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Comparison of Career Statistics and Season Statistics in Major League Baseball

Mark Joseph Ammons

COMPARISON OF

CAREER STATISTICS AND SEASON STATISTICS

IN MAJOR LEAGUE BASEBALL

by

MARK J. AMMONS

(Under the Direction of Pat Humphrey)

Abstract

This is a comparison of statistics for some of the best seasons and careers of players from Major League Baseball; using data collected on batting average, at-bat to homerun ratio, and earned run average. Two teams were created, composed of season leaders and career leaders (chosen for their outstanding offensive and pitching abilities), and were pitted against one another to determine superiority. These two teams also compared against a team from each "era" of major league baseball. The season and career leaders challenged: the 1918 Boston Red Sox, 1927 New York Yankees, 1955 Brooklyn Dodgers, 1961 New York Yankees, 1985 Kansas City Royals, and the 2005 Chicago White Sox. All of these teams were champions of baseball during their seasons.

INDEX WORDS: Baseball, Statistics, Thesis, College of Graduate Studies, Mark Ammons, Master's of Science, Georgia Southern University

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CHAPTER 1: INTRODUCTION

The game of baseball was first invented in the early nineteenth century. This is the widely accepted date for the beginning of baseball, but the first mention of the name of baseball was in the late seventeen hundreds in Pittsfield, Massachusetts. The game was mentioned in a town law that banned the game being played within eighty yards of city hall. The first written rules for the game were created in 1845 by Alexander Cartwright for the Knickerbocker Club of New York. The first professional baseball team came along in the mid-nineteenth century and was called the Cincinnati Red Stockings. The Red Stockings were started and stopped many times from 1869-1890 (Light 157-159). They did not officially become the Reds franchise that competes today until they switched to the National league in 1890 (Light 159). The game began with multiple leagues that competed financially with one another. The very first of these leagues was the National League which is still in existence today. The American League, the other league that survives today, started in 1894. Baseball as we know it, where two different leagues compete for the "world" crown, did not come to pass until the early twentieth century. Beginning in 1903, the two major leagues decided that a champion from each league would play for the World Series title every year. This establishes baseball as the oldest professional sport in America, hence the name "America's Pastime".

Baseball is known as a game of numbers or statistics, depending on your point of view. Almost every action that occurs in each game is written down and analyzed. The field of statistics has evolved as much as the game of baseball since its conception in the early 1800's. There are pitching statistics, batting statistics, fielding statistics, and base

running statistics. The two main defining statistics for pitchers are Earned Run Average (ERA) and Walks and Hits per Inning Pitched (WHIP). ERA is considered the basis for assessing the talent of a starting pitcher, while WHIP is used more to determine the talent level of a relief pitcher. ERA was first used as a National League Statistic in 1912 and was created earlier in the century. The formulas used for these statistics are:

$$\textbf{ERA} = 9 \times \frac{ER}{IP}$$

$$\textbf{WHIP} = \frac{BB + Hits}{IP}$$

ER = Earned Runs
A run that is scored without the aid of an error, passed ball, obstruction, or catcher's interference and that is charged to the pitcher. (Dickson 173)
IP = Innings Pitched
A pitcher's statistic referring to the opposition's times at bat, expressed in fractions, with each out counting as one-third of an inning. (Dickson 271-272)
BB = Base on Balls
To advance a batter to first base by pitching four balls; to give a base on balls to a batter. (Dickson 528)

A batter's talent has always been calculated with what is known as a batting average, which is total number of hits divided by total number of at-bats. Hitting an average of .300, which is achieving three hits for every ten at bats, has been widely accepted as the sign of a good hitter. Batting averages have been commonly used to discuss a player's ability; but as time has passed, batting average has not been shown to be the best descriptor of a player's ability. In today's game, extra base hits can compensate for a lower batting average. It is considered acceptable for a professional player to bat .260 if he hits 45 homeruns and drives in 130 runs, otherwise know as runs batted in (RBI). There are many different statistics that try to determine a hitter's talent

level, but there is currently no absolute formula to determine a player's skill. Some of these statistics are:

$$\textbf{BA} = \frac{H}{AB}$$

$$\textbf{Slugging \%} = \frac{1B + 2 \times 2B + 3 \times 3B + 4 \times HR}{AB}$$

$$\textbf{On-Base \%} = \frac{H + BB + HBP}{AB + BB + HBP + SF}$$

OPS = On-Base % + Slugging %

H = hits
A batted ball that moves in fair territory and allows the batter to reach a base safely before the ball and without the help of an error and without the ball being caught on the fly. Although most are obvious and automatic, the official scorer may have to decide whether a given batted ball is to be credited as a hit or an error. (Dickson 246)
AB = At Bats
An official statistic for the batter coming to the batter's box, excluding those appearances when the batter walks, sacrifices, is hit by a pitched ball, or is interfered with by the catcher. (Dickson, p.18)
1B = Single
A base hit on which the batter reaches first base safely (Dickson 451)
2B = Double
A base hit on which the batter reaches second base safely (Dickson162)
3B = Triple
A base hit on which the batter reaches third base safely (Dickson 511)
HR = Home Runs
A four-base hit on which the batter scores. It is usually accomplished by driving the ball out of the playing area but into fair territory. The batter and his team are awarded a run when he has touched all four bases (Dickson 256)
HBP = Number of times a batter has been hit by a pitch
A batter hit by a pitched ball. If the batter makes a reasonable effort to get out of the way of the pitch and does not swing at the ball, he is awarded first base. (Dickson 248)
SF = Total number of sacrifices – There are two different types of sacrifices:

sacrifice bunt – A sacrifice hit in which a bunted ball with less than two outs advances one or more baserunners and the batter is put out at first base, or would have been put out except for a fielder's error. The batter is not credited with an official at-bat and may be credited with a run batted in if a baserunner scores. (Dickson 425)

sacrifice fly – a sacrifice hit in which a fly ball or line drive, either fair or foul, with less than two outs, is caught but hit deep enough for an outfielder (or an infielder

running in the outfield) to handle and to allow one or more baserunners to tag up and score. (Dickson 425)

Even though these four statistics are generally used to describe a player's offensive ability, each one has its flaws. Batting average does not reveal how well a hitter can hit for power. A power hitter is defined as a hitter who tends to achieve more extra base hits than singles. While it tells a statistician how successful a hitter can be at getting a hit, there are no additional details about the type of hit included. Slugging percentage is one of the newer statistics. The problem with this statistic is the fact that someone can have a batting average of .360 and above, which would probably lead their league in hitting, but could potentially produce a very low slugging percentage. Slugging percentage tends to make singles hitters undesirable. On-Base Percentage loses its luster for the same reason as batting average.

There are some other very prevalent statistics that are widely used today that have not always been around. The *save* is the credit given to one relief pitcher for ensuring his team's victory by protecting the lead in a given game (Dickson 430). This became an official MLB statistic in 1969 (Dickson). On-base percentage did not become an official MLB statistic until 1984 (Light 525). This statistic is generally used for lead off hitters, which is the person who bats first in the lineup. Major League teams want their leadoff hitters to get on base forty percent of the time. A base on balls was originally considered a hit but this was a short-lived idea. On-base percentage plus slugging percentage (OPS) is a fairly new statistic (first popularized in 1984), and a problem with it is the fact that the formula weighs on-base percentage equally with slugging percentage.

Professional baseball has existed for more than one hundred years. During this lengthy time span it has gone through many "eras". The first of these "eras" was from

1900-1919 and was called the “Dead Ball Era”. This era was so labeled because of the low scoring for games. Although this was a dead era it still produced some lasting marks in baseball’s record book, like the career batting average record held by Ty Cobb, which is a mark of .367. The equipment is most likely to blame for the lack of scoring over the era. Most games would use the same ball for an entire game if possible (compared to today’s baseball games averaging between 60-70 baseballs a game). This era also produced lasting pitching records, which will probably never be broken due to today’s style of the game. Pitchers by the name of Cy Young, Walter “Big Train” Johnson, and Christy Mathewson dominated the hitters of this era. It is hard to say whether these pitchers or the quality of the equipment is the reason why runs weren’t scored in this time period. All three pitchers are in the top 60 players in history in terms of career ERA and career wins. Cy Young has the most career wins in MLB history at 511 (Baseball-Reference).

The “Dead Ball Era” ended in 1920 with the start of the “Live Ball Era” which lasted from 1920-1941. The changing of several rules was one of the reasons why a new era of baseball was ushered in. One rule change stipulated that umpires were to remove balls from the game that had been scuffed or damaged. This rule took a large advantage from the pitcher, while giving a great deal of power to batters. Another major reason for the death of the “Dead Ball Era” presented itself with the arrival of the “King of Baseball” George Herman Ruth, otherwise known as Babe Ruth. Ruth’s season statistics blew away entire teams’ offensive output. The Babe hit 60 homeruns in 1927, amassing more than every other team in Major League Baseball. Ruth retired with career records in homeruns and RBIs to name a few. He also retired with the record for slugging

percentage in a season at .847 which lasted until 2001 when Barry Bonds of the San Francisco Giants broke it with .863. (Baseball-Reference)

World War II sparked the introduction of another era of baseball. Many major league players served for their country's armed forces during the time of need from 1940-1945. This diluted talent throughout the major leagues; with most of the full time players gone, the development of the Negro leagues began to increase. In 1947, the first non-white players joined major league baseball: Jackie Robinson and Larry Doby. During this time period one of baseballs' most treasured records was set: Joe DiMaggio's 56 game hitting streak. It is a record that still stands today, and no player has yet to come within 10 games of breaking this record. If we think of this record as a Bernoulli trial, with a hit being a success and no hits in a game not being a success, the probability of obtaining 56 consecutive successes is extremely low, especially when one considers each player typically has multiple at bats in a game. This era also has the last recorded season of an individual batting average over .400 set by Ted Williams. Ted Williams could have possibly broken many baseball records during his tenure with the Boston Red Sox, but instead spent three of his prime years in the armed services during World War II and flying planes in Korea.

The "Expansion Era" brought many new teams to Major League Baseball, and lasted from 1961-1976. During this time period eight teams were added to Major League Baseball. This growth reduced the talent level per club and affected strategies of the game. The method with which a batter is pitched has a big outcome on the player's success rating. The American League adopted the designated hitter during this era with hope of boosting team offensive output. The designated hitter rule change allowed

another position player take the at bats for the pitcher. In doing so, the American League became a predominately better hitting league without the pitcher at bat because pitchers are generally known as notoriously bad hitters. There are some pitchers who are exceptions to this rule; but because they focus on their pitching, there is little time to focus on batting skills. This is why adding another position player boosts a team's offensive performance.

The "Free Agency Era" lasted from 1977-1993. During this era players bargained that after six years of professional baseball they earned the right to look for higher contracts from other teams. This was a wild era, and MLB saw fourteen different "world" champions in seventeen years. The game began to be displayed on TV increasingly more often. Pete Rose had a 44 game hit streak during this era, which is the closest anyone has ever come to breaking Joe DiMaggio's record. Pete "Charlie Hustle" Rose also broke Ty Cobb's career record for hits. Pete Rose later became a black mark on professional baseball, when in 1989 he was banned from the sport for gambling while managing and playing for the Cincinnati Reds.

Today's modern era is called the "Long Ball Era". It is a time where the number of homeruns has soared along with the number of strikeouts. It was once considered a taboo for a player to strikeout over a hundred times in a season, but today's player can strike out over one hundred times without anyone blinking an eye if he is also hitting homeruns and driving in runs. Many new ballparks were built during this part of baseball's history that favor the hitter. This happens during today's game because fans come to the park to see runs scored. Balls are flying out of parks at tremendous rates. Players now attend off season conditioning programs that help increase stamina, speed,

and power. This time period's reputation is also stained by the reported use of performance enhancing drugs, although there is no conclusive evidence that all or even many players are using them. Many distinguished records have been broken. The seasonal homerun record, which was originally set at 61 in 1961, was broken six separate times during this era (3 times by Sammy Sosa, twice by Mark McGwire, and once by Barry Bonds) (Baseball-Reference). One interesting fact is that this was done over a four year span from 1998-2001.

Because of its long history and heavy reliance on statistics to summarize the action that took place in a game, as well as general player abilities, the author (a long-time fan) thought a statistical investigation of some questions of interest related to the game would be appropriate as a research topic. Statistics have been a part of baseball since the start of the game. Teams are built on player performance. Most players make money based on past seasons offensive or pitching superiority, and new players are paid on potential. Statistics are the driving force behind every decision that a franchise makes. Hopefully, during the upcoming simulations, some answers will be obtained abut the differences between seasons and career statistics.

CHAPTER 2: LITERATURE REVIEW

As stated earlier, baseball is seen by most as a game of numbers or statistics. These are used by managers of teams in making decisions about lineups and strategy; they are also used by mathematicians and statisticians to study various elements of the game. The American Statistical Association has had a Section on Statistics in Sports since 1992. Their two sponsored sessions of invited papers at the 2007 Joint Statistical Meetings were well attended and included four presentations devoted to baseball. "Devlin's Angle," a monthly column on the Mathematical Association of America's website, often features sports and baseball. To further understand some of the questions that have been asked in scientific curiosity about the game, a search of recent scholarly papers and books was undertaken.

Baseball is a game designed to be played in nine innings with nine players on each team. Statistics is at the forefront of the game now. Professional baseball has been played for over one hundred years and during this time period vast amounts of data have been recorded. Every organization tries to put together a team that showcases their superior skill. This skill is measured with statistical output in ways different from other professional sports. Players are not measured in height, weight, and muscle mass; instead they are measured by statistics such as: velocity of throwing, running speed, bat speed, previous offensive output, and previous pitching statistics. An organization doesn't sign players just because of their potential. It signs them for the numbers they have produced over a pre-determined amount of seasons in high school, college, etc. As shown in the book Moneyball, the general manager of the Oakland Athletics was able to put together a highly successful team despite having one of the lowest budgets in the league (Lewis).

Billy Beane was that general manager and his first major hire was Paul DePosdesta, who was an economics major from Harvard (Lewis). The two created an inexpensive winning team in 1997 by signing free agents that on paper did not look that eye-catching, but when assembled in the correct order created a winning machine.

By using this technique interesting questions came about: for instance, how did they know that if a certain player had a high on-base percentage that his performance would be similar for their team? What other significant offensive, defensive, or pitching statistics did they use to measure a player's talent level? There are four main offensive categories that are still used today: Batting Average, Slugging Percentage or Average, On-Base Percentage, and OPS. Batting averages have been used since the start of professional baseball and have always been on the forefront of a player's worth. Until recently it was a decent measure of a player's value. In today's game batting average is not as important as long as a player is driving in runs and hitting the ball out of the ballpark. Batting averages do not tell how well a batter drives in runs. It is nothing but successes and failures. On-base percentages also have the same problem. Even though this is a good way to possibly determine the worth of a lead-off-hitter, it doesn't help a general manager determine who is worth what amount of money. Slugging Percentage is a great statistic for calculating how well a player can hit for extra bases. It is a weighted average of the number of homeruns, triples, doubles, and singles. The problem with this statistic is the fact that a singles hitter is not statistically important when it comes to slugging percentage (Berry). For example, Ichiro of the Seattle Mariners in 2004 hit .372, but only had a slugging percentage of .455 which is not considered very high (Baseball-Reference).

There are certain events that happen every so often in baseball that are wonderful. Some of these events that we reminisce about are no-hitters, triple plays and hitting for the cycle. A no-hitter occurs when one particular team plays an entire game and does not give up a base hit to the other team. A triple play happens when there are two or three runners on the bases and a ball gets put into play by the hitter and three outs are recorded off of that one single at bat. Hitting for the cycle occurs when a batter gets a single, double, triple, and homerun in the same game; order does not matter. There have been 529 triple plays turned since 1900, which breaks down to 4.9 a year. There has been 235 cycles hit for since 1900, which is an average of 2.2 per year (Players Who Have Hit for the Cycle). There have been 213 no-hitters since 1900, which has an average of 1.99 per year (No Hitters Chronologically). Of course there are deviations from the mean; there are not exactly 5 triple plays, 2 cycles, and 2 no-hitters a year. This does show that these baseball events do not deter the event from happening again (Are They Memoryless). One can use a Poisson process model to show that one occurrence of these events is independent of another (Huber).

Statistics are also used to represent situational events in Major League Baseball. Do certain players attain more success during these types of events? Take "clutch hitting" for example. Players who are considered "clutch" are the ones who seem to be more successful when the game is at a meaningful point. A "clutch" hitter is hitter who is more successful when there are runners on base. Instead of determining the batting average for a player with runners in scoring position, maybe a value of runs produced should be determined. This value can be calculated in a percentage of how often a hitter

is successful in driving in a run. Hitters can also be more productive given the situation they are put in, like runners on second and third with nobody out (Albert).

Some of baseball's most hallowed marks are Joe DiMaggio's 56 game hitting streak and hitting .400 or better for a season. The closest anyone has come to DiMaggio's record was Pete Rose in 1978 with a 44 game hit streak. The last man to bat over .400 in a season was Ted Williams hitting .406 in 1941. There have been a few hitters who have come very close to the .400 mark like George Brett hitting .390 in 1980 and Tony Gwynn hitting .394 in 1994 before the season was cancelled in September due to the player strike. Both of these marks can be represented as a binomial distribution with successes and failures. Hitting over .400 can be viewed as a hitter achieving a hit (success) forty percent of the time. A hitting streak is looked at in the same way with a player obtaining a hit in successive games (success). Every player will have a different probability of success which could depend on: player ability, batting order, pitcher faced, ballpark, and weather. According to Lackritz, the probability of seeing another 56 game hitting streak in our lifetime is almost zero, but a player hitting over .400 has a much higher chance of happening in the next quarter century.

Does a catcher's "game calling" ability affect the statistics of a pitcher? Certain catchers are considered better defensive players. In baseball a catcher is the one to study hitters' tendencies and set up a game plan with the pitcher on how to go about retiring a certain lineup. People have tried to formulate a catcher's ability to call a game. One of these formulas is catcher's ERA (CERA). This is the study of how well certain catchers perform with certain pitchers. This is not what most major league teams use to determine which catchers catch which pitchers. "Currently, the most common way to evaluate

game calling in the majors right now is expert evaluation – in other words managers' and coaches' opinions and assessments" (Woolner 2). In statistical terms, the null hypothesis in this case is that there is no game calling skill. Data was collected and evaluated by setting up a statistic known as the average run value of each plate appearance. The data were then transformed into a statistical Z-score and a test of normality was done. The results rejected the null hypothesis. The next test was done to see if one year could predict the outcome of future years. There was no evidence to support a relationship from one year to another. Finally, a test was done to see if the skill level of the catcher could determine how well a pitcher did the next season. Once again, there was no evidence to support a relationship from one year to another depending on the skill level of the catcher. "Though we would colloquially say that game-calling doesn't exist, it's more accurate to say that if there is a true game calling ability it lies below the threshold of detection" (Woolner 13).

There have been questions about the 1919 World Series for many years after the series concluded. These questions continue even today. Did the "Black Sox" actually throw the World Series? No players were found guilty of trying to throw the Series in 1919, but eight players were banned. Jay Bennett created a statistical method that would model a players expected output for a certain game or Series. It was determined that the most famous of these "Black Sox", "Shoeless" Joe Jackson, actually performed as well as expected. Still, no one knows whether or not he intentionally did not play as hard as he could (Albert).

