementation. Iceland has three organizations that are responsible for these activities: The Marine Research Institute of Iceland, The Ministry of Industries and Innovation, and The Directorate of Fisheries (Iceland Responsible Fisheries, n.d). The Ministry of Industries and Innovation use research from The Marine Research Institute on species stocks to determine the total allowable catch for each species of Iceland's fish stocks and makes the political policies and regulations. The Directorate of Fisheries enforces the policies and regulations (Iceland Responsible Fisheries, n.d).

During early settlement, fish were the main source of food for Iceland's inhabitants and were caught by farmers who owned rowing boats (Knutsson & Gestsson,

2006). As cited by Knutsson & Gestsson, the fishing industry went through five stages starting with rowing boats and moving to sailboats, motor boats and trawlers, innovation trawlers and Swedish boats, stern trawlers, and then to processing trawlers (2006). Icelanders were behind other countries in the development of their own fishing industry, and it was not until the 19th century that they had their own fleet of decked boats (Knutsson & Gestsson, 2006).

Iceland has an extensive history of fishing territory disputes with Britain. A paper on the negotiations between Iceland and Britain by Guðmundur Guðmundsson (2006) explains the developments in gaining Icelandic fishing territory. There were four main events: the 4-mile dispute, the 12-mile dispute, the 50-mile dispute, and the 200-mile dispute. Each of these events was an attempt by Iceland to extend their fishing limits, and the country argued with Britain for a long time to win each dispute. The limits were proposed by Iceland to reduce over-fishing, and Iceland was very aggressive in gaining the fishing limits—sometimes even threatening the country's resignation from the North American Trade Organization (NATO) and to get rid of the US forces base on Icelandic soil (Guðmundsson, 2006).

After Iceland established the fishing territory or economic zone, quotas were developed on important species to assist declining fish stocks (Knutsson & Gestsson, 2006). These were different than previous quotas because they introduced the individual transferable quota (ITQ). The ITQ allows the buy or sell of quotas between ships and requires that each ship catch at least 50% of their quota or they lose their quota share. This system creates a decrease in the allocation of quotas and has resulted in companies getting increasingly larger as it has allowed for companies to buy or merge with less

effective companies ultimately resulting in more profits for the country (Magnusson, 2006).

According to a report on the profitability of fishing and fish processing published by Statistics Iceland, the net profit of fishing and fish processing in Iceland decreased between 2013 and 2014, but return on equity increased from 28.2% to 32.3% (Statistics Iceland, 2016). These statistics show that management may be using their equity base more efficiently to optimize return to shareholders, but the future may call for more than optimizing shareholder return.

CHAPTER 3

METHODOLOGY

The method used for this study consisted of five steps. Step one was to assess the managerial culture of the Icelandic fishing industry; the goal was to capture the attitudes and actions towards climate change within the industry. Step two was to conduct an environmental analysis of the industry that consisted of the current and future environmental trends facing the industry derived from the IPCC AR5. The next step was to use the literature on climate change and the ocean to assess possible opportunities and threats to fisheries under each environmental trend. The goal of this analysis was to examine the extent to which environmental trends could impact the industry. The next step was to construct three Icelandic fishing company profiles to represent a range of different management styles to serve as a basis on which to conduct scenario analysis. The final step of this research was to analyze the possible implications for each company profile under each climate scenario and assess how this information could be used to assist the Icelandic fishing industry improve on adaptive capacity.

Managerial Culture

Tours were taken of two Icelandic fish processing plants and interviews were conducted with two professionals in the Icelandic fishing industry to gain better understanding of the industry and the managerial thinking within the industry. The interviews were semi-structured and took place with managers who worked at the

processing plants of two separate fisheries in Iceland. The questions were:

1. What species of fish do you catch?
2. How long have you been a fisherman/fisherwoman?
3. What are your thoughts on climate change? Do you feel climate change will have any impact to you, your business, or the fishing industry in Iceland?
4. Are you aware of any projected environmental changes due to climate change?
5. Have you noticed any changes in the oceans and/or ocean behavior in your time as a fisherman/fisherwoman?
    a. What changes, if any, do you think could have resulted from a change in climate?
6. What changes, if any, have you noted with regard to the species you are catching?
7. Are there plans in place within your fishery in preparation for the changing oceans/climate?
8. If the water temperature increases, what species of fish do you suspect will no longer be viable? And/or, what new species may migrate into your area?
9. If warmer ocean temperatures were to result in fish migration, do you think you will likely experience positive or negative impacts to your business?
10. If sea levels rise, how might that impact your fishing practices?
11. The Intergovernmental Panel on Climate Change reports that the warming of the ocean has caused some species of fish to move to deeper waters or further from the coastline. If this happens to the species of fish you work with, would you still be able to fish for them? How would changing your current fishing

strategies (having to travel further from the coastline, fishing in deeper waters, etc.) impact your business? Would it have any impact on your profits?

