MARINE SCIENCE AND TECHNOLOGY BULLETIN

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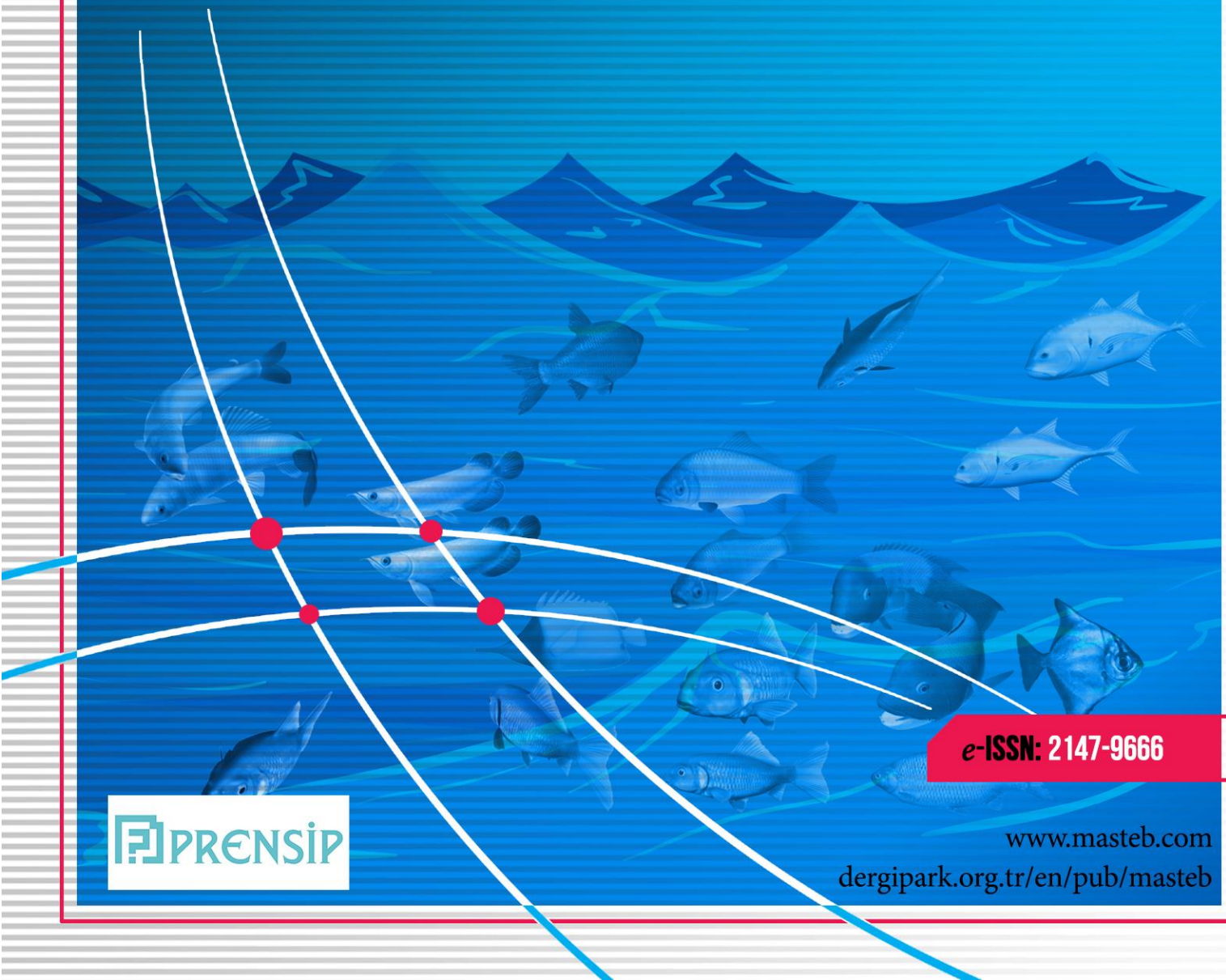

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Research areas include (but not limited):

Marine Sciences
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  - Results
  - Discussion
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  - Acknowledgement (if required)
  - Compliance with Ethical Standards
    - Authors' Contributions
    - Conflict of Interest
    - Statement on the Welfare of Animals
    - Statement of Human Rights
    - Data availability
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Hampton, S., Rabagliati, H., Sorace, A., & Fletcher-Watson, S. (2017). *Autism and bilingualism: A qualitative interview study of parents' perspectives and experiences*. PsyArXiv, *Preprint*. https://doi.org/10.31234/osf.io/76xfs

Hetland, B., McAndrew, N., Perazzo, J., & Hickman, R. (2018). *A qualitative study of factors that influence active family involvement with patient care in the ICU: Survey of critical care nurses*. PubMed Central, *Preprint*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5736422/?report=classic

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Brown, C., Laland, K., & Krause, J. (Eds.) (2011). Fish Cognition and Behavior. 2nd ed. Wiley-Blackwell.

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An old tradition and a new technology have converged to make possible an unprecedented public good. The old tradition is the willingness of scientists and scholars to publish the fruits of their research in scholarly journals without payment, for the sake of inquiry and knowledge. The new technology is the internet. The public good they make possible is the worldwide electronic distribution of peer-reviewed journal literature and completely free and unrestricted access to it by all scientists, scholars, teachers, students, and other curious minds. Removing access barriers to this literature will accelerate research, enrich education, share the learning of the rich with the poor and the poor with the rich, make this literature as useful as it can be, and lay the foundation for uniting humanity in a common intellectual conversation and the quest for knowledge.

The literature that should be freely accessible online is that which scholars give to the world without expectation of payment. Primarily, this category encompasses their peer-reviewed journal articles, but it also includes any unreviewed preprints that they might wish to put online for comment or to alert colleagues to important research findings. There are many degrees and kinds of wider and easier access to this literature. By "open access" to this literature, we mean its free availability on the public internet, permitting any users to read, download, copy, distribute, print, search, or link to the full texts of these articles, crawl them for indexing, pass them as data to software, or use them for any other lawful purpose, without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. The only constraint on reproduction and distribution, and the only role for copyright in this domain, should be to give authors control over the integrity of their work and the right to be properly acknowledged and cited.

While the peer-reviewed journal literature should be accessible online without cost to readers, it is not costless to produce. However, experiments show that the overall costs of providing open access to this literature are far lower than the costs of traditional forms of dissemination. With such an opportunity to save money and expand the scope of dissemination at the same time, there is today a strong incentive for professional associations, universities, libraries, foundations, and others to embrace open access as a means of advancing their missions. Achieving open

access will require new cost recovery models and financing mechanisms, but the significantly lower overall cost of dissemination is a reason to be confident that the goal is attainable and not merely preferable or utopian.

To achieve open access to scholarly journal literature, we recommend two complementary strategies.

I. Self-Archiving: First, scholars need the tools and assistance to deposit their refereed journal articles in open electronic archives, a practice commonly called, self-archiving. When these archives conform to standards created by the Open Archives Initiative, then search engines and other tools can treat the separate archives as one. Users then need not know which archives exist or where they are located in order to find and make use of their contents.

II. Open-access Journals: Second, scholars need the means to launch a new generation of journals committed to open access, and to help existing journals that elect to make the transition to open access. Because journal articles should be disseminated as widely as possible, these new journals will no longer invoke copyright to restrict access to and use of the material they publish. Instead they will use copyright and other tools to ensure permanent open access to all the articles they publish. Because price is a barrier to access, these new journals will not charge subscription or access fees, and will turn to other methods for covering their expenses. There are many alternative sources of funds for this purpose, including the foundations and governments that fund research, the universities and laboratories that employ researchers, endowments set up by discipline or institution, friends of the cause of open access, profits from the sale of add-ons to the basic texts, funds freed up by the demise or cancellation of journals charging traditional subscription or access fees, or even contributions from the researchers themselves. There is no need to favor one of these solutions over the others for all disciplines or nations, and no need to stop looking for other, creative alternatives.

Open access to peer-reviewed journal literature is the goal. Self-archiving (I.) and a new generation of open-access journals (II.) are the ways to attain this goal. They are not only direct and effective means to this end, they are within the reach of scholars themselves, immediately, and need not wait on changes brought about by markets or legislation. While we endorse the two strategies just outlined, we also encourage experimentation with further ways to make the transition from the present methods of dissemination to open access. Flexibility, experimentation, and adaptation to local circumstances are the best ways to assure that progress in diverse settings will be rapid, secure, and long-lived.

The Open Society Institute, the foundation network founded by philanthropist George Soros, is committed to providing initial help and funding to realize this goal. It will use its resources and influence to extend and promote institutional self-archiving, to launch new open-access journals, and to help an open-access journal system become economically self-sustaining. While the Open Society Institute's commitment and resources are substantial, this initiative is very much in need of other organizations to lend their effort and resources.

We invite governments, universities, libraries, journal editors, publishers, foundations, learned societies, professional associations, and individual scholars who share our vision to join us in the task of removing the barriers to open access and building a future in which research and education in every part of the world are that much more free to flourish.

For various reasons, this kind of free and unrestricted online availability, which we will call open access, has so far been limited to small portions of the journal literature. But even in these limited collections, many different initiatives have shown that open access is economically feasible, that it gives readers extraordinary power to find and make use of relevant literature, and that it gives authors and their works vast and measurable new visibility, readership, and impact. To secure these benefits for all, we call on all interested institutions and individuals to help open up access to the rest of this literature and remove the barriers, especially the price barriers, that stand in the way. The more who join the effort to advance this cause, the sooner we will all enjoy the benefits of open access.

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Double-Blind Review and Evaluation Process

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The views of referees have a decisive place in the publication quality of *Marine Science and Technology Bulletin*.

Marine Science and Technology Bulletin uses the double-blind review method, which means that both the reviewer and author identities are concealed from the reviewers, and vice versa, throughout the review process, in the evaluation process of all studies. For this reason, the authors are asked to erase their names while uploading the articles to the system.

All the studies submitted to *Marine Science and Technology Bulletin* are evaluated by double-blind review method according to the following steps.

1. Initial Evaluation Process

The studies submitted to *Marine Science and Technology Bulletin* are first evaluated by the editor. At this stage, studies that are not in line with the aim and scope of the journal, are weak in terms of language and narrative rules in English contain scientifically critical mistakes, are not original worthy and cannot meet publication policies are rejected. Authors of rejected studies will be notified within one month at the latest from the date of submission. Eligible studies are sent to the field editor to which the study is relevant for pre-evaluation.

2. Pre-Evaluation Process

In the pre-evaluation process, the field editors examine the studies, introduction and literature, methods, findings, results, evaluation

and discussion sections in detail in terms of journal publication policies, scope and authenticity of study. Study which is not suitable as a result of this examination is returned to the author with the field editor's evaluation report within four weeks at the latest. The studies which are suitable for the journal are passed to the referee process.

3. Referee Process

The studies are sent to the referees according to their content and the expertise of the referees. The field editor examining the study may propose at least two referees from the pool of Marine Science and Technology Bulletin Advisory Board or referee pool according to their field of expertise or may propose a new referee appropriate to the field of study.

The editors evaluate the referee's suggestions coming from the field editor and the studies are submitted to the referees. Referees are obliged to guarantee that they will not share any process or document about the study they are evaluating.