This same method was also used to see if one could show the differences in how players who possibly used steroids career paths differ. Career models were used on some

of the great homerun hitters from baseball: Mike Schmidt, Mickey Mantle, Babe Ruth, and Willie Mays. All four of these models showed the same statistical pattern. The number of homeruns, per particular player, increased until that player reached their early to mid-thirties and then homerun production decreased every year after that. Similar models were done for Mark McGwire, Sammy Sosa, and Barry Bonds, all three of whom are suspected steroid users. The results showed that Sammy Sosa's career path followed the other four players, while Bond's and McGwire's did not. Bond's and McGwire's paths show an increase in homeruns after their mid thirties, which never really happened before. Bond's career path showed a slight drop in his early thirties then immediately started increasing again until he was forty. This does not prove that these players took steroids. It just shows that these players' deterioration is not typical of even of great players (Albert).

There are many baseball games that deal with statistical data from actual players. One of the most famous games is Strat-O-Matic Baseball. This game is played with player's data on individual performance cards. Each game player will field a team and play against one another. Teams must be conforming to the rules of baseball. A pair of dice is used to determine the outcome of each at-bat. This game does have a few problems. This game can not simulate a pitcher tiring throughout a game. If a team has a dominant pitcher, that pitcher can pitch every inning of every game. Another problem is the fact that whether or not you use the hitter or pitchers card is fifty-fifty. There have been many attempts to make baseball simulated games and there are some good ones. However, there are not any simulation games that are completely realistic (Hastings).

Throughout the literature review, different ways of evaluating player potential were discussed. Originally, there was an idea of building a baseball simulator to test different players. However, building a simulator proved too difficult, for lack of programming languages and difficulty simulating a real game. A very reasonable simulator was found online, that was deemed worthy of use. A paper containing the probabilities of a player hitting over .400 or a 56 game hitting streak brought to mind the idea of differences of seasonal statistics and career statistics. How different could some of the best careers and seasons be? Could a baseball team from history compete with the teams of leaders? Given that these teams are statistically superior; will there be a significant difference in offensive and pitching statistics?

CHAPTER 3: COMPARISON OF CAREER LEADERS AND SEASON LEADERS

Were some of the "greatest" players in major league baseball history really that good or were they good compared with the other players of their time? Some of the questions we chose to investigate are:

1.) When comparing teams composed of career leaders and season leaders, who would be more likely to win and how much more likely are they to win?
2.) When the "best" face off against one another, how much of a decrease will there be in batting average?
3.) When the "best" face off against one another, how much of an increase will there be in at-bats per homerun?
4.) When the "best" pitchers face off against the "best" hitters, how much will their ERA increase?
5.) How often do no-hitters, cycles, and other rare events occur?

Career leaders are players that are able to keep their offensive or pitching skills and statistics in the upper 10% for a sustained period of time. Season leaders are players who are able to achieve production in the top 10% for a single season. It is much more difficult to sustain high production for an entire career than for a single season. A baseball team is considered good when it is able to win above 62% of its games. If the season leaders win over 70% of their games, they would then be a great baseball team. Player's batting averages tend to be less impressive when they play against superior pitching. Since these teams have some of the greatest pitching statistics, expectations are for the batting average of players to decrease. If a pitching staff is able to decrease an opponent's batting average by over .100 points, the staff would be considered very successful. When a player's at-bat per homerun ratio is increased, a pitching staff has done well. The increase in the ratio means that there are fewer homeruns being hit which in turn means fewer runs are being scored. A 10% increase in this ratio would be highly

successful. A run per game can make a difference in the outcome. A pitcher's ERA raised by one or even 0.5 would be considered a large increase from a hitter's prospective.

Rare events such as no-hitters and hitting for the cycle happen every so often in the game of baseball. The occurrence of these events can not be measured by a formula with respect to time. When one event happens it does not divulge when the next will happen. An expectation for the simulations would be that rare events occur less often because of the increased talent levels.

Section 3.1: Player Selection

There are nine different positions per baseball team. Each position requires different talents. The catcher is a position that requires no speed. When a catcher hits for a high average or for good power numbers, it is generally considered a luxury not a necessity. A catcher is responsible for working with the pitching staff on strategy and the wear and tear on their bodies because of sustained crouching, foul balls, etc. over a season tends to decrease their offensive ability. Corner infielders, first and third basemen, are considered power positions. Those two positions generally produce higher batting numbers because these are the least two strenuous positions on the diamond. There are many offensively successful players at these two positions, which made it more difficult to choose the best players. Corner outfielders, right and left fielders, are very similar to corner infielders with respect to offensive numbers and mobility, but the outfielders have to cover more ground than their infield counterparts. Second basemen, shortstops, and centerfielders are generally smaller, quicker players due to all the ground they must cover on defense. The batting numbers for these positions are not as good

when compared to corner positions; however, some of the players with the highest baseball averages for careers and seasons played one of these three positions. These players are prototypical lead-off men whose job is to get on base and score runs.

Players were chosen to fill the real aspects of a major league team, which means there are eight position players with suitable backups for each position. There is also a pitching staff with a bullpen for relief roles. The players from both teams were chosen from among those with the best season and career records. No players were chosen that played before the year 1900 because major league baseball was not the same game it is today. The first World Series was held in 1903. For players who are still competing, statistics are compiled until September 14, 2007, the date when the simulations for this project began. Specific seasons and careers were decided upon by judging a player's overall statistics. Career and season statistics were obtained from Baseball-Reference.com, www.baseball-reference.com/. Homeruns and batting averages were used as starting points in selecting non-pitchers. Members of the career team own certain major league records like the top three homerun hitters and the career batting average record. Fielding percentage was not taken into account because all considered player percentages were greater than or equal to 95%. The simulation program used also does not distinguish certain aspects of fielding; for example, how successfully a catcher throws out potential base stealers. This part of the criteria eliminates many catchers as a possibility. The basis used for an acceptable batting average was .300. The career batting average record, which is .367 by Ty Cobb, was used as the peak mark when selecting players. There are exceptions to this rule; the only time sub .300 batting averages were allowed on the teams were when the player produced many homeruns or

had a high on base percentage, or if there was a lack of other significant players at that position. The lowest career average that was accepted was .281, which was Robin Yount. The lowest season average that was accepted was .298, which was Mark McGwire. Both of these averages were accepted due to abundance of homeruns or for a lack of overall batting talent at a certain position. The team batting averages for both teams are well over the .300 requirement. The career leaders have a team batting average of .321 and the season leaders have an average of .343. Historic batting averages will be compared with those obtained in the simulations. Average homeruns per season is skewed in favor of the season leaders. The career leaders averaged 28 homeruns per player per season while the season team averaged 41 homeruns per player. Tables 3.2and 3.3 describe the players selected.

Starting pitchers were chosen almost solely based on ERA. Their number of strikeouts had nothing to do with the selection process. Relief pitchers had more criteria that they had to surpass. Originally, we wanted to select relief pitchers based on walks and hits per inning pitched (WHIP). Since the program did not support this statistic, qualifications were changed. Relievers were then chosen on a combination of ERA and saves. The career leaders relief pitchers contain four of the top five all-time saves leaders. The season leaders' relief pitchers may not have the number of saves the career leaders have, but their ERAs are astonishingly low. One cannot judge a pitcher on wins because wins have more to do with a combination of the team that is around him and a quality start. In other words, a pitcher does not have pitch successfully to get a win. The starting rotation for each team is as follows:

Table 3.1: Starting Rotations.

Career Rotation	Season Rotation
Christey Mathewson	Walter Johnson
Walter Johnson	Greg Maddux 94
Whitey Ford	Greg Maddux 95
Pedro Martinez	Tom Seaver
Tom Seaver	Sandy Koufax

ERA was also used to determine who started and in what order. These are the lowest ERAs for starting pitchers on their respective teams. Choosing the rotation in this manner helped eliminate possible bias.

Certain players appear multiple times. Some players participate on both teams: Ivan Rodriguez, Mike Piazza, Albert Pujols, Lou Gehrig, Craig Biggio, George Brett, Alex Rodriguez, Barry Bonds, Babe Ruth, and Ichiro Suzuki. These players show up multiple times because they have had exceptional careers as well as exceptional seasons. Assume the career leaders statistics are the mean for that player across all years. There will be deviations from this mean, both high and low. When the career leaders had a higher mean statistic, they also generally had a higher variability. In one case a pitcher shows up twice on the same team: Greg Maddux from 1994 and 1995. In both of these seasons, he was significantly lower than the league's ERA which in both seasons was over four.

Table 3.2: Career Leaders. This chart details the Career leaders' team. It has the position players, names, batting averages, and homeruns. We also display the pitchers' names, ERA, and strikeouts. All numbers are based per season.

Player		Position	BA	HR
Rodriguez	Ivan	Catcher	0.303	22
Piazza	Mike	Catcher	0.308	36
Pujols	Albert	First Base	0.331	42
Gehrig	Lou	First Base	0.341	37
Biggio	Craig	Second Base	0.281	17
Hornsby	Rogers	Second Base	0.358	22
Rodriguez	Alex	Third Base	0.307	44
Brett	George	Third Base	0.305	19
Jeter	Derek	Shortstop	0.318	17
Yount	Robin	Shortstop	0.285	14
Cobb	Ty	Outfield	0.367	6
Williams	Ted	Outfield	0.345	37
Bonds	Barry	Outfield	0.298	41
Ruth	Babe	Outfield	0.342	46
Suzuki	Ichiro	Outfield	0.334	10
Aaron	Hank	Outfield	0.305	37

Player		Position	ERA	SO
Ford	Whitey	Starting Pitcher	2.75	142
Johnson	Randy	Starting Pitcher	3.22	279
Clemons	Roger	Starting Pitcher	3.13	224
Maddux	Greg	Starting Pitcher	3.09	157
Johnson	Walter	Starting Pitcher	2.17	162
Mathewson	Christey	Starting Pitcher	2.13	143
Santana	Johan	Starting Pitcher	3.18	220
Seaver	Tom	Starting Pitcher	2.86	189
Martinez	Pedro	Starting Pitcher	2.80	248
Eckersley	Dennis	Relief Pitcher	3.50	114
Hoffman	Trevor	Relief Pitcher	2.71	77
Rivera	Mariano	Relief Pitcher	2.33	73
Smith	Lee	Relief Pitcher	3.03	82

Table 3.3: Season Leaders. This chart details the Season leaders' team. It has the position players' names, batting averages, and homeruns. The chart also displays the pitchers' names, ERA, and strikeouts. All numbers are based per season.

Season	Player		Position	Average	HR
1999	Rodriguez	Ivan	Catcher	0.332	35
1997	Piazza	Mike	Catcher	0.362	40
2006	Pujols	Albert	First Base	0.331	49
1998	McGwire	Mark	First Base	0.299	70
1927	Gehrig	Lou	First Base	0.373	47
1998	Biggio	Craig	Second Base	0.325	20
1999	Alomar	Roberto	Second Base	0.323	24
1999	Jones	Chipper	Third Base	0.319	45
1980	Brett	George	Third Base	0.390	24
2000	Garciaparra	Nomar	Shortstop	0.372	21
2003	Rodriguez	Alex	Shortstop	0.298	47
1994	Gwynn	Tony	Outfield	0.394	12
1956	Mantle	Mickey	Outfield	0.353	52
2001	Bonds	Barry	Outfield	0.328	73
1927	Ruth	Babe	Outfield	0.356	60
2004	Suzuki	Ichiro	Outfield	0.372	8
1930	Wilson	Hack	Outfield	0.356	56
1997	Griffey Jr.	Ken	Outfield	0.304	56

Season	Player		Position	ERA	SO
1995	Maddux	Greg	Starting Pitcher	1.63	156
1996	Smoltz	John	Starting Pitcher	2.94	276
1990	Clemons	Roger	Starting Pitcher	1.93	230
1994	Maddux	Greg	Starting Pitcher	1.56	181
1913	Johnson	Walter	Starting Pitcher	1.14	243
1963	Koufax	Sandy	Starting Pitcher	1.88	306
2004	Santana	Johan	Starting Pitcher	2.61	265
1971	Seaver	Tom	Starting Pitcher	1.76	289
1988	Hershiser	Orel	Starting Pitcher	2.26	178
2003	Gagne	Eric	Relief Pitcher	1.20	137
2004	Rivera	Mariano	Relief Pitcher	1.94	66
1990	Eckersley	Dennis	Relief Pitcher	0.61	73
2003	Smoltz	John	Relief Pitcher	1.12	73

Simulations were done with the "Strategic Baseball Simulator" by D.B. Schmidt found at http://sbs-baseball.com/. This program was found on the internet and after testing the simulator it proved to work better and be more efficient, than any simulator

programmed by the author. This simulator was tested for its ability to reasonably replicate actual results and worked well. Thus it was used for the simulations that later occurred. Data files were constructed to describe the two teams: Seasonal Leaders and Career Leaders. In these files, different statistics were required: At Bats, doubles, triples, homeruns, walks, strikeouts, runs batted in, fielding percentage, stolen bases, number of times caught stealing, total games, and whether the player bats right handed, left handed or is a switch hitter. Once the data files were created, they were tested to make sure that the program was interpreting them as it should. These data files can be seen in Appendix B. Originally, the career data file did not work as intended. The career numbers were inserted into the file, but the program did not support values over three significant digits. The career statistics were then recomputed, thanks to *Baseball-Reference.com*, so that the player's career averages were used as a replacement for career totals. Simulations began with a comparison between the two teams. One hundred-sixty two games (a season) over twenty years (a "career") were used as the basis for this study. The teams competed in twenty different simulations. There were a total of 64800 games simulated between the two teams.

Section 3.2: Win/Loss Percentage

When comparing teams composed of career leaders and season leaders, who would be more likely to win and how much are likely are they to win? The career leaders managed a winning percentage of around 31.4% while the season leaders won 68.6% of the time. The season leaders averaged 2222.5 wins per "career" while the career leaders won 1017.5 games during the same time span. The average seasonal wins for the season leaders was 111.1 wins and the career leaders averaged 50.9 wins per season.

Table 3.4: Win/Loss Records for the entire simulation.

Season Totals				Career Totals			
Records	**Wins**	**Loses**	**Win %**	**Records**	**Wins**	**Loses**	**Win %**
Career1	2205	1035	0.6806	**Career1**	1035	2205	0.3194
Career2	2210	1030	0.6821	**Career2**	1030	2210	0.3179
Career3	2251	989	0.6948	**Career3**	989	2251	0.3052
Career4	2259	981	0.6972	**Career4**	981	2259	0.3028
Career5	2247	993	0.6935	**Career5**	993	2247	0.3065
Career6	2233	1007	0.6892	**Career6**	1007	2233	0.3108
Career7	2238	1002	0.6907	**Career7**	1002	2238	0.3093
Career8	2254	986	0.6957	**Career8**	986	2254	0.3043
Career9	2212	1028	0.6827	**Career9**	1028	2212	0.3173
Career10	2231	1009	0.6886	**Career10**	1009	2231	0.3114
Career11	2227	1013	0.6873	**Career11**	1013	2227	0.3127
Career12	2222	1018	0.6858	**Career12**	1018	2222	0.3142
Career13	2221	1019	0.6855	**Career13**	1019	2221	0.3145
Career14	2203	1037	0.6799	**Career14**	1037	2203	0.3201
Career15	2173	1067	0.6707	**Career15**	1067	2173	0.3293
Career16	2183	1057	0.6738	**Career16**	1057	2183	0.3262
Career17	2206	1034	0.6809	**Career17**	1034	2206	0.3191
Career18	2202	1038	0.6796	**Career18**	1038	2202	0.3204
Career19	2256	984	0.6963	**Career19**	984	2256	0.3037
Career20	2217	1023	0.6843	**Career20**	1023	2217	0.3157
Total	44450	20350	0.6860	**Total**	20350	44450	0.3140

Each simulation of 3240 games yielded similar results in winning percentage. During a single simulation, the season team won a high of 112.8 games and a low of 108.7 games during an individual simulation. The career team won a high of 53.4 games and a low of 49.1 games. The overall winning percentages are basically two-thirds to one-third. This shows that the season leaders are on the border of greatness, but they never reach a winning percentage over seventy.

Section 3.3: Batting Average

When comparing the "best", how much of a decrease will there be in batting average? Once the better pitchers and hitters face each other, batting averages should

drop. Averages only remain high when hitters get to face pitchers of lesser talent periodically. Good pitching generally stops good hitting. The odds are always in favor of the pitcher; if not there would be some extreme offensive output.

Table 3.5: Season leader's offensive production. This chart contains the number of at-bats, hits, and batting average for the Season leaders before and after simulation. There is also a column containing the difference in the two batting averages.

Player		AB	Hits	BA	Sim. AB	Sim. AB	Sim. BA	Difference
Rodriguez	Ivan	600	199	0.332	130063	36223	0.279	-0.053
Piazza	Mike	556	201	0.362	115023	33736	0.293	-0.069
Pujols	Albert	535	177	0.331	81758	20714	0.253	-0.078
McGwire	Mark	509	152	0.299	71163	13857	0.195	-0.104
Gehrig	Lou	584	218	0.373	90234	25962	0.288	-0.085
Biggio	Craig	646	210	0.325	138326	38436	0.278	-0.047
Alomar	Roberto	563	182	0.323	109771	29359	0.267	-0.056
Jones	Chipper	567	181	0.319	129558	31242	0.241	-0.078
Brett	George	449	175	0.390	109326	35696	0.327	-0.063
Garciaparra	Nomar	529	197	0.372	145073	45298	0.312	-0.060
Rodriguez	Alex	607	181	0.298	170147	39562	0.233	-0.065
Gwynn	Tony	419	165	0.394	55369	18943	0.342	-0.052
Mantle	Mickey	533	188	0.353	149897	39890	0.266	-0.087
Bonds	Barry	476	156	0.328	197574	41235	0.209	-0.119
Ruth	Babe	540	192	0.356	69644	18063	0.259	-0.097
Suzuki	Ichiro	704	262	0.372	141413	47658	0.337	-0.035
Wilson	Hack	585	208	0.356	132960	35907	0.270	-0.086
Griffey Jr.	Ken	608	185	0.304	213837	48598	0.227	-0.077

Table 3.6: Career leader's offensive production. This chart contains the number of at-bats, hits, and batting average for the Career leaders before and after simulation. There is also a column containing the difference in the two batting averages.

Player		AB	Hits	BA	Sim. AB	Sim. Hits	Sim. BA	Difference
Aaron	Hank	607	185	0.305	120622	25413	0.211	-0.094
Biggio	Craig	619	174	0.281	112913	23607	0.209	-0.072
Bonds	Barry	534	159	0.298	102686	19183	0.187	-0.111
Brett	George	619	189	0.305	183965	41485	0.226	-0.079
Cobb	Ty	610	224	0.367	208273	59345	0.285	-0.082
Gehrig	Lou	599	204	0.341	122561	28567	0.233	-0.108
Hornsby	Rogers	586	210	0.358	109431	28709	0.262	-0.096
Jeter	Derek	655	208	0.318	99831	23899	0.239	-0.079
Piazza	Mike	587	181	0.308	114589	24495	0.214	-0.094
Pujols	Albert	604	200	0.331	126499	28528	0.226	-0.105
Rodriguez	Ivan	621	188	0.303	128275	29320	0.229	-0.074
Rodriguez	Alex	626	192	0.307	116004	25291	0.218	-0.089
Ruth	Babe	544	186	0.342	152724	33219	0.218	-0.124
Suzuki	Ichiro	692	231	0.334	199656	52781	0.264	-0.070
Williams	Ted	545	188	0.345	219082	49349	0.225	-0.120
Yount	Robin	624	178	0.285	93832	20114	0.214	-0.071

The differences in the batting averages are fairly large. The season leaders had an average drop off of 0.072, while the career leader's averages dropped off by 0.092. The batting averages and homerun per at-bat differentials are consistent with what the win/loss records have already shown. Every player, on both teams, had statistics fall considerably from their historic averages. The career team's batting averages fell by .092 on the average. Using a one sample t-test, with hypotheses H_0: $\mu = 0$ vs. H_A: $\mu < 0$. The following results from Minitab are: $t = -20.70$ with a p-value of 0.000. This shows that the career leaders' drop in average was highly significant. The Season team's batting averages fell by .073. Using a similar one sample t-test, the following results from Minitab are: $t = -14.40$ with a p-value of 0.000. The larger t-value shows that the career

leaders' drop in average was even more highly significant. Using a two sample t-test on whether or not the drop offs were similar with hypotheses: H_0: $\mu_0 - \mu_1 = 0$ vs. H_A: $\mu_0 \neq \mu_1$, the following results from Minitab are: $t = 2.78$ with a p-value of 0.009. We reject the null hypothesis, so there is a difference between the two teams. The season leaders did not have as bad a drop off as the career leaders. This confirms that when players at the highest talent level compete against players with an equal talent, they are not as offensively productive as they originally were.

