

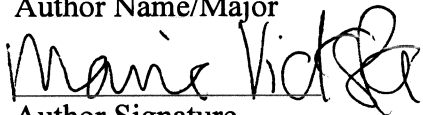
## ABSTRACT

### Present Management Practices and Future Possibilities for the Concha Prieta (*Anadara tuberculosa*) in the community of San Felipe, Ecuador

San Felipe is a small fishing village on the Caraquez estuary on the coast of Ecuador. Only twenty years ago, this community was able to sustain itself on clam collecting, but due to poor management and mangrove destruction, it can no longer sustain itself on this industry alone. This project examines the possible involvement of community stakeholders in future management practices that empower local changes based on issues in legal limits, local management, and land use change. It was found that municipal management does not foster the sustainable use of the resource. The community regularly harvests clams of all sizes with impunity in violation of the legal limits put in place by the local municipality. Fortunately, the release of waste water containing chemicals by commercial shrimp pools does not seem to be negatively impacting the clam population. The land use change in the past 20 years has drastically altered the estuary where community members live and work, mainly through the conversion of mangrove forests to shrimp pools. Although these results may look bleak, after interviews with community members the attitude and motivation appears to exist to attempt some alternative mode of action.

Marie Vicksta, Biology

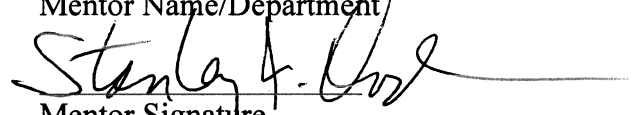
Author Name/Major



Author Signature

Stanley Dodson, Zoology

Mentor Name/Department



Mentor Signature

5/8/07

Date

## COVER SHEET

TITLE: Present Management Practices and Future Possibilities for the Concha Prieta  
(*Anadara tuberculosa*) in the community of San Felipe, Ecuador

AUTHOR'S NAME: Marie Vicksta

MAJOR: Biology

DEPARTMENT: Zoology

MENTOR: Stanley Dodson

DEPARTMENT: Zoology

MENTOR(2): \_\_\_\_\_

DEPARTMENT(2): \_\_\_\_\_

YEAR: 2007

(The following statement must be included if you want your paper included in the library's electronic repository.)

**The author hereby grants to University of Wisconsin-Madison the permission to reproduce and to distribute publicly paper and electronic copies of this thesis document in whole or in part in any medium now known or hereafter created.**

Present Management Practices and future  
Possibilities for the Concha Prieta (*Anadara  
tuberculosa*) in the community of San  
Felipe, Ecuador

Marie Katherine Vicksta  
Biology Honors Thesis  
University of Wisconsin  
May 2007

Advisor: Dr. Stanley Dodson

## **Abstract**

San Felipe is a small fishing village on the Caraquez estuary on the coast of Ecuador. Only twenty years ago, this community was able to sustain itself on clam collecting, but due to poor management and mangrove destruction, it can no longer sustain itself on this industry alone. This project examines the possible involvement of community stakeholders in future management practices that empower local changes based on issues in legal limits, local management, and land use change. It was found that municipal management does not foster the sustainable use of the resource. The community regularly harvests clams of all sizes with impunity in violation of the legal limits put in place by the local municipality. Fortunately, the release of waste water containing chemicals by commercial shrimp pools does not seem to be negatively impacting the clam population. The land use change in the past 20 years has drastically altered the estuary where community members live and work, mainly through the conversion of mangrove forests to shrimp pools. Although these results may look bleak, after interviews with community members the attitude and motivation appears to exist to attempt some alternative mode of action.

## **Introduction**

Community based conservation has recently emerged as a tool that makes the critical connection of humans to their environment. It has long been understood that humans alter the areas where they live and work, but it has not been until recently that this fact has been incorporated into research and conservation strategies (Berkes 2004, Salafsky 2001). This strategy for conservation actively involves communities that have

stakes in the preservation of the land and its resources. Theoretically, by involving communities through education and policy development, conservation policies can emerge that create a healthy compromise between the needs of the people and the resource (Roe and Jack 2001).

Some of the problems that have been found in community based conservation stem from the fact that the communities are as dynamic as the ecosystems that they rely on. Often communities have complex interests and interactions that are hard to initially diagnose (Berkes 2005). These interactions are not limited to the community; often there are external influences that force a behavior or action. These limitations lead some to believe that management at the community level will not be adequate (Berkes 2005). Also, finding the balance between communities' economic needs and ecosystems' conservation needs is incredibly complex and must be examined carefully (Salafsky 2001). Many times the implementation of the community based conservation plans are difficult because the conservation goals are often complicated and the management plans lack organization and consistent leadership (Kellert et al. 2000). The good intentions linked to community based conservation, like local empowerment, preserving traditional practices, and biodiversity protection are often compromised and can lead to ultimately unsuccessful projects (Kellert et al. 2000).

In the small community of San Felipe on the Northern coast of Ecuador, the consequences of extreme land use change and resource exploitation have community members seriously concerned and looking for solutions (Mera 2006, Vera2006). This is a small village of "concheros" who make a living largely through clam collecting and fishing. The village of San Felipe is a community that can trace its roots to four founding

matriarchs (Vera 2006). These sisters instituted the trade of clam collection and it is a trade that has been passed down for the past four generations. They have taken steps in order to attempt self regulation, but these attempts were unsuccessful. They established an association of fishermen and concheros in 1999 (Mera 2006). This association was meant to help organize the way the community used the estuary, however, it has proven difficult for the community to maintain any consistency in meetings or decisions (Mera 2006, Vera 2006).

### Land Use Change

The estuary that the clam depends upon for survival was devastated in the 1970s and 1980s by mangrove deforestation for the development of shrimp farming (Sealy & Bustamente 1999, Historia de San Vicente 2005, PMRC, MacKenzie, Jr. 2001). It is estimated that over 90% of mangrove forests have been destroyed to make way for shrimp ponds (Stram et al. 2005). In Ecuador, 118,000 hectares of shrimp ponds were created between the years 1969 and 1987, and of those 28,000 hectares were mangrove forests (Southgate and Whitaker 1992, Terchunian et al 1986). This has left the ecosystem much more vulnerable to both biotic and abiotic factors that affect the ecosystem. The El Nino effect, for example was amplified in 1997 and 1998 because of the absence of the mangroves protection (Stram et al. 2005, PMRC 2006). The loss of habitat has resulted in reduced productivity in the estuary as well, which has direct economic consequences on the surrounding communities (Cruz et al. 2003).