4. Referee Evaluation Process

The period given to the referee for the evaluation process is 15 days. Proposals for corrections from referees or editors must be completed by the authors within 1 month according to the "correction instruction".

Referees can decide on the suitability of the study by reviewing the corrections and may also request multiple corrections if necessary.

Referee Reports

Referee evaluations are based in general on the originality of the studies, the method used, and the conformity with the ethical rules, the consistent presentation of the findings and results, and the examination of the literature.

This review is based on the following elements:

1. Introduction and Literature: The evaluation report contains the presentation and purpose of the problem addressed in the study, the importance of the topic, the scope of the relevant literature, the timeliness and the originality of the study.

2. Methodology: The evaluation report includes information on the suitability of the method used, the choice and characteristics of the research group, validity and reliability, as well as on the data collection and analysis process.

3. Findings: The evaluation report includes opinions on the presentation of the findings obtained in the frame of the method, the correctness of the analysis methods, the aims of the research and the consistency of the findings, the presentation of the required tables, figures and images and the conceptual evaluation of the tests used.

4. Evaluation and discussion: The evaluation report includes the opinion on the subject based on findings, relevance to research questions and hypotheses, generalizability and applicability.

5. Conclusion and suggestions: The evaluation report contains the opinion on the contributions to the literature, future studies and recommendations for the applications in the area.

6. Style and narration: The evaluation report includes compatibility of the headline with the content, appropriate use of English in the study, and references in accordance with the language of the study and APA rules.

7. Overall evaluation: The evaluation report contains opinion on the authenticity of the study as a whole, its contribution to the educational literature and the applications in the area.

The journal considers that scientists should avoid research which kills or damages any species of fish which, using IUCN criteria, is regarded as threatened or is listed as such in a Red Data Book appropriate for the geographic area concerned. In accordance with this view, papers based on such research will not be accepted by the Journal, unless the work had clear conservation objectives.

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RESEARCH ARTICLE

Population structure, exploitation status, and prospects of brown meagre *Sciaena umbra* Linnaeus, 1758 from the Turkish coast of the Black Sea

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ABSTRACT

The brown meagre (*Sciaena umbra* Linnaeus, 1758) population has experienced dramatic population declines, and it was regionally assessed as "Near Threatened" in the Mediterranean. In this study, the current status of brown meagre populations in the Black Sea was evaluated by estimating growth and mortality rates based on age readings from the otolith. All specimens were collected by commercial trammel nets between March 2019 and February 2020 in the Turkish coast of the Black Sea. A total of 324 brown meagre were sampled during the study period, ranging in age from 0 to 26. The peak spawning season of the species was from June to July. The Von Bertalanffy growth parameters of (L_∞ = 54.15, k = 0.14 yr^{-1}, t_0 = -3.11) supports previous studies and suggests that brown meagre is a long-lived and slow-growing species. The exploitation ratio of 0.53 for females and 0.47 for males. Life-history features and mortalities indicate that the brown meagre has relatively high fertility but may be undefended to intense fishing pressure. However, the impact of overfishing, pollution and climate change can have increasingly detrimental effects on the overall population size of this population.

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Introduction

The brown meagre (*Sciaena umbra* Linnaeus, 1758) occurs in the Eastern Atlantic, Mediterranean, and the Black Sea (Chao & Trewavas, 1990). It is a demersal species inhabiting coastal areas, mostly on hard substrata such as rocks and rock cavities and among seagrass meadows (Harmelin, 1991). *S. umbra* is a slow-growing and long-lived species which can live for up to 31 years (Morat et al., 2017). Individuals mature at 3–4 years of age and reproduce in summer (Grau et al., 2009). The small-scale

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artisanal fishery frequently prefers brown meagre, because of its economic value (Engin & Seyhan, 2009). In Türkiye, otoliths are pulverized and used in the treatment of urinary tract infections (Frimodt, 1995), this has not been proven (Ergin et al., 2017). The brown meagre fisheries mostly occurred by trammel nets, hand lines in the Black Sea, and commercial scorpion-fish nets as bycatch (Aydın et al., 2015). Spearfishing is also common in brown meagre on the Black Sea coast. Individuals are extremely susceptible to spearfishing as it is slow-moving and accessible (Grau et al., 2009). The stock abundance of brown meagre in the world experienced a rapid decline in the last decades, and it has become a protected species (Chauvet, 1991). FAO catch statistics the overall trend shows a gradual increase in landings since the early 2000s (FAO, 2019). Chater et al. (2018) reported that this species is slightly over-exploited in the Gulf of Tunis. *S. umbra* has been listed as "Near Threatened" in the IUCN Red List of Threatened Species due to the decreasing population trend in the Mediterranean Sea (Chao, 2020). With the decrease of the brown meagre populations along the Mediterranean Sea, brown meagre is protected with Annexe III (Protected Fauna Species) of the Barcelona and Bern Conventions. In Türkiye, there is only a length prohibition to protect individuals smaller than 35 cm (Directorate General of Fisheries and Aquaculture, 2020). Several studies have been published on the population status of brown meagre from different regions (Chauvet, 1991; Chakroun-Marzouk & Ktari, 2003; Ragonese et al., 2004; Artüz, 2006; La Mesa et al., 2008; Engin & Seyhan, 2009; Chater et al., 2018; Aydın & Bodur, 2021). Despite its economic and ecological importance, studies on brown meagre populations are either sparse or lacking in the world and the Black Sea (Froese & Pauly, 2022). The objective of this work was to reveal the current status of the populations of brown meagre on the Turkish coast of the Black Sea and examine it in terms of multi population parameters. This study provides valuable assumptions about the future of populations by evaluating the growth, mortality rates, and exploitation of brown meagre for female and male individuals together, as opposed to reports from previous studies.

Material and Methods

Study Area, Sampling and Laboratory Routines

This study was conducted on the Turkish coast of the Black Sea (between 41°37'13.2" N–36°07'06.8" E and 40°54'54.0" N–40°09'41.0" E) between March 2019 and February 2020 (Figure 1). Specimens were monthly captured by commercial trammel nets with various mesh sizes (inner panel: 20 – 120 mm; outer panel: 120 – 240 mm) in rocky and hard substrata regions at 0–30 m depth.

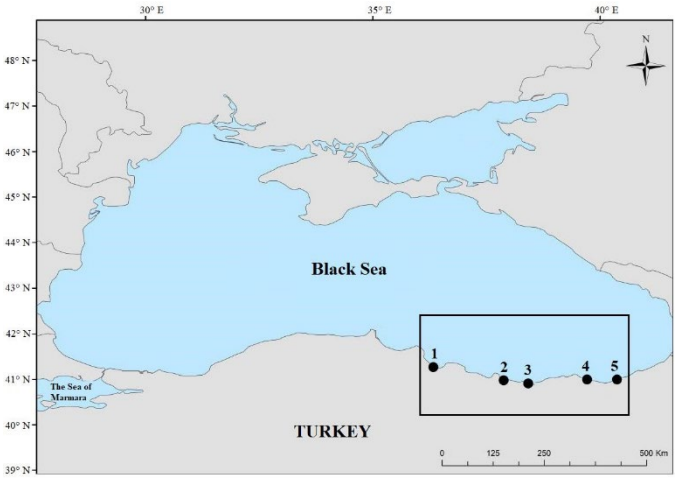

Figure 1. Study area from the Turkish coast of the Black Sea (1: Samsun, 2: Ordu, 3: Giresun, 4: Trabzon, 5: Rize)

Total length (TL) was measured to the nearest 0.1 mm using an ichthyometer, and total weight (W) was taken by an electronic balance of 0.01 g accuracy. Sex determination was made by macroscopic gonadal examination according to the shape and color of gonads (West, 1990; Murua et al., 2003). Age determined was based on otolith readings and confirmed by length frequency analysis. Sagittal otoliths embedded in polyester resin were cut through the 0.375 mm cross-section from the nucleus using a low-speed saw (Buehler Isomet) equipped with a diamond blade. Sectioned otoliths were placed on glass slides and analyzed at 20× magnification with a calibrated ocular microscope using imaging software (Nikon NIS Elements 3.0) (Secor et al., 1992). Age readings were completed by two readers without reference to the size or catch details for each fish. The index of average percentage error (IAPE) (Beamish & Fournier, 1981) was calculated to compare readings. For IAPE values equal to or greater than 10% (13 samples), a third reading was performed. There was no IAPE greater than or equal to 10% after third readings. All otoliths were included in the dataset. The otolith image of the oldest female individual determined for the Black Sea population is given in Figure 2.

Data Analysis

The overall sex ratio (M:F) was calculated as the proportion of males to females, and the Chi-squared test (χ^2) was used to detect the variation from the expected ratio (1:1) (Düzgüneş et al., 1983). The length-weight relationship (LWR) was calculated using the Eq. (1):

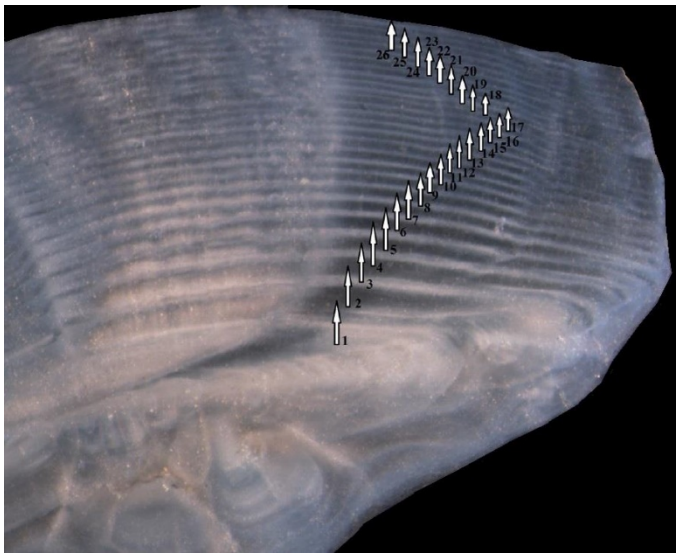

Figure 2. Surface view of the sagittal otoliths of a 26-year-old female *Sciaena umbra* captured in the Fener Island, Fatsa, Ordu (41°03'41.2" N – 37°30'37.2" E).

