CLUSTERING LOUISIANA COMMERCIAL FISHERY PARTICIPANTS FOR THE ALLOCATION OF GOVERNMENT DISASTER PAYMENT: THE CASE OF HURRICANES KATRINA AND RITA

by

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Abstract

The purpose of this study is to evaluate the effectiveness of the methods used for allocating disaster funds to assist commercial fishery participants as a result of Hurricanes Katrina and Rita of 2005 and to examine alternative methods to aid in determining an efficient criterion for allocating public funds for fisheries assistance. The trip ticket data managed by the Louisiana Department of Wildlife and Fisheries were used and analyzed using a cluster analysis.

Results from the clustering procedures show that commercial fishermen consist of seven clusters, while wholesale/retail seafood dealers consist of six clusters. The three tiers into which commercial fishermen were originally classified can be extended to at least eleven (11) clusters, made up of three (3) clusters in tier 1 and an equal number of clusters (4) clusters in tier 2 and tier 3. Similarly, the original three tiers of wholesale/retail seafood dealers can be reclassified into at least nine (9) clusters with two clusters in tier 1, four (4) clusters in tier 2 and three (3) clusters in tier 3.

As a result of the clustering reclassifications, alternative compensation plans were developed for the commercial fishermen and wholesale/retail seafood dealers. These alternative compensation plans suggest a reallocation of disaster assistance funds among individual groups of fishermen and among individual groups of dealers. We finally recommend that alternative classification methods should always be considered in order to select the most efficient criterion for allocating public funds in the future.

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Dedication

To my wife, Beatrice, for her support and for pushing for the timely completion, not only of this report, but also of the entire M.S. program.

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Chapter 1 - Introduction

The Gulf of Mexico, a region that is comprised of the States of Texas, Louisiana, Mississippi, Alabama and Florida, has been battered by several tropical events of different magnitudes within the last decade. In the aftermath of these tropical events, people are usually dislocated and economic or business activities become disrupted due to damages to private, commercial and public assets as well as loss of income and business revenues.

Specifically, hurricanes Katrina and Rita in 2005 and hurricanes Gustav and Ike in 2008 caused disproportional disruptions of and damages to the coastal seafood sectors (shrimp, crab, oyster, wild crawfish and finfish) of the Gulf region, perhaps, because of its physical location and marine dependence. Louisiana, whose seafood industry is the largest, with an annual dockside seafood sales or purchases valued at an average of $261 million between 2006 and 2009 (Trip Ticket Data), and the hardest hit among the five Gulf of Mexico States, incurred a total economic loss of $582,660,258 (Caffey *et al*, 2007) from hurricanes Katrina and Rita alone. These damages are comprised of $103,522,186 (commercial dealers), $63,836,142 (commercial processors), $191,297,444 (commercial fishermen), and $224,004,486 (recreational vessels). As a result of this bitter experience from hurricanes Katrina and Rita, investors more adequately prepared for hurricanes Gustav and Ike, resulting in a minimal amount of damage to the Louisiana's seafood industry in 2008.

However, hurricanes Katrina and Rita of 2005 brought in federal funding for the restoration of the Gulf of Mexico's fishery industry. For example, $128 million was earmarked for the Gulf for this purpose under the first Emergency Disaster Recovery Program (EDRP I) with an additional $84.9 million under EDRP II (Simpson, 2007; 2008). Louisiana's total share of these funds was approximately $92 million. As a result of hurricanes Gustav and Ike that landed in 2008, additional funds were earmarked for Louisiana resulting in a total of $132.9 million of federal funds that have accrued to Louisiana due to hurricane disturbances since 2005. These dollars, provided through three separate congressional appropriations, funded a number of fishery recovery and assistance programs consistent with the purpose outlined by Congress.

From the $132.9 million, a total of $15 million was earmarked for direct payments to fishery participants who participated in a cooperative research project via a voluntary survey to measure the recovery of Louisiana's fisheries. More than half of this money ($8 million) was earmarked for resident commercial fishermen who held a valid commercial fisherman license in 2008 and had documented trip ticket landings (amount of seafood catch in pounds, sacks, etc.) during the period September 1, 2005 to August 31, 2008 and the remaining portion ($7 million) was earmarked for commercial wholesale/retail seafood dealers who held a valid commercial wholesale/retail dealer license in 2008 and had documented trip ticket purchases during the period September 1, 2005 to August 31, 2008. Seafood landings and other trip level information such as length of fishing vessel (in feet), length of fishing trip (in hours), type of fishing gear, fishing sites (where majority of seafood catch was harvested), etc., are reported via fishery-dependent forms or data sheets known as trip ticket forms.

1.1 Participation in Cooperative Research Survey

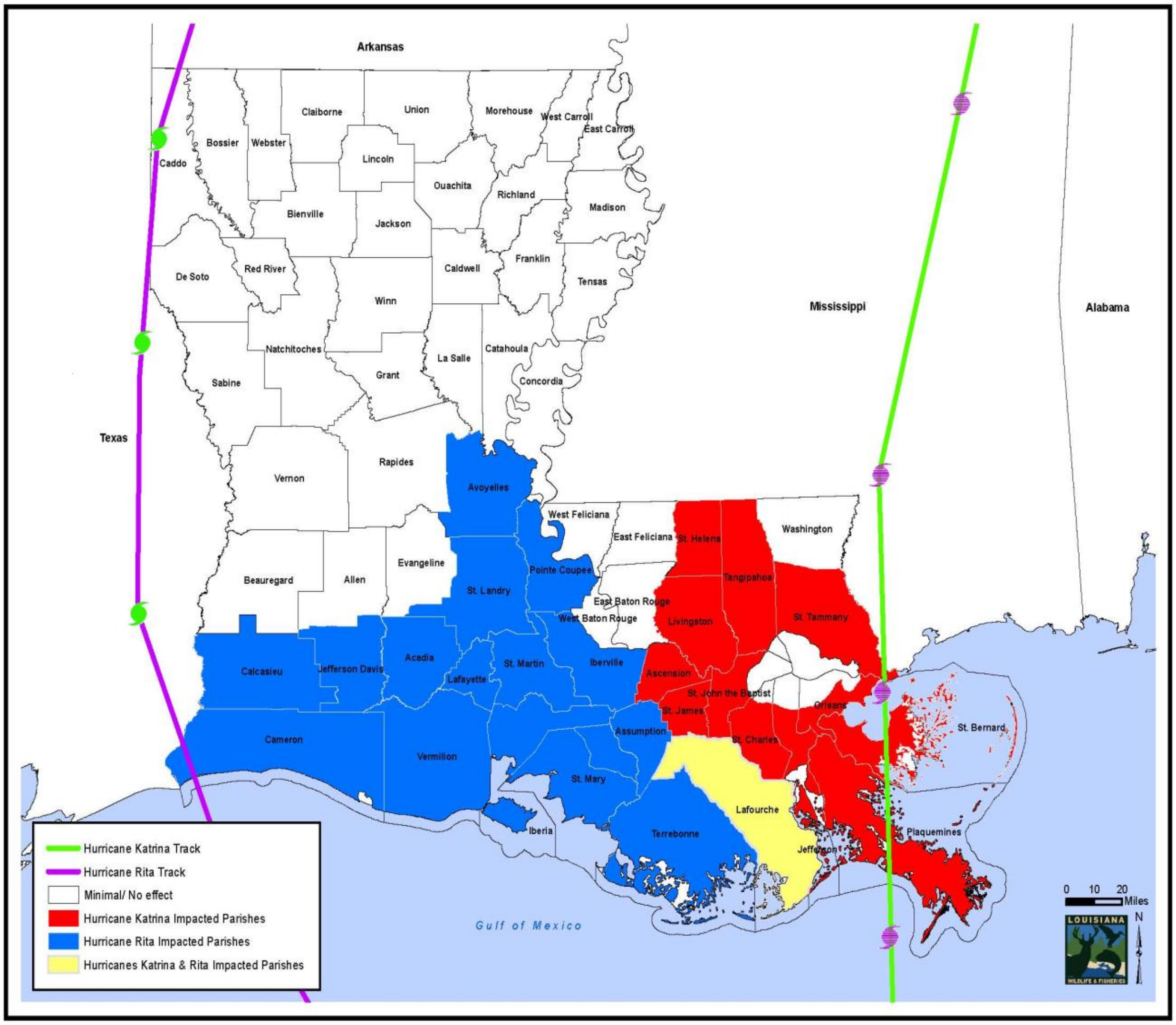
In the aftermath of hurricanes Katrina and Rita of 2005, a cooperative research program or survey (COOP program or survey) was initiated to elicit fisheries information from participating commercial fishermen and wholesale/retail seafood dealers. To qualify for participation in the cooperative research survey, in addition to holding a valid resident commercial license in 2008, fishermen must have had a reported total sale of seafood (shrimp, oysters, crabs, fresh- and saltwater finfish and wild-caught crawfish) valued at $5,948 or more (i.e., the 30th percentile of distribution of dockside sales) and dealers must have had a reported total purchases of seafood valued at $20,756 or more (i.e., the 30th percentile of distribution of seafood purchases) between September 1, 2005 and August 31, 2008. Seafood harvest (or landings) and purchases information are, by statute, mandatorily reported on trip ticket forms and kept in a database managed by the Louisiana Department of Wildlife and Fisheries (LDWF). All commercial fishermen (or seafood dealers) who landed (or purchased) marine fish were eligible and persons who landed (or purchased) freshwater finfish and wild-caught crawfish were eligible only if the fishermen resided or the dealers operated in any of the 26 hurricane-impacted parishes or counties identified by the LDWF (Figure 1.1). Commercial fishermen who possessed a certified fisherman endorsement from LDWF (having shown that commercial fishing constitutes 50% or more of his/her earned income) and having had any level of seafood landings during the qualifying period received an additional $500 compensation for participating in the research survey.

To facilitate smooth distribution of the federal funds for the cooperative research survey, individual groups of eligible fishery participants were categorized into three independent tiers using percentile methods. Participants in each tier received an average amount which was determined by the percentile of the 3-year-averages of their revenues from seafood harvest, sales and purchases within the qualifying period (September 1, 2005 to August 31, 2008).

1.1.1 Commercial Fishermen's Participation

Table 1.1 shows the summary of the distribution of commercial fishermen by percentile-based tiers including their minimum seafood sales and the amounts of the direct payments they received for their participation in the cooperative research survey. There were 1,265 eligible

Figure 1.1 Parishes Impacted by Hurricanes Katrina and Rita in 2005



Source: S. Armand, Louisiana Department of Wildlife and Fisheries, LAGISDVD, ESRI, NOAA, Nov. 15, 2010

Table 1.1 Distribution of Commercial Fishermen Eligible to Participate in the Cooperative Research Survey by Tier, Sales and Compensation

Number of Eligible Fishermen	Tier Level	Minimum Sales Level	Payment Amount	Percentile
1,265	Tier 1	$5,948	$208.83	30th
1,581	Tier 2	$24,786	$870.22	50th
1,581	Tier 3	$108,804	$3,820.05	75th

Source: LDWF Commercial Fisherman Cooperative Research Survey Packet, July 2009. Note: A total of $8 million ($7,679,486 plus $320,514 additional payment to individuals who possessed a certified fisherman endorsement from LDWF – 50% or more of earned income is from commercial fishing) was shared among the eligible fishermen. License resident commercial fishermen who did not report sales or reported sales of less than $5,948 during the qualifying period are not eligible to participate.

commercial fishermen (those between the 30th and 50th percentiles) in tier 1 who had seafood sales of between $5,948 and $24,785 during the qualifying period. Tier 2 consisted of 1,581 fishermen (those between the 50th and 75th percentiles) with sales of between $24,786 and $108,803. Tier 3 is made up of the eligible commercial fishermen whose dockside sales were at or above the 75th percentile and has an equal number of fishermen as tier 2 (i.e., 1,581) but with seafood sales of $108,804 or more.

The amounts of compensation to individual fishermen for their participation in the research survey were $208.83 for tier 1, $870.22 for tier 2 and $3,820.05 for tier 3. Table 1.2 shows how LDWF computed these amounts, which was based on the minimum seafood sales within individual tiers. For easy understanding of the computations, the columns in the table are labeled A to E. The minimum levels of seafood sales by tier are presented in the second column, labeled column (A), while the numbers of fishermen in individual tiers are in column (B). Column (C) is the product of columns (A) and (B). Entries in column (D) are calculated by dividing each entry in column (C) by their column total ($218,730,010). Payments given to individual fishermen within their tiers (column (E)) are computed by dividing the share of funds for each tier by the number of fishermen in the tier.

Table 1.2 Allocation of Disaster Funds among Commercial Fishermen by Tier

Tier	Minimum Sales Level (A)	Number of Fisherman (B)	Lower Limit of Total Sales C = (A x B)	Tier Share of Allocation $D = (C_i/C_t) \times S_F$	Individual Share of Allocation E = (D / B)
1	$5,948	1,265	$7,524,220	$264,171	$208.83
2	$24,786	1,581	$39,186,666	$1,375,822	$870.22
3	$108,804	1,581	$172,019,124	$6,039,493	$3,820.05
Total	$139,538	4,427	$218,730,010	$7,679,486	-

Note: Basic allocation to fishermen (S_F) = $7,679,486. The rest ($320,514) was reserved for an additional payment to individuals who possessed a certified fisherman endorsement from LDWF (i.e., 50% or more of earned income is from commercial fishing).

1.1.2 Commercial Wholesale/Retail Seafood Dealers' Participation

The summary of the distribution of seafood dealers by tiers including their minimum seafood purchases and direct payments they received for their participation in the cooperative research survey is presented in Table 1.3. Tier 1 consists of 113 eligible seafood dealers (those between the 30th and 50th percentiles of all eligible dealers) who had seafood purchases of between $20,756 and $67,526 during the qualifying period. Tier 2 has 141 dealers (50th percentile to 75th percentile) who purchased between $67,527 and $632,461 worth of seafood. There are 141 seafood dealers (75th percentile or over) who had seafood purchases of $632,462 or more in tier 3.

The amount of compensation for participating in the research survey is $1,437.91 for tier 1 dealers, $4,678.05 for tier 2 dealers and $43,814.97 for tier 3 dealers. These amounts of compensation were based on the minimum level of seafood purchases and computed as shown in Table 1.4. Aside from the difference in the total amount of allocated funds (i.e., $7 million), computation for the seafood dealers is similar to that of the commercial fishermen.

Table 1.3 Distribution of Commercial Wholesale/Retail Seafood Dealers Eligible to Participate in the Cooperative Research Survey by Tier, Purchases and Compensation

Number of Eligible Dealers	Tier Level	Minimum Purchases Level	Payment Amount	Percentile
113	Tier 1	$20,756	$1,437.91	30^{th}
141	Tier 2	$67,527	$4,678.05	50^{th}
141	Tier 3	$632,462	$43,814.97	75^{th}

Source: LDWF Wholesale / Retail Seafood Dealers Cooperative Research Survey Packet, July 2009. Note: A total of $7 million was shared among the eligible dealers. License resident wholesale / retail dealers who purchased less than $20,756 during the qualifying period are not eligible to participate.