Not only are there negative effects from the degradation of the mangroves to create shrimp farms, the practices that they utilize also weaken the ecosystem. The residual water from these shrimp pools is routinely released back into the estuary with no

attempt at treatment to remove chemicals and growth supplements which are very commonly used, such as rotenone, a controversial piscicide, and amifloxacin, an antibiotic (Historia de San Vicente 2005, Acosta 2006, Stram et al 2005, PMRC 2006). This weakened ecosystem is what the people in the area depend on for survival, and these negative effects will only get worse if continued.

### Legality and Management

The livelihood of the conchero is becoming increasingly unappealing as habitat degradation and overexploitation has created a stress on the ecosystem that is becoming harder and harder to ignore. Community members used to be able to sustain themselves by collecting clams from the estuary. The clams are sold for about \$8-10 per 100 at market. In the past, concheros said that they would have been able easily collect 100 or more. One conchera said that her greatest catch was over 1100 in one day (Vera 2006). However, the stresses of over harvesting and habitat destruction have caused the population of black clams, *Anadara tuberculosa*, to become so greatly reduced that these concheros are being driven elsewhere to find work.

*Anadara tuberculosa* is a clam species that is found in the several centimeters below the mud at the base of red mangrove trees. In Costa Rica, the clams maturity has been found to begin at shell lengths between 23-26 mm, although reproductive patterns of *Anadara* mollusks have been found to vary with environmental conditions (Ampie and Cruz 1989, Caraenas and Aranda 2000, Cruz 1983). Other important aspects of the life history of this mollusk, such as the time it takes to reach maturity and life expectancy, remain relatively unknown.

The stress caused by overexploitation has become increasingly noticeable. Due to the lack of government control, the estuary shoreline where the clams are collected is an open access resource (Southgate and Whitaker 1992, Mackenzie 2001). There is no regulation on how many people may have access nor are there limitations on how much they may take. Therefore, the clams' decreasing size and population density are both red flags to community members that a change is necessary. The local municipality has established 4.5 cm diameter as the legal minimum for collection, but this policy is rarely enforced.

The ultimate purpose of this study is to help develop a community based conservation effort. My project focused on three central questions. The first was; what kinds of land use changes have the people of San Felipe experienced in the past thirty years? The second was; is the management practice of releasing pool waste water into the estuary having any effect on the clam population? The third was; are restrictions in place providing the protection necessary for a viable clam population?

## **Study Site**

The study site was in the coastal pueblo of San Felipe, which is 3 km. from the municipal city of San Vicente in the province of Manabí ( $0^{\circ} 36' 13''\text{S}$ ,  $80^{\circ} 23' 32''\text{W}$ ). San Felipe is located on the estuary of Caraquez, which is formed by the rivers Chone and Carrizal (Fig. 1). This area's primary industries are fishing and shrimp aquaculture. The sampling sites were on what the concheros called Esteros, narrow canals that drained out to the estuary, and Entradas, the shoreline that was along the estuary.

## **Methods**

### Interviews

Interviews were conducted within the community and with experts in the area. The key informants of the community were Municipal President Gualberto Mera and former president Marianna Vera. Gualberto Mera was interviewed several times at his home. He acted as the voice of the community, raising many of the concerns community members had regarding their future. Marianna Vera was interviewed both at her home and while on the boat during collection periods. She provided a wealth of knowledge of the history of the community and the changes that have occurred in the estuary in the last 30 years. The experts that were interviewed were Dr. Miguel Acosta, a university professor at the Universidad Catolica, Manabi and Javier Palma, the harbor master. These interviews were both conducted in their offices. Both Dr. Acosta and Mr. Palma provided information on the health of the estuary and municipal management practices. All of the interviews were conducted in Spanish by Laura Kuhl, undergraduate at Middlebury College, and myself.

Map outlines of the estuary were created to obtain community input on the changes in land use. This information was added to the maps at community meetings to document the current condition of the estuary and the memory the community members have of the estuary 20 years ago. Dario Proano, a local environmental expert, facilitated these sessions. The information gathered was related to land use and resource extent. This was supplemented by information gathered from key informants, Marianna Vera Mera and Sergio Aurelio Mera. They supplied data on land history and extent of clam collecting during several boat trips to the estuary to collect GPS points.

### Legality and management

Two methods were used to investigate the effectiveness of the local management restrictions. Clams were purchased on multiple occasions to examine the sizes of clams sold at market. These clams were weighed and measured. Clams were also collected from 3 designated sites, Estero Piangual, Entrada Piangual, and Entrada Piangual, with the assistance of Sergio Aurelio Mera and Marianna Vera over a three month period. These clams were also weighted and measured.

A method was also developed to examine the collection behaviors of the San Felipe community members. Concheros were given 56 numbered clams of varying sizes and were then asked to separate the clams based on whether they would release them back to the estuary, take them to market, or save them for home consumption. They were also asked what prices they would expect for the clams if they were taken to market. In total, 15 concheros were interviewed.

### Statistical Methods

The data collected from the sample sites over the 3 month period were tested for independence using the Chi square at 0.05 confidence level. The test was run in two ways, testing independence among dates and sample sites. Linear correlation  $R^2$  values were also calculated to examine the significance of the change in variables over the sampling period.

## **Results**

### Effects of Land Use Shift

Maps that were generated by the community members represent the state of the estuary roughly 20 years ago and at present (Fig 2). The input on these maps was used to make the computer generated maps of the location of mangroves and shrimp farms on the estuary.

### Legality and Management

The values calculated amongst dates yielded few significant values and no notable trends. Clam weights were significantly different between the sites Estero Piangual and Entrada Piangual and also between Estero Piangual and Entrada Juaquin for the first three sample dates. These significant differences were only consistent throughout the first three sample dates and only for the weight of the clam and weight of clam meat.

Consistently, the average weight of the entire clam, weight of the clam meat, and size of the clam from the Entrada Piangual site was greater than those from the Esteros Piangual and Juaquin (Fig. 3) The  $R^2$  value was also calculated for each variable over time (Table 1). Entrada Piangual had some values that could be considered a significant correlation between these variables and time period. There was no noticeable correlation between these variables and time period. The data collected from the site sampling was then analyzed from the perspective of legality (Fig 4). There was no consistency found that the majority of clams collected were below the legal limit. However, when looking at the legality between the three sites, the difference is quite striking (Fig. 4). There is

about a 75% probability of collecting a legal clam over an illegal clam in Estero Piangual, whereas in the Entradas the probability of collecting a legal clam is much lower. The collecting periods were timed in order to extrapolate a general rate of collection in order to determine the effort expended by concheros (Table 2). On average, 3 hours went into collecting about 30 clams. There was only one time period where the ratio of legal clams was less than that of illegal clams.