12. Are you worried about what may happen to your business in 30 or 50 years? Or are you very much focused on the present?
13. Do you have a strategic planning process that you go through to prepare for the future?
    a. Can you detect changes in the ocean that may occur in your area before they happen? If so, how do you come up with a strategy to adapt to the changes?
14. Do the fishing policies you are required to follow have the potential to hinder your adaptations to changes in the ocean and respective changes to species?
15. What kind of strategies do you have as an organization in order to profit as a business? Do you have specific fishing quotas and goals?
16. What roles do other fisheries play in your area? Is there a sense of competition between each fishery?
    a. If so, what kind of impacts would this competitive atmosphere have on your adaptive strategies? Would this atmosphere make your organization want to adapt quicker to get ahead of the competition?
17. Who are the primary stakeholders in the Icelandic fishing industry as a whole? What role does each of these groups have in decision-making?
18. When trying to adjust your fishing practices to adapt to changes in the species or ocean, what challenges might you face socio-economically?
    a. What kind of restrictions or costly expenditures may arise from making changes to your fishing practices?

b. Would it possibly be too expensive to make drastic adaptations when they are needed?

c. What kind of restrictions would fishing policy have on your adaptations?

19. What kind of role do your political leaders play in your decision-making?

a. What kind of restrictions does your fishery face in result to your political leaders?

Further information was gathered from university professors from the University of Akureyri, leaders in the Icelandic Arctic Cooperation Network, and a fisherman from Alaska who was able to provide a fisherman's perspective on climate change. This information was used to gauge the extent to which Icelandic fisheries are actively planning for future changes to the climate. A key lesson learned from this experience was that management at Icelandic fisheries know the climate to be so unpredictable that they feel it is impossible to prepare for future changes. Both professionals interviewed emphasized the notion of being reactive vs proactive and expressed that they have always been reactive to alterations in the climate and that ambiguity hinders their ability to be successfully proactive. In other words, they are comfortable with their ability to adjust to a situation when it presents itself rather than anticipating and preparing for a situation before it happens. The two professionals that were interviewed do not represent all of the fisheries in Iceland and do not provide a complete dataset. However, their inputs provided some valid information about the industry and some direction for the research and scenario development and were, therefore, included in this research as part of the scenario analysis process.

Environmental Analysis

For this study, an environmental assessment was conducted on the Icelandic fishing industry to act as a prerequisite to the scenario planning process. This particular analysis was an in depth version of the environment portion of the PESTEL (Political, Economic, Socio-Cultural, Technological, Environmental, and Legal environment of a business or industry) analysis framework. The Intergovernmental Panel on Climate Change (IPCC) releases a series of reports about every six years that assess what is known and what are the projected future impacts of climate change. The projections included in the reports are based on the current rates and trends of Earth's climate at the time they are written. For this study, projections provided in the most recent IPCC assessment report, IPCC AR5, were used to create scenarios to compare three different fisheries—ranging from not prepared to very prepared—and their possible opportunities and challenges if faced with each selected IPCC projection. This study involved using three climate change projections from the IPCC AR5 to analyze the possible impacts on three different fisheries. These company scenarios have been constructed with varying adaptive capacities to showcase the opportunities and threats that different companies might face when confronted with changes in the climate.

Scenario Climate Projections

Three projected changes in the Atlantic Ocean were utilized from the IPCC AR5 report for this analysis: increase in Atlantic Ocean temperature, increase in Ocean acidification, and increase in variability of Atlantic Ocean circulation. As cited in the IPCC AR5, "the Atlantic Ocean has warmed more than any other ocean basin;" this warming has been "driven by global warming and the current warm phase of the Atlantic

Multi-decadal Oscillation (AMO)" (p. 1678). Projections of future ocean temperatures show that the ocean will continue warming due to anthropogenic greenhouse gas emissions. The IPCC states that "[f]urther increases in atmospheric CO_2 are virtually certain to further acidify the Ocean and change its carbonate chemistry" (p.1674). Further, according to the IPCC AR5, the AMOC is projected to weaken, but the rate and degree of impact is uncertain (2014). The behavior of the AMOC is highly sensitive to anthropogenic and natural releases in greenhouse gasses, and this sensitivity increases the variability of its impacts (IPCC AR 5, 2014). Table 1 reflects the three scenarios evaluated during this project based on the aforementioned projections from the IPCC AR 5.