Table 1.4 Allocation of Disaster Funds among Wholesale/Retail Seafood Dealers by Tier

Tier	Minimum Purchases Level (A)	Number of Dealers (B)	Lower Limit of Total Purchases C = (A x B)	Tier Share of Allocation $D = (C_i/C_t) \times S_D$	Individual Share of Allocation E = (D / B)
1	$20,756	113	$2,345,428	$162,484	$1,437.91
2	$67,527	141	$9,521,307	$659,605	$4,678.05
3	$632,463	141	$89,177,283	$6,177,911	$43,814.97
Total	$720,746	395	$101,044,018	$7,000,000	-

Note: Total allocation to seafood dealers (S_D) = $7,000,000.

1.2 Objectives of the Study

This study's objectives are to evaluate the effectiveness of the percentile methods used for allocating disaster funds to the eligible fishery participants who were affected by Hurricanes Katrina and Rita and to examine alternative methods to aid in determining an efficient criterion for allocating public funds earmarked for fisheries assistance program.

1.3 Justification of the Study

Classification by fisheries (shrimp, crab, oyster, finfish and wild crawfish), in which fishery participants (commercial fishermen and seafood dealers) participate, is the major known form of classification that has existed not only in Louisiana fisheries but fisheries of other states, regions or countries. This classification scheme has existed mainly for fishery management or policy purposes. The benefits of management-oriented classification of fishery participants can, however, be less optimal when socioeconomic and fishery restoration dimensions become important aspects of management especially after the occurrence of a devastating natural disaster.

In the aftermath of hurricanes Katrina and Rita in 2005 and hurricanes Gustav and Ike in 2008 when federal funding was earmarked to restore Louisiana fisheries and assist fisheries participants, the percentile method was used to partition into tiers the commercial fishermen and the wholesale/retail seafood dealers, who are eligible to participate in the voluntary cooperative research survey. However, this method is limited in three ways: First, it provides a one-dimensional clustering, that is, it is solely based on one variable (seafood sales or purchases). The use of only one variable may be inadequate to capture relevant issues related to commercial fisheries such as differences in fishing efforts (e.g., fishing experience, types and sizes of fishing boats and fishing gear, number and length of fishing trips, etc.) and variation in fisheries related risks including disaster-related losses.

Second, the percentile method appears to have created inconsistent variations among the ranges of the levels of seafood sales and levels of seafood purchases. Third, it also creates inconsistent variations among payment amounts to the individual groups of fishermen and dealers. For example, a seafood dealer who was $1 short of being a member of tier 3 would fall in tier 2 and lose approximately $39,136. Such a dealer would ridicule this compensation plan and this might explain the reason why some participants declined to participate in the research survey. Presuming they possess important and sizable information, the omission of their information in the data analysis might distort the results, resulting in misleading conclusions which might affect future studies. In this study, the use of a two-dimensional clustering is considered which is expected to provide a better classification procedure.

1.4 Organization of the Study

The rest of this study is organized as follows. Chapter 2 describes the conceptual framework and review of literature for the study and Chapter 3 presents a discussion of the data and the analytical procedures. Chapter 4 contains the results and discussion, while Chapter 5 presents the summary and the conclusion.

Chapter 2 - Conceptual Framework and Literature Review

This chapter describes relevant concepts regarding approaches to classifying objects and reviews past studies in which clustering classification tools have been applied.

2.1 Conceptual Framework

Partitioning objects or people into distinct groups having homogenous characteristics has been performed to a large extent in many professions. This is often done in order to make informed decisions on how best to efficiently and equitably allocate scarce resources within or among the different subgroups and in order to perform further analyses on the groups. Classification schemes that have been used in the literature for partitioning into subgroups include percentile methods, graphical aids such as scatter plots and stem-and-leaf plots, discriminant analysis, clustering methods, multidimensional scaling, etc. Choosing an appropriate classification scheme depends on the task, the number of measured variables that is involved in the decision making process and available resources.

Cluster analysis involves techniques that produce classifications from data that are initially unclassified and, in most cases, from data having more than one measured variable. It is performed using algorithms that use a measure of distance (similarity or dissimilarity) between two individual observations and then proceeds to measure the similarity or dissimilarity between two clusters of observations. Johnson (1998) described three forms of these distance measures. These are:

(1) Euclidean or Ruler Distance:

$$d_{rs} = \left[(x_r - x_s)'(x_r - x_s)\right]^{\frac{1}{2}}$$

(2) Standardized Ruler Distance:

$$d_{rs} = \left[(z_r - z_s)' (z_r - z_s)\right]^{\frac{1}{2}}$$

(3) The Mahalanobis Distance:

$$d_{rs} = \left[(x_r - x_s)' \Sigma^{-1} (x_r - x_s)\right]^{\frac{1}{2}}$$

where d_{rs} is the distance between observations $\boldsymbol{x_r}$ and $\boldsymbol{x_s}$ (or points z_r and z_s) in the p-dimensional space, z is the standardized Z score for the variable x and Σ is the within cluster variance-covariance matrix. The use of the first two distance measures is prevalent in past studies, perhaps, because the variance-covariance matrix required for the Mahalanobis distance is difficult to generate.

2.1.1 Properties of Distance Measures

The choice of the distance measures must be made carefully depending on the type of study, for findings from a clustering analysis can be highly sensitive to the distance measure and clustering algorithms used. Research opinions are divided, however, as to the most appropriate distance measure to be used (Sokal 1977; Seber 1984). Nevertheless, Mimmack *et al.* (2001) advocated that the following properties are fundamental to all measures of distance:

a) *Symmetry*: The distance from x_r to x_s is the same as the distance from x_s to x_r, that is, $d_{rs} = d_{sr}$.

b) *Nonnegativity*: Distance is measured as a nonnegative quantity, that is, $d_{rs} \geq 0$.

c) *Identification*: The distance between x_r and x_r is zero, that is, $d_{rr} = 0$.

d) *Definiteness*. If the distance between x_r and x_s is zero, then x_r and x_s are the same, that is, $d_{rs} = 0$ only if $x_r = x_s$.

e) *Triangle Inequality*. The length of one side of the triangle formed by any three points cannot be greater than the total length of the other two sides—that is, $d_{rs} \le d_{rk} + d_{sk}$.

Properties (d) and (e) are desirable to ensure that the distance measures are metrics (Mielke 1985, Mardia *et al*. 1979; Krzanowski 1988). Distances that are not metrics have the problem that one can have a zero distance without the points being coincident, and also that a projection of the *n* points into lower-dimensional space may be problematic (Krzanowski 1988).

In addition to distance measures, graphical aids are very useful for verifying, evaluating and fine-tuning the results from clustering algorithms. Such graphical aids include scatter plots, principal components, Andrews' plots, three-dimensional plots, blob plots or bubble plots, Chernoff faces and star or sun-ray plots (Johnson 1998).

2.1.2 Clustering Methods and Algorithms

Searching for clusters involves two general methods: hierarchical and nonhierarchical methods. Nonhierarchical cluster analysis methods select an initial set of cluster seed points and then build clusters around individual seeds by assigning an observed data point to its closest seed using dissimilarity measure to measure the distances between data points and the cluster seeds. However, nonhierarchical methods may produce misleading results because they rely on an initial guess of the seed points and the number of clusters. In addition, some computing packages choose seed points depending on the order in which the data are read into the computer and too many seed points and clusters may result.

Hierarchical methods group observed data points into clusters in a nested sequence of clustering. Single-link clustering methods are the most efficient hierarchical methods. The single-link methods include the nearest neighbor method (where the distance between clusters is the distance between their two closest members), the furthest neighbor method (where the distance between clusters is the distance between their two furthest members), the centroid method (via distance between cluster means), the average method (distance between clusters determined by the average of all dissimilarities between all pairs of points) and Ward's minimum variance method (distance between two clusters is the square of the distance between cluster means divided by the sum of the reciprocals of the number of points within each cluster) (Johnson, 1998). These methods differ from one another in the forms of distance measures they use.

Several statistical procedures and a hierarchical tree diagram (or icicle plot) can be used to decide when to stop the clustering process (i.e., when an appropriate number of clusters has been determined). The statistical procedures include Beale's F-type statistic (which helps to determine an appropriate number of clusters), a pseudo Hotelling's T^2 test (which helps to decide whether pairs of clusters should be combined), the cubic clustering criterion, or CCC (which provides many choices as to the number of clusters) and the principal components analysis.

The CCC, developed through extensive simulations by Sarle (1983), can be used for crude hypothesis testing and estimating the number of population clusters. It is based on the assumption that a uniform distribution on a hyperrectangle will be divided into clusters shaped roughly like hypercubes (or squares in a two-dimensional case). In large samples that can be divided into the appropriate number of hypercubes, this assumption gives very accurate results (SAS 1999) but only if clustering variables are not highly correlated (Lewis et al., 2006). In other cases the approximation is generally conservative. Specifically, the CCC is obtained by comparing the observed coefficient of determination (R^2) to the approximate expected R^2 using an approximate variance-stabilizing transformation. The CCC tests the following hypothesis:

H0 = the data have been sampled from a uniform distribution on a hyperbox

H1 = the data have been sampled from a mixture of spherical multivariate normal distributions, with equal variances and sampling probabilities.

H0 will be rejected if the CCC values are positive, which means that the value of the observed R^2 is greater than would be expected if the sampling was from a uniform distribution and therefore indicates the possible presence of clusters (SAS, 1983).

Examples of a hierarchical tree diagram and a CCC plot (a plot of CCC values against the number of clusters) that can be produced from a clustering procedure with nine data points are shown in Figures 2.1 and 2.2. Using the hypothetical hierarchical tree diagram, one can be confident that the nine data points (represented by rectangular blocks on the plot) fall into three distinct clusters. There are two observations in cluster 1. Cluster 2 contains three observations and cluster 3 contains four observations. Clustering procedures assign clusters to the data points using a measure of distance between individual data points. That is, data points that are very close to each other are grouped into the same cluster. Likewise, if all points (number of clusters) on the CCC plot are joined by lines, the small peaks occurring at point number 3 and point number 6 indicate that the nine data points are from between three and six distinct clusters. In this example, however, a number of clusters that is greater than 3 may be inappropriate since it will result in some clusters having only one observation. Normally, peaks on a CCC plot that has a CCC value that is greater than three (CCC > 3) would correspond to an appropriate number of clusters.

Principal components analysis (PCA) is basically used as a tool for screening multivariate data as well as verifying distributional assumptions such as normality of the variables and the independence of the experimental units (Johnson, 1998). The PCA creates a new set of uncorrelated variables, called principal component scores, from a set of correlated variables. The

Figure 2.1 A Hierarchical Tree Diagram for Nine Hypothetical Data Points

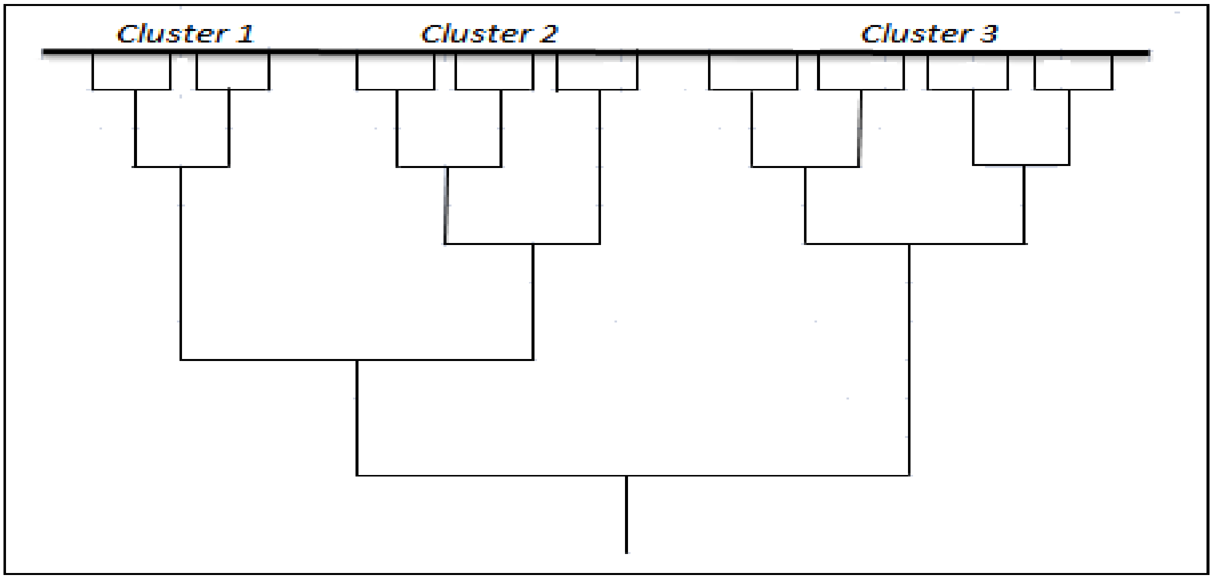
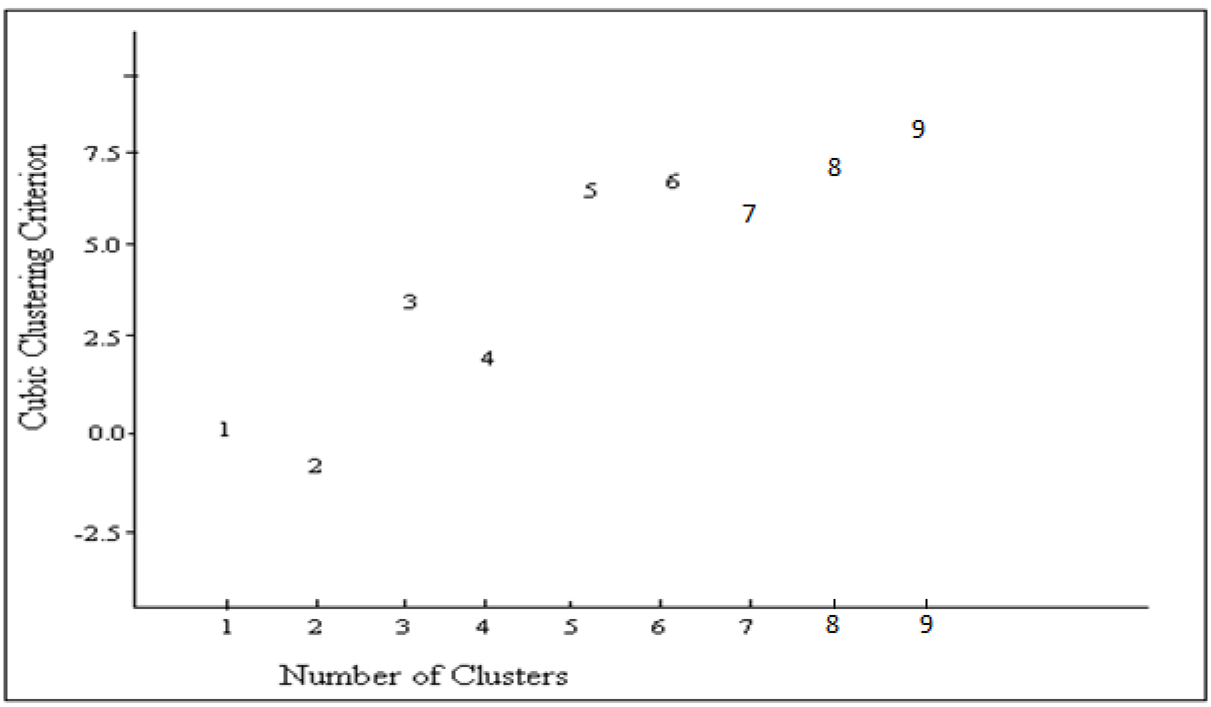


Figure 2.2 A Cubic Clustering Criterion Plot for Nine Hypothetical Data Points



new variables can be used as inputs for graphing and plotting programs. When used in clustering programs, the principal component scores are plotted in order to screen clusters and associated observations.

