A Study in Maritime Piracy

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Abstract

This MQP evaluated four policies aiming to eliminate piracy off the Somali coast. The rise in piracy caused global concern; in 2009, more than 20 warships from several nations were deployed on anti-piracy missions. The Pirate Fisherman Model was built using system dynamics, and allowed for simulating, testing, and comparison of the four policies.

Table of Contents

Table of Figures

Table of Tables

Chapter 1: Introduction

Shipping by sea remains a vital method of transporting goods between nations. Piracy has become an increasing problem that has affected both commercial and private shipping, especially off the coast of Somalia. Somalia, a third world country on the horn of Africa, has a population of fishermen that convert to pirates in efforts to remove themselves from poverty. These pirates join together under a leader and make organized and planned attacks, seizing ships with valuable cargo (including oil and military tanks) and holding its crew hostage until their demand for ransom is met.

With number of pirate attacks increasing every year since 2006, along with increasing amounts of ransoms paid, this problem has drawn international attention. Naval forces from dozens of countries, including the US, have been tasked with patrolling international waters off of Somalia and providing safe passage for ships. This Major Qualifying Project hopes to simulate the best policies that the international community should enact to stop piracy and provide safety to shipping lanes.

Simulations are done through the use of the system dynamics software iThink. The main policies compared are: 1. Increase the amount of external law enforcement (such as US Navy ships) to capture and arrest pirates, 2. Create a Somali police force that can arrest pirates, 3. Adjust fisherman income, so fewer fishermen are tempted to become pirates to avoid poverty, 4. Demand that nations whose ships are being ransomed refuse to pay the pirates, reducing the pirate payoff. The president of Somalia, Sheikh Sharif Sheikh Ahmed, hopes to establish a Somali police force or army to deal with pirates; while this is a realistic goal, the country does not currently have enough funds to establish such a force. However, the simulation model was adapted to account for this possible force, and its effects.

The policies will be evaluated for benefits and effectiveness, and the end result will be recommendations for the international community, Somali government leaders, and even the foreign forces serving to stop pirates. The amount of time needed for the effects of the policies to appear, the cost of policy implementation, and the overall effectiveness of the policy will be taken into account to determine the best policy for recommendation.

Chapter 2: Background

2.1 History of Piracy

Pirates have become a symbol for menace and lawlessness. Historical records from over 2,000 years ago indicate that early civilizations, such as the Greeks and Romans, dealt with piracy. A story tells of Julius Caesar being ransomed by pirates, whom he returned to crucify; ancient Egyptian records tell of Cyprus being attacked by Lukkan pirates; Alexander the Great battled in vain against numerous pirates in the Mediterranean (Raffaele, 2007). Some civilizations, such as the Vikings, were based upon the attacking of other ships and raiding villages along coastline.

The Golden Age of Piracy was between 1620 and 1720, when piracy was often authorized by governments. Referred to as "privateering," ships were encouraged to attack and plunder ships from other nations, then share profits with their government (Royal Naval Museum Library, 2002).

Life on a merchant ship in the Golden Age of Piracy was considered extremely harsh. Sailors were often underpaid on commercial ships. Pirate crews would receive portions of plunder, and were not held to obey national laws. Pirate captains, after capturing a ship, would ask for volunteers to join his or her crew. The desire for more pay (or plunder) was motivation for honest sailors to turn to a life of piracy (Royal Naval Museum Library, 2002).

2.1.1 Additional terms

There are several terms that are variations of "pirate." Privateers, as previously mentioned, were authorized by a government to plunder enemy ships. Buccaneers were pirates (and privateers) that operated primarily in the West Indies and Caribbean. Corsairs, known to sail the Mediterranean, took on a religious connotation, typically Christian or Muslim. A recognized Muslim sect known as the Barbary Corsairs kept in the region of Northern Africa. The Barbary Corsairs remained an active threat until the early 1800s, preying on ships of the slave trade. In opposition of the Barbary Corsairs were the Maltese Corsairs, instructed by the Christian Knights of St John to target Turkish (Muslim) vessels (Royal Naval Museum Library, 2002).

Pirate ships varied based on location. Schooners, which extended very little below the water, were able to maneuver close to the coast. These were commonly used by pirates along North America. Galleys, which are long, narrow, and powered by slaves forced to row, were used by the Barbary Corsairs. Pirates in Chinese territory used a type of ship called a junk, which were flat-bottomed boats held together by bamboo, often having three masts (Royal Naval Museum Library, 2002). Pirates today have adapted modern boats, usually speedboats, by outfitting them with automatic weapons.

2.1.2 Famous pirates

Sir Francis Drake was a privateer for England, famous for his successful attacks on Spanish galleons for the Queen Elizabeth I. He eventually became mayor of Plymouth and earned a seat in the English Parliament. Held as a hero by the English and as a villainous pirate by the Spanish, Drake nevertheless is recognized for his cunning as a naval commander (Britannia.com, 1999)

Blackbeard, or Edward Teach, is possibly the most recognized pirate. Another privateer, Blackbeard was authorized by the English Queen Anne to attack French and Spanish vessels during the War of Spanish Succession. Named for his wild beard and hair, which he supposedly braided, Blackbeard used fear and intimidation to control his crew of approximately 250 pirates. His lack of discretion when capturing ships and taking hostages is also famous; one story tells of hostages, including women and children, being ransomed for medical supplies (Kirkpatrick, 2008).

He eventually settled in North Carolina, where he was forced to battle against Royal Navy sloops. Killed by Lieutenant Robert Maynard, Blackbeard's death was a symbol of the end of the Golden Age of Piracy (Royal Naval Museum Library, 2002).

Ching Shih was a female Chinese pirate. She was not exceptional merely because of her gender – she supposedly commanded a fleet consisting of 80,000 pirates and 2,000 vessels. Known for her strict code of conduct, she would harshly punish anyone who disobeyed her. One crime, for which death was the penalty, was raping a female captive. Her fleet would target not only merchant ships, but also villages along the coast. She eventually was granted a pardon by the Chinese government, opened a brothel and gambling house, and died at the age of 60 (Vallar, 2008).

2.2 Modern Piracy

Modern-day pirates threaten lives, commerce, and the environment as they target ships and crew transiting through international waters. The rising piracy in the Gulf of Aden not only poses a threat to global commerce, but also threatens aid delivery by the United Nations World Food Programme to Somalis. Approximately 2.4 million Somalis depend on the shipments.

After 2005, instances of piracy have risen. Figure 1 illustrates the locations where pirate attacks occurred off the coast of Somalia, which has the highest number of attacks (CNN.com, 2008).

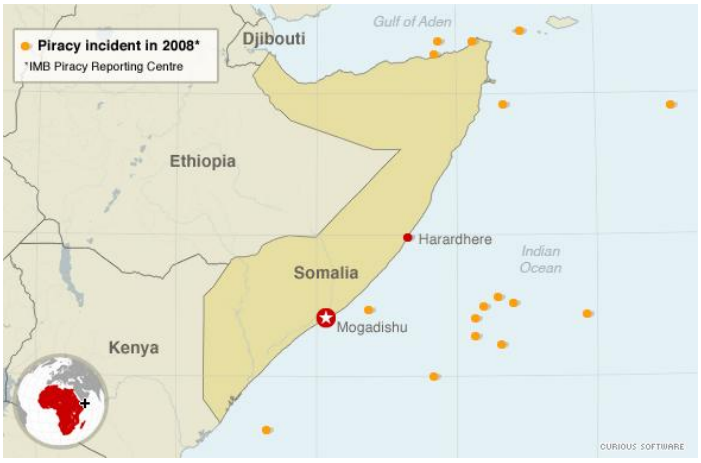

Figure 1: Map of piracy cases off the coast of Somalia

There is much speculation as to the causes for workers, often fishermen, to revert to piracy as a way of living. One theory is that fishermen resorted to piracy after foreign fishing companies illegally depleted their territorial waters of fish. Regardless, the recent cases of piracy have

been alarmingly effective. For example, American and Russian naval forces were the first stationed off the Somali coast to monitor the cargo ship carrying Ukrainian tanks that was seized by Somali pirates. The Somali pirates demanded $20 million; two other cargo ships were also ransomed by the same pirates (NPR.org, 2008).

The 22-ship Yemen Navy asked for aid from the US Navy in addressing the daily distress calls from pirate attacks. Another account that occurred on August 21, 2008 was the capture of a German ship and crew; the pirates received $1 million in ransom (NPR.org, 2008). A spokesman for the US Navy says that more than just the US and coalition forces are needed to combat the rise in piracy (NPR.org, 2008).

The International Maritime Bureau reported a 10% increase in cases of piracy from 2006 to 2007; Figure 2 charts the rise in Somali piracy over the past decade (International Maritime Bureau, 2009) while Figure 3 illustrates the number of attacks in the Northwestern Africa area (BBCnews.com, 2008)

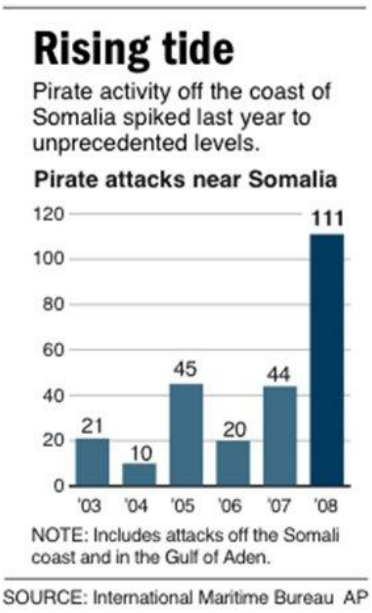

Figure 2: Pirate attacks since '03

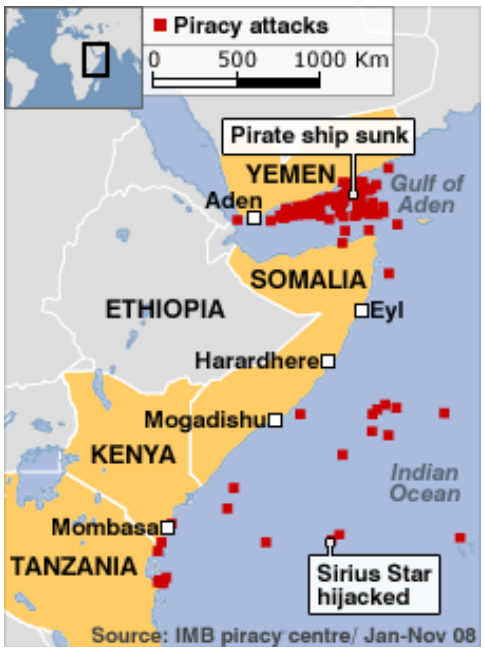

Figure 3: Map of Somali Pirate Attacks

The Malacca Straits are noted as a high-risk area; this is of concern to the international market. Japan especially is concerned because most of its oil supply is imported through the Malacca

Straits, making it a significant threat to the Japanese economy. Malaysia is attempting to use intelligence on pirate activity to efficiently catch pirates (Brant, 2008).