IPCC Scenario 1	Ocean temperatures will continue to increase
IPCC Scenario 2	Surface pH will continue to decrease
IPCC Scenario 3	Decrease in Atlantic Meridional Overturning Circulation/Increase in variability

Figure 2. Climate Projections. Source: IPCC AR5

Opportunities and Threats

Each IPCC scenario presents similar threats to Icelandic fisheries. Increases in Atlantic Ocean temperatures can cause invasive species or species migration, which can result in alterations in the food web (Kirby & Beaugand, 2009) and depletions in fish stocks due to the limited adaptive capacities of the species (Chevin et al., 2010). Increases in Atlantic Ocean acidification can result in reduced quality of fish catch and permanent ecosystem damage, which also leads to alterations of the food web due to circumstances such as species migrating out of the area or sources of food becoming sparse as a result to the damaging effects of acidification (Kroeker et al., 2013; Pörtner et

al., 2014). Further, decreases in Atlantic Ocean circulation, along with increases in uncertainty, lead to increases in variability of ocean temperatures and increases in extreme events (IPCC AR 5, 2014).

Even though there may be more threats than opportunities, climatic changes in the Ocean can potentially present opportunities to fisheries. For example, in Scenario 1, a potential opportunity is that of new species migration. If a new species migrates into Icelandic territory, depending on the type of fish, they may be able to create a market for the new species and begin to obtain new profits. This event has happened in Iceland recently with the migration of Mackerel (Rúnarsson, personal communication, 201Ásbjörnsson, personal communication, 2015). Due to the warmer ocean temperatures, Iceland has an abundance of Mackerel that it did not have before, thus, Icelandic fisheries have created a market for the Mackerel and have prospered from its profitability. This particular opportunity has, however, created a new potential threat to the ecosystem in Icelandic fishing territory. Mackerel is an invasive species that feeds on other profitable fish in Icelandic territory, causing fisheries to be skeptical of the new species' presence. There are no known opportunities for fisheries that come from increased ocean acidification and variability in ocean circulation.

IPCC Scenario	Opportunities	Threats
1	New profitable species Increase in variety of fish stock	Invasive species Northern species migration Altercation in food web Depletion of fish stocks
2	No known opportunities	Reduced quality in fish catch Permanent ecosystem damage Altercation in food web Reduce maximum catch potential
3	No known opportunities	Increased variability in sea temperature Increase in extreme events (storms)

Figure 3. Opportunities and Threats.

Company Profiles

The purpose of developing the three aforementioned IPCC scenarios was to establish a focus for the environmental analysis of the fishing industry. For the purpose of this study, three company scenarios were also created to represent different levels of preparedness, ranging from low to high preparedness. The low-level company (A) represents a fishery taking no steps to plan for future environmental changes in their business plan. The mid-level company (B) represents a fishery that is making small preparations and understands the changes in the climate, but, overall, does not believe they are threatened by climate change. The high-level company (C) represents a fishery that is fully prepared and continuously improving on adaptive capacity. See Table 2 for a complete description of each company profile assumed in this research.

Company	Management style
Company A	Management recognizes climate changes after the changes have already directly impacted their company. The company is not concerned about future climate variability, and no plans are in place to prepare for future ecosystem changes.
Company B	Management recognizes changes in the climate, but they do not believe the changes will have long-term impacts to their profits. Management acknowledges that disruptions in the ecosystem could occur due to the climate, but they are confident of their reactive capabilities to face that problem when it presents itself.
Company C	Management recognizes changes in the climate and the impacts those altercations have had on the ocean environment. The company is also implementing mitigation strategies by purchasing new oil-efficient trawlers and anticipating increased environmental regulations by implementing technology in the new trawlers that can uphold to future increase in environmental regulations. Management is worried about the migration of fish and is keeping an eye on new species entering into their waters. By making these observations of future impacts often, the company creates a longer decision-making timeline.