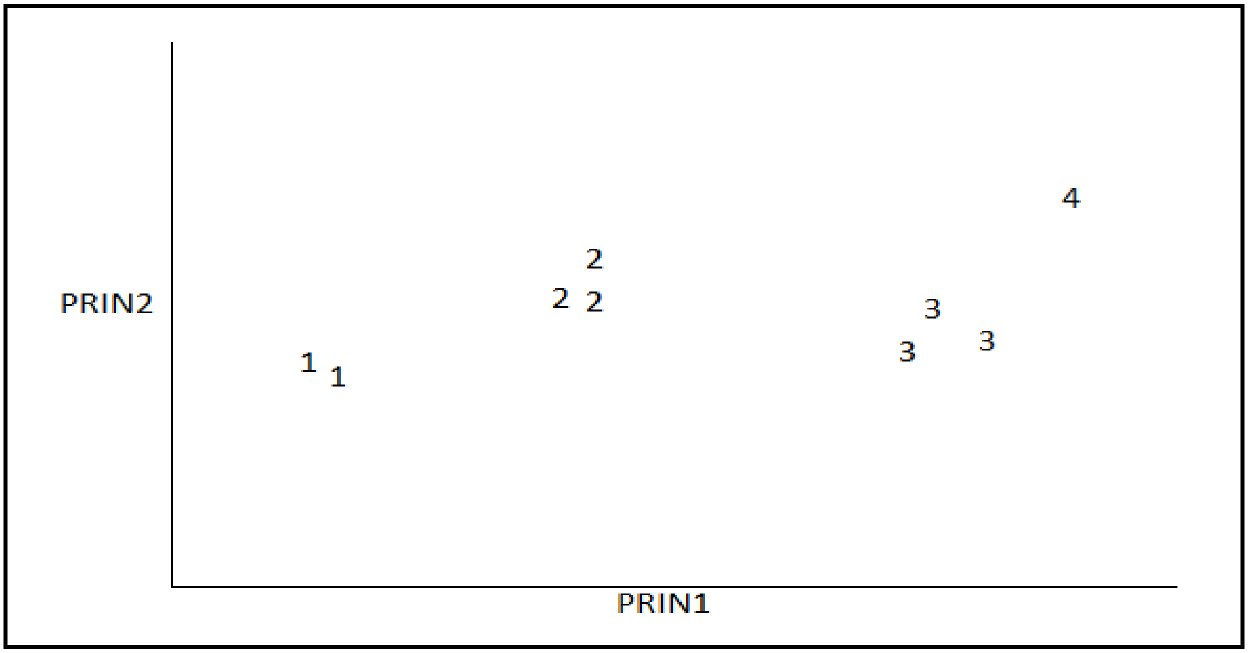
Figure 2.3 shows a two-dimensional plot of the principal component scores from a clustering program with nine hypothetical data points. The principal component scores for the first variable (PRIN1) are plotted on the horizontal axis, while the scores for the second variable (PRIN2) are plotted on the vertical axis. It appears that there are four clusters in this dataset with cluster 1 containing two observations and an equal number of observations (3) contained in Cluster 3. Cluster 4, which contains only one observation, may be misleading. However, since it is closer to cluster 3, it might be appropriate to merge it with cluster three, resulting in a total of three clusters.

A consensus between the icicle plot, the CCC plot and the plot of the principal component scores will, therefore, result in three clusters. Further discussion of the various clustering methods, common clustering packages and programs, empirical comparisons of the performance of clustering algorithms can be found in Punj and Stewart (1983) and Johnson (1998).

2.2 Review of Literature

This section provides a synopsis of studies that have applied the concept of cluster analysis. While none of these studies focuses specifically on natural resource sectors, the phenomenon of clustering that is addressed is applicable to this sector as well. Three notable areas where the use of cluster analysis has been commonly demonstrated are in medical and nutrition, marketing as well as economic/financial fields.

Figure 2.3 A Plot of Principal Component Scores for Nine Hypothetical Data Points



In a clinical study, Haldar *et al*. (2008) explored the application of a k-means cluster analysis to identify distinct phenotypic groups in three independent asthma populations in order to examine differences in asthma outcomes (exacerbation frequency and change in corticosteroid dose at 12 months) within or between the groups. The first two populations are primary to the clinical study and included a population of 184 patients under management in primary care with predominantly mild to moderate disease and a refractory asthma population consisting of 187 patients who were managed in secondary care. The third population is an offshoot of a separate study completed earlier (Haldar *et. al*., 2006) and consists of 68 patients with predominantly refractory asthma clustered at entry into a randomized trial comparing a strategy of minimizing eosinophilic inflammation (inflammation guided strategy) with standard care.

The results showed that a 3-cluster model best fits the primary care population dataset, 4-cluster models best fits the secondary care population and a 3-cluster model best fits the third population. Considering asthma outcomes, two clusters (early onset atopic and obese, non-eosinophilic) were common to both populations of subjects managed in primary and secondary care. However, two clusters characterized by marked discordance between symptom expression and eosinophilic airway inflammation (early onset symptom predominant and late onset inflammation predominant) were specific to refractory asthma. The results also found that inflammation guided management was superior for both discordant subgroups leading to a reduction in exacerbation frequency in the inflammation predominant cluster and a dose reduction of inhaled corticosteroid in the symptom predominant cluster. The study concluded that cluster analysis offers a novel multidimensional approach for identifying asthma phenotypes that exhibit differences in clinical response to treatment algorithms.

Psoter *et al.* (2009) conducted cluster analysis on dataset comprise of 5,169 Arizona children in the U.S., with an age range of 5-59-months. The goal was to delineate patterns of caries (the criteria defined as a visual break in enamel surface, pit and fissure discoloration with adjacent opacity, evidence of marginal ridge undermining, and anterior shadowing on transillumination) in the primary dentition of pre-school children without *a priori* pattern definitions. Authors used all data for children ages 0-4 years in aggregate for all subjects as well as for subjects without crowned restored teeth (i.e., ages in aggregate and ages in aggregate excluding subjects with crown restorations). Each of these two sets of analyses consisted of 8 differently specified cluster analyses as a validation procedure. These eight different cluster analyses involve two hierarchical clustering methods (furthest neighbor and average between group linkages) using four proximity (similarity/dissimilarity) measures (simple matching, Hamann, Euclidean squared distance and variance).

The clustering analysis identified four caries patterns among the patients: smooth surfaces (other than the maxillary incisor), maxillary incisor, occlusal surfaces of first molars as well as pit and fissure surfaces of second molars. The study concluded that the cluster analysis findings were consistent with results produced by multidimensional scaling and that the cross-validated patterns identified may represent resulting disease conditions from different risks or the timing of various risk factor exposures. As such, the patterns may be useful case definitions for caries risk factor investigations in children under 60 months of age.

Risvas *et al.* (2008) conducted a mailed survey to assess awareness and behavioral change for healthy diets (i.e., food consumption, nutrition knowledge and factors associated with dietary change) among 2,439 fifth and sixth grade students in Attica and Thessaloniki regions of Greece. The study was done to identify some mediating parameters necessary for planning interventions to promote healthy nutrition. The k-means cluster analysis in conjunction with principal components analysis was used to analyze the data. Three distinct clusters were identified for each segment of the study. For the food consumption segment, they found that the students demonstrated unbalanced nutrition, balanced nutrition and low food intake. The three groups identified for nutrition knowledge consist of students who demonstrated a good, medium and bad knowledge of nutritional issues. With regard to dietary habits, students were classified based on their responses as to how their environment and perceptions on the health value of foods have affected them. Groups identified include those that demonstrated a negative effect, a health oriented group and a group reinforced to eat healthy diets like fruits and vegetables.

In a study involving a financial data of stock portfolio, Tola *et al.* (2008) used correlation matrices whose inherent information (or properties) were filtered by the single linkage and average linkage clustering procedures (i.e., the correlation coefficient between two time series is assumed to be a measure of the similarity between the two time series) in order to examine the reliability of the financial portfolio. The authors compared the findings from the clustering algorithms with the results provided by other methods such as random matrix theory (RMT) filtering and Markowitz optimization. The results show that, under idealized and realistic conditions, the use of clustering methods to build financial portfolios can provide more reliable portfolios (in terms of the error in the forecasted risk) than the ones obtained with RMT filtering and with Markowitz optimization. They also noted that for this set of data, the realized risk (a measure of the riskiness of the portfolio) obtained with the clustering method is almost always smaller than the realized risk of the RMT portfolio. Additional information on correlation based clustering which has been applied to infer the hierarchical structure of a portfolio of stocks from its correlation coefficient matrix can be found in Mantegna (1999) and Bonanno *et al*. (2001, 2003).

Chapter 3 - Data and Analytical Procedures

Fisheries data from the trip ticket information compiled by the Louisiana Department of Wildlife and Fisheries (LDWF) is used for this study. The trip ticket forms were developed to collect information on commercial fishing trips, fishing gear use, dockside sales of seafood harvest and dockside purchases of different seafood such as shrimp, crabs, wild-caught crawfish, oysters and freshwater and saltwater finfish. Specifically, commercial seafood harvest (i.e., seafood landings), sales and purchases are the primary information used in this analysis.

A cluster analysis, which is based on the hierarchical, single-linkage, average method, was conducted in SAS (User's Guide, 2004) to categorize commercial fishermen and wholesale/retail seafood dealers into groups (or clusters) using the three-year averages of seafood landings and revenues they reported through the trip ticket forms. The seafood landings (measured in pounds) and revenues (measured in dollars) are standardized for transformation into comparable units to avoid undue influence of a particular variable on the outcomes of the analysis. The means and standard deviations of seafood landings and the dockside seafood sales for individual original tiers of commercial fishermen are shown in Table 3.1. The table shows that the standard deviations for the seafood landings are greater than the standard deviations for the dockside seafood sales for all tiers of fishermen. Using unstandardized data would result in seafood landings having more weight in identifying clusters than dockside seafood sales. Similar information is provided in Table 3.2 for the wholesale/retail seafood dealers where the standard deviations of the seafood landings are greater than the standard deviations for the dockside seafood purchases for all tiers of seafood dealers.

Table 3.1 Means and Standard Deviations of Seafood Landings and Dockside Sales by the Commercial Fishermen

	Seafood Landings		Dockside Seafood Sales	
Original Tier	Mean (Lbs.)	Std. Dev.	Mean ($)	Std. Dev.
Tier 1	18,030	12,480	13,690	5,335
Tier 2	70,274	46,315	57,191	23,521
Tier 3	828,131	6,119,054	325,979	368,068

Table 3.2 Means and Standard Deviations of Seafood Purchases and Dockside Purchases by the Wholesale / Retailer Dealers

	Seafood Landings		Dockside Seafood Purchases	
Original Tier	Mean (Lbs.)	Std. Dev.	Mean ($)	Std. Dev.
Tier 1	45,156	54,360	42,102	14,253
Tier 2	313,672	343,958	248,831	151,131
Tier 3	19,307,258	107,390,855	5,164,129	7,775,519

The correlation coefficients between commercial fishermen's seafood landings and dockside values (revenues) of seafood sales and the correlation coefficients between commercial wholesale/retail dealers' seafood purchases and dockside values (revenues) of seafood purchases are presented in Table 3.3. The table shows a positive linear relationship between the two variables for individual fisheries participants. Except for the tier 1 of both commercial fishermen and wholesale/retail seafood dealers, the correlation coefficients are approximately 0.60 or greater. In a study like this where the researchers have little or no control over the population from which the data were collected, these numbers would be considered large enough to be of practical importance but not too high to distort the results of the clustering procedures, especially regarding the correctness of the values of the cubic clustering criterion discussed in Chapter 2.

Table 3.3 Pearson Correlation Coefficients between Seafood Landings, Sales and Purchases

Commercial Fishery Participants	Sample Size	Correlation Coefficients
Fishermen (Landings vs. Sales)		
Tier 1	1,265	0.5471
Tier 2	1,580	0.5914
Tier 3	1,577	0.6940
Total	4,422	0.6370
Seafood Dealers (Landings vs. Purchases)		
Tier 1	113	0.3645
Tier 2	141	0.6188
Tier 3	141	0.6617
Total	395	0.6467

Note: Values were missing on seafood landings and dockside seafood sales for a fisherman in tier 2 and four fishermen in tier 3. The missing data were removed prior to computing summary statistics.

As shown in the previous sections, the variability within each of the seafood landings and values of seafood sales for the commercial fishermen as well as the variability within each of seafood purchases and the values of purchases for the seafood dealers are moderately large. To facilitate an easy visualization of the relationships among these variables, logarithmic transformations are performed on the data. The scatter plot of the log transformations of the seafood landings and dockside values of seafood sales for the entire population of commercial fishermen is shown in Figure 3.1. Also the scatter plot of the log transformations of the seafood purchases and dockside values of seafood purchases for the entire commercial wholesale/retail seafood dealers is shown in Figure 3.2. Similarly, the scatter plots of the fishermen specific variables by tier and seafood dealers' specific variables by tier are shown in Appendix Figures A.1 to A.6. The information in these scatter plots is consistent with the information provided in Table 3.3.

