Su Ürünleri Dergisi (2013)
Ege J Fish Aqua Sci 30(3): 99-104 (2013)

http://www.egejfas.org
DOI: 10.12714/egejfas.2013.30.3.02

RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

Benefits of artificial reefs in Altınoluk (Northern Aegean), Turkey: Assessment of potential users' opinions via fuzzy pair wise comparison approach

Altınoluk'da (Kuzey Ege) yapay resiflerin faydaları: Bulanık eşli karşılaştırma yaklaşımı ile potansiyel kullanıcıların görüşlerinin değerlendirilmesi

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Özet: Yapay resifler, **kıyıya sahip** birçok ülkede balıkçılık yönetimi aracı olarak kullanılmaktadır. Bu çalışmanın amacı, kullanıcı grupların yapay resiflerden faydalarını değerlendirmektir. Altınoluk'da (Edremit Körfezi, Türkiye'nin Kuzey Ege Kıyısı) kullanıcıların temel potansiyel faydalarını ortaya koymak üzere Bulanık Eşli Karşılaştırma (BEK) Yöntemi kullanıldı. Sosyal, biyolojik ve ekonomik faydaları kapsayan yapay resiflerin 3 faydası ticari balıkçılar, rekreasyonel balıkçılar ve yöre sakinlerine sunuldu. Ardından, faydaların ağırlıkları BEK Yöntemi'nde ikili kıyaslamalar ile hesaplandı. Araştırma verisi ticari ve rekreasyonel balıkçılar ile yöre sakinlerini kapsayan potansiyel kullanıcılar ile soru formu kullanarak yüz yüze görüşmeler yoluyla toplandı. BEK Yöntemi'nden elde edilen sonuçlara göre, ticari balıkçılar yapay resiflerin ekonomik faydasını en yüksek düzeyde seçerken, rekreasyonel balıkçılar ve yöre sakinleri yapay resiflerin biyolojik faydasını daha yüksek düzeyde seçmiştir. Sonuç olarak, kullanıcıların algısını ölçmeden gerçekleştirilen yapay resif uygulamaları hedefleri karşılamayabilir. Yapay resiflerin ilgili gruplarının algısını ölçmeyi amaçlayan çalışmalar planlama sürecinde karar vericilere yol gösterici olur.

***Anahtar kelimeler*:** Yapay resifler, sosyal ve biyolojik faydalar, ekonomik faydalar, bulanık eşli karşılaştırma, tobit regresyon analizi.

Abstract: Artificial Reefs (ARs) are used in many coastal countries, mainly for fisheries management purposes. The aim of this study is to assess user's benefits from artificial reefs. Fuzzy Pair-Wise Comparison (FC) Method was used to introduce users' opinions on main potential benefits of ARs in Altınoluk (Edremit Bay, North Aegean Coast of Turkey). Three benefits of artificial reefs including social, biological and economic were represented to commercial fishermen, recreational fishermen and local residents. Then, the weights of the benefits were calculated by pair-wise comparisons in the FC Method. Survey data was obtained by face-to-face interviews using questionnaire forms with potential users including commercial fishermen, recreational fishermen and local residents. According to the results gathered from the FC Method, commercial fishermen ranked economic benefits of artificial reefs as highest whereas recreational fishermen and local residents were agreed on biological benefits. In conclusion, ARs deployments without measuring perception of users may not meet the objectives. Studies aiming to measure the perception of AR related groups guide decision makers during the process of planning.

***Keywords*:** Artificial reefs, social and biological benefits, economic benefits, fuzzy pair-wise comparison, tobit regression analysis.

INTRODUCTION

There is a general lack of reports or studies about the demand for artificial reefs and the socioeconomic efficacy of these projects. Most studies that have been conducted focus on areas with the greatest reef-building activity (Milon *et al.* 2000). Existing scientific literature regarding biological aspects of artificial reefs (ARs) is also not sufficient to understand AR deployments (Lök, 1995), moreover; there are limited number of studies concerning social and economic aspects of ARs of which majority conducted in United States.

As there are limited number of biological and socioeconomic studies in the world, AR practices in Turkey have increased in recent years, during which considerable attention has been paid to the limited biological and technical research that exists (Lök, 1995; Düzbastılar and Tokaç 2003; Lök and Gül, 2005; Ulaş, 2007).

Additionally, the first economic study for ARs deployments in Turkey was conducted to analyze investment in AR projects (Tiryakioğlu, 2008). This first socioeconomic study was conducted more than a decade after Lök (1995), and recently, a study of socioeconomic and management assessments of ARs including its economic value has been concluded (Tunca, 2011; Tunca *et al.*, 2012).