Section 3.4: At-Bats per Homerun

When comparing the "best", how much of an increase will there be in at-bats per homerun? An at-bat per homerun ratio tells how often a player hits a homerun. It is not an exact science but it gives an estimate. This ratio also excludes walks and sacrifices because they are not official at-bats. In any case, an increase in the ratio means the pitchers facing any set player have been successful.

Table 3.7: Season leader's homerun production. This table displays the Season leader's number of homeruns, at-bats, and the ratio of at-bats to homeruns historically and after simulation on a per season basis.

Player		HR	AB	AB/HR	Sim HR	Sim AB	Sim AB/HR	Diff
Rodriguez	Ivan	35	600	17.14	3303	130063	39.38	22.240
Piazza	Mike	40	556	13.90	3502	115023	32.84	18.940
Pujols	Albert	49	535	10.92	3194	81758	25.60	14.680
McGwire	Mark	70	509	7.27	4027	71163	17.67	10.400
Gehrig	Lou	47	584	12.43	3106	90234	29.05	16.620
Biggio	Craig	20	646	32.30	1887	138326	73.30	41.000
Alomar	Roberto	24	563	23.46	2011	109771	54.59	31.130
Jones	Chipper	45	567	12.60	4321	129558	29.98	17.380
Brett	George	24	449	18.71	2591	109326	42.19	23.480
Garciaparra	Nomar	21	529	25.19	2490	145073	58.26	33.070
Rodriguez	Alex	47	607	12.91	5663	170147	30.05	17.140
Gwynn	Tony	12	419	34.92	712	55369	77.77	42.850
Mantle	Mickey	52	533	10.25	6264	149897	23.93	13.680
Bonds	Barry	73	476	6.52	12476	197574	15.84	9.320

Ruth	Babe	60	540	9.00	3240	69644	21.50	12.500
Suzuki	Ichiro	8	704	88.00	665	141413	212.65	124.650
Wilson	Hack	56	585	10.45	5392	132960	24.66	14.210
Griffey Jr.	Ken	56	600	10.86	8405	213837	25.44	14.580

Table 3.8: Career leader's homerun production. This table displays the Career leader's number of homeruns, at-bats, and the ratio of at-bats to homeruns historically and after simulation on a per season basis. There is also a column containing the difference in the simulated and the original ratio.

Player		HR	AB	HR/AB	Sim. HR	Sim. AB	Sim. HR/AB	Diff.
Aaron	Hank	37	607	16.41	2583	120622	46.70	30.29
Biggio	Craig	17	619	36.41	1068	112913	105.72	69.31
Bonds	Barry	41	534	13.02	2594	102686	39.59	26.57
Brett	George	19	619	32.58	1946	183965	94.53	61.95
Cobb	Ty	6	610	101.67	697	208273	298.81	197.14
Gehrig	Lou	37	599	16.19	2616	122561	46.85	30.66
Hornsby	Rogers	22	586	26.64	1398	109431	78.28	51.64
Jeter	Derek	17	655	38.53	973	99831	102.60	64.07
Piazza	Mike	36	587	16.31	2581	114589	44.40	28.09
Pujols	Albert	42	604	14.38	2979	126499	42.46	28.08
Rodriguez	Ivan	22	621	28.23	1610	128275	79.67	51.44
Rodriguez	Alex	44	626	14.23	3030	116004	38.29	24.06
Ruth	Babe	46	544	11.83	4317	152724	35.38	23.55
Suzuki	Ichiro	10	692	69.20	1018	199656	196.13	126.93
Williams	Ted	37	545	14.73	4932	219082	44.42	29.69
Yount	Robin	14	624	44.57	812	93832	115.56	70.99

The changes in at-bat per homerun reflected the changes in batting average in terms of lower performance. The career team's average homerun to at-bat ratio increased an extra 57 at-bats per home run while the season team's homerun ratio grew by only 28 at-bats. A test of normality was run on the differences in at-bats per homerun and it showed that the data for both teams was not normal. Once non-normality was determined, a bootstrap distribution was computed to estimate the difference, see Appendix C. Since the bootstrap distribution was approximately normal the bootstrap 95% confidence interval is (-57.5764, -6.37243). Since zero is not in the confidence

interval, this shows that there is a significant difference in the two team's at-bat per homerun ratio. This agrees with the batting average differences and with the win loss percentages. The career leaders are at-bats per home run increased about twice as much compared to the increase for the season team (on average).

Section 3.5: Difference in Pitching

When the "best" pitchers face off against the "best" hitters, how much will those pitchers' ERA increase? ERA can be affected by the number of strikeouts a pitcher has; a decrease in strikeouts means more hitters are putting the ball into play. With more balls are being put into play, the probability of hits and errors increases. If there are more hits then more runs will score, thus raising the ERA. Offensive numbers have already been shown as decreasing so theoretically, pitching numbers should improve. However, when ERA numbers begin low, it is very difficult to decrease or even keep them at the same level when playing against a great as compared to a typical team.

Table 3.9: Career leader's pitching production. This chart displays the Career leaders and their original statistics of innings pitched, strikeouts, and ERA. It also contains their simulated innings pitched, ERA, and strike outs. All data are for seasonal use.

Player		IP	SO	ERA	Sim IP	Sim SO	Sim ERA
Clemons	Roger	236	224	3.13	17	16	5.62
Eckersley	Dennis	156	114	3.50	4	3	6.93
Ford	Whitey	230	142	2.75	223	137	6.77
Hoffman	Trevor	72.7	77	2.71	8	7	5.54
Johnson	Randy	233.3	279	3.22	16	17	6.44
Johnson	Walter	273.7	162	2.17	276	154	3.46
Maddux	Greg	231.3	157	3.09	17	11	5.34
Martinez	Pedro	219.7	248	2.80	262	225	4.76
Mathews	Christey	274	143	2.13	273	143	3.59
Rivera	Mariano	81.3	73	2.33	7	9	4.21
Santana	Johan	208.7	220	3.18	75	72	6.06

Seaver	Tom	249.3	189	2.86	242	171	5.88
Smith	Lee	85	82	3.03	5	4	5.68

Table 3.10: Career leader's pitching differences. This table displays the differences in ERA, strike outs, and innings pitched for the Career leaders.

Player		ERA	SO	IP
Clemons	Roger	+2.49	-208	-219
Eckersley	Dennis	+3.43	-111	-152
Ford	Whitey	+4.02	-5	-7
Hoffman	Trevor	+2.83	-70	-65
Johnson	Randy	+3.22	-262	-217
Johnson	Walter	+1.29	-8	2
Maddux	Greg	+2.25	-146	-214
Martinez	Pedro	+1.96	-23	42
Mathews	Christey	+1.46	0	-1
Rivera	Mariano	+1.88	-64	-74
Santana	Johan	+2.88	-148	-134
Seaver	Tom	+3.02	-18	-7
Smith	Lee	+2.49	-78	-80

Table 3.11: Season leader's pitching production. This chart displays the Career leaders and their original statistics of innings pitched, strikeouts, and ERA. It also contains their simulated innings pitched, ERA, and strike outs. All data are for seasonal use.

Season	Player		ERA	IP	SO	Sim ERA	Sim IP	Sim SO
1990	Eckersley	Dennis	0.61	73	73	2.46	7	5
2003	Gagne	Eric	1.20	82	137	1.49	8	11
1988	Hershiser	Orel	2.26	267	178	3.85	44	21
1913	Johnson	Walter	1.14	346	243	2.37	287	144
1963	Koufax	Sandy	1.88	311	306	3.08	280	199
1994	Maddux	Greg	1.56	210	181	2.62	276	163
1995	Maddux	Greg	1.63	202	156	2.82	279	154
2004	Rivera	Mariano	1.94	79	66	3.30	7	4
2004	Santana	Johan	2.61	228	265	3.70	1	1
1971	Seaver	Tom	1.76	286	289	3.64	273	201
2003	Smoltz	John	1.12	64	73	2.61	5	4
1996	Smoltz	John	2.94	254	276	2.25	0.01	0.008

Table 3.12: Season leader's pitching differences. This table displays the differences in ERA, strike outs, and innings pitched for the Season leaders.

Season	Player		ERA	SO	IP
1990	Eckersley	Dennis	+1.85	-68	-66

2003	Gagne	Eric	+0.29	-126	-74
1988	Hershiser	Orel	+1.59	-157	-223
1913	Johnson	Walter	+1.23	-99	-59
1963	Koufax	Sandy	+1.20	-107	-31
1994	Maddux	Greg	+1.06	-18	66
1995	Maddux	Greg	+1.19	-2	77
2004	Rivera	Mariano	+1.36	-62	-72
2004	Santana	Johan	+1.09	-264	-227
1971	Seaver	Tom	+1.88	-88	-13
2003	Smoltz	John	+1.49	-69	-59
1996	Smoltz	John	-0.69	-276	-254

In both teams, there were differences in ERA, strike outs, and innings pitched. The career leader's starting pitchers pitched over 87% of their team's total innings, while the season leader's starting pitchers pitched over 95% of their team's total innings. Both of these percentages are considerably higher than major league baseball's percentage today which is roughly between 60-70%. The difference in strikeouts can also be partially explained by the differences in innings pitched. These pitchers are also facing hitters who historically do not strike out very often; this also decreases their number of strikeouts. The Career leader's ERA increased by an average of 2.56. Using a one sample t-test, with hypotheses H_0: $\mu = 0$ vs. H_A: $\mu > 0$. The following results from Minitab are: $t = 11.68$ with a p-value of 0.000. This shows that the Career leader's increase in ERA was highly significant. The Season leader's ERA increased by an average of 1.13. Using a similar one sample t-test, the results from Minitab are: $t = 9.81$ with a p-value of 0.000. The season leaders' average ERA increase is almost a run and a half lower than the career leaders. The difference in t-values shows that the increase of the career leaders' ERA was more significant than the season leaders. Using a two sample t-test on whether or not the increases in ERA were similar with the hypothesis:

H_0: $\mu_0 - \mu_1 = 0$ vs. H_A: $\mu_0 \neq \mu_1$, the results from Minitab are: t = -4.72 with a p-value of 0.000. This shows that there are considerable differences in the increases of both team's pitching staffs. Because starting pitchers are pitching large amounts of innings, there could be a small flaw in the simulator. This program does not calculate a decline in accuracy due to exhaustion. It would be extremely difficult to calculate how quickly a pitcher fatigues. The only pitcher, whose ERA dropped, was John Smoltz from 1996. Over the combined 64800 games, he only pitched four innings so his performance in the simulations was not included in the comparison. There are differences in strikeout production by pitchers; this is due to the fact that they are facing "great" hitters who generally do not strike out very often.

Section 3.6: Rare Events

How often do no-hitters, cycles, and other rare events occur? Since 1900 there have been 213 no-hitters, which average to about 1.99 a year. Throughout the simulations there were 72 no-hitters, which average to almost a no-hitter every five years; this is a significant drop off. During the same time period there were 235 cycles hit, which is an average of 2.2 per year. The simulations resulted in 78 cycles, which is an average of 0.2 per year. Both cycles and no-hitters went from happening almost twice a year to both happening about once every five years. Since 1900 there have only been four hitting streaks over forty games. During simulations two different hitting streaks went over forty games with the peak steak being a forty-four game streak. Curiously enough, both streaks were done by the same player, Nomar Garciaparra from 2000. These events occur so rarely, percentages are really not worth calculating. A few other

rare events happened: there were 18 four homerun games, twenty eight 6-hit games by a single player, twenty 9 RBI games, and two 5 stolen base games.

Section 3.7: Conclusion

Throughout the simulations it appeared obvious that the season leaders were a significantly better team than the career leaders. The batting statistics for both teams contained decreases in batting average and homeruns. Both of these statistics are independent variables for the dependent variable of runs scored. If a team does not score runs, they cannot win a baseball game. The season leaders did not decrease as much as the career leaders did in the offensive categories. The reduction of offensive ability brings more questions to mind: How significant was the decline of runs scored, did fielding percentage allow a significant number of extra runs, and did run production decrease due to a decrease of batting average or a decrease of homeruns?.

Pitching statistics increased significantly for both teams throughout the simulations. The increase in ERA was due to pitchers never getting an easy batter throughout the entire lineup. A designated hitter was used in our simulation; which forced the pitcher to face one more hitter in the lineup, as opposed to another pitcher. An increase in ERA also occurred coincidently with the decrease of the number of strikeouts. The increase in ERA also brings about questions relating to the allowance of runs: how does a decrease in the number of strikeouts affect ERA, does the pitcher's homerun per at-bat ratio increase significantly, how significant is the pitcher's tendency to walk batters?

CHAPTER 4: COMPARISON OF "ERA" LEADERS

How good were some of the greatest teams in major league baseball history? How well are they going to match up with the career and season leaders?

1.) Since the season leaders beat the career leaders, how much more lopsided will their record be against the "Era" Leaders?

2.) For whom is there a more significant change in batting average: For the season and career leaders or for the "Era" leaders?

3.) For whom is there a more significant decrease in at-bats per homerun: For the season and career leaders or for the "Era" leaders?

4.) How much change will there be in pitching ERA?

5.) Do any specific career accomplishments stand out for any particular series?

6.) Is there an increase in specific highlights throughout the simulations?

Season leaders are composed of players with the best seasonal statistics; career leaders are composed of players with some of the greatest careers in major league baseball history. The season leaders won 66% of their games against the career leaders. This has already been shown in Chapter 3. Since both teams are stellar performers, they are expected to dominate actual teams. Any winning percentage over 70% shows that there is a significant difference in the talent levels of the teams. Normally, a winning percentage of 62% would be considered a very good baseball team. In this aspect, winning percentages that significantly favor the season and career leaders will be expected. Some of their batting averages are already extremely high, which makes it very difficult to increase productivity with respect to average. Any increases in batting average for these two teams would be very good. When regular baseball teams play,

there is usually a significant drop off in pitching from the number one starter to the fifth starter. When batters get to face lesser pitching talent, their at-bats per homerun are going to decrease. A decrease of a full at-bat per homerun would be highly significant for any baseball team. The ERAs of the career and season leaders are expected to decrease. We expect neither of our teams to have any specific weak points except when playing each other. There should be no drop off in ERA unless certain pitchers are not needed to pitch. The career leaders and season leaders are expected to break many major league baseball records over the course of these simulations which are: HR, BA, ERA, etc... Some offensive records might not fall because of lack of at-bats. There should be significant highlight increases over the previous simulation. Statistically superior players playing against regular teams should result in an increase of rare events.

Section 4.1 - Opposition Selection

The Season leaders and Career leaders teams were used from Chapter 3 for this part of the simulation process. There were six different teams chosen from six different "eras" to take part in this simulation. All six of these teams were World Series Champions. All teams were chosen from the team files that came with the simulation program. The six teams are as follows: 1918 Boston Red Sox, 1927 New York Yankees, 1955 Brooklyn Dodgers, 1961 New York Yankees, 1985 Kansas City Royals, and the 2005 Chicago White Sox. All teams are some of the best of the defined "eras." The White Sox were chosen due to lack of options. They were the only World Series champion from the "long ball era" whose statistics were included. After all teams were chosen, files of data containing each team's statistics were checked to make sure that the player's statistics were correct.

Table 4.1: The 1918 Boston Red Sox

Player	Position	BA	HR
Sam Agnew	Catcher	0.166	0
Joe Bush	Outfield	0.276	0
George Cochran	Third Base	0.127	0
Jack Coffey	Third Base	0.159	1
Dick Hoblitzell	First Base	0.175	0
Harry Hooper	Outfield	0.289	1
Wally Mayer	Catcher	0.224	0
Carl Mays	Outfield	0.288	0
Stuffy McInnis	First Base	0.272	0
Babe Ruth	Outfield	0.300	11
Wally Schang	Catcher	0.244	0
Everett Scott	Short Stop	0.221	0
Dave Shean	Second Base	0.264	0
John Stansbury	Third Base	0.128	0
Amos Strunk	Outfield	0.257	0
Fred Tomas	Third Base	0.257	1
Frank Truesdale	Second Base	0.278	0
George Whiteman	Outfield	0.266	1

Player	Position	ERA	SO
Lore Bader	Pitcher	3.33	10
Joe Bush	Starting Pitcher	2.11	125
Jean Dubuc	Pitcher	4.09	1
Sam Jones	Starting Pitcher	2.25	44
Walt Kinney	Pitcher	1.80	4
Dutch Leonard	Starting Pitcher	2.71	47
Carl Mays	Starting Pitcher	2.21	114
Dick McCabe	Pitcher	2.70	3
Vince Molyneaux	Pitcher	3.27	1
Babe Ruth	Starting Pitcher	2.22	40

Table 4.2: The 1927 New York Yankees

Player	Position	BA	HR
Benny Bengough	Catcher	0.247	0
Pat Collins	Catcher	0.275	7
Early Combs	Outfield	0.356	6
Joe Dugan	Third Base	0.269	2
Cedric Durst	Outfield	0.248	0
Mike Gazella	Third Base	0.278	0
Lou Gehrig	First Base	0.373	47
Johnny Grabowski	Catcher	0.277	0
Mark Koenig	Shortstop	0.285	3
Tony Lazzeri	Second Base	0.309	18
Bob Meusal	Outfield	0.337	8
Ray Morehart	Second Base	0.256	1
Ben Paschal	Outfield	0.317	2
Babe Ruth	Outfield	0.356	60
Julie Wera	Third Base	0.238	1

Player	Position	ERA	SO
Walter Beall	Pitcher	9.00	0
Joe Giard	Pitcher	8.00	10
Waite Hoyt	Starting Pitcher	2.63	86
Wiley Moore	Starting Pitcher	2.28	75
Herb Pennock	Starting Pitcher	3.00	51
George Pipgras	Pitcher	4.12	81
Dutch Reuther	Starting Pitcher	3.38	45
Bob Shawkey	Pitcher	2.86	23
Urban Shocker	Starting Pitcher	2.84	35
Myles Thomas	Pitcher	4.87	25

Table 4.3: The 1955 Brooklyn Dodgers

Player	Posititon	BA	HR
Sandy Amoros	Outfield	0.247	10
Bob Borkowski	Outfield	0.135	0
Roy Campanella	Catcher	0.286	32
Carl Furillo	Outfield	0.314	26
Jim Gilliam	Second Base	0.249	7
Don Hoak	Third Base	0.240	5
Gil Hodges	First Base	0.289	27
Dixie Howell	Catcher	0.262	0
Frank Kellert	First Base	0.325	4
Don Newcombe	Outfield	0.359	7
Pee Wee Reese	Shortstop	0.282	10
Jackie Robinson	Third Base	0.256	8
George Shuba	Outfield	0.275	1
Duke Snider	Outfield	0.309	42
Rube Walker	Catcher	0.252	2
Don Zimmer	Second Base	0.239	15