Figure 3.1 Scatter Plot of Seafood Landings and Dockside Sales for Commercial Fishermen

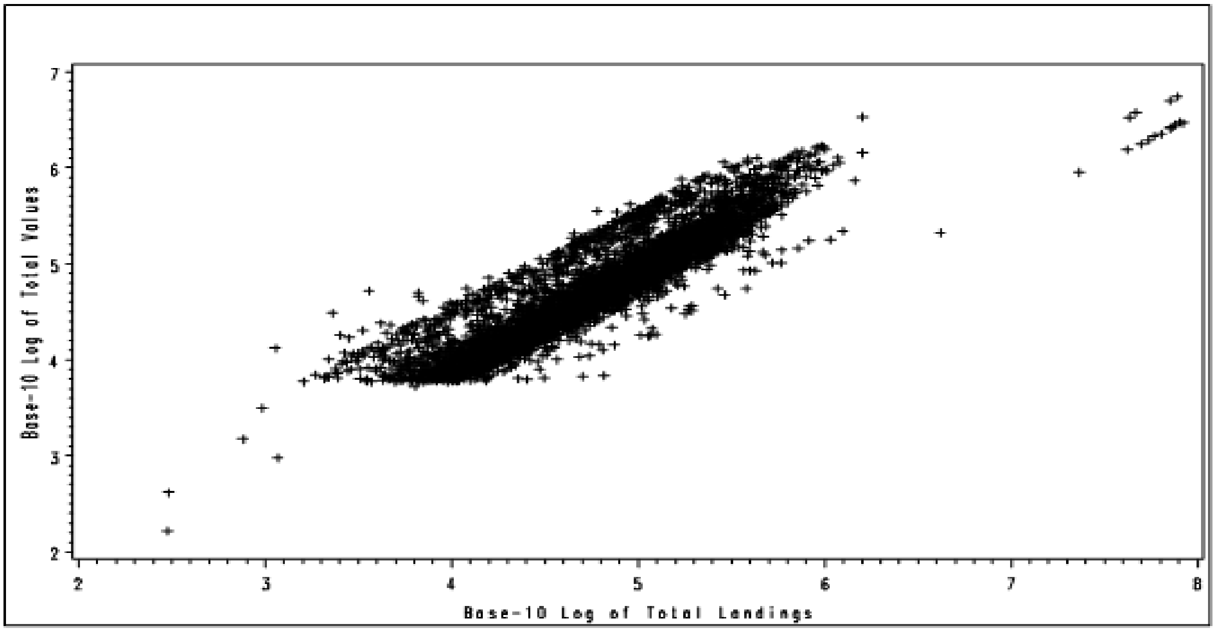
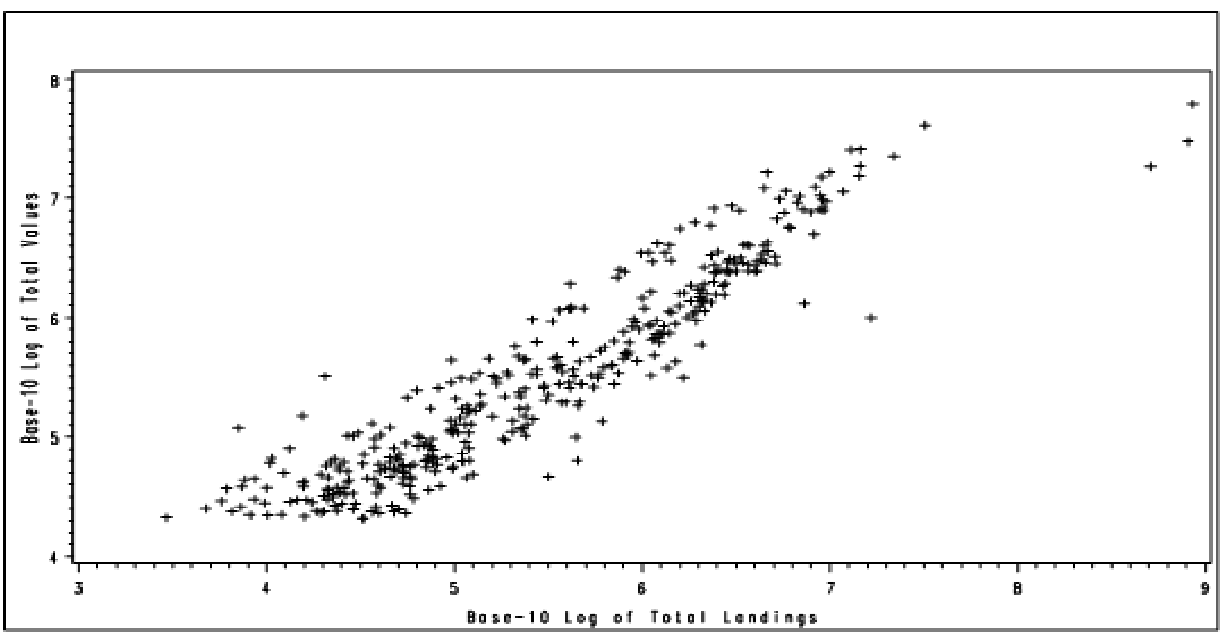


Figure 3.2 Scatter Plot of Seafood Purchases and Dockside Values for Wholesale/Retail Seafood Dealers



The results from the cluster programs are verified, evaluated and fine-tuned using graphical aids including icicle plots (hierarchical tree diagram), plots of cubic clustering criterion as well as two-dimensional plots of principal component scores to decide when to stop the clustering process. Average revenues from fishermen's seafood sales and dealers' seafood purchases are calculated and compared among clusters and thereafter used to determine an alternative compensation plan for each of the two participant groups. The amount of compensation received by individual fishermen and seafood dealers in their original tiers are then compared to the amount of compensation suggested by individual clusters in order to examine if existing administrative processes have ensured a more equitable distribution of disaster payment funds to seafood participants.

Chapter 4 - Results and Discussion

The Z scores derived via standardization of the original seafood landings and dockside sales for commercial fishermen and wholesale/retail dealers' seafood purchases (in quantities and values) were analyzed by cluster procedures using the hierarchical, single-linkage, average method. A consensus numbers of clusters were determined among seafood fishermen and dealers using a combination of the icicle plot, pseudo Hotteling's T^2 test, the cubic clustering criterion (CCC) and two-dimensional plot of principal components scores. The CCC values are negative for both fishermen and dealers, satisfying Sale's (1983) crude hypothesis for possible presence of clusters. The results are presented in three parts, which consist of results for the fishermen, results for the seafood dealers, followed by comparisons of initial compensation plans and newly suggested compensation plans for allocating hurricanes assistance funds to both groups.

4.1 Results of Cluster Analysis on the Commercial Fishermen

The pseudo Hotteling's T^2 test results[a] and a plot of the cubic clustering criterion (Appendix Figure B.1) were used to determine the initial number of clusters (between 4 and 14 clusters) for the commercial fishermen who were eligible to participate in the cooperative research program. To derive the appropriate number of clusters, a hierarchical tree diagram (Appendix Figure B.2) and a two-dimensional plot of the principal component scores (Appendix Figure B.3) were employed to verify and fine-tune the initial results. This effort leads to a combination of clusters that are very close to each other. To ensure legally required

[a] The table containing these results is very large and therefore not included in this report. This table may be requested from the author.

confidentiality of information on fisheries participants in Louisiana, any cluster or entry containing information for fewer than four participants is merged with its nearest neighbor.

Clusters in Appendix Figure B.3 were labeled 1 to 14 with the clustering program showing only the first digits for clusters numbers above 9 (i.e., 10 to 14). Thus, Cluster 10 represents the digits of 1s beside Cluster 9 and Cluster 13 is the single number 1 at the top right corner of Cluster 10. Both Clusters (10 and 13) were merged with Cluster 1 below them. Cluster 11 (above Cluster 2) is merged with Cluster 5, while Cluster 12 (at the right side of Cluster 6) was merged with Cluster 6. Cluster 14, containing a single observation, was also merged with Cluster 8. This exercise eventually resulted in seven (7) clusters among the commercial fishermen. Listing them by the magnitude of their average seafood sales therefore, Cluster A combines the previous Clusters 5 and 11, Cluster B consists of Clusters 2 and 7, Cluster C merges Clusters 4 and 9, Cluster D replaces Cluster 3, and Cluster E combines Clusters 1, 10 and 13. Initial Clusters 6 and 12 were combined to form Cluster F, while Clusters 8 and 14 form Cluster G.

Table 4.1 shows the distribution of the commercial fishermen into the seven (7) clusters, namely Clusters A through G, and the regroup of fishermen from the original three tiers. On the redistribution of the fishermen in the original tiers, the table shows that from the original tier 1, five hundred and sixteen (517), six hundred and ninety four (694) and fifty five (55) fishermen are redistributed into Clusters A, B and C, respectively. Cluster B received additional two hundred and seventy five (275) fishermen from tier 2, which also supplied the greater number of individuals (765) to cluster C. Five hundred and thirty three (533) fishermen from tier 2 and three hundred and ninety four (394) fishermen from tier 3 reconstitute Cluster D, while Cluster E consists of seven (7) tier 2 and nine hundred and ninety two (992) tier 3 fishermen. Clusters F

Table 4.1 Number of Commercial Fishermen by Tier and Cluster

Cluster	Number of Fisherman by Tier			Total Number of Fishermen by Cluster
	Tier 1	Tier 2	Tier 3	
A	517	-	-	517
B	694	275	-	969
C	55	765	-	820
D	-	533	394	927
E	-	7	992	999
F	-	-	180	180
G	-	-	15	15
Total Number of Fishermen by Group	**1,265**	**1,581**	**1,581**	**4,427**

Note: The total number of fishermen by tier may not add up correctly due to merging of cells for confidentiality purposes.

and G are comprised of 180 fishermen and 15 fishermen, respectively, from the tier 3. Thus, three new groups would be contained in the original tier 1 and at least four new groups would be contained in the original tier 2. Tier 3 would contain four different new groups.

The summary statistics on the seafood landings and dockside seafood sales for Clusters A to G of commercial fishermen are presented in Table 4.2 and Table 4.3, respectively. The standard deviations of seafood landings (Table 4.2) might be misleading since they might contain landings from different seafood types, resulting to adding pounds of shrimp to pounds of finfish. This combination might have led to the large variations within and between clusters and tiers. The standard deviations for dockside seafood sales within individual clusters and tiers (Table 4.3) are smaller when compared to the total standard deviations for the original tiers except for that corresponding to Cluster G, which is caused by tier 3. For example, the standard deviation

Table 4.2 Summary Statistics of Seafood Landings by Tiers and Clusters of the Commercial Fishermen

Cluster	Tier1		Tier 2		Tier 3		Total By Cluster	
	Mean (Lbs.)	Std. Dev.	Mean (Lbs.)	Std. Dev.	Mean (Lbs.)	Std. Dev.	Mean (Lbs.)	Std. Dev.
A	9,793	5,054	-	-	-	-	9,778	5,060
B	21,268	7,577	25,248	9,218	-	-	22,398	8,269
C	54,442	23,058	57,367	26,341	-	-	57,170	26,131
D	-	-	107,964	32,359	115,583	43,689	111,202	37,760
E	-	-	388,309	142,551	247,249	166,225	248,238	166,426
F	-	-	-	-	686,231	1,701,368	686,231	1,701,368
G	-	-	-	-	59,496,838	21,207,325	59,496,838	21,207,325
Group Total	**18,030**	**12,480**	**70,268**	**46,301**	**826,556**	**6,111,383**	**325,432**	**3,670,651**

Note: The seafood landings for group total by tier may not correspond to those in Table 3.1 due to merging of cells for confidentiality purposes.

Table 4.3 Summary Statistics of Seafood Dockside Sales by Tiers and Clusters of the Commercial Fishermen

Cluster	Tier1		Tier 2		Tier 3		Total By Cluster	
	Mean ($)	Std. Dev.	Mean ($)	Std. Dev.	Mean ($)	Std. Dev.	Mean ($)	Std. Dev.
A	8,739	2,085	-	-	-	-	8,781	2,296
B	16,841	3,995	32,155	6,001	-	-	21,187	8,327
C	20,364	3,576	48,199	14,047	-	-	46,332	15,279
D	-	-	82,546	15,279	136,393	26,640	105,432	33,833
E	-	-	96,032	10,155	267,216	109,619	266,017	110,167
F	-	-	-	-	842,205	274,723	842,205	274,723
G	-	-	-	-	2,967,428	1,122,721	2,967,428	1,122,721
Group Total	**13,689**	**5,335**	**57,188**	**23,513**	**325,696**	**367,645**	**140,650**	**260,352**

Note: The seafood sales for group total by tier may not correspond to those in Table 3.1 due to merging of cells for confidentiality purposes.

for dockside seafood sales for fishermen in original tier 1 (row total) is 5,335. This statistic is greater than the largest standard deviation (3,995) corresponding to Cluster B within the same tier 1. When the standard deviation of a series within a cluster is larger than the standard deviation of the series from the original tier in which the cluster lies, the culprits are likely to be connected to the smaller number of observations in the cluster or the merging of two or more clusters to form that particular cluster. That, perhaps, is the case for the cell corresponding to the intersection of Cluster G and tier 3.

4.2 Results of Cluster Analysis on the Commercial Wholesale/Retail Seafood Dealers

Similar to section 4.1, which reports the results for the commercial fishermen, the pseudo Hotteling's T^2 test results[b] and a plot of the cubic clustering criterion (Appendix Figure C.1) were used to determine the initial number of clusters (between 3 and 8 clusters) for the wholesale/retail seafood dealers who were eligible to participate in the cooperative research program. To derive the appropriate number of clusters, a hierarchical tree diagram (Appendix Figure C.2) and a two-dimensional plot of the principal component scores (Appendix Figure C.3) were employed to verify and fine-tune the initial results. Merging of clusters is done only to satisfy Louisiana's confidentiality obligations requiring non-reporting of participants information when their number is less than 4.

Figure C.3 labels clusters from 1 to 8. Listing these clusters by the magnitude of their average seafood purchases, Cluster A replaces previous Cluster 1, Cluster B combines previous

[b] The table containing these results is very large and therefore not included in this report. This table could be requested from the author.

Clusters 6 and 8, Cluster C, D and E replace Cluster 2, 3 and 4, respectively, and cluster F combines Clusters 5 and 7.

Table 4.4 shows the classification of the three hundred and ninety five (395) seafood wholesale/retail dealers, which initially were tiered into three groups, into six new clusters (Clusters A to F). Any cluster or entry violating the State's confidentiality law is merged with the closest neighbor. Thus, Cluster A is made up of ninety five (95) dealers from original tier 1 and twenty five (25) dealers from original tier 2. Cluster B contains sixteen (16) dealers from tier 1 and four (4) dealers from tier 2, while all ninety four (94) dealers in Cluster C are from tier 2. Cluster D is made up of twenty (20) dealers from tier 2 and twenty nine (29) dealers from tier 3. The rest of the dealers in tier 3 are split between Clusters E (74 dealers) and Cluster F (38 dealers). Thus, there would be two new clusters in original tier 1, four new clusters in original tier 2, and three new clusters in the original tier 3.

The summary statistics for individual clusters with the original tiers used by the Louisiana Department of Wildlife and Fisheries (LDWF) to allocate disaster funds to individual qualifying wholesale/retail seafood dealers are presented in Table 4.5 and Table 4.6. As previously stated, the summary statistics for the seafood landings sales or purchases (Table 4.5) might be misleading since it allows addition of pounds of different seafood such as shrimp and finfish. Hence, this section focuses on the summary statistics from dollar of seafood purchases.

Table 4.6 shows that the standard deviations within individual clusters for the dockside seafood purchases are smaller when compared to the standard deviations for the original tiers (total by tier) except for the cell corresponding to cluster F and tier 3 or the total standard deviation for cluster F. For example, the standard deviation for dockside seafood purchases by wholesale/retail seafood dealers in the original tier 1 is 14,253. The cluster with the largest

Table 4.4 Number of Commercial Wholesale/Retail Seafood Dealers by Tier and Cluster

Cluster	Number of Dealers By Tier			Total Number of Dealers By Cluster
	TIER 1	**TIER 2**	**TIER 3**	
A	95	25	-	120
B	16	4	-	20
C	-	94	-	94
D	-	20	29	49
E	-	-	74	74
F	-	-	38	38
Total Number of Dealers by Group	**113**	**141**	**141**	**395**

Note: The total number of dealers by tier may not add up correctly due to merging of cells for confidentiality purposes.

