SIMULATION OF YACHT MOVEMENTS IN GÖCEK BAYS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
THE MIDDLE EAST TECHNICAL UNIVERSITY

BY

ASLI NUMANOĞLU GENÇ

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

THE DEPARTMENT OF CIVIL ENGINEERING

MARCH 2004

Approval of the Graduate School of the Natural and Applied Sciences

____

Prof. Dr. Canan Özgen
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Doctor of Philosophy.

Prof. Dr. Erdal Çokça
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Doctor of Philosophy.

Prof.Dr. Erdal Özhan
Supervisor

Examining Committee Members

Prof.Dr. Ayhan İnal

Prof.Dr. Erdal Özhan

Prof.Dr. Özdemir Akyılmaz

Asst. Prof.Dr. Hikmet Bayırtepe

Assoc. Prof. Dr. Lale Balas

ABSTRACT

SIMULATION OF THE YACHT MOVEMENTS IN GÖCEK BAYS

Aslı Numanoğlu Genç

Ph.D., Department of Civil Engineering

Supervisor: Prof.Dr. Erdal Özhan

March 2004, 103 pages

Fethiye-Göcek area is one of the nine coastal Specially Protected Area (SPA) in Turkey. Since mid-80's Göcek town has developed to be a yachting center, and the bays of Göcek have acquired a well-earned international fame as a paradise for boating vacations. However, the uncontrolled yachting in this bay area presents a growing pressure on the environment, and the coastal and marine ecosystem.

In this thesis a computer model for simulating the movements of yachts in Göcek Bays is developed. The computer model uses the Multinomial Logit Model (MNL) to find the probabilities for the boaters to select the next bay to visit. The model predicts the number of boats in each bay at the end of a day, the number of boats visited each bay during the day and the distribution of boater categories among the bays throughout the simulation time. In order to get the data needed for the inputs, a questionnaire was formed, and a detailed survey was carried out in Göcek Bays. In addition to the questionnaires, the number of the boats anchored were also observed in the field studies.

The model is applied to the Göcek Bays and the results obtained are compared with the data obtained in the field. In the following years, the yacht movements and distributions at various anchor locations can be predicted with this model. These predictions will be useful in a future management plan that aims to control of yacht movement and anchoring.

Keywords: Yachting, simulation modeling, management plan, Multinomial logit model, Göcek.

ÖZ

GÖCEK KOYLARI'DAKİ YAT HAREKETLERİNİN ÖYKÜNÜMÜ

Aslı Numanoğlu Genç

Doktora, İnşaat Mühendisliği Bölümü

Tez yöneticisi: Prof.Dr. Erdal Özhan

Mart 2004, 103 sayfa

Fethiye-Göcek bölgesi Türkiye'de bulunan dokuz kıyısal Özel Çevre Koruma Alanları'ndan (ÖÇKA) birisidir. Göcek ve koyları 1980'lerin ortasından sonra, yat turizmi açısından uluslararası üne kavuşmuş ve Göcek kasabası yat merkezi haline gelmiştir. Ancak, özellikle turizm sezonunda gerçekleşen kontrolsüz yatçılık bir yandan çevre ve ekosistem üzerinde olumsuz etkiler yaratırken bir yandan da kalabalık, gürültü ve deniz kirliliği nedeniyle tatillerin kalitesini düşürmektedir.

Bu tezde, yatların hareketlerini inceleyen bir öykünüm modeli geliştirilmiştir. Yatçıların koy seçimlerindeki olasılıkları belirleyebilmek için matematiksel model olarak çok terimli logit model kullanılmıştır. Geliştirilen öykünüm modeli gün sonunda her koydaki tekne sayısını, gün içerisinde koylara girip çıkan tekne sayısını ve tüm oykünüm süresi için yatçı gruplarının koylara dağılımını hesaplamaktadır. Bu model için gerekli olan girdileri elde edebilmek amacıyla, Göcek Koylarında kapsamlı bir anket çalışması yapılmış ve ayrıca koylardaki tekne sayıları farklı zamanlarda gözlemlenmiştir.

Bu öykünüm modelini baz alan bilgisayar programı Göcek Koylarına uygulanmış ve model sonuçları, saha incelemelerinden elde edilen veriler ile karşılaştırılmıştır. İleriki yıllar için daha çok sayıda yatın bulunacağı durumlarda, bu modelin yardımıyla dağılım tahminleri yapılabilecektir. Bu tahminler yat trafiğinin ve konaklamanın denetlenmesini amaçlayan bir yönetim planı çerçevesinde yararlı bir araç olacaktır.

Anahtar kelimeler: Yatçılık, öykünüm modeli, yönetim planı, çok terimli logit model, Göcek.

To my beloved husband, Oğuzhan Genç
For his great support, love and patience,

To my wonderful mother and father,
Who have inspired me both personally and professionally,

To my lovely sisters, Bilge and Ceren
For supporting me totally and unconditionally,

And to my dear friend, F. Selcen Pamuk Phelps
For being the light, when the path was dark.

ACKNOWLEDGEMENTS

I would like to acknowledge my supervisor, Prof. Dr. Erdal Özhan, for his patient guidance and helpful suggestions during my dissertation study. This work began with one of his many ideas, and I feel very fortunate to have been one of his students. I would also like to thank to Prof. Dr. Ayhan İnal and Assoc. Prof. Dr. Hikmet Bayırtepe for serving on my doctoral committee, and for their suggestions. Thanks are extended to my examining jury member Assoc. Prof. Dr. Lale Balas for her valuable comments.

It gives me great pleasure to thank to Assoc. Prof. Dr. Ahmet Cevdet Yalçıner who has given his time and support so generously that I will always be grateful. I am also grateful to Assoc. Prof. Dr. Gül Ergün for her extremely helpful contributions to my thesis. It was indeed a pleasure to get to know her during my studies.

I am thankful to Çağdaş Demircioğlu, Öncü Gönenç, Ümüt Görgülü and Cem Ozan who did a great work in the field studies. Thanks are extended to Seyfullah Değirmenci for his contribution in the last phase of this dissertation. I would also like to thank to Ken Phelps for his encouragement and friendship.

Finally, special thanks go to my elder sister, Dr. Yasemin Özdoğan Nielsen who patiently listened to many late night phone calls, and helped me to weather all the storms of graduate student life.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

In Turkey, there are nine Specially Protected Areas (SPA's) of coastal nature. The first batch of SPA's, including three sites (Gökova, Dalyan-Köyceğiz, Fethiye-Göcek), were established in July 1988 as the follow-up of intergovernmental agreements in the framework of Mediterranean Action Plan (MAP) of UNEP. More than a year later, the ASPA (Agency for Specially Protected Areas) was established in October 1989 under the Prime Ministry for managing the SPA's. In March 1990, other coastal sites (Göksu, Kekova, Patara), and in November 1990 the last group (Belek, Datça Peninsula, Foça) were declared as SPA's, to complete the nine coastal SPA's of a total of twelve. With the formation of the Ministry of Environment, ASPA was moved to this ministry in August 1991 (Özhan, 1996).

One of the most important outcomes of SPA experience in Turkey has been the cancellation of many tourism projects in coastal sites with very high landscape or habitat values. Furhermore, it has contributed significantly to curbing tourism and secondary holiday housing developments on mass scale. On the other hand, however, it has brought national and international publicity to several of these sites, most noticebly to Dalyan and Göcek Bays, and the recreational and tourism activities in these areas increased significantly.

Fethiye-Göcek SPA has an area of 613 km^2, much of which is the sea including the bays of Fethiye and Göcek. The whole sea area of this SPA in general, and the bays of Göcek in particular, have been acquiring an international fame as a paradise for in-boat vacations, and the town of Göcek has become a yachting center. The pine covered hilly shores of Fethiye-Göcek SPA, with numerous coves, tiny bays and small islands, exhibit one of the most beautiful, pristine Mediterranean coastal landscapes. The most important environmental pressure on the Göcek Bays is again provided by the boating activities, which presently are not managed. There is no monitoring of the boating activities in the area. The yachts can go wherever they like without any limitation, and can stay overnight at anywhere they choose. Consequently, the uncontrolled yachting in Göcek Bays presents a significant pressure on the environment and the ecosystem, and deteriorates the quality of holidays due to congestion, noise and water pollution. Presently, there exists no regulations enforced on yachters, except those of nature.

1.1 The Scope and Methodology of the Study

The scope of the present study is to develop a model simulating the yacht movements among the Göcek Bays. The model developed provides a tool for predicting the number of yachts anchored in Göcek Bays when the number of boats increases in the future.

As the first step of the present study, the mathematical model to find the preferences of boaters among the alternative bays was determined. As a result of the literature research on choice models, the Multinomial Logit Model was chosen as the mathematical model for the simulation. As the next step, the flowchart of the computer program was formed, and the questions that the simulation model is required to answer were determined. Depending on these models developed, the data needed was determined.

In order to get the input data needed for the model, the yachting activities in Göcek Bays was studied by field surveys carried during the summers of 2000 and 2001. In these studies, the holiday activities of the boaters, the factors that affect the boaters in choosing an anchor site and their view on a future management plan for the area were investigated. A total of 430 questionnaires (given in Appendix A) were applied to the boaters.

There are four groups of questions in the questionnaires. The first group involves questions about the demographic data (type of boat, age, nationality, sex, occupation etc.) of the boaters. The second group is about the months preferred by the boaters for their holiday, the information that they have about the Göcek Bays and the frequency of their cruising holidays. The third group includes questions about the holiday activities of the boaters, the qualities of the bays that affect their choice for anchoring, and the factors that contribute to their decision in choosing the next bay to anchor. The last group of questions examines the preferences of the boaters for several measures that could be incorporated in a future management plan for the area.

In addition to the questionnaire study, the number of the yachts anchored in the bays was also noted. Additionally, the boaters were asked to give their opinion about the physical characteristics of the bays.

In order to find the input distributions for the simulation model, the field data was statistically analyzed. The boaters were divided into different groups, and the input probability distributions were obtained. In Chapter 3, the results of the statistical analysis of the field data are given. Using these distributions, the computer program developed for the simulation of yacht movements is tested under a variety of hypothetical cases and is applied to Göcek Bays as a real life application.

The mathematical model used for the prediction of the boaters' choices, and the computer model developed for simulating the boats' movements are presented in Chapter 4. Additionally, the results of runs for a number of hypothetical cases and application of the computer program to Göcek Area are discussed. Chapter 5 provides the findings of the study. Recommendations for future studies are also given in this final chapter.

CHAPTER 2

REVIEW OF THE RELEVANT LITERATURE

In this chapter, the theories of individual choice behavior and some of the statistical tools used in data analysis, and clustering techniques are presented. Applications of the MNL model in coastal management and transportation travel demand are also given in this chapter.

2.1 Theories of Individual Choice Behavior

Choice models have received a great deal of attention in marketing literature. The steps of decision-making process of an individual can be summarized as the definition of the problem, identification of the alternatives, evaluation of the attributes of the alternatives, making the choice and implementation of the choice. Ben-Akiva and Lerman (1985) states that “the theory of behavior is descriptive -it defines how human beings behave not prescribes how they ought to behave there; abstract – it can be formalized in terms that are not specific to particular circumstances, and operational – it results in models with measurable parameters and variables”. They also emphasize that there is not a single, universally accepted choice theory that satisfies the above requirements.

Manrai (1995) has made an extensive study on mathematical models of brand choice behavior. The following overview is based on his discussion of the subject.

Categories of choice models are classified as:

i) Multi-attribute choice models

ii) Preference and choice mapping models

iii) Conjoint analysis

With these models, the underlying process by which an individual consumer integrates information to select a brand from a set of competing brands can be represented. Their difference comes from the underlying structure that drives them since they have been developed with varying assumptions and purposes. Among these models, multi-attribute choice models have been popular in marketing research for determination of market structure, demand forecasting, product positioning and buyer segmentation, and prediction of consumer choice.

Multi-attribute choice models can be classified in two ways based on two different principles, namely, i) the principle of utility maximization founded in economic theory, and ii) the psychological principle of feature – or "attribute based processing". The difference between the two approaches comes from the assumptions about the way consumers process information.

In the principle of utility maximization, it is assumed that a consumer uses all relevant available information and selects the brand that maximizes his/her utility. The consumer considers all the attributes in a simultaneous compensatory structure by assigning a utility value to each brand. Then the comparison is made and the brand with the highest total utility is selected. This process is also called the “brand-based processing”. An example for that approach is the independent multinomial logit (MNL) model.

On the other hand, the principle of attribute-based processing suggests that the selection is made through a simplified heuristic and consumer may not use all the relevant information at the time of choice, and makes his/her choice by comparing brands on attribute-by-attribute basis. A prime example of these models is Elimination-By-Aspects model.

In marketing, the brand choice models usually assume that the consumers have the needed knowledge about the brand characteristics and thus make their decisions in a deterministic framework. However when there are new innovative brands in the market place, this assumption may not hold true. Under these conditions, a probabilistic framework, in which the consumer may assign probabilities to various possible values of characteristics of brands, may be used. The expected utility is maximized in this approach.

2.1.1 Choice models driven by the economic principle of utility maximization

In this class, brand choice behavior models are also called "brand-based processing" models. Here, the common assumption is that a brand is a bundle of multiple attributes relevant to the choice process. The utility function is mostly a linear compensatory model of attributes of the brand and consumers have no uncertainty regarding various characteristics of brands in the selection process. The competing brands are represented in terms of one or more perceptual attribute dimensions believed to be relevant to the choice process. Attribute weights at the individual or aggregate level are derived by using scaled preference or choice data. Utility values for various competing brands are calculated by combining the derived attribute weights and attribute values for those brands. These utilities are transformed to choice probabilities through several choice models. These models can be classified as models with independence from irrelevant alternative (IIA) property or with the ones with non-IIA property.

2.1.1.1 Independent random utility models of brand choice behavior

In the multi-attribute utility approach, the competing brands are assumed to be in a multidimensional space, with the axes related to the attributes of those brands. Economists use a space spanned by physical attributes whereas marketers use a perceptual space of reduced dimensionality.

The space spanned by perceptual attributes is defined as follows: Let S={1, 2, ..., N} be a set of competing brands, with brand i having coordinates $X_i=(x_{i1}, x_{i2}, ..., x_{iK})$ in the K-dimensional perceptual attributes space. Utility V_i is defined as a weighted additive function of attribute levels according to a linear compensatory preference model.

$$V_i= \beta_1 x_{i1} + \beta_2 x_{i2} + ... + \beta_K x_{iK} \tag{1}$$

where $\beta' = (\beta_1, \beta_2, ..., \beta_K)$ is a vector of attribute importance weights. V's are utilities summarizing the attractiveness of competing brands. Independent Multinomial Logit Model (MNL) uses the compensatory model like the one given in (1), with an additively separable linear form to introduce the error term. The model assumes that

$U_i = V_i + \in_i$ and $V_i = \beta' X_i$ (2)

The above model assumes that a consumer selects a brand with highest utility and the errors $\in_i$ are independently distributed with the type I extreme value distributions or the Weibull distribution. Under these assumptions the probability of choosing brand i from the set S is:

$P(i / S) = \text{Prob} (U_i \geq U_j, j \in S \text{ and } j \neq i)$ (3)

for $P(\in_i \leq \in) = \exp(- \exp(\in))$; it can be shown that

$$P(i/S) = \frac{e^{V_i}}{\sum_j e^{V_i}} = \frac{e^{\beta \cdot X_i}}{\sum_j e^{\beta \cdot X_i}}, j \in S \qquad (4)$$

This model has many diverse applications in the marketing field since it is simple and easy to estimate. Additionally, the preference scale values of a brand depends only on the attributes of that brand not on the competing brands. It can be seen that independence from irrelevant alternatives, the IIA axiom holds, i.e., P{i/S}/P{j/S} is a constant for all choice sets S such that i, j $\in$ S. The main advantage of the IIA axiom is that samples of brands from a large set of competing brands can be analyzed. The main disadvantage of that axiom is that models with IIA property ignore the effect of similarities among competing brands on the probability of choice.

2.1.1.2 Non-IIA models of brand choice

The main purpose of the non-IIA models is to overcome the problems due to the IIA property of the MNL model. This purpose has often been achieved by computational complexity. Typically, the assumption of independence among errors of the MNL model is replaced in non-IIA models and a more general pattern of correlations in the error structure is allowed.

Extensions of the MNL model to non-IIA models

a) DOGIT Model: DOGIT model is one of the first attempts to extend the MNL model. This model is called DOGIT since it is a generalized logit model that "dodges" the IIA assumption. To capture similarity between pairs of brands, this model employs an additional parameter. DOGIT model was partially successful because the added parameter is not modeled as a direct function of the similarity of the brand attributes and it is computationally complex.

b) The generalized extreme value (GEV) model

The GEV gains brand interdependence by assuming hierarchical relationships, which imply more substitution among some pairs of brands than others. It is assumed that a consumer partitions the set of competing brands into r subsets represented by S_s, s=1, 2, ..., r of similar brands so that IIA property of the MNL model holds within these sets but not between them.

c) Nested multinomial logit (NMNL) model

The NMNL model assumes that the decision process has a hierarchical or tree structure so it may also be classified as an attribute-based processing model. The hierarchical transition probabilities are assigned to be MNL with scales and they capture the inclusive values of the branches under each node of the decision tree.

d) Multinomial probit model

The multinomial probit model (MNP) is an alternative to the extensions of the logit type models, which are discussed above. To overcome the problems caused by the IIA property of the MNL model, the MNP model works with a general or factor analytic covariance structure by focusing on the covariance between random utilities arising out of variation of the preference factor or due to a distribution on consumers' ideal points. However these models become computationally complex for choice sets larger than 3 or 4 brands since computations involve multiple integrals.

The generalized multinomial probit model (GMNP) introduces independence by estimating the covariance among random utilities for competing brands based on the most general specification of $\Sigma_{\in}$ which allows for negative exponential, extreme value, independent probit, and hybrid model as special cases.

e) Generalized logit models

Generalized logit models are non-IIA models. GLM assumes that the utilities U_1, ..., U_N for S={1, 2, ..., N} brands are independent across brands conditional on a consumer type "c", and the distribution of the utilities depends on the brands by powers $w_1(c)$, ..., $w_N(c)$ of a fixed unidimensional distribution function F. F can be any suitable form of a unidimensional distribution function.

f) Multiplicative competitive interaction (or attraction) model

Multiplicative competitive interaction (MCI) or "Attraction model" has the mathematical structure given below:

$$MS_i = \frac{A_i}{\sum_{j-1}^{N} A_j} \quad , \tag{5}$$

$$A_j = \prod_{k=1}^{K} f_k (X_{ki})^{\beta_k} \tag{6}$$

where MS_i is the market share of the brand i; A_i is the attraction of brand i; N is the number of brands; K is the number of attributes; X_{ki} is the value of kth attribute for brand i; f_k is a monotone transformation function on X_{ki} and β_k are parameters to be estimated.

Usually random utility models are estimated by maximum likelihood estimation (MLE) procedures requiring nonlinear search. For the direct variants of the MNL model it is not a problem typically. Since there is a high degree of nonlinearity involved in the MNP, GMNP, GEV, and NMNL, they are known to present numerical analysis problems of convergence and high computation time.

2.1.2 Brand choice models driven by the psychological principle of attribute-based sequential elimination

"Attribute-based processing" models commonly assume that brands are collections of measurable attributes and a consumer selectively and sequentially uses information relating to attributes of brands to eliminate brands from the choice set until only one brand remains in the set.

2.1.2.1 Eliminaton-By-Aspects (EBA) model of brand choice

EBA model is a probabilistic model of choice and is based on covert elimination process. In EBA an aspect or feature is selected with a probability proportional to its utility or weight at each stage of the choice process. The brand that do not include the selected aspect is eliminated from the choice set and this process continues until all brands but one are eliminated.

EBA has not been widely used in marketing for consumer choice modeling since it is found to be less suitable for its requirement of estimation of large number of parameters.

2.1.2.2 EBA-like models of brand choice

a) PRETREE model of brand choice

In generic term preference tree or PRETREE models a consumer selects a branch from the tree with probability proportional to its length and eliminates all brands that do not include that branch. This process is applied until only one brand remains.

b) Elimination-by-cutoffs model of brand choice

The elimination-by-cutoffs (EBC) model has been developed as an extension of EBA model in a continuous multi-attribute space. This model uses ratings on multiple perceptual attributes derived from the location of competing brands in a perceptual map and yields choice probabilities in the EBA framework.

2.1.3 Two-stage brand choice models

The principle of attribute-based sequential elimination (generally employed in stage 1) and the principle of utility maximization (generally employed in stage 2) are combined in the two-stage models.

2.2 The Concept of "utility"

The utility function is defined as: "The concept of a numerical measure to describe the value of alternative choices has come to be referred to as utility theory, with the utility function being the numerical measure itself."(Watson andBuede, 1987). In other words utility is simply the index of attractiveness of an alternative.

The utility can be measured in any units, and depending on the attributes it can either take positive or negative values.

Hypothesis of choice-independent utilities states that the utility function U_m over the attributes of a set of choices is independent of the specific choices being compared. In this hypothesis it is assumed that all the aspects of each choice that may be influencing a consumer's decision in a utility function, whose parameters are independent of the choices, are included (e.g. $U_m=\alpha t_m + \beta c_m$ for each mode).

Hypothesis of choice-independent utilities is often not completely realistic. This hypothesis may be invalid if the attributes that the consumer considers important are ignored; the attributes are not measured in the same way the consumer measures or the knowledge of the weights the consumer places on the attributes is imperfect.