Although there have been 38 artificial reef projects planned in Turkey, to date, only 26 of these projects have

been completed. The main objectives of those projects were: (1) to support small-scale and traditional fisheries, (2) to create new sites for recreational fishing and diving, (3) to protect biodiversity, especially in the littoral zone, (4) to protect fish-spawning and nursery areas (e.g., Posidonia meadows) from illegal trawling. There is no long term monitoring/data collection for studies on ARs in Turkey except limited research efforts of several universities (Lök, 2012).

While conducting stakeholder's assessment via socioeconomic researches, it is significant to identify stakeholders' opinions on ARs. Evaluation of different stakeholders' opinions covering objectives is supportive to constitute future AR policy. Besides, attitudes and perceptions of relevance groups are other considerable points to identify economic and social behaviors.

The main purpose of this study is to determine stakeholders' opinions about possible benefits of ARs. Additionally, respondents' socioeconomic dimensions affecting the selection of 3 alternatives; social benefits (SS), biological benefits (BB) and economic benefits (EB) were analyzed. This study is generally aimed to contribute improvement of future AR deployments as well as provide fundamental information for decision makers.

MATERIALS AND METHOD

Study site

The research was carried out in Altınoluk which is fishing and tourism district with the 13,800 population located at northern Aegean coast of Turkey (TSI, 2011). Small-scale fishery dominates fishing activity and 95% (N=55) of fishers are organized under the Altınoluk Fishery Cooperative in the region. Altınoluk Fishery Cooperative was established in 2006 with the support and leadership of an extraordinary and innovator local fisher. The cooperative keeps 7 employees permanently during the whole year and 20 employees temporarily during the summer time due to it also runs cafe, restaurant and aquarium (Ünal *et al*., 2009).

In the Altınoluk region, 6,680 concrete blocks were proposed for deployment as a pilot project under the National Artificial Reef Program. Ministry of Food, Agriculture and Livestock allocated 5 Million TL (Turkish Lira) (1 TL = €0.4) for the two-year project of ARs deployment in Altınoluk located in North Aegean coast in Turkey. Enhancements of habitats, commercial fishing, recreational fishing and diving tourism are the main purposes of the project. Commercial fishing is identified as important economic activity in the region because fishermen's livelihood depends on the marine resources.

Data collection and analysis

Field studies were conducted to collect data from target survey groups. Target survey groups were found as 20 CF (N=55) who are the members of The Altınoluk Fishery Cooperative, 58 RF (N=400) who participate recreational fishing on shore or on a boat, and 67 (N=13,800) LR who live in the site for pilot project of National AR Project called Altınoluk. Proportional sampling size formula was used to determine sampling sizes for each group with the following formulation (Equation 1):

$$n = \frac{Np(1-p)}{(N-1)\sigma_{px}^2 + p(1-p)} \qquad \text{(Equation 1)}$$

Where n is the sample size, N is the population of each target group (CF, RF and LR), p is the contribution ratio to ARs (0.50 is fitted to reach the maximum sample size), and σ_{px}^2 is the variance.

Face-to-face interviews were conducted to collect data from each group via specific questionnaires. Representative sample size was calculated for each group according to 95% confidence interval and 5% tolerances (Miran, 2003).

Fuzzy Pair-Wise Comparison Methodology

With the Fuzzy Pair-Wise Comparison (FC) Methodology, it was aimed to put forward results on users' priorities about effects of ARs by making pair-wise comparisons among three benefits including social, biological and economic. FC Method shows similarity with the simple pair-wise comparison. For each of them, two alternatives are compared by respondents. In addition, priority levels of one alternative over another are put forward with FC methodology.

In this method, unlike numerical size estimation method, numerical value of each aim is based on compared objectives' cluster. Partial membership is central concept of fuzzy set theory. In the standard membership theory, a cluster is accepted well-described only if each element of universal set is element (1) or is not element (0) of set in question. In partial membership, fuzzy set is take part in [0,1] closed interval. Therefore, one element of cluster is given a value between 0 and 1. Fuzzy set theory is based on uncertain preferences. In this method, first stage is to gather data. In the data gathering phase the diagram is used below in Figure 1 (Günden and Miran, 2007).