Figure 2.1. Company Profiles. Guided by interviews and tours at Icelandic fisheries.

These company profiles were inspired by the interviews with the two Icelandic professionals who provided insight into the management priorities of their company. These profiles do not reflect the fishing industry as a whole and served to provide sample companies on which to perform scenario analyses. The varied levels of preparedness provide examples of the ways companies differ in their strategic approach and offer a framework for showing the different ways each would be impacted by the selected climate scenarios.

CHAPTER 4

RESULTS AND DISCUSSION

Results

Company A. Since Company A's management is not concerned with or planning for future climate changes, the planning entity would not foresee changes in the ecosystem and therefore would not have noticed the opportunity of a new profitable species quickly enough to reap most of the benefit. The negative impact of the threats would be exacerbated by the lack of foresight. Company A's lack of preparation for the future would increase the severity of the impact of a declining fish stock and have a harder hit on profits than if they were able to anticipate the dwindling fish stocks. As cited by Allison et al., an increase in invasive species results in reduced production of target species (2009). For example, cod has been one of Iceland's most abundant species, and the invasion of the mackerel threatens to disrupt the cod production (Rúnarsson, personal communication, 2015; Ásbjörnsson, personal communication, 2015). Management in company A would be unprepared for change in fish stocks because they would not see the changes coming and, in turn, this unpreparedness would limit the company in making the necessary changes they would need such as updating technology and gear on the ships to switch to a new species and diversifying the markets for which the company serves. This company would not have time to find another target market for a new species, therefore, a new species would pose a threat to their productivity. Aside

from a change in the ecosystem, the increased variability in the weather will cause the environment to become more and more unpredictable making it more difficult to make strategic future decisions even for a company that is preparing for climate change. Since Company A's management style is not that of forward-thinking, the increased variability would put additional strains on the reactive capacity of the company.

Company B. Since Company B's management is confident with their reactive ability to invasive species and other disruptions in the ecosystem, they are not likely to project future changes and prepare for them. Similarly to Company A, this lack of preparation could mean late entry into new markets if more new species enter into Icelandic territory. Company B's management thinks changes in the Ocean are temporary, and they may lack understanding that the impacts of Ocean acidification are virtually irreversible (IPCC, 2013). Due to this lack of science literacy, management may mistakenly make decisions based on hopes of ecosystem recovery. Management's confidence in being reactive is faced with an increased rate of change (IPCC, 2014) which may put stress on the company's reactive capacity by creating shorter decision timelines. For example, if the cod stocks start to dwindle due to the invasive mackerel, Company B will most likely be late movers on adapting to this change by reacting only when they notice the change occurring rather than analyzing possible future changes ahead of time. Scenario construction and analysis helps management explore uncertainties and allows for better reactive decisions to be made (Caves et al., 2013). Since Company B relies on their reactive capacity, scenario planning could help increase the timeline for decisions to be made by providing management with insight into possible futures ahead of time. The reliance on reactive capacity will not be productive for

combating the threat of increased frequency of storms. This company would not be monitoring for extreme weather events as often as would be necessary to limit the risks to employees.

Company C. Company C is most likely to correctly anticipate changes in the ecosystem in which it fishes. Management's close observations of the fish in their territory create an opportunity for competitive advantage over the other companies by allowing them to be first movers into new markets if new species migrate into the area. Company C is likely to notice invasive species and depletion in quality of fish stocks soon enough to create a longer decision time-line for reactive action. This response capability also helps in keeping up with the increased variability in climate due to changes in Ocean circulation by recognizing changes as soon as possible to provide the most decision-making time (OECD, 2010). This company is likely to be the first to create new markets for fish species that migrate into Icelandic territory and have the best chance for competitive advantage. Management at Company C is likely to monitor the weather more closely as they will be aware of the increase in extreme events, such as storms, due to climate change. This increased frequency in storms causes fishermen to be at sea for fewer days and increases the risk associated with the job (Allison et al.). Management that is aware of these increased risks will be more eligible to develop a strategy to lessen the impacts.

These results provide a glimpse into the scenario analysis process and exhibit the illustrative scenarios that come from thinking of the implications of various plausible futures. Management that conducts a full scenario analysis will start off with something similar to what was done in this study. Once management has thought of many possible

futures, they will be able to make better informed strategic decisions about their business operations and investments. These descriptive analyses of possible future opportunities and threats also allow management to begin thinking about how they can react to or limit the impact of each of the changes in climate. The company analyses and scenarios presented in this study are considered preliminary and showcase primary scenarios, and a full scenario process would include more in depth internal and external analyses as well as more descriptive scenarios.