$$W = a\,L^b \tag{1}$$

where W is the total body weight (g), L is the TL measurement (cm), a is the intercept, and b is the slope (Le Cren, 1951). The b value of sexes was checked by Pauly t-test (Zar, 1999) in order to approve if it was importantly different from the isometric growth (H_0: $b = 3$). Fulton's condition factor (Kn) was estimated equation as per formula given Eq. (2):

$$Kn = \frac{W \times 100}{L^3} \tag{2}$$

where W is the total body weight (g), L is the TL measurement (cm). The von Bertalanffy growth functions (VBGF) were calculated for each sex group by using Eq. (3):

$$L_t = \mathrm{L}_\infty\,(1 - \mathrm{e}^{-\mathrm{k}(\mathrm{t}-\mathrm{t}_0)}) \tag{3}$$

where L_t is the mean length at age t, L_∞ is asymptotic length (cm), t is age (year), k is the growth coefficient (year^{-1}), and t_0 is the hypothetical age at which the length is zero (year) (Beverton & Holt, 1957; Pauly, 1983). Considering the growth parameters, the Phi-prime growth performance index (φ') makes it possible to compare the growth of different populations estimated using Eq. (4) (Pauly & Munro, 1984):

$$\varphi' = \log K + 2\log L_\infty \tag{4}$$

The total mortality (Z) was computed using and age-based catch curve analysis (Chapman & Robson, 1960):

$$\log\left(\frac{N_t}{\Delta t}\right) = a + b_t \tag{5}$$

where N is the number of samples of relative age (t), Δt is the time needed to grow from the lower (t_1) to the upper (t_2) limit, and t is the relative age suitable to the midrange of the length class. The absolute value of the curve's slope (b) gives Z. Natural mortality (M) was calculated using the length-growth data by the multiple regression (Pauly, 1980):

$$\log_{10} M = -0.0066 - 0.279\,\log_{10} L_\infty + 0.6543\,\log_{10}(K) + 0.4634\,\log_{10}(T) \tag{6}$$

where M is the natural mortality, L_∞ (TL, cm) is the asymptotic size of the samples and K samples growth coefficient. The value of T is the annual mean temperature (in °C) of the seawater. Fishing mortality (F) was estimated in Eq. (7):

$$F = M - Z \tag{7}$$

Exploitation ratio (E) was calculated, which permits one to (roughly) define if a stock is overfished or not, on the assumption that the ideal value is approximately equal to 0.5 according to Eq. (8):

$$E = \frac{F}{Z} \times 100 \tag{8}$$

The spawning period was estimated by monthly analysis of gonadosomatic index changes:

$$GSI = (W_g \times (W - W_g)^{-1}) \times 100 \tag{9}$$

where W_g is the gonad weight (g), and W is the total weight (g) of fish (Avşar, 2005). The gravimetric process was used for fecundity calculations (Bagenal & Braum, 1978; Murua et al., 2003). This involves subsampling eggs by weighing from the gonad for fecundity estimation. In order to calculate fecundity (F), all oocytes in each ovary sub-sample were counted directly under stereoscopic and calculated according to Bagenal (1978). Egg diameters were measured across the longest axis to the nearest 0.01 µm and calculated by averaging the diameters for each batch (Jakobsen et al., 2009).

The descriptive statistics of the morphometric features were calculated using the statistics software SPSS v26.0. The normality of the variables was checked using the Kolmogorov-Smirnov test, depending on the sample size. Because the data were not normally distributed, statistical analyses by sexes were compared using the non-parametric Mann-Whitney U test. Non-parametric Krusukal-Wallis H test was used to test the

difference of GSI and *Kn* values between months. Significance levels for all statistical tests were established at $P = 0.05$ a priori.

Results

Sex Ratio

During the present study, 324 brown meagres were collected, with 181 (55.86%) and 143 (44.14%) individuals of females and males, respectively. The sex ratio (males: females) in the catches was 1:1.27, sex ratio was significantly differed from the expected ratio (χ^2 test = 4.457, $df = 1$, $P = 0.035$).

Length-Weight Distribution

The TL of the samples ranged 11.9 – 58.0 cm (32.2 ± 0.7 cm on mean) and 11.7 – 53.0 cm (28.9 ± 0.8) for females and males, respectively. The TL frequency distribution (Figure 3) differed from the normal distribution in the females (KS-test = 0.111, n = 181, $P < 0.001$) and males (KS-test = 0.136, n = 143, $P < 0.001$). The difference between the TL was significant by sexes (Mann-Whitney U test, $U = 10332.5$, $Z = -3.116$, $N_f = 181$, $N_m = 143$, $P = 0.002$). The W of the females and males was 11.3 – 2485.2 g (595.5 ± 40.4 g) and 16.4 – 1825.0 g (416.7 ± 33.3 g), respectively. The frequency distributions of the W of the females and males differed from normal distributions (KS-test = 0.192, $N_f = 181$, $N_m = 143$, $P < 0.001$). The difference between the W was significant by sexes (Mann-Whitney U test, $U = 10159.0$, $Z = -3.323$, $N_f = 181$, $N_m = 143$, $P = 0.001$).

Length-Weight Relationship and Condition Factor

The LWR equation was estimated $W = 0.007TL^{3.201}$ ($r^2 = 0.982$) for females, $W = 0.007TL^{3.190}$ ($r^2 = 0.986$) for males and $W = 0.007TL^{3.203}$ ($r^2 = 0.984$) for both sexes. The *b* values were significantly higher than 3, meaning that the body shape of female (t–test, $t_{181} = 6.19$, $P < 0.05$), male (t–test, $t_{143} = 5.83$, $P < 0.05$) and both sexes (t–test, $t_{324} = 8.95$, $P < 0.05$) displays a positive allometric form.

The mean *Kn* values were calculated as 1.34 ± 0.01 for females (ranging from 1.21 to 1.56) and 1.27 ± 0.02 for males (ranging from 1.10 to 1.40) (Figure 4). *Kn* values showed a significant difference among sexes (Mann-Whitney U test, U = 8492.0, Z = -3.365, $P < 0.05$). The mean *Kn* were significantly different across months for females (Kruskal-Wallis test, H = 23.240, df = 11, $P < 0.05$) and males (Kruskal-Wallis test, H = 44.297, df = 11, $P < 0.05$).

Spawning Period, Fecundity and Egg Diameters

The monthly mean GSI values ranged from 0.89 (December) to 3.76 (June) for females (with a mean value of 1.92 for the year) and ranged from 0.19 (December) to 3.21 (June) for males (with a mean value of 1.15 for the year). Spawning occurred in one clear peak from June to July (Figure 5). GSI values showed a significant difference among sexes (Mann-Whitney U test, U = 5745.0, Z = -7.071, $P < 0.05$). The mean GSI were significantly different across months for females (Kruskal-Wallis test, H = 23.654, df = 11, $P < 0.05$) and males (Kruskal-Wallis test, H = 33.036, df = 11, $P < 0.05$).

The mean fecundity per female was estimated as 480,274 ± 49,133 egg·ind^{-1} (ranged from 271,694 to 1,091,538 egg·ind^{-1}). The mean fecundity was estimated as 480,275. There were linear correlations between fecundity with TL (F = 18993TL + 261851; n = 20; $r^2 = 0.261$) and W (ED = 456.99W - 104801; n = 20; $r^2 = 0.504$). The mean egg diameter was measured as 719 ± 39 µm, with a range among females from 525 to 1140 µm. The relationship between ED and TL was estimated as ED = 5.78TL + 463.72 (n = 20; $r^2 = 0.016$), while between ED and W was estimated as ED = -0.02W + 750.62 (n = 20; $r^2 = 0.002$).

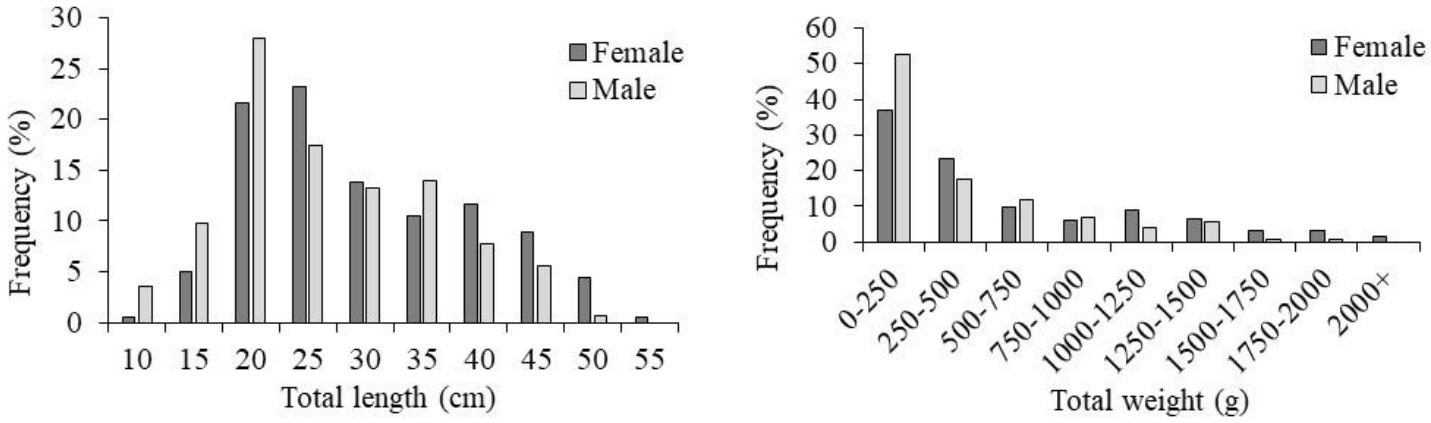

Figure 3. Sex-specific total length (cm) and total weight (g) frequency distribution of *Sciaena umbra* in the Black Sea

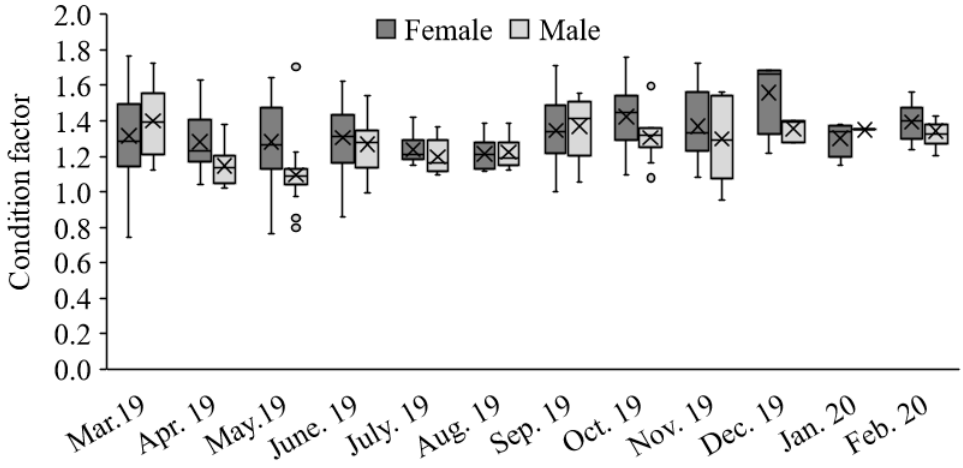

Figure 4. Monthly change of condition factor of *Sciaena umbra* by sexes in the Black Sea (2019-2020)

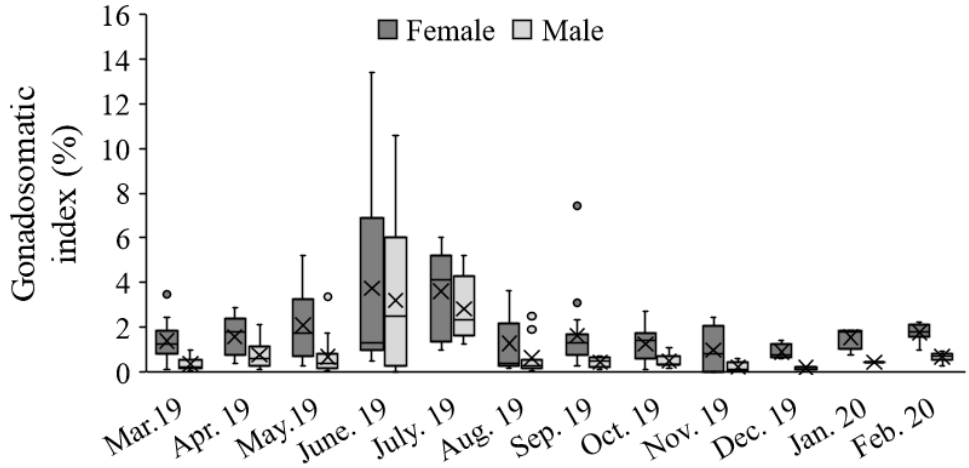

Figure 5. Monthly change of gonadosomatic index of *Sciaena umbra* by sexes in the Black Sea (2019-2020)

Age Composition and Growth Parameters

Among the total sections examined (n = 324), 313 (96.6%) yielded useful age estimates and reading of 13 sections were repeated as they showed disagreement between the two readings. An APE value of less than 10% was obtained in all sections after the third readings.