The international threat of piracy has been addressed by international forces – the EU sent a flotilla to aid in the fight. The address of the piracy threat by these forces has been given the name Operation Atalanta (Reynolds, 2008). The flotilla consisted of six warships and a few aircraft specializing in reconnaissance. These forces replaced the NATO ships that were largely unsuccessful in stopping the increase in piracy attacks. The NATO forces were officially relieved on December 15, 2008. One major problem that the EU hoped to address is whether the EU flotilla will be allowed to take action and board pirate ships – warships from other countries (including the United States, India, Russia, and Malaysia) that patrol the waters board and search the suspected pirate vessels captured in international waters (International Herald Tribune, 2008).

In 2008 alone, pirates collected about $150 million in ransom (Hunter, 2008). With little more than a small boat, ladders or grappling hooks, and automatic weapons, fishermen-turned-pirates are able to board vessels and hold crews and cargo hostage. Interestingly, negotiations typically take place over satellite phone with the aid of a middle man, usually a trusted relative of one or more of the pirates. Once the ransom is settled, the pirates arrange to have cash brought to a separate vessel. After counting the money and even determining its authenticity, the pirates leave the captured vessel to be reclaimed by tugboats or the local navy. The pirates then evenly distribute the ransom (Hunter, 2008).

Merchant ships learned to defend themselves using nonlethal force. Evasive maneuvers and the employment of a high-powered spray hose discourage pirates from boarding the ship. However, as international law enforcement increases in attempt to arrest pirates, the threat against ships seems greater than before. In March of 2009, two vessels were seized in less than 24 hours, reportedly with a larger-than-average pirate crew of 16 to 18 men. In fact, March of 2009 pirates attempted attacks nearly on a daily basis. Maritime Intelligence speculates that because much of the international warships are concentrated in the Gulf of Aden, those commercial ships traveling along the Indian Ocean part of the Somali coastline have been more frequently (and successfully) targeted (Lekic, 2009).

2.2.1 Punishment for pirates

Pirates are arrested when they are caught in international waters. At the end of 2008, the US Navy arrested several pirates, killing two in the process. Those that were arrested stood trial in Kenya. Pirates captured by international forces are sent to stand trial in Kenya due to a dangerous Somali judicial system that could dole out harsh sentences; many pirates are minors (BBCnews.com, 2008). Further political developments allowed for the international law enforcement to stop, search, and seize any small vessels suspected of piracy, regardless of whether or not they are in Somalia's territorial waters.

The only land-based law enforcement present in Somalia, where piracy is thriving most, is Somali forces. This "army" is comprised of young soldiers that are often under the command of someone linked to piracy. Unfortunately, land-based UN peacekeeping forces were as ineffective as those at sea, partially due to the government that did not seem to have any incentive to stop piracy because it is a lucrative business – the former president of Somalia, Abdullahi Yusuf Ahmed, never gave any indication that he would cooperate with the anti-piracy coalition (Reynolds, 2008).

There is new hope that the piracy that has consumed Somalia will be coming to an end. President Sheikh Sharif Sheikh Ahmed, who was president before US-backed troops from Ethiopia forced him out of office, was re-elected in early 2009. With no justice system, Somalia will need the aid of international forces to establish law; President Ahmed has shown willingness to work with the Obama Administration and the US government in effort to stop piracy. A key aspect of the change in government that may provide results is that President Ahmed has stated he will not accept bribes from pirates, as the former president did. Ahmed hopes to eventually establish a justice system that will be upheld by a national police force (Setrakian & Hughes, 2009). Until a justice system and police force are established, Somalia will continue to rely on allies for the capture, detainment, prosecution, and punishment of pirates.

2.3 Somalia: the source of the greatest modern piracy threats

2.3.1 General Information

Somalia is located on the Horn of Africa; it has extensive coastline (about 1,880 miles) along a highly utilized shipping route. The Gulf of Aden is along the northern coastline and the

Indian Ocean is along its eastern coast. With extensive coastline, Somalia is able to have many port cities. Its capital city Mogadishu is on the coast of the Indian Ocean. Figure 4 is a map of Somalia (mdgmonitor.org, 2009).

Figure 4: Map of Somalia

Roughly the size of the state of Texas, Somalia has a desert climate that has monsoons in the southern regions. Due to the rainfall in the south, as well as the two rivers Shabelle and Juba, farmers are able to grow crops most of the year. However, droughts, dust storms, and flooding are common natural hazards. Desertification is also a problem, as is the lack of fresh water. Farmers often allow livestock to overgraze, leading to soil erosion. Less than 2% of Somalia is used for agriculture (CIA WorldFactBook, 2009).

Although the majority of Somalis are farmers, the country suffers from famine. The estimated population is 8.7 million (mdgmonitor.org, 2009); its largest city Mogadishu has an estimated population of 2 million. An estimated 1.4 million Somalis are threatened by drought and hunger (Bryden, 2006). The UN has been working to alleviate the famine; the UN's Millennium Campaign, which seeks to halve global poverty by 2015, is being applied in Somalia. This campaign outlines 8 goals (UN.org, 2009):

1. End poverty and hunger
2. Establish universal education
3. Promote gender equality

4. Promote child health
5. Promote maternal health
6. Combat the spread of HIV/AIDS
7. Promote environmental sustainability
8. Create a global partnership

These goals have been given equal priority for implementation in Somalia. Less than 9% of the population receives primary education. The average lifespan of a Somali is only 45.9 years; the median age of the population is about 18 years old. Somali women experience some of the highest rates of maternal mortality in the world; the infant mortality rate is also high compared to first-world nations (UN.org, 2009).

The spread of HIV/AIDS, which is a major problem for many other African nations, is not as prominent in Somalia. The major health problems concern fresh water, and the lack of its availability. Somalis are at high risk of contracting water borne diseases, including hepatitis A and E and schistosomiasis. Only 29% of the total population has access to improved drinking water (UN.org, 2009).

January 31st 2009, Sheikh Sharif Sheikh Ahmed was elected President of Somalia by Somali Parliament. The President preceding him was suspected of being corrupt, and was profoundly against Western aid and influence. President Ahmed is the opposite; upon being declared the new leader of Somalia, he vowed to bring peace. After an Osama bin Laden tape, released in March of 2009, encouraged citizens to overthrow the new pro-Western government, Ahmed denounced the al-Qaida terrorist organization (Nor, 2009).

Somalia has no official military. Were it to raise an army, over one million of its male citizens would be within the general age range for military service. The President of Somalia has declared that he wishes to start a police force to focus on arresting anyone linked to piracy, as well as establishing a legal system. Islamic law has been implemented in many regions to provide conflict resolution. Currently, the largest barrier to creating a police force and justice system is that the government has no funds with which to establish them. As discussed in the next section, the economic status of Somalia makes it one of the poorest nations in the world.

2.3.2 Economy

Somalia's economy is mostly dependent on agriculture and livestock. Nomads raise livestock, which accounts for about 40% of Gross Domestic Product. The chief exports are livestock, hides, fish, charcoal, and bananas; the main imports are sugar, sorghum, corn, qat, and machined goods. Somalia used to have an industrial sector, but factories were looted for metal parts. Surprisingly, telecommunications are successful, especially in Mogadishu. Somalia has the lowest rates for international calls on the African continent.

Africa is now seeking a "stimulus package" from the G-20 nations (Group of Twenty Finance Ministers and Central Bank Governors). Somalia's estimated Official Development Assistance (ODA), or the value of how much foreign aid the nation receives, was $392 billion for 2006 (unicef.org, 2009).

While the average male in Somalia has work, the females typically raise children (the average number of children per woman is 6). With the average yearly earnings per person below $600 per year, many Somalis live in poverty. Many have turned to a life of crime, as brought to light by international media when Somali fishermen choose to become pirates, taking ships hostage for ransom. When confronted about their choice to become a pirate, many cite poverty as a motivation.

Somalia is an impoverished nation that suffers not only from famine and natural disasters, but also from poor, corrupt leadership. The history of the country is filled with oppression, violence, and poverty. With the aid of Western nations and the support of a new government, Somalia can rise out of its current state and become a self-sufficient nation. Piracy is a key barrier to Somalia becoming peaceful; it also impedes trade between nations.