Discussion

Using a scenario planning approach to climate change can help fisheries management make strategic decisions and reduce economic risk to the company. There are three main findings from this study that support this claim and one challenge that may be a reason this approach has not been implemented. The first important finding is that Iceland's fishing industry has already dealt with changes in the climate and will continue to be greatly impacted by climate change. Companies similar in preparedness to the Company A and B profiles in this study would benefit from knowing the impact of climate change on the ocean because then they would be able to make strategic decisions accordingly. The IPCC 5^{th} Assessment Report showed that the sea surface temperature has increased with the increase in CO_2 and both of the Icelandic professionals involved in this study provided insight into how the increased temperature has brought about a new species to their waters. This migration of species due to increased temperatures is the most apparent impact on the Icelandic fishing industry currently, but the projected climate scenarios derived from the IPCC provide evidence that the climate is going to continue to change and cause increased variability in the weather patterns and ocean

temperatures. Since Iceland will experience further climate changes and increased uncertainty, fisheries could use scenario planning to prepare for multiple likely outcomes.

The second finding from this study is that the industry does not have a specific planning approach to climate change. After reviewing the literature and speaking with the two Icelandic professionals, there is no apparent scenario planning process in place for climate change adaptation within the fishing industry in Iceland. The reasons behind this lack of concern for climate change adaptation are uncertain, but the two interviews that were conducted and other independent research suggest that Icelanders believe it is impossible to predict changes in the ocean because of its natural high variability. This notion suggests that scenario planning has not been used in Icelandic fisheries management because the ability of scenario planning to plan for possible outcomes of high-variability systems is not fully understood by management. If Company A and B analyzed possible future climate scenarios, the management would be able to begin decision timelines for multiple possible outcomes which would ultimately benefit the company by eliminating reaction lag time.

The third finding from this study is that the scenario planning process is an ideal tool for dealing with complex issues such as climate change. The literature review on scenario planning provided information explaining that scenario planning is an adequate approach when dealing with areas of high uncertainty because it allows participants to imagine all possible situations that could occur to them and provide a foundation on which to develop reactions and preparations to each plausible scenario. This process proved to be successful for the oil industry when Shell Oil used it to avoid the oil crisis of 1973, and the oil industry is one of high uncertainty. Company C in this study recognizes

that analyzing scenarios is beneficial in providing optimal planning time for issues of high uncertainty and variability such as climate change. If Companies A and B used a scenario planning process, they would reduce the common overwhelming feeling that changes in the ocean cannot be predicted. Management would be able to better understand climate change impacts on the ocean and how those changes can be anticipated.

The challenge realized from this study is that a successful scenario planning process is difficult to achieve due to a lack of time and resources. This notion is the biggest challenge derived from the literature facing organizations because of the need to have a large interdisciplinary pool of stakeholders working together to complete the scenario planning process. Icelandic fisheries management would need to meet with a wide range of stakeholders including those individuals within fisheries policy and the government of Iceland to provide adequate input for realistic scenarios. If a scenario planning group was analyzing a future climate scenario that would require their company to make a change in their business operations, management would need to have a diverse group of individuals involved in the analysis to provide information from different disciplines about what changes are possible and if any current policies would need to change to adapt to the projected future.

This work is important because the literature on scenario planning and climate change show that a benefit from this a scenario planning process is that it provides management with a comprehensive explanation of the complexity of climate change impacts. Companies A and B in this study lack understanding of the implications of climate change on the ocean and their fisheries. A scenario planning process would not

only help to improve comprehension among management, but would also serve as guidance for adaptation to climate change. This study has started the scenario planning process, which has not previously been conducted within the Icelandic fishing industry.

The scenario planning process is most applicable to top-level management and those individuals who have decision making power and access to resources. However, preliminary studies like this one could be done by lower-level management to create comprehensive scenarios to present to upper-level management in a way that would be appealing enough to create a sense of urgency to change the strategic planning process within the company. Upper-level management could then use the preliminary study from lower-level management to begin a full scenario planning process if they wish.

Perhaps the most important concept to note from this study is that the increase in the rate of change will challenge the Icelandic fisheries' reactive capacity by creating more frequent changes and thus requiring more frequent reactions. The planning processes that management has used in the past have worked for the changes Iceland has seen thus far, but will not suffice for the increased rate of changes coming in the future. The rate of change and the increase in variability requires that scenario planning not only be conducted once, but on a regular basis as environmental trends change.