In order to accurately predict the consumer's behavior, in the utility function one or more elements that are specific to a particular choice and that reflect the attributes of the choice which are omitted or measured imperfectly, must be incorporated. These are called choice-specific attributes where the utility function might look like as follows (Manheim, 1979):

$$U_m = \beta_m + \sum_i \alpha_{mi} X_{mi} \tag{7}$$

2.3 Applications of Choice Models

Choice models have received a great deal of attention in marketing literature. Harlam and Lodish (1987), in their study for modeling consumer choices of multiple items, introduced the variety seeking concepts into choice for purchase models, which focus on circumstances in which consumers purchase some quantity of a single item in a product category on each shopping. They defined the utility of an item as being equal to the sum of the utilities offered by the factors/characteristics of item that describe the relationships among purchase within and across shopping trips with a particular set of items available on the shelf. They used a compensatory vector model can be used to represent utility:

$$U_{h,i,o} = ISC_{h,i} + \sum_{f=1}^{F} v_{h,f,i,o} + E_{i,o} \tag{8}$$

where;

h: household, where h=(1,….,H). H is equal to the total number of households.

i: items, where i = (1,….,j,….I). I is equal to the number of different choice alternatives or stock keeping units (SKU) in the product category.

o: purchase opportunities, where o=(1,…,q,…O). The total number of purchase opportunities,O, is equal to the number of purchases.

f: factors or characteristics of items where f=(1,…,F). F is equal to the total number of factors in category.

$U_{h,i,o}$= the utility for household h of item I on purchase opportunity o.

$ISC_{h,i}$= the item specific constant utility provided by item i.

$v_{h,f,i,o}$= the utility for household h provided by factor for item i on purchase opportunity o.

$E_{i,o}$ = the utility provided by store marketing mix environment for item i during purchase opportunity.

To find the conditional probability that h chooses item i on purchase opportunity o, they used the Multinomial Logit Model:

$$p_{h,i,o} = \frac{e^{U_{h,i,o}}}{\sum_{j \in K_{h,o}} e^{U_{h,j,o}}} \qquad (9)$$

where, $K_{h,o}$=set of items available to household h for purchase during item purchase opportunity o.

In another study, Fader and Hardie (1996) described the direct benefits of modeling consumer choice among SKUs (stock keeping units) by demonstrating a powerful yet parsimonious modeling approach that enables a researcher to include all of the distinguishing attributes that characterize a particular product category's set of SKU's. They used the standard approach to modeling product choice with scanner data, the multinomial logit model (MNL), which has the following structure:

$$P_i = \frac{e^{v_i}}{\sum_i e^{v_i}} \tag{10}$$

where ignoring household and time indices, p_i is the probability of choosing item i and v_i is called the deterministic component of item i's utility. The v_i are viewed as having two components: (1) a preference component, $v_{pref}(i)$, which represent the household's base preference toward item i, and (2) a marketing mix component $v_{mm}(i)$ which represents the effects of marketing variables (e.g. price, presence or type of promotion) on the household's choice behavior.

The choice models have many applications in travel demand. The early applications of these models have been made for the binary choice of travel mode. While some of these studies have focused on the estimation of a "value of time", the trade off between travel time and travel cost implied by a travel demand model, the others put emphasize on the development of policy-sensitive models for predictions of the market shares of alternative modes.

As the discrete choice modeling methods improved, transportation applications progressed further. The choice of mode for travel has been applied for more than two alternatives and has been investigated by many researchers. In those studies, different types of data from widely different areas have been used, more comprehensive model specifications with socioeconomic variables have been developed and the forecasting accuracy of the models have been tested with data from before and after changes in transportation system (Ben-Akiva and Lerman, 1985).

In coastal management, Lipton and Hicks (1999), estimated a multinomial logit discrete choice model to examine the factors that determine the boater's preference of State among all of the States of U.S.A. for principal use by using the data collected from a survey of documented boat owners. The utility of a boater gets is defined as follows:

$$v_{ij} = \alpha q_{ij} + \beta z_j + e_{ij} \tag{11}$$

where v_{ij} is the utility individual i gets from principally using their boat in state j, q_{ij} are the characteristics of state j that are specific to individual i, z_j are the attributes of state j that matter to boaters, α and β are the vectors of parameters to be estimated, and e_{ij} is the stochastic term representing the factors that are unobserved by the researcher.

With some statistical assumptions, the probability of boater i choosing to register in state j is calculated and given as follows:

$$P_{ij} = \frac{\exp\left[\alpha q_{ij} + \beta z_j\right]}{\sum_j \exp\left[\alpha q_{ij} + \beta_j\right]} \tag{12}$$

The model is designed to test only one of the many impacts that is lowering the excise tax or providing for a trade-in allowance would have on the Maryland boating economy. The number of documented boaters which would be enticed to declare Maryland as their state of principal use as a result of reduced taxes is the impact examined. As for future studies, the authors suggest additional research on understanding the factors that constitute the boaters' perception of quality.

2.4 Statistical Tools used in Data Analysis

In any kind of research that involves data collection by surveys, the first step is data preparation, which involves logging the data in and checking it for accuracy, entering the data into the computer, transforming the data, and developing and documenting a database structure that integrates various structures. The most common statistical techniques used in data analysis are factor analysis, correspondence analysis and conjoint analysis.

The next step is data analysis, which involves describing the data (descriptive statistics) and testing hypothesis and models (inferential statistics).

Descriptive statistics describe what the data shows. They provide simple summaries about the sample and the measures, and form the basis of virtually every quantitative analysis of the data with simple graphics analysis.

Inferential statistics are used to reach conclusions from the data to more general conditions by investigating questions, models and hypothesis. Most of the tools used in the inferential statistics come from a general family of statistical models known as General Linear Model, which includes the t-test, Analysis of Variance (ANOVA), Analysis of Covariance (ANCOVA), regression analysis, and most of the multivariate methods such as factor analysis, multidimensional scaling, cluster analysis, discriminant function analysis and so on. Among these analysis techniques, cluster analysis is the tool that will be used in the grouping of the data collected.

2.4.1 Hypothesis testing

When a hypothesis is tested for a specific research question using the data collected, the first step is to state the null hypothesis (H_0), which is defined as the hypothesis of "no effect" and is usually formulated for the express purpose of being rejected. If the null hypothesis is rejected, then the alternative hypothesis, the operational statement of the experimenter's research hypothesis, (H_1), is supported. After stating the null and alternative hypothesis, the next step is to choose the appropriate statistical test and specify a level of significance (α). The test procedure can be summarized as H_0 is rejected in favor of H_1 if a statistical test yields a value whose associated probability of occurrence under H_0 is equal to or less than α. Common values of α are 0.05 and 0.01 (Siegel and Castellan, 1988).

There may be two kinds of errors in hypothesis testing, Type I and Type II errors. Type I error is rejecting the hypothesis H_0 when it is, in fact, true. Type II error is failing to reject the null hypothesis H_0 when in fact, it is false. The significance level α indicates the probability of committing a Type I error. The larger α, the more likely it is that a Type I error will be committed. The probability of committing a Type II error is given by β. In order to calculate β, there must be a specific alternate hypothesis (Montgomery and Runger, 1999).

When a hypothesis is to be constructed, the null hypothesis is always stated as an equality so that the probability of Type I error α can be controlled at a specific value. Depending on the conclusion to be drawn if H_0 is rejected, the alternate hypothesis can be either one-sided or two-sided. If an objective is to be made with claims involving statements such as “greater than”, “less than”, “superior to”, “exceeds”, “at least”, and so forth, then a one-sided alternate is appropriate. If there is no direction to be made by the claim, or if the claim “not equal to” is to be made, then a two-sided alternate should be used.

2.4.2 Cluster analysis

Cluster analysis, also known as segmentation analysis or taxonomy analysis, is the name given to a group of different classification algorithms that seek to identify homogenous subgroups of cases in a population. Basically, to form groups from a certain set of data, cluster analysis “identifies groups of respondents in a manner that minimizes differences between members of each group while maximizing differences between members of a group and those in all other groups”. (http://www.dssresearch.com/library/segment/understanding.asp).

Types of cluster analysis are given below:

1) Joining (Tree clustering): The purpose of this type of clustering is to join objects into successively larger clusters, using some measure of similarity or distance. Hierarchical tree is a typical measure of this type of clustering.

2) Two-way joining: This type of clustering groups the data using both objects and cases (observations) or variables. Though two-way joining is the least commonly used cluster method, some

researchers believe that it offers a powerful exploratory data analysis tool.

3) K-means clustering: This method is different from the other two types discussed above. K-means produces k-different clusters of greatest possible distinction. In forming clusters, the procedure starts with k random clusters and the move objects between those clusters by aiming to minimize variability within clusters and to maximize variability between clusters. Computationally this is a reverse analysis of variance (ANOVA) which "evaluates the between group variability against the within group variability when computing the significance test for the hypothesis that the means in the groups are different from each other. In k-means procedure objects are tried to be moved in and out of groups (clusters) to get the most significant ANOVA result" (http://www.statsoftinc.com/textbook/stcluan.html).

4) EM (Expectation Maximization) Clustering: This method computes probabilities of cluster memberships based on one or more probability distributions instead of maximizing means. The goal is, given the clusters, to maximize the overall probability or likelihood of the data. So each observation belongs to each cluster with a certain probability. EM clustering can be applied to both continuous and categorical variables.

CHAPTER 3

STATISTICAL ANALYSIS OF THE FIELD DATA

3.1 Field Study

In order to obtain the input data of the simulation program, field studies were carried out among Göcek Bays. For that purpose, a questionnaire was designed to evaluate the demographic data and preferred holiday activities of the boaters, the factors that affect the boaters in choosing the anchor sites and their view on a management plan that may be created for the area. A total of 200 questionnaires were applied in the summer of 2000, and a total of 230 questionnaires were applied in the summer of 2001 using an updated version of the questionnaire used in 2000. The area of study is given in Figure 3.1.

There are four groups of questions in the questionnaires. The first group involves questions about the demographic data (type of boat, age, nationality, sex, occupation etc.) of the boaters. The second group is about the months preferred by the boaters for their holiday, the information they have about the Göcek Bays and how often they go for cruising holiday. The third group involves questions about the holiday activities of the boaters, the qualities of the bays they prefer for anchoring and the factors that affect their decision in choosing the next bay to anchor. The last group of questions evaluates the response of the boaters for a future management plan for the Göcek Bays and the measures that the boaters prefer to be included in that plan.

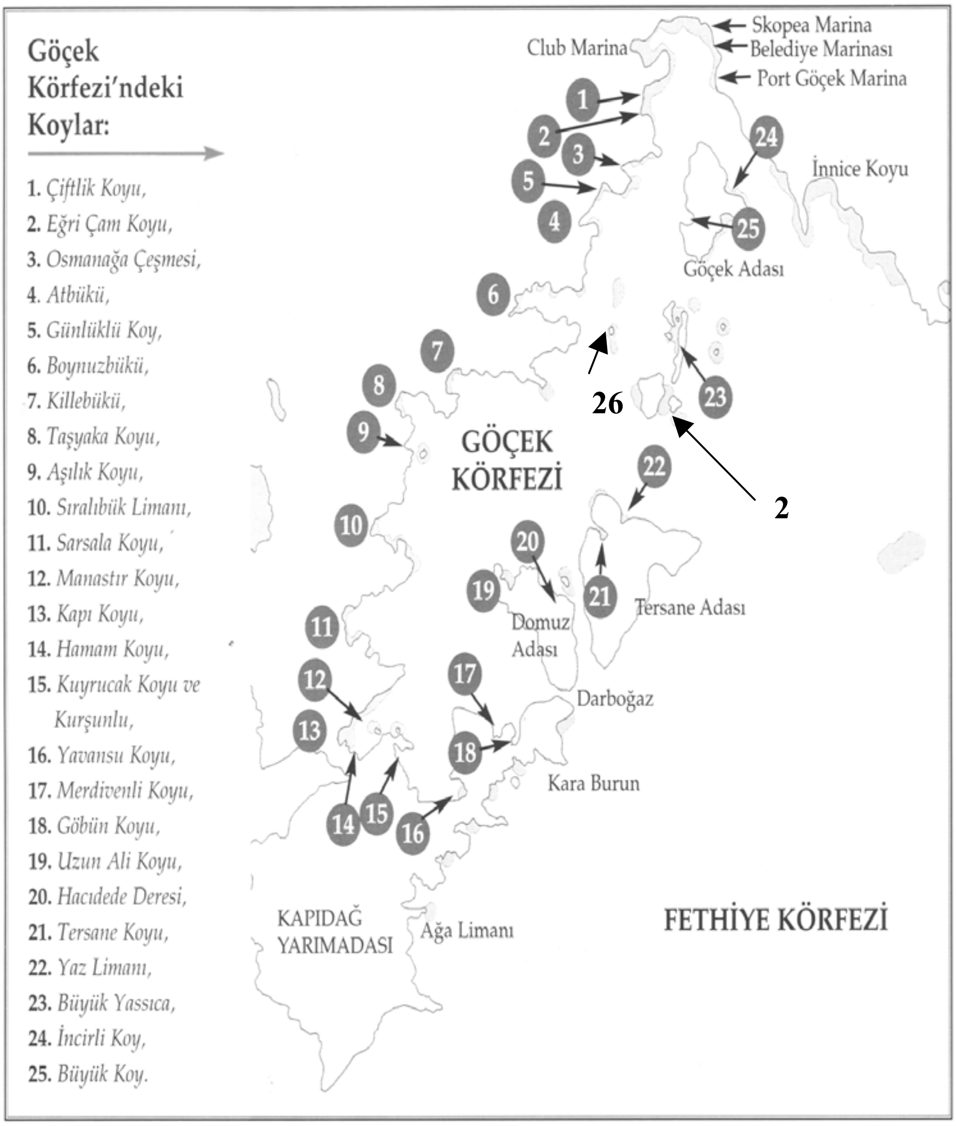

Figure 3.1 Site Map for Göcek Bays (Boro, 2000)

3.2 Grouping of Boaters with Similar Preferences

One of the important expected outcomes of the field survey is dividing the boaters into meaningful groups according to the importance they give in the attributes of a bay. As stated in Chapter II, there are a number of clustering techniques available for grouping data. However before going through the cluster analysis, some statistical analysis and tests are applied to the demographic data to search whether the boaters can be categorized according to the demographic variables or not. For this purpose, the data collected during the summers of 2000 and 2001 are coded and entered into SPSS software for the analysis. The question used for the analysis is stated as "indicate the importance of qualities of a bay as listed below in deciding the next anchorage location (day time)". The qualities (or attributes) of a bay are aesthetic quality, cultural remains, anchorage capacity, restaurants, water sports activities, tranquility and wind shelter, lack of water pollution, lack of litter, lack of crowd and lack of noise. Then data of the both surveys are combined (a total of 430 cases), and attributes of a bay, which are common in the two years, are used in all of the analysis discussed below.

3.2.1 Correlation between the demographic variables and the bay attributes

The first statistical analysis used to search the relation between the demographic variables and the bay attributes is finding the correlation between these two groups of data. The "Bivariate Correlations" procedure, which computes Pearson's correlation coefficient, Spearman's rho and Kendall's tau-b with their significance levels, is applied to the data using the SPSS software. The correlations obtained from this analysis show how variables or rank orders are related. Since ordinal and nominal data is compared in the analysis, Spearman's correlation coefficient, which is a measure of association between rank orders, is selected in the calculations.

The correlation coefficients are given in Table 3.1. The discussion on these coefficients depends on the fact that positive and higher values show a positive correlation, whereas negative and smaller ones show a negative correlation. As it is seen from Table 3.1, the correlation values do not show a direct dependence between the variables tested. So it can be stated that it may not be possible to group the boaters according to demographic variables. The second tool used is hypothesis testing, and is given in Section 3.2.2.

Table 3.1 Correlation coefficients of demographic variables and bay attributes

	Ownership	Gender	Age	Nationality	Education	Occupation
Aesthetic quality	-.126	.062	.016	-.021	.055	-.041
Cultural remains	-.038	.055	.067	.026	.032	.053
Anchorage capacity	-.105	-.005	.141	-.005	-.054	-.031
Restaurants	.126	.014	.061	.021	-.079	.053
Water sports activities	.170	-.026	-.147	-.143	-.050	.059
Tranquility and wind shelter	-.096	-.039	.116	.029	.091	-.043
Lack of water pollution	-.040	.078	.030	-.060	.075	-.021
Lack of litter	-.090	.102	.041	-.068	.041	-.020
Lack of crowd	.040	-.021	.013	-.029	.075	-.031
Lack of noise	.004	-.063	.068	-.064	.135	-.103

3.2.2 Hypothesis testing

In this section, the hypothesis tested is whether the importance of attributes of bays differs according to demographic data. The statistical test selected is the chi-square test which is a nonparametric test used to assess the significance of differences among k independent groups, when the data consists of frequencies in discrete categories (either nominal or categorical or sometimes ordinal).

The null hypothesis tested is as follows:

H_0: The importance of attributes of a bay in choosing the next anchoring location is independent of demographic data, which are ownership of the boat, gender, age, nationality, education and occupation.

The alternate hypothesis is as follows:

H_1: The importance of attributes of a bay in choosing the next anchoring location is not independent of demographic data, which are ownership of the boat, gender, age, nationality, education and occupation.

Significance level of $\alpha = 0.05$ is selected. Since the H_1 does not specify a direction of difference, a two-tailed test is used. So H_0 will be rejected if $\alpha_0<\alpha/2$, and it will be concluded that the importance of attributes of a bay in choosing the next anchoring location is not independent of demographic data which are ownership of the boat, gender, age, nationality, education and occupation.

The results of the chi-square test are given in Table 3.2. The shaded cells show the rejected hypothesis. As it is seen from Table 3.2, the importance of aesthetic quality changes with respect to the nationality of the boaters. In other words, the ratings of aesthetic quality can be grouped according to nationality only. The same argument can be done for other shaded areas. For some of the results it may also be discussed that there may be Type I or Type II errors there. However, the important result of the test is that the demographic data is not sufficient enough to make significant groups. Consequently, cluster analysis techniques will be used to group the boaters.

Table 3.2 Chi-square test results

	Ownership	Gender	Age	Nationality	Education	Occupation
Aesthetic quality	0.069	0.920	0.310	0.023	0.470	0.967
Cultural remains	0.789	0.051	0.183	0.275	0.796	0.960
Anchorage capacity		0.275	0.498	0.216	0.223	0.082
Restaurants	0.041	0.017	0.574	0.067	0.590	0.083
Water sports activities	0.002	0.163	0.117	0.044	0.517	0.055
Tranquility and wind shelter	0.032	0.931	0.249	0.18	0.285	0.178
Lack of water pollution	0.022	0.576	0.066	0.000	0.901	0.974
Lack of litter	0.117	0.333	0.536	0.000	0.885	0.762
Lack of crowd	0.042	0.785	0.024	0.119	0.100	0.969
Lack of noise	0.153	0.816	0.907	0.054	0.001	0.565

3.2.3 Cluster analysis

In order categorize the boaters according to their preferences, a cluster analysis software, Clustan Graphics Primer (Wishart, 2003), is used. This program offers a number of cluster analysis tools to the user. These are hierarchical cluster analysis, k-means and focal point clustering.

As it was stated in the previous section, the question used for the cluster analysis is given as: "indicate the importance of qualities of a bay as listed below in deciding the next anchorage location (daytime)". The qualities (or attributes) of a bay are aesthetic quality, cultural remains, anchorage capacity, restaurants, water sports activities, tranquility and wind shelter, lack of water pollution, lack of litter, lack of crowd and lack of noise.

The method followed in clustering the boater data is as follows. Firstly, an excel file, which involves all the data needed for the classification, is formed as an input file to the software. Secondly, after this file is read by the software, the clustering method is selected. The clustering method selected is "Increase in Sum of Squares (also know as the Ward's Method)", which is an effective method if one is interested in finding clusters that are relatively homogeneous with respect to all of the variables. The hierarchical tree obtained after this analysis is given in Figure 3.2.

The most frequent question asked after obtaining this tree is the best number of clusters in the data. In order to find the best number of clusters in the data, the tree validation procedure was used. The approach in this validation procedure is to expect to find structure in data and to search partitions that manifest the greatest departure from randomness. In order words, this procedure tests the null hypothesis that the structure displayed by a partition of a given tree is random, and seeks to reject the hypothesis. To do this, using the randomized data, the program randomizes the input data, compute a proximity matrix, which is a matrix containing similarities or dissimilarities of a set of data and hence obtain a tree. Having obtained a randomized variant of the data, this procedure is repeated for a series of random trials. Each trial gives a different tree for the given data, in random order, and the series of trials provides a mean tree and confidence interval. Then, looking for a significant departure from random, the given tree is compared with the randomized trees. Here, the null hypothesis that the given data are random and contain no structure is tested.

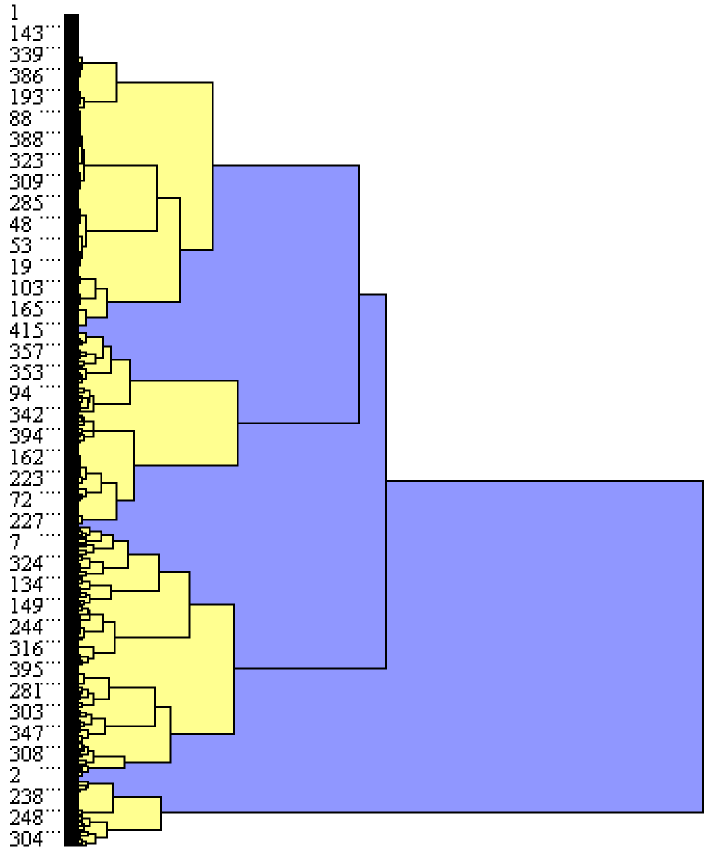

Figure 3.2 The hierarchical tree after Ward's method

In Figure 3.3, the resulting graphic of the validation procedure is given. In this figure, the blue solid at the bottom of the graph shows the fusion values corresponding to the actual data. The yellow band shows the range of fusion values obtained from 120 trials of randomizing the data; in this confidence interval, the central line represents the mean of the fusion values for each number of clusters obtained from the random trials. The red zones show where the fusion values for the given data depart significantly from random. The most significant departure from randomness is the best number of clusters. In our case, the best number of clusters is found to be as 4, and the hierarchical tree given in Figure 3.2 is the tree partition corresponding to this number.

