

# **Environmental and Economic Impact of Galápagos Fisheries**

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### ***Abstract***

Though the Galápagos Islands are home to a great diversity of species, loss of endemic species threaten the islands. Exploitation of aquatic species may occur due to over-fishing within the Galápagos Islands. An analysis of environmental and economic impact on fish populations was completed by assessing previously published data. Harvesting aquatic species may not only harm the environment but also the economy as well. With the dollar amount that fishermen can earn two challenges are faced: should natural resources be exploited for a short-term economic gain or as a long-term, dependable, source of income.<sup>1</sup> Education about the situation may be a way to reduce exploitation and extinction from occurring in the future. This will ultimately save the Galápagos Islands from being stripped of the World Heritage Site classification.

### ***Introduction***

#### *Background of the Galápagos Islands*

The Galápagos Islands, which lie about 600 miles off the coast of Ecuador, were declared a World Heritage Site in 1978, establishing preservation efforts on the islands. These islands are important historically because of observations concerning the species on the Galápagos made in 1835 by Charles Darwin, played a vital part in the development of his theories about evolution presented in the ‘The Origin of the Species.’ In this seminal work, written after his return to England, Darwin contemplates on the idea of natural selection, adaptation to the environment and genetic mutation. Organisms which are on these oceanic islands (islands that emerged lifeless from a submarine volcano), established themselves and survived, with each successive population more adapted to the environment of the Galápagos. If an organism is absent from an island it suggests that organism was never able to reach the island or that after arriving it was not able to establish itself.<sup>2</sup> The Galápagos Islands have organisms that other parts of the world do not and these islands still contain 95% of their original biodiversity. This biodiversity includes fish which are restricted or distinctive to this specific locality. These endemic fish are 17% of the 306 teleost (fish with a bony rather than a cartilaginous skeleton) species in this region.<sup>3</sup> Loss of species, especially aquatic varieties, has been one of the greatest threats to the islands as the number of tourists (nine percent annually) and population in the area continues to increase by six percent

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<sup>1</sup> Merry Camhi, “Industrial Fisheries Threaten Ecological Integrity of the Galápagos Islands.” *Conservation Biology*, Vol. 9, No. 4 (August 1995): 715-719.

<sup>2</sup> Pierre Constant, *The Galápagos Islands*. New York: W.W. Norton & Company, Inc.

<sup>3</sup> Camhi

annually.<sup>4</sup> The focus of this paper will be on local and commercial fishing to analyze the environmental impact they have on the fish populations and economic impact between fisheries.

### *Tragedy of the Commons*

Fisheries all over the world have been subject to over-fishing, depletion and overcapitalization, as fishermen rushed to beat their competitors to the catch. Garrett Hardin describes this phenomenon as the Tragedy of the Commons. When a common area is available for use by every citizen, and citizens share responsibility for these areas, problems can arise due to lack of accountability for individuals using the vicinity. The result is that the area is used for the private interest rather than for the public good.<sup>5</sup> Reproduction of marine life was once faster than its consumption, but as human population increases, so does the demand for seafood. Many parts of the ocean have been exploited so intensively that many species can no longer reproduce fast enough to replace their populations.<sup>6</sup>

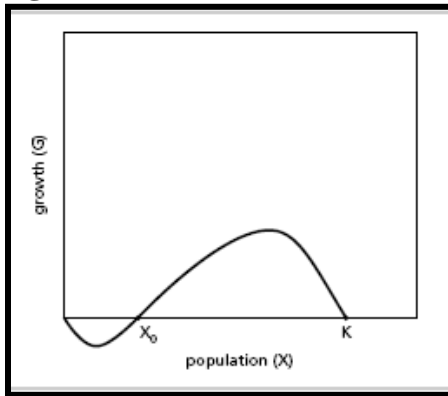
If the population falls below a certain level, growth will start to become negative and then population will become irreversibly headed towards zero. Figure 1 shows this critically unsettled growth function, where  $X_0$  denotes the minimum feasible population. Banning a harvest or implying fishing seasons help deter the population growth from becoming negative. Since most of the fishing seasons are during the spawning season for each separate species, when a ban takes place or the fishing season is followed, this allows the allotted time for a species to reproduce.

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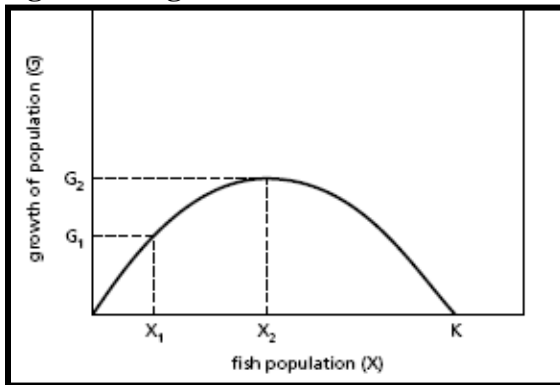
<sup>4</sup> Jose Villa. INGALA representative. Interview by author and class. 12 January 2006.

<sup>5</sup> John S. Dryzek. *The Politics of the Earth: Environmental Discourse*. New York: Oxford University Press, 1997.

<sup>6</sup> Douglas Segar, *Introduction to Ocean Sciences*. Belmont: Wadsworth Publishing Company, 1997.

**Figure 1. Growth Function with Critical Depensation<sup>7</sup>**

When a species is able to reproduce without any disturbances the growth may become compensated. Initially when a population starts out low there may be little or no growth, but when population increases the amount of growth also increases [Figure 2]. After reaching a certain area of growth ( $X_2$ ) population will begin to decline naturally because of competition for resources. If harvesting occurs before population can grow, the population may be headed towards an irreversible situation [Figure 1].

**Figure 2. Logistic Growth Function<sup>8</sup>**

In addition to the direct damage caused by high absolute numbers of fish that are harvested, high fishing mortality also can alter reproductive rates of a species. Juveniles may not grow to the full reproductive status because of early harvesting. When juveniles

<sup>7</sup> James R. Kahn, *The Economic Approach to Environmental and Natural Resources*.

<sup>8</sup> Kahn, 378

survive and grow to adult sizes they then face natural death or harvesting. If too much harvesting is allowed, populations may be doomed to extinction.

### *Forms of Reproduction*

Depending on the reproduction method (asexual or sexual), populations can increase at strikingly different rates and the Tragedy of the Commons may be more or less likely to be realized for that species. Some species reproduce asexually, which occurs when a single parent produces an offspring with out the participation of egg and sperm.<sup>9</sup> Other species are able to reproduce sexually, which is a process of reproduction through fertilization.<sup>10</sup> Of the three most harvested species in the Galápagos, both these types of reproduction are present.