Table 4.5 Summary Statistics of Seafood Landings Purchased by Tier and Cluster of the Commercial Wholesale/Retail Dealers

Cluster	Tier1		Tier 2		Tier 3		Total By Cluster	
	Mean (Lbs.)	Std. Dev.	Mean (Lbs.)	Std. Dev.	Mean (Lbs.)	Std. Dev.	Mean (Lbs.)	Std. Dev.
A	44,274	27,100	56,424	20,497	-	-	46,805	26,256
B	7,946	2,428	14,103	5,539	-	-	9,177	3,985
C	-	-	251,576	150,453	-	-	254,409	150,397
D	-	-	980,789	411,918	907,743	369,375	937,558	384,796
E	-	-	-	-	2,851,559	2,031,559	2,851,559	2,031,559
F	-	-	-	-	65,394,302	201,596,165	65,394,302	201,596,165
Group Total	**45,156**	**54,360**	**313,672**	**343,958**	**19,307,258**	**107,390,855**	**7,016,845**	**64,668,909**

Table 4.6 Summary Statistics of Seafood Dockside Purchases by Tier and Cluster of the Commercial Wholesale/Retail Dealers

Cluster	Tier1		Tier 2		Tier 3		Total By Cluster	
	Mean ($)	**Std. Dev.**	**Mean ($)**	**Std. Dev.**	**Mean ($)**	**Std. Dev.**	**Mean ($)**	**Std. Dev.**
A	42,794	14,204	89,194	16,289	-	-	52,461	23,894
B	36,379	13,522	167,866	106,903	-	-	62,676	69,718
C	-	-	247,881	121,080	-	-	243,777	123,002
D	-	-	468,945	100,138	975,673	303,094	768,845	347,675
E	-	-	-	-	2,386,930	933,395	2,386,930	933,395
F	-	-	-	-	13,768,810	11,034,350	13,768,810	11,034,350
Group Total	**42,102**	**14,253**	**248,831**	**151,131**	**5,164,129**	**7,775,519**	**1,944,266**	**5,221,836**

standard deviation for seafood purchases within tier 1 is Cluster A having a standard deviation of 14,204, which is smaller than the total for that same tier. This phenomenon, coupled with a large standard deviation for Cluster F, is likely to be connected to the smaller numbers of observations or the merging of clusters.

4.3 Evaluation of Compensation Plans

The minimum values of seafood sales by commercial fishermen and seafood purchases by wholesale/retail seafood dealers were used by the Louisiana Department of Wildlife and Fisheries (LDWF) to compute the amount of compensation paid to the individual participants in the Cooperative Research Program. This method appears to be inconsistent with the average method (a measure of central tendency), which is common in the literature. In addition, the two-variable clustering methods (adopted for this analysis), in contrast to the one-variable percentile methods (used by LDWF), might have resulted in the clusters of individuals having overlapped minimum values. As a result of these observations, the average values of seafood sales and purchases within individual clusters are used to compute the compensation for individual clusters and participants. Table 4.7 shows how the computations of these average measures were done for individual clusters of commercial fishermen. Similar computations were performed for all clusters of the wholesale/retail seafood dealers (Table 4.8).

In order to examine whether the original compensation plans (developed using the percentile methods) were effective in ensuring a fair and equitable distribution of hurricanes assistance funds, the original compensation plan for commercial fishermen consisting of approximately $7,679,486, the original compensation plan for wholesale/retail seafood dealers consisting of an earmark of $7 million, and the average values of seafood sales and purchases are used to develop an alternative compensation plan for commercial fishermen and an

Table 4.7 Allocation of Disaster Funds among Commercial Fishermen by Cluster

Cluster	Average Sales Level (A)	Number of Fisherman (B)	Average Total Sales (C) = (A) x (B)	Cluster Share of Allocation (D) = (C_i/C_t) x S_F	Individual Share of Allocation E = (D / B)
A	$8,781	517	$4,539,777	$55,991	$108.30
B	$21,187	969	$20,530,203	$253,207	$261.31
C	$46,332	820	$37,992,240	$468,574	$571.43
D	$105,432	927	$97,735,464	$1,205,412	$1,300.34
E	$266,017	999	$265,750,983	$3,277,617	$3,280.90
F	$842,205	180	$151,596,900	$1,869,707	$10,387.26
G	$2,967,428	15	$44,511,420	$548,978	$36,598.52
Total	**$4,257,382**	**4,427**	**$622,656,987**	**$7,679,486**	**-**

Note: C_i represents computed shares of allocation for each cluster while C_t is the sum of all C_i in column (C). S_F= $7,679,486 (total of disaster funds allocated to commercial fishermen).

Table 4.8 Allocation of Disaster Funds among Wholesale/Retail Seafood Dealers by Cluster

Cluster	Average Purchases Level (A)	Number of Dealers (B)	Average Total Purchases (C) = (A) x (B)	Cluster Share (D) = (C_i/C_t) S_D	Individual Share of Allocation E = (D / B)
A	$52,461	120	$6,295,320	$57,380	$478.17
B	$62,676	20	$1,253,520	$11,426	$571.28
C	$243,777	94	$22,915,038	$208,865	$2,221.97
D	$768,845	49	$37,673,405	$343,384	$7,007.84
E	$2,386,930	74	$176,632,820	$1,609,966	$21,756.30
F	$13,768,810	38	$523,214,780	$4,768,979	$125,499.44
Total	**$17,283,499**	**395**	**$767,984,883**	**$7,000,000**	**-**

Note: C_i represents computed shares of allocation for each cluster while C_t is the sum of all C_i in column (C). S_D = $7,000,000 (total of disaster funds allocated to seafood dealers).

alternative compensation plan for the seafood dealers.

The alternative compensation plan for the commercial fishermen, which is based on their average seafood sales per cluster, is shown by Table 4.9 (See Appendix Table B.1 for a comparable compensation plan, which is based on the minimum seafood sales). The table shows that the new compensation structure for the commercial fishermen would consist of $108.30 for Cluster A, $261.31 for Cluster B, $571.43 for Cluster C, and $1,300.34 for Cluster D. Individuals in Clusters E, F, and G would receive $3,280.90, $10,387.26, and $36,598.52,respectively. The remaining part of this section compares this new payment structure with the original compensation plan (See Table 1.1) consisting of $208.83 for tier 1, $870.22 for tier 2 and $3,820.05 for tier 3 to examine whether there has been over-compensation or under-compensation of commercial fishermen who participated in the cooperative research survey.

Using the new compensation structure, five hundred and seventeen (517) commercial fishermen who were reclassified from tier 1 to Cluster A would have been paid $100.53 less for their participation in the cooperative research program. In Cluster B, six hundred and ninety four (694) fishermen from tier 1 would be paid an additional $52.48, while two hundred and seventy five (275) fishermen from tier 2 would be paid $608.91 less when compared to the original amounts ($208.83 and $870.22, respectively) which they actually received. Fifty five (55) individuals from original tier 1, who now fall in Cluster C, would receive an additional $362.60 compared to $208.82 they actually received, while seven hundred and sixty five (765) from tier 2, who fall in cluster C, would be paid $298.79 less compared to $870.22 actually paid to them. Cluster D contains five hundred and thirty three (533) individuals from tier 2 and three hundred and ninety four (394) individuals from tier 3, who would receive $2,519.71 less and $430.12 more, respectively, of what they actually received. In Cluster E, seven (7) fishermen would be

Table 4.9 Average-Sales-Based Alternative Compensation Plan for Commercial Fishermen Who Participated in the Cooperative Research Program

Cluster and Recommended (New) Payment Amount			Number of Fisherman by Original Tier and Payment Amount			Number of Fishermen by Cluster	Amount of Payment per Cluster
Cluster	New Pay	New Pay - Original Pay	Tier 1 ($208.83)	Tier 2 ($870.22)	Tier 3 ($3,820.05)		
A	$108.30	- $100.53	517	-	-	517	$55,991
B	$261.31	- $608.91	.	275	-	969	$253,209
		$52.48	694	-	-		
C	$571.43	- $298.79	-	765	-	820	$468,573
		$362.60	55	-	-		
D	$1,300.34	- $2,519.71	-	-	394	927	$1,205,415
		$430.12	-	533	-		
E	$3,280.90	- $539.15	-	-	992	999	$3,277,619
		$2,410.68	-	7	-		
F	$10,387.26	$6,567.21	-	-	180	180	$1,869,707
G	$36,598.52	$32.778.47	-	-	15	15	$548,978
Total			**1,265**	**1,581**	**1,581**	**4,427**	**$7,679,492**

Note: The total number of fishermen by tier may not add up correctly due to merging of cells for confidentiality purposes. See Appendix Table B.1 for the minimum-sales-based alternative compensation plan for the same fishermen.

paid an additional $2,410.68 and nine hundred and ninety two (992) will receive $539.15 less than they were paid. The results are more interesting for Clusters F and G, which are made up of a smaller portion of the original tier 3. Specifically, the new compensation plan would pay $6,567.21 more to a hundred and eighty (180) fishermen, who are now in Cluster F and $32,778.47 more to the top fifteen (15) commercial fishermen who are in Cluster G and had a total average seafood sales of approximately $3 million (7.1% of total sales). The original payment received by individual commercial fishermen in tier 3 was $3,820.05.

Table 4.10 presents an alternative compensation plan for the wholesale/retail seafood dealers based on the average seafood purchases by cluster (See Appendix Table C.1 for a comparable compensation plan, which is based on the minimum seafood purchases). The original compensation structure paid $1,437.91, $4,678.05 and $43,814.97 to dealers in tier 1, tier 2 and tier 3, respectively, while the new compensation structure suggests payment plan including $478.17 (Cluster A), $571.28 (Cluster B), $2,221.97 (Cluster C), $7,007.84 (Cluster D), $21,756.30 (Cluster E) and $125,499.44 (Cluster F). The remaining part of this section compares this new payment structure with the original compensation plan (See Table 1.3) consisting of $1,437.91 for tier 1, $4,678.05 for tier 2 and $43,814.97 for tier 3 to examine whether there has been over-compensation or under-compensation of seafood dealers who have participated in the cooperative research survey.

Of the one hundred and twenty (120) seafood dealers who are in Cluster A, ninety five (95) come from the original tier 1 and twenty five (25) come from tier 2. Both groups would receive $4,199.88 and $959.74 less, respectively, in the new compensation plan than they actually received from the cooperative research program's original payment plan. The majority (16) of the twenty (20) individuals in Cluster B would receive $866.63 less, while the remaining

Table 4.10 Average-Purchases-Based Alternative Compensation Plan for Wholesale / Retail Seafood Dealers Who Participated in the Cooperative Research Program

Cluster and Recommended (New) Payment Amount			Number of Dealers by Original Tier and Payment Amount			Number of Dealers by Cluster	Amount of Payment per Cluster
Cluster	New Pay	New Pay - Original Pay	Tier 1 ($1,437.91)	Tier 2 ($4,678.05)	Tier 3 ($43,814.97)		
A	$478.17	- $4,199.88	-	25	-	120	$57,380
		- $959.74	95	-	-		
B	$571.28	- $4,106.77	-	4	-	20	$11,426
		- $866.63	16	-	-		
C	$2,221.97	- $2,456.08	-	94	-	94	$208,865
D	$7,007.84	- $36,807.13	-	-	29	49	$343,384
		$2,329.79	-	20	-		
E	$21,756.30	- $22,058.67	-	-	74	74	$1,609,966
F	$125,499.44	$81,684.47	-	-	38	38	$4,768,979
Total			**113**	**141**	**141**	**395**	**$7,000,000**

Note: The total number of dealers by tier may not add up correctly due to merging of cells for confidentiality purposes. See Appendix Table C.1 for the minimum-purchases-based alternative compensation plan for the same dealers.

four (4) would receive $4,106.77 less than what were given to them. All ninety four (94) dealers in Cluster C would receive $2,456.08 less. Most (29) of the twenty nine (49) dealers in Cluster D would be paid $36,807.13 less while the remaining twenty (20) will be paid $2,329.79 more. Clusters E (with 74 dealers) and F (with 38 dealers) contains the majority (112) of dealers who were initially grouped into tier 3. They would receive $22,058.67 less and $81,684.47 more, respectively, than they have received.

The comparisons between the tier-based and cluster-based contributions of commercial fishermen to the total values of seafood sold at Louisiana docks as well as their associated allocations of hurricanes assistance funds are presented in Table 4.11 and Table 4.12, respectively. Specifically, Table 4.11 shows disproportional allocations of assistance funds when compared with the fishermen's contribution to values of seafood sales. For example, the contributions to seafood sales were approximately 2.8 percent, 14.5 percent, and 82.7 percent for fishermen who were in tier 1, tier 2, and tier 3, respectively. With approximately 3.4 percent of allocated disaster funds, tier 1 fishermen were compensated more than their contributions to total seafood sales. Tier 2 fishermen, with 17.9 percent, were also overcompensated. The amounts with which these fishermen were overcompensated were deduction from allocations for tier 3 fishermen who received 78.6 percent. Table 4.12, however, shows that the proportions of disaster funds allocated to fishermen in individual clusters are the same with the proportions of their contributions to the total values of seafood sales.

Likewise, the comparisons between the tier-based and cluster-based contributions of wholesale/retail seafood dealers to the total values of seafood purchased at Louisiana docks as well as their associated allocations of hurricanes assistance funds are presented in Table 4.13 and Table 4.14, respectively. In Table 4.13, seafood dealers in tier 1 received 2.3 percent of

Table 4.11 Contribution of Commercial Fishermen to Total Values of Seafood Sold at Louisiana Docks and Allocated Disaster Funds by the Original Tier

Tier	Values of Seafood Sold	Percent of Total Values of Sales	Disaster Funds Allocated	Percent of Total Funds Allocated
1	$17,317,171	2.78%	$264,171	3.44%
2	$90,414,544	14.52%	$1,375,822	17.92%
3	$514,925,838	82.70%	$6,039,493	78.64%
Total	**$622,657,553**	**100.00%**	**$7,679,486**	**100.00%**

Table 4.12 Contribution of Commercial Fishermen to Total Values of Seafood Sold at Louisiana Docks and Allocated Disaster Funds by the Original Cluster

Cluster	Values of Seafood Sold	Percent of Total Values of Sales	Disaster Funds Allocated	Percent of Total Funds Allocated
A	$4,539,943	0.73%	$55,991	0.73%
B	$20,530,561	3.30%	$253,207	3.30%
C	$37,992,229	6.10%	$468,574	6.10%
D	$97,735,690	15.70%	$1,205,412	15.70%
E	$265,750,814	42.68%	$3,277,617	42.68%
F	$151,596,890	24.35%	$1,869,707	24.35%
G	$44,511,426	7.15%	$548,978	7.15%
Total	**$622,657,553**	**100.00%**	**$7,679,486**	**100.00%**

Table 4.13 Contribution of Wholesale/Retail Seafood Dealers to Total Values of Seafood Purchased at Louisiana Docks and Allocated Disaster Funds by the Original Tier

Tier	Values of Seafood Purchased	Percent of Total Values of Purchases	Disaster Funds Allocated	Percent of Total Funds Allocated
1	$4,757,514	0.62%	$162,484	2.32%
2	$35,085,240	4.57%	$659,605	9.42%
3	$728,142,119	94.81%	$6,177,911	88.26%
Total	**$767,984,873**	**100.00%**	**$7,000,000**	**100.00%**

Table 4.14 Contribution of Wholesale/Retail Seafood Dealers to Total Values of Seafood Purchased at Louisiana Docks and Allocated Disaster Funds by the Original Cluster

Cluster	Values of Seafood Purchased	Percent of Total Values of Purchases	Disaster Funds Allocated	Percent of Total Funds Allocated
A	$6,295,274	0.82%	$57,380	0.82%
B	$1,253,528	0.16%	$11,426	0.16%
C	$22,915,054	2.98%	$208,865	2.98%
D	$37,673,416	4.91%	$343,384	4.91%
E	$176,632,818	23.00%	$1,609,966	23.00%
F	$523,214,783	68.13%	$4,768,979	68.13%
Total	**$767,984,873**	**100.00%**	**$7,000,000**	**100.00%**

allocated disaster funds where as they contributed only approximately 0.6 percent of total seafood purchases. The seafood dealers in tier 2 also received 9.4 percent of disaster funds in spite of a lower contribution (4.6%) from them to the total seafood purchases. Tier 3 seafood dealers were, however, compensated (with 88.3% of disaster funds) less than their contributions (94.8%) to total seafood purchases. Similar to the commercial fishermen, Table 4.14 shows that the proportions of disaster funds allocated to wholesale/retail seafood dealers in individual clusters are the same with the proportions of their contributions to the total values of seafood purchases.