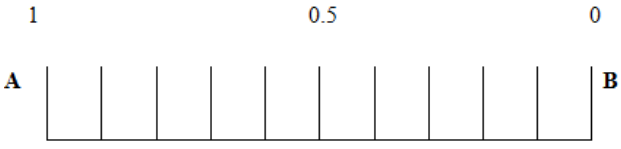

Figure 1. Fuzzy pairing approach used for comparison between A and B

Alternatives A and B are placed points on opposite sides of line. Respondents are required to put 'X' sign on line for the purpose of state self preference. While comparing alternatives; if which alternative is close to 'X' signal, it can be said that alternative close to 'X' is preferred to other alternative. Preference level of A to B, RAB, is measured distance from 'X' to A. Total distance from A to B is 1.

If RAB<0.5 B>A

If RAB=0.5 A≈B

If RAB>0.5 A>B

In the case of certain preferences RAB=1 or RAB=0

Number of paired comparisons concerning alternatives, K, is defined as:

$$K = n*(n-1)/2 \qquad \text{(Equation 2)}$$

Here, n states number of objectives. For each paired comparison R_{ji} (i≠j) is obtained. Measurement of preference level of j according to i: R_{ji}=1 - R_{ij}.

Second stage is to compose fuzzy preference matrix. After data is gathered and operated through stages above, fuzzy preference matrix of respondents can be composed. For this below explanations are useful:

$$R_{ij} = \begin{cases} 0 & eger\ i = j\ \forall i, j = 1,...,n \\ r_{ij} & eger\ i \neq j\ \forall i, j = 1,...,n \end{cases}$$

This method can be expressed by ixj dimensional fuzzy preference matrix (R).

$$R = \begin{bmatrix} 0 & r_{12} & r_{13} & . & . & . & r_{1j} \\ r_{21} & 0 & r_{23} & . & . & . & r_{2j} \\ r_{31} & r_{32} & . & . & . & . & . \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ . & . & . & . & . & 0 & r_{i-1\,j} \\ r_{i1} & r_{i2} & . & . & . & r_{ij-1} & 0 \end{bmatrix}$$

Third stage of method is to measure fuzzy weights. It is possible to calculate preference level (*I*) concerning each alternative from respondents' preference matrix. Following formula is used for measurement of preference density of each alternative separately.

$$I_j = 1 - \left(\sum_{i=1}^{n} R_{ij}^2 / (n-1) \right)^{1/2}$$

Last stage is to arrange alternatives. I_j values vary between 0 and 1. It is important to know how much the value close to 1, because preference density becomes bigger if it becomes close to 1. After 'I_j's are gathered, alternatives are put in order from most effective to least effective (Günden and Miran, 2007; Günden *et al.*, 2008).

Tobit model

TREG model is an extension of probit regression (PREG) model. It is placed among limited dependent variable models (Gujarati, 2008). In this model, dependent variable, Y holds an asymmetry between positive and negative or 0 values (Ramanathan, 1998). Common formulation of TREG model, as is PREG model, is given based on an index function below (Greene, 2003).

$Y_i^* = ß'x_i + u_i$, If $Y_i^* <= 0$, $Y_i = 0$; If $Y_i^* < 0$, $Y_i^* = 0$

As is in PREG model, estimators in PREG model are calculated by maximum likelihood method (Gujarati, 2008).

RESULTS

Main possible effects of ARs

Priorities for SB, BB and EB given by CF were found as 0.26, 0.45 and 0.62, orderly. CF was found to have high tendency to choose EB preference which may be expressed by livelihood of CF in the region is depended on fisheries. RF gave higher priority to BB (0.60) compared to SB and EB which were weighted as nearly equal priorities (0.40 and 0.35, orderly). Lastly, like in the case of RF, LR also indicated that ARs have higher BB compared to SB and EB. According to these results, ARs are perceived mostly as biological tools by RF and LR whereas, CF is perceived ARs as an economic tool (Table 1).

Table 1. Priorities of alternatives given by CF, RF and LR

	Alternatives	Mean	SD	Min	Max
CF	SB	0.26	0.21	0	0.65
	BB	0.45	0.29	0	1.00
	EB	0.62	0.25	0.29	1.00
RF	SB	0.40	0.24	0.05	1.00
	BB	0.60	0.31	0	1.00
	EB	0.35	0.28	0	1.00
LR	SB	0.34	0.19	0	1.00
	BB	0.65	0.24	0.10	1.00
	EB	0.38	0.21	0	0.90