Sea cucumbers are able to reproduce both sexually and asexually, possibly causing the population to grow more rapidly than if only through sexual reproduction.<sup>11</sup> Sea cucumbers also reproduce by releasing sperm and ova into the ocean water, which is considered sexual reproduction.<sup>12</sup> With these types of reproduction, the amount of harvesting may not reduce the population as much as thought.

Lobsters and sharks, on the other hand, can only reproduce through sexual reproduction, with two different individuals producing the egg and sperm, which then combine to form a zygote.<sup>13</sup> A healthy lobster (weighing approximately 1.5 pounds) can produce up to 8,000 eggs. After the eggs are fertilized they are carried internally for 9-12 months and then externally for the same amount of time. When the eggs hatch the larvae then float near the surface of the water for approximately four to six weeks. Out of the 8,000 eggs only about three will survive to reach the legal market size of 1.5 pounds.<sup>14</sup> Since the market size of a lobster and the size of a lobster that has the highest average reproduction is 1.5 pounds. Harvesting more then what survives to this size may cause a large decline within the population. Sharks also practice internal fertilization. Many

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<sup>9</sup> Robert Leo Smith and Thomas M. Smith. *Elements of Ecology*. Page 220.

<sup>10</sup> Ibid

<sup>11</sup> Asexual reproduction by induced transverse fission in the sea cucumbers *Bohadschia marmorata* and *Holothuria atra*. <<http://www.spc.int/coastfish/news/BDM/23/BDM23-Laxminarayana.pdf>> (25 March 2006).

<sup>12</sup> Wikipedia. <[http://en.wikipedia.org/wiki/Sea\\_cucumber](http://en.wikipedia.org/wiki/Sea_cucumber)> (17 April 2006).

<sup>13</sup> Ibid

<sup>14</sup> Calculations based off of: Marine Life. <<http://collections.ic.gc.ca/western/mlife.html>> (14 April 2006).

sharks bear fully developed, live young. With only a few individuals born per litter, fishermen may quickly reduce a population because of the low production.

### *Marine Reserve*

Since fishing activity may disrupt the reproductive process and threaten aquatic species, the Ecuadorian government created a 29,000 square mile Marine Reserve to limit exploitation of fish and other species in the waters around the Galápagos Islands.<sup>15</sup> This Marine Reserve was established in 1986. Later in August of 1992 a plan was established by the Charles Darwin Foundation, and scientific experts from around the world, to provide a biological defensible zone allowing local, traditional, and artisanal fishing along with tourism and catch-release fishing within the reserve.<sup>16</sup> In 1998 the reserve was extended to 51,000 square miles, making it the second largest marine reserve in the world, compared to that of the Great Barrier Reef in Australia.<sup>17</sup>

Open-access techniques are regulations that modify the fishing behaviors of participants in a fishery and is used to maintain fish stocks at a target level. Within this reserve, which fish may be caught, where fish may be caught, and how fish may be caught are restricted by open-access regulations.<sup>18</sup> Laws within the reserve enforce such regulations by allowing certain fishing techniques and having a maximum allowable catch in order to help deter further exploitation.

### *Fishing Methods*

Often a fisherman will acquire an incidental catch, which is when a fisherman catches more than the species they seek. This is due to the multiple methods of fishing which are used by both local and commercial fishermen. Small-scale local fishermen use hand lines, baited hooks, weighted hooks, and hand nets, whereas industrial-commercial fishermen use long-lining, nets, and trapping techniques. Catch-release and spear-

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<sup>15</sup> Jeffrey P. Cohn, "Sea cucumbers and takeovers of scientific institutions." *Bioscience*, Vol. 46, Iss. 1 (January 1996): 70.

<sup>16</sup> Camhi, 716.

<sup>17</sup> Constant, 194.

<sup>18</sup> Kahn .

fishing, which are used by local fishermen, can not be properly managed.<sup>19</sup> This is not a major concern though because these methods are not commonly used. These types of fishing methods (hand lines, baited hooks, weighted hooks, and spear fishing) do not discriminate among fish species and are expected to lead to further exploitation because both the desired species and untargeted species are caught.

One discriminating method is long-lining, which is one of the greater threats to the Galápagos' oceanic area because all sea organisms are at risk.<sup>20</sup> Long-lining consists of multiple hooks connected to a single fishing line which is spread out for miles along the ocean and often catches more sea birds, sea lions, and tortoises than targeted fish.<sup>21</sup> Another harmful method is hand nets, which are open fabrics of twine or equivalent material, woven or tied with meshes of any size, designed and used for capturing fish or other aquatic animals in their native element.<sup>22</sup> Hand nets can also catch turtles, manta rays, hammerhead sharks, and other non-intended animals within them.<sup>23</sup> Another method which catches a large number of aquatic species is traps. Traps are devices that lure animals by reason of some voluntary action and either catch, wound, paralyze, kill the said animals or in general render them helpless.<sup>24</sup> Spear-fishing is comprised of a shank having a pointed head and catches aquatic animals by being thrown or thrust into them.<sup>25</sup> Hand lines are an apparatus that attempts to catch or gather fish and convey the catch to a boat.<sup>26</sup> Baited hooks (used over the rocky reefs) are used to encourage a fish to nibble at a hook with a source of temptation and then act in such a way as to force the barbed end of the hook into the fish's mouth to securely hook it.<sup>27</sup> Some local fishermen also use weighted hooks (a single hook connected to a weight made of lead) to fish about

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<sup>19</sup> Martha Honey, *Ecotourism and Sustainable Development: Who Owns Paradise?* Washington D.C.: Island Press, 1999.

<sup>20</sup> Daniel Howden and Michael McCarthy, "Wildlife faces wipeout in the cradle of evolution; Experts warn of 'catastrophic' fishing threat to Galápagos Islands." *The Independent*, 31 March 2005, page 12.

<sup>21</sup> John Otis, "Creatures no comfort to Galápagos isles/Fragile ecosystem overrun by tourists, other alien species." *Houston Chronicle*, 17 April 2004, page 1.

<sup>22</sup> Fishing, Trapping, and Vermin Destroying. Class Definitions: Class 43, May 2005. <<http://www.uspto.gov/go/classification/uspc043/defs043.htm>> (23 March 2006).

<sup>23</sup> "Man Versus Nature Puts Galapagos' Beauty at Risk." *China Daily*, 18 January 2002, page 12.

<sup>24</sup> Fishing, Trapping, and Vermin Destroying.

<sup>25</sup> Ibid

<sup>26</sup> Ibid

<sup>27</sup> Ibid

two tons per day.<sup>28</sup> Hand lines and baited hooks are the most basic of the techniques since only one sea animal can be caught at a time, while nets, traps and long-lines catch more than the intended targeted species.