With the findings presented so far, this study has been able to establish that efficient management of variability within individual groups of observations as well as the use of an analytical procedure (clustering methods), which allows more than one measured variable are key to making proper classifications and robust analysis. Specifically, the inclusion of the seafood landings variable in the analysis, especially for the commercial fishermen, is important for certain reasons. First, the seafood landings could represent a composite measure that proxies the measures of fishing efforts (in terms of fishing experience, types and sizes of fishing boats and fishing gear, number and length of fishing trips, etc.) and production (harvest) risks for the commercial fishermen and for the dealers. This contrasts well with the use of only one variable (seafood sales or purchases), which is greatly influenced by price differences among seafood types. A small price difference can favor the participants in one fishery (e.g., oysters) more than the participants in other fisheries. Second, landings inclusion might mitigate the concern that lumping of different seafood types into one analysis might generate, thereby minimizing its effects on the results and inferences made from them.

In addition, the use of measure of central tendency (i.e., the averages) is considered to be more appropriate standard as it resulted in compensation plans with direct payments, which are proportional to the contributions of program participants to the total seafood sales and purchases in Louisiana. The analytical method presented in this study would therefore provide more rational classifications of commercial fishermen and wholesale/retail seafood dealers as well as ensure an equitable distribution of assistance funds based on the inherent variability of seafood sales and purchases of eligible participants.

Chapter 5 - Summary and Conclusion

The focus of this study was to evaluate the effectiveness of the methods used for allocating disaster funds as a result of Hurricanes Katrina and Rita of 2005 and to examine alternative methods to aid in determining an efficient criterion for allocating public funds earmarked for fisheries assistance program. The trip ticket data managed by the Louisiana Department of Wildlife and Fisheries were used and were analyzed using a cluster analysis.

The number of clusters was determined using a pseudo Hotelling's T^2 test, the cubic clustering criterion (CCC) and a tree diagram. The results of the clustering procedures were fine-tuned by computing principal components scores and plotting the scores on a two-dimensional graph. In addition, the average dockside seafood sales and purchases were used to develop alternative compensation plans for commercial fishermen and wholesale/retail seafood dealers who participated in the cooperative research survey.

Results show that commercial fishermen and the wholesale/retail seafood dealers can be classified into more groups based on their seafood harvest, dockside seafood sales and dockside seafood purchases than used in the original compensation plans and under the alternative grouping relative to the original tiers, some commercial fishermen and dealers might have been overcompensated while others might have been undercompensated for participating in the research survey.

Future analysis could be done to improve the findings presented in this paper. It is possible to partition commercial fishermen on one hand and seafood dealers on the other hand into individual fishery sectors they participated in (e.g., shrimp, crabs, oysters, wild crawfish, and finfish) before conducting a cluster analysis on the individual sectors. Availability of more variables than the two variables used (seafood landings, sales or purchases) in this study might also help to fine-tune the results of the analysis.

Conducting pair-wise comparison tests of the means of seafood landings and values of dockside seafood sales and purchases between individual clusters could be attempted in conjunction with the pseudo Hotelling's T^2 test that was considered to select the number of clusters in the study.

Finally, one important aspect of successfully implementing an assistance program, which allocates payments to individuals is widespread support from the eligible participants. This requires that the distribution plan be straight forward and easily explainable to an audience not well versed in statistical theory nor anything other than the simplest of mathematical formulas. Nevertheless, the alternative plan using cluster analysis was a good evaluation of the robustness of the percentile based plan which was successfully implemented.

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Appendix A - Scatter Plots of Seafood Landings and Transactions

Figure A.1 Scatter Plot of Seafood Landings and Dockside Sales for Commercial Fishermen (Tier 1)

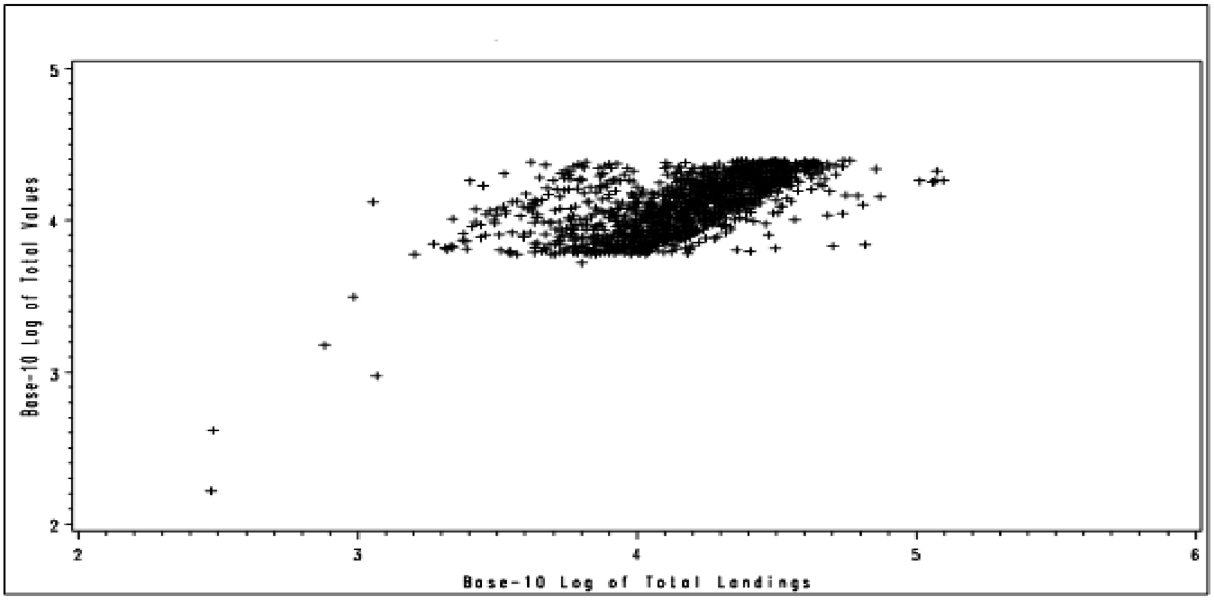


Figure A.2 Scatter Plot of Seafood Landings and Dockside Sales for Commercial Fishermen (Tier 2)

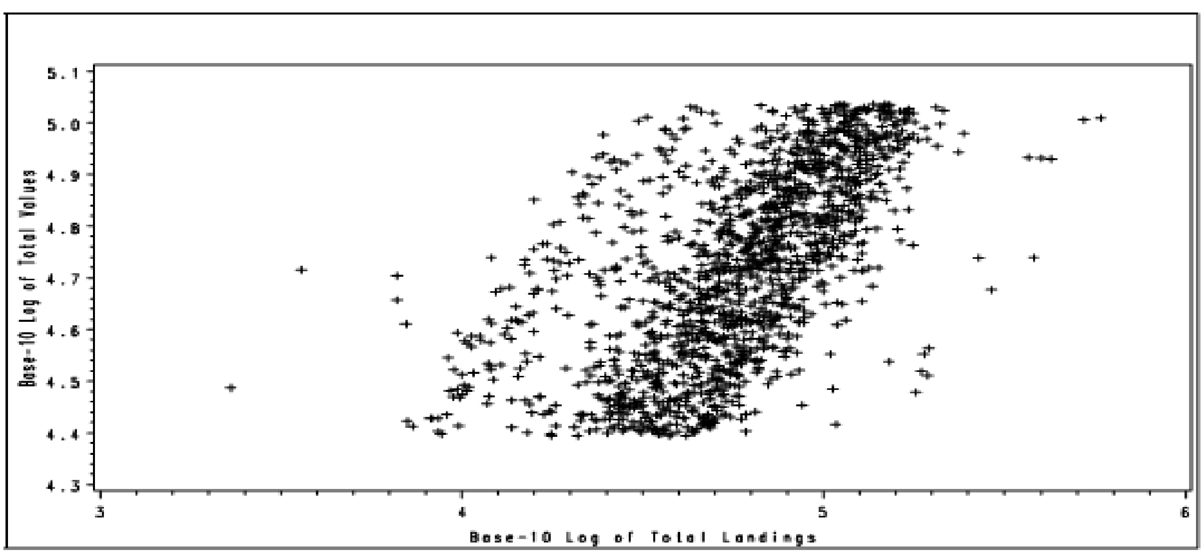


Figure A.3 Scatter Plot of Seafood Landings and Dockside Sales for Commercial Fishermen (Tier 3)

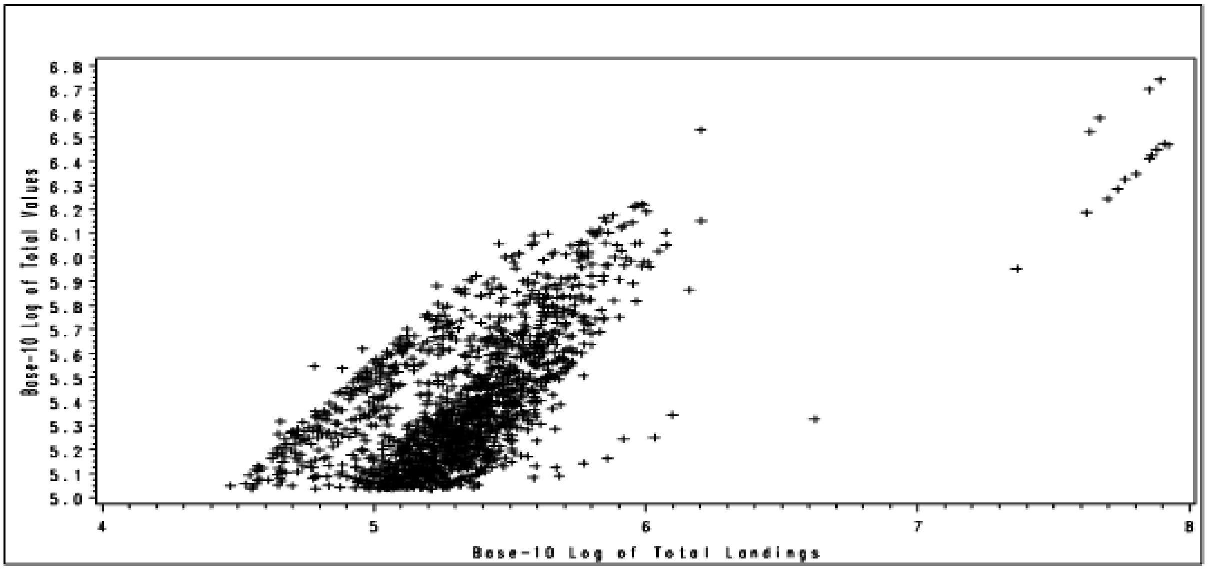


Figure A.4 Scatter Plot of Seafood Purchases and Dockside Values for Wholesale/Retail Seafood Dealers (Tier 1)

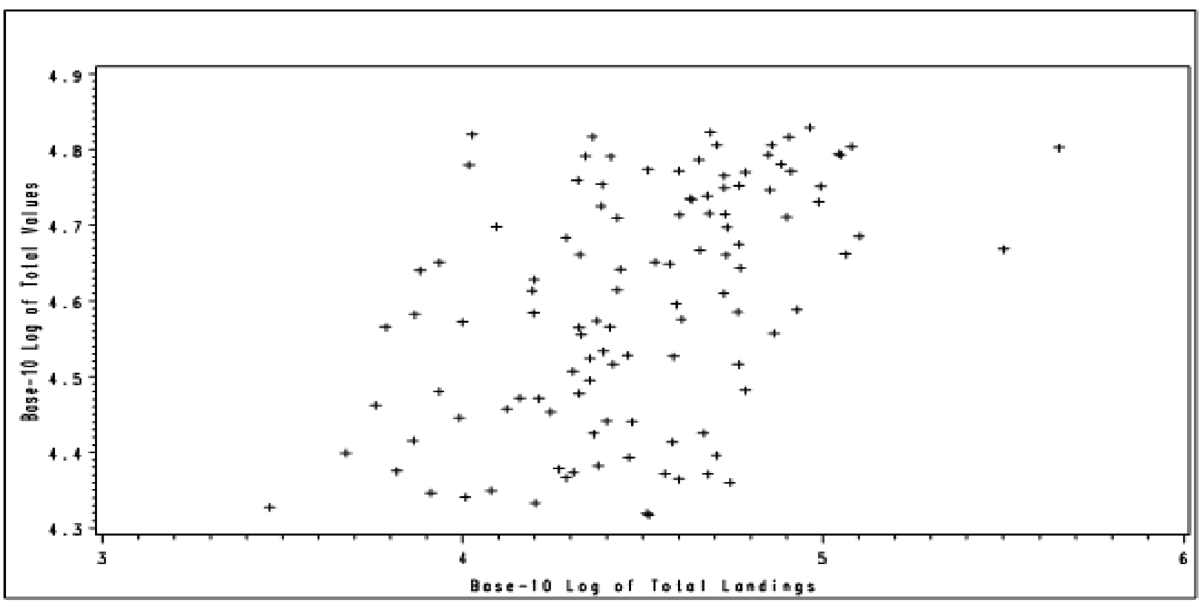


Figure A.5 Scatter Plot of Seafood Purchases and Dockside Values for Wholesale/Retail Seafood Dealers (Tier 2)