2.4 US Navy policy toward piracy

One of the main missions of the Navy is to protect sea commerce; for this reason, fighting piracy has become a priority. Several naval warships are tasked to patrol the international waters off of Somalia, at least 12 nautical miles away from the coast. The actual numbers of ships deployed in the region changes frequently, but are assigned from the Fifth Fleet. Fleets in the US Navy operate in designated areas – Fifth Fleet is assigned the Horn of Africa, as well as the Straits of Hormuz, Persian Sea, and Red Sea. The US Navy is working with

ships from 20 other nations, and has assigned the Cruiser USS VELLA GULF to act as flagship, coordinating patrols. The Combined Maritime Force, or CMF, works to promote maritime security not only for commercial vessels transiting the area, but also for local Somali fishermen. Using "approach and assist" tactics, the international forces have been promoting friendly relations with locals (Schaeffer, 2009).

The Chief of Naval Operations, Admiral Gary Roughead, stated on February 12, 2008:

> The presence of our forces and coalition forces in the Gulf are enabling and allowing the flow of that very important commerce that takes place -- the energy resources coming out, the goods that are going in. And it's that naval force, the coalition naval force, that's there that is guaranteeing that free flow and the safety and security of those very precious commodities. That's what navies do. And the fact that we're operating in concert with our friends in the region and other nations who contribute to that coalition speaks to the essence of our maritime strategy, which is one of cooperation and collaboration.

The US Navy has been tasked with detaining captured pirates until they can be received by Kenya for prosecution. This will be in effect until the Somali government has established a justice system. As of February 12, 2009, the US Navy has 16 suspected pirates in custody. Naval vessels are allowed to search and board suspected pirate boats if they are in international waters – once the pirates enter Somali territorial waters, the Navy would need permission for pursuit. The Obama Administration declared that pirates need to experience law enforcement, and want to ensure that pirates are not simply detained and released (Lowe, 2009). Kenya has provided detainment facilities and temporarily allows Somali pirates to pass through their judicial system.

Chapter 3: Methodology

3.1 Introduction to System Dynamics

System Dynamics was created by Jay Forrester in the 1950s while teaching at MIT (Sterman, 2000). The purpose of System Dynamics is to visually map a specific problem in a system. Systems can be anything from a small business to the global economy, or the Amazon rainforest in Brazil. An important lesson to remember about system dynamics is that *problems* must be modeled, not simply a system. For example, deforestation in the rainforest would be a problem within the system of Brazil's economy, or within the logging market.

The models are made up of three key components: stocks, flows, and variables. A common analogy is a bathtub filling and draining water: the bathtub is a stock; the faucet is a flow (in). A drain would be another flow (out). Variables affect the flows – an example would be a growing clog in the drain, which would act as a delay on the outflow of water from the bathtub. Figure 5 (Sterman, 2000) is an illustration of the bathtub analogy.

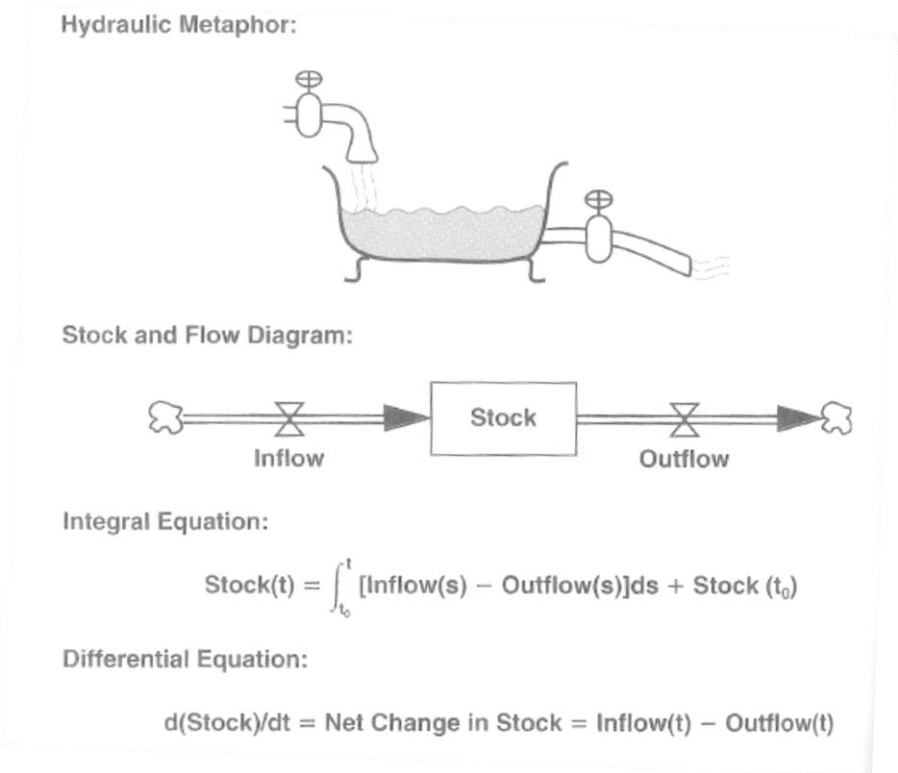

Figure 5: Bathtub Analogy

A group of stocks, flows, and variables can form feedback loops. Loops are a fundamental part of system dynamics. Loops are typically assigned a positive or negative polarity to indicate growth pattern. Positive feedback loops generate growth; negative feedback loops generate balance and equilibrium (Sterman, 2000). Models are built with a goal in mind, and typically this goal will be addressed by altering or adding various policies. For example, a model of the Amazon rainforest deforestation problem could illustrate policy makers' goal of slowing the rate of tree loss through a tough government policy restricting loggers.

The polarity of feedback loops determines the pattern or mode of the loop behavior. There are three basic modes: exponential growth (positive loop), goal seeking (negative loop), and oscillating (negative loop with delays) (Sterman, 2000). Delays are made with variables that affect flows.

It is also important to recognize the limitations of system dynamic modeling. Constructed based on reality, there is always a limit on accuracy. Models can only be detailed to a certain extent; too much detail may detract from the overall problem. It is vital to remain focused on a problem when building a system dynamics model.

Chapter 4: A Model of Piracy

4.1 Beginning with the Farmer-Bandit Model

Models can be very simple, with one stock, or complex and extensive, containing dozens of stocks and variables. Models are an illustration of problems, made for the purpose of finding the best solution. The model constructed for this MQP used another model, the Farmer-Bandit Model, as a basis for design.

Suppose there are a number of farmers that are just beginning to experience some difficulty in profiting off their work. A few of these farmers choose to turn to a life of crime, becoming bandits, who rob the farmers. This increases the difficulty for the farmers – causing more farmers to choose to become bandits. In the meantime, as the number of bandits grows, the government takes action by using soldiers to suppress the bandits. The supply of soldiers comes from the stock of farmers. As the number of farmers decreases (which it does more rapidly as the number taken to become soldiers rises) the difficulty of farming rises as well. However, the amount of soldiers begins to have an effect on the crime and the number of bandits decreases. The bandits revert back to farmers, resulting in a lessening need for soldiers. Soldiers become farmers again, and the model returns to its original state. Figure 6 is a causal loop diagram illustrating the relationships between key variables in the Farmer-Bandit model.

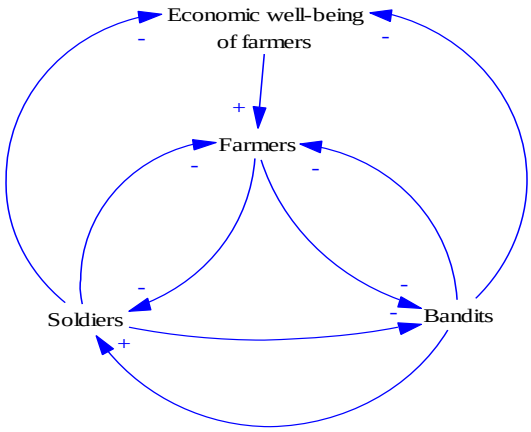

Figure 6: Causal Loop Diagram for Farmer-Bandit model

To adapt this model to fit the current global problem presented by piracy, several aspects will need to be altered. First, it is important to note that pirates do not loot fisherman, as bandits do farmers in the original model. Piracy earns profits in the millions of dollars by ransoming ships and hostages. Another key difference is that the External Law Enforcement variable increases, but does not directly affect the number of fishermen; there is a separate stock of Police that draws from the Fisherman stock.

The relationship between the key variables included in the system dynamics model is displayed in the causal loop diagram, Figure 7, below.

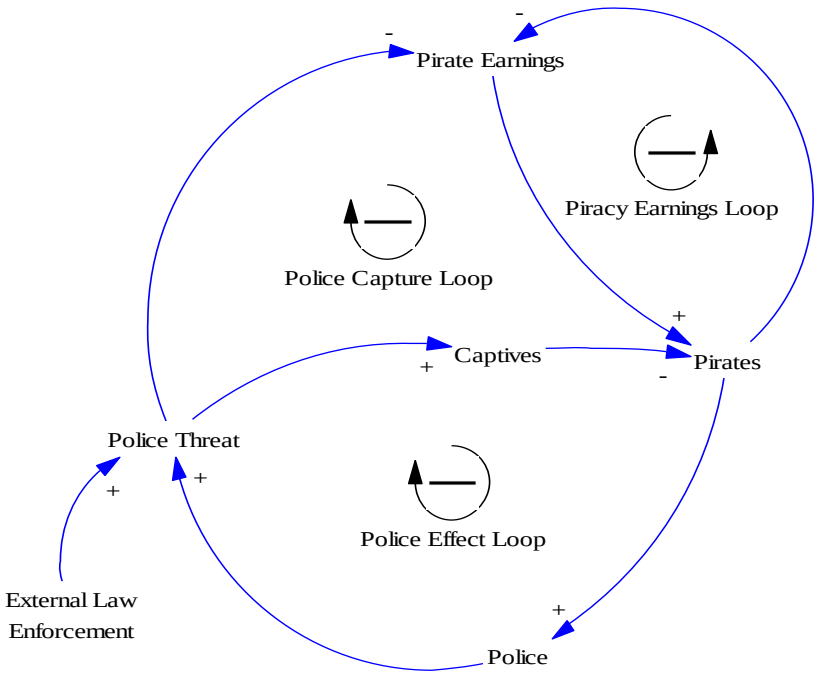

Figure 7: CLD of Pirate Fisherman Model

There are three negative loops: Piracy Earnings, Police Capture, and Police Effect. The Piracy Earnings loop shows the relationship between pirate earnings, pirates, police, and police threat. As pirate earnings increases, it increases the number of pirates; the number of police responds to this increase by also increasing (and is supported by external enforcement), which raises the police threat. The police threat decreases pirate earnings, effectively showing how the

establishment of a police force will decrease pirates through decreasing the potential earnings. The Police Capture loop illustrates how the police force will reduce pirates by increasing the number of captive pirates (captives). As the number of police increases, the number of captives will increase, decreasing the number of pirates. The third loop, Police Effect, shows the simple effect police have on pirate earnings: as the number of pirates increases, the amount of pirate earnings (per pirate) decreases.