Long-lines are perhaps the most preferred method by fishermen because it takes less effort to catch more, though long-lining is not legal in the Galápagos. Since a majority of the 20,000 inhabitants of the Galápagos Islands live off fishing, only 1,000 fishermen being registered within the islands, many want long-lining legalized.<sup>29, 30</sup> By legalizing long-lining, the fishermen will be able to catch a larger amount than would be possible with just one hook, and with this technique it would make it easier to exploit fish stocks.

### *Types of fisheries*

When the mainland fishermen exhausted coastal stocks off the shores of Ecuador, they came to the Galápagos Islands to continue their harvest of fish species. Assistance from local fishermen help commercial fishermen obtain their catch ‘legally.’ The ocean may start to become depleted of aquatic species because of commercial fishermen acquiring help from the local ‘artisanal’ fishermen.

### *Local fishermen*

In order to be considered a local, small-scale fisherman, there are requirements that must be met. One must be a permanent resident of the Galápagos Islands and must be affiliated with one of the small-scale fishing cooperatives of the Galápagos Islands.<sup>31</sup> The size, composition, and outlook of the local fishermen varies from one island to the next, depending on the importance of fishing in the local economy.<sup>32</sup> Local fishermen use what they catch towards feeding their families and helping the local community.

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<sup>28</sup> Local Galápagos Fisherman.

<sup>29</sup> Steven Dudley, “Galápagos Islands Face a Complex Stream of Threats.” Knight Ridder Tribune News Service, 29 December 2005, page 1.

<sup>30</sup> Steven Edwards, “Illegal Fishing Threatens Galápagos.” *The Gazette*, 7 April 2005, A16

<sup>31</sup> The National Congress: The Plenary Session of the Legislative Commissions. *The Genuine Book of Ecuadorian Laws*.

<sup>32</sup> Paola Oviedo, “Part 2: Costal Areas: Chapter 8: The Galápagos Islands: Conflict Management in Conservation and Sustainable Resource Management.”



### *Commercial fishermen*

Commercial fishermen use their catch for exportation and economic gain and therefore are in conflict with local fishermen. Since fish are more abundant near the Galápagos Islands and particular kinds are within the marine reserve, commercial fishermen go to the islands to exploit sea cucumbers, shark fins, black coral, and sea lion teeth and genitalia.<sup>33</sup> The existence of a commercial market often leads to overexploitation of a species because it is difficult to reject a profitable income from fishing.<sup>34</sup> If commercial fisheries are restricted, it may mean unemployment for the industry and industrial bankruptcy. If the amount of fishing is increased, however, the over usage may cause a failure in the environmental system and the industry may collapse due to depletion of aquatic species.

### *What's being fished?*

The Galápagos Islands allow lobster and sea cucumber fishing seasons within the reserve for local fisherman. The lobster season consists of a four month time span from September 1<sup>st</sup> until December 31<sup>st</sup> and a sea cucumber season of two months from July 1<sup>st</sup> until August 31<sup>st</sup>.<sup>35</sup> An alternative to harvesting sea cucumbers in the Galápagos can be captive raising, an initiative which takes place in Japan.<sup>36</sup> Fishermen originally sought sea cucumbers by the mainland, but the species became so scarce that they began to long-line for sharks, tuna, swordfish, and squid.<sup>37</sup> Sea cucumbers are harvested by commercial fisheries for export to be used for Chinese aphrodisiacs as well as a sushi delicacy.

Other Chinese aphrodisiacs include sea lion genitalia and shark fins. Sea lions are starting to be caught more and more for their genitalia while sea lion meat is used for shark bait. Sharks that are caught are often finned (the process of cutting off all four fins) and then tossed back into the ocean, ultimately resulting in their death. The fins are then used for Asian or Chinese aphrodisiacs as well as a sea food delicacy.

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<sup>33</sup> Harry Thurston, "Last Look at Paradise?" *International Wildlife*.

<<http://nwf.org/internationalwildlife/galapago.html>> (23 February 2006).

<sup>34</sup> Peter Raven, et al, *Biology*. New York: McGraw-Hill Companies, Inc., 2005.

<sup>35</sup> Constant, 190

<sup>36</sup> Cohn, 70

<sup>37</sup> Edwards, "Illegal Fishing," A16

Even though commercial fishing is banned within the marine reserve it is difficult for the rangers to enforce the law. Not only is enforcement weak, but the fines for illegal fishing are so minimal commercial fishermen, either fishing for themselves or paying local fishermen for their catches, are willing to take the chance of being caught. The standard fine is a mere four cents and two weeks of “jail time,” which is served on a personal boat with shore leaving privileges.<sup>38</sup>

Commercial fishermen use constant pressure to legalize their ability to come within the reserve to catch sharks, sea cucumbers, lobsters, and sea urchins for export.<sup>39</sup> Commercial fisheries offer local fishermen money for the help they provide when harvesting the sea cucumbers and sharks. With the Galápagos fishing industry earning six million dollars a year for the Ecuadorian economy, three million of which comes from the sea cucumber industry alone, the Ecuadorian government feels forced to please the fishermen.<sup>40, 41</sup> Since local fishermen barely make the minimum *monthly* wage of \$71, finding out that they can make \$100 a *day* by seeking out shark, lobster, and sea cucumbers for the Chinese and Hong Kong buyers, they began to do so because this is exceptional economic opportunity. Within the Galápagos Islands one pound of sea cucumbers is worth roughly \$0.45, in the Asian market sea cucumbers are worth between \$12 to \$18 per pound, and in Hong Kong one pound is worth between \$18 and \$40.<sup>42, 43</sup>

Local fishermen not only fish for the commercial industries but also to support local consumption and to supply seafood to the tourism sector, this use of fish stocks was approved by the 1992 plan agreed upon by the Charles Darwin Foundation and scientific experts from around the world.<sup>44</sup>

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<sup>38</sup> “Video of Dolphin Deaths Highlights Continued Threat to Galapagos Marine Reserve from Illegal Fishing.” U.S. Newswire, 23 July 2002, page 1

<sup>39</sup> Camhi, 716.

<sup>40</sup> Steven Edwards, “Fishing imperils Galápagos: Ecuador islands face de-listing by United Nations.” The Vancouver Sun, 7 April 2005, A6.

<sup>41</sup> D’Vora Ben Shaul, “Galápagos Islands: Out of the frying pan, into the fire.” Jerusalem Post, 22 July 2001, page 18.

<sup>42</sup> Richard Lapper, “China’s dynamism puts Galápagos at risk: There is a bitter conflict between local fishermen, conservationists and commercial pressures.” Financial Times, 4 May 2004, page 10.