CHAPTER 5

CONCLUSIONS AND FUTURE WORK

Management may be reluctant to start a scenario planning approach due to the time and resources needed to create useable scenarios such as manpower, data collection, and participation across disciplines. The benefits of doing a scenario planning analysis could, however, potentially save a company from losing resources and capital in the future. Climate change is a reality to Icelandic fisheries and they have been successful in reacting to the changes thus far, but a scenario analysis could provide a longer decision timeline for reactions to changes in the climate because they could project changes that might occur and be proactive in preparing for those futures. This preparation will be even more important due to the increasing rate of change because regardless of the fisheries' adaptations in the past, changes are happening faster than ever (IPCC AR 5). Fisheries management in Iceland has no such scenario process and could use this work and these primary scenarios to begin the process at a larger scale. Companies like Company A in this study could use the scenario analysis to learn about the implications of climate change on fisheries and gain an understanding of how scenario planning works to help management think through the complexities of climate change adaptation. Companies could look at the company profiles and decide where their company falls within the A to C spectrum and get an idea of how prepared they are for climate change. Using a scenario planning process could allow for the industry to be as prepared as they can be

for the uncertainties of climate change. This is especially important for Iceland since the country's economy is heavily dependent on its fishing industry, wherein ocean changes are inevitable and can be catastrophic.

This research is preliminary in nature. Further data and analysis about the industry such as performing more interviews would help gather a more robust and fully comprehensive dataset which could increase the broader implications this work could have. A limitation of the study was the analysis of the Icelandic fishing industry as a whole. This focus presents problems because the implications may be different for each type of fishery (i.e. mackerel vs. crab fisheries). Climate change impacts on crab could be different from those of mackerel because they have different sources of nutrients and food. Each of these fisheries would need to be analyzed using scenarios and data relevant to their target species and equipment.

To gain insight into the fishing industry and the competitors within, further research could be conducted to see if climate changes would shift the power of suppliers or competitive advantage between fisheries. This could include an industry analysis such as the Porter's Five Forces analysis and would require an even larger number of stakeholders. Porter's Five Forces is a framework developed by Michael Porter to analyze an industry's profitability by looking at five variables: power of suppliers, power of buyers, threat to new entry, threat of substitutes, and competitive rivalry.

References

Carlsen, H., Dreborg, K., Wikman-Svahn, P. (2013). Tailor-made scenario planning for local adaptation to climate change. Mitigation and Adaptation Strategies for Global Change, 18(8), 1239-1255. Retrieved from Springer Science & Business Media B. V., database.

Caves, J. K., Bodner, G. S., Simms, K., Fisher, L. A., Robertson, T. (2013). Integrating collaboration, adaptive management, and scenario-planning: Experiences at Las Cienegas National Conservation Area. Ecology and Society 18(3). Retrieved from http://www.ecologyandsociety.org/vol18/iss3/.

Central Intelligence Agency. (2016, February). The World Factbook: Europe: Iceland. Retrieved from the CIA World Factbook website: https://www.cia.gov/library/publications/the-world-factbook/geos/ic.html.

Chermack, T. J., Coons, L. M., Nimon, K., Bradley, P., Glick, M. G. (2015). The effects of scenario planning on participant perceptions of creative organizational climate. Journal of Leadership & Organizational Studies 22(3), 355-371. Retrieved from Business Source Premier, database.

Cheviin, L., Lande, R., Mace, G. M. (2010, April). Adaptation, plasticity, and extinction in a changing environment: towards a predictive theory. PLoS Biology, 8(4), 1-8. Retrieved from Academic Search Complete, database.

Cubasch, U., D. Wuebbles, D. Chen, M.C. Facchini, D. Frame, N. Mahowald, and J.-G. Winther, 2013: Introduction. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Einarsson, M. (1984). Climate of Iceland, in H. van Loon (editor): World Survey of Climatology: 15: Climates of the Oceans. Elsevier, Amsterdam, 1984, pp 673-697. http://en.vedur.is/media/loftslag/myndasafn/frodleikur/Einarsson.pdf

Environmental Protection Agency. (2016, February). Glossary of climate change terms. Retrieved from the United States Environmental Protection Agency website: http://www3.epa.gov/climatechange/glossary.html .