Player	Posititon	ERA	SO
Don Bessent	Starting	2.71	29
Roger Craig	Pitcher	3.29	78
Carl Erskine	Starting Pitcher	3.79	84
Jim Hughes	Pitcher	4.19	20
Sandy Koufax	Starting Pitcher	3.00	30
Clem Labine	Starting Pitcher	3.29	67
Billy Loes	Starting Pitcher	3.59	85
Russ Meyer	Pitcher	5.42	26
Don Newcombe	Starting Pitcher	3.20	143
Johnny Podres	Pitcher	3.95	114
Ed Roebuck	Pitcher	4.71	33
Karl Spooner	Pitcher	3.65	78

Table 4.4: The 1961 New York Yankees

Player	Posititon	BA	HR
Yogi Berra	Outfielder	0.271	22
Johnny Blanchard	Outfield	0.305	21
Clete Boyer	Third Base	0.224	11
Bob Cerv	Outfield	0.271	6
Joe DeMaestri	Shortstop	0.140	0
Billy Gardner	Third Base	0.212	1
Bob Hale	First Base	0.154	1
Elston Howard	Catcher	0.348	21
Deron Johnson	Third Base	0.105	0
Tony Kubek	Shortstop	0.276	8
Hector Lopez	Outfield	0.222	6
Mickey Mantle	Outfielder	0.317	54
Roger Maris	Outfield	0.269	61
Jack Reed	Outfielder	0.154	0
Bobby Richardson	Second Base	0.261	3
Moose Skowron	First Base	0.267	28
Earl Torgenson	First Base	0.111	0

Player	Position	ERA	SO
Luis Arroyo	Pitcher	2.19	87
Tex Clevenger	Pitcher	4.78	14
Jim Coates	Starting Pitcher	3.45	80
Bud Daley	Pitcher	3.96	83
Art Ditmar	Pitcher	4.67	24
Whitey Ford	Starting Pitcher	3.21	209
Danny McDevitt	Pitcher	7.62	8
Hal Reniff	Pitcher	2.60	21
Rollie Sheldon	Starting Pitcher	3.59	84
Bill Stafford	Starting Pitcher	2.68	101
Ralph Terry	Starting Pitcher	3.16	86
Bob Turley	Pitcher	5.75	48

Table 4.5: The 1985 Kansas City Royals

Player	Position	BA	HR
Steve Balboni	First Base	0.243	36
Buddy Biancalana	Shortstop	0.188	1
George Brett	Third Base	0.335	30
Onix Concepcion	Shortstop	0.204	2
Dane Iorg	Outfield	0.223	1
Lynn Jones	Outfield	0.211	0
Dave Leeper	Outfield	0.088	0
Hal McRae	DH	0.259	14
Omar Moreno	Outfield	0.243	2
Darryl Motley	Outfield	0.222	17
Jorge Orta	DH	0.267	4
Greg Pryor	Third Base	0.219	1
Jamie Quirk	Catcher	0.281	0
Pat Sheridan	Outfield	0.228	3
Lonnie Smith	Outfield	0.257	6
Jim Sundberg	Catcher	0.245	10
John Wathan	Catcher	0.234	1
Frank White	Second Base	0.249	22
Willie Wilson	Outfield	0.278	4

Player	Position	ERA	SO
Joe Beckwith	Pitcher	4.07	80
Steve Farr	Starting Pitcher	3.11	36
Mark Gubicza	Starting Pitcher	4.06	99
Mark Huismann	Pitcher	1.93	9
Danny Jackson	Starting Pitcher	3.42	114
Mike Jones	Pitcher	4.76	32
Mike LaCoss	Pitcher	5.09	26
Charlie Leibrandt	Starting Pitcher	2.69	108
Dan Quisenberry	Pitcher	2.37	54
Brett Saberhagen	Starting Pitcher	2.87	158

Table 4.6: The 2005 Chicago White Sox

Player	Position	BA	HR
Geoff Blum	Third Base	0.200	1
Joe Crede	Third Base	0.252	22
Jermaine Dye	Outfield	0.274	31
Carl Everett	DH	0.251	23
Willie Harris	Second Base	0.256	1
Tadahito Iguchi	Second Base	0.278	15
Paul Konerko	First Base	0.283	40
Pablo Ozuna	Third Base	0.276	0
Timo Perez	Outfield	0.218	2
A.J. Pierzynski	Catcher	0.257	18
Scott Podsednik	Outfield	0.290	0
Aaron Rowand	Outfield	0.270	13
Frank Thomas	DH	0.219	12
Juan Uribe	Shortstop	0.252	16
Chris Widger	Catcher	0.241	4

Player	Position	ERA	SO
Mark Buehrle	Starting Pitcher	3.12	149
Jose Contreras	Starting Pitcher	3.61	154
Neal Cotts	Pitcher	1.94	58
Freddy Garcia	Starting Pitcher	3.87	146
Jon Garland	Starting Pitcher	3.50	115
Dustin Hermanson	Pitcher	2.01	33
Orlando Hernandez	Pitcher	5.12	91
Bobby Jenks	Pitcher	2.75	50
Damaso Marte	Pitcher	3.77	54
Brandon McCarthy	Starting Pitcher	4.03	48
Cliff Politte	Pitcher	2.00	57
Shingo Takatsu	Pitcher	5.97	32
Luis Vizcaino	Pitcher	3.73	43

Section 4.2 – Win/Loss Percentage

Since the season leaders beat the career leaders, how much more lopsided will their record be against the World Series champions from different "eras?" The career leaders did very well against the opposing "era" leaders. They had an average winning percentage of 0.792. Their following win/loss records are in the following chart:

Table 4.7: Win/Loss chart for the Career leaders

Career	Wins	Loses	Win%
1918 Boston Red Sox	2763	477	0.853
1927 New York Yankees	2168	1072	0.669
1955 Brooklyn Dodgers	2606	634	0.804
1961 New York Yankees	2560	680	0.790
1985 Kansas City Royals	2687	553	0.829
2005 Chicago White Sox	2678	562	0.827

Table 4.8: Win/Loss chart for the Season leaders

Season	Wins	Loses	Win%
1918 Boston Red Sox	3089	151	0.953
1927 New York Yankees	2730	510	0.843
1955 Brooklyn Dodgers	3048	192	0.941
1961 New York Yankees	2968	272	0.916
1985 Kansas City Royals	2984	256	0.921
2005 Chicago White Sox	3041	199	0.939

The career leaders had a peak winning percentage of 0.853 against the 1918 Boston Red Sox. Their lowest winning percentage was 0.669 against the 1927 New York Yankees. The season leaders have an average winning percentage of 0.922, which can be viewed as complete dominance over the respected best teams in Major League Baseball history. The season leader's peak winning percentage was against the 1918 Boston Red Sox and their lowest winning percentage was against the 1927 New York Yankees. After viewing the win/loss records, one could claim that the 1918 Red Sox are the worst team in the simulations and the 1927 Yankees are the best team in the simulations. The season leaders won 13% more of their games than the career leaders, which is a significant difference between the two teams.

Section 4.3: Batting Average

The career and season leaders have a significant advantage going into the simulations. The historic batting averages for the career leaders and season leaders are 0.321 and 0.343. The historic batting averages, in seasonal numerical order, for the "era" leaders are: 0.253, 0.316, 0.277, 0.272, 0.252, and 0.264.

Section 4.3.1: Career and season leaders

Is there a significant change in batting average for the season leaders and career leaders? Is there a significant decrease in at-bats per homerun for the season and career leaders? With the initial statistics clearly in favor of the career leaders and season leaders, offensive production is expected to increase.

Table 4.9: Season leader's batting averages. This chart displays the batting averages for the Season leaders against each team they played and their historic averages.

Player		1918	1927	1955	1961	1985	2005	Historic
Alomar	Roberto	0.296	0.299	0.305	0.294	0.311	0.303	0.323
Biggio	Craig	0.294	0.312	0.301	0.314	0.319	0.304	0.325
Bonds	Barry	0.295	0.270	0.314	0.291	0.266	0.297	0.328
Brett	George	0.354	0.363	0.353	0.368	0.376	0.368	0.390
Garciapara	Nomar	0.335	0.351	0.340	0.354	0.355	0.349	0.372
Gehrig	Lou	0.330	0.345	0.349	0.342	0.356	0.344	0.373
Griffey Jr.	Ken	0.277	0.272	0.286	0.274	0.265	0.278	0.304
Gwynn	Tony	0.340	0.368	0.390	0.366	0.384	0.361	0.394
Jones	Chipper	0.291	0.295	0.297	0.296	0.291	0.290	0.319
Mantle	Mickey	0.332	0.313	0.328	0.324	0.309	0.321	0.353
McGwire	Mark	0.261	0.248	0.273	0.265	0.254	0.283	0.299
Piazza	Mike	0.324	0.331	0.339	0.343	0.334	0.335	0.362
Pujols	Albert	0.306	0.307	0.312	0.295	0.301	0.298	0.331
Rodriguez	Alex	0.282	0.275	0.271	0.276	0.276	0.265	0.298
Rodriguez	Ivan	0.310	0.311	0.322	0.312	0.326	0.301	0.332
Ruth	Babe	0.318	0.311	0.337	0.321	0.299	0.330	0.356
Suzuki	Ichiro	0.330	0.350	0.347	0.358	0.371	0.348	0.372
Wilson	Hack	0.320	0.316	0.328	0.330	0.326	0.335	0.356

Table 4.10: Career leader's batting averages. This chart displays the batting averages for the Career leaders against each team they played and their historic averages.

Player		1918	1927	1955	1961	1985	2005	Historic
Aaron	Hank	0.274	0.282	0.282	0.286	0.281	0.286	0.305
Biggio	Craig	0.254	0.261	0.273	0.273	0.267	0.273	0.281
Bonds	Barry	0.269	0.267	0.268	0.273	0.273	0.273	0.298
Brett	George	0.281	0.285	0.277	0.282	0.290	0.282	0.305
Cobb	Ty	0.322	0.339	0.337	0.342	0.354	0.342	0.366
Gehrig	Lou	0.303	0.304	0.327	0.313	0.320	0.313	0.341
Hornsby	Rogers	0.329	0.344	0.342	0.335	0.357	0.335	0.358
Jeter	Derek	0.292	0.312	0.302	0.299	0.312	0.299	0.318
Piazza	Mike	0.295	0.278	0.283	0.292	0.300	0.292	0.308
Pujols	Albert	0.298	0.298	0.314	0.314	0.317	0.314	0.331
Rodriguez	Ivan	0.274	0.292	0.283	0.288	0.287	0.288	0.303
Rodriguez	Alex	0.272	0.288	0.289	0.280	0.285	0.280	0.307
Ruth	Babe	0.308	0.299	0.328	0.315	0.305	0.315	0.342
Suzuki	Ichiro	0.303	0.304	0.316	0.309	0.322	0.309	0.334
Williams	Ted	0.313	0.302	0.323	0.318	0.322	0.318	0.345
Yount	Robin	0.253	0.270	0.281	0.265	0.289	0.265	0.285

Table 4.11: Season leader's differences in batting average. This chart displays the batting average differences for the Season leaders against each team they played and their historic averages.

Player		1918	1927	1955	1961	1985	2005
Alomar	Roberto	-0.027	-0.024	-0.018	-0.029	-0.012	-0.020
Biggio	Craig	-0.031	-0.013	-0.024	-0.011	-0.006	-0.021
Bonds	Barry	-0.033	-0.058	-0.014	-0.037	-0.062	-0.031
Brett	George	-0.036	-0.027	-0.037	-0.022	-0.014	-0.022
Garciapara	Nomar	-0.037	-0.021	-0.032	-0.018	-0.017	-0.023
Gehrig	Lou	-0.043	-0.028	-0.024	-0.031	-0.017	-0.029
Griffey Jr.	Ken	-0.027	-0.032	-0.018	-0.030	-0.039	-0.026
Gwynn	Tony	-0.054	-0.026	-0.004	-0.028	-0.010	-0.033
Jones	Chipper	-0.028	-0.024	-0.022	-0.023	-0.028	-0.029
Mantle	Mickey	-0.021	-0.040	-0.025	-0.029	-0.044	-0.032
McGwire	Mark	-0.038	-0.051	-0.026	-0.034	-0.045	-0.016
Piazza	Mike	-0.038	-0.031	-0.023	-0.019	-0.028	-0.027
Pujols	Albert	-0.025	-0.024	-0.019	-0.036	-0.030	-0.033
Rodriguez	Alex	-0.016	-0.023	-0.027	-0.022	-0.022	-0.033
Rodriguez	Ivan	-0.022	-0.021	-0.010	-0.020	-0.006	-0.031
Ruth	Babe	-0.038	-0.045	-0.019	-0.035	-0.057	-0.026
Suzuki	Ichiro	-0.042	-0.022	-0.025	-0.014	-0.001	-0.024
Wilson	Hack	-0.036	-0.040	-0.028	-0.026	-0.030	-0.021

Table 4.12: Career leader's differences in batting average. This chart displays the batting average differences for the Career leaders against each team they played and their historic averages.

Player		1918	1927	1955	1961	1985	2005
Aaron	Hank	-0.031	-0.023	-0.023	-0.019	-0.024	-0.019
Biggio	Craig	-0.027	-0.020	-0.008	-0.008	-0.014	-0.008
Bonds	Barry	-0.029	-0.031	-0.030	-0.025	-0.025	-0.025
Brett	George	-0.024	-0.020	-0.028	-0.023	-0.015	-0.023
Cobb	Ty	-0.044	-0.027	-0.029	-0.024	-0.012	-0.024
Gehrig	Lou	-0.038	-0.037	-0.014	-0.028	-0.021	-0.028
Hornsby	Rogers	-0.029	-0.014	-0.016	-0.023	-0.001	-0.023
Jeter	Derek	-0.026	-0.006	-0.016	-0.019	-0.006	-0.019
Piazza	Mike	-0.013	-0.030	-0.025	-0.016	-0.008	-0.016
Pujols	Albert	-0.033	-0.033	-0.017	-0.017	-0.014	-0.017
Rodriguez	Ivan	-0.029	-0.011	-0.020	-0.015	-0.016	-0.015
Rodriguez	Alex	-0.035	-0.019	-0.018	-0.027	-0.022	-0.027
Ruth	Babe	-0.034	-0.043	-0.014	-0.027	-0.037	-0.027
Suzuki	Ichiro	-0.031	-0.030	-0.018	-0.025	-0.012	-0.025
Williams	Ted	-0.032	-0.043	-0.022	-0.027	-0.023	-0.027
Yount	Robin	-0.032	-0.015	-0.004	-0.020	0.004	-0.020

It is an obvious fact that both the Season leaders and Career leaders had a decrease in average no matter which team they were playing. Only once did a player's average increase. That player was Robin Yount during the simulation against the 1985 Kansas City Royals. This can possibly be explained by the fact that Robin Yount has the lowest historic batting average that was chosen for either the Career leaders or the Season leaders. The Season leader's batting average decreased by 0.028 on average while that of the Career leaders decreased by 0.022. Since these decreases were small, we were interested in whether they were real or due to randomness. We used a one-way analysis of variance with hypotheses H_0: all means are equal vs. H_A: at least one is different from the rest. For the career leaders, we found $F = 2.55$ with p-value = 0.024. This indicates the batting average against at least one of the "era" leaders teams is different from historic. Follow-up analysis with a 95% Tukey simultaneous confidence intervals indicated their performance against the 1918 Red Sox was lower than their historic values. Looking back at the starting rotation for the 1918 Red Sox, they had considerable lower ERAs that the other "era" teams. Performing the same analysis of variance test for the season leaders team gives $F = 2.10$ with p-value 0.058. Their drops in batting average were not statistically different from their historic average. The Season and Career leaders' batting averages started out so high; the probability of them maintaining their averages is next to nothing. When a specific player is hitting, let's say over 0.350, the discussion is never about him increasing his average over the remaining amount of games. The discussion is whether or not the player will be able to maintain that average over the remaining games in the season.

Section 4.3.2: "Era" leaders

The batting averages for the "Era" leaders are expected to decrease dramatically. Each team will have different levels of success because they are all separated by many years. Some of these teams come from highly offensive eras and some come from a time period with slim amounts of offensive production.

Table 4.13: Differences in batting average for the 1918 Boston Red Sox. This chart displays the 1918 Boston Red Sox historic, simulated against the Season leaders, simulated against the Career leaders, and the differences of both batting averages compared with their historic average.

Player	Historic	Career	Season	Career Diff	Season Diff
Sam Agnew	0.166	0.155	0.135	-0.011	-0.031
Joe Bush	0.276	0.245	0.210	-0.031	-0.066
George Cochran	0.127	0.113	0.092	-0.014	-0.035
Jack Coffey	0.159	0.142	0.115	-0.017	-0.044
Dick Hoblitzell	0.175	0.151	0.124	-0.024	-0.051
Harry Hooper	0.289	0.253	0.221	-0.036	-0.068
Wally Mayer	0.224	0.184	0.165	-0.040	-0.059
Carl Mays	0.288	0.269	0.216	-0.019	-0.072
Stuffy McInnis	0.272	0.251	0.217	-0.021	-0.055
Babe Ruth	0.300	0.239	0.216	-0.061	-0.084
Wally Schang	0.244	0.207	0.180	-0.037	-0.064
Everett Scott	0.221	0.195	0.185	-0.026	-0.036
Dave Shean	0.264	0.242	0.207	-0.022	-0.057
John Stansbury	0.128	0.111	0.090	-0.017	-0.038
Amos Strunk	0.257	0.236	0.199	-0.021	-0.058
Fred Tomas	0.257	0.230	0.210	-0.027	-0.047
Frank Truesdale	0.278	0.263	0.221	-0.015	-0.057
George Whiteman	0.266	0.230	0.208	-0.036	-0.058

Table 4.14: Differences in batting average for the 1927 New York Yankees. This chart displays the 1927 New York Yankees historic, simulated against the Season leaders, simulated against the Career leaders, and the differences of both batting averages compared with their historic average.

Player	Historic	Career	Season	Career Diff	Season Diff
Benny Bengough	0.247	0.245	0.202	-0.002	-0.045
Pat Collins	0.275	0.227	0.205	-0.048	-0.070
Early Combs	0.356	0.313	0.279	-0.043	-0.077
Joe Dugan	0.269	0.238	0.213	-0.031	-0.056
Cedric Durst	0.248	0.242	0.195	-0.006	-0.053
Mike Gazella	0.278	0.244	0.206	-0.034	-0.072
Lou Gehrig	0.373	0.280	0.250	-0.093	-0.123
Johnny Grabowski	0.277	0.247	0.228	-0.030	-0.049
Mark Koenig	0.285	0.258	0.237	-0.027	-0.048
Tony Lazzeri	0.309	0.261	0.213	-0.048	-0.096
Bob Meusal	0.337	0.297	0.255	-0.040	-0.082
Ray Morehart	0.256	0.228	0.194	-0.028	-0.062
Ben Paschal	0.317	0.262	0.244	-0.055	-0.073
Babe Ruth	0.356	0.263	0.212	-0.093	-0.144
Julie Wera	0.238	0.226	0.184	-0.012	-0.054

Table 4.15: Differences in batting average for the 1955 Brooklyn Dodgers. This chart displays the 1955 Brooklyn Dodgers historic, simulated against the Season leaders, simulated against the Career leaders, and the differences of both batting averages compared with their historic average.