4.2 The Pirate Fisherman Model

The problem that the Pirate Fisherman Model addresses is determining what policy may best work to end piracy off of the country of Somalia. The model is divided into sectors, and incorporates the relationships between pirates, fishermen, (internal) police, and external law enforcement.

Figure 8 shows the entire model, which is divided into sectors: Police, Police Supply, Police Demand, Fisherman, Pirate, Pirate Attractiveness, Captivity, and Initial Sectors.

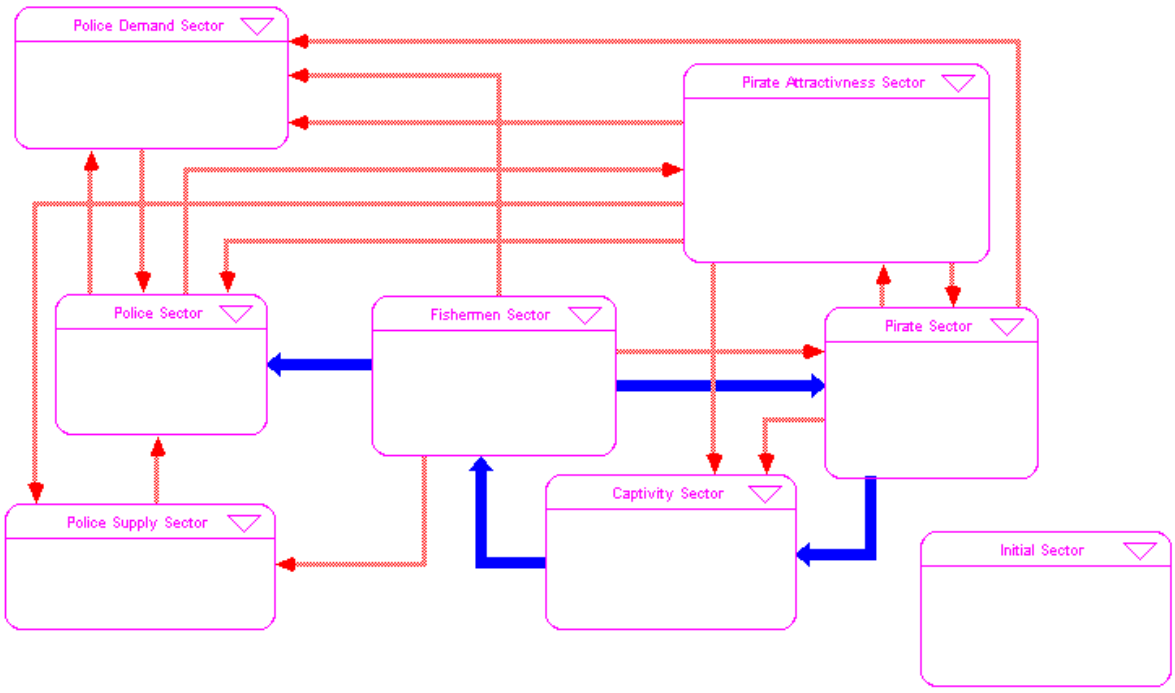

Figure 8: The Pirate Fisherman Model

The next sections will explain the details of each sector.

4.2.1 Police Sector

The Police Sector shows the process of fishermen becoming police. There is a brief Police Adjustment Delay, to imitate the need for training time before police are deployed. Desired Additional Domestic police increases the rate. External Enforcement, a switch that is activated to simulate the presence of international forces, will decrease the Desired Additional Domestic Police. Figure 9 is an image of the Police Sector.

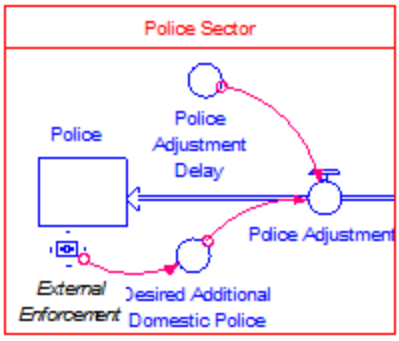

Figure 9: Police Sector

4.2.2 Police Supply Sector

The Police Supply sector includes the variables that affect the flow between the fishermen and police stocks. The Average Earnings per Fisherman and Average Police Earnings affect how attractive it is to become a policeman. The Ratio of Fishermen Seeking Police Employment is the number of fishermen that want to become police (based on desired additional police) and is a graph of predicted behavior. Figure 10 is an image of the Police Supply Sector.

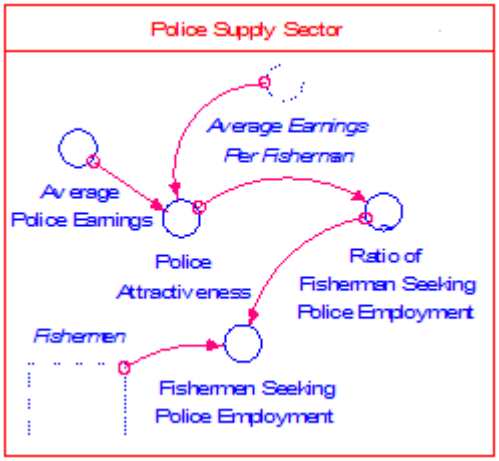

Figure 10: Police Supply Sector

4.2.3 Police Demand Sector

The Police Demand Sector contains several important variables. The Marginal Efficiency of Police represents how successful (or unsuccessful) police are in capturing and arresting pirates. Desired Additional Police is the number of police needed to fight a rise in piracy represented by Excess Pirates. Lawlessness is the attitude of the Total Population – whether or not Somalis accept pirates or would rather not have any pirates. If Lawlessness is high but Acceptable Lawlessness (a switch) is off, then desired additional police will contribute to a larger police force. Figure 11 is an image of the Police Demand Sector.

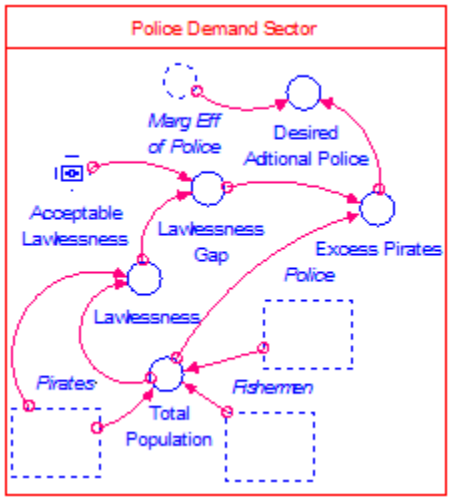

Figure 11: Police Demand Sector

4.2.4 Fisherman Sector

Fishermen is the stock that Pirates and Police draws from. Because there are biflows, or a two-way flow, between these stocks, it is possible for pirates and police to return to being fishermen. Figure 12 is an image of the Fisherman Sector.

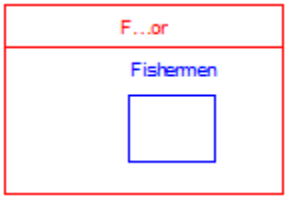

Figure 12: Fisherman Sector

4.2.5 Pirate Sector

The Pirate Sector shows the basic flow to and from Pirates, with an adjustment time that acts as a delay. This delay is to represent the time needed for fishermen to convert to pirates, or vice versa. Figure 13 is an image of the Pirate Sector.

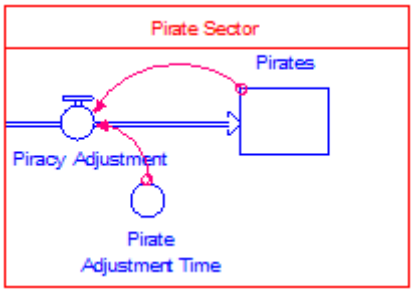

Figure 13: Pirate Sector

4.2.6 Pirate Attractiveness Sector

The Pirate Attractiveness Sector shows the variables that impact the flow between fishermen and pirates. When Pirate Attractiveness is high, fishermen will become pirates faster. The Marginal Effectiveness of Police, both domestic and external, increase Police Threat as they increase. Pirate Chance of Failure affects Pirate Chance of Success, which in turn affects Expected Pirate Payoff. Potential Pirate Earnings will decrease as the number of pirates rises, because the share each pirate will receive will be smaller. Expected Pirate Payoff and Potential Earnings per Pirate are important variables, because they increase or decrease Pirate Attractiveness. Figure 14 is an image of the Pirate Attractiveness Sector.