Guðmundsson, G. (2006, June). The cod and the cold war. Scandinavian Journal of History, 31(2), p. 97-118. Retrieved from Academic Search Complete, database.

Gunnarsdóttir, N. (n.d.). Waterfalls in Iceland. Guide to Iceland. Retrieved from the guide to Iceland website: https://guidetoiceland.is/nature-info/waterfalls-in-iceland

Hansen, H. S. (2013). Meeting the climate change challenges in river basin planning: A scenario and model-based approach. In the International Journal of Climate Change Strategies and Management, 5(1), 21-37. Retrieved from ProQuest, database.

Hoegh-Guldbert, O., R. Cai, E.S. Poloczanska, PG. Brewer, S. Sundby, K. Hilmi, V.J. Fabry, and S. Jung. (2014, September-November). The Ocean. In Climate change 2014: impacts, adaptation, and vulnerability. Part B: Regional aspects. Working group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R, C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L White 9eds.0]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1655-1731.

Iceland Responsible Fisheries. (n.d). The fisheries management system in Iceland. Retrieved from the Iceland responsible fisheries website: http://www.responsiblefisheries.is/seafood-industry/management-and-control-system/

Icelandic Met Office. (2012, May). Climatological Data. Retrieved from the Icelandic Met Office website: http://en.vedur.is/climatology/data/.

Ingólfsson, Ó. (2008, May). Icelandic glaciers. The University of Iceland. Retrieved from the professor of glacial and quaternary geology's website: https://notendur.hi.is/oi/index.htm.

IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B.

Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Johnson, J. E., Welch, D. J. (2010). Marine fisheries management in a changing climate: A review of vulnerability and future options. In Reviews in Fisheries Science, 18(1), 106-124.

Jones, M. C., Dye, S. R., Pinnegar, J. K., Warren, R., Cheung, W. W. L. (2015). Using scenarios to project the hanging profitability of fisheries under climate change. In Fish and Fisheries, 16, 603-622.

Kahn, H., Wiener, A. (1967). The year 2000: a framework for speculation on the next thirty-three years. New York, NY: The Macmillan Company.

Karvetski, C. W., Lambert, J. H., Keisler, J. M., Linkov, I. (2011, January). Integration of decision analysis and scenario planning for coastal engineering and climate change. IEEE Transactions on Systems, Man, and Cybernetics—Part A: Systems and Humans, 41(1), 63-73. Retrieved from IEEE Xplore Digital Library, database.

Kennedy, C., Lindsey, R. (2015, June). What's the difference between global warming and climate change? National Oceanic and Atmospheric Administration. Retrieved from the NOAA website: https://www.climate.gov/news-features/climate-qa/whats-difference-between-global-warming-and-climate-change.

Kirby, R. R., & Beaugrand, G. (2009, December). Trophic amplification of climate warming. Proceedings of the Royal Society B: Biological Sciences, 276(1676), 4095-4103. Retrieved from JSTOR, database.

Kloss, L. L. (1999, September). The suitability and application of scenario planning for national professional associations. Nonprofit Management and Leadership 10(1), 71-83. Retrieved from Business Source Premier (EBSCO), database.

Knutsson, O. & Gestsson, H. (2006, March). The Icelandic fishing industry: a comprehensive overview until the end of 2001. A faculty of business administration at the University of Akureyri working paper series. Retrieved from: http://skemman.is/stream/get/1946/1106/3309/1/fishindustry.pdf

Kroeker, K. J., Kordas, R. L., Crim, R., Hendriks, I. E., Ramajo, L., Singh, G. S., Duarte, C. M., Gattuso, J. (2013, June). Impacts of ocean acidification on marine organisms: quantifying sensitivities and interaction with warming. Global Change Biology, 19(6), 1884-1896. Retrieved from Academic Search Complete, database.

Kuhlbrodt, T., Griesel A., Montoya, M., Levermann, A., Hofmann, M., and Rahmstorf, S. (2007, April). On the driving processes of the Atlantic meridional overturning circulation. Reviews of Geophysics 45(2). Retrieved from AGU Publications. http://onlinelibrary.wiley.com/doi/10.1029/2004RG000166/epdf.

Lawler, J. J. (2009). Climate change adaptation strategies for resource management and conservation planning. In Annals of the New York Academy of Sciences, 11621(1), 79-98. Retrieved from Academic Search Complete, database.