The proportion of individuals aged five years and younger in the population was 69.06% for females and 71.33% for males (Figure 6). According to the frequency of occurrence, the highest number of individuals was in age-class 2, with 64 females and 35 males. The maximum age of the females and males was 26 and 24 years, respectively. The age-length key of the sampled brown meagre is detailed in Table 1.

The maximum observed lengths for males and females were higher than the calculated value of the asymptotic length of sampled brown meagre. The growth performance of females (φ' = 2.7) was calculated as higher than that of males (φ' = 2.57). The VBGF growth curve of the sampled brown meagre was detailed in Table 2.

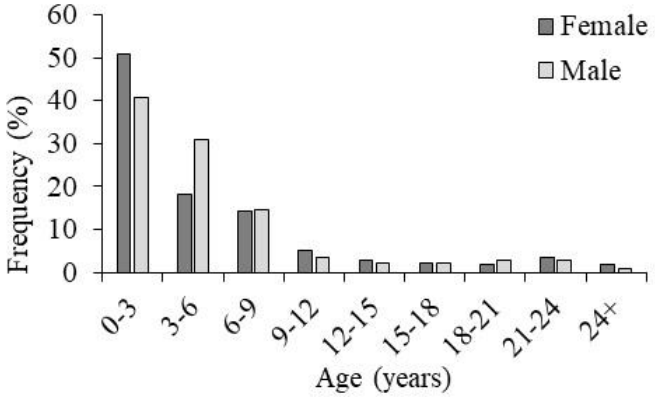

Figure 6. Sex-specific age (years) frequency distribution of *Sciaena umbra* in the Black Sea

Mortality, Exploitation and Survival Rate

The estimates of Z from the descending slope of the catch curve were 0.85 for females and 0.67 for males. The values of M were calculated to be 0.40 for females and 0.35 for males. The corresponding F was estimated as 0.45 for females and 0.32 for males. The E of brown meagre was estimated, with 53% for females and 47% for males. The survival rate (S) was calculated as 0.51 in females and 0.49 in males.

Table 1. The age-length key of the sampled *Sciaena umbra* in the Black Sea according to size class

Age groups	Total length, cm										
	10	***15***	***20***	***25***	***30***	***35***	***40***	***45***	***50***	***55***	***Total***
0	6	3									9
1		18	24								42
2		2	51	43	3						99
3			4	17	16	2					39
4				7	8	2	1				18
5					11	8	1				20
6					5	9	5	1			20
7						11	4				15
8					1	5	6				12
9						2	4				6
10							4	1			5
11							1	2			3
12							1	2			3
13							1	1			2
14							1	2			3
15							1	2			3
16								2			2
17								2			2
18							1	1			2
19							1	1			2
20								3			3
21								2	2		4
22								1	1		2
23								1	3		4
24									2		2
25									1		1
26										1	1
Total	6	23	79	67	44	39	32	24	9	1	324

Table 2. Estimates of von Bertalanffy growth parameters of sampled *Sciaena umbra* in the Black Sea

VBGF parameters	Female	Male	Combined
L_∞ (cm)	52.30	49.72	54.15
W_∞ (g)	2086.59	1725.80	2332.13
k·year^{-1}	0.18	0.15	0.14
t_0 (year)	-1.67	-10.54	-3.11
φ'	2.7	2.57	2.6

Discussion

A female-biased population was detected in the Black Sea region, similar to the ratio found in the Gulf of Tunis (Chakroun-Marzouk & Ktari, 2003) and Balearic coasts (Grau et al., 2009). Male-dominated populations also exist in the north-western Adriatic (La Mesa et al., 2008) and Gulf of Tunis (Chater et al., 2018). Males were dominant during the early sizes, but after a larger 25 cm, the sex ratio changed in favor of females. The fact that females are the majority in the Black Sea population seems promising for the reproductive potential and the continuity of the stocks. The maximum age was determined as 26 years for a female in the Black Sea. Several authors reported a shorter life cycle (up to age 20) on northern Tunisian coasts (Chauvet, 1991), Maltese coasts (Ragonese et al., 2004), and the Sea of Marmara (Artüz, 2006). The most extended lifespan of the brown meagre reported so far was 31 years in the natural populations of the marine reserve of Scandola (Morat et al., 2017) and the Gulf of Tunis (Chater et al., 2018). The *b* values calculated for the Black Sea population were within the expected ranges of 2.5 – 3.5 (Carlander, 1969). Positive allometric growth was observed in fish from the Black Sea (current study), as in different regions (Morey et al., 2003; Karakulak et al., 2006; La Mesa et al., 2008; Engin & Seyhan, 2009; Grau et al., 2009; Bilge et al., 2014; Chater et al., 2018; Aydın & Bengil, 2020; Aydın & Bodur, 2021), indicating that individuals grow faster in weight than in length. High conditions ($Kn > 1$) estimated for brown meagre in the Black Sea may be signs of favourable environmental conditions and good nutrition (Le Cren, 1951; Ujjania et al., 2012).

High t_0 (-3.109) indicated the rapid growth rate of juveniles. During the first three years of their life, females have reached 54% and males 50% of their maximum length. A rapid increase in size attained approximately 50% of their L_{max} was verified during the first three years of life for brown meagre (Chakroun-Marzouk & Ktari, 2003; La Mesa et al., 2008; Chater et al., 2018). The theoretical length of the individuals in the current study (L_∞ = 54.15 cm TL) was not different from values estimated for the northern Tunisian coasts (Chauvet, 1991) and Gulf of Tunis (Chakroun-Marzouk & Ktari, 2003). Artüz (2006) reported a very high value (L_∞ = 69.80 cm TL) from the Sea of Marmara. The determined longer L_∞ in this study compared to specimens in Maltese coasts (Ragonese et al., 2004), northwestern Adriatic (La Mesa et al., 2008), southeastern Black Sea (Engin & Seyhan, 2009) and Gulf of Tunis (Chater et al., 2018) might indicate that Black Sea populations have better environmental conditions for growth. As in previous studies (Table 3), females (k = 0.18 yr^{-1}) were also found to grow faster than males (k = 0.15 yr^{-1}) in the Black Sea. The values of the k confirmed slow attainment of the maximum size, which is rather typical of long-life cycle species. The k value was not noticeably different from values estimated for some Tunisian brown meagre populations (Chauvet, 1991; Chakroun-Marzouk & Ktari, 2003; Chater et al., 2018) which have varied between 0.10 yr^{-1} and 0.22 yr^{-1} among sexes. Significantly higher k values were reported from the Sea of Marmara, Türkiye, which has k values of 0.42 yr^{-1}. These results were slightly lower than the calculated for the Southern Black Sea (Engin & Seyhan, 2009) and Northwestern Adriatic (La Mesa et al., 2008). Differences in growth performance between regions are likely due to environmental conditions (such as temperature and food availability) between sampled areas (Tuck et al., 1997; Campana, 2001), the unequal distribution of size classes (Mouine-Oueslati et al., 2015). The growth performance index of the Black Sea populations ($\varphi' = 2.70$) was quite close to previous studies (Chauvet, 1991; Chakroun-Marzouk & Ktari, 2003; Engin & Seyhan, 2009; Chater et al., 2018) which may further clarify the various maximum theoretical length in populations from different regions.

Estimates of *Z* for the brown meagre were low, characteristic of a long-lived and slow-growing species. These estimates are higher than the *M* values reported in the Gulf of Tunis (Chater et al., 2018). The overall annual mortality rate includes recreational fishing and natural sources of mortality. The *Z* for females (Z = 0.85 yr^{-1}) was greater than males (Z = 0.67 yr^{-1}). The higher *M* values in females may be due to their larger size, making them more sensitive to fishing. Fishing mortality results demonstrate that males (F = 0.45 yr^{-1}) are fished at a higher rate than females (F = 0.32 yr^{-1}). The current exploitation rate of the Black Sea population was calculated near the optimum exploitation level (E = 0.5) of fish populations (Patterson, 1992). The brown meagre stock in the Black Sea appears mainly unexploited (E ~ 50%, $F/M < 1$) for females and males.

The peak spawning season of the brown meagre occurred from June to July in the Black Sea. The spawning season was reported similarly from July to August from the Gulf of Tunis (Chakroun-Marzouk & Ktari, 2003) and only in June from the southeastern Black Sea (Engin & Seyhan, 2009). Distinctive spawning aggregations of brown meagre (Harmelin, 1991) can

Table 3. The von Bertalanffy growth parameters obtained from different regions for the *Sciaena umbra*