Player	Historic	Career	Season	Career Diff	Season Diff
Sandy Amoros	0.247	0.206	0.171	-0.041	-0.076
Bob Borkowski	0.135	0.125	0.094	-0.010	-0.041
Roy Campanella	0.286	0.229	0.194	-0.057	-0.092
Carl Furillo	0.314	0.257	0.219	-0.057	-0.095
Jim Gilliam	0.249	0.214	0.188	-0.035	-0.061
Don Hoak	0.240	0.206	0.173	-0.034	-0.067
Gil Hodges	0.289	0.235	0.202	-0.054	-0.087
Dixie Howell	0.262	0.228	0.235	-0.034	-0.027
Frank Kellert	0.325	0.253	0.245	-0.072	-0.080
Don Newcombe	0.359	0.295	0.274	-0.064	-0.085
Pee Wee Reese	0.282	0.241	0.202	-0.041	-0.080
Jackie Robinson	0.256	0.213	0.181	-0.043	-0.075
George Shuba	0.275	0.251	0.176	-0.024	-0.099
Duke Snider	0.309	0.237	0.195	-0.072	-0.114
Rube Walker	0.252	0.218	0.196	-0.034	-0.056
Don Zimmer	0.239	0.191	0.160	-0.048	-0.079

Table 4.16: Differences in batting average for the 1961 New York Yankees. This chart displays the 1961 New York Yankees historic, simulated against the Season leaders, simulated against the Career leaders, and the differences of both batting averages compared with their historic average.

Player	Historic	Career	Season	Career Diff	Season Diff
Yogi Berra	0.271	0.217	0.189	-0.054	-0.082
Johnny Blanchard	0.305	0.226	0.201	-0.079	-0.104
Clete Boyer	0.224	0.192	0.163	-0.032	-0.061
Bob Cerv	0.271	0.214	0.197	-0.057	-0.074
Joe DeMaestri	0.140	0.144	0.117	0.004	-0.023
Billy Gardner	0.212	0.179	0.165	-0.033	-0.047
Bob Hale	0.154	0.120	0.106	-0.034	-0.048
Elston Howard	0.348	0.298	0.258	-0.050	-0.090
Deron Johnson	0.105	0.089	0.090	-0.016	-0.015
Tony Kubek	0.276	0.246	0.216	-0.030	-0.060
Hector Lopez	0.222	0.189	0.161	-0.033	-0.061
Mickey Mantle	0.317	0.229	0.196	-0.088	-0.121
Roger Maris	0.269	0.192	0.158	-0.077	-0.111
Jack Reed	0.154	0.122	0.116	-0.032	-0.038
Bobby Richardson	0.261	0.236	0.209	-0.025	-0.052
Moose Skowron	0.267	0.218	0.196	-0.049	-0.071
Earl Torgenson	0.111	0.080	0.067	-0.031	-0.044

Table 4.17: Differences in batting average for the 1985 Kansas City Royals. This chart displays the 1985 Kansas City Royals historic, simulated against the Season leaders, simulated against Career leaders, and the differences of both batting averages compared with their historic average.

Player	Historic	Career	Season	Career Diff	Season Diff
Steve Balboni	0.243	0.184	0.164	-0.059	-0.079
Buddy Biancalana	0.188	0.169	0.146	-0.019	-0.042
George Brett	0.335	0.266	0.230	-0.069	-0.105
Onix Concepcion	0.204	0.183	0.158	-0.021	-0.046
Dane Iorg	0.223	0.196	0.162	-0.027	-0.061
Lynn Jones	0.211	0.198	0.151	-0.013	-0.060
Dave Leeper	0.088	0.078	0.074	-0.010	-0.014
Hal McRae	0.259	0.205	0.176	-0.054	-0.083
Omar Moreno	0.243	0.212	0.187	-0.031	-0.056
Darryl Motley	0.222	0.185	0.158	-0.037	-0.064
Jorge Orta	0.267	0.232	0.205	-0.035	-0.062
Greg Pryor	0.219	0.190	0.174	-0.029	-0.045
Jamie Quirk	0.281	0.268	0.241	-0.013	-0.040
Pat Sheridan	0.228	0.186	0.171	-0.042	-0.057
Lonnie Smith	0.257	0.221	0.196	-0.036	-0.061
Jim Sundberg	0.245	0.210	0.179	-0.035	-0.066

John Wathan	0.234	0.201	0.181	-0.033	-0.053
Frank White	0.249	0.213	0.181	-0.036	-0.068
Willie Wilson	0.278	0.248	0.218	-0.030	-0.060

Table 4.18: Differences in batting average for the 2005 Chicago White Sox. This chart displays the 2005 Chicago White Sox historic, simulated against the Season leaders, simulated against the Career leaders, and the differences of both batting averages compared with their historic average.

Player	Historic	Career	Season	Career Diff	Season Diff
Geoff Blum	0.200	0.176	0.160	-0.024	-0.040
Joe Crede	0.252	0.212	0.176	-0.040	-0.076
Jermaine Dye	0.274	0.221	0.188	-0.053	-0.086
Carl Everett	0.251	0.205	0.180	-0.046	-0.071
Willie Harris	0.256	0.236	0.205	-0.020	-0.051
Tadahito Iguchi	0.278	0.237	0.206	-0.041	-0.072
Paul Konerko	0.283	0.221	0.190	-0.062	-0.093
Pablo Ozuna	0.276	0.259	0.226	-0.017	-0.050
Timo Perez	0.218	0.201	0.166	-0.017	-0.052
A.J. Pierzynski	0.257	0.219	0.192	-0.038	-0.065
Scott Podsednik	0.290	0.265	0.234	-0.025	-0.056
Aaron Rowand	0.270	0.232	0.208	-0.038	-0.062
Frank Thomas	0.219	0.137	0.115	-0.082	-0.104
Juan Uribe	0.252	0.211	0.186	-0.041	-0.066
Chris Widger	0.241	0.206	0.188	-0.035	-0.053

The “Era” leader’s batting averages against the both career leaders and season leaders decreased. There was not a single player that was able to increase or maintain their batting average. Then using a paired t-test on whether or not the drop offs were similar with hypotheses: H_0: $\mu_D = 0$ vs. H_A: $\mu_D \neq 0$, where differences were computed as career-season. This confirmed that there was a significant difference between each “era” leader and who they were playing.

Table 4.19: P-values. This chart displays the p-values and t-values for the difference of means of the "era" leaders when competing against the season and career leaders.

Season	P-value	T-Value
1918	0.000	11.74
1928	0.000	11.81
1955	0.000	7.22
1961	0.000	8.72
1985	0.000	12.46
2005	0.000	17.82

Even considering the fact that several tests were run, we can comfortably say that these teams batting averages were worse against the season leaders. All p-values are zero to three significant digits.

Section 4.4: At-Bat to Homerun Ratio

For whom is there a more significant change in at-bats per homerun: the season and career leaders or the "Era" leaders? The average historic at-bat to homerun ratio for the career leaders and season leaders are 21.74 and 13.55. The historic at-bat to homerun ratio, in seasonal numerical order, for the "era" leaders are: 252.07, 31.4, 24.9, 20.98, 35.69, and 27.31.

Section 4.4.1: Career and season leaders

The season leaders and career leaders expected at-bat to homerun ratio should decrease from their historic ratio. Playing against normal teams is the cause for this increase in productivity.

Table 4.20: Differences in AB/HR ratio for the Season leaders. This chart displays the differences in the at-bat to homerun ratio for the Season leaders against each team they played and their historic ratios.

Player		1918	1927	1955	1961	1985	2005
Alomar	Roberto	2.75	4.94	1.62	6.22	12.06	1.45
Biggio	Craig	7.34	9.65	1.78	4.79	24.90	-1.02
Bonds	Barry	0.67	2.31	0.37	1.08	4.04	0.65
Brett	George	1.13	5.55	1.59	5.22	9.68	1.18
Garciapara	Nomar	2.29	3.14	1.07	2.40	14.49	0.71
Gehrig	Lou	0.86	3.37	-0.20	0.70	8.19	0.53
Griffey Jr.	Ken	0.46	2.22	0.07	2.30	5.27	0.18
Gwynn	Tony	15.66	3.33	4.57	5.47	26.33	2.12
Jones	Chipper	1.25	2.74	0.28	2.83	7.09	0.70
Mantle	Mickey	0.20	2.95	0.25	1.86	5.46	0.58
McGwire	Mark	0.73	2.01	0.14	1.42	4.39	0.43
Piazza	Mike	2.14	2.97	1.04	2.55	8.05	1.72
Pujols	Albert	0.24	2.97	0.85	1.77	5.32	0.96
Rodriguez	Alex	0.99	4.02	0.75	1.73	4.97	1.80
Rodriguez	Ivan	0.01	13.59	1.40	2.61	9.91	2.16
Ruth	Babe	0.10	2.64	0.76	2.28	4.80	0.50
Suzuki	Ichiro	10.78	9.97	-4.08	-0.60	57.62	-11.67
Wilson	Hack	0.35	3.25	0.44	1.54	6.34	0.71

Table 4.21: Differences in AB/HR ratio for the Career leaders. This chart displays the differences in the at-bat to homerun ratio for the Career leaders against each team they played from their historic ratios.

Player		1918	1927	1955	1961	1985	2005
Aaron	Hank	1.36	3.84	0.59	0.48	10.79	0.48
Biggio	Craig	7.20	10.12	3.11	1.52	31.48	1.52
Bonds	Barry	0.65	3.07	1.01	1.40	6.63	1.40
Brett	George	-2.38	8.28	-0.53	-0.86	20.38	-0.86
Cobb	Ty	4.54	-5.76	-4.34	10.20	55.23	10.20
Gehrig	Lou	2.42	3.78	0.41	0.21	10.53	0.21
Hornsby	Rogers	3.55	4.30	1.50	3.42	13.77	3.42
Jeter	Derek	-2.65	9.82	3.33	3.59	28.46	-4.51
Piazza	Mike	0.35	3.65	3.01	0.90	7.59	0.90
Pujols	Albert	1.81	4.97	-0.21	-1.04	7.79	-1.04
Rodriguez	Ivan	3.91	3.23	-0.82	2.45	15.17	2.45
Rodriguez	Alex	0.96	3.25	0.39	1.32	7.07	1.31
Ruth	Babe	0.81	3.34	0.26	1.77	6.12	1.77
Suzuki	Ichiro	6.14	11.85	4.79	5.35	39.29	5.35
Williams	Ted	1.36	4.35	0.12	-0.66	8.34	-0.66
Yount	Robin	10.68	16.07	3.52	-2.84	21.07	-2.84

The changes in at-bat per homerun reflected the changes in batting average in terms of lower performance. The majority of the players' at-bat to homerun ratio elevated from their historic averages, but some players against certain teams had individual decreases. The data for the career leaders and season leaders was not normal, so an overall F test comparing the simulated at-bat to home run ratios to historic values could not be done. A bootstrap distribution was used estimate the difference in average performance against the "era" teams. In other words, we were trying to see if the increase in at-bat to homerun ratio was similar for the career leaders and season leaders against the same opponents. The following 95% confidence intervals were obtained from the bootstrap distribution.

Table 4.22: 95% Bootstrap confidence intervals. This chart contains the 95% bootstrap confidence intervals for the difference of means of the Career and Season leaders.

Season	95% C.I.
1918	(-2.78291, 2.258541)
1927	(-1.71347, 3.70181)
1955	(-0.90590, 1.49333)
1961	(-2.32403, 0.85771)
1985	(-3.7124, 14.1850)
2005	(-0.84903, 3.35625)

All of the confidence intervals contain zero, so there is basically no difference between the career leaders and season leaders. Even allowing for the fact that we have computed several confidence intervals, family-wise 95% intervals would only be wider. The changes of the at-bat to homerun ratio are the similar for the season leaders and career leaders when they are playing each team.

Section 4.4.2: "Era" leaders

The at-bat per homerun ratio should increase dramatically for the "era" leaders. We anticipate some problems with this data; many of the teams had players who did not hit homeruns during the time span from which the data was collected. Since one cannot divide by zero, their historic numbers have been set to zero.

Table 4.23: Differences in AB/HR for the 1918 Boston Red Sox. This chart displays the differences in the at-bat to homerun ratio for the 1918 Boston Red Sox against each team they played and their historic ratios.

Player	Career	Season	Historic	Career Diff	Season Diff
Sam Agnew	2919	1053.25	0.00	2919.00	1053.25
Joe Bush	509.67	0	0.00	509.67	0.00
George Cochran	0	0	0.00	0.00	0.00
Jack Coffey	142.36	113.21	44.00	98.36	69.21
Dick Hoblitzell	1449	2719	0.00	1449.00	2719.00
Harry Hooper	1074.89	1906	474.00	600.89	1432.00
Wally Mayer	2152	2016	0.00	2152.00	2016.00
Carl Mays	1861	1720	0.00	1861.00	1720.00
Stuffy McInnis	1793	2605.5	0.00	1793.00	2605.50
Babe Ruth	81.79	88.54	28.82	52.97	59.72
Wally Schang	1597.57	3712	0.00	1597.57	3712.00
Everett Scott	2295.8	2723.5	0.00	2295.80	2723.50
Dave Shean	1512.86	10157	0.00	1512.86	10157.00
John Stansbury	1687	0	0.00	1687.00	0.00
Amos Strunk	3049.75	1488.63	0.00	3049.75	1488.63
Fred Tomas	417.33	622.5	144.00	273.33	478.50
Frank Truesdale	0	872	0.00	0.00	872.00
George Whiteman	453.44	542.23	214.00	239.44	328.23

Table 4.24: Differences in AB/HR for the 1927 New York Yankees. This chart displays the differences in the at-bat to homerun ratio for the 1927 New York Yankees against each team they played and their historic ratios.

Player	Career	Season	Historic	Career Diff	Season Diff
Benny Bengough	0.00	0.00	0.00	0.00	0.00
Pat Collins	82.11	81.49	35.86	46.25	45.63
Early Combs	300.44	267.27	108.00	192.44	159.27
Joe Dugan	336.15	517.56	193.50	142.65	324.06
Cedric Durst	2558.00	0.00	0.00	2558.00	0.00
Mike Gazella	0.00	1213.50	0.00	0.00	1213.50
Lou Gehrig	32.40	36.51	12.43	19.97	24.08
Johnny Grabowski	0.00	2031.00	0.00	0.00	2031.00
Mark Koenig	395.94	509.65	175.33	220.61	334.32
Tony Lazzeri	68.17	89.99	31.67	36.50	58.32
Bob Meusal	157.98	193.64	64.50	93.48	129.14
Ray Morehart	402.40	689.47	195.00	207.40	494.47
Ben Paschal	181.20	150.55	41.00	140.20	109.55
Babe Ruth	21.30	30.49	9.00	12.30	21.49
Julie Wera	110.78	68.64	42.00	68.78	26.64

Table 4.25: Differences in AB/HR for the 1955 Brooklyn Dodgers. This chart displays the differences in the at-bat to homerun ratio for the 1955 Brooklyn Dodgers against each team they played and their historic ratios.

Player	Career	Season	Historic	Career Diff	Season Diff
Sandy Amoros	91.71	140.13	38.80	52.91	101.33
Bob Borkowski	702.50	1397.00	0.00	702.50	1397.00
Roy Campanella	34.72	45.36	15.50	19.22	29.86
Carl Furillo	50.82	55.67	20.12	30.70	35.55
Jim Gilliam	168.98	204.80	76.86	92.12	127.94
Don Hoak	126.82	170.93	55.80	71.02	115.13
Gil Hodges	50.72	55.68	20.22	30.50	35.46
Dixie Howell	952.00	0.00	0.00	952.00	0.00
Frank Kellert	37.11	48.70	20.00	17.11	28.70
Don Newcombe	38.78	43.32	16.71	22.07	26.61
Pee Wee Reese	129.03	174.91	55.30	73.73	119.61
Jackie Robinson	112.56	116.07	39.63	72.93	76.44
George Shuba	250.00	159.86	51.00	199.00	108.86
Duke Snider	30.28	38.67	12.81	17.47	25.86
Rube Walker	221.25	174.06	51.50	169.75	122.56
Don Zimmer	41.82	49.42	18.67	23.15	30.75

Table 4.26: Differences in AB/HR for the 1961 New York Yankees. This chart displays the differences in the at-bat to homerun ratio for the 1961 New York Yankees against each team they played and their historic ratios.

Player	Career	Season	Historic	Career Diff	Season Diff
Yogi Berra	45.66	51.85	17.95	27.71	33.89
Johnny Blanchard	28.76	31.75	11.57	17.19	20.18
Clete Boyer	118.04	129.69	45.82	72.22	83.87
Bob Cerv	53.92	58.77	19.67	34.25	39.10
Joe DeMaestri	0.00	1324.00	0.00	0.00	1324.00
Billy Gardner	419.00	265.25	99.00	320.00	166.25
Bob Hale	27.08	27.55	13.00	14.08	14.55
Elston Howard	46.81	57.24	21.24	25.57	36.00
Deron Johnson	0.00	0.00	0.00	0.00	0.00
Tony Kubek	204.21	227.81	77.13	127.09	150.69
Hector Lopez	77.62	103.32	40.50	37.12	62.82
Mickey Mantle	23.97	25.17	9.52	14.45	15.65
Roger Maris	22.93	25.65	9.67	13.26	15.98
Jack Reed	0.00	0.00	0.00	0.00	0.00
Bobby Richardson	638.38	520.12	220.67	417.71	299.45
Moose Skowron	47.20	53.69	20.04	27.17	33.66
Earl Torgenson	0.00	0.00	0.00	0.00	0.00

Table 4.27: Differences in AB/HR for the 1985 Kansas City Royals. This chart displays the differences in the at-bat to homerun ratio for the 1985 Kansas City Royals against each team they played and their historic ratios.

Player	Career	Season	Historic	Career Diff	Season Diff
Steve Balboni	40.13	45.47	16.67	23.47	28.80
Buddy Biancalana	438.86	325.56	138.00	300.86	187.56
George Brett	43.60	53.32	18.33	25.27	34.99
Onix Concepcion	478.67	365.58	157.00	321.67	208.58
Dane Iorg	238.90	251.67	130.00	108.90	121.67
Lynn Jones	2804.00	0.00	0.00	2804.00	0.00
Dave Leeper	657.00	647.00	0.00	657.00	647.00
Hal McRae	67.91	66.15	22.86	45.05	43.29
Omar Moreno	124.91	83.63	35.00	89.91	48.63
Darryl Motley	52.29	59.59	22.53	29.76	37.06
Jorge Orta	225.04	221.92	75.00	150.04	146.92
Greg Pryor	372.83	0.00	114.00	258.83	-114.00
Pat Sheridan	188.11	193.29	68.67	119.44	124.63
Lonnie Smith	154.56	191.95	74.67	79.89	117.29
Jim Sundberg	105.81	107.78	36.70	69.11	71.08
John Wathan	690.75	448.33	145.00	545.75	303.33
Frank White	66.78	74.37	25.59	41.19	48.77
Willie Wilson	450.79	361.15	151.25	299.54	209.90

Table 4.28: Differences in AB/HR for the 2005 Chicago White Sox. This chart displays the differences in the at-bat to homerun ratio for the 2005 Chicago White Sox against each team they played and their historic ratios.

Player	Career	Season	Historic	Career Diff	Season Diff
Geoff Blum	359.00	168.83	95.00	264.00	73.83
Joe Crede	47.13	56.37	19.64	27.49	36.73
Jermaine Dye	44.42	52.94	17.06	27.35	35.88
Carl Everett	53.55	54.58	21.30	32.24	33.28
Willie Harris	243.90	297.67	121.00	122.90	176.67
Tadahito Iguchi	74.81	101.17	34.07	40.74	67.11
Paul Konerko	38.00	41.07	14.38	23.62	26.69
Pablo Ozuna	1402.33	3815.00	0.00	1402.33	3815.00
Timo Perez	357.80	279.31	89.50	268.30	189.81
A.J. Pierzynski	57.34	67.20	25.56	31.79	41.65
Scott Podsednik	2709.50	10393.00	0.00	2709.50	10393.00
Aaron Rowand	120.45	133.74	44.46	75.99	89.27
Frank Thomas	22.76	24.52	8.75	14.01	15.77
Juan Uribe	72.70	104.98	30.06	42.64	74.91
Chris Widger	105.12	109.32	35.25	69.87	74.07

The at-bat to homerun ratio for the "era" leaders is elevated in random cases. When a player has not hit a homerun in the data that was put into the simulator, there is a very low probability that he will hit a homerun during a simulation. There are only five players on the 1918 Boston Red Sox who hit homeruns which makes it very difficult to do comparisons. For comparison purposes, the players who did not hit homeruns in the original data will be ignored.