<sup>43</sup> Calculations based on James Brooke, “Ban on Harvesting Sea Cucumber Pits Scientists Against Fishermen.” New York Times, 2 November 1993, C4

<sup>44</sup> Camhi, 718.

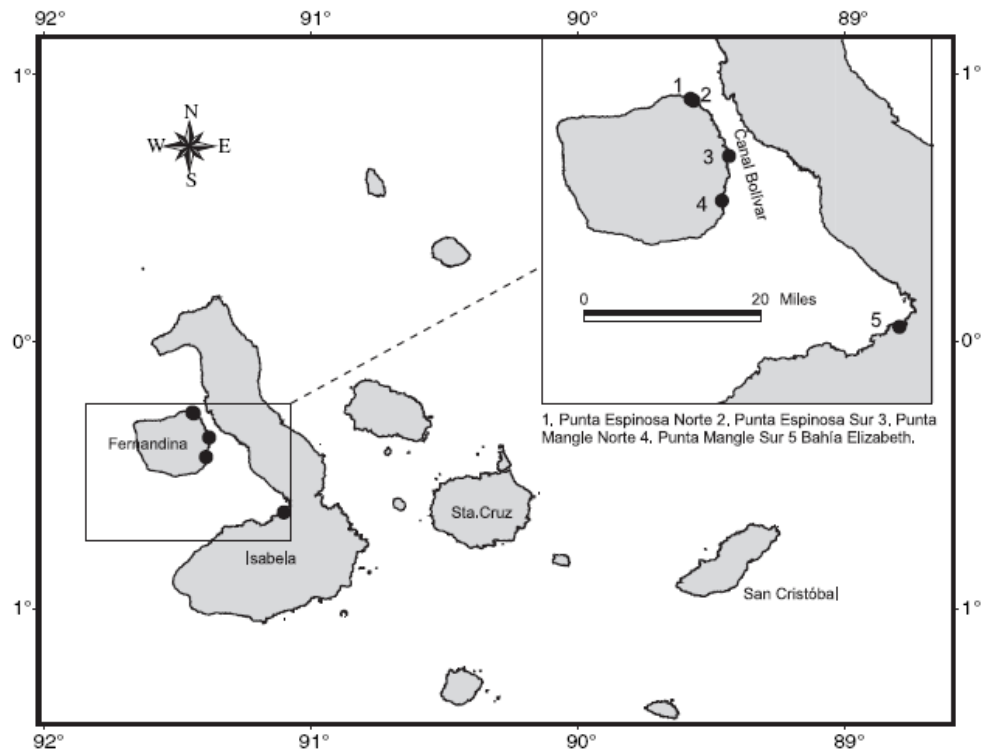
***How much is being fished?***

Open-access regulations may limit how many fish may be captured during the certain fishing seasons. The most heavily fished areas are those that are most accessible, such as along the shores of Santa Cruz near the port by the Darwin Station.<sup>45</sup> The limits made by the regulations of the open-access policy may be in the form of weight caught, number of fish caught, or volume of catch. The fisheries off the ports of Santa Cruz, San Cristobal, and Isabela include a program involving control and management of sea cucumber monitoring [Figure 3 shows where sea cucumbers are harvested the most]. This program consists of patrolling in the zones of concentration of the fishery fleet, monitoring of the fishery on the islands of Española, Fernandina, western Isabela, San Cristobal, and Santa Cruz, biological monitoring of the captures, and controlling the product sold to vendors because of large amounts of marine life being caught and sold.<sup>46</sup>

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<sup>45</sup> Benjamin I. Ruttenberg, "Effects of Artisanal Fishing on Marine Communities in the Galápagos Islands." *Conservation Biology* Vol. 15, No. 6 (December 2001): 1691-1699.

<sup>46</sup> Sea Cucumber Fishery, 1999 Season. <<http://www.darwinfoundation.org/ourwork/marine/m14.html>> (12 February 2006).

**Figure 3. Area where sea cucumbers are harvested the most.<sup>47</sup>**

Due to the large amount of lobsters being caught within the Galápagos, such as the 396,832 pounds being caught in 1960, approximately 143,300 pounds in 1965, and 207,235 pounds in 1983 [Figure 4 shows the amount of lobsters caught in the various years], a total ban was imposed for seven years, beginning in January 1, 1993 until the year 2000 in order to restock the lobster species.<sup>48, 49</sup> An agreed upon amount of 110,231 pounds maximum of lobsters within the four month season was reached, this total is worth \$1.5 million per 110,231 pounds.<sup>50</sup> This quota has not been enforced completely. For example in the four month season during the year of 1999, 500 fishermen caught a total of 119,050 pounds of lobsters. In 2000 the maximum quota decreased to 77,162 pounds within the four month lobster season, but 939 fishermen caught approximately

<sup>47</sup> Alex Hearn, et al. "Population Dynamics of the Exploited Sea Cucumber *Isostichopus fuscus* in the Western Galápagos Islands, Ecuador." *Fisheries Oceanography*, Vol. 14, No. 5 (2005):377-385.

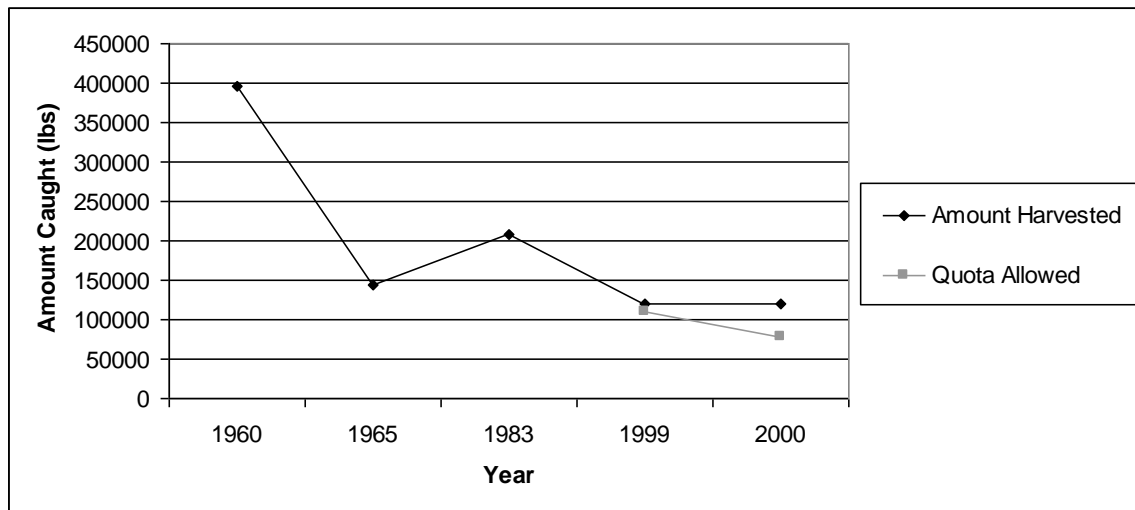
<sup>48</sup> Constant, 193

<sup>49</sup> Constant, 193.