Number of observations: 67
SD, Standard Deviation; Min, Minimum; Max, Maximum

Tobit Regression Analysis

TREG analysis was used to find out respondents' characteristics affecting preference of compared variables; SB, BB or EB of ARs. Dependent and independent variables used in the TREG model were defined in table 2. Age variable signifies different age groups of respondents as 1: Under 25, 2: Between 26-45, 3: Between 46-60, 4: Higher than 61. Edu variable describes respondents' level of education in four groups as 1: 1-5 years, 2: 6-8 years, 3: 9-11 years, 4: 12 years and higher. SocSec, as a dummy variable, represents the ownership of a social security of respondents by close-ended Yes/No answers. Inc variable indicates the respondents' monthly income by eight different groups as 1: Lower than 500 TL, 2: Between 501-1,000 TL, 3: Between 1,001-1,500 TL, 4: Between 1,501-2,000 TL, 5: Between 2,001-2,500 TL, 6: Between 2,501-3,000 TL, 7: Between 3,001-3,500 TL, 8: Higher than 3,500 TL. While ResInd variable exhibits the number of individuals that the respondents are responsible to take care of, FamPop demonstrates the total family population of respondents. Other dummy variables including OwnHouse; respondents' house ownership status, HeardReef; Respondents' status of knowledge about AR concept and *HeardPro;* Respondents' status of knowledge about national AR project are assessed by close ended Yes/No options. *NEP* shows respondents' environmental attitudes calculated by New Environmental (NEP) Paradigm Scale, with *1-5 scale, 1 is Absolutely non-environmentalist; 5: Absolutely environmentalist. TotRecDay and AfReef, respectively,* shows the current number of days in a year that respondents attend to a recreational activity and the number of future visits that stated to be conducted by respondents' after AR deployment. Lastly, three dependent variables which were also compared in FC method, *LR_SB, LR_BB and LR_EB* indicates weighted score given by LR for SB, BB and EB of ARs by 0-10 scale of pair-wise comparison (Table 2).

Descriptive statistics of dependent and independent variables used for TREG models were demonstrated in table 3. Most of respondents are included in ages between 26 and 45, whereas average education level is 9-11 years of education. 81% of respondents have social security and monthly incomes of respondents are averagely between 500-1,000 TL. The number of individuals that the respondents are responsible to take care of and the total number of family population of respondents are found as below 1.

Table 2. Dependent and independent variables used for TREG models

	Variable	Definition
Independent Variables	***Age***	*Respondents' age (1: ≤25, 2: 26-45, 3: 46-60, 4:61≤)*
	Edu	*Respondents' education level (1:1-5, 2:6-8, 3:9-11, 4:12≤)*
	SocSec	*Social security status of respondents (1:Yes; 0:No)*
	Inc	*Respondents' monthly income (1: ≤¨500, 2: ¨501-1,000, 3: ¨1,001-1,500, 4: ¨1,501-2,000, 5: ¨2,001-2,500, 6: ¨2,501-3,000, 7: ¨3,001-3,500, 8: ¨3,500≤)*
	ResInd	*The number of individuals that the respondents are responsible to take care of*
	FamPop	*Respondents' total family population*
	OwnHouse	*Respondents' house ownership status (1:Yes; 0:No)*
	HeardReef	*Respondents' status of knowledge about AR concept (1:Yes; 0:No)*
	HeardPro	*Respondents' status of knowledge about national AR project (1:Yes; 0:No)*
	NEP	*Respondents' Environmental attitudes under New Environmental Paradigm (NEP) (1:Absolutely non-environmentalist; 5:Absolutely environmentalist; 1-5 scale)*
	TotRecDay	*Respondents' total number of recreational days in one year (trip, scuba diving or recreational fishing)*
	AfReef	*Number of visits that respondents are willing to attend after reef deployment*
Dependent Variables	***LR_SB***	*Weighted score for social benefits of ARs given by LR (0-10 Scale)*
	LR_BB	*Weighted score for biological benefits of ARs given by LR (0-10 Scale)*
	LR_EB	*Weighted score for economic benefits of ARs given by LR (0-10 Scale)*

55% of respondents have house, while 46% of them heard AR concept before, 91% do not have any idea about proposed AR project. Respondents are found to be mildly environmentalist via New Environmental Paradigm Scale. The yearly total recreational days of respondents are represented as 41.37±66.98, 18.18±22.65. Lastly, respondents gave highest priority to the *BB* with 0.65 in 0-1 scale while *EB and SB* got 0.38 and 0.34 values, orderly (Table 3).