Table 4.29: 95% Bootstrap confidence intervals for AB/HR. This chart contains the 95% bootstrap confidence intervals for the difference of means of at-bats per homerun for each "era" leader against the Career and Season leaders.

Season	95% C.I.
1918	(-713.85, 189.89)
1927	(-142.085, 47.827)
1955	(-40.2264, 30.6007)
1961	(-63.503, 94.515)

1985 (-30.228, 139.238)
2005 (-42.4154, 59.7962)

Again, all of the confidence intervals contain zero; there is virtually no difference between the at-bat to homerun ratio for each "era" leader regardless of which team they are playing, even allowing for the fact that these are individual confidence intervals and not family-wise which would make the interval wider. Every player for the "era" leaders had an increase in at-bats per homerun.

Section 4.5: Differences in ERA

How much change will there be in pitching ERA? The career leaders and season leaders put up some good offensive numbers. This in turn should make the "era" leaders ERA increase. The Career and Season leaders ERA should decrease since they are playing teams with lesser all- around talent.

Section 4.5.1: Season and career leaders

The Career and Season leader's ERA is expected to decrease during the simulations against the "era" leaders. After seeing the dismal offensive numbers that some of the "era" leaders displayed, there should be total domination by the season leaders and career leaders.

Table 4.30: Differences in ERA for the Season leaders. This chart displays the differences in ERA for the Season leaders against each team they played and their historic ratios. Omitted values are from seasons which pitchers did not meet the minimum required innings.

Season	Player		1918	1927	1955	1961	1985	2005
1990	Eckersley	Dennis	0.88	0.52		0.66	0.21	-0.13
2003	Gagne	Eric	0.08	0.69	-0.39	-0.33	0.36	-0.63
1988	Hershiser	Orel	-0.34	0.65	0.45	0.53	-0.35	0.12
1913	Johnson	Walter	0.30	1.11	0.37	0.27	0.36	0.27
1963	Koufax	Sandy	-0.27	0.86	0.26	0.31	-0.07	0.02

1994	Maddux	Greg	-0.13	0.98	0.19	0.10	0.08	0.14
1995	Maddux	Greg	0.20	1.20	0.40	-0.05	-0.18	-0.09
2004	Rivera	Mariano	0.68	1.53	0.04	0.05	-0.36	-0.41
1971	Seaver	Tom	-0.02	1.37	0.98	0.59	0.31	0.41
2003	Smoltz	John	0.50	0.89	1.01	0.37	0.31	1.49

Table 4.31: Differences in ERA for the Career leaders. This chart displays the differences in ERA for the Career leaders against each team they played and their historic ratios.

Player		**1918**	**1927**	**1955**	**1961**	**1985**	**2005**
Clemons	Roger	-1.68	1.64	-1.02	-0.12	-1.71	-0.12
Eckersley	Dennis	-1.54	0.70	-0.78	-1.53	-0.23	-1.53
Ford	Whitey	-0.19	1.69	1.15	0.50	0.11	0.50
Hoffman	Trevor	-1.14	0.08	-0.26	0.20	0.06	0.20
Johnson	Randy	-1.13	1.87	-0.14	-0.04	-1.78	-0.04
Johnson	Walter	0.12	1.29	0.18	-0.27	-0.22	-0.27
Maddux	Greg	-0.98	0.51	0.16	-0.28	-0.82	-0.28
Martinez	Pedro	-0.97	0.64	0.14	-0.40	-0.64	-0.40
Mathews	Christey	0.14	1.39	0.21	0.02	-0.01	0.02
Rivera	Mariano	-0.65	1.08	-0.27	-0.34	-0.43	-0.34
Santana	Johan	-1.41	0.99	-0.12	-0.33	-0.19	-0.33
Seaver	Tom	-0.67	1.56	0.61	-0.10	-0.33	-0.10
Smith	Lee	-1.39	0.24	0.69	-1.27	-0.26	-1.27

When running a test of significance on the data for ERA, a problem was noticed. When a pitcher does not throw very many innings, his ERA will fluctuate greatly. An innings pitched minimum was set at 30 for further consideration. We used a one-way analysis of variance with hypotheses H_0: all means are equal vs. H_A: at least one is different from the rest. For the Career leaders, we found $F = 3.73$ with p-value = 0.003. This indicates the ERA against at least one of the "era" leaders teams is different from historic. Follow-up analysis with a 95% Tukey simultaneous confidence intervals indicated their performance against the 1927 New York Yankees was higher than their historic values. Performing the same analysis of variance test for the Season leaders team gives $F = 16.88$ with p-

value 0.000. In this case, there were two significantly different teams from the historic values. ERAs were lower against the 1918 Boston Red Sox and ERAs were higher that historic 1927 New York Yankees.

Section 4.5.2: "Era" leaders

Will the ERA for the "era" leaders increase substantially? Two player's statistics will be eliminated during data processing for failing to reach the minimum innings pitched. Shingo Takatsu, who played for the 2005 Chicago White Sox, and Walter Beall, who played for the 1927 New York Yankees, were the two players. After seeing the above offensive statistics, ERA is expected to increase significantly.

Table 4.32: Differences in ERA for the 1918 Boston Red Sox. This chart displays the ERA for the 1918 Boston Red Sox against each team they played, their historic values, and the differences between the two.

Player	Career	Season	Historic	Career Diff	Season Diff
Lore Bader	7.92	11.21	3.33	4.59	7.89
Joe Bush	7.04	8.87	2.11	4.93	6.77
Jean Dubuc	10.76	12.08	4.09	6.67	7.99
Sam Jones	6.59	8.95	2.25	4.34	6.70
Walt Kinney	3.30	4.59	1.80	1.50	2.79
Dutch Leonard	8.17	10.87	2.71	5.46	8.16
Carl Mays	5.65	7.08	2.21	3.44	4.87
Dick McCabe	9.25	13.31	2.70	6.56	10.61
Vince Molyneaux	2.64	5.68	3.27	-0.63	2.41
Babe Ruth	5.17	6.85	2.22	2.95	4.63

Table 4.33: Differences in ERA for the 1927 New York Yankees. This chart displays the ERA for the 1927 New York Yankees against each team they played, their historic values, and the differences between the two.

Player	Career	Season	Historic	Career Diff	Season Diff
Walter Beall	2.23	2.12	9.00	-6.77	-6.88
Joe Giard	11.29	15.50	8.00	3.29	7.50
Waite Hoyt	5.50	7.27	2.63	2.87	4.64
Wiley Moore	3.69	4.04	2.28	1.41	1.76

Herb Pennock	5.09	6.42	3.00	2.09	3.42
George Pipgras	4.39	5.36	4.12	0.27	1.24
Dutch Reuther	7.47	9.67	3.38	4.09	6.29
Bob Shawkey	5.66	6.08	2.86	2.80	3.22
Urban Shocker	6.20	7.82	2.84	3.36	4.98
Myles Thomas	9.51	11.48	4.87	4.64	6.61

Table 4.34: Differences in ERA for the 1955 Brooklyn Dodgers. This chart displays the ERA for the 1955 Brooklyn Dodgers against each team they played, their historic values, and the differences between the two.

Player	Career	Season	Historic	Career Diff	Season Diff
Don Bessent	5.63	7.73	2.71	2.92	5.02
Roger Craig	6.54	8.34	3.29	3.25	5.05
Carl Erskine	7.63	9.81	3.79	3.84	6.02
Jim Hughes	6.54	11.00	4.19	2.35	6.81
Sandy Koufax	6.71	7.90	3.00	3.71	4.90
Clem Labine	6.18	7.48	3.29	2.89	4.19
Billy Loes	6.88	9.33	3.59	3.29	5.74
Russ Meyer	9.61	11.67	5.42	4.19	6.25
Don Newcombe	6.43	8.32	3.20	3.23	5.12
Johnny Podres	6.67	7.99	3.95	2.72	4.04
Ed Roebuck	7.58	10.43	4.71	2.87	5.72
Karl Spooner	6.18	7.24	3.65	2.53	3.59

Table 4.35: Differences in ERA for the 1961 New York Yankees. This chart displays the ERA for the 1961 New York Yankees against each team they played, their historic values, and the differences between the two.

Player	Career	Season	Historic	Career Diff	Season Diff
Luis Arroyo	3.51	4.15	2.19	1.33	1.96
Tex Clevenger	9.90	12.65	4.78	5.12	7.87
Jim Coates	6.63	8.85	3.45	3.18	5.40
Bud Daley	7.83	10.20	3.96	3.87	6.24
Art Ditmar	8.16	11.71	4.67	3.49	7.04
Whitey Ford	5.50	6.82	3.21	2.29	3.61
Danny McDevitt	13.05	18.76	7.62	5.43	11.14
Hal Reniff	5.71	6.37	2.60	3.11	3.77
Rollie Sheldon	6.70	8.17	3.59	3.11	4.58
Bill Stafford	5.46	6.26	2.68	2.78	3.58
Ralph Terry	5.56	6.81	3.16	2.40	3.65
Bob Turley	10.68	14.51	5.75	4.93	8.76

Table 4.36: Differences in ERA for the 1985 Kansas City Royals. This chart displays the ERA for the 1985 Kansas City Royals against each team they played, their historic values, and the differences between the two.

Player	Career	Season	Historic	Career Diff	Season Diff
Joe Beckwith	7.33	9.05	4.07	3.26	4.98
Steve Farr	6.66	8.01	3.11	3.55	4.90
Mark Gubicza	6.56	8.52	4.06	2.50	4.46
Mark Huismann	3.35	4.04	1.93	1.42	2.11
Danny Jackson	5.88	6.48	3.42	2.46	3.06
Mike Jones	8.83	11.34	4.76	4.07	6.58
Mike LaCoss	11.08	11.49	5.09	5.99	6.40
Charlie Leibrandt	5.83	6.78	2.69	3.14	4.09
Dan Quisenberry	5.03	6.09	2.37	2.66	3.72
Brett Saberhagen	5.01	6.18	2.87	2.14	3.31

Table 4.37: Differences in ERA for the 2005 Chicago White Sox. This chart displays the ERA for the 2005 Chicago White Sox against each team they played, their historic values, and the differences between the two.

Player	ERA	ERA	Historic	Career Diff	Season Diff
Mark Buehrle	5.39	6.42	3.12	2.27	3.30
Jose Contreras	6.63	8.44	3.61	3.02	4.83
Neal Cotts	4.08	4.63	1.94	2.14	2.69
Freddy Garcia	6.95	8.26	3.87	3.08	4.39
Jon Garland	6.32	7.96	3.50	2.82	4.46
Dustin Hermanson	4.24	5.86	2.01	2.23	3.85
Orlando Hernandez	9.48	11.57	5.12	4.36	6.45
Bobby Jenks	6.49	7.80	2.75	3.74	5.05
Damaso Marte	10.07	14.12	3.77	6.30	10.35
Brandon McCarthy	7.45	9.76	4.03	3.42	5.73
Cliff Politte	4.49	6.24	2.00	2.49	4.24
Shingo Takatsu	8.58	18.54	5.97	2.61	12.57
Luis Vizcaino	8.71	10.70	3.73	4.98	6.97

The data appeared approximately normal so a paired t-test on whether or not the increases in ERA were similar against both the career and season leaders with the hypotheses: H_0: $\mu_D = 0$ vs. H_A: $\mu_D \neq 0$ was used.

Table 4.38: P-values and T-values. This chart displays the p-values and t-values for the paired t-test of the season and career leaders when playing against each "era" team.

Season	P-value	T-value
1918	0.000	-7.67
1927	0.003	-4.27
1955	0.000	-7.65
1961	0.000	-4.97
1985	0.000	-5.97
2005	0.000	-7.20

Even considering the fact that several tests were run, we can comfortably say that these teams ERAs were worse against the season leaders. All but one of the p-values is zero to three significant digits. The above values show that almost all of the "era" leader's ERA depends on which team they are playing. All of the teams had increases in ERA with the exception of the players who did not meet the minimum innings pitched.

Section 4.6: Career Records

Do any specific career accomplishments stand out for any particular series? Since simulations went on for twenty year's worth of Major League Baseball seasons, we can see whether or not any of these players might have set new Major League records. During the "Era" simulations, the season leaders broke the current homerun record (762) a combined eleven times, Barry Bonds six times and Ken Griffey Jr. five times. Barry Bonds hit over one thousand homeruns against every team except the 1985 Kansas City Royals. There were three occasions of the 700 homerun club, nine occasions of the 600 homerun club, and seven occasions of the 500 homerun club; all of these are considered Major League milestones. The career leaders broke the homerun record twice, both by Ted Williams. Ted Williams hit over 600 homeruns on two different occasions and once

over 700, but it did not break the current record. Babe Ruth joined the 600 homerun club once and the 500 homerun club four times.

The Major League career batting average is 0.367 by Ty Cobb. There were a few occasions where this record was broken or equaled. No players from the career leaders were able to break this record. The season leaders had a few people break this record: Tony Gwynn broke this record four times, George Brett broke this record three times, and Ichiro Suzuki broke it once. The batting averages that these players broke the record with were lower than their season batting average for which they were selected for the team.

The Major League record for strikeouts, in a career, is 5714 held by Nolan Ryan. The career leaders did not break this record, but they had some pitchers reach career milestones for strikeouts. Pedro Martinez recorded strikeouts of great numbers: over 5000 batters twice, over 4000 batters once, and over 3000 batters twice. Tom Seaver struck out over 4000 batters twice and over 3000 batters once. Whitey Ford and Walter Johnson both recorded over 3000 strikeouts twice. The season leaders managed to break the strikeout record once. Tom Seaver struck out 5878 batters against the 2005 Chicago White Sox. Members of the 5000 strikeout club are Sandy Koufax and Tom Seaver. Members of the 4000 strikeout club are Sandy Koufax (3), Tom Seaver (3), Walter Johnson, and Greg Maddux (1994 (2), 1995). Members of the 3000 strikeout club are Greg Maddux (1994 (2), 1995 (3)), Walter Johnson, Sandy Koufax, and Tom Seaver.

Since every pitcher's ERA has risen during simulation, there isn't anyone who could have broken the career record for ERA. Overall some of Major League Baseball's most important records fell during these simulations. This is due to the fact that

statistically superior teams are competing against real teams from throughout baseball history.

Section 4.7: Rare Events

There are many rare events that happened during baseball, for instance: no-hitters, hitting for the cycle, hitting streaks over 30 games, achieving 6 hits in a game, and 4 homeruns in a game. During the simulations the "era" leaders did not produce many rare events. The "era" leaders achieved 3 cycles and one no-hitter against the season leaders. The "era" leaders did a little better against the career leaders achieving 5 cycles, 3 no-hitters, and a player stole 5 bases in a game. This is not surprising knowing how the "era" leaders were dominated in offensive and pitching categories.

The season leaders achieved many rare events. There were a grand total of 52 cycles, 72 no-hitters, 25 players had 4 homeruns in a game, and 54 players had at least six hits in a game. There were 17 hitting streaks that went over thirty games; two of these, both by Nomar Garciapara, went over forty games. Three different players set a Major League Record with five homeruns in a game. Those players were Barry Bonds, Mickey Mantle, and Mark McGwire. On twenty occasions a player managed to get more than 10 RBI. In the simulations, the rates at which players are throwing no-hitters and hitting for the cycle are well below the Major League average per season. The season leaders averaged 0.6 no-hitters a year, well below the MLB average of 1.99. They also averaged 0.43 cycles a year well below the average of 2.12 a season. While the season leaders did some impressive things, they did not manage to increase the rate of some rare events.

The career leaders did not accomplish the number of rare events the season leaders did. They managed 33 no-hitters, 31 cycles, 2 players who hit 4 homeruns in a

game, and 27 players who had at least six hits in a game. Babe Ruth and Barry Bonds both accomplished hitting four homeruns in a game. There were also only seven hitting streaks that were at least 30 games long. Only three players managed to record ten RBI in a game, and they were Rogers Hornsby, Babe Ruth, and Ted Williams. The career leaders averaged a cycle and a no-hitter about every four years, which is a large decrease from the Major League average.

Section 4.8: Conclusion

The simulations resulted in the "era" leaders being completely dominated. Both the career leaders and season leaders managed considerably better offensive production, pitching, and rare events. This shows that these teams are statistically superior to any regular Major League team. This study did reveal some unexpected results. None of the "era" leaders were expected to perform well. Surprisingly enough, certain teams performed considerably better than the others. With a continuation of this, it could be possible to identify some of the best teams of Major League Baseball history.

CHAPTER 5: CONCLUSION

Throughout this research many questions were asked and answered. When simulations began the season leaders were expected to out perform the career leaders. The level of performance was still to be determined. The season leaders and career leaders were also expected to out perform the "era" leaders as well, with the offensive output to be increased. A few statistical packages and programs were used to maintain, manipulate, and graph the data. Microsoft Excel was used to store the data and calculate batting averages, at-bat per homerun ratios, and ERA. Minitab and SPSS were used to obtain significance levels and graphs of the changes in the data. The One-Way ANOVA F-test, student t-test, the difference of means t-test, and the paired t-test were used in Minitab.

The individual simulations of the season leaders versus the career leaders divulged a few surprising results. The overall winning percentage of the two teams was slightly surprising to say the least. The season leaders won about 68% of the games. It was obvious before the simulations that the season leaders had better offensive and pitching statistics. The players on the season leaders only had to keep their statistics elevated over a 162 game season. This made it much easier to keep their statistics so much higher than their career averages. The season leaders were expected to beat the career leaders but they were not expected to win as often as they did.

The win/loss records for the "era" simulations were also surprising. The "era" leaders were expected to win a higher percentage of games. The career leaders dominated the "era" leaders winning over 80% of their games. This is not as good as the season leaders who managed to win just over 90% of their games. With winning

percentages this high, one must determine if the luck factor has been taken out of the game. When two teams are completely equal, there will be a luck factor to help determine who wins. Maybe one team gets a good call from an umpire or catches a lucky bounce. No one can determine or plan for luck in a game. When a team wins over 90% of their games, one can not say they were lucky 90% of the time.

Other interesting feats occurred when doing simulations. Nomar Garciaparra of the season leaders was the only player during simulation to hit in over forty consecutive games. One could attribute this fact due to luck but it happened on multiple occasions. Was there something in his player data that made him more probable to have a long hitting streak? Other players had hitting streaks between 30-39 games. However, none of these players ever reached the 40 game mark. Certain players had problems reaching this for lack of playing time. Since this is simulated baseball the computer does not control for the fact that a player that does not play very often, needs time to adjust to playing. Theoretically, it should be easier for a simulated player to hit in over 40 straight games.

Pitching statistics for all teams rose during each individual simulation. This was a surprising result until the idea that all the pitchers that were used for simulation had extremely low ERAs was considered. When a pitcher's ERA is exceedingly low, a pitcher gives up very few runs a game, preferably one or less. This is a hard feat for any pitcher to achieve, no matter how historically good they are. Strikeout numbers for pitchers were not far away from their historic averages. Innings pitched was a problem in simulation. Today's professional baseball teams, the starting pitcher's pitch between 60-70 % of their teams innings. During simulation, the starting pitchers were pitching closer

to 90% of their team's innings, which is unheard of.