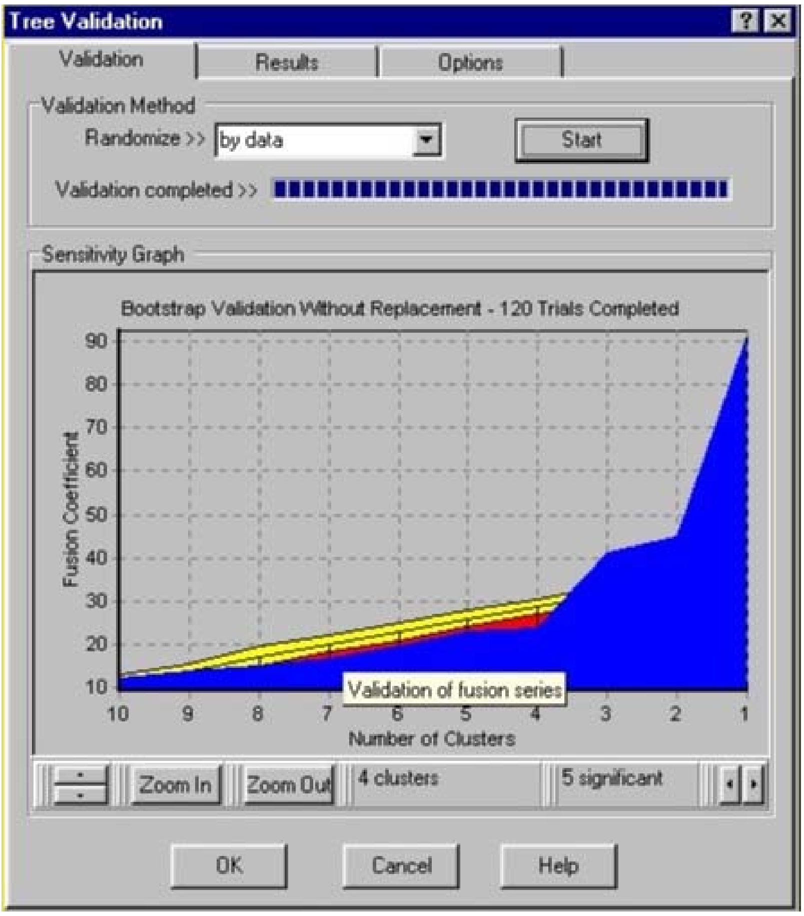

Figure 3.3 The resulting graph of the validation procedure

After finding the best number of clusters of the data, k-means analysis is used to calibrate the cluster model. K-means analysis calibrates the model by removing the outliers, tightening the cluster centers and refining the cluster membership by relocating any mis-classified cases. This analysis is done at 4 cluster level using tree partitions as initial cluster centers and by removing outliers at distances greater than 1.8. After outlier analysis, 21 outliers (5 % of the cases which have an acceptable level) was deleted. The cluster centers of the data are given in Table 3.3. In addition to that table, a graphical representation of the centers is given in Figure 3.4.

Table 3.3 The cluster centers of clusters (boater groups)

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Aesthetic quality	4.23	4.51	4.67	4.52
Cultural remains	2.86	3.37	3.22	3.07
Anchorage capacity	3.60	4.20	3.83	4.10
Restaurants	2.16	3.17	1.47	3.89
Water sports activities	1.93	3.97	1.15	1.48
Tranquility	3.84	4.49	4.55	4.69
Lack of water pollution	4.69	4.87	4.94	4.82
Lack of litter	4.40	4.86	4.94	4.77
Lack of crowd	3.24	4.58	4.90	4.52
Lack of noise	3.51	4.55	4.93	4.70

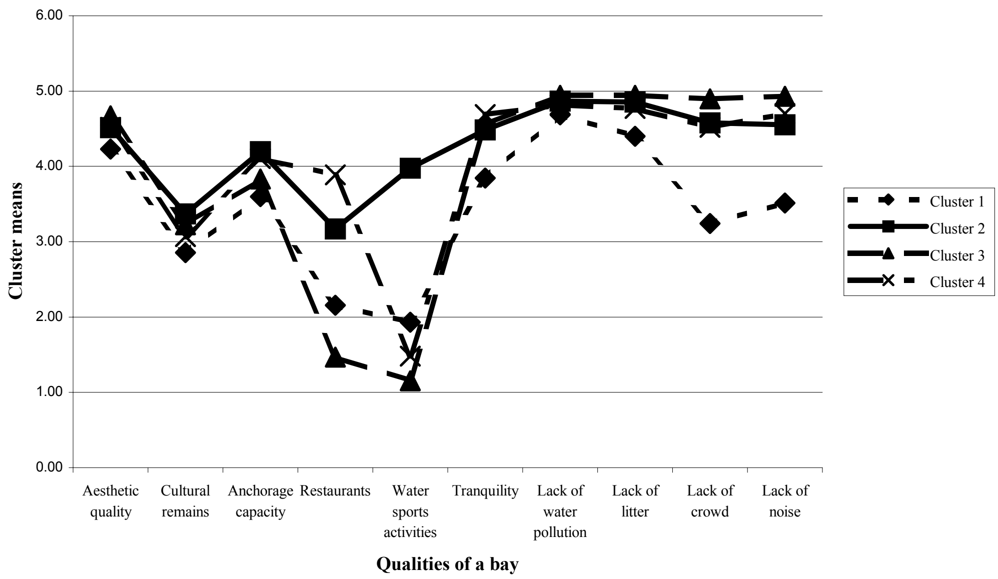

Figure 3.4 The graphical representation of the cluster means

3.3 Evaluation of the Utilities

The utility values assigned to each bay, by each boater category is the input data, which is be used in the equation of MNL model. This value is obtained by the following equation:

$$u_{x,z} = \sum_{i=1}^{n} w_{x,i} s_{z,i} \qquad 3.1$$

where i=1,…,n is the index of bay attributes, $w_{x,i}$ is the utility weight assigned to attribute i by boater category x, and $s_{z,i}$ is the score of bay z on attribute i.

The resulting average scores for the attributes of the bays are calculated are given in Table 3.5. The resulting utility values are obtained by using Table 3.3 and Table 3.5, and are given in Table 3.4.

Table 3.4 Utility values of Göcek Bays

Boat Type	Bay 1	Bay 2	Bay 3	Bay 4	Bay 5	Bay 6	Bay 7	Bay 8	Bay 9	Bay 10	Bay 11	Bay 12	Bay 13
1	122	130	122	128	130	136	127	124	133	126	121	119	131
2	147	157	147	155	158	165	155	149	160	152	146	144	159
3	139	148	139	144	147	154	143	142	149	144	137	134	148
4	143	152	143	150	153	160	150	144	157	148	141	138	153

Table 3.5 The resulting attribute scores of the bays

		Attributes of the Bay									
Bay number	*Name of the bay*	Aesthetic quality	Cultural remains	Anchorage capacity	Restaurants	Water sports activities	Tranquility and wind shelter	Lack of water pollution	Lack of litter	Lack of crowd	Lack of noise
1	Atbükü	4.6	2.6	3.8	2.4	2.4	4.0	3.2	3.6	3.8	3.6
2	Boynuzbükü	4.5	2.1	4.2	2.4	2.4	4.1	4.1	4.2	4.0	3.8
3	Bedri Rahmi Bay	4.2	3.1	4.0	2.5	2.3	3.5	3.8	4.0	3.3	3.4
4	Sarsala Bay	4.1	2.1	4.0	3.5	2.5	3.9	4.3	4.1	3.6	3.6
5	Manastır Bay	4.3	3.0	4.2	3.7	2.5	3.5	4.2	4.2	3.4	3.7
6	Hamam Bay	4.6	3.5	3.8	3.7	2.7	3.7	4.4	4.4	3.6	4.0
7	Kuyrucak/Kursunlu Bay	4.3	2.8	3.9	3.5	2.8	4.0	3.8	3.5	3.8	3.6
8	Yavansu Bay	3.8	2.8	3.9	1.8	2.4	3.8	4.3	3.6	4.0	3.8
9	Göbün Bay	4.3	2.6	4.2	4.0	2.5	4.4	4.2	4.2	3.3	3.6
10	Domuz Island	4.0	2.4	3.8	2.6	2.4	3.6	4.5	3.9	3.9	3.9
11	Tersane Bay	4.1	3.3	3.4	2.7	2.3	4.1	4.2	3.9	3.0	2.8
12	Yassıca Island	4.4	2.9	3.6	2.2	2.9	3.5	3.9	3.8	3.0	3.1
13	Göcek Island	4.3	2.7	3.8	2.8	3.1	4.1	4.1	4.1	3.8	3.9

CHAPTER 4

THE MODEL AND ITS APPLICATIONS

In this chapter the mathematical model that is developed for simulating the boats' movements from one bay to the other is presented. The results of runs for a number of hypothetical cases, which were tested for verification of the computer program, are discussed. Finally, the application of the program to Göcek Bays is presented, and the results are discussed.

4.1 Model Development

Modeling can be defined as the act of mimicry (Mihram, 1972). Uncertainty Principle of Modeling implies that any conscientious mimicry, or model, of a system of interdependent and interacting elements will probably require inclusion of random phenomena within the model's structure. These random effects present in the system that is being modeled are also needed to be mimed. Most systems of interest develop their characteristic behavior over time, so that any proposed model of this behavior needs to be of dynamic (as opposed to static) class. Furthermore, the Uncertainty Principle of Modeling will usually impose upon the modeler the need to construct a model of the stochastic variety.

The initial stage of model development is the study of the system: its component parts, their interactive behavior, their interrelationships, and the aspects of the system requiring a probabilistic description. This stage is termed as system analysis. This stage is centered about organized, analytical procedures for studying a system before its formulation as a simulation model. A fundamental concept in the analysis of a system is the specification of a (closed) boundary for the system. The system's interactions occur within the boundary, giving the system its characteristic behavior. However, the concept of a closed boundary does not preclude external occurrences; it merely implies that outside influences do not provide the intrinsic behavior pattern of the system. The entities of the system (the symbolic representations of the objects, or elements of the system), their attributes (the recorded characteristics of the entities) and their relationships (the connections existing among the entities) must be studied in this stage.

Once system analysis is completed, system synthesis, which is concerned with organizing diverse results, as ascertained in the system analysis stage, into a unified logical structure, begins. Flow charts, data array structures, and programming instructions constitute the essence of the system synthesis stage. This stage ends whenever the computer program, which describes the system and which therefore represents the symbolic model, is completed.

The third stage is the verification stage. Elementary aspects of model verification include the correction of syntax in the model's component statements, as well as the other activities, normally called debugging; yet, the more fundamental questions which must be answered in the verification stage relate to whether the model will produce the behavior anticipated of it. This stage is concerned with establishing the rectitude of the programmed, logical structure of the model.

The fourth stage, validation stage of model is undertaken, when possible, in order to establish the degree of compatibility between the model and the system it is miming. Model validation is concerned with the comparison of the model's responses with those of modeled system, whenever the conditions producing each are essentially the same; model verification, on the other hand, is directed toward establishing whether or not the logical structure of the model is compatible with its programmers intentions.

The fifth and final stage of model development is the use of verified and validated model in order to make inferences regarding the behavior and response of the modeled system. This is the model analysis or the analysis stage. During this stage the analyst is engrossed in experimentation with encounters of the model so as to ascertain either: (a) the static effects of the model's responses, or (b) the dynamic effects of the model's behavior (Mihram, 1972).

Once a mathematical model of a system is built and if it is simple enough, then an analytical solution may be obtained by working with its relationships and quantities. However in general many systems are highly complex. In this case the model must be studied by means of simulation, which can be defined as numerically exercising the model to see how the inputs in questions affect the output measures of performance. Simulation models can be classified as follows:

1. Static vs. Dynamic Simulation Models: In static simulation models time plays no role whereas dynamic simulation model is a representation of a system that evolves over time.
2. Deterministic vs. Stochastic Simulation Models: Deterministic models do not contain any random (probabilistic) components. Stochastic models contain random (probabilistic) models.
3. Continuous vs. Discrete Simulation Models: In discrete-event simulation the state variables change instantaneously at separate points in time whereas in continuous simulation concerns the state variables change continuously with respect to time. (Law and Kelton, 1991)

The initial step in simulation modeling is defining the problem exactly. Like other computer applications, a simulation model can only do what is designed to do therefore careful determination of the model design and level of detail represented in the model is critical. A good way is to make a list of questions that the model will answer. After determining the problem to be solved, the next step is to gain a thorough understanding of the system or the facility being simulated. Once an understanding of the system to be simulated is gained, planning of the simulation project starts. The goals and objectives of the project are set at this step. The goal as a modeler should be to limit the size and scope of the model to only what is required to address the project objectives and answer the key questions. Following these steps the basics for simulation modeling should be learned and it must be confirmed that simulation is the right tool to solve the problem. Determination of available data and data needed is the next step. After then assumption about the problem should be developed and outputs needed to solve the stated problem should be stated (Banks and Gibson, 1996).

4.2 The Mathematical Model

The mathematical model, which is used to find the boaters' choices among the bays, is introduced in the following paragraphs.

The utility that is supplied from bay z to a boater of category x, is defined as;

$$u_{x,z} = \sum_{i=1}^{n} w_{x,i} s_{z,i} \qquad 4.1$$

where i=1,…,n is the index of bay attributes, $w_{x,i}$ is the utility weight assigned to attribute i by boater category x, and $s_{z,i}$ is the score of bay z on attribute i.

Let K be the set of alternative bays that a boat can reach depending on its physical properties from its current anchorage position. Then, the probability of boater category x choosing bay z among other alternative bays is:

$$P_{x,z} = \frac{e^{u_{x,z}}}{\sum_{j \in K} e^{u_{x,j}}} \qquad 4.2$$

where $P_{x,z}$ is the probability of boater category x choosing bay z, $u_{x,z}$ is the utility of boater type x supplied from bay z, and $u_{x,j}$ is the utility of boater type x supplied from alternative bays.

The utility weights, $w_{x,i}$, assigned to attributes by boater categories and the score of bays on attributes, $s_{z,i}$, obtained from the analysis of bay evaluations were given in Chapter 3, Tables 3.3 and 3.4 respectively.

4.3 The Simulation Model

Prior to the description of the computer model, the information on the system of study, the system parameters and the system variables are given below.

The system of interest is the area (including bays, hinterland and sea route) in Göcek Bays. The entities in the system and their attributes are listed below. Here, it is important to note that the boat is the entity representing the decision-makers.

- Boat (or Yacht)

  1. Ownership
  2. Gender
  3. Age
  4. Nationality
  5. Education
  6. Occupation
  7. Type of holiday activities during yachting

- Bays

  1. Aesthetic quality
  2. Cultural value

3. Anchorage capacity
4. Facilities (organized recreational activities, restaurants)
5. Water sports activities
6. Tranquility
7. Water Pollution
8. Litter
9. Crowd
10. Noise

The attributes of the bays are the factors that make the bays attractive or unattractive. Consequently, the importance of these attributes according to different boater categories is the factor affecting the decisions in selecting the next anchorage location. The importance of these attributes is shown mathematically by the utility function. The equation of this function is given in Section 4.2. It is also shown in Section 4.2 that the probability of boater category x choosing bay z among other alternative bays is related to the utility of a boater category x supplied by the bay z.

The computer program, SIM-BOAT, designed for simulation of yacht traffic in Göcek Bays is written in Delphi 6.0, which is a Pascal based programming language. This program gives the total number of boats visiting each bay on a daily basis, the number of boats staying overnight in each bay and the distribution of boater categories among the bays throughout out the simulation time.

The system parameters of the program are the capacities of the bays, the average interarrival time, the average stay duration in a bay and the average cruise time of a boat, the utility values of all bays assigned by the boater categories and the distribution of the boater categories. Using these input parameters the arrival times of the boats in the system, stay durations in the bays selected, total cruise times, the cumulative probability distribution to find the bays to be anchored, and the boater categories of the boats are calculated by the program. Among the parameters listed above, the utility values and the quotas of the bays are the two important parameters that affect the resulting statistical distributions of the program. As it can be seen from Equation 4.2, as the utility value increases, the resulting selection probability of a certain bay increases exponentially. So it can be stated that a small change in the utility values will affect the distribution of the boats among the bays significantly. As for the quotas of the bays, it is clear that a significant change in the quota value of a bay will force the boats to move to the other bays, and thus it will also affect the resulting boat distributions significantly.

The SIM-BOAT runs as follows: At the start of the program the system is initialized, i.e. the system time, the number of boats in the system, and the statistical counters are set to zero. The arrival of the first boat to the system is scheduled and written in the even list. Then the program checks whether the stopping criterion is met or not. The stopping criterion is based on either time or the number of boats. If the reply is “NO” then the system time is increased and the next event is read. Depending on the type of event, the relevant subprogram is executed.

If the type of event is a new “arrival” process, then the type of boat, the cruise time and the bay to be visited is determined, and the anchoring time to the next bay is added to the event list. The arrival of the next boat is scheduled and written in the event list.

If the next event type is an “anchoring” at the bay selected, then the bay capacity and the system time of the boat are checked. If the bay capacity is available, then the boat anchors to that bay; its stay duration in that bay is calculated and the time of its departure (or leaving) from that bay is added to the event list. If the capacity of bay is full and the system time of the boat is not over, then next bay to be anchored is determined and added to the event list. If the system time of the boat is finished, then the boat is taken out of the system.

If the event type is “leaving” and if the system time of the boat is not over, then the boat leaves the current bay and the next bay to be anchored is added to the event list. If the cruise time is over, then the boat leaves the system. This loop continues until the stopping criterion is met.

The flowchart of the program, the detailed description of the main program and its subroutines are given in Appendix B.

The assumptions of the model are listed below:

- Interarrival times of the boats have the same probability distribution.
- Boats start and finish within the system.
- Boaters have all the information about the bays before they enter the system.
- Travel time between bays is constant for all boats.

- For the whole cruise period of a boat, a bay is visited only once.
- All of the bays are in the boaters' visiting list.
- A boat leaves the system either when its cruise time is over or its visiting list is empty, whichever comes first.
- Boats do not move between 08:00 P.M. and 08:00 A.M.

The input distributions of the program was also obtained from the field data. These distributions are given in Appendix B.

4.4 Verification

In order to test simulation models, there are some techniques that may be used for verification. One technique is to run the simulation program under a variety of settings of the input parameters and check to see that output is reasonable. Another technique is running the model under simplifying assumptions for which its true characteristics are known or can easily be computed (Law and Kelton, 1991).

For verification of the computer model described in Section 4.3, test runs for a number of hypothetical cases were carried out. The results of the statistical analysis of these cases and discussions on these results are given below.

CASE A

In Case A, in addition to the assumptions described before, it is assumed that the utility values of the bays within the boater categories are the same (Table 4.1). It is also assumed that, the quotas of the bays are constant, which is taken as 20 boats for each bay. The number of the bays to be visited is taken as 13. The average interarrival time, the average stay duration in a bay and the average cruise time of the boats are taken as 15 minutes, 4 hours and 5 days respectively, assuming that all of them are exponentially distributed.

The cumulative probability distribution, g(u), of the boater categories is given in Equation 4.1. The time of the simulation run is taken as 50 days.

$$g(u) = \begin{cases} 1 \rightarrow 0<u\leq 0.19 \\ 2 \rightarrow 0.19<u\leq 0.39 \\ 3 \rightarrow 0.39<u\leq 0.77 \\ 4 \rightarrow 0.77<u\leq 1 \end{cases} \quad (4.1)$$

Table 4.1 Utility values of Case A

Boat Type	Bay 1	Bay 2	Bay 3	Bay 4	Bay 5	Bay 6	Bay 7	Bay 8	Bay 9	Bay 10	Bay 11	Bay 12	Bay 13
1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4	4	4	4	4	4

The results of the statistical analysis of the output data shows that the interarrival time, stay duration and cruise time distributions fit to exponential distribution with means of 15.17 minutes, 3.94 hours and 4.94 days respectively. The statistical data of these distributions and the density plots of exponential distributions are given in Appendix C.

In Figure 4.1, the number of boats staying overnight in all of the bays are given with respect to days. As it is seen from Figure 4.1, after 50 days, the number of boats staying overnight decreases. As the simulation run time is 50 days, this is an expected result. After that day, the number of boats decreases rapidly since no new boat enters the system. Almost 90% of the boats leave the system within five days. This result is also expected as the average cruise time is obtained as 4.5 days.

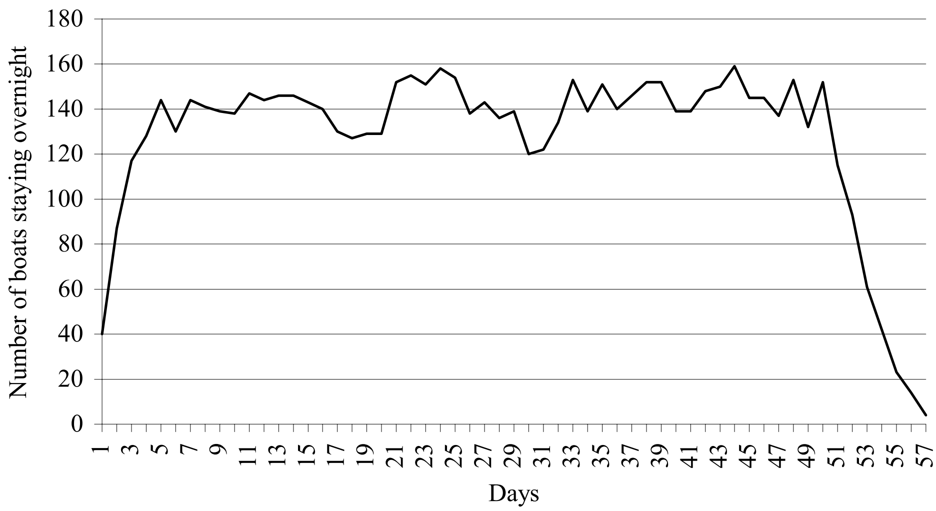

Figure 4.1 Number of boats staying overnight in Case A.