Only CF was accounted to put forward the relevance of variables affecting rating for social, biological and economic dimensions. Therefore, in Table 4, three Tobit model were calculated to represent relationship between dependent and

independent variables. First, variables affecting selection of LR_Soc variable was found as positively correlated with *SocSec* variable. Positive relationship was also found between *AfReef* and *LR_Bio* variables. Lastly, *LR_Econ* variable is negatively correlated with *ResInd* variable and positively correlated with *FamPop* variable. Lastly, for commercial fishing as a source of livelihood, as expected, CF gave first place to economic benefits alternative; however, RF and LR ranked firstly biologic benefits alternatives of AR. (Table 4).

Table 3. Descriptive statistics of dependent and independent variables used for tobit models

Variable	Mean	SD	Min	Max
Age	2.25	0.70	1	4
Edu	2.84	0.96	1	4
SocSec	0.81	0.40	0	1
Inc	1.52	0.59	0	3
ResInd	0.22	0.42	0	1
FamPop	0.48	0.50	0	1
OwnHouse	0.55	0.50	0	1
HeardReef	0.46	0.50	0	1
HeardPro	0.09	0.29	0	1
NEP	3.89	0.46	2.77	4.69
TRA	41.37	66.98	0	300
AfReef	18.18	22.65	0	1045
LR_Soc	0.34	0.19	0	1.00
LR_Bio	0.65	0.24	0.10	1.00
LR_Econ	0.38	0.21	0	0.90

Number of observations: 67
SD, Standard Deviation; Min, Minimum; Max, Maximum

DISCUSSION AND CONCLUSION

This study is mainly aimed to explore users' possible benefits from ARs using FC method in Altınoluk, Turkey.

Besides, the factors affecting perception of the benefits of ARs are regressed for LR via TREG analysis.

EB of ARs was ranked as first by CF which explains CF's dependence on the marine resources as a source of livelihood as one of the benefits of ARs is considered as fisheries enhancement. However, RF gave higher priority to BB (0.60) compared to SB and EB which were weighted as nearly equal priorities (0.40 and 0.35, orderly). According to this result, RF who are both not attending a commercial fishing activity and also the second top visitor to the AR site in question were supposed to give the most objective priority on benefits of ARs. Lastly, LR also indicated that ARs have higher BB (0.65) compared to SB (0.34) and EB (0.38).

LR who has a social security ranked the SB of ARs, mostly. In addition, positive relationship was also found between the numbers of visits that LR is willing to attend after AR deployment and priority given for BB variables by LR. Moreover, priority given for EB of ARs was found as negatively correlated with the number of individuals that LR responsible for and positively correlated with the total family population of respondent. In conclusion, under the FC method, commercial fishing as a source of livelihood for CF, EB of ARs got first choice by CF, however; RF and LR ranked BB of AR on the top.

In conclusion, understanding the stakeholders of ARs before and after reef deployment by using methods like FC is supportive to reach the objectives of ARs. This study proved the possibility of using FC method to analyze benefits of ARs through better decision making process for the management of ARs.

Table 4. TREG results of variables.

Dependent Variables	LR_Soc		LR_Bio		LR_Econ	
Independent Variables	**Coeff**	**SE**	**Coeff**	**SE**	**Coeff**	**SE**
Age	-0.03	0.04	0.09	0.06	0.00	0.04
Education	0.02	0.03	-0.02	0.04	0.01	0.03
SocSec	0.19***	0.07	-0.15	0.09	-0.06	0.07
Income	-0.00	0.05	0.01	0.07	0.03	0.05
ResInd	-0.07	0.08	-0.16	0.11	0.19**	0.08
Fampop	0.08	0.06	0.09	0.09	-0.18***	0.07
OwnHouse	-0.01	0.05	0.13	0.08	-0.09	0.06
HeardReef	-0.04	0.06	0.05	0.09	-0.05	0.07
HeardPro	0.01	0.09	0.03	0.13	-0.03	0.09
NEP	0.02	0.06	0.08	0.09	-0.11	0.06
TRA	-0.00	0.00	0.00	0.00	0.00*	0.00
AfReef	0.00	0.00	0.00*	0.00	0.00	0.00
Constant	0.14	0.27	0.25	0.37	0.85	0.28
Sigma	10.19	0.02	0.26	0.03	0.19	0.02
Logarithmic Likelihood	9.64		-16.37		7.65	
Likelihood Ratio Chi-Squared	12.44		9.66		16.76	
Probability > Chi-Squared	0.41		0.65		0.16	

*** Coefficient significant at $P \leq 0.05$ or better. ** Coefficient significant at $P \leq 0.05$ or better.
* Coefficient significant at $P \leq 0.10$ or better. Number of observations: 67; SE, Standard Error; Coeff, Coefficient.

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