References	Region	Sex	n	TL (cm)	Age max	TL_∞ (cm)	k (yr^{-1})	t_0 (years)
Chauvet (1991)	Tunisian coasts	Females	–	12.5 – 52.5	21	53.90	0.190	-0.002
		Males	–	12.4 – 44.5	15	46.70	0.224	-0.120
Chakroun-Marzouk & Ktari (2003)	Gulf of Tunis	Females	484	13.4 – 49.6	9	53.70	0.186	-0.828
		Males	394	13.6 – 44.4	9	45.00	0.225	-0.817
Ragonese et al. (2004)	Maltese coasts	Females	51	31.1 – 48.5	26	47.60	0.116	-6.132
		Males	129	30.5 – 43.0	17	42.30	0.145	-5.765
Artüz (2006)	Sea of Marmara	Combined	921	–	21	69.80	0.418	-1.075
La Mesa et al. (2008)	Northwestern Adriatic	Females	118	20.0 – 49.7	16	47.20	0.279	-1.823
		Males	128	16.5 – 48.0	19	44.90	0.268	-2.168
Engin & Seyhan (2009)	Southeastern Black Sea	Combined	329	–	18	51.14	0.270	-0.930
Chater et al. (2018)	Gulf of Tunis	Females	113	19.1 – 49.2	31	50.10	0.105	-5.710
		Males	113	17.6 – 43.3	22	43.83	0.145	-4.880
Current study	Black Sea	Females	181	11.9 – 58.0	26	52.30	0.180	-1.670
		Males	143	11.7 – 53.0	24	49.72	0.150	-10.54
		Combined	324	11.7 – 58.0	26	54.15	0,.137	-3.109

make them particularly vulnerable to spearfishing in caves in the summer. Gonad development of brown meagre was not followed in the current study, but the smallest ovigerous female was 37.0 cm, which was relatively high compared to other populations. Although the first maturity length of the brown meagre was reported to be about 20 cm in the Gulf of Tunis (Chakroun-Marzouk & Ktari, 2003), southeastern Black Sea (Engin & Seyhan, 2009), and 30 cm on Balearic coasts (Grau et al., 2009). Although the L_{max} observed in this study is close to the L_∞, approximately 35% of the females in the population had a reproductive potential (>35 cm). To make possible recovery of this recently over-fished population, a more restrictive arrangement was put forward, where only individuals larger than 35 cm are caught. The brown meagre populations are protected by catch size limitations in Türkiye; currently the legal length size has been increased from 25 cm to 35 cm in the national regulation (Directorate General of Fisheries and Aquaculture, 2020). Such an arrangement would allow most individuals to reach sexual maturity and breed at least once before being caught. This will also protect older and larger individuals with high reproductive capacity. The stock abundance of brown meagre in the world experienced a critical decline, becoming a species to be protected (Chauvet, 1991; Harmelin, 1991; Chater et al., 2018). The brown meagre is not included in any special protection program outside of marine protected areas globally. Unlike the catch size limitation, brown meagre is not protected by any prohibition in Türkiye and is open for commercial and sportive fisheries in the Black Sea. Balanced mortality rates (both natural and fishing) and the presence of older females with high reproductive potential indicate that the welfare level of the population is sustainable for the Black Sea population. This status of stocks does not mean that the brown meagre is resistant to exploitation. As with all marine populations, the brown meagre will not show excessive resistance to overfishing exploitation, so additional

management and conservation measures should be taken to minimize the impact of fishing activities on stocks.

Conclusion

Consequently, anthropogenic pressures and human activities on the Black Sea coasts are increasing daily. Fisheries management strategies should consider environmental aspects of the ecosystem in addition to conventional fisheries regulations. It should be noted that further efforts are needed to protect the existence of female adults and juveniles. Small-scale fisheries on the coast of the southern Black Sea must be regulated to minimize their direct impact on brown meagre populations. Trammel nets are fragile in selectivity, and brown meagre creates high bycatch in these nets. Large individuals, including mature females, are attractive for spearfishing and are highly caught. As a long-lived but slow-growing species, we underline those adult females should be excluded from catching for whatever reason. In particular, the survival of all females larger than 35 cm plays a crucial role in the sustainability of brown meagre stocks. It is recommended to create new artificial structures to create shelter, hiding and breeding areas for individuals. Because rocky ecotones are the brown meagre's primary habitat, a special conservation plan is needed to protect these areas. These measures will contribute to the sustainability of brown meagre populations.

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Compliance With Ethical Standards

Authors' Contributions

BB, MA, & UK: Study design, Writing.
BB & UK: Sampling, Writing.
MA: Supervision, Statistical analysis, Writing
All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that for this article they have no actual, potential, or perceived conflict of interests.

Ethical Approval

For this type of study, formal consent is not required. All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author, [UK], upon reasonable request.

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RESEARCH ARTICLE

Container port employees' organizational culture perception, job satisfaction & intention to stay at work

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ABSTRACT

Employees' importance has recently started to be discussed by maritime organizations with the emergence of employee-oriented management strategies. While organizations are competing in today's wild market environment, the success of companies depends on keeping employees happy. Besides job satisfaction of the employees trigger their performance especially in the maritime sector. This study aims to reveal the relationship among organizational culture, job satisfaction and intention to stay at work in a container port management organization. Data obtained through an online Likert-scale questionnaire of organizational culture perception, job satisfaction and intention to stay at work from 302 land-based employees of a Turkish port operator organization were tested with the Structural Equation Model. The uncertainty avoidance, masculinity, time-oriented, power distance, individuality dimensions of organizational culture have been tested. Results showed that the time-orientation dimension of organizational culture is effective on job satisfaction and job satisfaction has a positive effect on the intention to stay at work.

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Introduction

Human resources are one of the most crucial resources for organizations in today's world. The establishment of new factories during the Industrial Revolution created the need for a different working class, and workers began to be employed in an uncontrolled manner under difficult conditions, with overtime and low wages (Friedman & Lee, 2010). For this reason, human resources have become increasingly important for the success of the organization, and employees may provide the best return on investment for long-term competitive advantage (Luthans & Youssef, 2004). While human capital becomes the organization's most valuable asset, it is observed that being satisfied with the workplace and having a high level

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of job satisfaction increase productivity and performance positively (Davidescu et al., 2020). According to Lambert et al. (2001), scholars believe that comprehensive measures of job satisfaction predict employee turnover; in other words, high job satisfaction is linked with low employee turnover. Furthermore, analysis demonstrates that intentions moderate the relationship between job satisfaction and actual employee turnover. Therefore, employees' turnover intention reaches considerably a low level. Institutions develop some policies under the name of employee-friendly workplace to keep talented employees in their own bodies, to attract those outside the organization, and to make employees feel like the stakeholders of the organization (Kılıç & Altun, 2019). As a result of COVID-19 pandemic, the concept of "employee-friendly" human resource management has merged in daily life in the rapidly evolving environmental circumstances (Senbursa, 2022a). With the changing technological conditions, the importance of human resources increases, and organizations starts to construct organizational culture applications and to apply some practices such as flexible schedules, job sharing, and remote work to improve the conditions of their employees and to keep their work and life in balance (Tosun & Keskin, 2017). Satisfaction of the employees in their private and professional lives has a positive impact on organizations. Work-life balance initiatives increase profitability and value creation in employee-friendly organizations, as well as productivity (Senbursa, 2022b).

In recent years, employees in an organization have been of vital importance for the organization to continue its existence, and it has been accepted by managers that employees are a strategic value (Keep, 2014). As so the balance of work-life of the working employees and the satisfaction of the employees in their personal and business lives affect the organizations positively (Senbursa, 2022b). On the other hand, organizations serving nationally and internationally in the world require to provide qualified manpower for their activities, applications to increase the motivation, happiness, and performance of their employees, renew themselves to keep up with the changing technology, provide and support the necessary training opportunities for their employees (Achor, 2011). As there have been numerous studies on interpersonal relationships in organizations, the literature on the outcomes of organizational behavior is quite extensive. When new research is carried out, it is likely that something new will be added to the literature (Ozdemir et al., 2022). To achieve excellence, organizations need to provide those employees have the necessary training to increase the productivity of their employees, develop and improve employees, and produce new jobs (Bulut & Culha, 2010). According to the literature review, there is a very scarce number of studies on organizational culture, job satisfaction and the intention to stay in the maritime industry. Therefore, the importance of this study is notable for the maritime industry in which organizational behavior subjects are recently trend. In this context, it is thought that giving the employees the opportunity to develop themselves, providing training support and training opportunities to strengthen the working personnel will contribute to their adaptation to the developing and changing conditions. So as to benefit more from the knowledge and skills of employees in organizations, employees need to be allowed to participate in decisions and their opinions and suggestions need to be evaluated. Consequently, the purpose of the study is to reveal the relationship among organizational culture, job satisfaction and intention to stay in a maritime organization that serves in port management services field in Turkey.

Organizational Culture

The concept of organizational culture has started to be used intensively after the 1980s (Kılıç, 2013). Two important studies carried out in these years play an important role in the field of organizational culture. Deal & Kennedy's (1982) book "Corporate Culture", which they wrote by developing the concept of organizational culture, and Peters & Waterman's (1982) book "In Search of Excellence" formed the basis for the emergence and spread of the concept (Unutkan, 1995).

According to the system's approach, organizations are in constant interaction with their environment. In this context, organizations are influenced by the culture of the country they are in, that is, the upper system that surrounds them (Kaya, 2008). On the other hand, many researchers working on organization theory considers organizations as cultural environments; define an organization as a system of socially constructed and shared meanings by its members (Morgan et al., 1982; Şişman, 2002). Some of the dimensions or basic elements of national cultures are the tolerance of the society against uncertainty, values for power distance, collectivist, or individualistic values and feminine or masculine characteristics. These dimensions affect the culture of the organization within the borders of a country (Hofstede, 1991). According to Wu (2006), organizational culture dimensions consist of five factors which are uncertainty avoidance, individuality, masculinity, power distance and time orientation. Uncertainty avoidance is when people living in a country prefer specified situations over unspecified ones (Hofstede, 1993). Individualism refers to the degree to which people living in a

country want to behave individually or as a member of a group (Hofstede, 1993). In countries where individualism is effective, the values of individual success, freedom and competition are emphasized; In countries where pluralism is effective, group cohesion, commitment and cooperation are very strong and the importance of agreement and solidarity among individuals is emphasized (George & Jones, 2008). The other dimension is expressed as masculinity and its opposite is femininity. In studies on the importance of business purposes, social goals such as human relations, helping others, and physical conditions are considered by women; Individual goals such as career and money are considered more important by men (Hofstede, 2001). While focusing on time orientation, long-term oriented societies, individuals carry their values such as thrift and persistence to the future; In short-term societies, individual's direct values such as respect for their traditions and fulfilling social obligations to the past or present time (Hofstede, 1993).

Organizational behavior refers to the attitudes and behaviors of the members of the organization towards people and jobs in the inside and outside environments of the organization. Organizational culture determines organizational behavior; it plays a complementary role in employee behavior in increasing individual and organizational effectiveness. The other main field of study is the philosophy of management, the views, understanding, attitudes and behaviors of the management and the organizational structure of the managers. Therefore, organizational culture also expresses the basic understandings of management philosophy of the organization. Organizational communication, on the other hand, is the exchange of messages between employees in the organizational environment, verbally and in writing. By providing interaction among employees, it ensures the adoption of the organizational goals by the employees, the continuation of the operation and the achievement of the organization's goals. All this functioning takes shape according to the organizational culture (Tutar, 2017).

The concept of organizational culture provides an understanding of how organizations differ from each other, how organizational members adapt to each other and how they interact with each other (Adler & Jelinek, 1986). So, culture as a whole belonging to the values, beliefs and attitudes shared within the organization is recognized and adopted by the members of the organization (Robbins & Judge, 2008). According to some theorists, the organizational culture is not something the organization has, but what the organization is. Therefore, culture is such a complex and integral element that it cannot be separated from the organization by including all parts of the organization (Thompson & Luthans, 1990). In addition, Schein (1997) states the characteristics of organizational culture as; behavioral systems such as the meanings, relationships, habits, traditions and rituals shared by the members of the organization, the mission, vision, policies, ideological ideas and values of the organization, slogans that provide organizational unity and solidarity, mental symbols and organizational language, the basic principles that individuals have for predetermined tasks, skills, hierarchical and authoritarian relations within the organization, teamwork, leadership types, decision making and level of participation in these decisions, organizational rewards. Moreover, organizational culture is the set of thoughts, norms and values that shape the behavior of the members working at all levels of the organization, as well as the general image (Frost et al., 1991). According to Keller (1990), organizational culture is the whole of values, thoughts and norms that shape all employee behaviors and the organization, that can be learned and taught with symbols, transferred from generation to generation and changed over time. Finally, the concept of organizational culture, which is still popular today, enables us to understand how organizations differ from each other, how organizational members adapt to each other and how they interact with each other (Adler & Jelinek, 1986).