Other questions arose during the evaluation of the data. How did the number of strikeouts per pitcher affect their individual ERA? What would happen if pitchers were able to get tired during simulations? Did player's strikeout numbers increase from their historic averages? How did a player's walk total affect his total offensive performance? Did a pitcher's walk total affect how he pitched? If a player has a high homerun total, is his strikeout total also elevated?

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APPENDICIES

APPENDIX A: RARE EVENTS

These events occurred during simulations of the two teams, career leaders and season leaders. Each "career" consists of a simulation of twenty seasons of 162 games. There are equal numbers of home and away games for both teams. The careers were labeled in the order in which the simulations were conducted.

Career 1

Game #	Team	Player	Rare Event
389	Career	Ty Cobb	30 Game Hit Streak
918	Season	Tom Seaver	No-Hitter
950	Season	George Brett	Cycle
1146	Season	Alex Rodriguez	6 Hits
512	Season	Lou Gehrig	Cycle
756	Season	Hack Wilson	Cycle
906	Season	Barry Bonds	4 HR
1057	Season	Walter Johnson	No-Hitter
1277	Season	Walter Johnson	No-Hitter
1409	Season	Hack Wilson	Cycle
1511	Season	Sandy Koufax	No-Hitter

Career 2

Game #	Team	Player	Rare Event
311	Season	Ivan Rodriguez	Cycle
316	Season	Barry Bonds	Cycle
829	Career	Ichiro Suzuki	32 Game Hit Streak
838	Career	Ty Cobb	Cycle
891	Season	George Brett	6 Hits
1277	Season	Nomar Garciaparra	6 Hits
1538	Season	Ichiro Suzuki	32 Game Hit Streak
393	Season	Tony Gwynn	39 Game Hit Streak
426	Season	Mickey Mantle	4 HR
771	Season	Chipper Jones	9 RBI
805	Season	George Brett	Cycle
810	Season	Greg Maddux 95	No-Hitter

818	Career	Ty Cobb	6 Hits
1514	Career	Ty Cobb	6 Hits

Career 3

Game #	Team	Player	Rare Event
20	Career	Walter Johnson	No-Hitter
301	Season	Nomar Garciaparra	6 Hits
711	Career	Tom Seaver	No-Hitter
928	Season	Lou Gehrig	Cycle
931	Season	Chipper Jones	4 HR
982	Season	Chipper Jones	4 HR
1546	Season	Alex Rodriguez	9 RBI
389	Season	Greg Maddux 94	No-Hitter
931	Career	Babe Ruth	Cycle
953	Season	Sandy Koufax	No-Hitter
1243	Career	Christey Mathews	No-Hitter
1302	Season	Tom Seaver	No-Hitter

Career 4

Game #	Team	Player	Rare Event
26	Season	Walter Johnson	No-Hitter
517	Career	George Brett	Cycle
914	Season	Greg Maddux 94	No-Hitter
969	Season	Greg Maddux 94	No-Hitter
1352	Season	Sandy Koufax	No-Hitter
226	Season	Alex Rodriguez	Cycle
419	Season	Greg Maddux 94	No-Hitter
776	Season	Ken Griffey Jr.	Cycle

Career 5

Game #	Team	Player	Rare Event
466	Season	Sandy Koufax	No-Hitter
703	Season	Ken Griffey Jr.	6 Hits
704	Season	Ichiro Suzuki	6 Hits
748	Career	Albert Pujols	6 Hits
1209	Season	Greg Maddux 94	No-Hitter
1258	Career	Ichiro Suzuki	30 Game Hit Streak
1283	Season	Albert Pujols	9 RBI
1425	Career	Ichiro Suzuki	6 Hits
79	Season	Greg Maddux 94	No-Hitter
254	Season	Nomar Garciaparra	Cycle
376	Season	Sandy Koufax	No-Hitter

947	Season	Albert Pujols	9 RBI
1212	Career	Lou Gehrig	Cycle
1243	Season	Ichiro Suzuki	6 Hits

Career 6

Game #	Team	Player	Rare Event
2	Season	George Brett	Cycle
214	Season	Nomar Garciaparra	6 Hits
231	Season	Sandy Koufax	No-Hitter
241	Season	George Brett	9 RBI
438	Season	Tom Seaver	No-Hitter
710	Season	George Brett	Cycle
861	Season	George Brett	Cycle
1018	Season	George Brett	Cycle
1171	Season	Mickey Mantle	Cycle
1254	Career	Pedro Martinez	No-Hitter
1268	Career	Ichiro Suzuki	Cycle
1316	Career	Lou Gehrig	Cycle
85	Season	Ken Griffey Jr.	Cycle
849	Season	Greg Maddux 94	No-Hitter
1026	Season	Chipper Jones	9 RBI
1213	Career	Christey Mathews	No-Hitter

Career 7

Game #	Team	Player	Rare Event
372	Season	Albert Pujols	Cycle
530	Season	Lou Gehrig	Cycle
632	Season	George Brett	Cycle
686	Season	Sandy Koufax	No-Hitter
1167	Season	Hack Wilson	9 RBI
1245	Career	Ty Cobb	6 Hits
1356	Season	Nomar Garciaparra	44 Game Hit Steak
57	Season	Barry Bonds	4 HR
956	Season	Hack Wilson	Cycle
1251	Season	Babe Ruth	10 RBI
1278	Season	Lou Gehrig	Cycle

Career 8

Game #	Team	Player	Rare Event
593	Season	Tom Seaver	No-Hitter
1012	Career	Hank Aaron	Cycle
1013	Season	Tom Seaver	No-Hitter
1387	Season	Lou Gehrig	Cycle

1520	Career	Ted Williams	9 RBI
657	Season	Nomar Garciaparra	Cycle
785	Season	Lou Gehrig	Cycle

Career 9

Game #	Team	Player	Rare Event
599	Season	Ivan Rodriguez	6 Hits
681	Season	Barry Bonds	6 Hits
762	Season	Walter Johnson	No-Hitter
770	Career	Lou Gehrig	Cycle
846	Season	Lou Gehrig	Cycle
946	Season	George Brett	Cycle
1376	Season	Babe Ruth	9 RBI
496	Season	Chipper Jones	6 Hits
603	Season	Babe Ruth	Cycle

Career 10

Game #	Team	Player	Rare Event
53	Season	Tom Seaver	No-Hitter
232	Season	Mickey Mantle	Cycle
775	Season	Lou Gehrig	Cycle
969	Season	Roberto Alomar	9 RBI
1126	Season	Sandy Koufax	No-Hitter
1211	Season	Ichiro Suzuki	6 Hits
1432	Season	Barry Bonds	9 RBI
1	Career	Alex Rodriguez	6 Hits
159	Season	Lou Gehrig	Cycle
164	Season	Babe Ruth	Cycle
370	Season	Nomar Garciaparra	31 Game Hit Streak
612	Season	Hack Wilson	4 HR
625	Career	Babe Ruth	Cycle
768	Season	Tom Seaver	No-Hitter
782	Season	Mark McGwire	9 RBI
782	Season	Mark McGwire	4 HR
1027	Career	Ty Cobb	Cycle

Career 11

Game #	Team	Player	Rare Event
274	Season	Greg Maddux 94	No-Hitter
290	Season	Greg Maddux 95	No-Hitter
1284	Career	Pedro Martinez	No-Hitter
62	Season	Walter Johnson	No-Hitter
262	Season	Walter Johnson	No-Hitter

940	Season	Greg Maddux 95	No-Hitter
947	Season	Barry Bonds	4 HR
1061	Season	Sandy Koufax	No-Hitter
1524	Season	George Brett	Cycle

Career 12

Game #	Team	Player	Rare Event
443	Career	Christey Mathews	No-Hitter
502	Season	Craig Biggio	Cycle
1086	Season	Sandy Koufax	No-Hitter
1182	Season	Chipper Jones	Cycle
1207	Season	Barry Bonds	Cycle
64	Season	Nomar Garciaparra	39 Game Hit Streak
505	Career	Walter Johnson	No-Hitter
815	Career	Walter Johnson	No-Hitter

Career 13

Game #	Team	Player	Rare Event
161	Season	Babe Ruth	9 RBI
213	Season	Tom Seaver	No-Hitter
242	Season	Walter Johnson	No-Hitter
426	Career	Hank Aaron	6 Hits
426	Career	Hank Aaron	4 HR
517	Season	George Brett	6 Hits
90	Career	Barry Bonds	9 RBI
122	Season	Walter Johnson	No-Hitter
816	Career	George Brett	Cycle
1146	Season	Mickey Mantle	9 RBI
1437	Season	Lou Gehrig	10 RBI

Career 14

Game #	Team	Player	Rare Event
273	Season	Tom Seaver	No-Hitter
355	Season	Albert Pujols	9 RBI
511	Season	Hack Wilson	Cycle
880	Season	Ken Griffey Jr.	Cycle
1064	Season	Barry Bonds	9 RBI
1247	Season	Nomar Garciaparra	40 Game Hit Streak
1406	Season	Barry Bonds	4 HR
1596	Career	Alex Rodriguez	Cycle
21	Season	Sandy Koufax	No-Hitter
841	Career	Derek Jeter	Cycle
903	Career	Ty Cobb	6 Hits

1403	Season	Babe Ruth	Cycle

Career 15

Game #	Team	Player	Rare Event
79	Career	Ty Cobb	5 SB
263	Season	Lou Gehrig	Cycle
482	Season	Mickey Mantle	4 HR
585	Season	Alex Rodriguez	Cycle
1262	Season	Ken Griffey Jr.	4 HR
1441	Season	Nomar Garciaparra	34 Game Hit Streak
1449	Season	Ichiro Suzuki	Cycle
151	Season	Ken Griffey Jr.	9 RBI
318	Season	Tom Seaver	No-Hitter
821	Season	Sandy Koufax	No-Hitter
987	Season	George Brett	9 RBI
1325	Career	Ty Cobb	32 Game Hit Streak

Career 16

Game #	Team	Player	Rare Event
42	Season	Babe Ruth	Cycle
284	Season	Craig Biggio	Cycle
691	Season	Barry Bonds	Cycle
838	Career	Christey Mathews	No-Hitter
876	Career	Rogers Hornsby	Cycle
1445	Career	Walter Johnson	No-Hitter
105	Season	Greg Maddux 95	No-Hitter
118	Career	Ty Cobb	Cycle
309	Season	Ken Griffey Jr.	Cycle
382	Season	Barry Bonds	9 RBI
814	Season	Lou Gehrig	Cycle
816	Season	Mickey Mantle	10 RBI
828	Season	Ichiro Suzuki	6 Hits
1079	Season	Greg Maddux 94	No-Hitter
1349	Season	Mickey Mantle	Cycle
1461	Season	Sandy Koufax	No-Hitter
1498	Season	Tom Seaver	No-Hitter

Career 17

Game #	Team	Player	Rare Event
39	Season	Greg Maddux 94	No-Hitter
282	Season	Hack Wilson	6 Hits
346	Season	Lou Gehrig	Cycle
397	Season	Hack Wilson	Cycle

726	Season	Sandy Koufax	No-Hitter
1090	Season	Mickey Mantle	Cycle
1115	Season	Ichiro Suzuki	32 Game Hit Streak
1131	Career	Albert Pujols	Cycle
14	Season	Alex Rodriguez	4 HR
221	Season	Sandy Koufax	No-Hitter
942	Season	Craig Biggio	6 Hits
1428	Season	Tom Seaver	No-Hitter
1438	Season	Tom Seaver	No-Hitter

Career 18

Game #	Team	Player	Rare Event
84	Season	Greg Maddux 94	No-Hitter
170	Season	Ken Griffey Jr.	6 Hits
174	Career	George Brett	Cycle
614	Career	Ichiro Suzuki	6 Hits
726	Season	Alex Rodriguez	Cycle
1365	Season	Greg Maddux 95	No-Hitter
1614	Season	Ken Griffey Jr.	4 HR
26	Season	Sandy Koufax	No-Hitter
446	Season	Nomar Garciaparra	Cycle
614	Season	Barry Bonds	10 RBI
614	Season	Barry Bonds	4 HR
985	Season	Greg Maddux 95	No-Hitter
1245	Season	Greg Maddux 95	No-Hitter

Career 19

Game #	Team	Player	Rare Event
661	Season	Ken Griffey Jr.	4 HR
783	Season	Craig Biggio	5 SB
881	Career	Lou Gehrig	Cycle
938	Career	Christey Mathews	No-Hitter
1422	Season	George Brett	Cycle
1508	Season	Tom Seaver	No-Hitter
1521	Season	Babe Ruth	6 Hits
813	Season	Albert Pujols	Cycle
1013	Season	Christey Mathews	No-Hitter
1502	Season	Walter Johnson	No-Hitter

Career 20

Game #	Team	Player	Rare Event
52	Season	Barry Bonds	4 HR
57	Season	Nomar Garciaparra	Cycle
417	Career	Ted Williams	Cycle
809	Career	Ty Cobb	32 Game Hit Streak
896	Season	Babe Ruth	Cycle
121	Season	Lou Gehrig	Cycle
191	Season	Sandy Koufax	No-Hitter
270	Season	Ichiro Suzuki	30 Game Hit Streak
514	Season	Nomar Garciaparra	30 Game Hit Streak
604	Career	Pedro Martinez	No-Hitter
866	Career	Ted Williams	Cycle
887	Season	Walter Johnson	No-Hitter
1066	Season	Alex Rodriguez	4 HR
1223	Season	Lou Gehrig	10 RBI

These events occurred during simulations of the career leaders versus the "era" leaders. Each series consists of a simulation of twenty seasons of 162 games. There are equal numbers of home and away games for both teams. They are labeled as the team the career leaders obtained the rare events against. The (V), next to the game number, denotes when a player on the "era" leaders obtained a rare event.

1918 Boston Red Sox

Game #	Player	Rare Event
38	George Brett	6 Hits
334	Pedro Martinez	No-Hitter
447	Ty Cobb	7 Hits
620	Lou Gehrig	Cycle
732	George Brett	Cycle
790	Walter Johnson	No-Hitter
818	Christey Mathews	No-Hitter
958	Christey Mathews	No-Hitter
1000	Walter Johnson	No-Hitter
1161	George Brett	Cycle
650	Barry Bonds	4 HR
1054	Pedro Martinez	No-Hitter

1927 New York Yankees

Game #	Player	Rare Event
1	Lou Gehrig	Cycle
9	Lou Gehrig	6 Hits
219	Ichiro Suzuki	6 Hits
364	Babe Ruth	Cycle
402	Rogers Hornsby	31 Game Hit Streak
564	George Brett	Cycle
(V) 1003	Joe Dugan	Cycle
1359	Craig Biggio	Cycle
1408	Christey Mathews	No-Hitter
273	Lou Gehrig	Cycle
(V) 445	Wiley Moore	No-Hitter
596	Tom Seaver	No-Hitter
737	Ty Cobb	6 Hits
92	Ivan Rodriguez	6 Hits
1057	Lou Gehrig	6 Hits
1057	Craig Biggio	6 Hits
1091	Ty Cobb	32 Game Hit Streak
1093	George Brett	Cycle
1348	George Brett	6 Hits
1611	George Brett	6 Hits

1955 Brooklyn Dodgers

Game #	Player	Rare Event
103	Christey Mathews	No-Hitter
329	Pedro Martinez	No-Hitter
(V) 343	Clem Labine	No-Hitter
459	Robin Yount	Cycle
604	Ty Cobb	Cycle
1061	Tom Seaver	No-Hitter
1343	Alex Rodriguez	Cycle
1379	Craig Biggio	Cycle
15	Ty Cobb	33 Game Hit Streak
547	Ichiro Suzuki	6 Hits
700	Ty Cobb	6 Hits
755	Hank Aaron	7 Hits
(V) 909	Frank Keller	Cycle
964	Pedro Martinez	No-Hitter
1044	Barry Bonds	6 Hits
1126	Lou Gehrig	Cycle
1569	Albert Pujols	Cycle

1961 New York Yankees

Game #	Player	Rare Event
(V) 86	Elston Howard	Cycle
178	Albert Pujols	Cycle
410	George Brett	7 Hits
467	Rogers Hornsby	Cycle
495	Ty Cobb	6 Hits
525	Walter Johnson	No-Hitter
1000	Ichiro Suzuki	Cycle
1002	Babe Ruth	10 RBI
1051	George Brett	9 RBI
(V) 1481	Tony Kubek	Cycle
1554	Pedro Martinez	No-Hitter
37	Mike Piazza	9 RBI
(V) 244	Rollie Sheldon	No-Hitter
786	Ted Williams	6 Hits
957	Ty Cobb	Cycle
960	Ted Williams	Cycle
116	Tom Seaver	No-Hitter
1145	George Brett	7 Hits
1180	Lou Gehrig	Cycle
1403	Christey Mathews	No-Hitter
1510	Walter Johnson	No-Hitter

1985 Kansas City Royals

Game #	Player	Rare Event
64	Ty Cobb	Cycle
75	Ty Cobb	6 Hits
140	Derek Jeter	Cycle
460	Robin Yount	6 Hits
476	Ty Cobb	35 Game Hit Streak
493	Ichiro Suzuki	Cycle
635	Mike Piazza	6 Hits
657	Walter Johnson	No-Hitter
(V) 729	Lonnie Smith	5 SB
1043	Whitey Ford	No-Hitter
1322	Rogers Hornsby	6 Hits
1525	Tom Seaver	No-Hitter
6	Rogers Hornsby	10 RBI
82	Alex Rodriguez	Cycle
90	Walter Johnson	No-Hitter
174	George Brett	6 Hits
180	Walter Johnson	No-Hitter
276	Ivan Rodriguez	9 RBI

276	Ivan Rodriguez	Cycle
425	Ichiro Suzuki	6 Hits
914	Babe Ruth	Cycle
1261	Tom Seaver	No-Hitter
1450	Walter Johnson	No-Hitter
1453	Christey Mathews	No-Hitter
1509	Ty Cobb	6 Hits

2005 Chicago White Sox

Game #	**Player**	**Rare Event**
111	Babe Ruth	4 HR
241	Tom Seaver	No-Hitter
333	Albert Pujols	Cycle
463	Ted Williams	9 RBI
482	Whitey Ford	No-Hitter
528	Barry Bonds	9 RBI
872	Ty Cobb	Cycle
878	Christey Mathews	No-Hitter
1073	Ted Williams	10 RBI
1452	Ichiro Suzuki	32 Game Hit Streak
(V) 1454	Frank Thomas	Cycle
1501	Albert Pujols	37 Game Hit Streak
1583	Ted Williams	9 RBI
227	George Brett	Cycle
396	Ty Cobb	31 Game Hit Streak
577	Whitey Ford	No-Hitter
723	Christey Mathews	No-Hitter
818	Christey Mathews	No-Hitter
1077	Whitey Ford	No-Hitter
1105	Ty Cobb	6 Hits
1105	Babe Ruth	6 Hits
1224	Rogers Hornsby	Cycle