### Community and Management

Questionnaire results revealed that the fate of the clam is based on its size (Fig. 5). The proportion of clams that would be taken from the estuary to be sold at market illegally is over double the amount of legally sized clams that are being taken to market. However, those that are returned to the estuary or consumed at home are predominately clams of illegal size.

To highlight the significance of the percentages it is important to show a graph of the actual numbers that were obtained (Fig. 5). The percentages are very promising because; over 80% of the clams that would have been returned to the estuary and consumed at home would have been illegal. When you see that this 80% does not even equal 200 clams and that more than twice that would have been taken to market illegally, a very different conclusion can be reached.

The clams that were measured at the market were also graphed based on legality (Fig 6). There is only one date sampled where the percentage of legal clams was greater than illegal clams. The other dates the percentage of legal clams being sold was never greater than 25% of the sample.

## **Discussion**

### Effects of Land Use

While these maps (Fig 2) are only based upon the communities' recollections, a strong sentiment of nostalgia permeates among the community members for the landscape of the past. This landscape and the community of San Felipe have experienced a great deal of change over the past 20 years. When asked about the past, community members would shake their heads and tell stories of their childhood, their memories of collecting with their parents or siblings, or playing in the mangroves. Also, when asked about the clams in the past, they would repeatedly reminisce on the larger size of the clams of a mere generation ago. Many times they would hold up their hands to give a visual, "this big", and their hands showing the entire size of their face. "It wasn't necessary to work hard to earn your daily bread. "All [the conchas] were huge." (Vera 2006). This sense of nostalgia could be an integral part of establishing a community based conservation effort. The sense of pride that these people have in their community and the connection that they have with the resource were very clear during the meetings we organized to create these maps as well as in the conversations we had with community members.

The deforestation that these maps document directly pinpoints the major factor affecting the success of the clam population. There are areas on these maps where we were told mangroves extended several hundred meters from the shore line. Now these areas are meters wide and only kept to protect the shrimp pools from erosion. The community members blame most of the problems that they are experiencing with the

clam resource on the shrimp farms. They recognize that the pools that have replaced the mangroves are impacting more than just the clam populations. However, they feel very helpless to bring about positive change.

The feeling that the community had a responsibility for the reduction in the clam population seemed to be absent. . The people interviewed focused on blaming the shrimp farms and the changes they had brought, rather than admit to the role their community also had in driving these changes. The connection between many people over exploiting a shrinking resource and the resource's viability had not been made. There are fewer people collecting clams now than previously, but that is only because people were finding it harder and harder to support their families, not out of the realization that the population was stressed. It is possible that they see their contribution as insignificant in comparison to the changes that the shrimping industry had brought.

The local municipal government recognizes the stress that the shrimping industry has put on the estuary. We obtained local documents that mention the ecological problems that have resulted from shrimp aquaculture. However, there has been no action that we are aware of to mitigate this stress through any sort of government implemented management plan. In an interview with the community president, Gualberto Mera, it was very clear that he felt that the local municipality was not there to take care of their needs. "They send people here, they take measurements, but do we ever see any change? No." (Mera 2006). In fact, municipal engineers working 3 km from San Felipe did not know that the community existed. It is not through lack of initiative that these people are struggling, but lack of empowerment and confidence in their ability to initiate change in their environment.

## Legality and Management

These results indicate that there is inconsistency in the data as to whether the shrimp pool waste water is having any effect on the clams. The results from the Chi square test indicate that the sample obtained is independent from the date the samples were collected. This is reinforced by the R squared data obtained that there is little to no correlation between the samplings and the date they were collected. This was unexpected considering that the estuary is very seasonably variable. There is a distinct wet and dry season that is characterized by very different water and salinity levels (PMRC 18). It would be expected that this variability would affect the life cycle or at least the breeding patterns of the clams. It is quite possible that the sampling period was not long enough in order to capture the true range of variability that can be seen in the estuary.

It was expected that there would be a difference between the Estero Piangual and the Entradas Piangual and Juaquin. All of the esteros (canals) that lead out to the estuary are connected directly to one or more shrimp pool release pumps. These shrimp farms routinely pump out the water along with everything that was added to it from their pools, into the estuary via esteros. It was hypothesized that there would be a correlation between clam size and habitat location, given that there are any number of chemicals added to this water in order maximize the efficiency of the farms. The opposite trend would also have been a viable expectation, considering pesticides are also pumped out. These outcomes were not exactly what were observed. The first three dates had a significant difference between weights of both the entire clam and the meat of the clams collected at the Estero Piangual and the Entradas Piangual and Juaquin. This trend,

however, was not continued throughout the sampling period. It is hard to say what would cause this difference. Tissue samples were taken in order to obtain data on whether any of these chemical contaminants would be found, however, due to the cost involved in testing tissue, especially without having a confirmed list of chemicals to look for, was far too great to continue this line of investigation. In hind sight, water samples should have been taken for preliminary testing, which is much cheaper than testing tissue. These preliminary results could then have been used to pinpoint which chemicals to look for in the tissue samples collected.

During the three months of my research, even though there was not a notable correlation in size and sampling date, the average data collected at the Estero Piangual were all nearly always greater than the data collected from both Entradas. Without any additional data it is difficult to say why this difference in size exists. The concheros voiced no preference or advantage in collecting in the Entradas over the Esteros that would cause a difference in the size distributions.

It was also surprising to find that of the clams collected, there was no consistency in them being predominately legal or illegal. This result suggests that although the population is greatly reduced from previous numbers, the existing population may have an even age class distribution. This is assuming that the size limit of 45 mm correlates to the median age of the population. Unfortunately, no information could be found to explain why this limit exists. Neither the harbor master, nor the university professors could give a reason other than conjecture that it correlated to sexual maturity. Though the pooled data gives the appearance of a balance, when the data is separated by site, it can be interpreted differently. In the Estero, there is a 75% probability of collecting a

legally sized clam, whereas at the Entradas the probability of collecting a legally sized clam is reduced to about 45%. Considering this difference and the fact that the average rate of collection is 10-12 clams an hour, it would seem like the collecting effort of the concheros would be best focused in the Esteros.

Do the concheros really consider this minimum size limit when they are out collecting for themselves? It seems that the amount of effort that is put into clam collection must be justified by taking every clam you collect, whether or not it is of legal size. In our interviews, the concheros were very quick and confident in their methods of separating these clams for different uses. It was encouraging to learn that when they identified clams that should be returned, they were correct. However, of the 70% of the clams would have been taken to market, more than 60% were of an illegal size.