<sup>50</sup> Nicholas Moss, "Warning Over Galápagos Fish Protests." *Financial Times*, 13 December 2000, page 7.

42,770 pounds over this quota.<sup>51</sup> A total of 119,932 pounds was caught within a two month time span, which is only half of the season.<sup>52</sup>

**Figure 4. Number of Lobsters Caught in the Galapagos Islands**



When fishermen protested an allowable catch of four million sea cucumbers was granted. Since the fishermen were not able to meet the amount granted to them a two-year ban was placed on sea cucumber harvesting.<sup>53</sup> In 1992 this increased to a ten year ban being issued on sea cucumbers, but with additional protests from fishermen, the ban was lifted and an amount of 500,000 adult sea cucumbers were allowed to be harvested.<sup>54</sup> A complete ban was put into place when an estimate of six to ten million sea cucumbers were harvested, which is more than ten times the legal limit of to 500,000.<sup>55</sup> It has been evaluated that since 1993 the sea cucumber population has been reduced by more than eighty percent.<sup>56</sup> It was then estimated for 2001 that if there was another four million sea cucumbers taken it would have been possible to remove most of the remaining stocks and push the Galápagos closer to similar fish stocks elsewhere, such as the case by the

<sup>51</sup> Constant, 194.

<sup>52</sup> Malcolm Scully, "The Fragile Galápagos and Ecosystem Under Siege." *The Chronicle of Higher Education*, Vol. 47, Iss. 25 (2 March 2001): B13.

<sup>53</sup> Vicky Collins, "Galapagos: Political evolution as rangers strike over new director; Island-wide protest after appointment of pro-fishing boss." *The Herald*, 15 September 2004, page 3.

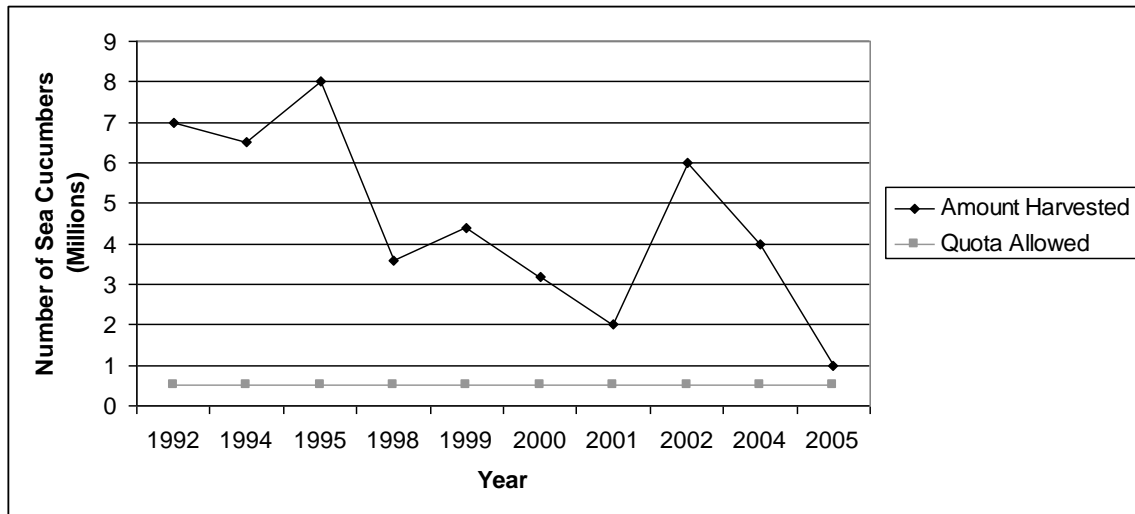
<sup>54</sup> Shaul, 18

<sup>55</sup> Cohn, 70

<sup>56</sup> Constant, 193

mainland.<sup>57</sup> With a lack of regulations in 2002, over six million were harvested.<sup>58</sup> [Figure 5 represents a slow decline on the amount of sea cucumbers harvested through out various years.] In 1995 a ban was put into place when more than six million sea cucumbers were harvested which may have caused numbers to be lower. Once the sea cucumbers are gone, sharks, lobsters, and groupers may become the focus for additional harvesting.<sup>59</sup>

**Figure 5. Amount of Sea Cucumbers Harvested in the Galapagos Islands**



Sharks have already fallen victim to harvesting. Compared to 1996's annual total of 2,661 shark fins being harvested, in 2004, during the month of January alone, an astounding total of 2,291 shark fins were seized.<sup>60</sup> This shows a drastic increase in the number of animals being exploited. The value of shark fins range from \$25 to \$50 per pound. Fishermen have been caught with dozens of sharks trailing on long-lines and hundreds of shark fins in freezers.<sup>61</sup> Sharks which are presently caught on long-lines are at or below the size at which they reproduce and ultimately the older reproductive sharks

<sup>57</sup> Larry Rohter, "What will it be: fish or people?: Galápagos fishermen resist Ecuador's conservation efforts." *The Gazette*, 31 December 2000, D4

<sup>58</sup> Hearn, 381

<sup>59</sup> Camhi, 717

<sup>60</sup> Lapper

<sup>61</sup> Nicholas Moss, "Ecuador battles to preserve spell of the 'enchanted isles': The delicate environment of the Galapagos Islands is coming under increasing threat, particularly from illegal fishing. But protecting the archipelago is no easy task." *Financial Times*, 9 August 2001, page 4

will die off, making it unlikely that these populations will recover from their depleted state unless there is a reduction in fishing pressure.<sup>62</sup>

### ***Methods***

To assess the extent of the environmental and economic impacts of increasing fishing pressure, a comparison of the variability of registered fishermen, amount of lobsters harvested and sea cucumbers harvested over the years of 1999 and 2000 was made. In order to determine if fishermen have a certain economic advantage of harvesting sea cucumbers, lobsters, or shark fins, the average amount that was harvested was compared with the average amount of registered fishermen (between the years 1999 and 2000), the dollar amount per unit caught, total dollar amount, and the dollar amount per average number of fishermen per one year [Table 1].

Average number harvested per year was calculated by the addition of the amount sea cucumbers, lobsters or shark fins for each year researched, then divided by the total number of years. Average number harvested per fishermen of sea cucumbers, or shark fins, was calculated by taking the average total number harvested and then dividing by the average number of fishermen. Total dollar amount of sea cucumbers was based upon a sea cucumbers' average weight, which was then calculated into pounds. This total was then multiplied by average number harvested to get total pounds, and by the dollar amount per unit caught to calculate the total dollar amount for the harvest. Then this divided by the average number of fishermen equals the total dollar amount per fishermen [Table 2].