In Figure 4.2, the total number of boats in all bays with respect to the boater categories are given. It can be seen from the figure that the number of boats in each bay is more or less equal. Since the utility values of the bays are equal within each category, this is an expected result. It can also be seen that, the boater category 3, which has the highest probability range among the other categories has the highest number of boats. It is followed by the boater category 4 which has the second largest probability range. As the probability ranges of boater categories 1 and 2 are approximately equal, the curves of those categories show a similar and a closer behavior. In Figure 4.3, the "night-stay" distribution of boats among the bays are given. The 21st, 22nd, 23rd, 24th and 25th days are chosen for the graphical distribution. As it is seen from the figure, the system never reaches its full capacity. It is also seen that the number of boats in the bays ranges between 10 and 15. This distribution is an expected result due to the random nature of the system.

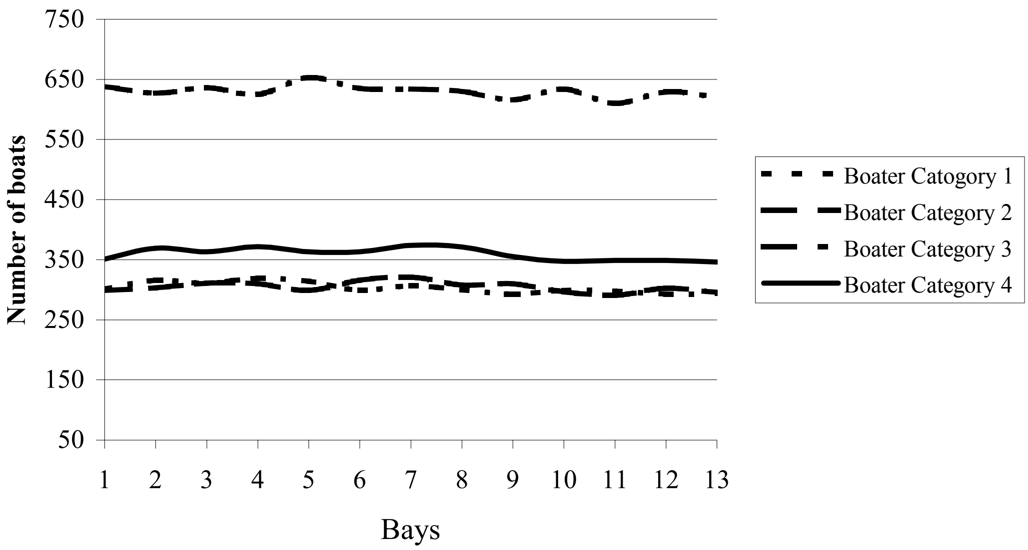

Figure 4.2 The total number of boats in all bays w.r.t. the boater categories in Case A.

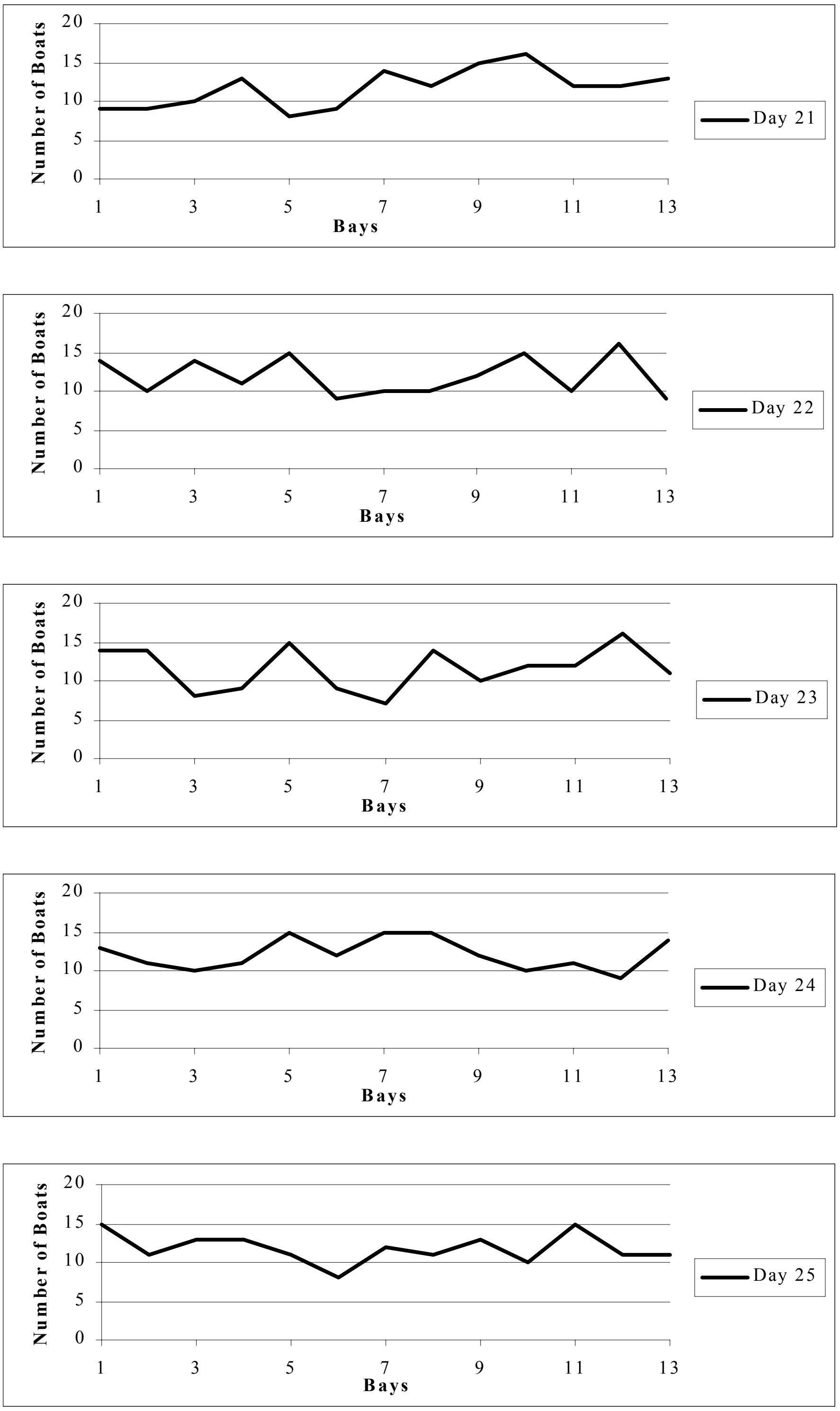

Figure 4.3 The "night-stay" distribution of boats among the bays in Case A.

CASE B

In Case B, the assumptions and the input data is the same as Case A except for the utilities. The utility values are assumed to be linearly increasing and given in Table 4.2.

Table 4.2 Utility values of Case B

Boat Type	Bay 1	Bay 2	Bay 3	Bay 4	Bay 5	Bay 6	Bay 7	Bay 8	Bay 9	Bay 10	Bay 11	Bay 12	Bay 13
1	1	2	3	4	5	6	7	8	9	10	11	12	13
2	2	3	4	5	6	7	8	9	10	11	12	13	14
3	3	4	5	6	7	8	9	10	11	12	13	14	15
4	4	5	6	7	8	9	10	11	12	13	14	15	16

The results of the statistical analysis of the output data shows that the interarrival time, stay duration and cruise time distributions fit to exponential distribution with means of 15.11 minutes, 4.3 hours and 4.57 days whereas the input values are 15 minutes, 4 hours and 5 days respectively. The statistical data of these distributions and the density plots of exponential distributions are given in Appendix C.

In Figure 4.4, the number of boats staying overnight in all of the bays are given with respect to days. As it is seen from Figure 4.1, after 51 days, the number of boats staying overnight decreases. As the simulation run time is 50 days, this is an expected result. After that day, the number of boats decreases rapidly as the boats start to leave the system. Most of the boats leave the system within five days. This result is also expected as the average cruise time is obtained as 4.57 days.

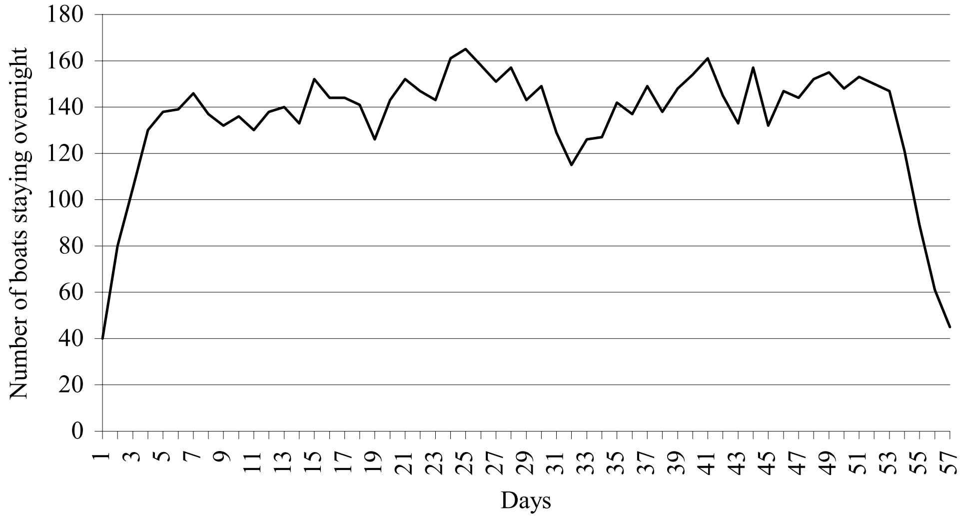

Figure 4.4 Number of boats staying overnight for Case B.

In Figure 4.5, the total distribution of boats among the bays with respect to the boater categories are given. As it is seen from the figure, the number of boats in each bay increases with the increasing bay number. This is an expected outcome of the program since the utility values of the bays increases as the bay number increases. Additionally, just like Case A, it is also seen that the boater category 3, which has the highest probability range among the other categories has the highest number of boats. It is again followed by the boater categories 4, 1 and 2 respectively.

In Figure 4.6, the “night-stay” distribution of boats among the bays are given. As it is seen from the Figure, the number of boats increases as the bay number increases. However this pattern is not as significant as the one in

Figure 4.5. This is due to the fact that, the decision on the bay selection is a random phenomeneon, and though high numbered bays have quite larger probabilities of selection, the low numbered bays have also a good chance of being chosen. The effect of utility on the boat distribution in the bays is more significant in Days 22 and 24.

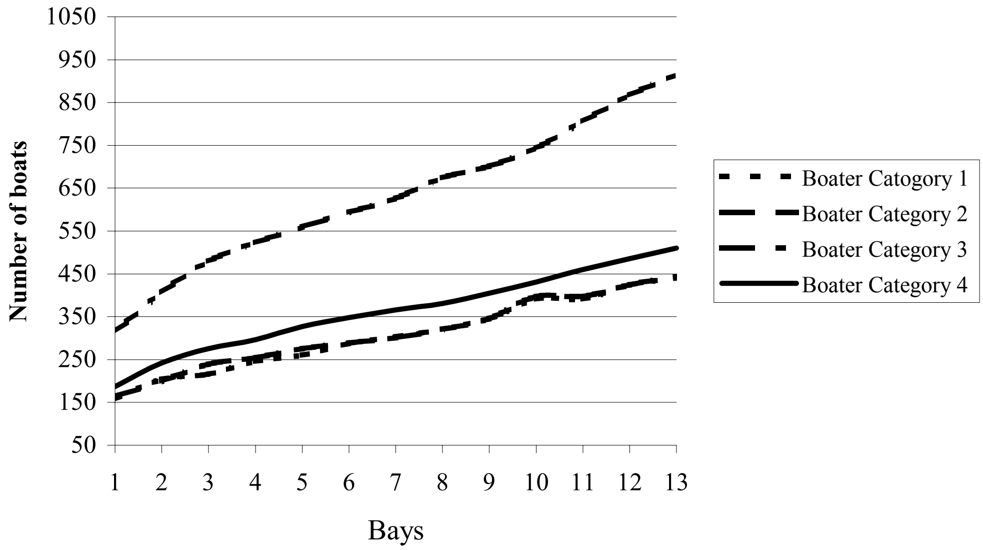

Figure 4.5 The total distribution of boats among the bays w.r.t. the boater categories for Case B.

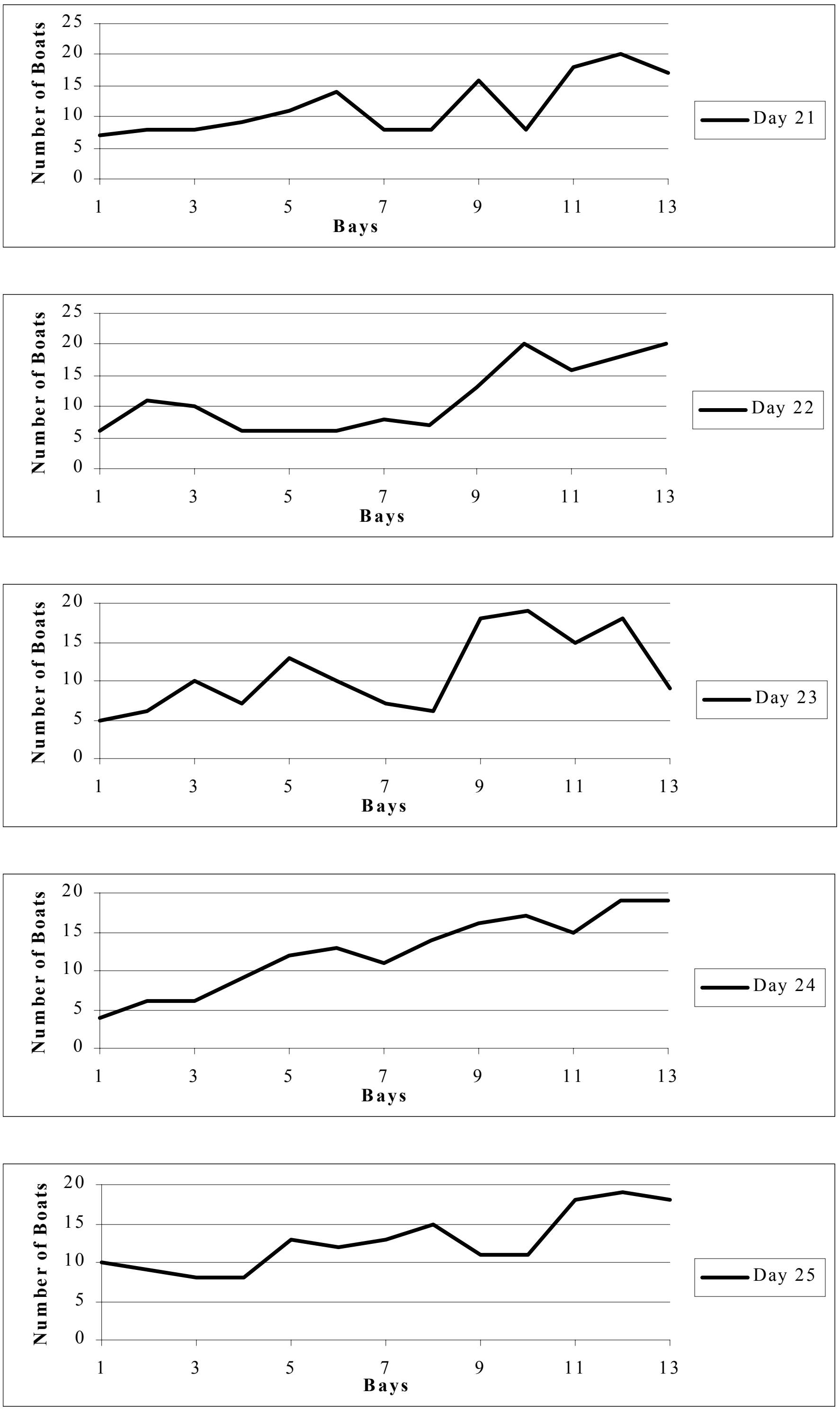

Figure 4.6 The "night-stay" distribution of boats among the bays for Case B.

CASE C

Similar to Case B, the assumptions and the input data of Case C are the same as Case A except for the utilities. The utility values of this case are given in Table 4.3.

Table 4.3 Utility values of Case C

Boat Type	Bay 1	Bay 2	Bay 3	Bay 4	Bay 5	Bay 6	Bay 7	Bay 8	Bay 9	Bay 10	Bay 11	Bay 12	Bay 13
1	1	2	3	4	5	6	7	6	5	4	3	2	1
2	2	3	4	5	6	7	8	7	6	5	4	3	2
3	3	4	5	6	7	8	9	8	7	6	5	4	3
4	4	5	6	7	8	9	10	9	8	7	6	5	4

The results of the statistical analysis of the output data shows that the interaarival time, stay duration and cruise time distributions fit to exponential distribution with means of approximately 15.6 minutes, 4.18 hours and 4.5 days whereas the input values are 15 minutes, 4 hours and 5 days respectively. The statistical data of these distributions and the density plots of exponential distributions are given in Appendix C.

As it is seen from Figure 4.7, after 52 days, the number of boats staying overnight decreases. As the simulation run time is 50 days, this is an expected result. After that day, the number of boats decreases rapidly as the boats start to leave the system. The same discussions made for Case A and Case B holds here, and the output obtained from Case C is also reasonable.

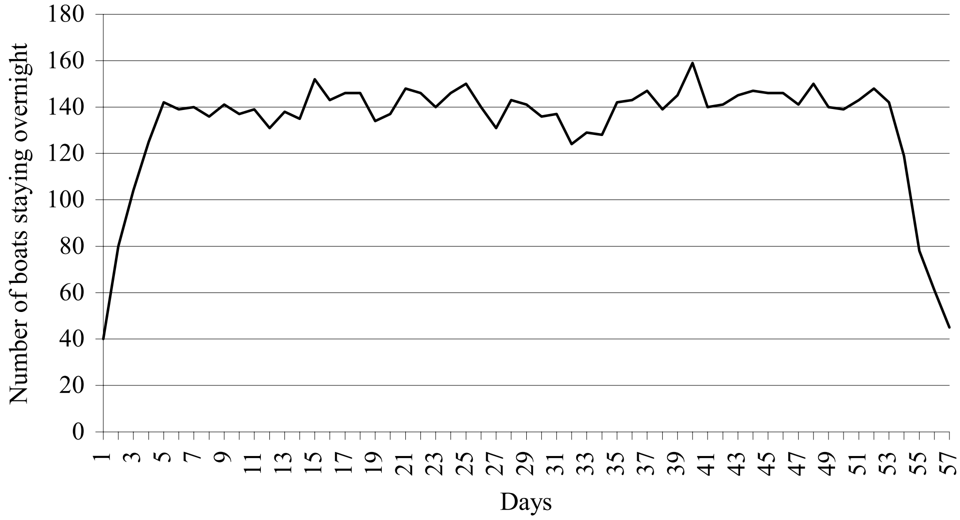

Figure 4.7 Number of boats staying overnight for Case C.

In Figure 4.8, the total distribution of boats among the bays with respect to the boater categories are given. As it is seen from the figure, the number of boats in each bay increases and reaches its peak value at Bay 7, which has the highest utility value among other bays. It is clearly seen from this figure that the curves follow the pattern of utility values. This result is expected since higher utility values mean higher probabilities. Additionally, just like Case A and Case B, it is also seen that the boater category 3, which has the highest probability range among the other categories has the highest number of boats. It is again followed by the boater categories 4, 1 and 2 respectively.

In Figure 4.9, the “night-stay” distribution of boats among the bays are given. As it is seen from the Figure, the bays with the higher number of boats are the ones with higher utility values. The utility effect is more significant in day 24 and 25, where the system is closer to the steady state.

As a final discusssion for all of the hypothetical cases given above, it can be stated that the outputs obtained are reasonable. Though the statistical analysis of the output distributions show some deviations from the input values, these deviations are at an acceptable level considering that the system has a random nature.

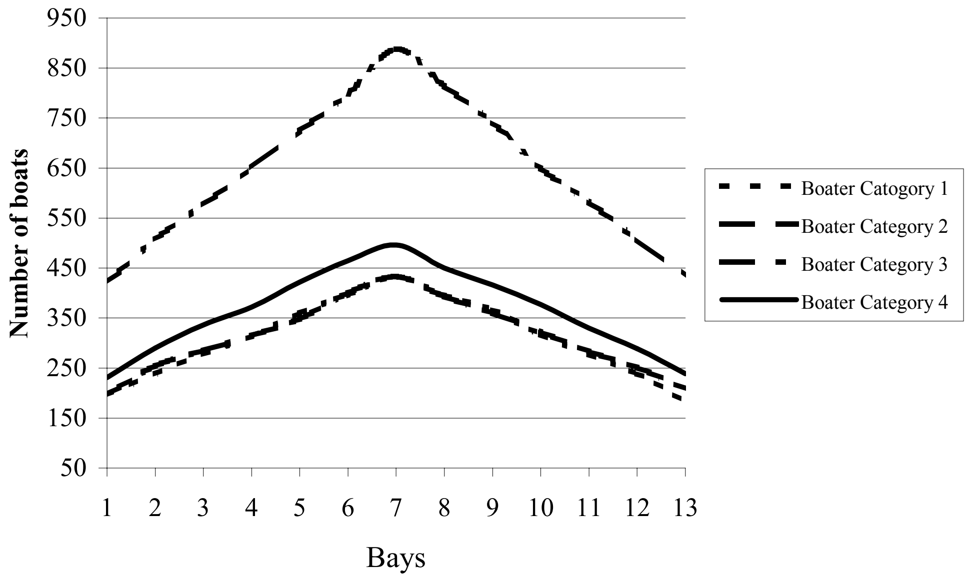

Figure 4.8 The total distribution of boats among the bays w.r.t. the boater categories for Case C.