This was verified from the data collected from the market. An overwhelming majority of clams we found to be under the legal limit, in one instance over 90% of the clams sampled were illegal. In fact, the woman that we collected our market data from eventually prohibited us from measuring her clams, probably in fear that we were working for the government. This is a reality that must be considered in the management of these clams. The people who depend upon them for survival are poor and this type of labor is unskilled. They need the \$8-\$10 a day that they could potentially earn from the clams. If this means that they must take clams that are under the limit in order to obtain the 100 needed for market trade, they will do it.

There must be a viable alternative for these people to sustain themselves on if any kind of clam rehabilitation is going to be successful. Both men and women of the

community relied on collecting clams, but now a shift away from this trade is being observed. Many men and women are now collecting clams for self-subsistence only.

The concheros are also trying to find other ways to sustain themselves that were independent of the estuary because of the growing inability to sustain themselves on clam collecting. Some men were instead earning a living by illegally taking sand from local beaches for construction. This shift is unreliable because construction companies do not have consistent demand. It is also not economically viable; the men are paid \$8-10 per truckload of sand to be split among the group which usually evens out to \$1-2 a truckload per person. Many of the men also work seasonally for the shrimp farms. This kind of work is only available a few times a year and is also in very limited demand. The President of San Felipe said that at most people work for the farms 4 times a year. Each farm only takes a 5-6 men for labor, but the pay is very good (Mera 2006). These options do not offer a reliable source of income for the community.

Women concheras are working more in the home or trying to find work in town. There was an attempt to create a women's sewing cooperative in the community by a foreign group to facilitate a shift for women from clam collection. They provided industrial sewing machines and capital for startup. It is important to remember that this community survives from day to day. Unfortunately, this startup capital was used for other community needs and the idea of a sewing cooperative is now seen as impossible.

## **Conclusion**

The ultimate purpose of this study is to help develop a community based conservation effort. It is very possible given the proper resources, guidance, and capital that a project could be very successful. The clam population does not appear to be in

such a state that localized extinction is imminent; however, some sort of management must be implemented soon. The greatest need in this case is habitat restoration and the community has proven to be capable of doing that given that they have the necessary empowerment to make a change.

Reforestation should be the ultimate goal in the management strategy, but proximately something has to be done to boost the clam population numbers. Most importantly, any action taken must be done with the cooperation and understanding of the community members. If they are given the information in this paper, the community could become directly involved in the development of a management plan that could succeed, instead of dictated limits and regulations from outside powers that are failing.

Efforts would need to be taken to ensure that this community based effort would not succumb to the kinds of problems that other projects have encountered. When projects are brought to them and proposed as possible, the community is very capable of taking action. The mangrove patches in the estuary in the second map were reforested with the help of the of the community members under foreign direction (Mera 2006, Vera 2006). Also, a water system was installed in four days and all the labor was provided by the community. As put by the President of San Felipe, “We may not have much, but we have strong backs” (Mera 2006). It is obvious that the community sees a need for change and has the follow through to make big changes in the short term when change is proposed as possible. Programs need to be implemented to give the community members the education necessary and the empowerment needed to support the new practices proposed in the long term and to prevent the continuation of current unregulated practices. By working with community members, new management practices can be

designed and adopted in order to support habitat restoration and sustainable collecting practices.

## **Further Studies**

The ultimate goal is work with community members towards a sustainable clam fishery. To continue working towards that goal with this community and its clam population, there are several areas that require more research before any sort of action be taken. Biologically, if some sort of clam rearing area is undertaken, maturation times and life expectancy needs to be better understood. Also, the population structure needs to be more accurately examined. It would also be valuable to know how quickly reforested areas could become repopulated. If repopulation relied on natural processes, what kind of time period would be needed?

Socially, the community dynamics need to be better understood. It seems that there would be some struggle for power within the community if management decisions were left to them. How would such decisions be made? Are there some families that have greater power and more influence in decision making? Could this kind of project be developed to benefit everyone?

It also must be known what community members would have an interest in learning about the clam and its environment. From conversations with community members the knowledge seemed to be limited to clam collection techniques. What do they know about how the estuarine environment works?

For any participatory project to be successful in this community these biological and social questions must be answered. The awareness of the need for action exists in this community, but the awareness of their capability of action needs to be realized and

incorporated into management action. An environmental education program would also be ideal. One trend in successful community based programs is the implementation of some sort of workshop or program that educates the community as to the reasons why their involvement is critical to the success of the species. Making them aware of the importance of their role in conservation would help in the project's success. Also, if the community is expected to self-regulate there must be a basic understanding about what they are regulating. This educational support would illustrate how the community is critical to the long term success of the clam species.

### **Acknowledgements**

I would like to thank my thesis advisor, Dr. Stanley Dodson, for the guidance and support he has given me throughout this project. Without his support this project would never have been realized. I would also like to thank Dario Proano for the support that he gave to us while we were in Ecuador. His guidance while we were in the field was also invaluable. Lastly, and most importantly, I would like to thank the community of San Felipe that so quickly accepted us into their community. Their eagerness to assist us and answer our unending questions ultimately made this project a success.

## Works Cited

- Acosta, Miguel. Personal Interview. June 14, 2006.
- Ampie, C.L., and R.A. Cruz. 1989. Tamano y Madurez sexual de *Anadara tuberculosa* en Costa Rica. *Brenesia*. 31:21-24.
- Berkes, Firket. 2004. Rethinking Community Based Conservation. *Conservation Biology* (18) 621-630.
- Cruz, Rafael A., 1983. Algunos aspectos de la reproducción en *Anadara tuberculosa* (Pelecypoda: Arcidae) de Punta Morales, Puntarenas, Costa Rica. *Revista de Biología Tropical*. 45-50.
- Google Earth. 2007. Image of Ecuador
- Google Earth. 2007. Image of Province of Manabí
- Historia de San Vicente. El Municipio de San Vicente. 2005
- Kellert, Stephen R., Mehta, Jai N., Ebbin, Syma A., and Laly L. Lichtenfeld. 2000. Community Natural Resource Management: Promise, Rhetoric, and Reality. *Society and Natural Resources*. 13:705-715.
- MacKenzie Jr., Clyde L., 2001. The Fisheries for mangrove cockles, *Anadara* spp. From Mexico to Peru, with descriptions of their habitats and biology, the fishermen's lives and the effects of shrimp farming. *Marine Fisheries Review*. 63:1-39.
- Mera, Gualberto. Personal Interview. June 10, 2006
- Programa de Manejo de Recursos Costeros. 2006. Estudio de Zonificación y manejo de conflictos de la pesca artesanal en la UVC Bahía. Bahía de Caraquez Ecuador.
- Salafsky, Nick. 2001. *Community Based approaches for combining conservation and development*. The Biodiversity Crisis: Losing What Counts. Edited, Micheal J. Novacek.. The New Press. New York.
- Sealy, Kathleen Sullivan and Bustamente, Georgina. Setting Geographic Priorities for Marine Conservation in Latin America and the Caribbean. Arlington: The Nature Conservancy. 1999.
- Southgate, Douglas. and Whitaker, Morris. 1992. Promoting Resource Degradation in Latin America: Tropical Deforestation, Soil Erosion, and Coastal Ecosystems. *Economic Development and Cultural Change*. 40:787-807.