Job Satisfaction

Job satisfaction is considered as another important concept of the business world. It expresses as the emotional result of an employee's personal expectations and wishes being met with the outcome of the job performed. The aforementioned outcome includes money, pride, appreciation from upper management, a special award, and/or related concepts (Locke, 1976). Also, job satisfaction is explained as the emotional reaction or general attitude of the employee towards her/his job (Tengilimoğlu, 2005). It is an important point to bear in mind that the importance of the satisfaction levels of the employees goes back to the neo-classical approach. Various studies conducted in this period reveal that employees are satisfied not only with physical but also with psychological and social motivators. Many studies after these studies aim to explain concepts such as motivation and satisfaction. Examples of these are Maslow's (1943) Hierarchy of Needs and Herzberg et al.'s (1959) Double Factor Theory (motive and hygiene factors) (Kılıç, 2013). According to Weiss (2002), it is the emotional, behavioral, and conceptual experiences of employees about their jobs. Job satisfaction can be evaluated as an indicator of

the relationship between the experience, achievement and emotions of the employee throughout his working life and the work he does and the work environment. This indicator sometimes appears as joy, sometimes as sadness, stress or anger. All these experiences create an experience for the employee. On the other side, Vroom (1967) explains the issue of job satisfaction, which he considers as the emotional reactions of employees, as job satisfaction when employees are happy at the workplace and give positive reactions, and job dissatisfaction when they are unhappy and exhibit negative behaviors. Also, Blenegen (1993) attributes job satisfaction to two main factors in general terms. The first is the employee's personal situation, structure, feelings and thoughts, wishes and needs, and their degree of severity. The second is organization's conditions. Job satisfaction can be mentioned to the extent that the expectations of the employee are met. Gibson et al. (1997) state that the job satisfaction of the employee is affected by factors such as his job, the environment of the job, managerial attitudes and behaviors, wage and wage distribution, promotion, workplace friendship relations, and the degree of importance of the job. Job satisfaction measurement studies in literature (Lawler & Porter, 1967; Gemmil & Heisler, 1972; Deutsch, 1975; Feldman & Arnold, 1985; Bogler, 2001) evaluate job satisfaction in two different aspects. The first is the research of the employee about the work he is currently doing, and the second is the environmental factors of the work. According to Bateman & Snell (1999), the products obtained by the employees from the work they do and the fair treatment they receive from their managers and coworkers are sufficient for the satisfaction of the employees. However, this does not mean that the satisfied employee is productive for the workplace. Thus, the concept known as job satisfaction in organization theory, can be viewed as a supplementary viewpoint for organizations to succeed in both disciplines (Tehci & Şenbursa, 2021).

Intention to Stay at Work

Intent to stay is the degree of likelihood of an employee continuing membership in an organization. It is also known as propensity to leave, intent to quit, intent to leave, behavioral commitment and attachment, turnover intention in the literature (O'Reilly & Caldwell, 1981; Halaby, 1986; Iverson, 1992). An employee leaving an enterprise is psychologically agonizing for both the company and other employees; it is not only a professional setback; however, but it also has an impact on the social life of the organization (Ghosh et al., 2013). Employees are more likely to stay in positions where they have some level of decision-making authority, according to Magner et al. (1996). On the other hand, job satisfaction and organizational commitment have a significant impact on an employee's intention to stay with his company (Igbaria et al., 1994). Calisir et al. (2011) also discover that satisfaction of work and work engagement explain intention to quit one's job in a study of information technology (IT) professionals' intention to quit their jobs in Turkey; role conflicts and work stress have negative indirect effects on such intention. For example, Walker (2001) defines seven parameters that can support retention: reimbursement and admiration for tasks undertaken; challenging work; learning opportunities; positive relationships with coworkers; acknowledgement of abilities and performance accomplishments; fair work-life integration; and open dialogue. Chew & Chan (2008) suggest that person-organization fit (P-O fit), reimbursement, acknowledgement, mentoring, and professional development all had a significant impact on intention to stay. Another research reveals that collective efficacy, however, is strongly related to both stressors and strains (job dissatisfaction, anxiety, frustration, and turnover intention) (Jex & Gudanowski, 1992). According to some studies, organizational justice perception is a principal reason of many variables affecting employee attitudes, including employee satisfaction, intention to stay at work, and organizational engagement and behaviors such as creative work behavior, organizational citizenship behavior, and job efficiency (Pan et al., 2018).

The Relationship of Organizational Culture, Job Satisfaction and Intention to Stay

When literature is reviewed, it is seen that many studies have been conducted in the management literature on organizational culture, job satisfaction & intention to stay. Lund's (2003) empirical study looks at the impact of organizational culture types on job satisfaction in a survey of marketing professionals from a variety of firms in the United States. The results suggest that job satisfaction was positively related to clan and adhocracy cultures. On the other side, the research of Tsai (2011) that focuses on hospital nurses in Taiwan showed that leadership behavior and job satisfaction is significantly and positively correlated with organizational cultures. According to Medina's (2012) research, job satisfaction is inversely related to intention to stay, and organizational culture moderates the magnitude of this relationship. Therefore, job satisfaction is more predictive of the intention to stay for younger employees, according to

subgroup analyses. On the other hand, the research that is conducted among primary care providers in China by Wang et al. (2020) reveal that there is a significant direct effect of job satisfaction on burnout and turnover intention. Also, Lin & Huang (2021) show in their study on employees in a telecommunications organization in Taiwan that the relationships among an organizational learning culture, employee intention to stay, and job performance are fully mediated by job satisfaction. Besides, another research that is done in Chinese family enterprises, unearths that the relationship between job satisfaction and turnover intention is insignificant for family members, but significant for non-family members (Shu et al., 2018). In the research of Paltu & Brouwers (2020) that has been conducted for South African manufacturing employees, the goal is also to see if organizational culture mediates the relationship between toxic leadership and specific job outcomes like job satisfaction, turnover intention, and commitment. Therefore, the mediation model tested whether organizational culture mediates the relationship among toxic leadership, job satisfaction, organizational commitment, and turnover intention. The results confirm that organizational culture does mediate the relationship between toxic leadership and turnover intention. In respect of job satisfaction, results indicated that organizational culture does mediate the relationship between toxic leadership and job satisfaction. Idiegbeyan-Ose et al. (2018) study the effect of organizational culture on turnover intention on library staff. The research findings show a significant relationship between organizational culture and the intention of library staff to leave in private university libraries in south-west Nigeria. Also, Soomro & Shah (2019) demonstrate that job satisfaction is impacted by organizational commitment, while organizational culture is influenced by job satisfaction. According to the findings of Meng & Berger (2019), the important impact that organizational culture and leader performance can have on the organizational commitment, trust, and job satisfaction of public relations professionals. Mesfin et al. (2020) reveal that the existing perceived clan culture (a sense of community and mutual aid, with a focus on empowerment and employee development) has a positive and significant relationship with health workers' satisfaction in the work relationship dimension. Lastly, Kucharska & Bedford (2019) conducted a survey of 910 Polish employees from various roles and industries. The results indicate that job satisfaction is a powerful mediator for an organization's culture aspects and information exchange by highly talented employees. Job satisfaction fully mediates the effect of masculinity, long-term perspective, and collectivism on knowledge sharing. On the other hand, Reed et al. (1994) discovers that job dissatisfaction and/or a lack of organizational commitment can lead to employees seeking alternative positions. Also, in the study of Lee (2000), the components of job satisfaction, as well as the need for challenge and achievement, play an important role in effecting turnover intentions among IT professionals. Ghiselli et al. (2001) investigate the impact of job and life satisfaction on turnover decisions. They unearth those managers who are happier with the essential components of their jobs, are happier with their lives, and older are less likely to leave their positions soon. Carraher et al. (2006) find that absenteeism, intention to stay, perceived organizational attractiveness for job seekers, organizational citizenship behaviors, and job performance all have significant relationships.

Therefore, the following hypotheses are proposed in this study.

H1: The uncertainty avoidance dimension of organizational culture is effective on job satisfaction.

H2: The masculinity dimension of organizational culture is effective on job satisfaction.

H3: The time-oriented dimension of organizational culture is effective on job satisfaction.

H4: The power distance dimension of organizational culture is effective on job satisfaction.

H5: The individuality dimension of organizational culture is effective on job satisfaction.

H6: Job satisfaction has a positive effect on the intention to stay at work.

Material and Methods

The universe of the research consists of the employees of a port operating container organization in the maritime industry in Turkey, and the sample consists of people selected from among these employees. The questions of the research survey were taken from the scales proven in the literature. Therefore, organizational culture, job satisfaction and turnover intention for employees; organizational culture Hofstede's scale used to determine national culture was tested by Wu (2006), job satisfaction developed by Hackman & Oldham (1975) and adapted into Turkish by Çetin (2011), and turnover intention scale developed by Bhuian et al. (2005) and adapted to Turkish by Sulu (2010). The turnover intention questions are reverse questions and have been rotated to intention to stay at work (Billingsley & Cross, 1992). In Table 1 scale items used are found.

Table 1. Scale items used in this study

Organizational Culture Scale Items
OC1. In a high position, I prefer a man to be the manager, rather than a woman
OC2. It is more important for men to have a professional career than for women to have a professional career.
OC3. When women encounter an organizational problem, they are often under the influence of their emotions, while men usually approach the problem with a cool mind.
OC4. Men, by nature, are more successful than women in solving organizational problems.
OC5. In married couples, it is important that the man is career higher than the woman.
OC6. Managers must make most decisions without consulting their subordinates.
OC7. It is necessary for a manager to exercise authority and power against his employees.
OC8. Managers should rarely ask their employees' opinions.
OC9. Employees should not disobey management's decisions.
OC10. Managers should not delegate important tasks to their employees.
OC11. It is important to have job requirements and detailed instructions. Thus, employees can always know what is expected of them.
OC12. Managers should expect their employees to follow instructions and procedures closely.
OC13. Rules and regulations are important. Because they show what the organization expects from employees.
OC14. Standard operating rules are helpful to employees doing the work.
OC15. Operational instructions are important for employees.
OC16. The happiness of the working group should be prioritized over individual happiness.
OC17. Group success should be more important than individual success.
OC18. Being accepted as a member of the group I work with is very important to me.
OC19. Employees should pursue their own goals after considering the happiness of the group.
OC20. It is important to regulate relations according to status / titles in workplaces and comply with these regulations.
OC21. It is important for employees to be frugal in the workplace.
OC22. It is important for employees to be persistent in workplaces.
OC23. It is important for employees in the workplace to have a sense of right and wrong (ethics).
Job Satisfaction Scale Items
OC1. My job is like a hobby to me.
OC2. I think I am happier at my job than most other people.
OC3. I think my current job is more interesting than any other job I could find.
OC4. I enjoy my job very much.
OC5. My job in general does not satisfy me.
Turnover Intention Scale
OC1. I often think about quitting my job.
OC2. I can leave this organization within the next year.
OC3. I might leave this organization one day in the next few years.