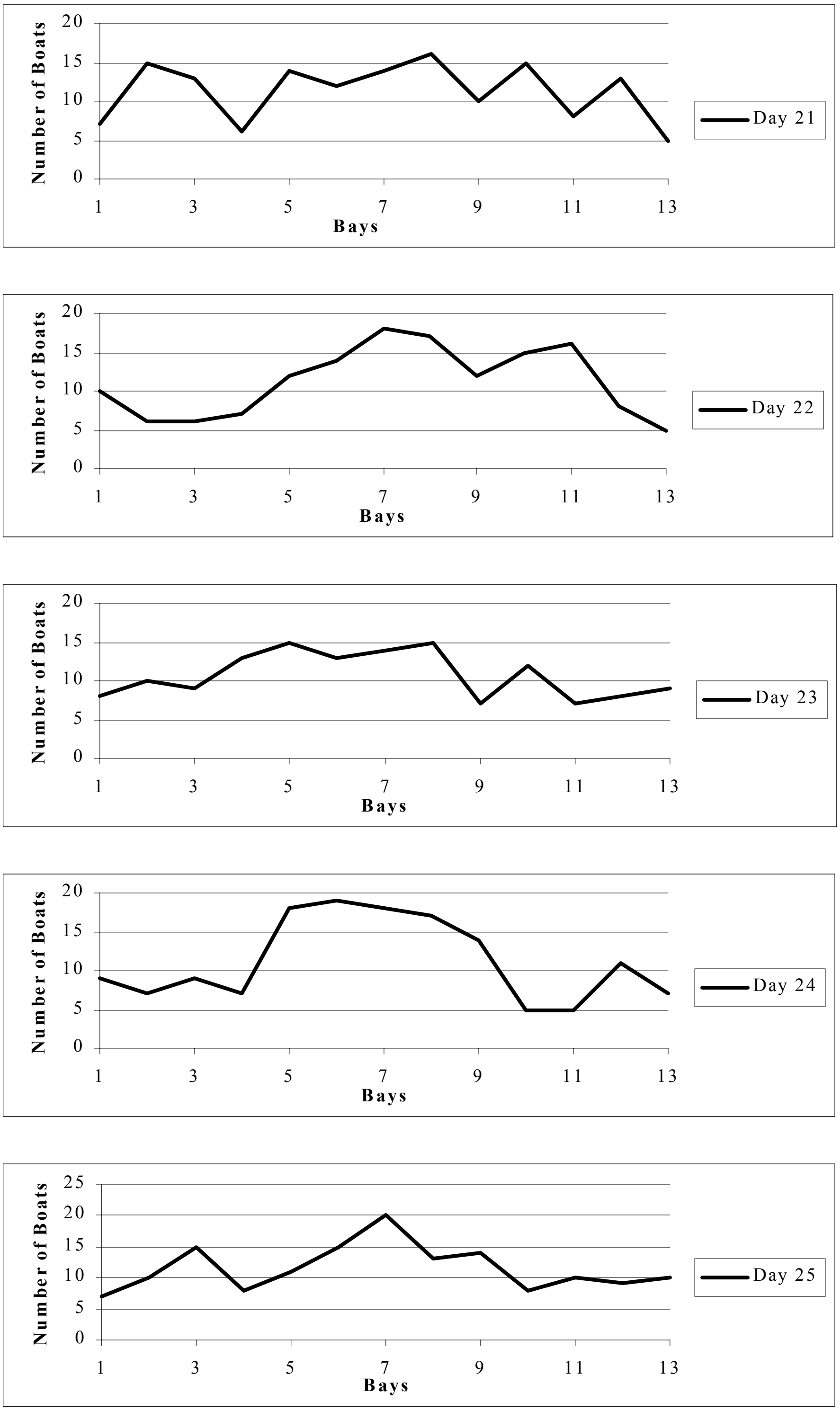

Figure 4.9 The "night-stay" distribution of boats among the bays for the inverse of Case C

4.5 Application to Göcek Bays

The computer program, SIM-BOAT, is applied to Göcek Bays as a real life application. The assumptions of this program run is the same as the ones listed before in Section 4.3, and the input distributions are given in Appendix B. The quota and the utility values assigned to each bay by four different boater categories are given in Tables 4.4 and 4.5 respectively. The quotas assigned to bays are based on the maximum number of boats counted in the relevant bay.

Table 4.4 List of bays and bay quotas

Bay number	*Name of the bay*	*Quota of the bay*
1	Atbükü	9
2	Boynuzbükü	18
3	Bedri Rahmi Bay	18
4	Sarsala Bay	22
5	Manastır Bay	9
6	Hamam Bay	22
7	Kuyrucak/Kursunlu Bay	14
8	Yavansu Bay	14
9	Göbün Bay	18
10	Domuz Island	18
11	Tersane Bay	9
12	Yassıca Island	18
13	Göcek Island	18

Table 4.5 Utility values

Boat Type	Bay 1	Bay 2	Bay 3	Bay 4	Bay 5	Bay 6	Bay 7	Bay 8	Bay 9	Bay 10	Bay 11	Bay 12	Bay 13
1	122	130	122	128	130	136	127	124	133	126	121	119	131
2	147	157	147	155	158	165	155	149	160	152	146	144	159
3	139	148	139	144	147	154	143	142	149	144	137	134	148
4	143	152	143	150	153	160	150	144	157	148	141	138	153

The results of the statistical analysis of the output data shows that the interarrival time, stay duration and cruise time distributions fit to exponential distribution with means of 6.012 minutes, 9.6 hours and 7.1 days whereas the input values are 6 minutes, 9.2 hours and 5 weeks respectively. The statistical data of these distributions and the density plots of exponential distributions are given in Appendix C. Within these distributions, only the mean of average cruise time is significantly different than the prescribed value of 5 weeks. The reason for this difference depends on the assumption that "a boat leaves the system either when its cruise time is over or its visiting list is empty, whichever comes first". Generally all of the bays are visited before the cruise time is over so the resulting average cruise time is shorter than the input value.

In Figure 4.10, the number of boats staying overnight in all of the bays are shown with respect to days. As it is seen from Figure 4.10, though the quota of the system is 207 boats, the predicted maximum number of the boats is 170. At that point it must be stated that the system reaches its maximum capacity at certain time intervals. Additionally, the capacities of some bays are full for night stay for a number of days and for other bays, the number of boats staying overnight is below their capacities.

The average of utility values given by the boater categories to each bay are graphically represented in Figure 4.11. In Figure 4.12, the total number of boats visited the bays throughout the system time are given. If Figures 4.11 and 4.12 are compared, it can be seen that the curves of these two figures are similar. This similarity is expected as the utilities are the factors that affect the bay selection of a bay by the boaters. Consequently, the curve representing the resulting number of boats in each bay follows the curve of utility values of bays. In order to make a statistical check for these two data sets, the correlation coefficient is calculated. The resulting correlation coefficient is found as 0.97 and it is concluded that these two data sets are highly correlated, as expected.

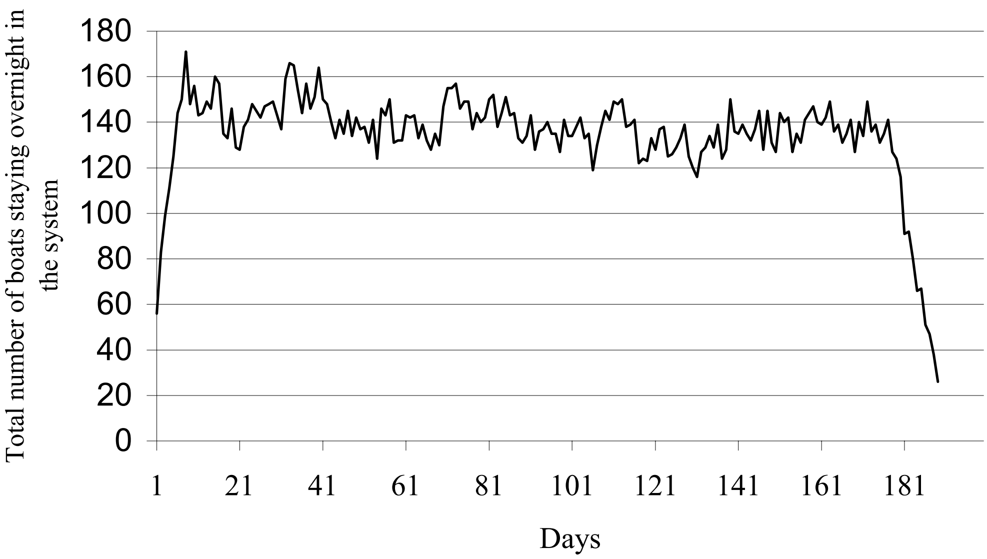

Figure 4.10 Distribution of number of boats vs. days

The correlation coefficients of the observed and predicted data for all bays are given in Table 4.6. Through Figures 4.13-4.22, the observed number of boats at a specific day and time vs. the predicted number of boats at the end of that day for different bays are given.

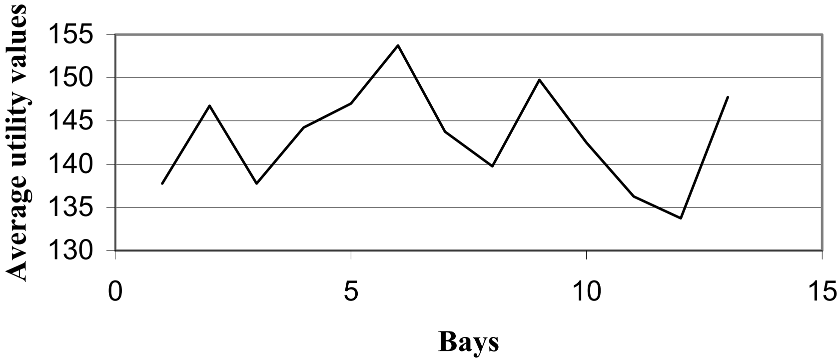

Figure 4.11 The average utility values

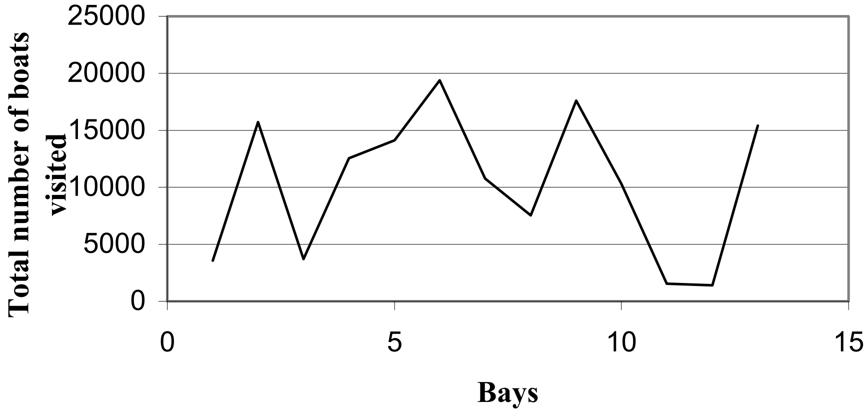

Figure 4.12 Total number of boats visited the bays throughout the system time

Table 4.6 The correlation coefficients of the observed and the predicted data

Name of the bay	*Correlation coefficient between observed and predicted data*
Atbükü	-0.1240
Boynuzbükü	0.0202
Bedri Rahmi Bay	0.8265
Sarsala Bay	0.5998
Hamam Bay	0.7919
Yavansu Bay	0.5672
Göbün Bay	0.5881
Domuz Island	0.5514
Tersane Bay	0.4513
Yassıca Island	0.0094

Figure 4.13 compares the predicted values with the field data for Atbükü Bay. This bay is known for its cool water especially in the hot summer days, and it also offers a nice shelter from wind (Boro, 2000). It is seen from Figure 4.16 that, the observed values are generally greater than or equal to the predicted values. However when the difference between the observed and predicted values are considered, it is seen that these numbers do not differ very much. Additionally, it must also be considered that the observations are made at specific times of the day, and the time of the observations may be a factor affecting the relation between the observed and predicted data.

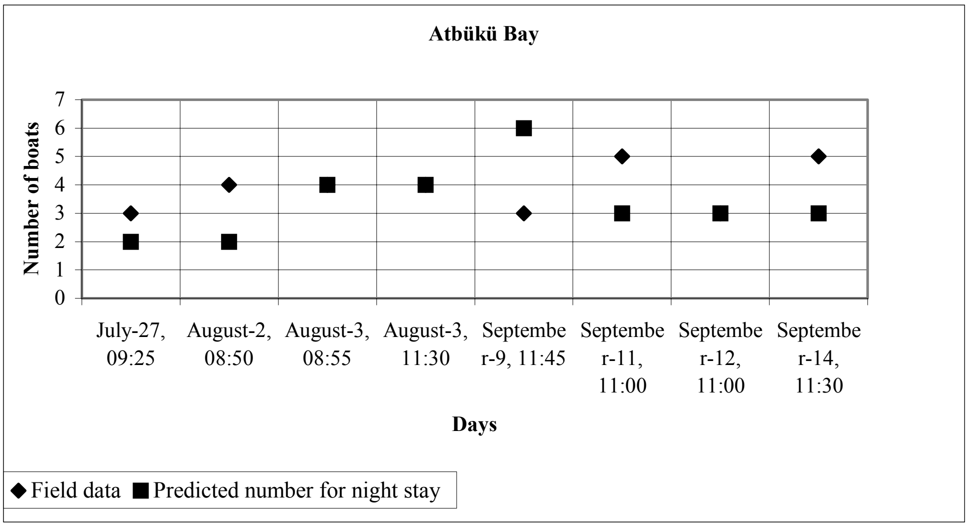

Figure 4.13 Field data vs. the predicted number of boats staying overnight for Atbükü Bay

Figure 4.14 compares the predicted values with the field data for Boynuzbükü Bay, which is one of biggest bays of the Göcek Bay Area and known for its clear water. This bay also provides a good shelter from wind

(Boro, 2000). There is a restaurant in that bay which provides potable water if requested. If the data in Figure 4.14 is examined, it is seen that most of the predicted data is greater than the observed data. However, as stated previously, the time of observation is an important factor. If the data points where the observed and predicted data are closer, are checked, it will be seen that the times of observation are either early hours of the day or late in the afternoon. As this bay provides good shelter from wind, it can be stated that boaters generally prefer this bay for night stay.

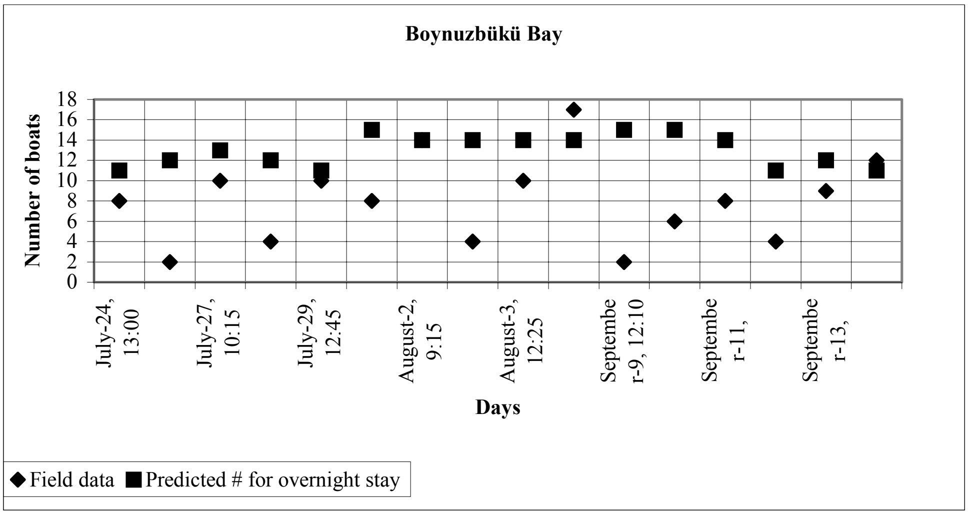

Figure 4.14 Field data vs. the predicted number of boats staying overnight for Boynuzbükü Bay

Figure 4.15 compares the predicted values with the field data for Bedri Rahmi (Taşyaka) Bay, which is one of the most beautiful and popular bays of Göcek (Boro, 2000). At the coast of this bay, there is a fish picture painted on a big stone by Bedri Rahmi Eyüpoğlu, a famous Turkish artist and poet, and a kite mosaic by Azra Erhat, a famous Turkish writer. There are also cultural remains from the Lykian times in this bay. There is a restaurant with a small wooden pier. Potable water is also available. In short, this bay is one of the bays that is at least once visited at any time of the day. Actually, if the resulting chart given in Figure 4.15 is examined, it will be seen that the observed and predicted data are highy correlated (see Table 4.6) reflecting the information given above.

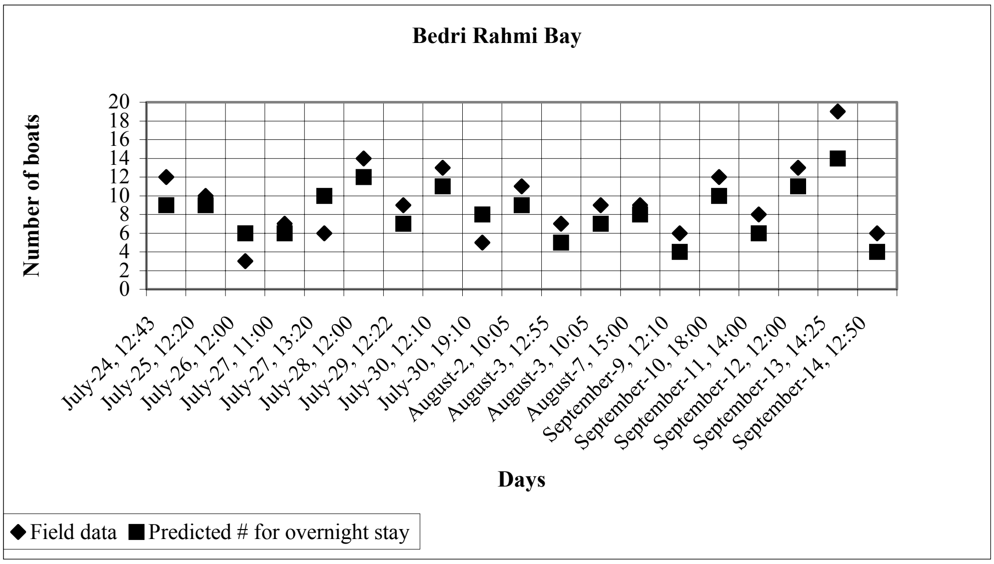

Figure 4.15 Field data vs. the predicted number of boats staying overnight for Bedri Rahmi Bay

Figure 4.16 compares the predicted values with the field data for Sarsala Bay, which is also one of the popular bays of Göcek. It is a big bay with a good wind shelter (Boro 2000). There is also a restaurant in that bay. It is seen from the Figure that, the predicted values are greater than the observed values. This may be due to the reason that, as this bay provides a good shelter from wind, boaters also prefer this bay for night stays as well as daily visits. Additionally, it must be stated that these two data sets show a significant correlation as given in Table 4.6.

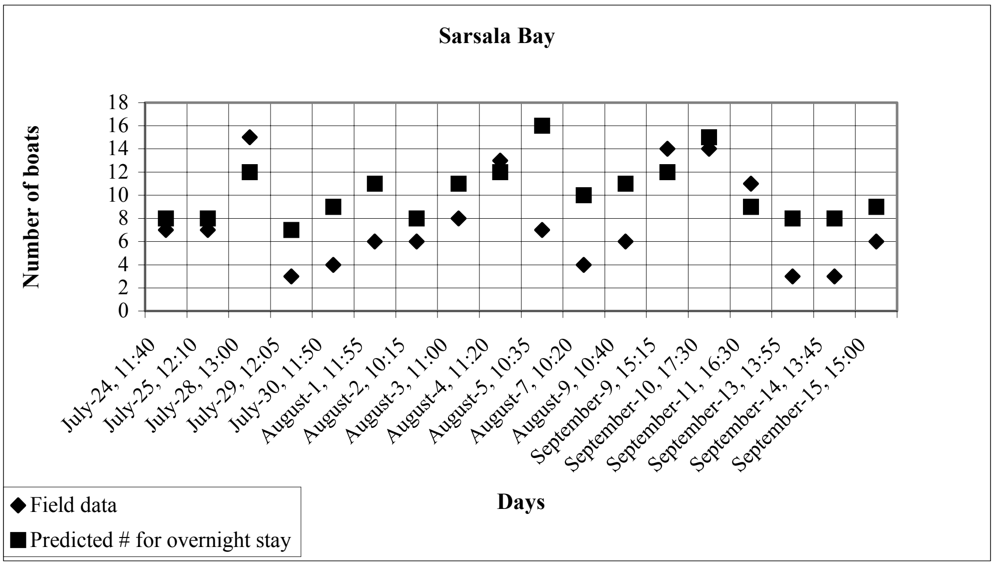

Figure 4.16 Field data vs. the predicted number of boats staying overnight for Sarsala Bay

Figure 4.17 compares the predicted values with the field data for Hamam Bay, which takes its name from the ancient bath ruins. This bay is also one of the popular bays of Göcek (Boro, 2000). It was also rated with the highest utility by the boaters during the questionnaire study of this thesis. As it is seen from the Figure, the predicted values are greater than the observed values. Here it may be argued that, as the MNL model used to find the probabilities of the bay selection depends on the utility values, the computer model gives Hamam Bay with full capacity for most of the times. However, as it is seen from Table 4.6, the observed and predicted data for this bay have a significant correlation factor. Consequently, depending on the discussions given above, the results of the model for this bay can be considered as reasonable.