Stram, D.L., Kincaid, C.R., and D.E. Campbell. 2005. Water Quality Modeling in the Rio Chone Estuary. *Journal of Coastal Research*. 21:797-810.

Terchunian, Aram., Klemas, Victor., Segovia, Alberto., Alvarez, Agustin., Vasconez, Byron., and Luis Guerrero. 1986. Mangrove Mapping in Ecuador: The Impact of Shrimp Pond Construction. *Environmental Management*. 10:345-350.

Vera, Marianna. Personal Interview. June 7, 2006.

## Tables

Table 1 - R squared values for regression lines

	Average Weights over sample period	Average weights of Clam Meat	Average Size
Entrada Piangual	0.45	0.007	0.72
Estero Piangual	0.081	0.313	0.115
Estero Juaquin	0.001	0.097	0.105

Table 2 Clam Collecting Effort

	5/28/2006	6/1/2006	6/6/2006	6/13/2006
Hours	3.50	3	3	2.75
Number of Legal Clams	21	17	22	21
Number of Illegal Clams	15	19	10	9
Total number of Clams	36	36	32	30
Clam/hr	10.29	12	10.67	10.91
Number Legal Clams/Number of Illegal Clams	1.40	0.89	2.20	2.33

## Figure Legend

Figure 1: Map of Ecuador and a zoomed image of the province of Manabí with a marker indicating the study site of San Felipe.

Figure 2: This group of figures are the maps of the estuary 20 years ago and now that were created by the community and also of the computer generated maps that were created from this data. These maps document from the communities' perspective the land use change over the last 20 years.

Figure 3: This group of graphs is of the average weights, sizes, and weights of clam meat over the three month sampling period. In each of the graphs the averages from the Entrada Piangual is greater than the averages from the Esteros Piangual and Jaquin.

Figure 4: This group of graphs is first of the percentage of clams that are legal to the percentage that are illegal over the sampling dates. The percentage of clams collected was not consistently below the legal limit across all the sampling sites. The next graph is of the breakdown of the ratio of legal to illegal between the sites. Here the ratio of legal to illegal clams is greatest at the Estero Piangual, about 3:1, whereas the Entradas are both about 2:3.

Figure 5: This group of graphs is of the responses received from our interviews regarding ultimate fates of clams based on their sizes. The first graph is of the percentages of clams that people said would be sold at market, returned to the estuary, consumed in home, and total. The next graph uses the numbers of clams given for these responses. Both graphs show that many of the clams being taken from the estuary are below the legal limit.

Figure 6: This graph is representing the percentage ratio of legal to illegal clams that we measured at the market. For the majority of these dates the illegal clams greatly outnumber the legal clams.

Figure 7: This is a picture taken from the boat of a section of shoreline where the only mangroves remaining are a meter wide and only kept to protect the shrimp pool behind it.

Figure 8: This is an aerial photo of the shoreline where the shrimp pools are actually built into the estuary. You can also see the pools that are along the shoreline.