The calculations of lobsters were based on a lobster's weight in pounds. To determine the amount of lobsters per fishermen the total amount of pounds harvested was then divided by the weight of a lobster (in pounds), which was then divided by the average amount of fishermen. Total dollar amount of lobsters was determined by multiplying the amount harvested by the dollar amount per unit caught. The total dollar amount was then divided by the average number of fishermen to retrieve the total dollar amount per fishermen.

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<sup>62</sup> Longline Fishing Threatens Galápagos Islands. <[http://www.adventure-life.com/galapagos/igota\\_longline\\_fishing.php](http://www.adventure-life.com/galapagos/igota_longline_fishing.php)> (12 February 2006).

Calculations for shark fins were based on the average weight of a shark multiplied by the percentage of weight from the fins. Total number of fins harvested was then multiplied by weight per fin to acquire total weight of fins harvested and by dollar amount per unit caught to calculate the total dollar amount. Total dollar amount per fishermen was calculated by dividing total dollar amount by the average number of fishermen.

## ***Results***

### *Calculations*

Average number of fishermen between the years 1999 and 2000 is a total of 648 fishermen. A sea cucumbers' average weight is 138.325 grams and with one gram equaling 0.002 pounds, an average sea cucumber weighs less than half a pound at 0.27665 lbs. Total pounds of the average harvest was determined by multiplying 4.56 million with a sea cucumbers average weight in pounds (calculated at 1,261,524 lbs).

The average 89.4 tons was multiplied by the amount of pounds per ton (2204.622) to total the average amount of lobsters in pounds, calculated at approximately 197,093 pounds of lobsters harvested. Take the average amount of lobsters harvested divided by the lobsters' average weight of 1.5 pounds to calculate total amount of lobsters harvested at approximately 131,395 lobsters.

A sharks' average weight is 250 pounds, 4.9% of which comes from the four fins.<sup>63</sup> Total fin weight equals 12.25 lbs, divided by 4 fins, totals 3.0625 pounds per fin. Total weight of fins harvested was 8,149.3125 pounds.

### *Environmental Impacts*

Not surprisingly, when the amount of registered fishermen increase so does the amount of lobsters that are harvested [Table 1]. With bans being placed on sea cucumber harvests, those numbers actually declined by 1.2 million between 1999 and 2000. These bans may help contain the amount that is harvested. Though fishermen harvested more sea cucumbers (4.4 in 1999 and 3.2 in 2000) than the ban allowed (500,000), the total

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<sup>63</sup> Sea Shepherd Conservation Society. <[http://www.seashepherd.org/news/media\\_031112\\_1.html](http://www.seashepherd.org/news/media_031112_1.html)> (26 April 2006).



amount of sea cucumbers over the two year period that was examined (7.6 million), was less than the amount harvested in 1995 by 0.4 million [Figure 5]. Even with the decline in the number harvested, reduction of species remains high; this reduction may not only harm the environment but the economy as well.

**Table 1. Comparison of amounts harvested and registered fishermen within the years 1999 and 2000.<sup>64</sup>**

	Registered Fishermen	Total Lobsters Caught	Total Sea Cucumbers Caught
1999	613	119,050 lbs	4.4 million
2000	682	119,932 lbs	3.2 million
Total		238,981 lbs	7.6 million

### *Economic Impacts*

Ecuador is economically dependent on their fishing industry. Table 2 shows an averaged economic comparison between aquatic species and fishermen for one year. For one fisherman, an average yearly harvest of sea cucumbers (~7000 cucumbers) would be worth over \$86,500, an average yearly catch of lobsters (304 lobsters) would bring in \$4,139. Shark fins are the least profitable, with one shark (four fins) worth approximately \$470. These amounts give fishermen more incentives to want to or actually use fishing methods such as long-lining because it takes less effort to catch more.

**Table 2. Economic Comparison of Harvest and Fishermen per one year.**

	Average number harvested	Average number harvested per fishermen	Dollar amount per unit caught	Total Dollar Amount for Harvest	Total Dollar Amount per Fishermen
Sea Cucumbers	4.56 million	7,037	\$44.45/lb	\$56,074,741.80	\$86,535.10
Lobster	197,093.21 lbs	304 lobsters	\$13.61/lb	\$2,682,438.60	\$4,139.57
Shark fins	2,661 fins	4 fins	\$37.50/lb	\$305,599.22	\$471.60

<sup>64</sup> Numbers acquired from: Constant, 189; 194

### *Discussion*

Despite regulations, fishing with in the Galápagos Islands still continues. The bans which were placed effect the amount that is able to be harvested, but lack of enforcement on these bans causes the amounts that are harvested to be over quota. The amount of lobsters and sea cucumbers harvested has been in a decline from the earlier years researched, but they still remain over quota. With this occurring, this may indicate a population decline and that the species are becoming harder to catch.

With sea cucumbers being the ocean's 'earth worm' filtering through the sediments of the oceanic floor, this could cause a problem if over-harvested.<sup>65</sup> Over-harvesting these aquatic creatures can leave harmful sediments on the ocean bottom. Once its population is reduced below a critical mass, sea cucumbers may not recover. Reproduction rates of each species could also be harmed by over harvesting. One fisherman harvesting at least two hundred and five lobsters per year can cause a slow but harmful decline of the lobster population. Harvesting this amount of lobsters will cause detriment to the population because many more lobsters are being caught then are able to grow to a reasonable reproductive size. This is because only two out of five thousand lobster eggs survive to reach a sellable market size of 1.5 pounds, which is also the size that produces the highest average amount of eggs.

With the amount of money earned per fisherman for one year, lobsters earn a reasonable amount while shark fins are the least profitable. Even with shark fins being the least profitable, for the fishermen it is still worth fishing for them because most of their shark catch comes from long-lining, making it one of the easier species for them to catch. The most profitable market for fishermen is the sea cucumber market. Since sea cucumbers reproduce both asexually and sexually they may not face as much of a problem as other species right away. In order to maintain these profits care needs to be taken not to overexploit the species. If this does not occur long-term economic stability is sacrificed for a short term gain.

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<sup>65</sup> Environmental Degredation: Fisheries: Sea Cucumbers.  
<<http://www.law.emory.edu/PI/GALAPAGOS/seacukes.htm>> (7 April 2006).

### *Future Research*

In order to understand how much time fishermen will have to continue harvesting, population dynamics of each species harvested should be calculated. Once calculated, the decline of the harvest and how harvesting is effecting the population of each species can be used to determine if there is a chance to develop long-term stability for fishermen. Life tables and reproductive rates are just a couple of other figures that should be looked at to help determine this.