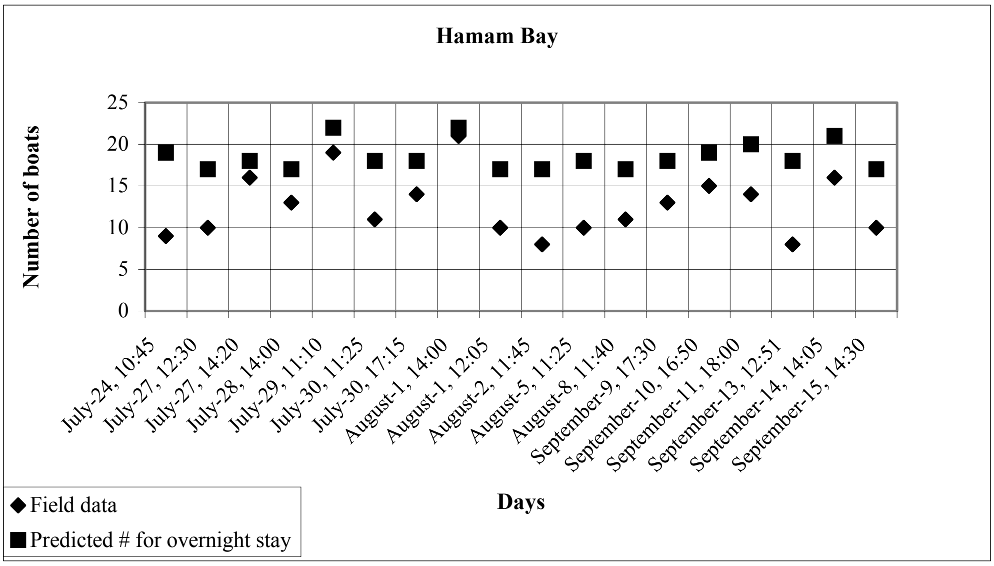

Figure 4.17 Field data vs. the predicted number of boats staying overnight for Hamam Bay

Figure 4.18 compares the predicted values with the field data for Yavansu Bay. This bay is placed close to the Fethiye Bay so most of the boaters that visit the Göcek Bay area generally stop by in this bay. As it is seen from the Figure, the predicted values are greater than the observed values. However, when the correlation between the observed and predicted values is considered, it is seen that they are siginificantly correlated (Table 4.6). Additionally, it must also be emphasized that the observations are made at a specific time of the day as the time of the observations may be a factor affecting the relation between the observed and predicted data.

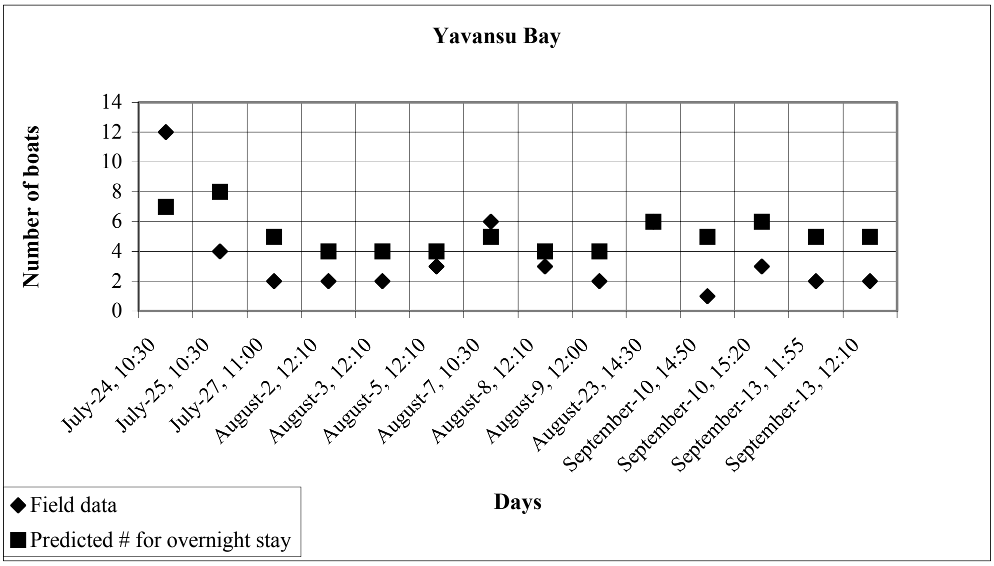

Figure 4.18 Field data vs. the predicted number of boats staying overnight for Yavansu Bay.

Figure 4.19 compares the predicted values with the field data for Göbün Bay, which is one of the special bays of the Göcek Area. This bay provides a very good shelter for the boats, and most of the foreign boats berth in this bay in winter (Boro, 2000). The restaurant at the coast of this bay is famous for its food. The landscape beauty of the bay is quite charming, especially at sunset. The landscape area of the bay is also a good spot for trekking. As this bay offers different kind of activities for the boaters, it is mostly crowded almost throughout the whole day. As it is seen from Table 4.6, the correlation between the observed and predicted values is significant. Actually, this correlation is clearly seen in Figure 4.19. Depending on the attributes of this bay discussed above, it may be stated that the results obtained are reasonable.

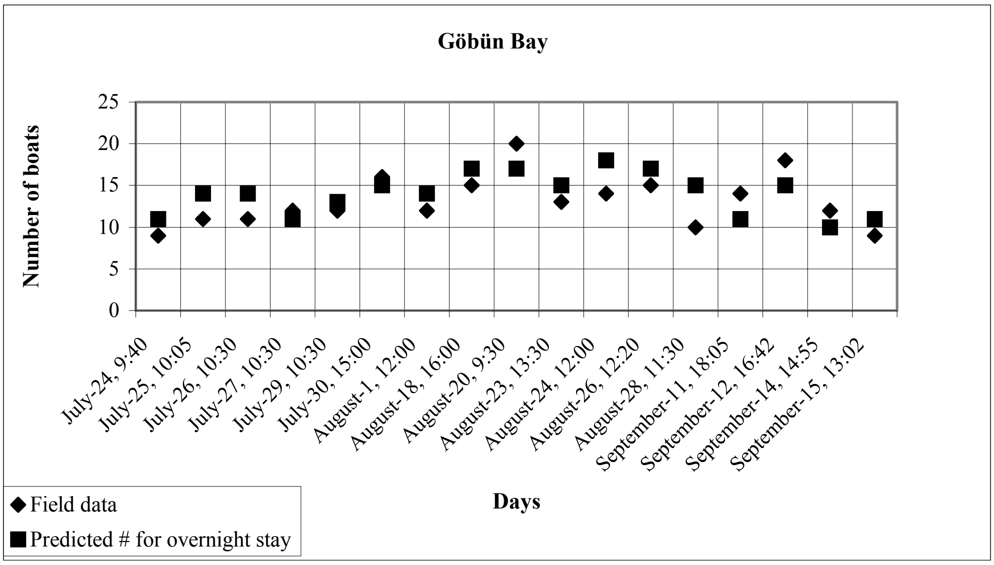

Figure 4.19 Field data vs. the predicted number of boats staying overnight for Göbün Bay.

Figure 4.20 compares the predicted values with the field data for Domuz Island. As it is seen from the figure, the predicted data differs from the observed data. The correlation factor of these two data sets show a significant value as given in Table 4.6. Additionally, it must be stated that observation time may be a factor affecting the relation between the observed and predicted data.

Figure 4.21 compares the predicted values with the field data for Tersane Bay. As it is seen from the Figure, the predicted data is lower than the observed data. From Figure 4.11, it is seen that the utility value of this bay is quite low. As discussed previously, due to the nature of the mathematical model used, low utility values may result in under predicted values. However, as the utility values are assigned by the boaters, it may also be argued that this bay is not that popular among the boaters, especially for night stay.

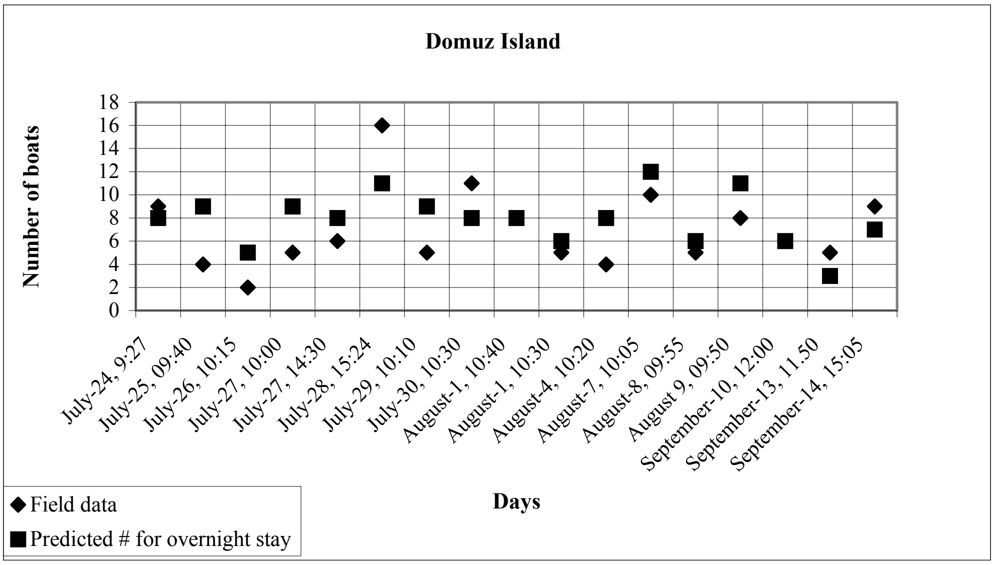

Figure 4.20 Field data vs. the predicted number of boats staying overnight for Domuz Island

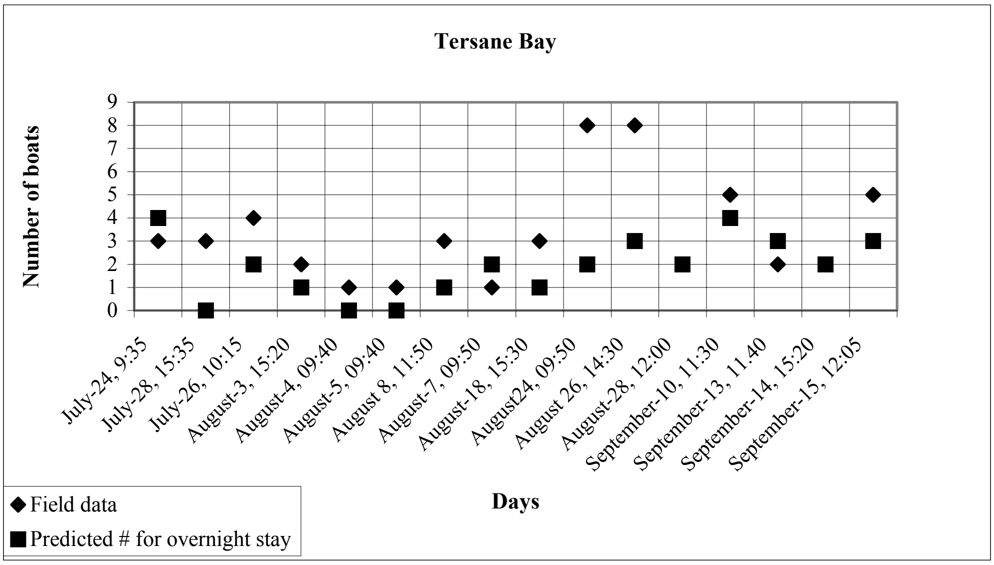

Figure 4.21 Field data vs. the predicted number of boats staying overnight for Tersane Bay

Figure 4.22 compares the predicted values with the field data for Yassıca Island. This island is between Tersane and Göcek Islands and it provides quite a good shelter for the boats. It is a swimming spot for the daily tour boats and is generally crowded at lunch hours. However for the rest of the day, this island is quite uncrowded (Boro, 2000). As it is seen from the Figure, the predicted values are lower than the observed values. Here it may be argued that, though Yassıca Island is considered as a popular anchoring place, it is not rated as a good anchor location by the boaters. Even though they visit the place, they may not be staying too long. The reason for difference in those two data sets may depend on the discussions given above.

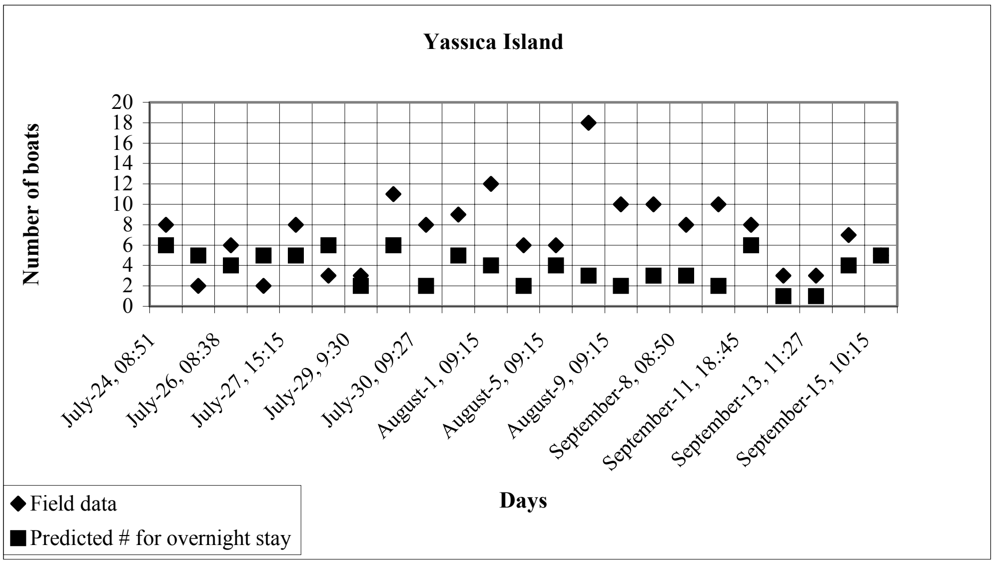

Figure 4.22 Field data vs. the predicted number of boats staying overnight for Yassıca Island

In this section, the application of the computer program to Göcek Bays is presented. Firstly, the statistical analysis of the output data for interarrival time, stay duration in a bay and cruise time is carried out, and it is seen that the output data fit to the input distributions. Secondly, the predicted data is compared with the observed data and discussions are made on the resulting chart of each bay. There are some important points observed as a result of these discussions. Firstly, it is seen that the time of observations is an important factor when these two data sets are compared. Secondly, for most of the bays which have a higher utility value generally resulted in more accurate results. This is due to the fact that the attributes and the facilities of these bays make them preferable for any time of the day. However the reverse is seen for Yassıca Island which has a smaller utility value and is generally crowded for a certain period of the day. Though the boaters have rated this island lower than the others, they still visit it for a short period of time.

The important question of the results of the application to Göcek Bays is whether the output is resonable or not. As the output data fits to input distributions, the distribution of the boats among the bays is highly correlated with the utility values of the bays, and the comparison of the observed and predicted data is acceptable, it can be concluded that the output of the program is reasonable.

CHAPTER 5

SUMMARY AND CONCLUSIONS

The followings are the important results and conclusions of the present dissertation:

- A computer model for simulating the movements of yachts in Göcek Bays is developed in this thesis. It uses the Multinomial Logit Model (MNL) to find the probabilities for the boaters to select the next bay to visit. The model predicts the number of boats in each bay at the end of a day and the number of boats visited each bay during the day. It also predicts the distribution of boater categories among the bays throughout the simulation time.
- The computer model consists of two modules, the Main Module and Statistics Module. In the Main Module, the system being studied is simulated. In the second module, the statistical results of the simulation are listed. User intervention is required for getting the statistical results.
- In order to find the input data of the program, a questionnaire study was carried out among the boaters in that area in the summer season. The statistical analysis for obtaining the input data was one of the most important phases of the study. The interarrival time,

duration of stay in a bay and cruise time distributions were obtained from the data. Additionally, the boaters were grouped according to their responses to these questionnaires. In the questionnaires, various features of the bays of Göcek were evaluated by the boaters visiting the area.

- It is seen that the boater categories and boaters' valuation of the attributes of the bays are the two important inputs of the simulation program. It is also seen that the input data quality is one of the important factors that affect the predictions of the model.
- For verification, the simulation model was run under a variety of hypothetical cases, and it was seen that the output was reasonable. The model was successfully applied to the Göcek Bays. It was shown that the model also gave reasonable results for this case, as the predictions were found comparable with the observations.
- This model would be a useful tool in supporting a coastal management plan, which may be developed for the Göcek Bays in the future. The distribution of the boat movement (e.g. distribution of the number of boats at various anchor locations) can be predicted with this model when the number of boats using the bays increases considerable in the future. These predictions would be useful in guiding a management plan that aims to control of yacht movement and anchoring.

- For future work, different choice models could be used to model the probabilities of bay selection, and different clustering techniques could be applied to group the boaters. The results could be compared with the ones obtained in this study.

REFERENCES

Banks, J. and Gibson, R.R., “Getting Started in Simulation Modeling”, IIE Solutions, Vol.28, issue 11, p.34, November 1996.

Ben-Akiva, M. and Lerman, S.R., “*Discrete Choice Analysis: Theory and Application to Travel Demand*”, The MIT Press, London, England, 1985.

Boro, Sadun, “*Vira Demir: Kuşadası’ndan Antalya’ya Denizciler için Rehber*”, TEB, İstanbul, 2000.

Demircioğlu, Çağdaş, “*A Questionnaire Study on Yachting in Göcek Bays*”, M.Sc. Thesis, Middle East Technical University, Ankara, 93 pp., December, 2003

Fader, P.S., and Hardie, B.G.S., “Modeling Consumer Choice Among SKUs”, Journal of Marketing Research, Vol. XXXIII, pp.442-452, November 1996.

Harlam, B.A. and Leonard, M. Lodish, “Modeling Consumer Choices of Multiple Items”, Journal of Marketing Research, Vol. XXXII, pp.404-418, November 1995.

http://www.dssresearch.com/library/segment/understanding.asp

http://www.statsoftinc.com/textbook/stcluan.html

Law, A.M. and Kelton, D.W., *"Simulation Modeling and Analysis",* Mc Graw Hill Inc., New York, 1991.

Law, A.M. and Vincent, S.T., "Unifit: An interactive package for fitting probability distributions to observed data", Version 2.15, 1985.

Mihram, G.A., *"Simulation: Statistical Foundations and Methodology"*, Academic Press, New York, 1972.

Montgomery, Douglas C. and Runger, George C., "*Applied Statistics and Probability for Engineers*", John Wiley & Sons, New York, 1999.

Özhan, E., "Coastal Zone Management in Turkey", :Ocean and Coastal Management, Elsevier Science Ltd., The Special MEDCOAST Issue (Ed. E. Özhan), Vol.30, No.2-3, pp.153-176.

Özhan, E., Numanoğlu Genç, A., and Demircioğlu, Ç., "A Questionnaire Study on Yachting Holidays in Göcek Bays", *Proceedings of the Sixth International Conference on the Mediterranean Coastal Environment*, MEDCOAST 03, E. Özhan (Editor), pp. 569-578, 7-11 October 2003, Ravenna, Italy.

Siegel, Sydney and Castellan, N. John Jr., "*Nonparametric Statistics for the Behavioral Sciences*", McGraw-Hill, New York, 1988.

Watson, S.R. and Buede, D.M., Decision Synthesis, Cambridge University Press, Cambridge, 1987.

Wishart, David (2003), "*ClustanGraphics Primer: A Guide to Cluster Analysis*", Edinburgh, 2003.

APPENDIX A

THE QUESTIONNAIRES

A. 1 Questionnaire of the Year 2000

This questionnaire is part of a project which aims to determine the yacht traffic density in Göcek Bays. It would mean a lot to this project if you would please take time to complete the following activity. It will only take 5-8 minutes to complete and all answers will be held strictly confidential.

Thank you for your assistance.

1. Name of the Bay: ………………………………………………………………
2. Name of the Boat: ……………………………………………………………
3. Type of the Boat: ❑ Power ❑ Sail
4. Ownership of the Boat: ❑ Privately owned ❑ Rent without crew
   ❑ Rent with crew ❑ Daily cruise boat
5. Boat Length …………………………………………… meters
6. Passenger capacity …………………………………………… people
7. Maximum cruise speed …………………………………… knots
8. Sex : ❑ Male ❑ Female
9. Age : ❑ Under 25 years ❑ 26-35 years ❑ 36-45 years
   ❑ 46-55 years ❑ 56-65 years ❑ over 65
10. Nationality ………………………………………………………
11. The highest level of education completed.
    ❑ Grade school ❑ High school ❑ College ❑ Graduate
12. Occupation ………………………………………………………
13. Annual income

❑ less than US$15,000 ❑ US$15,000 – US$100,000

❑ more than US$100,000

14. How many times a year do you take crusing vacation?

    ❑ 1-2 ❑ 3-5 ❑ more than 5

15. How many times have you been cruising along the Turkish Coasts on holidays (the Blue Voyage)?

    ❑ First time ❑ 2-5

    ❑ more than 5 (if possible, give the exact the number)…..

16. How long will you be crusing in this holiday?

    ❑ 1 week ❑ 1-2 weeks ❑ more than 2 weeks

    If this is not your first time in Blue Voyage, how many weeks on the average have you cruised on each Blue Voyage? …………………….........

17. Which month do you usually have the Blue Voyage? ……………………..

18. How do you decide on the places to visit/anchor when on a crusing holiday?

    ❑ Predetermined at the start of the trip

    ❑ By the common decision of the people on board on a daily basis

    ❑ By the decision of the leader of group on a daily basis

19. Please state whether other people on board have any influence on your decision.

    ❑ All the time ❑ Mostly ❑ Sometimes ❑ Seldom ❑ Never

20. Before you started your cruising, did you get detailed information about the Göcek Bays?

    ❑ Yes ❑ No

21. If your answer to Q.20 is “YES”, where did you get the information?

    ❑ From previous vacations ❑ Travel Agent ❑ Friends

    ❑ Books and magazines ❑ Other (please specify)

22. If you did not get detailed information about Göcek Bays before starting your cruise, did you get any information upon your arrival in Göcek?

❑ Yes ❑ No

If your answer is "YES", from where did you get the information?…………..
………………………………………………………………………………

23. Do you visit and anchor in more than one bay in a day?

❑ Always ❑ Usually ❑ Sometimes ❑ Rarely ❑ Never

If "YES", how many bays a day on the average? ………………………

24. What is your average duration of stay in a bay? (excluding night stays)

❑ 1-2 hrs. ❑ 3-5 hrs. ❑ 5-7 hrs.

❑ more than 7 hrs ❑ greatly varies

25. The harbor where the cruising started: ……………………………….

26. The names of the bays you have previously anchored:

1. …………………………… 5. ……………………………

27. The names of the bays you plan to visit/anchor:

1. …………………………… 5 …………………………….