# Figures

Figure 1

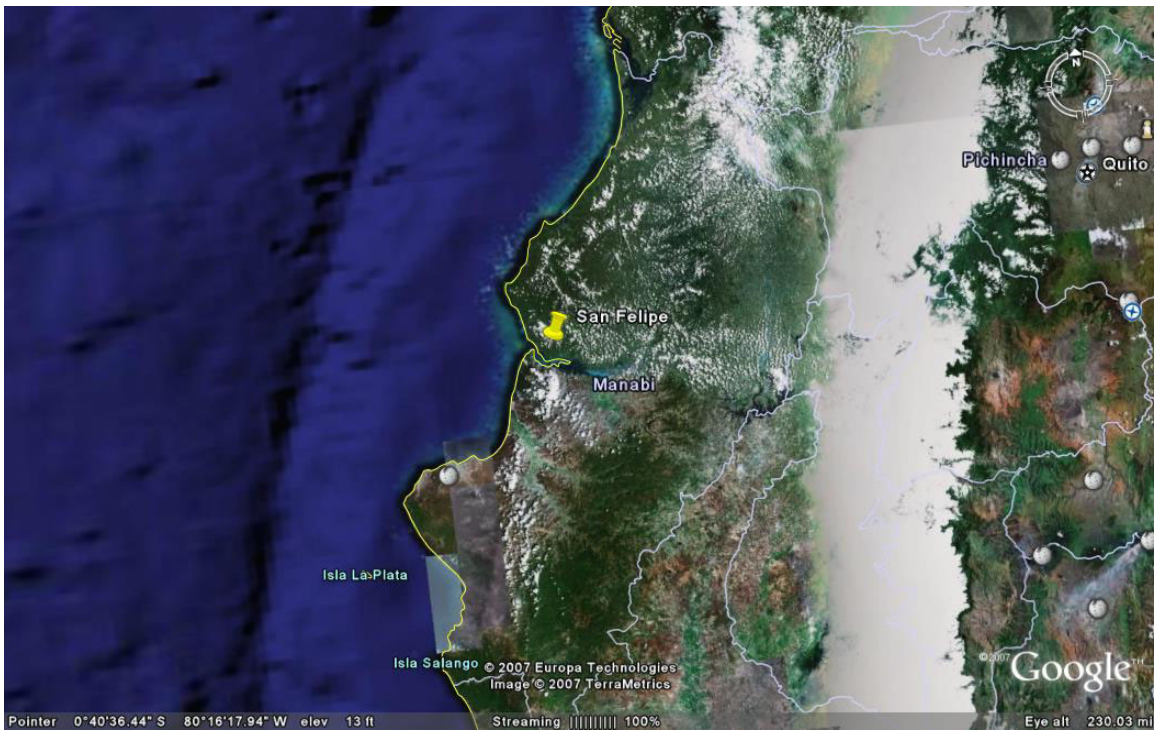


Figure 2

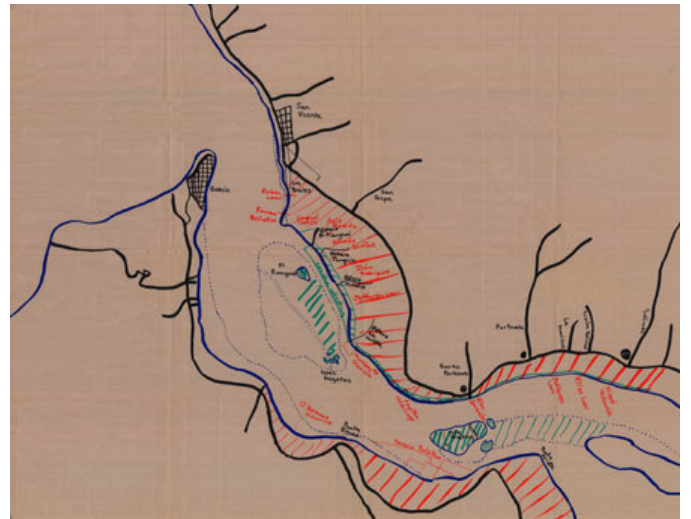
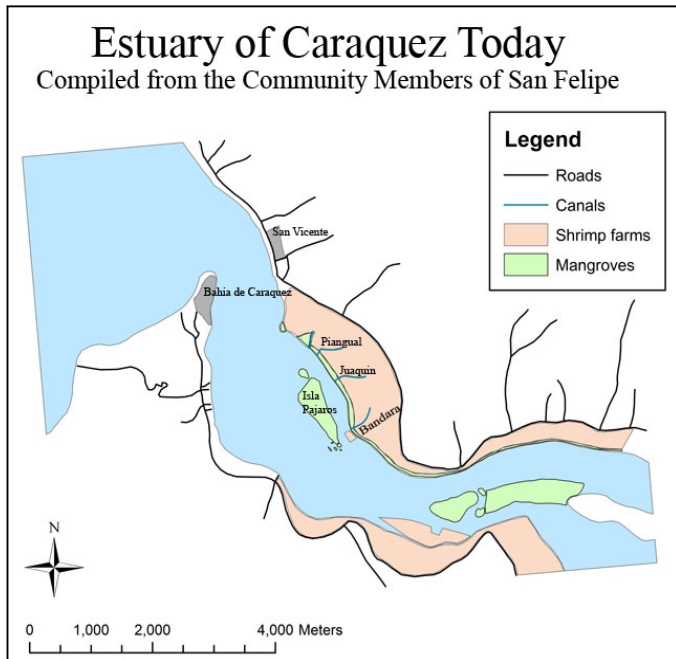
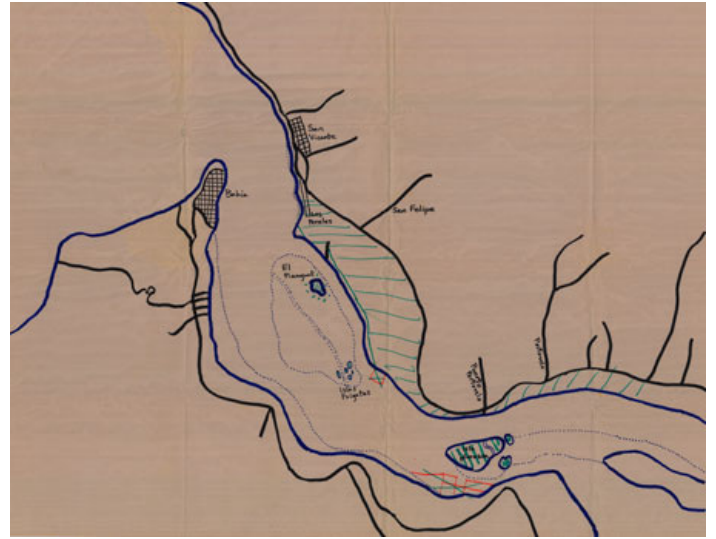
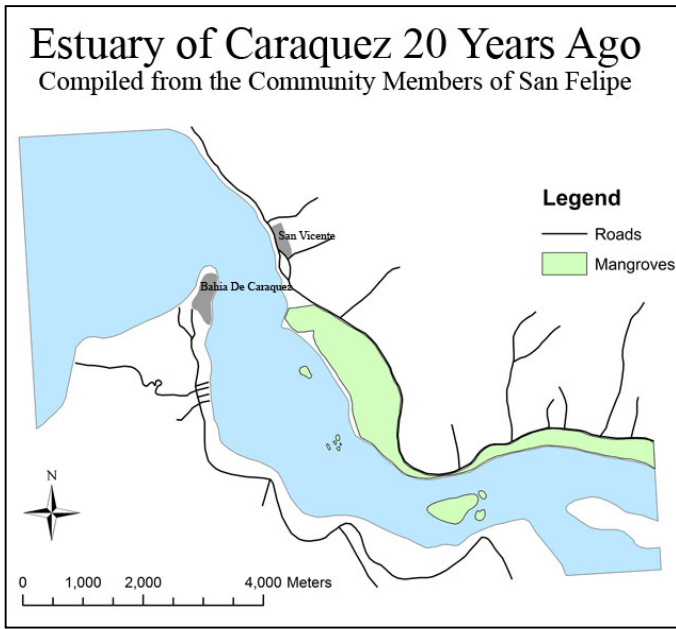