Also, more assessment on the number of lobsters caught within the Galápagos Islands [Figure 4] should be made. Data from between the years 1960 to 1965 should be looked at to evaluate the reason why there was a large decline of approximately 253,532 pounds being caught. Once this is calculated a comparison of the decline from then to the decline from more recent years can be made and possibly help establish better enforcement of bans.

A complete understanding of what is caused when sea cucumbers are not able to filter out certain sediments from the ocean bottom, when a shark's carcass is left to decay in the ocean and when over-harvesting lobsters takes place should be developed. This will help assess the environmental harm that is caused by over-harvesting these species.

### *Conclusion*

It may be possible to control the fisheries with incentives by making fishermen more aware of what harms can occur from over-harvesting.<sup>66</sup> Fishing technology, increasing demands, and open-exploitation of fisheries, have driven many fish stocks to such low levels that they are threatened with extinction.<sup>67</sup> Even though fish are a renewable resource (they can reproduce), they can also be extinguished if modern fishing technology is coupled with an increase in demand. This may occur due to the open-access exploitation of fisheries, which has driven many fish stocks to such low levels they are threatened with extinction. Unfortunately, with harvesting the marine life there is a possible chance that the Galápagos Islands will be stripped of their World Heritage

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<sup>66</sup> Thurston

<sup>67</sup> Kahn

Site classification, because this harvesting shows an unforced effort to help preserve the Galápagos Islands.<sup>68</sup>

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<sup>68</sup> Edwards, "Illegal Fishing," A16

Works Cited

Asexual reproduction by induced transverse fission in the sea cucumbers *Bohadschia marmorata* and *Holothuria atra*. <<http://www.spc.int/coastfish/news/BDM/23/BDM23-Laxminarayana.pdf>> (25 March 2006).

Brooke, James. "Ban on Harvesting Sea Cucumber Pits Scientists Against Fishermen." *New York Times*, 2 November 1993, C4.

Camhi, Merry. "Industrial Fisheries Threaten Ecological Integrity of the Galápagos Islands." *Conservation Biology*, Vol. 9, No. 4 (August 1995): 715-719.

Cohn, Jeffrey P. "Sea Cucumbers and Takeovers of Scientific Institutions." *Bioscience*, Vol. 46, Iss. 1 (January 1996): 70.

Collins, Vicky. "Galápagos: Political Evolution as Rangers Strike Over New Director; Island-Wide Protest After Appointment of Pro-Fishing Boss." *The Herald*, 15 September 2004, page 3.

Constant, Pierre. *The Galápagos Islands*. New York: W.W. Norton & Company, Inc.

Dryzek, John S. *The Politics of the Earth: Environmental Discourse*. New York: Oxford University Press, 1997.

Dudley, Steven. "Galápagos Islands Face a Complex Stream of Threats." *Knight Ridder Tribune News Service*, 29 December 2005, page 1.

Edwards, Steven. "Fishing Imperils Galápagos: Ecuador Islands Face De-Listing by United Nations." *The Vancouver Sun*, 7 April 2005, A6.

\_\_\_\_\_. "Illegal Fishing Threatens Galápagos." *The Gazette*, 7 April 2005, A16.

Environmental Degredation: Fisheries: Sea Cucumbers.  
<<http://www.law.emory.edu/PI/GALAPAGOS/seacukes.htm>> (7 April 2006).

Finely, Carmel. "Scientists Throw Data to 'Net' to Reel in Aid for Galápagos." *The Oregonian*, 9 March 1995, C8.

Fishing, Trapping, and Vermin Destroying. *Class Definitions: Class 43*, May 2005.  
<<http://www.uspto.gov/go/classification/uspc043/defs043.htm>> (23 March 2006).

Hearn, Alex, et al. "Population Dynamics of the Exploited Sea Cucumber *Isostichopus fuscus* in the Western Galápagos Islands, Ecuador." *Fisheries Oceanography*, Vol. 14, No. 5 (2005): 377-385.

Honey, Martha. *Ecotourism and Sustainable Development: Who Owns Paradise?* Washington, D.C.: Island Press, 1999.

Howden, Daniel and Michael McCarthy. "Wildlife Faces Wipeout in the Cradle of Evolution; Experts Warn of 'Catastrophic' Fishing Threat to Galápagos Islands." *The Independent*, 31 March 2005, page 12.

Kahn, James R. *The Economic Approach to Environmental and Natural Resources*.

Lapper, Richard. "China's Dynamism Puts Galápagos at Risk: There is a Bitter Conflict Between Local Fishermen, Conservationists and Commercial Pressures." *Financial Times*, 4 May 2004, page 10.

Longline Fishing Threatens Galápagos Islands <[http://www.adventure-life.com/galapagos/igtoa\\_longline\\_fishing.php](http://www.adventure-life.com/galapagos/igtoa_longline_fishing.php)> (12 February 2006).

"Man Versus Nature Puts Galápagos' Beauty at Risk." *China Daily*, 18 January 2002, page 12.

Marine Life. <<http://collections.ic.gc.ca/western/mlife.html>> (14 April 2006)

Moss, Nicholas. "Ecuador Battles to Preserve Spell of the 'Enchanted Isles': The Delicate Environment of the Galápagos Islands is Coming Under Increasing Threat, Particularly from Illegal Fishing. But Protecting the Archipelago is no Easy Task." *Financial Times*, 9 August 2001, page 4.

\_\_\_\_\_. "Warning Over Galápagos Fish Protests." *Financial Times*, 13 December 2000, page 7.

The National Congress: The Plenary Session of the Legislative Commissions. "The Special Law." *The Genuine Book of Ecuadorean Laws*.

Otis, John. "Creatures no Comfort to Galápagos Isles/Fragile Ecosystem Overrun by Tourists, Other Alien Species." *Houston Chronicle*, 17 April 2004, page 1.

Oviedo, Paola. "Part 2: Coastal Areas: Chapter 8: The Galápagos Islands: Conflict Management in Conservation and Sustainable Resource Management." <[http://www.idrc.ca/en/ev-27980-201-1-DO\\_TOPIC.html](http://www.idrc.ca/en/ev-27980-201-1-DO_TOPIC.html)> (2 December 2005).

Raven, Peter, et al. *Biology*. New York: McGraw-Hill Companies, Inc., 2005

Rohter, Larry. "What Will it be: Fish or People?: Galápagos Fishermen Resist Ecuador's Conservation Efforts." *The Gazette*, 31 December 2000, D4.

Ruttenberg, Benjamin I. "Effects of Artisanal Fishing on Marine Communities in the Galápagos Islands." *Conservation Biology* Vol. 15, No. 6 (December 2001): 1691-1699.