The research data are obtained as a result of the questionnaire applied to the employees between 01 November - 01 December 2022 with the convenience sampling method. The questionnaire form is applied to 302 employees. Volunteer employees are included in the survey analysis. Structural Equation Modelling is used to analyze the relationship of three scales. The first part of the questionnaire covers organizational culture, job satisfaction and turnover intention factors. In the questionnaire applied with the Five-point Likert Scale, the participants of the study are asked to answer each statement in the form of 1: strongly disagree, 2: disagree, 3: neutral, 4: agree, 5: strongly agree, in accordance with their own situation. The questions in the second part of the research are aimed at determining the demographic characteristics of the participants, such as gender, age, education level, marital status, working time, and the region where they operate. Demographic findings for the participants are given in Table 2.

Table 2. Demographic characteristics of participants

Gender	**N**	**%**
Female	64	21.2
Male	238	78.8
Age		
18-24	71	23.5
25-34	113	37.4
35-44	97	32.1
45-54	14	4.6
55 +	7	2.3
Educational Status		
Primary-Secondary School- High School	13	4.3
Vocational School	15	5.0
University	223	73.8
Postgraduate	51	16.9
Title		
Expert	86	28.5
Chief	26	8.6
Manager	37	12.3
Vice Manager	22	7.3
Office Staff	13	4.3
Technical Staff	10	3.3
Other	108	35.8
Experience	**N**	**%**
Less than a year	65	21.5
1-5 year	73	24.2
6-10 year	50	16.6
11-15 year	54	17.9
16 years +	60	19.9
Department		
Management	27	8.9
Marketing	22	7.3
Operations	39	12.9
Technical	18	6.0
Maritime	116	38.4
Logistics	41	13.6
Other	39	12.9
Marital Status		
Married	148	49.0
Single	154	51.0
Total	302	100

As it can be seen in Table 2, 21.2% of the participants were female and 78.8% are male. It is seen that 49.0% of the maritime company employees participating in the research are married and 51.0% are single, and the majority of them have worked in the relevant company for 1-5 years. 73.8% of the participants are university graduates and 4.3% are primary and high school graduates. The number of postgraduate graduates is at a very good level with 16.9%. In addition, 37.4% of the participants are in the age group of 25-34, 32.1% in the age group of 35-44, 4.6% in the age group of 45-54, 2.3% in the age group of 55 and over, and 23.5% in the age group of 18-24. According to the demographic findings of the research, it can be said that the majority of the organization's employees work as experts. Factor analysis results are given in Table 3.

The overall Cronbach alpha coefficient of the scales is found to be 0.815. According to Hair et al. (1998), factor loadings greater than 0.30 are considered to meet the minimal level; loadings greater than 0.40 are considered more important; and loadings greater than 0.50 are considered practically significant. Factor analysis (FA) can be defined as a multivariate statistic that seeks to explore finding a small number of conceptually significant new variables (factors, dimensions) by bringing together a large number of interrelated variables (Büyüköztürk, 2002). According to Stapleton (1997), factor analysis is a technique designed to examine the covariance structure of a group of variables and to explain the relationships between these variables in terms of a much smaller number of unobserved latent variables called factors. Rennie (1997), on the other hand, defines Factor analysis as an analytical technique with a computational logic based on the relationships between observed variables, aiming to reach a small number of explanatory factors (comprehension) that explains the maximum variance. The factor loading value is a coefficient that explains the relationship of the items with the factors. It is expected that the load values in the factor in which the items take place are high. If there is a cluster of items that are highly correlated with a factor, this finding means that those items together measure a cognitive factor. A factor load of 0.3 for a variable indicates that the variance explained by the factor is 9%. The variance at this level is remarkable and, in general, a load value of 0.60 and above is high regardless of its sign; A load value between 0.30-0.59 can be defined as medium magnitudes and is taken into account in variable subtraction (Kline, 1994). Since organizational culture has a multidimensional structure, factor analysis is applied. When factor analysis is applied to the scales as a whole, "JS5", "TM4", "PD4", "IN3" and "IN4" with factor loadings below 50% are removed and factor analysis is repeated. As a result, Bartlett's sphericity test findings in Table 3 show that there is a sufficient level of relationship between variables for factor analysis ($p<0.05$). The KMO Sampling

Table 3. Result of factor analysis

Variable	Question	Factor Load	Eigen Value	Cumulative Variance%
Uncertainty Avoidance	UA1	0.738	4.656	17.909
	UA2	0.816		
	UA3	0.807		
	UA4	0.756		
	UA5	0.800		
Masculinity	M1	0.782	1.066	29.846
	M2	0.700		
	M3	0.762		
	M4	0.788		
	M5	0.688		
Job Satisfaction	JS1	0.744	11.845	41.691
	JS2	0.754		
	JS3	0.655		
	JS4	0.784		
Intention to stay	IS1	0.730	7.659	49.350
	IS2	0.911		
	IS3	0.757		
Time Orientation	TM1	0.601	5.323	54.673
	TM2	0.791		
	TM3	0.860		
Power Distance	PD1	0.718	4.712	59.384
	PD2	0.575		
	PD3	0.717		
	PD5	0.510		
Individualism	IN1	0.864	4.461	63.846
	IN2	0.806		

Note: KMO: 0.752; Bartlett's Test of Sphericity: 2969.425; p: 0.000

Adequacy Test compares the size of the partial correlation coefficients to the identified correlation coefficients and indicates whether the data set is suitable for factor analysis. It is deemed good because the KMO value is 0.752. (Kaiser, 1974). The total Eigen value of each variable used in the study is greater than 1. Cumulative variance is 63.846%. It is also seen that the factor load in each scale in the study is 0.50 and above.

Structural Model and Hypothesis Testing

The Structural Equation Model which is used to test the validity of the measurement tool and to question the causal relationships between the variables, facilitates the discovery of the relationships between the variables in order to reduce the error in the model and helps the structures to be modelled at a higher level (Hair et al., 2014). Structural equation modelling (SEM) is frequently used by scientists to test the relationships between observed and latent variables based on a certain theoretical basis in many different fields such as social sciences, behavioral sciences, educational sciences, economics and medical sciences (Jöreskog & Sörbom, 1993; Hoyle, 1995; Bentler & Yuan, 1999; Cheung & Renswold, 2002; Onwuegbuzie & Leech, 2005; Leech et al., 2013). Structural equation model; it is defined as a combination of different statistical methods such as factor analysis, canonical correlation and multiple regression (Hox & Bechger, 1998; Ullman, 2001; Pallant, 2005). SEM includes factor analysis in terms of observing and latent variables and defining latent variables with observed variables, canonical correlations in terms of including many dependent and independent variables, and regression analysis in terms of defining causal relationships between variables (Kahn, 2006; Tabachnick & Fidell, 2007)

In this study, the general compatibility of Structural Equation Model (SEM) with the conceptual model and hypotheses was tested. The structural model and fit indices are shown in Figure 1 and Table 4.

Table 4. Model goodness of fit values

P	χ2	χ2/df	RMSEA	CFI	IFI	TLI
0.000	506.272	1.815	0.052	0.917	0.918	0.903

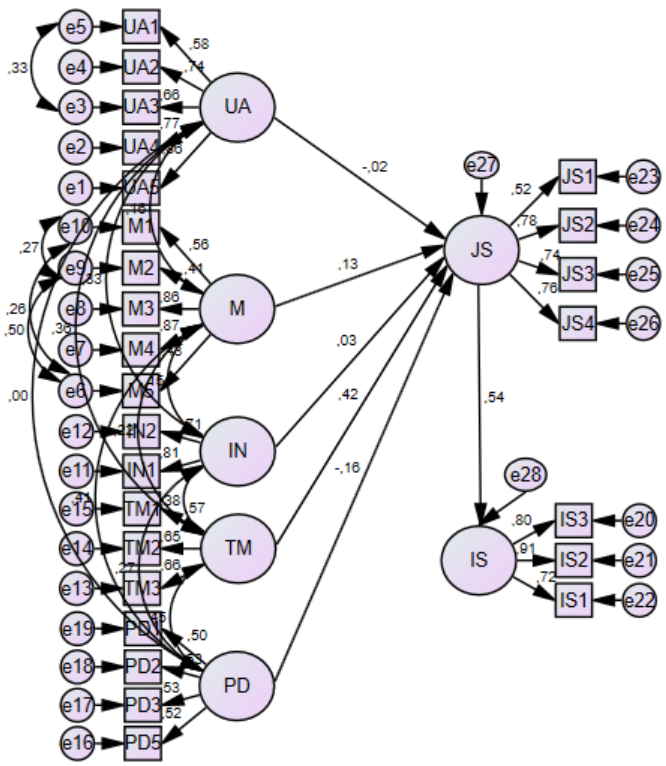

Figure 1. Structural model of the research

Goodness-of-fit tests are the stage at which the decision is made whether to accept the research model. These tests show how the research model explains the data (Mulaik et al., 1989). Goodness of fit indices are quite high. The researcher may use a few of the goodness-of-fit indices or may prefer to use all of them (Gerbing & Anderson, 1992; Schermelleh-Engel et al., 2003). The P (probability) value is a value used to determine the presence of statistical significance and the level of evidence of difference, if any (Dawson & Trapp, 2004). Goodness-of-fit values help determine how consistent the relationships in the model are with the data. Here, firstly, the ratio between chi-square and degrees of freedom was examined. This ratio is expected to be 3-4 at most. However, since the chi-square value is easily affected by the sample size, other goodness-of-fit values were produced. Root Mean Square of Approximation (RMSEA) value is a value used to test the hypothesis assuming an even correlation distribution. (Kline, 2005; Şimşek, 2007). In goodness of fit, other criteria are also taken into account besides this value. It compares RFI (Relative fit index), IFI (Incremental fit index) and CFI (Comparative fit index), RFI, IFI and CFI theoretical model and prediction model. The fact that these measures are close to 1.0 indicates that there is a good fit between the model and the data. CFI provides a more appropriate benchmark for model development or when the sample size is small. TLI (Tucker-Lewis index): TLI is a comparable index value between the prediction model and the theoretical model. It takes values between 0.0 and 1.0. A TLI value of 0.90 and above is desirable. RMSEA (Root mean square error approximation) is a criterion used for large sample volumes and takes values between 0.05 and 0.08.

Therefore, in this study, the most commonly used goodness-of-fit values ($\chi 2$) in literature are taken into account. It is desirable to have a low value of $\chi 2$, which tests whether the variable matrix is different from the default matrix. The $\chi 2/df$ used to evaluate the fit between the data and the model was found to be 1.815. According to this value, it can be said that the fit between the data and the model is at a good level (Kim, 2005). The hypothesis test results of the research are presented in Table 5.