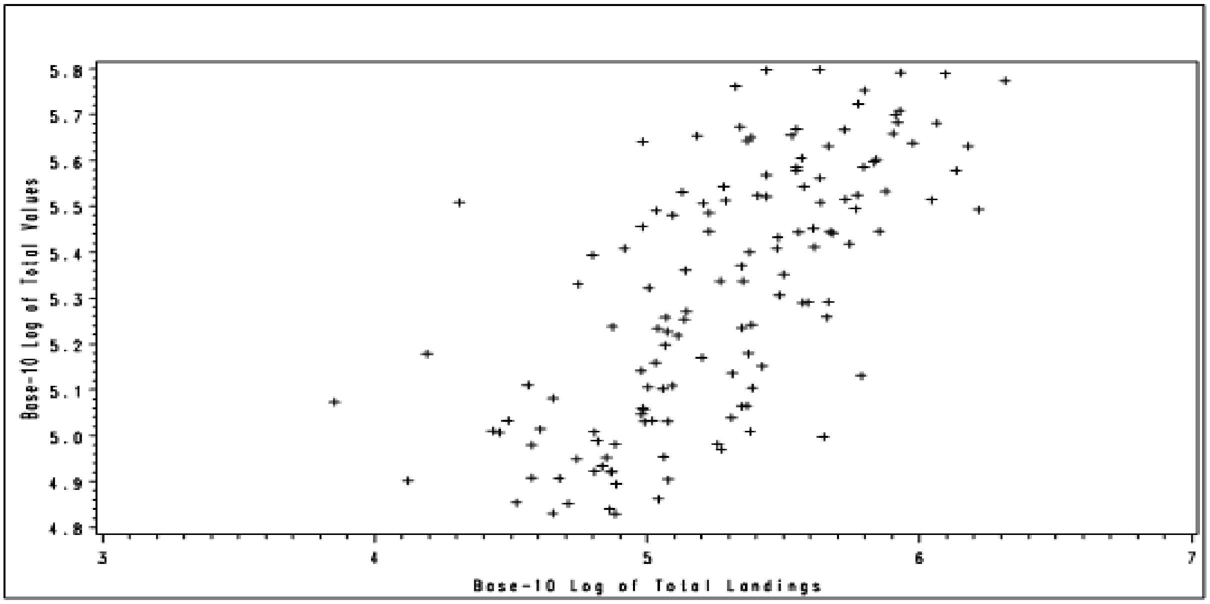
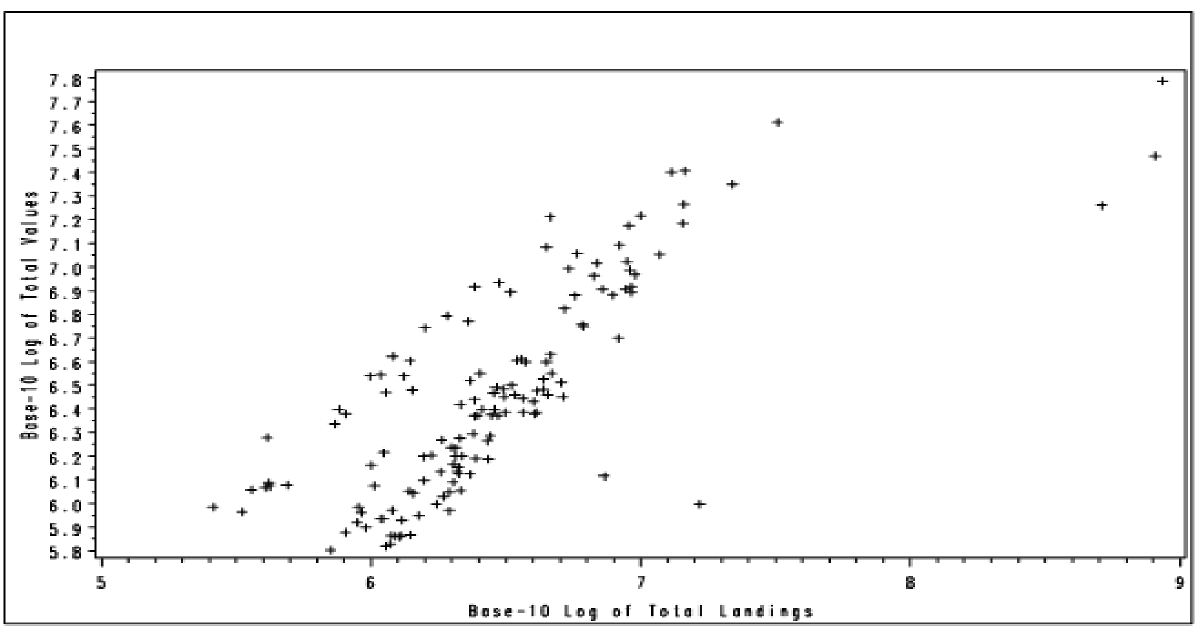


Figure A.6 Scatter Plot of Seafood Purchases and Dockside Values for Wholesale/Retail Seafood Dealers (Tier 3)



Appendix B - Verification Plots and Other Payment Plan for Commercial Fishermen

Figure B.1 Plot of the Cubic Clustering Criterion for the Commercial Fishermen

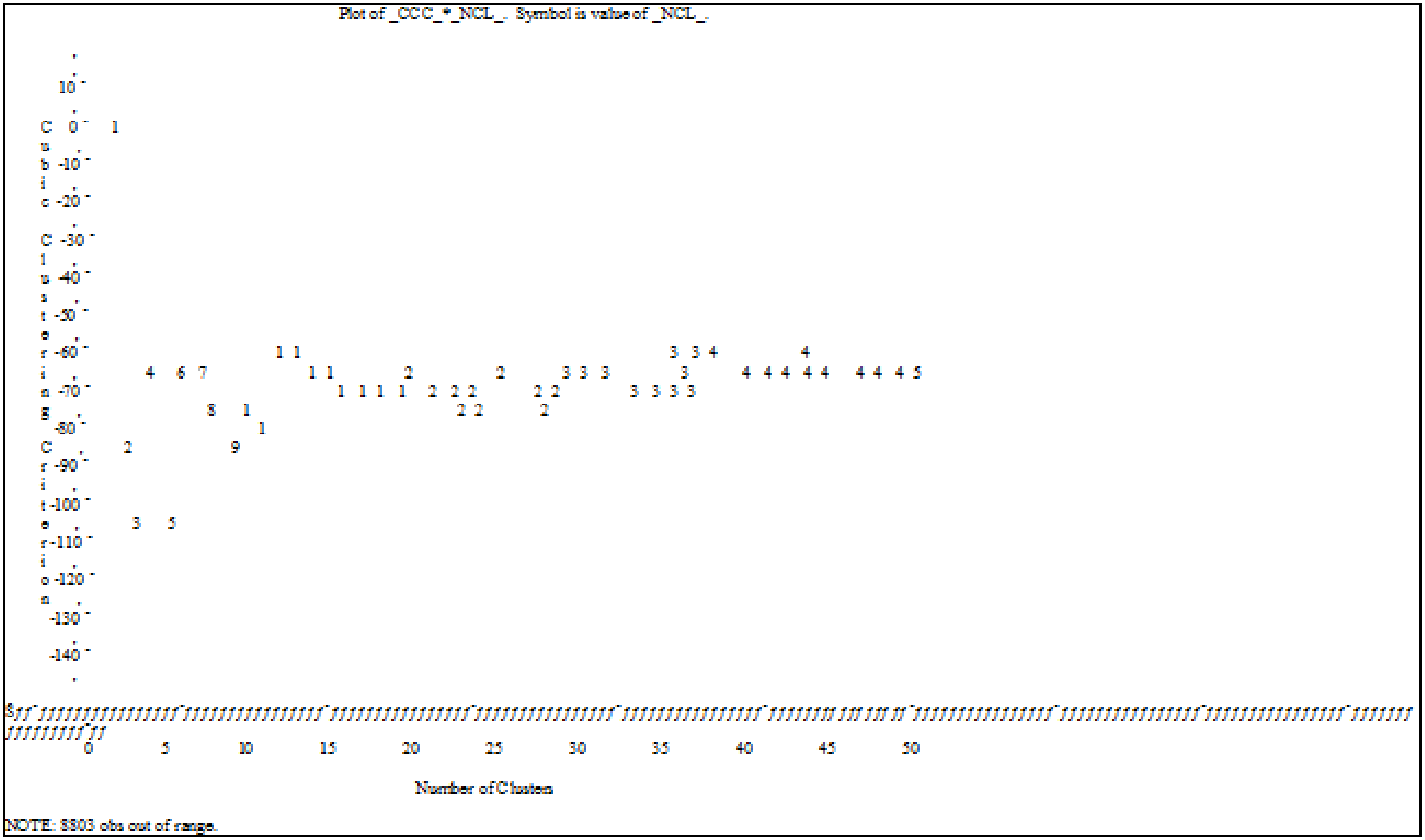
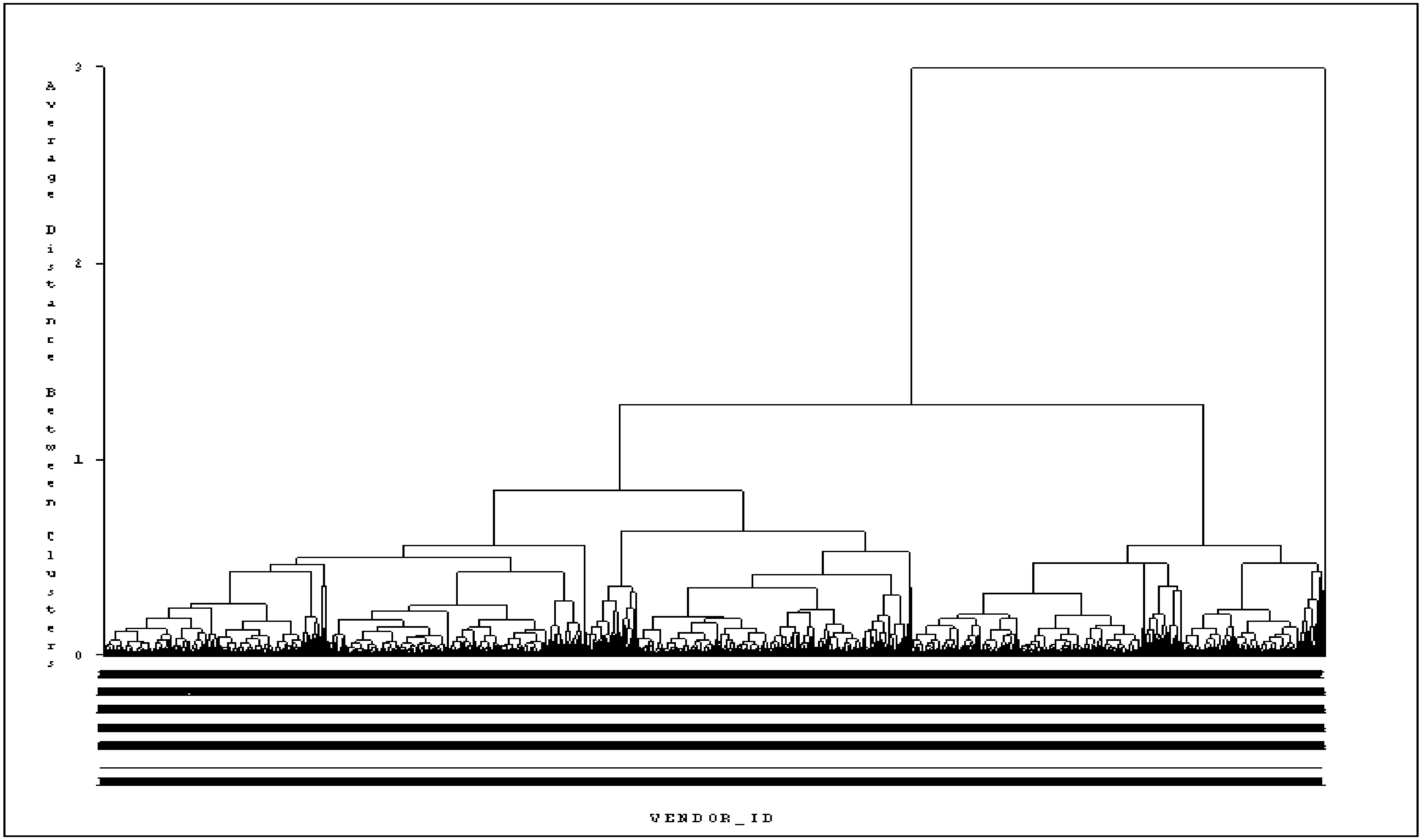


Figure B.2 Hierarchical Tree Diagram for the Commercial Fishermen



Note: Vendor_ID represents fishermen's identification numbers. The area below the tree diagram blacks out because it contains a very large number (4,427) of Vendor_ID.

Figure B.3 Plot of Principal Component Scores for the Commercial Fishermen

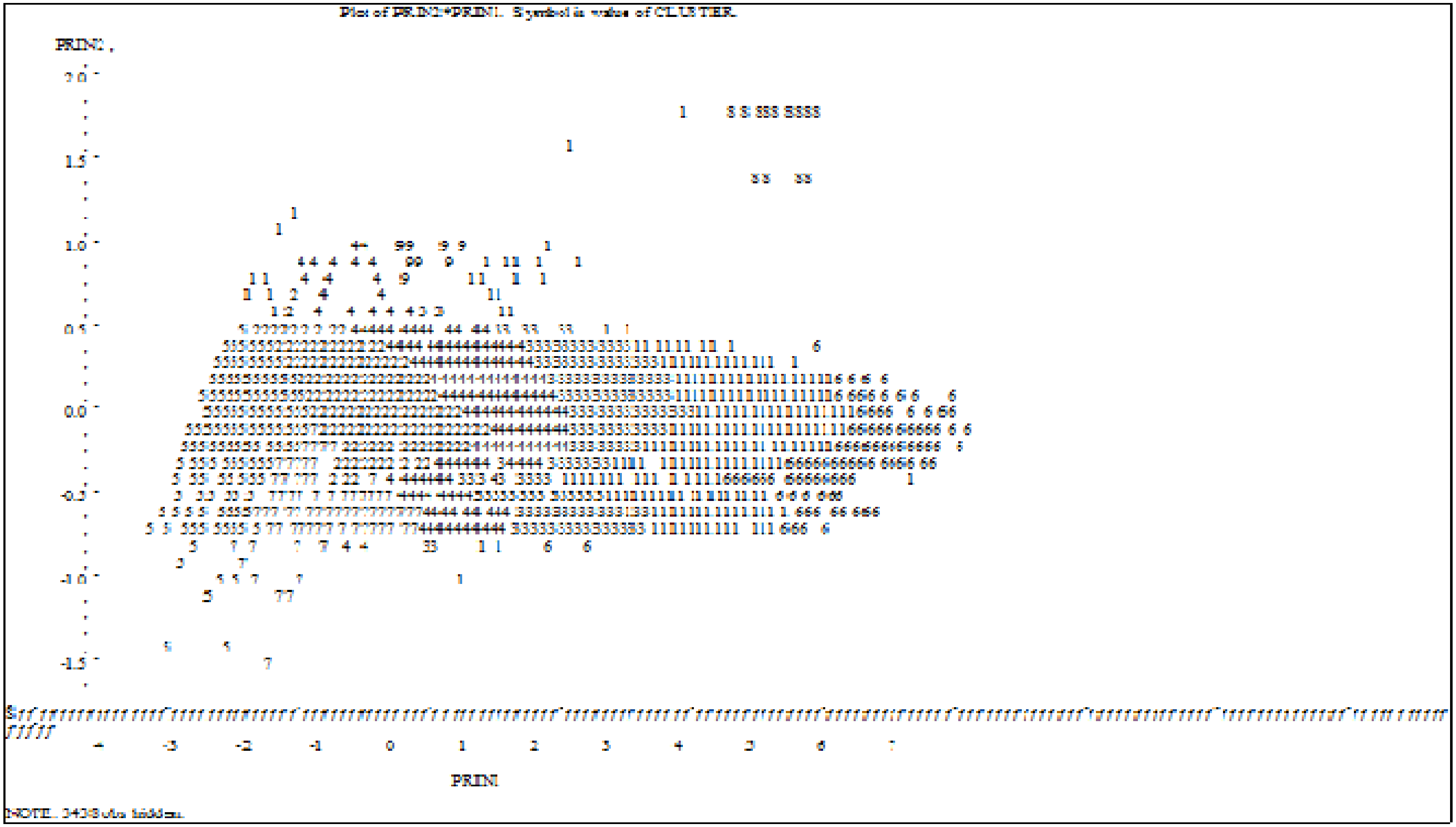


Table B.1 Minimum-Sales-Based Alternative Compensation Plan for Commercial Fishermen Who Participated in the Cooperative Research Program

Cluster and Recommended (New) Payment Amount			Number of Fisherman by Original Tier and Payment Amount			Number of Fishermen by Cluster	Amount of Payment per Cluster
Cluster	New Pay	New Pay - Original Pay	Tier 1 ($208.83)	Tier 2 ($870.22)	Tier 3 ($3,820.05)		
A	$183.07	$-25.76	517	-	-	517	$94,647
B	$219.11	$-651.11	.	275	-	969	$212,318
		$10.28	694	-	-		
C	$331.67	$-538.55	-	765	-	820	$271,969
		$122.84	55	-	-		
D	$1,486.83	-2,333.22	-	-	394	927	$1,378,291
		$616.61	-	533	-		
E	$2,619.28	-1,200.77	-	-	992	999	$2,616,661
		$1,749.06	-	7	-		
F	$13,311.03	$9,490.98	-	-	180	180	$2,395,985
G	$47,307.35	43,487.30	-	-	15	15	$709,610
Total			**1,265**	**1,581**	**1,581**	**4,427**	**$7,679,482**

Note: The total number of fishermen by tier may not add up correctly due to merging of cells for confidentiality purposes.