28. Indicate the times when you usually move from one anchor location to another

❑ 6:00-8:00 ❑ 8:00-10:00 ❑ 10:00-12:00

❑ 16:00-18:00 ❑ after 18:00 ❑ greatly varies

29. How much are you interested in environmental issues?

Extremely Interested ◄				► Not Interested At All
(5)	(4)	(3)	(2)	(1)

30. Have you taken any courses/training on environmental issues?

❑ Yes ❑ No

If "YES", please indicate the type of training:
………………………………………………………………………………

31. Please indicate your preferences for the following recreational activities during your cruising holiday:

	Extremely Important ◄			►	Not Important
Swimming	(5)	(4)	(3)	(2)	(1)
Reading	(5)	(4)	(3)	(2)	(1)
Water Sports	(5)	(4)	(3)	(2)	(1)
Visiting Archeological Sites	(5)	(4)	(3)	(2)	(1)
Trekking	(5)	(4)	(3)	(2)	(1)
Sun Bathing	(5)	(4)	(3)	(2)	(1)
Others (Please Specify)					
………………	(5)	(4)	(3)	(2)	(1)

32. Which of the below categories, would you consider most descriptive for yourself as a person?

❑ Cultural ❑ Nature loving ❑ Active ❑ Easygoing ❑ Inquisitive

33. Indicate the importance of qualities of a bay as listed below in deciding the next anchorage location.

	Extremely Important ◄			►	Not Important
Aesthetic quality	(5)	(4)	(3)	(2)	(1)
Cultural remains	(5)	(4)	(3)	(2)	(1)
Anchorage capacity	(5)	(4)	(3)	(2)	(1)
Facilities (organized recreational activities, restaurants)	(5)	(4)	(3)	(2)	(1)
Water sports activities	(5)	(4)	(3)	(2)	(1)
Tranquility	(5)	(4)	(3)	(2)	(1)
Water pollution	(5)	(4)	(3)	(2)	(1)
Litter	(5)	(4)	(3)	(2)	(1)
Crowd	(5)	(4)	(3)	(2)	(1)
Noise	(5)	(4)	(3)	(2)	(1)
Distance from the present location	(5)	(4)	(3)	(2)	(1)
Others (please specify)					
………………………..	(5)	(4)	(3)	(2)	(1)

34. What are the most important attributes of the bay which you choose for anchoring over the night?

	Extremely Important ◄			►	Not Important
Tranquility	(5)	(4)	(3)	(2)	(1)
Lack of crowd	(5)	(4)	(3)	(2)	(1)
Lack of Noise	(5)	(4)	(3)	(2)	(1)
Lack of Pollution	(5)	(4)	(3)	(2)	(1)
Natural Beauty and Seascape	(5)	(4)	(3)	(2)	(1)
Others (please specify)					
……………….	(5)	(4)	(3)	(2)	(1)

35. How essential are the followings for an anchor location?

	Extremely Essential	←	→		Not Essential
Reception of waste water	(5)	(4)	(3)	(2)	(1)
Collection of garbage from yachts	(5)	(4)	(3)	(2)	(1)
Provision of potable water	(5)	(4)	(3)	(2)	(1)
Sanitary facilities, (toilets, shovers on the shore)	(5)	(4)	(3)	(2)	(1)
Restaurants	(5)	(4)	(3)	(2)	(1)
Recreational facilities	(5)	(4)	(3)	(2)	(1)
Others (please specify)					
……………………….	(5)	(4)	(3)	(2)	(1)

36. Indicate how satisfying this bay is from the view point of the following qualities (If you are in a marina, please skip this question).

	Extremely Satisfying	←	→		Not Satisfying
Aesthetic quality	(5)	(4)	(3)	(2)	(1)
Natural Beauty and Seascape	(5)	(4)	(3)	(2)	(1)
Cultural remains	(5)	(4)	(3)	(2)	(1)
Anchorage capacity	(5)	(4)	(3)	(2)	(1)
Facilities (organized recreational activities, restaurants)	(5)	(4)	(3)	(2)	(1)
Water sports activities	(5)	(4)	(3)	(2)	(1)
Tranquility	(5)	(4)	(3)	(2)	(1)
Water pollution	(5)	(4)	(3)	(2)	(1)
Litter	(5)	(4)	(3)	(2)	(1)
Crowd	(5)	(4)	(3)	(2)	(1)
Noise	(5)	(4)	(3)	(2)	(1)
Distance from the present location	(5)	(4)	(3)	(2)	(1)
Others (please specify)					

37. To which extend the following measures should be included in the future management plan of Göcek Bays?

	Strongly Agree ◄			► Strongly Disagree
Strict Enforcement of quotas for number of boats in a bay at any time	(5)	(4)	(3)	(2)	(1)
Enforcement of limitations on some potentially dangerous water activities (water skiing, jet ski, speed boats)	(5)	(4)	(3)	(2)	(1)
Use of a patrol boat for enforcement of environmental rules	(5)	(4)	(3)	(2)	(1)
Restriction on loud music from boats and restaurants	(5)	(4)	(3)	(2)	(1)
Others (please specify)					
……………………………	(5)	(4)	(3)	(2)	(1)
……………………………	(5)	(4)	(3)	(2)	(1)
……………………………	(5)	(4)	(3)	(2)	(1)

38. As a last remark, is there anything that you would like to state specifically for Göcek Bays that you have seen so far regarding the present and future environmental issues and management measures?

Thank you for your contribution. If you would like to be informed about the results of this survey, please provide your correspondence details.

Fax:

E-mail:

Address:

A.2 Questionnaire of the Year 2001

This questionnaire aims to determine the yacht traffic density in Göcek Bays. It is part of a research project carried out by Middle East Technical University (Ankara) and supported by the Municipality of Göcek. It would mean a lot to this project if you would please take time to complete the following activity. All answers will be held strictly confidential.

Thank you for your assistance**.**

1. Name of the Bay: …………………………………………………………
2. Name of the Boat: ………………………………………………………
3. Type of the Boat: ❑ Power ❑ Sail
4. Ownership of the Boat: ❑ Privately owned ❑ Rent without crew ❑ Rent with crew
5. Sex : ❑ Male ❑ Female
6. Age : ❑ Under 25 years ❑ 26-35 years ❑ 36-45 years ❑ 46-55 years ❑ 56-65 years ❑ over 65
7. Nationality ………………………………………………………
8. The highest level of education completed.
   ❑ Primary school ❑ High school ❑ University ❑ Graduate Degree
9. Occupation (profession) ………………………………………………
10. How many times a year do you take cruising vacation?
    ❑ 1-2 ❑ 3-5 ❑ more than 5
11. How many times have you cruised along the Turkish Coasts on holidays (the Blue Voyage)?
    ❑ First time ❑ 2-3 ❑ 4-5 ❑ more than 5 (if possible, give the exact number)…..
12. How long will you be cruising during this holiday?
    ❑ 1 week ❑ 1-2 weeks ❑ 3-4 weeks ❑ 1 month ❑ 2 months ❑ longer
13. If this is not your first time in Blue Voyage, how many weeks on the average have you cruised on each Blue Voyage?
    ❑ 1 week ❑ 1-2 weeks ❑ 3-4 weeks ❑ 1 month ❑ 2 months ❑ longer

14. Which month(s) do you usually have the Blue Voyage? (you may tick more than one)

❑ April ❑ May ❑ June ❑ July ❑ August ❑ September ❑ October

❑ November ❑ other:

15. Please indicate your preferences for the following recreational activities during your cruising holiday:

	Extremely Important	◄	———	►	Not Important
Swimming	(5)	(4)	(3)	(2)	(1)
Reading	(5)	(4)	(3)	(2)	(1)
Water Sports	(5)	(4)	(3)	(2)	(1)
Visiting Archeological Sites	(5)	(4)	(3)	(2)	(1)
Trekking	(5)	(4)	(3)	(2)	(1)
Sun Bathing	(5)	(4)	(3)	(2)	(1)
Diving	(5)	(4)	(3)	(2)	(1)
Sailing	(5)	(4)	(3)	(2)	(1)
Snorkeling	(5)	(4)	(3)	(2)	(1)
Fishing/spear fishing	(5)	(4)	(3)	(2)	(1)
Others (Please Specify) ………………………	(5)	(4)	(3)	(2)	(1)

16. How essential are the followings for a good anchor location?

	Extremely Essential	◄	———	►	Not Essential
Reception of waste water	(5)	(4)	(3)	(2)	(1)
Collection of garbage from yachts	(5)	(4)	(3)	(2)	(1)
Provision of potable water	(5)	(4)	(3)	(2)	(1)
Sanitary facilities, (toilets, shovers on the shore)	(5)	(4)	(3)	(2)	(1)
Restaurants	(5)	(4)	(3)	(2)	(1)
Recreational facilities	(5)	(4)	(3)	(2)	(1)
Tranquility and wind shelter	(5)	(4)	(3)	(2)	(1)
Presence of anchor facilities	(5)	(4)	(3)	(2)	(1)
Others (please specify)					

17. Indicate the importance of qualities of a bay as listed below in deciding the anchorage location.

	Anchor during **the daytime**						Anchor for **the night**				
	Extremely Important	⟷			Not Important		Extremely Important	⟷			Not Important
Aesthetic quality	(5)	(4)	(3)	(2)	(1)		(5)	(4)	(3)	(2)	(1)
Natural Beauty & Seascape	(5)	(4)	(3)	(2)	(1)		(5)	(4)	(3)	(2)	(1)
Cultural remains	(5)	(4)	(3)	(2)	(1)		(5)	(4)	(3)	(2)	(1)
Anchorage capacity	(5)	(4)	(3)	(2)	(1)		(5)	(4)	(3)	(2)	(1)
Restaurants	(5)	(4)	(3)	(2)	(1)		(5)	(4)	(3)	(2)	(1)
Water sports activities	(5)	(4)	(3)	(2)	(1)		(5)	(4)	(3)	(2)	(1)
Provision of potable water	(5)	(4)	(3)	(2)	(1)		(5)	(4)	(3)	(2)	(1)
Medical facilities	(5)	(4)	(3)	(2)	(1)		(5)	(4)	(3)	(2)	(1)
Tranquility & Wind shelter	(5)	(4)	(3)	(2)	(1)		(5)	(4)	(3)	(2)	(1)
Absence of flies	(5)	(4)	(3)	(2)	(1)		(5)	(4)	(3)	(2)	(1)
Lack of Water pollution	(5)	(4)	(3)	(2)	(1)		(5)	(4)	(3)	(2)	(1)
Lack of Litter	(5)	(4)	(3)	(2)	(1)		(5)	(4)	(3)	(2)	(1)
Lack of Crowd	(5)	(4)	(3)	(2)	(1)		(5)	(4)	(3)	(2)	(1)
Lack of Noise	(5)	(4)	(3)	(2)	(1)		(5)	(4)	(3)	(2)	(1)
Distance from the present location	(5)	(4)	(3)	(2)	(1)		(5)	(4)	(3)	(2)	(1)
Others (please specify)											
………………………..	(5)	(4)	(3)	(2)	(1)		(5)	(4)	(3)	(2)	(1)

18. Indicate how satisfying this bay is in relation to the following qualities:

(If you are in a marina, please skip this question)

	Extremely Satisfying	⟷			Not Satisfying
Aesthetic quality	(5)	(4)	(3)	(2)	(1)
Natural Beauty and Seascape	(5)	(4)	(3)	(2)	(1)
Cultural remains	(5)	(4)	(3)	(2)	(1)
Anchorage capacity	(5)	(4)	(3)	(2)	(1)
Restaurants	(5)	(4)	(3)	(2)	(1)
Water sports activities	(5)	(4)	(3)	(2)	(1)
Provision of potable water	(5)	(4)	(3)	(2)	(1)
Medical facilities	(5)	(4)	(3)	(2)	(1)
Tranquility & wind shelter	(5)	(4)	(3)	(2)	(1)
Absence of flies	(5)	(4)	(3)	(2)	(1)
Lack of Water pollution	(5)	(4)	(3)	(2)	(1)
Lack of Litter	(5)	(4)	(3)	(2)	(1)
Lack of Crowd	(5)	(4)	(3)	(2)	(1)
Lack of Noise	(5)	(4)	(3)	(2)	(1)
Others (please specify)					

19. How will you spend your time in this bay? (you may tick more than one)

❑ Swimming ❑ Reading ❑ Water sports ❑ Visiting archeological sites

❑ Trekking ❑ Sun bathing ❑ Diving ❑ Sailing

❑ Snorkeling ❑ Fishing

20. How long will you stay in this bay?

❑ 1-2 hrs. ❑ 3-5 hrs. ❑ 5-7 hrs. ❑ more than 7 hrs

21. How would you rank the present bay as an anchor location?

Extremely Good	←		→	Extremely bad
(5)	(4)	(3)	(2)	(1)

22. How do you decide on the places to visit/anchor when on a cruising holiday?

❑ Predetermined at the start of the trip

❑ By the common decision of the people on board on a daily basis

❑ By the decision of the leader of group on a daily basis

23. Please state whether other people on board have any influence on the leader's decision.

❑ All the time ❑ Mostly ❑ Sometimes ❑ Seldom ❑ Never

24. Before you started your cruising, did you receive detailed information about the Göcek Bays?

❑ No

❑ Yes; from previous vacations ❑ Yes, from travel Agent

❑ Yes, from friends ❑ Yes, from books and magazines

❑ Yes, other (please specify)…………………

25. If you did not receive detailed information about Göcek Bays before starting your cruise, did you receive any information upon your arrival in Göcek?

❑ Yes (from): …………………………… ❑ No

26. How many bays on the average do you visit and anchor in a day?

❑ 1 ❑ 2-3 ❑ 3-4 ❑ 4-5 ❑ more than 5

27. What is your average duration of stay in a bay? (excluding night stays)

❑ 1-2 hrs. ❑ 3-5 hrs. ❑ 5-7 hrs. ❑ more than 7 hrs

28. Where did you start your cruise?

❑ Marmaris ❑ Bodrum ❑ Göcek ❑ Antalya ❑ Ayvalık

❑ Other ……………………

29. Please circle the names of the bays you have previously anchored during this holiday (please refer to the map at the end of the questionnaire for the name of the bays):

(1) Çiftlik Bay (Doruklu)	(10) Sıralıbük Harbour	(19) Uzun Ali Bay (Domuz Island)
(2) Eğri Çam Bay	(11) Sarsala Bay	(20) Hacıdede (Domuz Island)
(3) Osmanağa Çeşmesi	(12) Manastır Bay	(21) Tersane Bay
(4) Atbükü	(13) Kapı Bay	(22) Yaz Harbour
(5) Günlüklü Bay	(14) Hamam Bay	(23) Büyük Yassıca (Yassıca Island)
(6) Boynuzbükü	(15) Kuyrucak (Kurşunlu) Bay	(24) İncirli Bay (Göcek Island)
(7) Killebükü	(16) Yavansu Bay (Yavan)	(25) Büyük Bay (Göcek Island)
(8) Taşyaka Bay (Bedri Rahmi)	(17) Merdivenli Bay	(26) Yılanlı Island
(9) Aşılık Bay	(18) Göbün Bay	(27) Zeytinli Island
Other(s) ……….		

30. From which bay did you come from to this bay, and where will you go next? (please refer to the map at the end of the questionnaire for the name of the bays)

Come from: …………………………………………

Go to: …………………………………………

31. Indicate the times when you usually move from one anchor location to another

❑ 6:00-8:00 ❑ 8:00-10:00 ❑ 10:00-12:00 ❑ 12:00-16:00

❑ 16:00-18:00 ❑ after 18:00

32. How much are you informed about the marine/coastal environmental issues?

Extremely Informed ◄				► Not Informed At All
(5)	(4)	(3)	(2)	(1)

33. Have you taken any courses/training on marine/coastal environmental issues?

❑ No ❑ Yes (please specify): ………………………………………………..

34. Would you agree to include the following measures in the future management plan of Göcek Bays?

	Strongly Agree ◄				► Strongly Disagree
Strict Enforcement of quotas for number of boats in a bay at any time	(5)	(4)	(3)	(2)	(1)
Enforcement of limitations on some potentially dangerous water activities (water skiing, jet ski, speed boats)	(5)	(4)	(3)	(2)	(1)
Use of a patrol boat for enforcement of environmental rules	(5)	(4)	(3)	(2)	(1)
Restriction on loud music from boats and restaurants	(5)	(4)	(3)	(2)	(1)
Restriction on the usage of engine/generators during night time	(5)	(4)	(3)	(2)	(1)
Others (please specify) ……………………………	(5)	(4)	(3)	(2)	(1)
……………………………	(5)	(4)	(3)	(2)	(1)

35. Based on your observations, is there anything that you would like to inform us about the present and future environmental issues and management needs for Göcek Bays?

THANK YOU FOR YOUR CONTRIBUTION! If you would like to be informed about the results of this survey, please provide your correspondence details.

Fax:

E-mail:

Address:

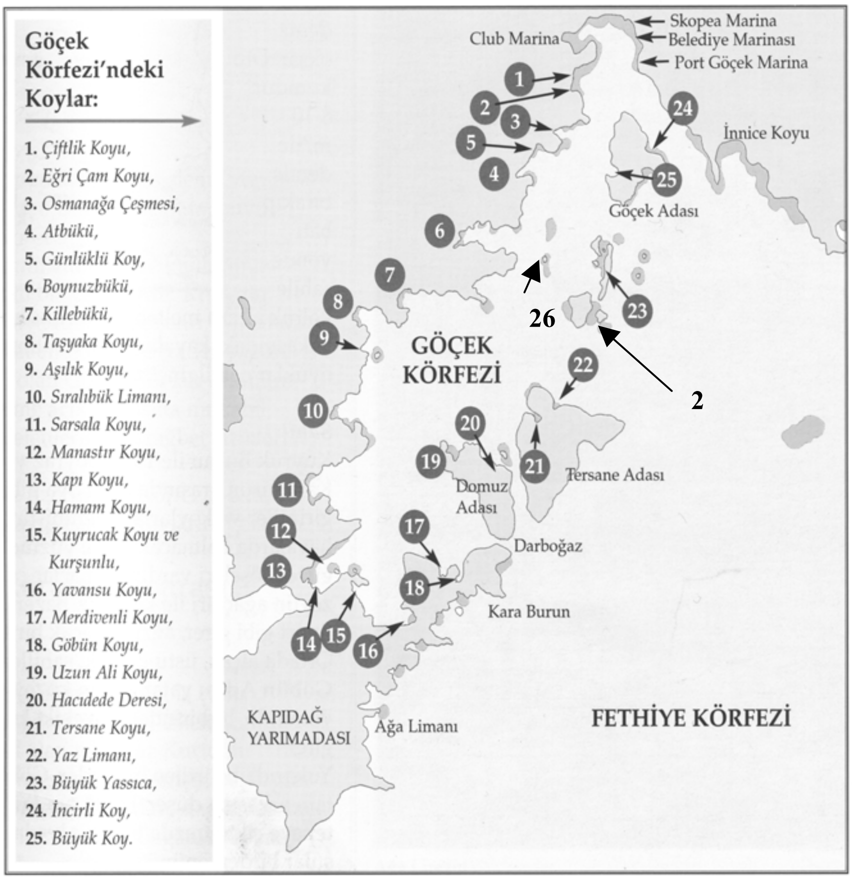

Figure A.1 Site Map for Göcek Bays (Boro, Sadun. "Vira Demir: A Guide for the Sailors from Kuşadası to Antalya", p.174, TEB, İstanbul, 2000 (In Turkish))

APPENDIX B

THE SIMULATION MODEL

The computer model designed for the simulation of yacht traffic in Göcek Bays is written in Delphi 6.0, which is a Pascal based programming language.

The program consists of two modules which are Main Module and Analysis Module.

B1. Main Module

The Main Module is the program module which simulates the boat movements in the Göcek Area. The algorithm of the main program is as follows:

MAIN PROGRAM

Call INIT

Call SCHEDULE ARRIVAL

Repeat TIMING until event list is empty or predefined stopping criterion is triggered.

Call Analysis Module.

This main program involves several subroutines which are listed below:

1) TIMING

Reads the next event and calls it.

2) SCHEDULE ARRIVAL

Using a random number, generates the time to the next arrival. Places the arrival event on the event list at that time.

3) EXECUTE ARRIVAL

Using a random number, generates the type of the arriving boat. The boat type is obtained from a cumulative discrete distribution, g(u).

Generates the maximum amount of time this boat will stay in the system from h(u).

Calls the LOGIT subroutine to determine which bay it will move to and places its anchoring (in that bay) on the event list for the appropriate time (depending on the decision it may either add the travel time between the bays or not). Calls SCHEDULE ARRIVAL for the next arrival.

4) EXECUTE ANCHORING

Determines whether the boat will remain in that bay (the limit of the bay may be full).

4.a. If the boat decides to leave the bay, decides whether it will leave the system (will leave the system if its cruise time is over, it has seen all the bays or the maximum number of bays defined for it) or will go to another bay.

4.a.i If it's time for the boat to leave the system, calls EXECUTE DEPARTURE

4.a.ii. If the boat will go on with its cruise, it calls LOGIT subroutine to decide where it will go and place its anchoring there on the event list.

4.b. If the boat stays in this bay, then, using random numbers, generates its stay duration from s(u). It places its leaving on the event list. It records the fact that this boat has already visited this bay (updates the boat's unvisited bay list).

5) EXECUTE LEAVING

Determines whether the boat leaves the system.

5.a. If the answer is YES, calls EXECUTE DEPARTURE

5.b. If the answer is NO, calls LOGIT subroutine to decide which bay to go and places its anchoring there on the event list.

6) EXECUTE DEPARTURE

Updates the records and takes the boat out of the system.

7) LOGIT

Uses the utilities for the appropriate boat type and the list of bays not yet visited by this boat to create a probability distribution. Using random numbers and this distribution, generates the next bay to be visited.

8) RANDOM

Generates random numbers between 0 and 1.

9) INIT

Sets system clock to zero, initializes system state, statistical counters and event list.

10) WRITE EVENT

Adds events to the event list.

B.2 Analysis Module

This module lists the statistical results of the program. Within this module, the total number of boats visiting each bay on a daily basis, and the number of boats staying in the bays at the end of each day is calculated. The total distribution of the boater categories among the Göcek Bays for the whole simulation run time is also given here.