Figure 3

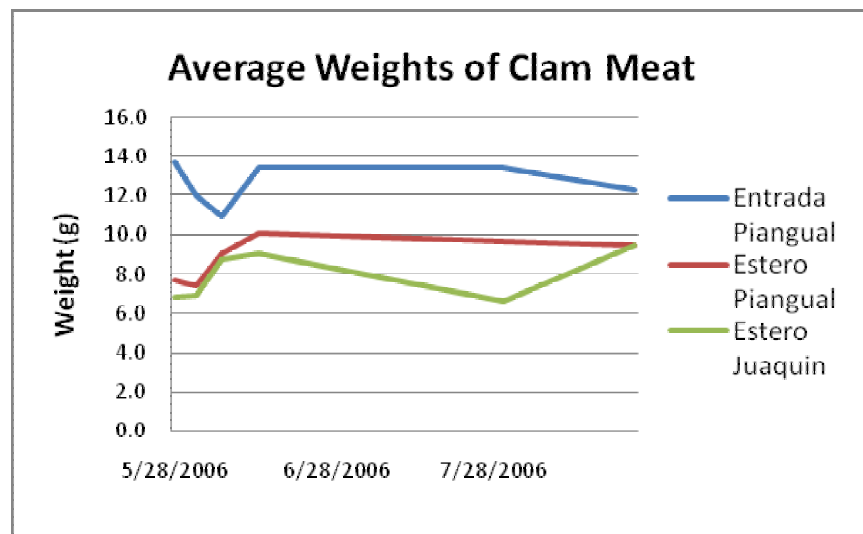
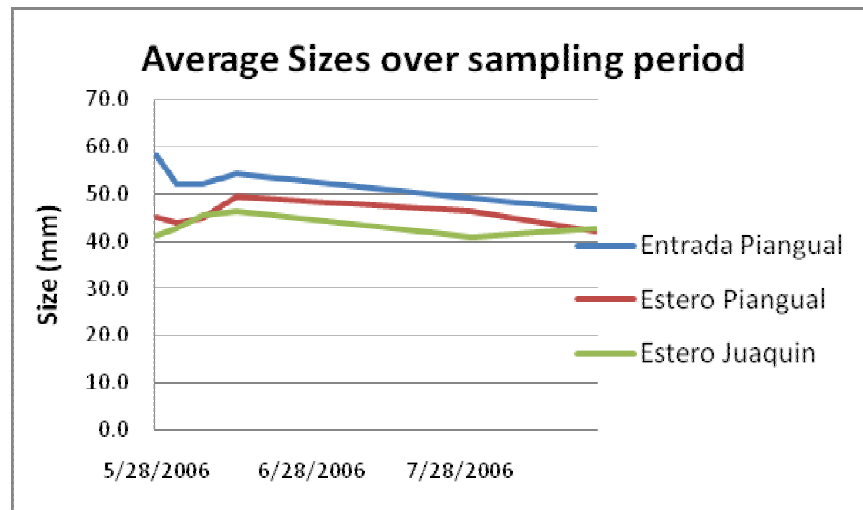
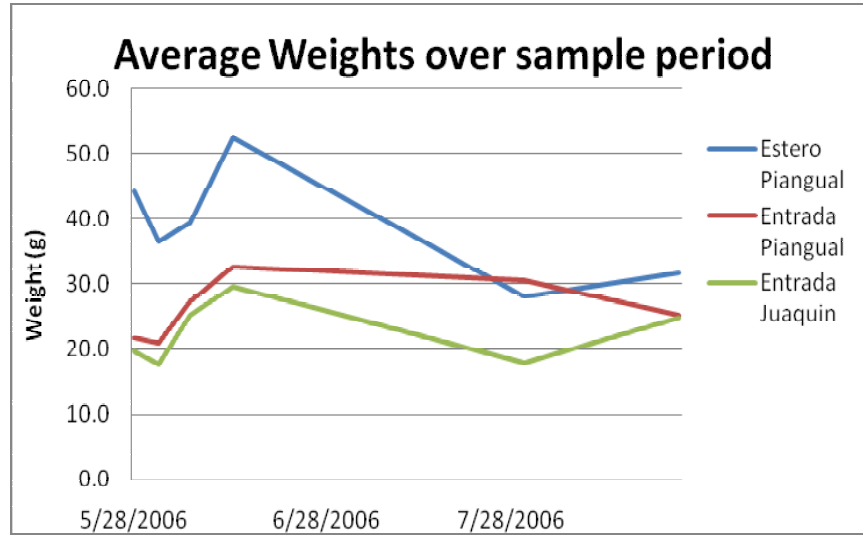


Figure 4

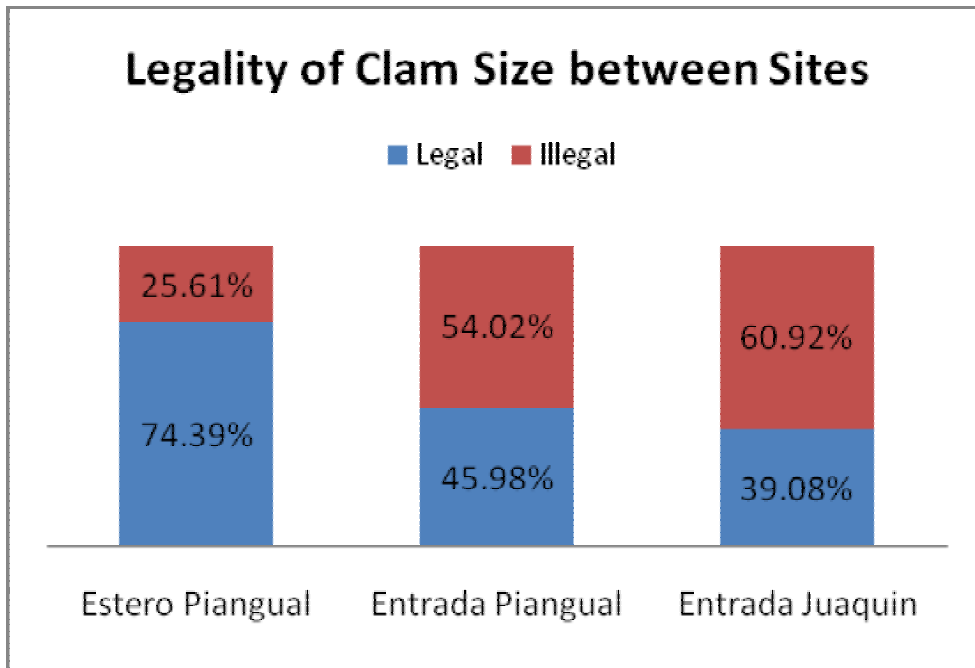
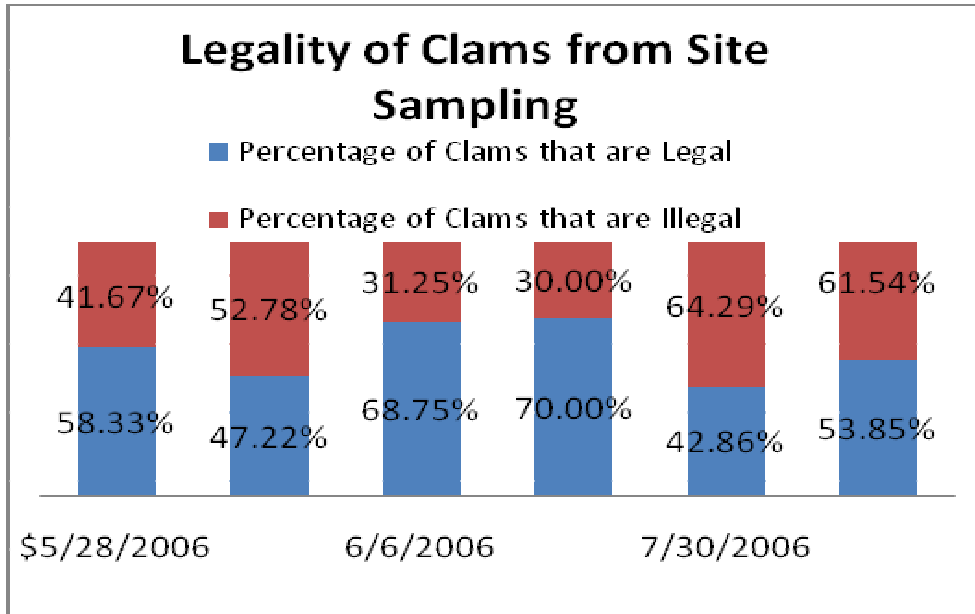