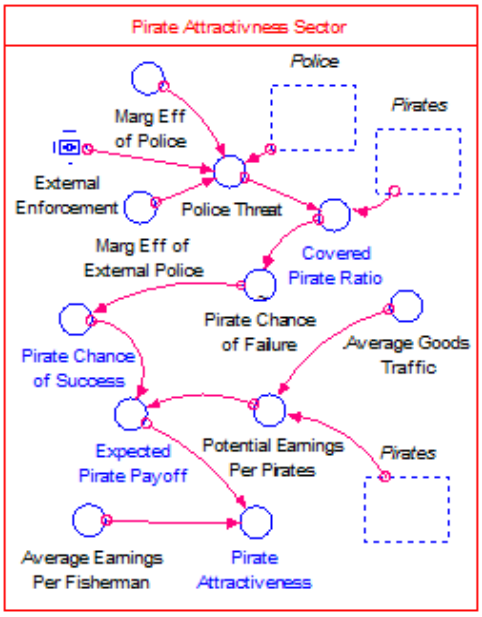

Figure 14: Pirate Attractiveness Sector

4.2.7 Captivity Sector

The Captivity Sector depicts the process captured pirates undergo. Captured pirates can be rehabilitated and return to being fishermen, or they are released and return to being pirates. For each of these rates at which people leave the Captured Pirates stock, there are delays that represent a rehabilitation process or jail time. Figure 15 is an image of the Captivity Sector.

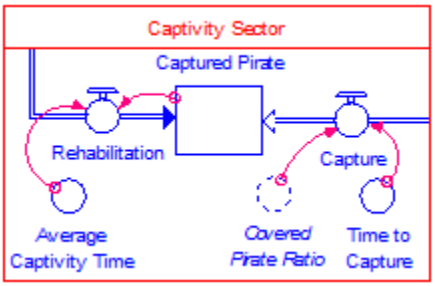

Figure 15: Captivity Sector

4.2.8 Initial Sector

The initial values represent the starting values for each of the stocks. These values were estimations of the current situation and population in Somalia – some fishermen and pirates, but no police. Figure 16 is an image of the Initial Sector.

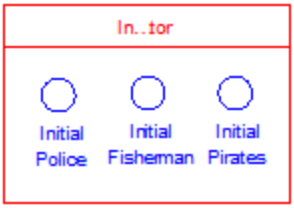

Figure 16: Initial Sector

The second part of this chapter is organized according to the standard method modeling process to describe and explain the model built to solve to Somali piracy problem. The standard method is a modeling development procedure that, like the scientific method for scientists, aids in successful modeling (Sterman, 2000). It clearly outlines the steps required to develop the model, as well as the policies that the model will test. When one step of the process is not met, the modeler must remain at that stage and address the problems. This way, after the process is complete evaluating the effects of the policies, a sound recommendation can be made.

4.3 Problem Articulation

The first step of the modeling process, the problem articulation poses a question that can be resolved by policy. It is vital that models are built with a problem in mind, rather than imitating a system. Also important (especially for the scope of this project) is that the problem the model is a simplification of the problem the model hopes to address. This section discusses the thorough development of the ideas the model is built to encompass.

4.3.1 Theme selection

The theme of the model will be to evaluate various policies that will reduce or end the amount of pirate attacks. Piracy has proven to be a problem worthy of international interference, costing organizations millions of dollars. Finding a solution to this problem, whether it is the least expensive or fastest to produce results, would be in the interest of dozens of nations whose commercial shipping has been impeded, and whose naval forces are deployed in effort to stop piracy. In general, it is also a humanitarian mission to end the poverty in Somalia, which drives so many Somalis to convert to pirates.

4.3.2 Key variables

There are several variables in the Pirate Fisherman Model that largely affect the others. These are Pirates, Pirate Attractiveness, Police, and Desired Police. The Pirates stock is important because it symbolizes the core problem the model is attempting to solve. Pirate attractiveness is key because it has a huge impact on the number of pirates. Finally, the number of police and the desired police impact are key because they counter the amount of pirates and pirate attractiveness. The absence of any of these variables would make the model useless; policy testing would also be impossible.

4.3.3 Time horizon

The time horizon is the length of time over which the simulation will run to test the policy. The time horizon for the Pirate Fisherman Model is five years. This should give ample time for the policies and delayed effects to impact the results. Also, it is realistic for a third world country to need at least that amount of time for a police force to be created; this may require less time with external aid.

4.3.4 Reference Modes

The reference modes are predictions of the behaviors for the key variables. These will be referred to during simulations, to compare the expected behavior to the behavior that policy change affects. Figure 17 shows the expected relationship between the desired police and pirate attractiveness. As the number of police rises, pirate attractiveness decreases; as the number of pirates rises, the desired police rise also.

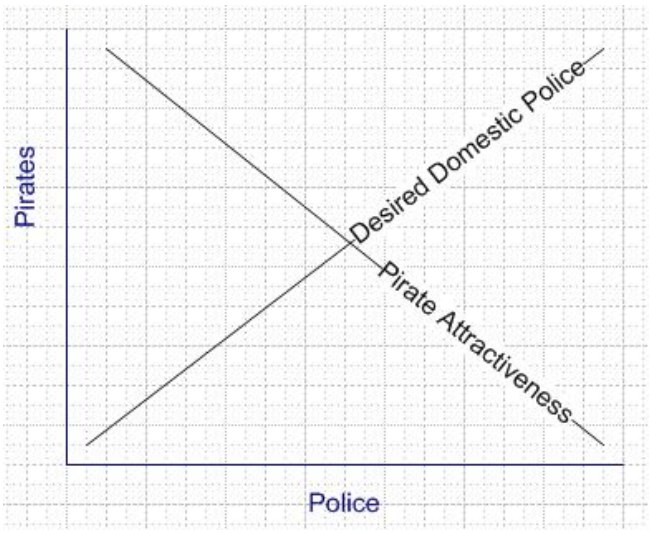

Figure 17: Reference mode for Police and Pirates

Figure 18 shows the expeceted behavior of the Police stock over time. Due to the number of pirates, police are recruited. After a delay, the number of police goes up and continues to rise until the number of pirates decreases.

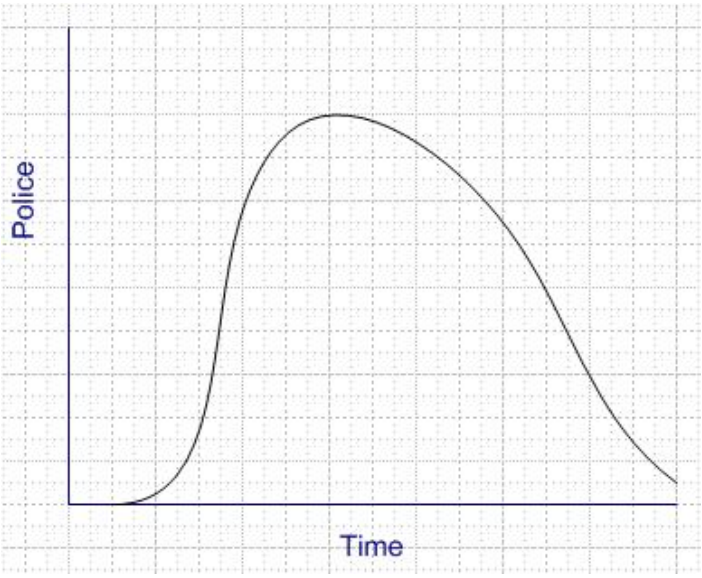

Figure 18: Reference mode for Police

Figure 19 is the reference mode for Pirates. As recent events have shown, the number of pirates increases, but decreases to a reasonable level over time. This is due to External law enforcement, domestic police, or both.

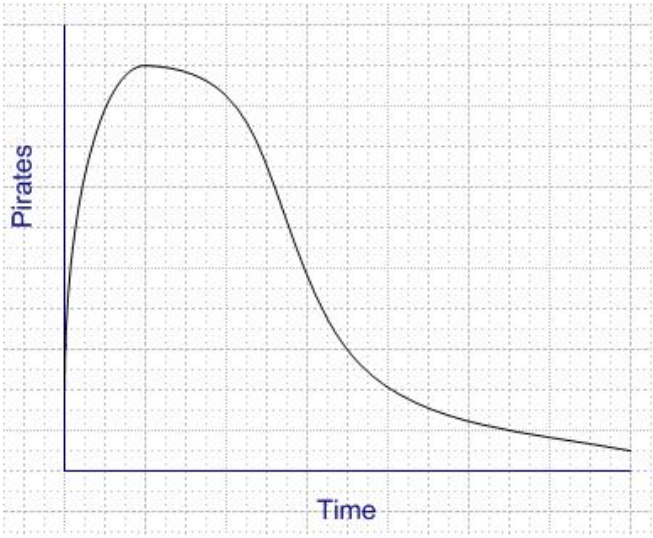

Figure 19: Reference mode for Pirates

While the previous reference modes have been for predicted variable behavior, the following reference modes (shown in Figure 20) for pirates and police show the desired and feared effects.

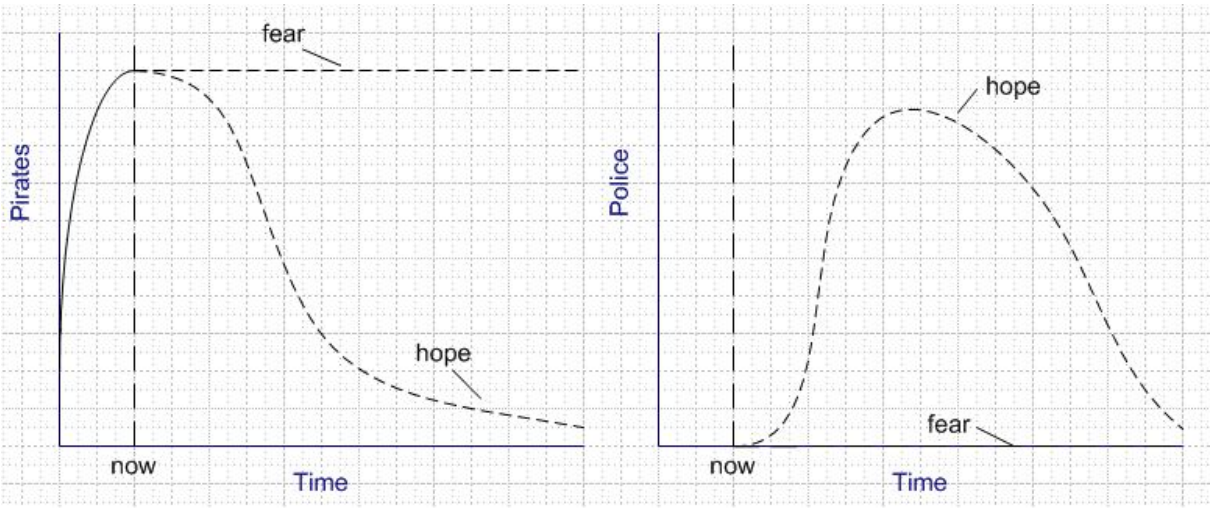

Figure 20: Desired and Feared reference modes for Police and Pirates

With time, the hope is that the amount of pirates will decrease; the fear is that they will continue operating at their peak level. The hope for police is that Somalia will eventually employ some; the fear is that a police force will never develop.