Appendix C - Verification Plots and Other Payment Plan for Wholesale/Retail Seafood Dealers

Figure C.1 Plot of the Cubic Clustering Criterion for the Wholesale/Retail Seafood Dealers

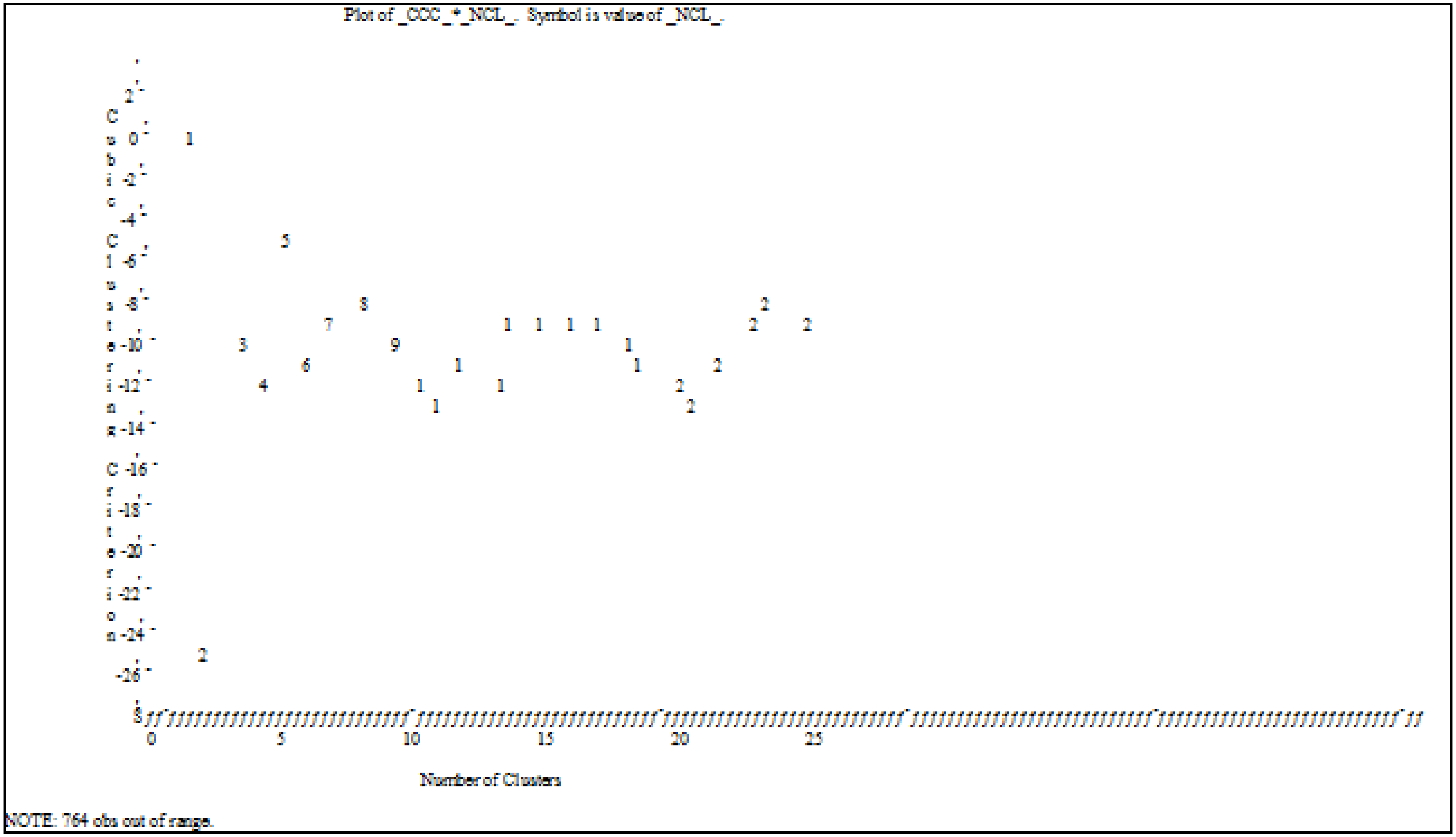
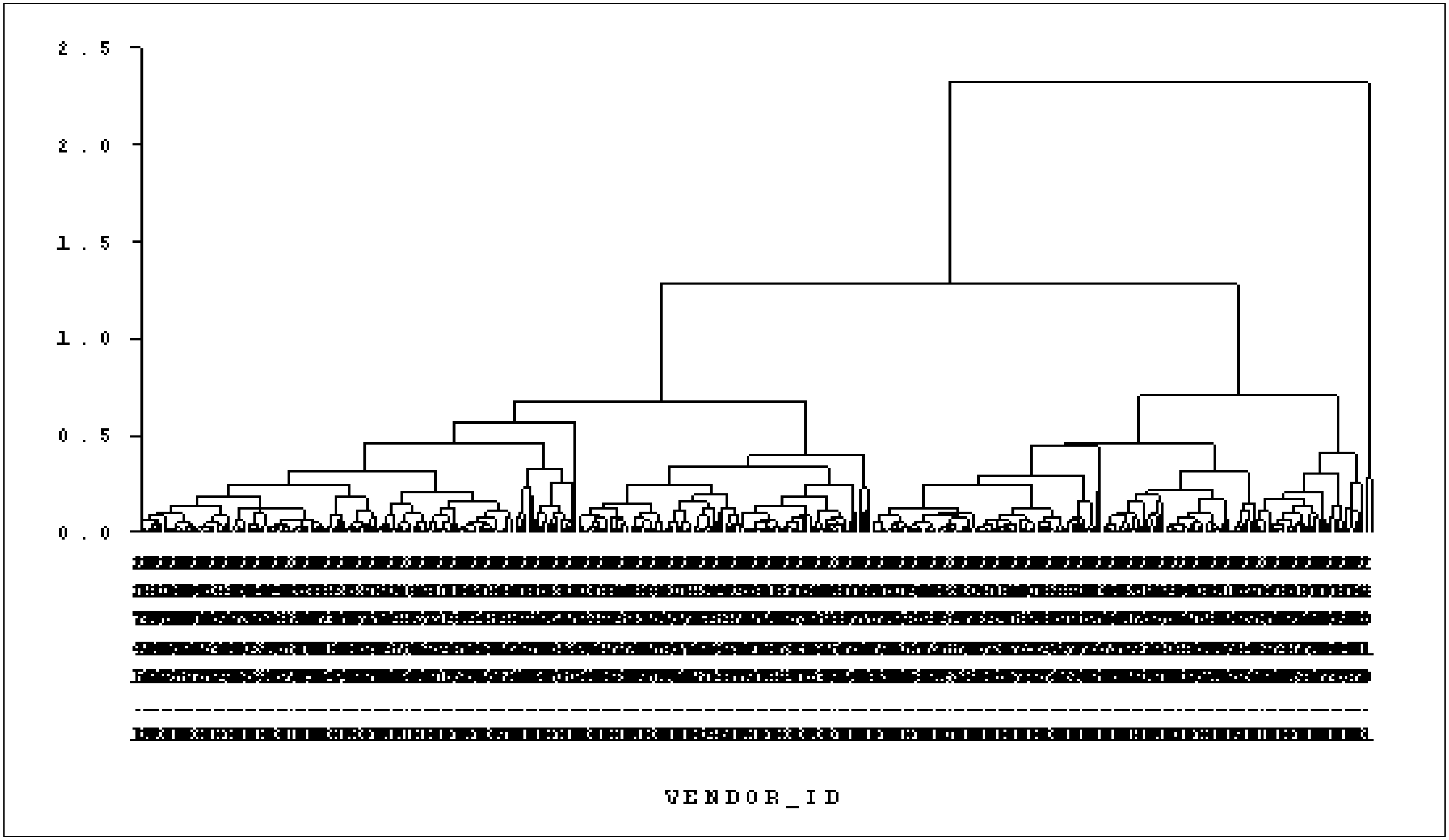


Figure C.2 Hierarchical Tree Diagram for the Wholesale/Retail Seafood Dealers



Note: Vendor_ID represents seafood dealers' identification numbers. The area below the tree diagram blacks out because it contains a very large number (4,427) of Vendor_ID.

Figure C.3 Plot of Principal Component Scores for the Wholesale/Retail Seafood Dealers

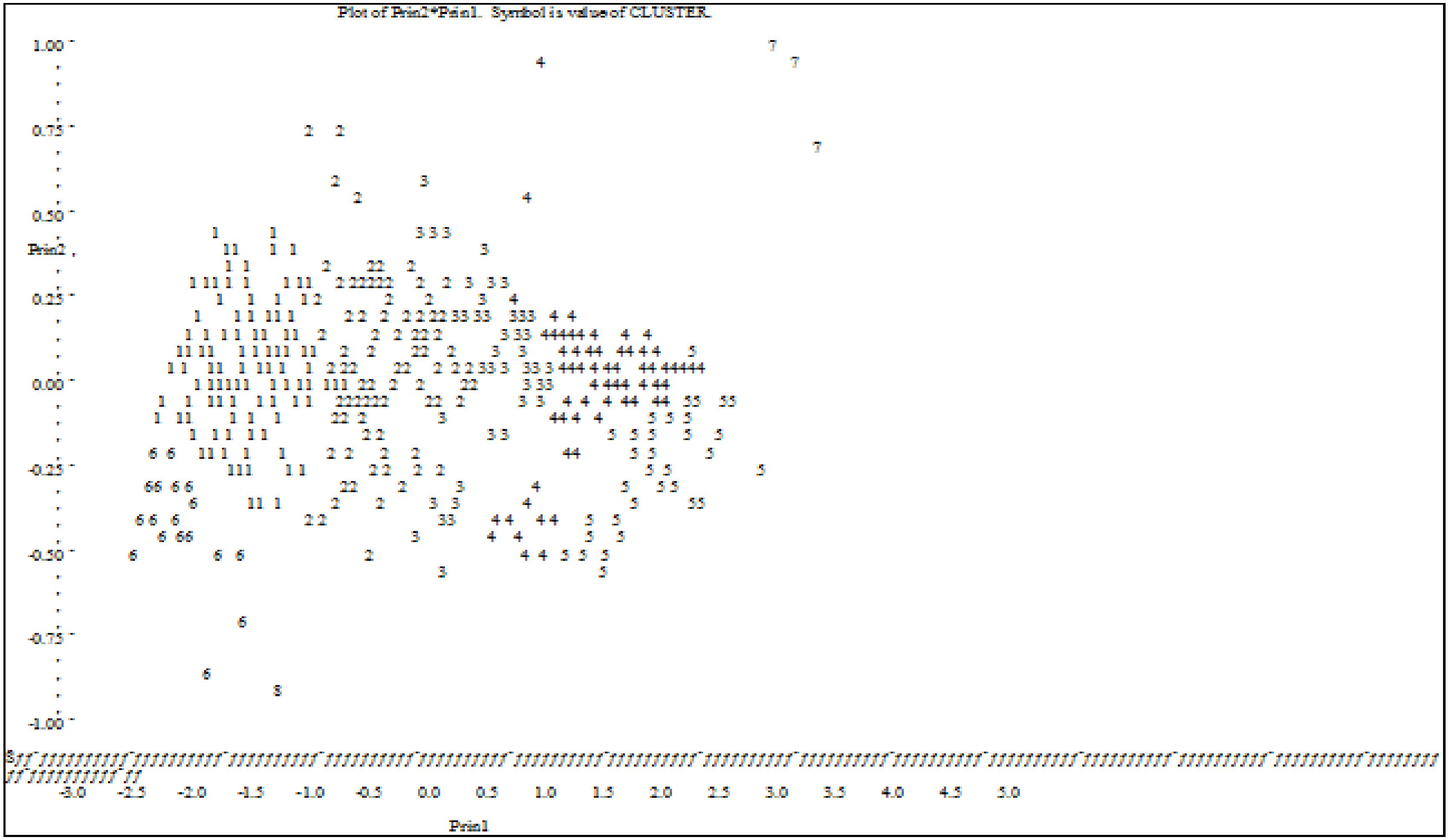


Table C.1 Minimum-Purchases-Based Alternative Compensation Plan for Wholesale / Retail Seafood Dealers Who Participated in the Cooperative Research Program

Cluster and Recommended (New) Payment Amount			Number of Dealers by Original Tier and Payment Amount			Number of Dealers by Cluster	Amount of Payment per Cluster
Cluster	New Pay	New Pay - Original Pay	Tier 1 ($1,437.91)	Tier 2 ($4,678.05)	Tier 3 ($43,814.97)		
A	$515.73	$-4,162.32	-	25	-	120	$61,888
		$-922.18	95	-	-		
B	$527.38	$-4,150.67	-	4	-	20	$10,548
		$-910.53	16	-	-		
C	$1,157.75	$-3,520.30	-	94	-	94	$108,829
D	$7,732.69	$-36,082.28	-	-	29	49	$378,902
		$3,054.64	-	20	-		
E	$23,189.73	$-20,625.24	-	-	74	74	$1,716,040
F	$124,310.39	$80,495.42	-	-	38	38	$4,723,795
Total			**113**	**141**	**141**	**395**	**$7,000,000**

Note: The total number of dealers by tier may not add up correctly due to merging of cells for confidentiality purposes.