Figure 5

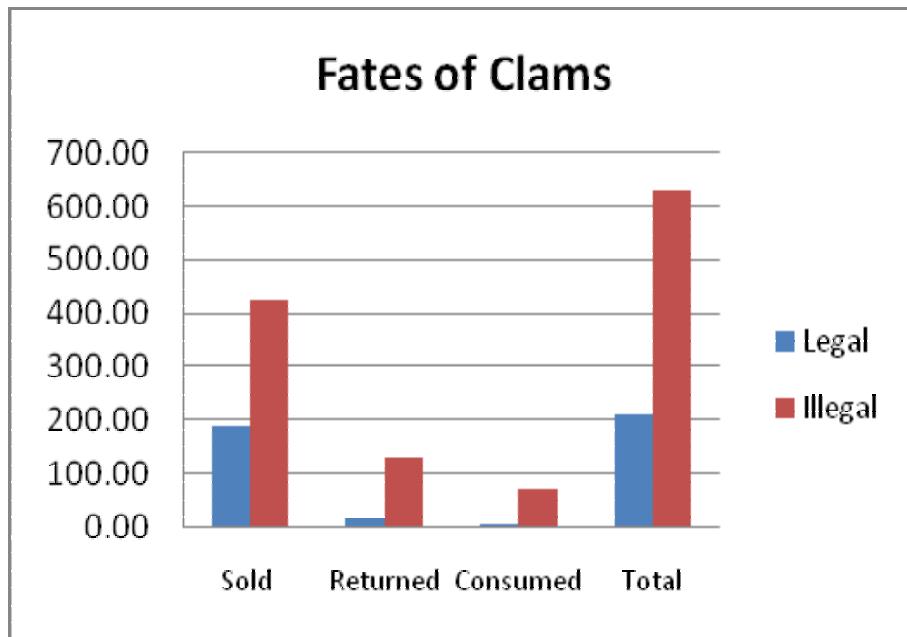
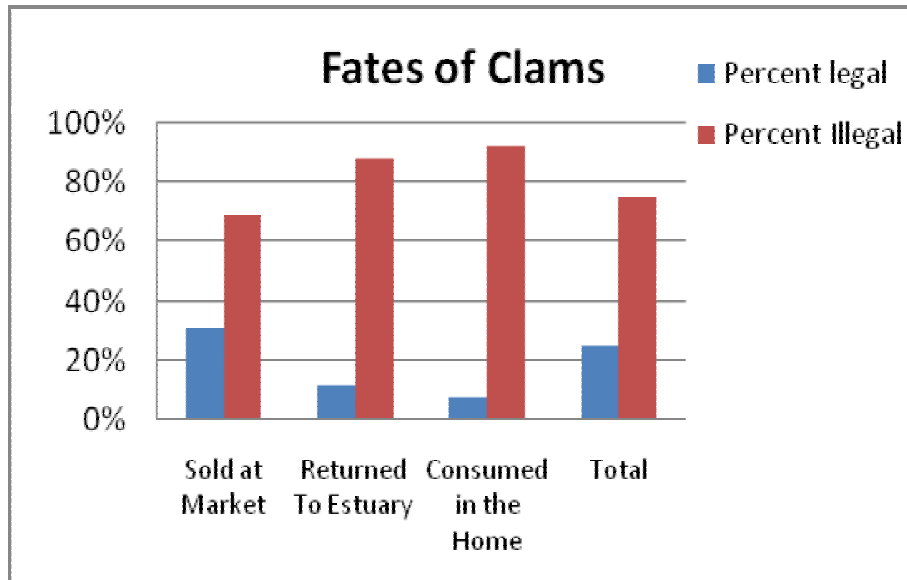


Figure 6

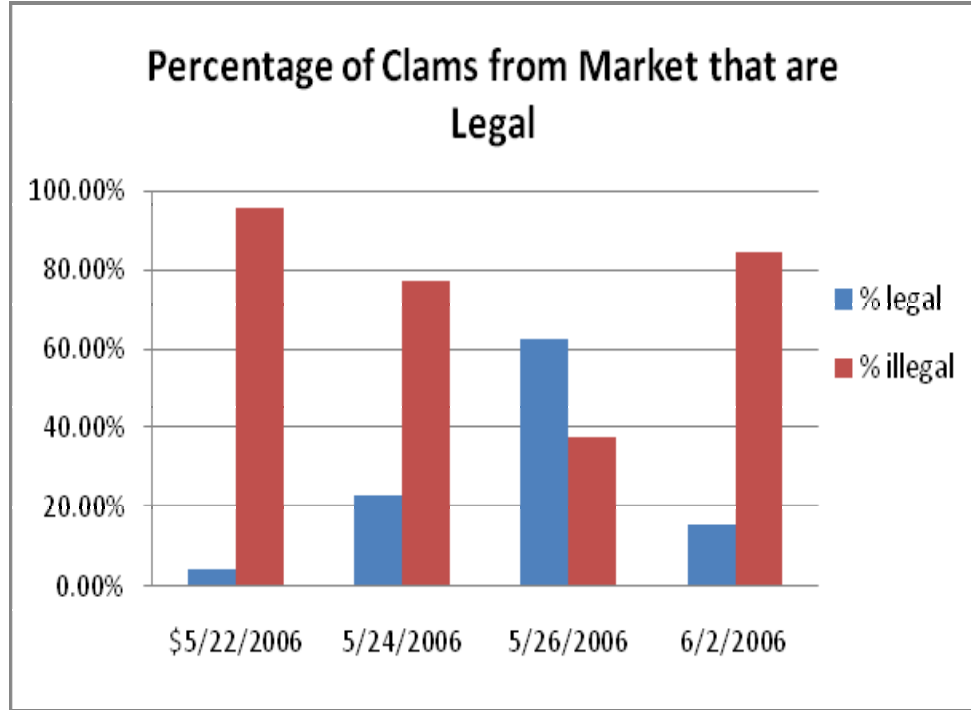


Figure 7



Figure 8