4.4 Formulation of Dynamic Hypothesis

The Dynamic Hypothesis is defined as "a working theory of how the problem arose" (Sterman, 2000). The dynamic hypothesis simplifies the complex relationship between the economic variables that cause the problem that the Pirate Fisherman model illustrates. It is also a simplification of the global political agenda.

The economic condition of the population is attributed with the reason fishermen desire to become pirates. This hypothesis is represented in the model by the variables for pirate payoff (or income): expected pirate payoff and potential earnings per pirate. As discussed in section 2.3.2, Somalia's economy is in poor condition, with much of the nation's population living below the poverty line.

4.4.1 Initial hypothesis generation – an Endogenous focus

The crises that Somalia is experiencing (droughts alternating with floods, famine, extreme poverty, disease) are an obvious source for the motivation for a fisherman to become a pirate. Research into Somali history shows that the nation has suffered through many wars, often producing tens of thousands of refugees. One journalist who covered Somalia for 17 years, wrote (Hartley, 2008):

> The pirate gangs, it turns out, are organized by ex-fishermen who got very annoyed by the way international boats poached Somalia's rich tuna-fishing grounds and dumped toxic waste along its ungoverned shores. In the early days they demanded poachers pay fines, but later they realized there was more money to be made from straightforward abductions. Today the gangs recruit ordinary youths. Most rank-and-file pirates cannot even swim. Their only required skill is to shoot straight. These youths usually participate only in a couple of operations, hoping to make enough money to get asylum in the West.

Along with the threat of poverty, poor government and the lack of a police force contributed to the lawlessness that allowed pirates to thrive. These explanations for what caused the piracy problem to develop are all internal factors – contributors that arose within Somalia, not from

outside factors. Internal causes are called endogenous. The hypotheses for the Pirate Fisherman Model involve mostly endogenous causes; the policies to be tested reflect this.

4.4.2 Mapping

A model boundary chart summarizes and categorizes the key variables of the model, and provides an easy way to determine the scope of the model. Table 1 lists key variables under three categories. Endogenous indicates that the variable is controllable to an extent; exogenous variables are those outside the control of the model. Excluded variables are important aspects that are not included in the scope of the model.

Table 1: Pirate Fisherman Model Boundary Chart

Endogenous	**Exogenous**	**Excluded**
Fishermen	External Law Enforcement	Government budget
Pirates	Fisherman Earnings	
Police	Average Goods Traffic	
Expected Pirate Payoff	Marginal Police Effectiveness	
Captured Pirates		

4.5 Formulation of a Simulation Model

The Pirate Fisherman Model was formulated to answer the question of which policy would best address the current piracy problem off the coast of Somalia.

4.5.1 Specification

The structure of the model was intended to be as simple as possible, while including the key variables that affect maritime piracy. Dividing the model into sectors helped unnecessary variables to be identified and removed. As the model grew in size and complexity, it was important to remain focused on the scope of the project.

4.5.2 Estimations

Little data about Somalia is reliable, if in existence at all. Some variables required estimations, including Average Fisherman Earnings. This value, $650 was chosen because it is

the average annual earning of a Somali worker (in dollars). The initial value for pirates was also estimated, because there was no data available. There was very little data about how effective pirates are on average, other than reports confirming that another ship had been captured. For this reason, many of the variables were designed as ratios.

4.5.3 Focus and Boundary

The focus of the model proved to act as guidance. The overall behavior of the model was designed to imitate what has occurred in Somalia, and what can realistically be expected. For example, if the general population discourages lawlessness, it will affect the number of desired police for internal law enforcement. On the other hand, if the general population promotes lawlessness, there will be fewer fishermen that convert to police. The model was designed to incorporate these aspects; there are political constraints as well as limitations on foreign influence.

4.6 Testing the Model

Testing is important to ensure that the model is as accurate as possible; because models are mere simplifications of a problem, there will always be some limitations on accuracy. The testing procedures are to ensure that the model behavior is normal and imitates the real world to the best of its ability. The following tests were applied to assess the Pirate Fisherman Model:

1. Boundary Adequacy
2. Structure Assessment
3. Dimensional Consistency
4. Parameter Assessment
5. Extreme Conditions
6. Integration Error
7. Behavior Reproduction
8. Behavior Anomaly
9. Surprise Behavior

All of the tests produced predicted results; any errors were quickly corrected. The Pirate Fisherman Model resembles the current crisis in Somalia, taking into account economic and social aspects.

4.6.1 Comparison to reference modes

The most important adjustable variables behaved as predicted, showing that the model accurately (as possible) replicates the situation. The Pirates stock fluctuated predictably based on other variables, including average pirate earnings and internal and external law enforcement. The External law enforcement variable behaved normally, diminishing according to the number of pirates. Pirate risk was also predictable; it rose as internal and external law enforcement and police rose, and diminished as the number of pirates increased. Lawlessness behaved predictably and positively impacted the police recruitment when it was generally discouraged by the overall population; this variable may prove inaccurate should the new Somali leadership be overthrown or become corrupt.

4.6.2 Robustness

The constant variables in the model were found to be robust, and behave predictably. To test the robustness, "extreme conditions" were used. This means that drastic values were used to simulate an unrealistic situation to ensure that the model performs in the same (correct) manner as it would were the conditions "normal." For example, would the Pirate stock behave as it should if the pirate rewards were extremely low or high? All of the variables passed the robustness test and behaved predictably.

An important test for modeling is unit checking. For the Pirate Fisherman Model, the units utilized were months, people, people per month, and US dollars per month. After much reworking, the model passed the units test.

4.6.3 Sensitivity

Sensitivity analysis consists of testing the model's behavior given uncertainty in parameters, initial conditions, model boundaries, and aggregations (Sterman, 2000). The Pirate Fisherman Model deals with some uncertainties, such as whether or not the government will be able to raise a police force, or how long the External Law Enforcement will remain. This may restrict the applicability of the policies. There were few other uncertainties; numerical information about Somalia and the forces fighting piracy was attainable.

4.7 Policy Design and Evaluation

As discussed in previous sections, the status of Somalia is poor. The main speculation is that fishermen choose a life of piracy to escape from poverty. Even if this is the case, the situation has spiraled out of control – ships carrying UN aid to Somalia and Kenya have been taken hostage, preventing food relief from being delivered to people in need. The fact that Somali pirates threaten lives (by carrying weapons and forcefully taking hostages) and resist law enforcement efforts is another sign that an effective policy to stop pirates is necessary. These policies applied to the Pirate Fisherman Model have few possible negative outcomes, but are feasible.

The four policies the Pirate Fisherman Model tests are discussed in detail in the following four sections.

4.7.1 Policy 1: Increasing External Law Enforcement

The first policy of increasing External Law Enforcement would only negatively affect the pirates; it is outside the scope of the model to predict other effects, such as fish populations leaving the coastal area due to all the ship traffic. However, there is the risk that with a continual presence of external law enforcement, Somalia will not desire to become self-sufficient. This policy would also be expensive for the nations that deploy warships to the area; however, it is a feasible course of action for the international community.

4.7.2 Policy 2: Create a Somali police force

The second policy could backfire were the police force to become corrupt. Positive effects would be the creation of jobs and the upholding of law (and the elimination of piracy). The successful implementation of this policy would also lead to Somalia becoming self-sufficient; it would require a solid government and infrastructure, and will have high initial startup costs. A key factor that has allowed pirates to flourish is that once on land, they cannot be pursued by naval forces. A Somali police force would prevent pirates from seeking haven on land.

4.7.3 Policy 3: Adjust fisherman income

The third policy could have the intended result of reducing or eliminating pirate attractiveness, or could have no effect other than reducing the number of fishermen willing to convert to police. A less obvious method of implementing this policy would be to ensure that international commercial fishing vessels do not fish in Somali waters. Somali fishermen were essentially driven to piracy due to the depletion of the fish population. By preventing foreign vessels from illegally fishing in Somali waters, the local fishermen would have a chance at profiting from fishing.

4.7.4 Policy 4: Decrease pirate payoff

The fourth policy, which requires that nations do not pay ransom for captured ships, could result in hostages being killed, or the decline of pirate attractiveness and potential earnings per pirate. This policy would be the most difficult to implement, because it would require the participation of every nation that is demanded to pay ransom. This would pose a risk to the hostages, because they would be at the mercy of pirates that are faced with receiving no ransom.

Chapter 5: Simulations

Simulations were run to test the four main policies that may bring an end to piracy off the coast of Somalia. These simulations were conducted by changing the values for the variables that represent the policy change.