Scully, Malcolm. "The Fragile Galápagos and Ecosystem Under Siege." *The Chronicle of Higher Education*, Vol. 47, Iss. 25 (2 March 2001): B13.

Sea Cucumber Fishery, 1999 Season.

<<http://www.darwinfoundation.org/Ourwork/marine/m14.html>> (12 February 2006).

Sea Shepherd Conservation Society

<[http://www.seashepherd.org/news/media\\_031112\\_1.html](http://www.seashepherd.org/news/media_031112_1.html)> (26 April 2006).

Segar, Douglas. *Introduction to Ocean Sciences*. Belmont: Wadsworth Publishing Company, 1997.

Shaul, D'Vora Ben. "Galápagos Islands: Out of the Frying Pan, into the Fire." *Jerusalem Post*, 22 July 2001, page 18.

Smith, Robert Leo and Thomas M. Smith. *Elements of Ecology*.

Thurston, Harry. "Last Look at Paradise?" *International Wildlife*

<<http://www.nwf.org/internationalwildlife/galapago.html>> (23 February 2006).

"Video of Dolphin Deaths Highlights Continued Threat to Galápagos Marine Reserve from Illegal Fishing." *U.S. Newswire*, 23 July 2002, page 1.

Wikipedia. <[http://en.wikipedia.org/wiki/Sea\\_cucumber](http://en.wikipedia.org/wiki/Sea_cucumber)> (17 April 2006).

### ***Interviews***

Local Galápagos Fisherman. Interview by author and class. 14 January 2006.

Villa, Jose. INGALA representative. Interview by author and class. 12 January 2006.

## **Bibliography**

Bellos, Alex. "Galápagos Turmoil: Tortoises Dragged Into Fishing War." *The Guardian*, 30 December 2000, page 17.

Brown, Paul. "Scientists Held Hostage on Darwin's Island: Fears for Rare Tortoises Caught up in Galápagos Fishermen's Protest." *The Guardian*, 28 February 2004, page 16.

"Ecosystem Crisis Grows in Ecuador/Galápagos Fishermen's Defiance on Catch Limits Irks Conservationists." *Houston Chronicle*, 29 December 2000, page 32.

Elliot, Harvey. "Survival of the Species in Peril on Darwin's Exotic Islands: The Unique Animals of the Galápagos Face the Destruction of Their Habitat as Population Growth and Illegal Fishing Continue Unchecked." *The Observer*, 21 March 2004, page 3.

Ferber, Dan. "Galápagos Station Survives Latest Attack by Fishers." *Science*, Vol. 290, Iss. 5499 (15 December 2000): 2059.

Frequently Asked Questions of the Sea Cucumber.

<<http://www.darwinfoundation.org/marine/FAQcuke.html>> (12 February 2006).

Grygiel, Chris. "Sea Shepherd Off to Galápagos Islands Conservation Society's Seattle-Based Ship to Enforce No-Fishing Zone." *Seattle Post – Intelligencer*, 27 November 2000, A9.

Gumbel, Andrew. "The Green Issue: The Galápagos Islands: PARADISE LOST?; Modern Life has Caught up With the Cradle of Evolution. Too Many Tourists, Expanding Population, Over-Fishing and Pollution are Endangering the Flora and Fauna." *The Independent*, 18 April 2005, page 24.25.

Hass, Peter M., Robert O. Keohane, and Marc A. Levy. *Institutions for the Earth: Sources of Effective International Environmental Protection*. Cambridge: The MIT Press, 1993.

Hider, James. "This Glorious Fellow is Facing Extinction. Who is to Blame?" *The Times*, 25 June 2005, page 55.

Howden, Daniel. "Ecuador Pressured to Save Galápagos Wildlife." *The Independent*, 1 April 2005, page 35.

"Human Impact Threatens Unique Galápagos Islands." *The Daily Yomiuri*, 3 June 2001, page 1.

Marking and Recapture of Lobsters in the Galápagos.

<<http://www.darwinfoundation.org/marine/lobster.html>> (12 February 2006).

Marshall, Bob. "Sharks to Get Needed Help." *Times-Picayune*, 25 April 1993, C15.

Nicholson, Jeanne. "Galápagos Islands are no Longer Darwin's Eden." *The Providence Journal*, 19 January 2003, K10.

Nuttall, Nick. "Fishing Threat to Wildlife Haven." *The Times*, 8 March 1997, page 17.

One More Year of Fisheries Monitoring.

<<http://www.darwinfoundation.org/Ourwork/marine/m13.html>> (12 February 2006).



Our Strategies and Our Progress.

<<http://www.darwinfoundation.org/Ourwork/history.html>> (12 February 2006).

Platt, Anne. "It's About More Than Sea Cucumbers." *World Watch*, Vol. 8, Iss. 3 (May 1995): 2.

Rohter, Larry. "Where Darwin Mused, Strife Over Ecosystem." *New York Times*, 27 December 2000, A1.

Schloon, Nicholas. "Marines on Sea Cucumber Alert." *The Independent*, 22 January 1996, page 11.

Schrader, Esther. "Galápagos Isles Threatened by Sea Harvest Over Fishing Stresses Fragile Chain." *Times – Picayune*, 9 April 1995, A32.

\_\_\_\_\_. "Sea Cucumber Mania Threatens Galápagos Islands." *The Oregonian*, 9 April 1995, A6.

\_\_\_\_\_. "Search for Sea Cucumbers Threatens Galápagos Tortoises – Fishermen Defy Call For Moratorium on Illegal Harvest." *Seattle Times*, 9 April 1995, A15.

Solano, Gonzalo. "Battle Over Ecosystem in Ecuador's Galápagos Islands Causes Waves a New Struggle is Raging in Puerto Ayora, Part of the Galápagos Islands. Fishermen who are Unwilling to Accept Limits on Their Catch are Openly and Violently Defying the Ecuadorian Government's Efforts to Preserve a Delicate and Threatened Ecosystem." *The Grand Rapids Press*, 29 December 2000, A14.

\_\_\_\_\_. "Struggle Grows Over Galápagos." *Milwaukee Journal Sentinel*, 29 December 2000, 17A.

Stone, Richard. "Fishermen Threaten Galápagos." *Science*, Vol. 267, Iss. 5198 (3 February 1995): 611.

Strike by Fishermen on Santa Cruz Island, Position Statement by Charles Darwin Foundation. <<http://www.darwinfoundation.org/news/news04290202.html>> (12 February 2006).

Young, Oran R. *The Effectiveness of International Environmental Regimes: Causal Connections and Behavioral Mechanisms*. Cambridge: The MIT Press, 1999.

### ***Interviews***

Larrea, Irma. World Wildlife Foundation. Interview by author and class. 17 January 2006.