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1918 Boston Red Sox

Game #	Player	Rare Event
80	Chipper Jones	6 Hits
140	Barry Bonds	Cycle
217	Barry Bonds	11 RBI
241	Sandy Koufax	No-Hitter
257	Nomar Garciaparra	9 RBI
327	Alex Rodriguez	Cycle
480	Babe Ruth	6 Hits
602	Barry Bonds	9 RBI
641	George Brett	36 Game Hit Streak
757	Hack Wilson	4 HR
849	Ichiro Suzuki	31 Game Hit Streak
944	Alex Rodriguez	Cycle
1024	Greg Maddux 94	No-Hitter
1221	Lou Gehrig	Cycle
1241	Barry Bonds	Cycle
1386	Sandy Koufax	No-Hitter
1433	Tom Seaver	No-Hitter
1436	Sandy Koufax	No-Hitter
1522	Walter Jonson	No-Hitter
1619	Barry Bonds	10 RBI
1619	Barry Bonds	5 HR
30	Mickey Mantle	6 Hits
30	Mickey Mantle	14 RBI
30	Mickey Mantle	5 HR
372	Walter Jonson	No-Hitter
436	George Brett	Cycle
500	Mickey Mantle	4 HR
516	Sandy Koufax	No-Hitter
636	Sandy Koufax	No-Hitter
751	Sandy Koufax	No-Hitter
857	Walter Jonson	No-Hitter
879	Greg Maddux 94	No-Hitter
892	Walter Jonson	No-Hitter
1323	Tom Seaver	No-Hitter
1467	Barry Bonds	9 RBI

1927 New York Yankees

Game #	Player	Rare Event
284	Ken Griffey Jr.	6 Hits
313	Roberto Alomar	6 Hits
375	Nomar Garciaparra	42 Game Hit Streak
421	Sandy Koufax	No-Hitter
729	Ken Griffey Jr.	10 RBI

913	Tony Gwynn	6 Hits
1013	Ichiro Suzuki	31 Game Hit Streak
1042	Albert Pujols	10 RBI
1107	Walter Jonson	No-Hitter
1299	Ichiro Suzuki	35 Game Hit Streak
1448	Tom Seaver	No-Hitter
13	Alex Rodriguez	Cycle
21	Sandy Koufax	No-Hitter
47	Lou Gehrig	6 Hits
47	Lou Gehrig	Cycle
110	Greg Maddux 95	No-Hitter
128	Nomar Garciaparra	6 Hits
329	Albert Pujols	6 Hits
344	Alex Rodriguez	Cycle
346	Tony Gwynn	9 RBI
462	Babe Ruth	6 Hits
462	Babe Ruth	10 RBI
499	Alex Rodriguez	Cycle
546	Barry Bonds	Cycle
582	Nomar Garciaparra	6 Hits
609	Roberto Alomar	6 Hits
609	Nomar Garciaparra	9 RBI
614	Hack Wilson	9 RBI
(V) 628	Herb Pennock	No-Hitter
663	Lou Gehrig	Cycle
671	Barry Bonds	4 HR
698	Tom Seaver	No-Hitter
726	Nomar Garciaparra	6 Hits
1042	Mark McGwire	10 RBI
1077	Lou Gehrig	Cycle
1086	Ivan Rodriguez	10 RBI
1132	Ken Griffey Jr.	4 HR
1134	Hack Wilson	7 Hits
1204	Albert Pujols	10 RBI
(V) 1238	Early Combs	Cycle
1284	George Brett	Cycle
1291	Alex Rodriguez	9 RBI
1291	Hack Wilson	6 Hits
1291	Hack Wilson	Cycle
1461	Lou Gehrig	Cycle
1501	Tony Gwynn	6 Hits
1519	George Brett	39 Game Hit Streak
1559	Mark McGwire	9 RBI
1574	Ken Griffey Jr.	9 RBI
1592	Barry Bonds	12 RBI
1592	Barry Bonds	4 HR

1955 Brooklyn Dodgers

Game #	Player	Rare Event
54	Mark McGwire	4 HR
87	Walter Jonson	No-Hitter
426	Mike Piazza	9 RBI
427	Hack Wilson	6 Hits
481	Sandy Koufax	No-Hitter
551	Hack Wilson	6 Hits
551	Albert Pujols	6 Hits
551	Albert Pujols	14 RBI
551	Albert Pujols	4 HR
661	Barry Bonds	4 HR
768	Mickey Mantle	10 RBI
854	Alex Rodriguez	Cycle
876	Sandy Koufax	No-Hitter
938	Mickey Mantle	4 HR
958	Alex Rodriguez	Cycle
1012	Walter Jonson	No-Hitter
1114	Mike Piazza	9 RBI
1136	Hack Wilson	Cycle
1219	Hack Wilson	Cycle
1321	Barry Bonds	4 HR
1352	Mike Piazza	4 HR
1597	Ichiro Suzuki	6 Hits
82	Lou Gehrig	Cycle
146	Tony Gwynn	6 Hits
274	Albert Pujols	9 RBI
287	Walter Jonson	No-Hitter
341	Hack Wilson	10 RBI
545	Babe Ruth	11 RBI
545	Babe Ruth	4 HR
598	Nomar Garciaparra	6 Hits
605	Ichiro Suzuki	7 Hits
617	Chipper Jones	9 RBI
668	George Brett	Cycle
676	George Brett	6 Hits
749	Greg Maddux 94	No-Hitter
767	Nomar Garciaparra	6 Hits
775	Tony Gwynn	Cycle
918	Barry Bonds	9 RBI
1017	Walter Jonson	No-Hitter
1128	Tony Gwynn	Cycle
1259	Nomar Garciaparra	40 Game Hit Streak
1296	Barry Bonds	10 RBI

1300	Lou Gehrig	Cycle
1381	George Brett	31 Game Hit Streak
1481	Alex Rodriguez	4 HR
1547	Lou Gehrig	Cycle
1555	Barry Bonds	9 RBI
1601	Mickey Mantle	Cycle

1961 New York Yankees

Game #	**Player**	**Rare Event**
66	Mickey Mantle	32 Game Hit Streak
96	George Brett	6 Hits
153	Nomar Garciaparra	6 Hits
201	Sandy Koufax	No-Hitter
203	Lou Gehrig	9 RBI
221	Hack Wilson	10 RBI
264	Mike Piazza	9 RBI
375	Barry Bonds	10 RBI
375	Barry Bonds	Cycle
375	Lou Gehrig	Cycle
392	Nomar Garciaparra	37 Game Hit Streak
465	Alex Rodriguez	Cycle
610	Lou Gehrig	Cycle
630	Lou Gehrig	9 RBI
780	Mike Piazza	6 Hits
791	Mickey Mantle	Cycle
838	Chipper Jones	4 HR
917	Mickey Mantle	9 RBI
917	Mickey Mantle	4 HR
969	Mickey Mantle	4 HR
978	Ichiro Suzuki	6 Hits
978	Mike Piazza	6 Hits
1003	Babe Ruth	6 Hits
1080	Ken Griffey Jr.	Cycle
1100	Ichiro Suzuki	6 Hits
1135	Greg Maddux 95	No-Hitter
1166	Mickey Mantle	6 Hits
1173	Mickey Mantle	9 RBI
1178	Hack Wilson	Cycle
1190	Mark McGwire	4 HR
1309	Ken Griffey Jr.	9 RBI
1309	Ken Griffey Jr.	4 HR
1310	Greg Maddux 95	No-Hitter
1316	Albert Pujols	6 Hits
1369	Greg Maddux 94	No-Hitter
1587	Ken Griffey Jr.	4 HR

1612	Walter Jonson	No-Hitter
33	Ichiro Suzuki	30 Game Hit Streak
73	Tom Seaver	No-Hitter
79	Chipper Jones	9 RBI
124	Lou Gehrig	9 RBI
(V) 131	Johnny Blanchard	Cycle
169	Ken Griffey Jr.	9 RBI
182	Barry Bonds	9 RBI
190	Greg Maddux 95	No-Hitter
227	George Brett	6 Hits
236	Babe Ruth	31 Game Hit Streak
301	Barry Bonds	9 RBI
320	Barry Bonds	6 Hits
326	Sandy Koufax	No-Hitter
430	Ichiro Suzuki	6 Hits
519	Hack Wilson	Cycle
896	Barry Bonds	Cycle
910	Nomar Garciaparra	39 Game Hit Streak
915	Mark McGwire	4 HR
945	Lou Gehrig	Cycle
1041	Ichiro Suzuki	30 Game Hit Streak
1180	Greg Maddux 95	No-Hitter
1219	Nomar Garciaparra	31 Game Hit Streak
1362	Ichiro Suzuki	30 Game Hit Streak
1379	Mark McGwire	9 RBI
1384	Greg Maddux	No-Hitter
1406	Sandy Koufax	No-Hitter
1567	Walter Jonson	No-Hitter
1613	Hack Wilson	9 RBI
1614	Greg Maddux 94	No-Hitter

1985 Kansas City Royals

Game #	**Player**	**Rare Event**
134	George Brett	Cycle
179	Lou Gehrig	10 RBI
256	Sandy Koufax	No-Hitter
264	Greg Maddux 94	No-Hitter
82	Lou Gehrig	Cycle
383	Mark McGwire	5 HR
491	Ivan Rodriguez	6 Hits
665	Greg Maddux 95	No-Hitter
780	Greg Maddux 96	No-Hitter
821	Nomar Garciaparra	Cycle
832	Walter Jonson	No-Hitter
836	Sandy Koufax	No-Hitter

971	Ken Griffey Jr.	6 Hits
1002	George Brett	6 Hits
1006	Nomar Garciaparra	34 Game Hit Streak
1061	Sandy Koufax	No-Hitter
1067	Tony Gwynn	6 Hits
1132	Alex Rodriguez	10 RBI
1132	George Brett	6 Hits
1146	Ivan Rodriguez	6 Hits
1485	Ken Griffey Jr.	9 RBI
1521	Ichiro Suzuki	6 Hits
1521	Alex Rodriguez	Cycle
62	George Brett	6 Hits
135	Mickey Mantle	6 Hits
135	Mickey Mantle	9 RBI
215	Ichiro Suzuki	7 Hits
295	Nomar Garciaparra	6 Hits
399	Nomar Garciaparra	6 Hits
430	Chipper Jones	9 RBI
448	Barry Bonds	9 RBI
448	Barry Bonds	4 HR
517	Walter Jonson	No-Hitter
552	Ivan Rodriguez	6 Hits
624	Nomar Garciaparra	6 Hits
673	George Brett	9 RBI
847	Walter Jonson	No-Hitter
972	Walter Jonson	No-Hitter
1016	Hack Wilson	11 RBI
1016	Hack Wilson	4 HR
1025	Greg Maddux 95	No-Hitter
(V) 1043	Willie Wilson	Cycle
1169	Greg Maddux 94	No-Hitter
1322	Walter Jonson	No-Hitter
1416	Sandy Koufax	No-Hitter
1475	Mickey Mantle	9 RBI
1543	Tom Seaver	No-Hitter
1561	Sandy Koufax	No-Hitter
1581	Sandy Koufax	No-Hitter

2005 Chicago White Sox

Game #	**Player**	**Rare Event**
18	Lou Gehrig	Cycle
69	Hack Wilson	Cycle
69	Chipper Jones	9 RBI
98	Tom Seaver	No-Hitter
794	Alex Rodriguez	Cycle

860	Roberto Alomar	Cycle
913	George Brett	6 Hits
939	Nomar Garciaparra	6 Hits
1021	Sandy Koufax	No-Hitter
1098	Ken Griffey Jr.	4 HR
1150	Lou Gehrig	Cycle
1200	Greg Maddux 95	No-Hitter
1242	Lou Gehrig	Cycle
1298	Ivan Rodriguez	9 RBI
1401	Barry Bonds	4 HR
1470	Greg Maddux 95	No-Hitter
1547	Mickey Mantle	7 Hits
1547	Mickey Mantle	4 HR
1555	Barry Bonds	Cycle
128	Tom Seaver	No-Hitter
172	Walter Jonson	No-Hitter
245	George Brett	Cycle
289	Greg Maddux 94	No-Hitter
300	Greg Maddux 95	No-Hitter
473	Tom Seaver	No-Hitter
612	Babe Ruth	Cycle
788	Babe Ruth	Cycle
818	Ken Griffey Jr.	Cycle
834	Greg Maddux 94	No-Hitter
1117	Walter Jonson	No-Hitter
1234	Greg Maddux 94	No-Hitter
1296	Sandy Koufax	No-Hitter
1397	Walter Jonson	No-Hitter
1400	Greg Maddux 95	No-Hitter

APPENDIX B: SIMULATION STATISTICS USED

Career Leaders

*A		Career	AB	Hit	2B	3B	HR	BB	SO	RBI	B	DEF	SB	CS	Gam	Gam-P	Gam-P	Gam-P	Gam-P
31	08	Cobb, Ty	610	224	39	16	6	67	19	103	L	961	48	10	156	156-8			
29	05	Rodriquez, Alex	626	192	34	2	44	77	129	128	R	974	23	5	162	81-6	81-5		
25	07	Bonds, Barry	534	159	33	4	41	139	84	108	L	984	28	8	159	159-7			
27	09	Ruth, Babe	544	186	33	4	46	133	86	143	L	968	8	8	154	77-7	77-9		
25	03	Gehrig, Lou	599	204	40	12	37	113	59	149	L	991	8	8	157	157-3			
28	10	Williams, Ted	545	188	37	5	37	143	50	130	L	974	2	1	156	156-7			
35	02	Rodriguez, Ivan	621	188	38	3	22	34	92	89	R	991	9	4	153	153-2			
24	06	Jeter, Derek	655	208	34	5	17	67	114	82	R	975	23	6	159	159-6			
28	04	Hornsby, Rogers	586	210	39	12	22	74	49	114	R	958	10	5	156	156-4			

*Pitching			Inn	Hit			HR	BB	SO	ERA	T	W	L	S	Gam	St	*	AB	Hit	HR	BB	SO
27	01	Ford, Whitey	230	200			16	78	142	275	L	17	7	0	36	31						
24	01	Johnson, Randy	233	185			22	86	279	322	L	17	9	0	34	33						
24	01	Clemons, Roger	236	201			17	75	224	313	R	17	8	0	34	33						
26	01	Maddux, Greg	231	227			15	46	157	309	R	16	10	0	34	33						
23	01	Johnson, Walter	274	227			4	63	162	217	R	19	12	1	30	24						
21	01	Mathews, Christey	274	241			5	48	143	213	R	21	10	1	36	31						
27	01	Santana, Johan	209	170			22	57	220	318	L	15	6	0	40	27						
30	01	Seaver, Tom	249	207			19	72	189	286	R	16	10	0	34	33						
26	14	Eckersley, Dennis	156	146			16	35	114	350	R	9	8	18	50	17						
36	14	Hoffman, Trevor	73	55			6	20	77	271	R	4	4	40	68	0						
35	14	Rivera, Mariano	81	64			4	20	73	233	R	5	3	37	67	0						
32	14	Smith, Lee	85	74			5	32	82	303	R	4	6	31	67	0	D					
26	01	Martinez, Pedro	267	212			17	58	248	280	R	17	7	0	35	31						

*Bench			AB	Hit	2B	3B	HR	BB	SO	RBI	B	DEF	SB	CS	Gam	Gam-P	Gam-P	Gam-P	Gam-P
29	02	Piazza, Mike	587	181	36	1	36	64	95	113	R	989	1	2	152	152-2			
32	03	Pujols, Albert	604	200	44	2	42	88	68	128	R	990	6	3	161	161-3			
29	04	Biggio, Craig	619	174	38	3	17	66	100	67	R	985	24	7	162	162-4			
31	06	Yount, Robin	624	178	33	7	14	55	77	80	R	972	15	6	162	162-6			
29	09	Suzuki, Ichiro	692	231	26	8	10	48	66	62	L	995	40	9	162	81-9	81-8		
33	07	Aaron, Hank	607	185	31	5	37	69	68	113	R	982	12	4	161	161-7			
26	05	Brett, George	619	189	40	8	19	66	54	95	L	970	12	6	159	159-5			

*PE=103/103

Season Leaders

*A	Season	AB	Hit	2B	3B	HR	BB	SO	RBI	B	DEF	SB	CS	Gam	Gam-P	Gam-P	Gam-P	Gam-P
31	08 Suzu, Ichiro04	704	262	24	5	8	49	63	60	L	992	36	11	162	158-9	3-D		
32	06 Rodrig, Alex03	607	181	30	6	47	87	126	118	R	989	17	3	161	158-6	3-D		
33	07 Bonds, Barry01	476	156	32	2	73	177	93	137	L	977	13	3	153	150-7	3-D		
30	09 Wilson, Hack30	585	208	35	6	56	105	84	191	R	951	3	0	155	151-9	4-D		
26	10 Ruth, Babe27	540	192	29	8	60	137	89	164	L	963	7	6	151	151-9			
36	03 Gehrig, Lou27	584	218	52	18	47	109	84	175	L	992	10	8	155	155-3			
24	05 Jones, Chip99	567	181	41	1	45	126	94	110	S	950	25	3	157	154-5	3-6		
23	02 Rodrig, Ivan99	600	199	29	1	35	24	64	113	R	993	25	12	144	144-2			
26	04 Alo, Roberto99	563	182	40	3	24	99	96	120	S	992	37	6	159	159-4			

*Pitching		Inn	Hit			HR	BB	SO	ERA	T	W	L	S	Gam	St	*	AB	Hit	HR	BB	SO
42	01 Smoltz, John96	254	199			19	55	276	294	R	24	8	0	35	35						
32	01 Clemon, Roger90	228	215			20	93	230	193	R	21	6	0	31	31						
26	01 Maddux, Greg94	210	147			8	23	181	156	R	19	2	0	28	28						
35	01 Johns, Walter13	346	232			9	38	243	114	R	36	7	2	48	36						
19	01 Koufax, Sandy63	311	214			18	58	306	188	L	25	5	0	40	40						
34	01 Santa, Johan04	228	156			24	54	265	261	L	20	6	0	34	34						
27	01 Maddux, Greg95	202	150			4	31	156	163	R	16	6	0	25	25						
28	01 Seaver, Tom71	286	210			18	61	289	176	R	20	10	0	36	35						
36	01 Hershi, Orel88	267	208			18	73	178	226	R	23	8	0	35	34						
35	14 Gagne, Eric03	82	37			2	20	137	120	R	2	3	55	77	0						
30	14 Rive, Mariano04	79	65			3	20	66	194	R	4	2	53	74	0						
28	14 Eck, Dennis90	73	41			2	4	73	061	R	4	2	48	63	0						
38	14 Smoltz, John03	64	48			2	8	73	112	R	0	2	45	62	0						

*Bench		AB	Hit	2B	3B	HR	BB	SO	RBI	B	DEF	SB	CS	Gam	Gam-P	Gam-P	Gam-P	Gam-P
27	02 Piazza, Mike97	556	201	32	1	40	69	77	124	R	986	5	1	152	152-2			
23	03 Pujols, Albert06	535	177	33	1	49	92	50	137	R	996	7	2	143	143-3			
21	03 McGwire, Mark98	509	152	21	0	70	162	155	147	R	992	1	0	155	155-3			
26	04 Biggio, Craig98	646	210	51	2	20	64	113	88	R	980	50	8	160	159-4	1-D		
27	05 Brett, George80	449	175	33	9	24	58	22	118	L	955	15	6	117	117-5			
42	06 Garpara, Nomar00	529	197	51	3	21	61	50	96	R	971	5	2	140	140-6			
26	09 Gwynn, Tony94	419	165	35	1	12	48	19	64	L	985	5	0	110	110-9			
36	07 Mantle, Mickey56	533	188	22	5	52	112	99	130	L	990	10	1	150	100-8	50-7	49-9	1-D
32	08 Griffey, Ken97	608	185	34	3	56	76	121	147	L	985	15	4	157	157-8			

*PE=99/99,PH=safeco.jpg

APPENDIX C: SAMPLE BOOTSTRAP CODE

Sample Bootstrap for difference of means

```
sample 18 c4 c6;
replace.
sample 16 c5 c7;
replace.
let c8(k1) = mean(c6) - mean(c7)
let k1 = k1 + 1
```

Sample Bootstrap

```
sample 18 c1 c7;
replace.
let c8(k1) = mean(c7)
let k1 = k1 + 1
```