5.1 Simulations for Policy 1

For the first policy, an increase the amount of external law enforcement (such as US Navy ships) to capture and arrest pirates, the variable External Law Enforcement was changed to a high value. The result was an eventual drop in piracy – which caused the External Law Enforcement to drop in response. Basically, flooding the Indian Ocean and Gulf of Aden with naval warships would be effective in the short run, but would not result in the elimination of piracy in Somalia. Figure 21 shows the drop in pirate population caused by the presence of external law enforcement.

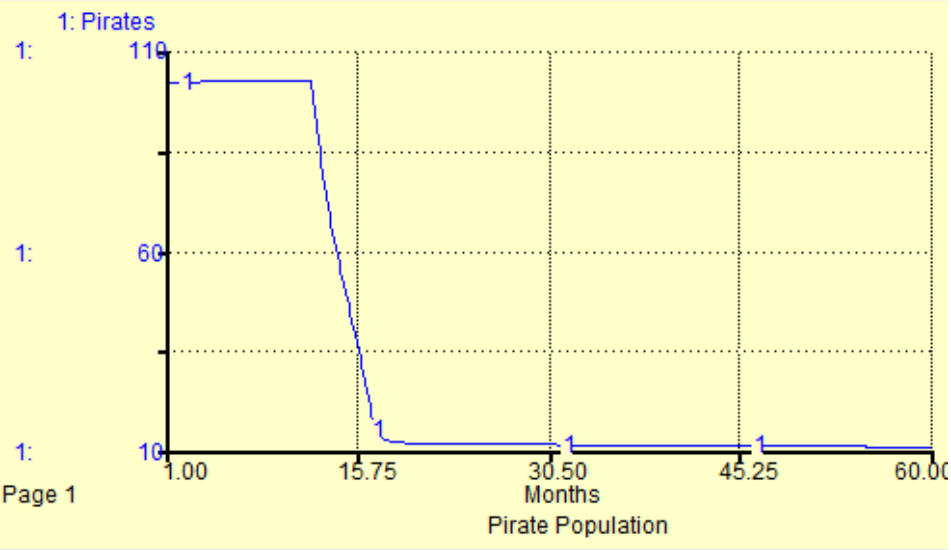

Figure 21: Policy 1 simulation result – Pirate Population

This policy also resulted in a large number of captives. This would be problematic for Somalia, which has no judicial system or facilities in which to jail captured pirates; Kenya would have to shoulder the burden. Figure 22 shows the number of captives when Policy 1 was simulated.

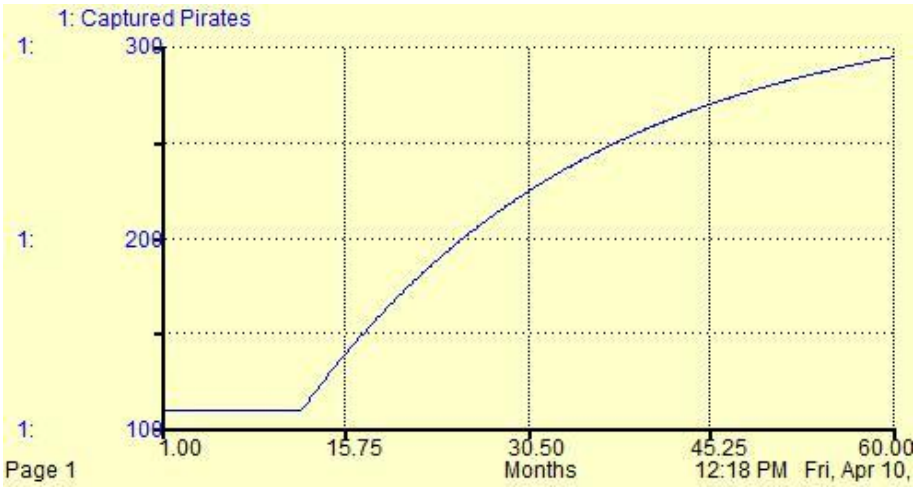

Figure 22: Policy 1 simulation result – Captured Pirates

5.2 Simulations for Policy 2

The second policy, the creation of a Somali police force that can arrest pirates, was far more effective in the long run. Once a police force was established (and rose with respect to the number of pirates), piracy diminished. While there were oscillations, the effectiveness of an internal police force was higher than that of an external force, especially over a long period of time. The number of police and pirates oscillated with respect to each other. Figure 23 shows the oscillating reaction of pirates.

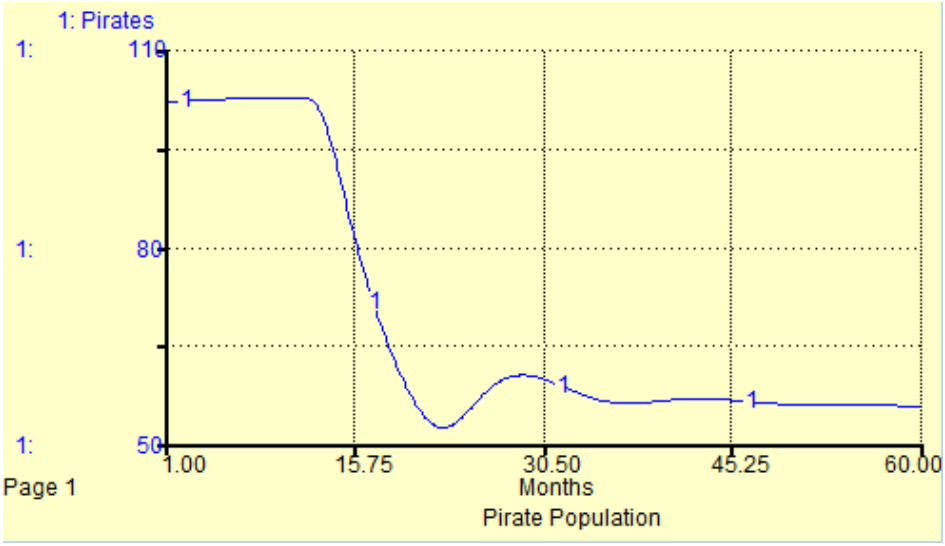

Figure 23: Policy 2 simulation result – Pirate Population

Overall, this policy made the economy of Somalia better off, promoted self-sufficiency and the creation of jobs, and had fewer captives. The level of captives from Policy 2 is shown in Figure 24; Figure 25 shows the leveling-off of police, indicating the creation of a new job market for Somalis.

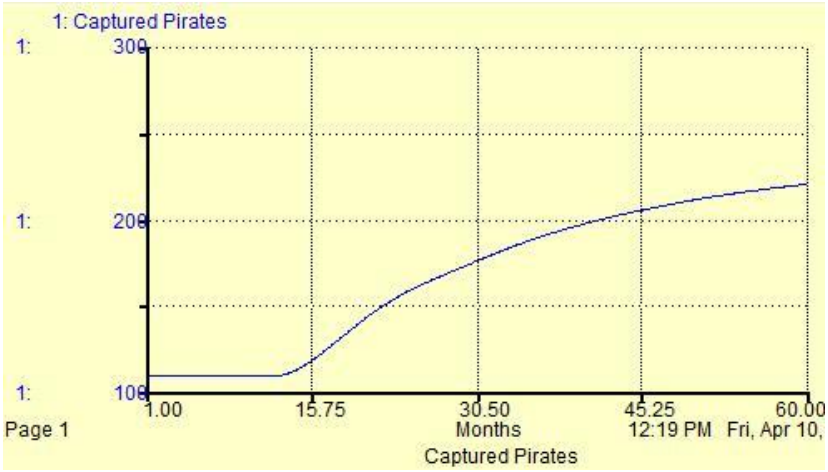

Figure 24: Policy 2 simulation result – Captured Pirates

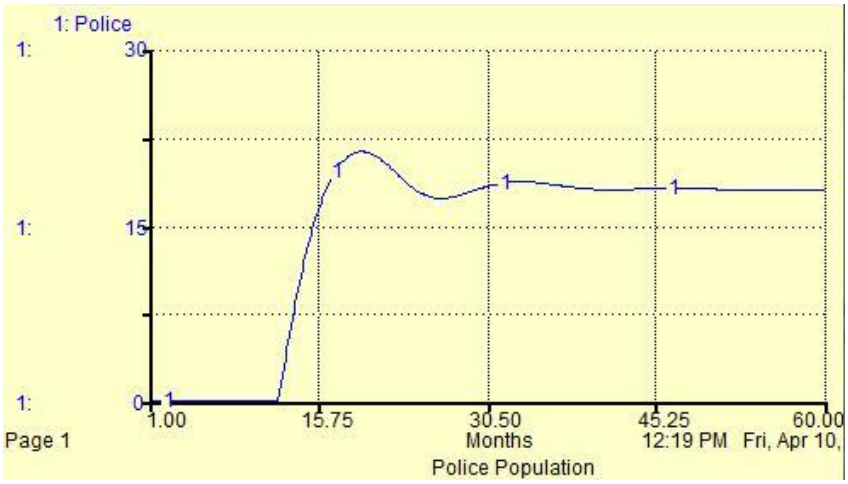

Figure 25: Policy 2 simulation result – Police Population

5.3 Simulations for Policy 3

The third policy, adjustment of fisherman income, contributed to the diminishing of pirates. The effect of this policy was that fewer fishermen were tempted to become pirates; it must be noted that expected pirate payoff is affected by the potential earnings for pirates as

well as the chance of success. The implementation of this policy would require the international community to fund the protection of Somali waters for fishermen, rather than funding the continuation of pirate hunting. Figure 26 shows the diminishing of pirates to a low number over time.