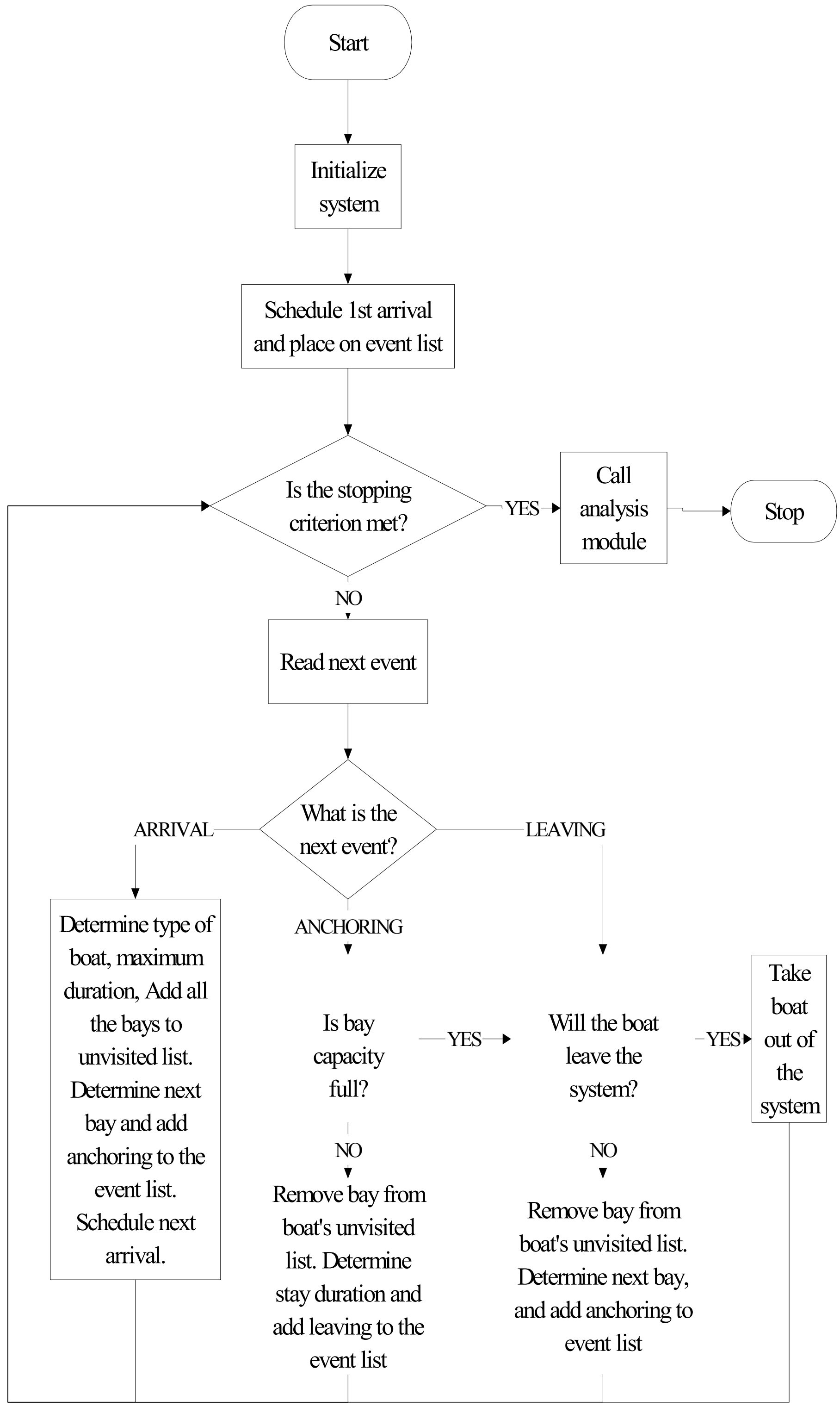

Figure B.1. The flow-chart of the main program

Table B.1 Sample trace of the simulation program

System Clock	**Statistical Counter**	**Arrivals, Anchoring and Departures**	**Library functions**
T = 0 T = 1 Boat 1 arrives T = 2 Boat 1 anchors Bay B T = 3 Boat 2 arrives T = 5 Boat 1 leaves Bay B T = 6 . . . . T = 11 Boat 1 departs	Time 0 1 2 3 Bay A: 0 0 0 0 Bay B: 0 0 1 0 . . . . Bay N	Boat 1: L1, L2 T=1 L1, L3 Type 1 L1, L10 t=10 L1, L5 Bay B T=2 (travel time is accepted as 1 time unit) L10, OK L1, L4 t=3 Boat 2: L1, T=3 .. …	L1: Random number generator L2: Arrival generator L3: Boat type generator L4: Stay duration generator L5….L9: Utility function equations for boat types L10: Distribution of total cruise time L11: Boat limits of bays

B.3 The Input Distributions

- The arrival distribution used is an exponential distribution given as $f(u) = -\beta_1 \ln(u)$. The interarrival time of the boats, β_1, is obtained as 6 minutes from the observed data.
- The stay duration in a bay is obtained from an exponential distribution, which is obtained by fitting the field data using the "Unifit" program (Law and Vincent, 1985). This distribution is given as:

  $s(u) = -\beta_3 \ln u$ where $\beta_3 = 9.2$ hrs (1)
- The cruise time of a boat is obtained from an exponential distribution, which is obtained by fitting the field data using the "unifit" program. This distribution is given as:

  $h(u) = -\beta_2 \ln u$, where $\beta_2 = 5$ weeks (2)
- The cumulative probability distribution of boater categories are given by g(u) where

$$g(u) = \{1 \rightarrow 0 < u \leq 0.19$$
$$2 \rightarrow 0.19 < u \leq 0.39$$
$$3 \rightarrow 0.39 < u \leq 0.77$$
$$4 \rightarrow 0.77 < u \leq 1\} \quad (3)$$

The cumulative probability distribution of boater categories are obtained by using the data in Table B.2:

Table B.2 The number of boaters in each boater category

Boater Category	Number of boaters
1	223
2	79
3	50
4	37

APPENDIX C

THE RESULTING DISTRIBUTIONS FOR CASE STUDIES AND APPLICATION TO GÖCEK BAYS

Table C.1 The model characteristics of interarrival times for Case A

Model Characteristics	*Value*
Number of observations	2394
Minimum observation	1
Maximum observation	237
Mean (minutes)	15.17
Variance	230.129

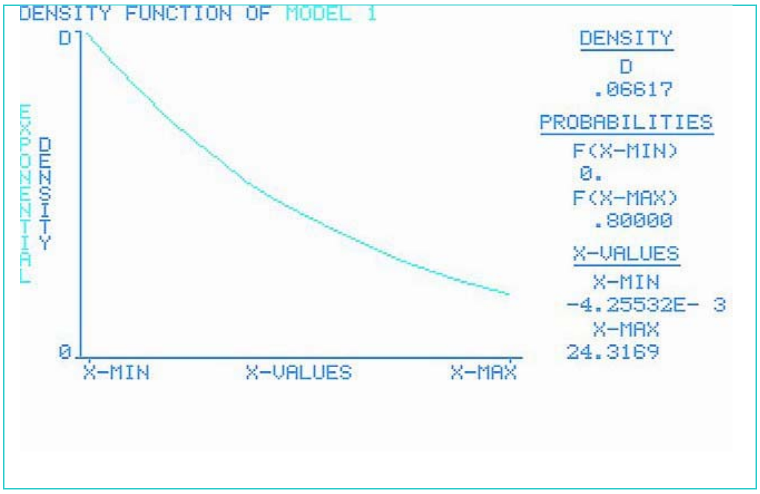

Figure C.1 The exponential distribution of interarrival times for Case A.

Table C.2 The model characteristics of cruise times for Case A

Model Characteristics	*Value*
Number of observations	2394
Minimum observation	15
Maximum observation	3.09530E+4
Mean (minutes)	3261.97
Variance	1.06405E+7

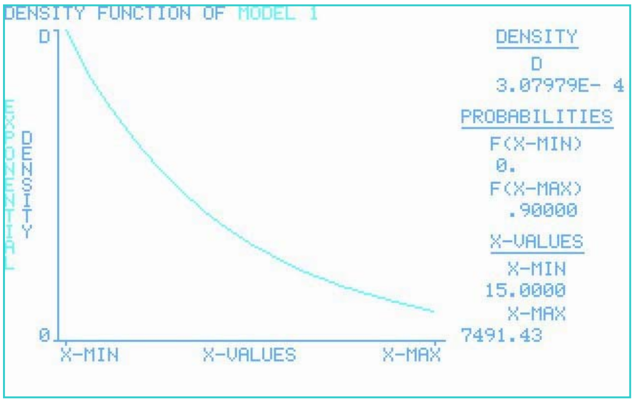

Figure C.2 The exponential distribution of cruise times for Case A.

Table C.3 The model characteristics of stay duration times for Case A

Model Characteristics	*Value*
Number of observations	2394
Minimum observation	1
Maximum observation	810.33
Mean (minutes)	236.573
Variance	5.5967E+4

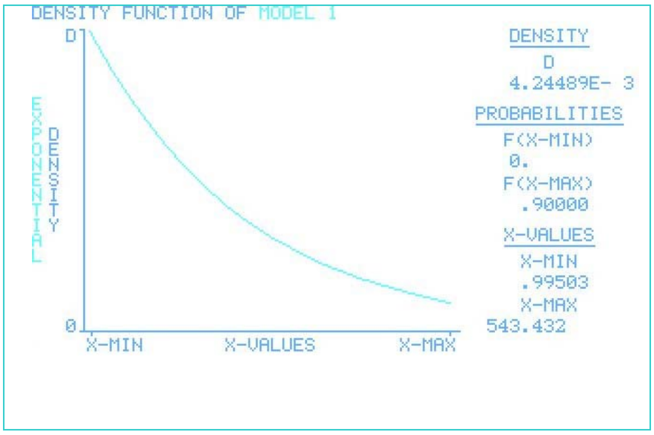

Figure C.3 The exponential distribution of stay duration times for Case A.

Table C.4 The model characteristics of interarrival times for Case B

Model Characteristics	*Value*
Number of observations	2393
Minimum observation	1
Maximum observation	240
Mean (minutes)	15.11
Variance	228.31

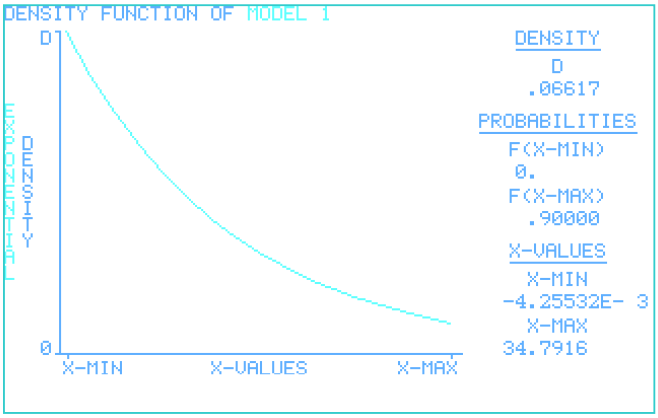

Figure C.4 The exponential distribution of interarrival times for Case B.

Table C.5 The model characteristics of cruise times for Case B

Model Characteristics	*Value*
Number of observations	2393
Minimum observation	1
Maximum observation	5.5468E+4
Mean (minutes)	3290.63
Variance	1.08282E+7

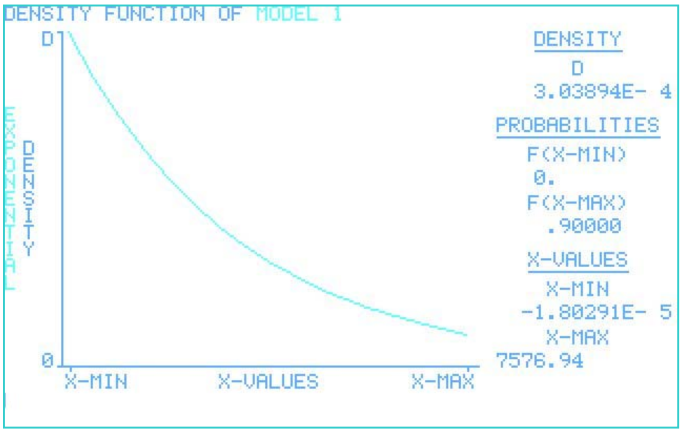

Figure C.5 The exponential distribution of cruise times for Case B.

Table C.6 The model characteristics of stay duration times for Case B

Model Characteristics	*Value*
Number of observations	2393
Minimum observation	1
Maximum observation	1525
Mean (minutes)	257.776
Variance	6.645E+4

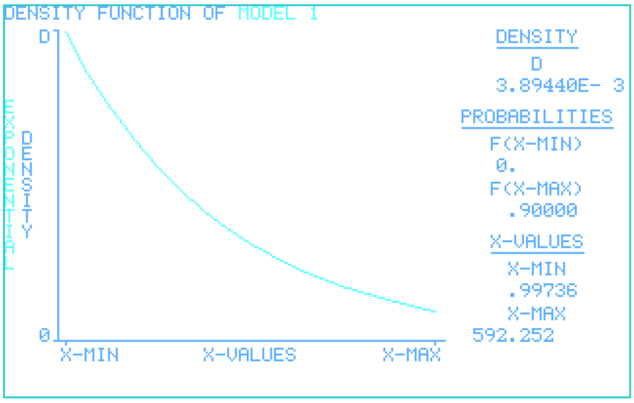

Figure C.6 The exponential distribution of stay duration times for Case B.

Table C.7 The model characteristics of interarrival times for Case C

Model Characteristics	*Value*
Number of observations	2388
Minimum observation	1
Maximum observation	237
Mean (minutes)	15.6
Variance	243.36

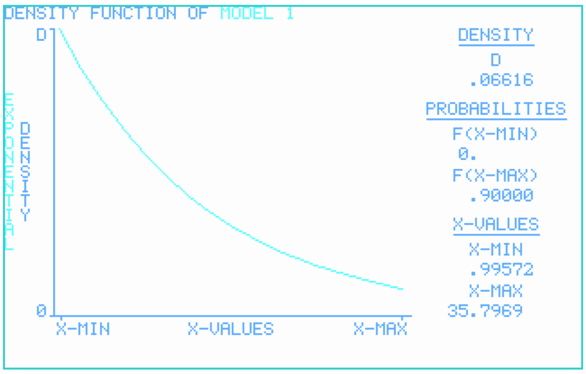

Figure C.7 The exponential distribution of interarrival times for Case C.

Table C.8 The model characteristics of cruise times for Case C

Model Characteristics	*Value*
Number of observations	2388
Minimum observation	1
Maximum observation	5.5468E+4
Mean (minutes)	3236.56
Variance	1.0475E+7

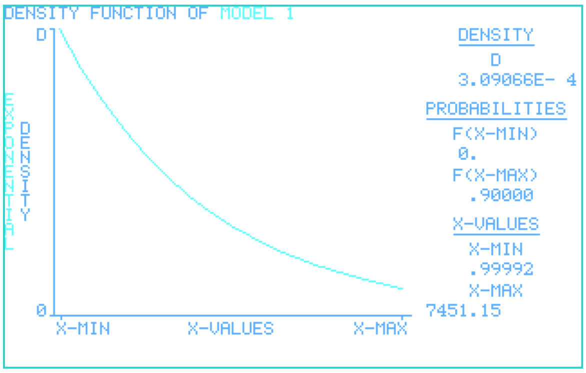

Figure C.8 The exponential distribution of cruise times for Case C

Table C.9 The model characteristics of stay duration for Case C

Model Characteristics	*Value*
Number of observations	2388
Minimum observation	1
Maximum observation	1010.50
Mean (minutes)	250.699
Variance	6.285E+4

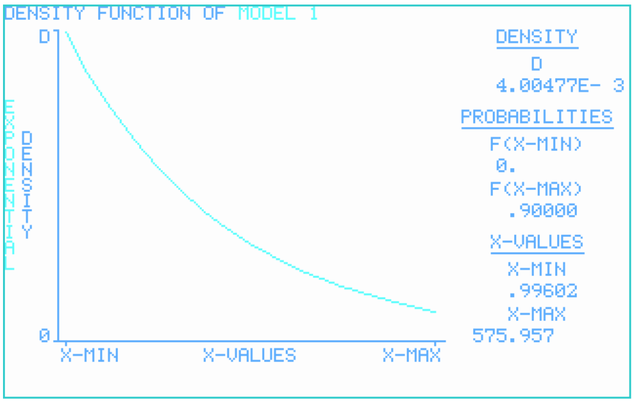

Figure C.9 The exponential distribution of stay duration times for Case C

Table C.10 The model characteristics of interarrival times for Göcek Bays

Model Characteristics	*Value*
Number of observations	20080
Minimum observation	1
Maximum observation	145
Mean (minutes)	6.012
Variance	36.1521

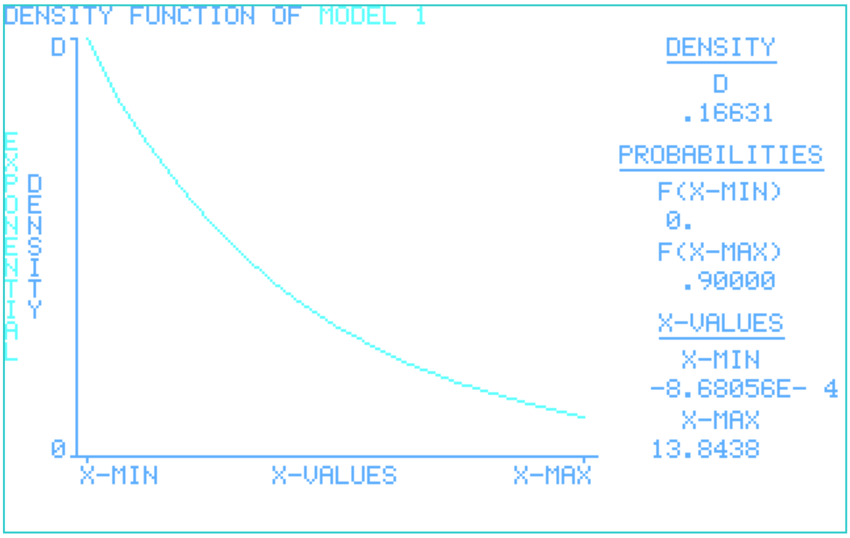

Figure C.10 The exponential distribution of interarrival times for Göcek Bays

Table C.11 The model characteristics of cruise times for Göcek Bays

Model Characteristics	*Value*
Number of observations	20080
Minimum observation	1
Maximum observation	1.6216E+4
Mean (minutes)	5112.91
Variance	2.6142E+7

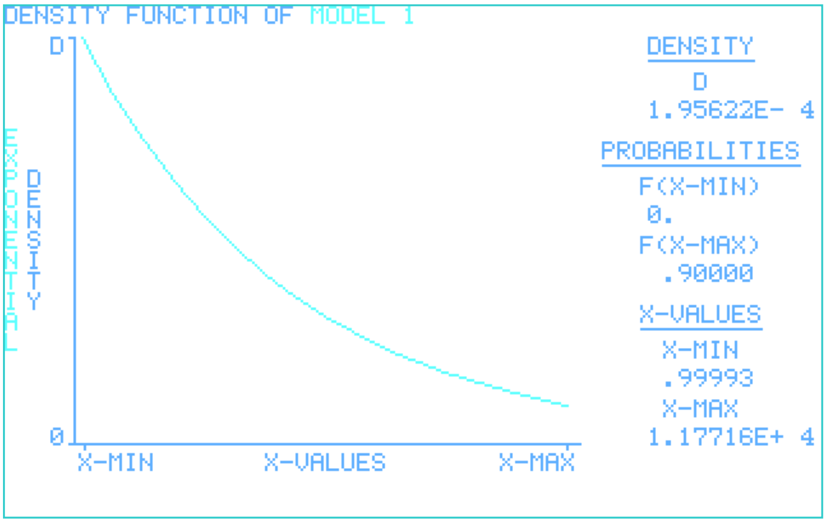

Figure C.11The exponential distribution of cruise times for Göcek Bays

Table C.12 The model characteristics of stay duration times for Göcek Bays

Model Characteristics	Value
Number of observations	20080
Minimum observation	1
Maximum observation	2702
Mean (minutes)	575.797
Variance	3.30024E+5

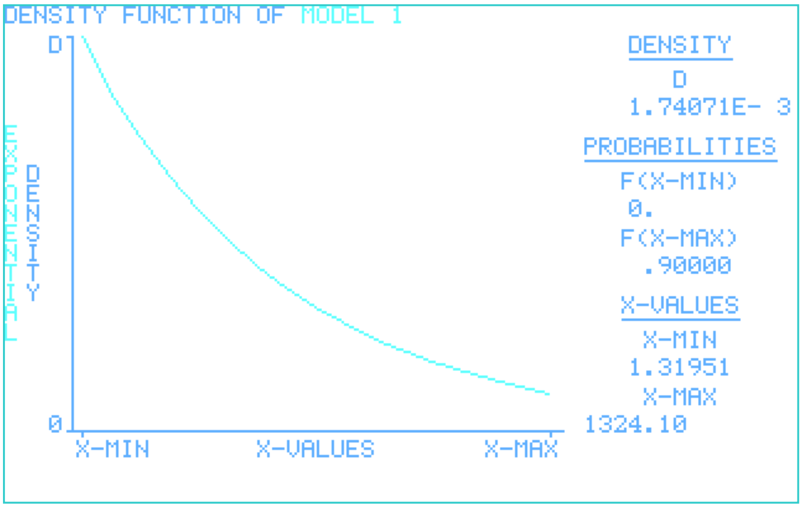

Figure C.12 The exponential distribution of stay duration times for Göcek Bays

VITA

Aslı Numanoğlu Genç was born in Ankara on July 1, 1971. She graduated from the Civil Engineering Department of the Middle East Technical University in June 1993. She received her M.Sc. degree in Civil Engineering from the Middle East Technical University in September 1996. She was a research assistant in the Civil Engineering Department of the Middle East Technical University between 1994 and 2001. She worked as the projects administrator in MEDCOAST between 2001-2003.