Linnenluecke, M. (2015, July). Executives' engagement with climate science and perceived need for business adaptation to climate change. Climate Change, 131 (2), p. 321-333. Retrieved from Academic Search Complete.

Magnusson, A. (2006). Icelandic fisheries: Economic perspectives. University of Iceland. Retrieved from: http://www.hafro.is/~arnima/pdf/2006-itq-econ.pdf

Marini, C. and Frankignoul, Claude. (2014, August). An attempt to deconstruct the Atlantick Multidecadal Oscillation. Climate Dynamics, 43(3/4), 607-625. Retrieved from Academic Search Complete, database.

Óladóttir, O. (2015, April). Tourism in Iceland in figures. Icelandic Tourist Board. Retrieved from the Icelandic tourist board website: http://www.ferdamalastofa.is/static/files/ferdamalastofa/Frettamyndir/2015/mai/tourism-in-iceland-in-figures_15.pdf

Phadnis, S., Caplice, C., Sheffi, Y., Mahender, S. (2015, September). Effect of scenario planning on field experts' judgment of long-range investment decisions. Strategic Management Journal 36(9), 1401-1411. Retrieved from Business Source Premier (EBSCO), database.

Pörtner, H.-O., D. Karl, P.W. Boyd, W. Cheung, S.E. Lluch-Cota, Y. Nojiri, D.N. Schmidt, and P. Zavialov, 2014: Ocean systems. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O.

Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 411- 484.

Promote Iceland. (n.d). Geography. Retrieved from the Promote Iceland website: http://www.iceland.is/the-big-picture/nature-environment/geography

Rickards, L., Ison, R., Fünfgeld, H., Wiseman, J. (a). (2014). Opening and closing the future: climate change, adaptation, and scenario planning. Environment and Planning C: Government and Policy, 32 (4) pp. 587-602.

Rickards, L., Wiseman, J., Edwards, T. (b). (2014). The problem fit: scenario planning and climate change adaptation in the public sector. In Environment and Planning C: Government and Policy 32, 641-662.

Schoemaker, P. (1995). Scenario planning: a tool for strategic thinking. MITSloan Management Review. Retrieved from http://sloanreview.mit.edu/article/scenario-planning-a-tool-for-strategic-thinking/.

Statistics Iceland (2015). Purchasing power per capita. Retrieved from the Statistics Iceland website: http://statice.is/statistics/economy/national-accounts/sector-accounts/.

Statistics Iceland. (2014). Export of marine products. Retrieved from the Statistics Iceland website: http://statice.is/statistics/business-sectors/fisheries/export-of-marine-products/

Statistics Iceland. (2014). The fishing fleet by region 2014. Retrieved from the Statistics Iceland website: http://statice.is/statistics/business-sectors/fisheries/fishing-vessels/

Statistics Iceland. (2015). GDP Growth. Retrieved from the Statistics Iceland website: http://statice.is/statistics/economy/national-accounts/gross-domestic-product/.

Statistics Iceland. (2016, February). Profitability in fishing and fish processing 2014. Retrieved from the Statistics Iceland website: http://statice.is/publications/publication-detail?id=56035

Steffen, W. (2011). A truly complex and diabolical policy problem. In J. S. Dryzek, R. B. Norgaard, D. Schlosberg (Eds.), The oxford handbook of climate change and society (pp. 21-37). Oxford, NY: Oxford University Press Inc.

Takacs, H. (2013, May/June). Teaching about climate change in the business curriculum: an introductory module and resource list. Journal of Education for Business, 88(3), p. 176-183. Retrieved from Academic Search Complete, database.

U.S. Geological Survey. (2011, April). Mid-ocean ridges. The Encyclopedia of Earth. Retrieved from the encyclopedia of earth website: http://www.eoearth.org/view/article/164696/

United States Environmental Protection Agency. (2016, February). Causes of climate change. Retrieved from the EPA website: https://www3.epa.gov/climatechange/science/causes.html

Wack, P. (a). (1985, September/October). Scenarios: uncharted waters ahead. Harvard Business Review 63(5), 73-89. Retrieved from Business Source Premier, database.

Wack. P. (b.) (1985, November/December). Scenarios: shooting the rapids. Harvard Business Review 63(6), 139-150. Retrieved from Business Source premier, database.

Wunsch, C. (2002, November). What is the thermohaline circulation? Science 298(5596), 1179-1181. Retrieved from Academic Search Complete, database.