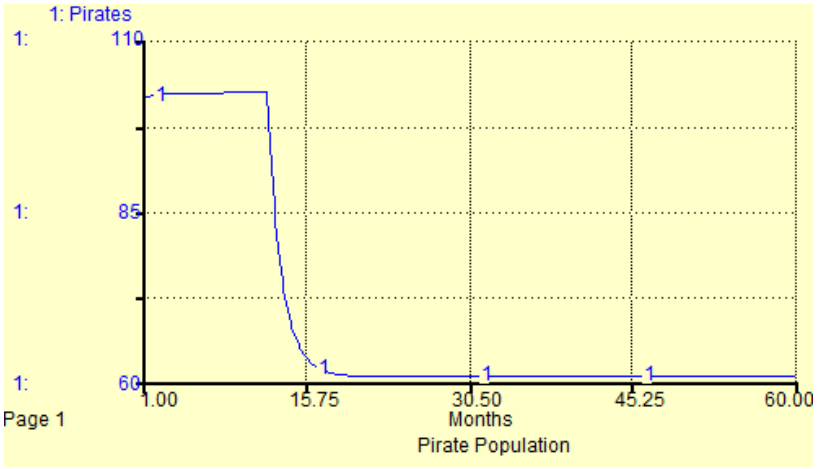

Figure 26: Policy 3 simulation result – Pirate Population

5.4 Simulations for Policy 4

The fourth policy, making pirate payoff less by demanding nations never pay ransoms, was also effective. After a short period of time, much of the pirates converted back to fishermen. This policy directly affected the piracy adjustment, resulting in a low number of remaining pirates. Figure 27 shows that the number of pirates diminishes (to a lower number than policy 3), due to reduced pirate payoff.

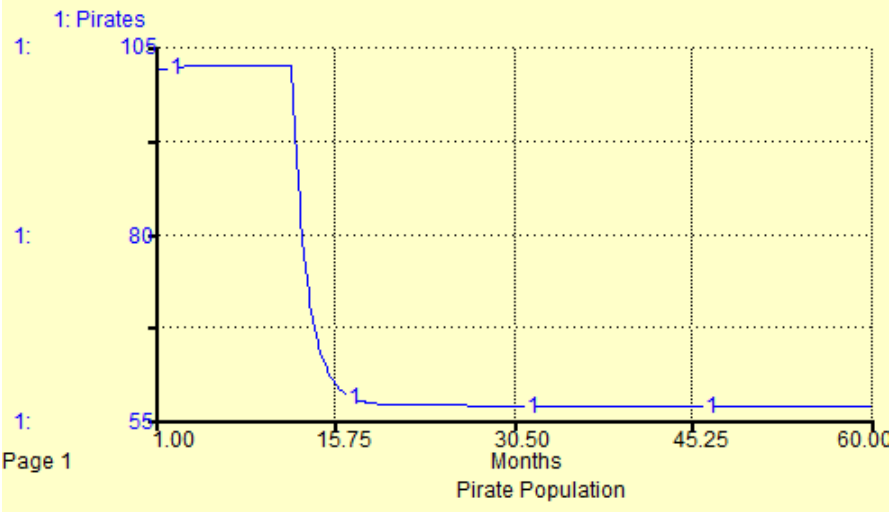

Figure 27: Policy 4 simulation result – Pirate Population

The combination of all four policies had a very interesting outcome: due to the overwhelming presence of External Law Enforcement, the internal Police force never developed. This indicates that if the international community maintains a large fleet of navy ships in the area, Somalia's government may not feel as strong a need to establish a police force. This would result in the resurgence of piracy, should the External Law Enforcement leave. However, with the implementation of an internal police force, piracy would be eliminated.

The expected results of all the policies are to reduce the number of pirates to zero. With a combination of more than one, or even all of, the policies, piracy will definitely be eliminated. However, the flood of External Law Enforcement may have an adverse effect on Domestic Police, because there will be no desired domestic police if External Law Enforcement captures most of the pirates – there would be no need for domestic police. The next chapter discusses the impacts of these simulation results, and which policies would be most effective and applicable.

Chapter 6: Conclusions and Recommendations

The simulation results present several options for the global community. First, it would be possible to ensure safe shipping (in the short term) along the horn of Africa by increasing External Law Enforcement. This would be costly for all nations that deploy ships to the Indian Ocean and the Gulf of Aden, and therefore not very feasible for the long term. For this reason, the recommendation is that international forces maintain a presence (and possibly increase in strength if piracy continues to rise) until a land-based Somali law enforcement is created and operational.

The second policy is key. The simulations determined that without an internal police force, piracy will always rise to become an international problem. For Somalia to become a self-sustaining nation, a judicial system (complete with the ability to capture and arrest pirates on land) is necessary. Creating this force will most likely require international monetary aid, and possibly a coalition of international forces based on land. Despite this, the main recommendation is that Somalia develops a police force that employs citizens to arrest pirates. Not only will this reduce the level of acceptable lawlessness, but it will also improve the economy by providing work. Without the threat of piracy, international aid will be deliverable, helping the millions of Somalis that depend on it. An internal police force would be most effective over the long term – making it the most recommended policy that this project evaluated.

The third policy is would also require monetary aid. With much of the population living below the poverty line, increasing fisherman income through national means is impossible. However, this policy in conjunction with the creation of an internal police force would encourage fisherman to continue being lawful, eventually leading to the reduction of attractiveness of being a pirate. This policy, while effective, would be dependent on the generosity of advanced nations.

The fourth policy was very effective, but may be considered infeasible. Reducing Pirate payoff due to refusal to pay ransoms caused pirate attractiveness to decrease drastically – however, the model does not account for the potential violent reactions of the pirates to this policy. Threats against captured crews' lives may be carried through to pressure companies

into paying ransoms. For this reason, this policy is not highly recommended, despite its effectiveness in the simulations.

6.1 Future work

The main recommendation, the establishment of a Somali police force, potentially involves land-based forces from the international community. Work for future projects could incorporate this aspect. Also, until the threat of piracy is eliminated, the model can be adapted to detail other economic, political, and social aspects that the Pirate Fisherman model was unable to include in its scope.

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Appendices

1. Model Equations

Captured_Pirate(t) = Captured_Pirate(t - dt) + (Capture - Rehabilitation) * dt
INIT Captured_Pirate = 0
INFLOWS:
Capture = (Pirates*Covered_Pirate_Ratio)/Time_to_Capture
OUTFLOWS:
Rehabilitation = Captured_Pirate/Average_Captivity_Time
Fishermen(t) = Fishermen(t - dt) + (Rehabilitation - Piracy_Adjustment - Police_Adjustment) * dt
INIT Fishermen = Initial_Fisherman
INFLOWS:
Rehabilitation = Captured_Pirate/Average_Captivity_Time
OUTFLOWS:
Piracy_Adjustment = ((Fishermen*Pirate_Attractiveness) - (Pirates/Pirate_Attractiveness)) /
Pirate_Adjustment_Time
Police_Adjustment = (MIN(Desired_Additional_Domestic_Police,
Fishermen_Seeking_Police_Employment)/Police_Adjustment_Delay)
Pirates(t) = Pirates(t - dt) + (Piracy_Adjustment - Capture) * dt
INIT Pirates = Initial_Pirates
INFLOWS:
Piracy_Adjustment = ((Fishermen*Pirate_Attractiveness) - (Pirates/Pirate_Attractiveness)) /
Pirate_Adjustment_Time
OUTFLOWS:
Capture = (Pirates*Covered_Pirate_Ratio)/Time_to_Capture
Police(t) = Police(t - dt) + (Police_Adjustment) * dt
INIT Police = Initial_Police
INFLOWS:
Police_Adjustment = (MIN(Desired_Additional_Domestic_Police,
Fishermen_Seeking_Police_Employment)/Police_Adjustment_Delay)
Acceptable_Lawlessness = 1
Average_Captivity_Time = 24
Average_Earnings_Per_Fisherman = 230
Average_Goods_Traffic = 1000000
Average_Police_Earnings = 250
Covered_Pirate_Ratio = Police_Threat/Pirates
Desired_Additional_Domestic_Police = Desired_Aditional_Police-External_Enforcement
Desired_Aditional_Police = Excess_Pirates/Marg_Eff_of_Police
Excess_Pirates = Lawlessness_Gap*Total_Population
Expected_Pirate_Payoff = Pirate_Chance_of_Success*Potential_Earnings_Per_Pirates
External_Enforcement = .5

Fishermen_Seeking_Police_Employment =
Ratio_of_Fisherman_Seeking_Police_Employment*Fishermen
Initial_Fisherman = 1000
Initial_Pirates = 124
Initial_Police = 0
Lawlessness = Pirates/Total_Population
Lawlessness_Gap = Lawlessness-Acceptable_Lawlessness
Marg_Eff_of_External_Police = .9
Marg_Eff_of_Police = .6
Pirate_Adjustment_Time = 12
Pirate_Attractiveness = (Expected_Pirate_Payoff/Average_Earnings_Per_Fisherman)*.01
Pirate_Chance_of_Success = 1-Pirate_Chance_of_Failure
Police_Adjustment_Delay = 12
Police_Attractiveness = Average_Police_Earnings/Average_Earnings_Per_Fisherman
Police_Threat = (External_Enforcement*Marg_Eff_of_External_Police) +
((Police)*Marg_Eff_of_Police)
Potential_Earnings_Per_Pirates = Average_Goods_Traffic/Pirates
Time_to_Capture = 2
Total_Population = Fishermen+Pirates+Police
Pirate_Chance_of_Failure = GRAPH(Covered_Pirate_Ratio)
(0.00, 0.00), (0.2, 0.405), (0.4, 0.645), (0.6, 0.795), (0.8, 0.87), (1.00, 0.915), (1.20, 0.935), (1.40, 0.94), (1.60, 0.945), (1.80, 0.945), (2.00, 0.945)
Ratio_of_Fisherman_Seeking_Police_Employment = GRAPH(Police_Attractiveness)
(0.00, 0.00), (0.2, 0.00), (0.4, 0.01), (0.6, 0.035), (0.8, 0.13), (1.00, 0.5), (1.20, 0.78), (1.40, 0.88), (1.60, 0.935), (1.80, 0.97), (2.00, 0.975)