Table 5 shows the relationships between the variables accepted at the 95% confidence level. According to the regression value showing the relationship between the variables, it is determined that the organizational culture's time orientation dimension has a powerful effect on job satisfaction for the employees of the said port business (H3), and job satisfaction has a strong positive effect on the intention to stay at work (H6). However, the uncertainty avoidance dimension of organizational culture has no significant effect on job satisfaction. The masculinity dimension of organizational culture does not have a significant effect on job satisfaction. The power distance dimension of organizational culture does not

Table 5. Hypothesis test results

Hypothesis	Regression Direction			Standard Regression Coefficient	Standard Error	Significance Level	Result
H1	Job satisfaction	←	Uncertainty Avoidance	0.019	0.085	0.821	Rejected
H2	Job satisfaction	←	Masculinity	0.131	0.098	0.113	Rejected
H3	Job satisfaction	←	Time orientation	0.424	0.115	0.000	Accepted
H4	Job satisfaction	←	Power distance	0.161	0.145	0.182	Rejected
H5	Job satisfaction	←	Individualism	0.027	0.061	0.756	Rejected
H6	Intention to stay	←	Job satisfaction	0.542	0.133	0.000	Accepted

have a significant effect on job satisfaction and finally, organizational culture's individuality dimension did not have a significant effect on job satisfaction. As a result, the hypotheses H1, H2, H4, H5 formed within the scope of the structural model of the research are rejected, and other hypotheses H3 and H6 are accepted.

Results and Discussion

Human Resources (HR) research areas have grown in importance as a result of the strategic importance of HR in organizational strategy, and the findings of HR research serve as the foundation for corporate-level decisions. The fundamental issues in HR research are determining the patterns and determinants of individual differences in human resource behavior in an organization (Bhattacharya, 2007). The purpose of this study is to reveal relations of port operations management employees' organizational culture, job satisfaction and turnover intention. When the literature is reviewed, it is observed that there is a scarce number of academic studies in the maritime field. The author can say that the findings of this study show parallelism with literature. According to the findings of this research, the time orientation dimension of organizational culture has a significant impact on job satisfaction of employees working in the port operator organization. Also, Chang & Lee (2007) found that organizational culture has a significant positive effect on employees' job satisfaction.

Moreover, this study reveals that job satisfaction has a significant impact on the intention to stay at work for the port employees. Several studies have focused on job satisfaction, including work-related values that have been linked to job satisfaction and intent to stay (Ravari et al., 2013). The findings show that an organization must encourage its employees. In this respect measures such as granting employees decision-making responsibility, ensuring that these employees feel a sense of belonging to the organization and stay on can be taken. Also, a fair salary that is equal to the market rate is an important point to be taken into consideration by employees' intention to stay (Ghosh et al., 2013). Bangwal & Tiwari (2018) reveal in their research on hospitality industry employees that workplace design features in the hospitality industry to positively impact employee retention through job satisfaction. Another study in the hotel sector shows that job satisfaction strongly and positively influences the intention to stay (Chiang et al., 2005). H1, H2, H4, H5 are not supported in this study. Parallel with the results of Olasupo (2011), this research shows that there is no significant relationship between job satisfaction and uncertainty avoidance, power distance, individualism, masculinity factors of organizational culture.

Conclusion

This study covers employees of a container operator port in Turkey. It can be considered that this is one of the limitations of study. Further research needs to be conducted for other maritime management organizations. The author hopes that this research will inform maritime business organizations about the impact of organizational culture activities in port operators and employee job satisfaction. Once the organizational culture is established in an organization, it needs to be transferred to the newcomers. Especially in this regard, human resources practices in the organization are of great importance in both the development and reinforcement of the culture. For this reason, it is recommended to implement employee-friendly practices that will strengthen the organizational culture and employee job satisfaction in the human resources departments of maritime organizations. Equal employment for women, an open-door policy, and promoting gender equality, diversity, and inclusion are examples of such practices.

Compliance With Ethical Standards

Conflict of Interest

The author declares that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

Data Availability

The data that support the findings of this study are available from the author upon reasonable request.

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RESEARCH ARTICLE

Port efficiency evaluation of Turkish container ports based on DEA-SCOR model: An effective sea gateways in Türkiye for one belt and one road initiative

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ABSTRACT

This study aims to investigate the relative operational efficiency of major Turkish container ports based on the Data Envelopment Analysis - Supply Chain Operations Reference (DEA-SCOR) model. While Turkish export and import figures are growing, the scientifical studies on operational efficiency of Turkish ports are gaining more attention day by day. Of course, one of the important import countries is China for Türkiye and BRI (One Belt and One Road Initiative) tends to support Turkish trade between western and eastern countries. Therefore, Turkish ports' efficiencies should be identified and suggestions have been presented for further development. The sampling frame was chosen from the members of TURKLIM and therefore, the SCOR and Data Envelopment Methodology examined 23 seaports. Both methodologies are generally used for analyzing the operational efficiency of ship inward-outward and stackings. The findings of the study show that four major ports are the most efficient gateways to handle inward and outward container traffic with their input variables. However, there are some challenges in port investment for BRI. This study should be used for the further analysis in the sector reports and scientific papers.

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Introduction

The maritime sector is more important to the economic survival of many developing countries. That notwithstanding, problems to seaports administration have created circumstances of excessive delays to import and export cargoes, human and vehicle congestion in and out ports, and inadequate superstructures or infrastructures leading to huge costs of port operations. To improve the predictability, consistency of port operations led to the better transformation of the port services. Besides, multinational and mutual trade agreements help regional trade and investment and directly benefit ports. China launched at the BRI, which covers many countries. However, Türkiye cannot fully benefit from China's BRI investments. This project creates a great business potential for China and Türkiye.

Great transportation networks demand fast and efficient infrastructures. Container port offers a service but it is not a production line. This service provides a link between different transportation modes. A role of container port is to be soft converter between these modes. It is actually a buffer. BRI recommends connecting common seaports along the Belt and Road so that stable, strong, and effective transport routes could be mutually built (NDRC, 2015)**Hata! Başvuru kaynağı bulunamadı.**. By connecting common seaports along the Belt and Road, the idea is to create stable, strong, and effective transport routes that can benefit participating countries by increasing trade and economic integration. Turkish ports may be the buffers ports to support the BRI supply chain. On the other hand, this study measures the efficiency of Turkish container ports over a wide period of time. In similar studies (Aynur & Yanginlar, 2017; Akdamar & Eren, 2021; Huang et al., 2021), port efficiency was measured in a single time interval, making it difficult to see the efficiency trend between different times. In this respect, the study is more original than the others.

Therefore, it proves that port efficiency is very important for building strategic strength for hinterland development, improving trade and investment facilitations, and supporting major public prosperity and developments. This study aims to investigate the relative operational efficiency of major Turkish container ports based on the DEA-SCOR model. With regard to the aim, the study also analyzes the Turkish port efficiency in their geographical region.

This study consists of four sections including literature review, methodology, findings and conclusion. In the methodology section, DEA-SCOR model explained in detail and all score values presented in the section of findings. Finally, recapitulation of the study has been presented.

Literature Review

This section consists of two sections including port efficiency studies for container ports and BRI with Turkish port industry scope. Both sections discuss the literature in terms of port efficiency within the scope of BRI.

Port Efficiency Studies for Container Industry

The common method for assessing the efficiency of seaports is categorized into two approaches: the parametric and the non-parametric. The parametric methods measure the efficiency through the measurement of a theoretical production. The deviation from the function line is associated partially to the deficiency of efficiency and partially to the presence of measurement error (Cullinane et al., 2006). The stochastic frontier analysis (SFA) is the most important parametric method, which is initially studied for the port industry by (Liu, 1995). Aynur & Yanginlar (2017) measured the operational efficiency of Turkish container ports by using Technique for Order Preference by Similarity (TOPSIS) methodology. They used various criteria including terminal area, annual container throughput, terminal capacity of handling, number of containers, number of quays, quay length, and maximum draft. Various scholars (Coto-Millan et al., 2000; Cullinane & Song, 2003; Tongzon, 2001; Yan et al., 2009) were studied the evaluation of efficiency of ports and terminals. Sağlam & Açık (2020) measured the efficiency scores of Turkish container ports by recursive and cluster methods. The non-parametric methods measure the efficiency without the adoption of a certain production function based on the empirical data. The widely preferred non-parametric method is data envelopment analysis (DEA) (Cullinane & Song, 2006; Wu & Goh, 2010). DEA comprises a data analysis approach focusing at the benchmark of technical efficiency of decision-making unit (DMU). DEA is a linear programming method which benefits from the inputs and outputs of production process. The elements of the input include labor, land, equipment, that is, production related elements and the elements of the output include sales volume, production numbers or cargo throughput. The first study to perform DEA test in the port sector was done by (Roll & Hayuth, 1993) and this study was used a hypothetical sample of 20 ports where the methodology was applied using the CCR model. DEA methodology offers advantages to consolidate different methodologies such as,

CCR, SCOR and BCC. Chen et al. (2019) tested the efficiency of the container port by using DEA-SCOR based model because, this model offers multiple input-output analysis in accordance with the components of port operation and service production, thereby likely to assess the whole performance of the ports (Wang et al., 2003). Therefore, this study performs the DEA-SCOR methodology to analyses the efficiency of container port. The SCOR model could ensure organizations from a variety of sectors with supply chain performance and relevant operations within companies, as well as comparison with other companies (SCOR Version 10.0, 2010). SCOR could describe and waive excessive and bad experiences in terms of supply chain; this situation has been seen in many industries, such as manufacturing (Hwang et al., 2008; Pottash et al., 2010; Li et al., 2011; Zhou et al., 2011; Hwang et al., 2014) construction (Cheng et al., 2010; Pan et al., 2010; Thunberg & Persson, 2014; Wibowo & Sholeh, 2016), service (Ellram et al., 2004; Yilmaz & Bititci, 2006; Sundarakani et al., 2018) and port (Wang, 2017; Wang & Du, 2019; Yan, 2019).

One Belt and One Road (BRI) Initiative and Turkish Port Industry within its Scope

The "One Belt One Road" project or initiative that China has been trying to develop in recent years for maritime transport and very important development for Turkish transportation infrastructure. The BRI has contributed to the development of infrastructure projects in Türkiye, such as the construction of the Istanbul-Ankara high-speed railway and the Trans-Anatolian Natural Gas Pipeline (TANAP). Additionally, the BRI has also created new trade and investment opportunities for Türkiye, and has strengthened economic ties between Türkiye and China. This initiative aims to create new trade routes, lines and job opportunities in order to better and more effective connection between China and Europe alongside with Transition Economies via 5 major routes. The application of the initiative started in 2015 but the project will be possible in the long term including all targeted countries. Countries covered by BRI; 52 African countries, Belarus, Bangladesh, Europe, Fiji, Georgia, India, Indonesia, Kyrgyzstan, Kazakhstan, Latvia, Malaysia, Myanmar, Pakistan, Sri Lanka, Russian Federation, Thailand, Tajikistan, Turkmenistan, Uzbekistan, Vietnam, Central and South America (Sismanyazici, 2017).

With regard to port industry and its relatedness with BRI, The Maritime Silk Road ends in the Shanghai, Shenzhen and Hong Kong, the three largest ports of China. The project begins from China's largest ports and uses canals and waterways. The two most important canals and waterways between the ports of Piraeus and China are the Suez Canal and the Strait of Malacca. The most important port in the Strait of Malacca is the state-owned Singapore port, the world's second largest container terminal. China's share and control of the container terminal in this port is very limited to a small stake. Another important port is Port Klang in Malaysia. In the MALAY Peninsula, China will spend 2 million USD to restore and develop the Kauntan port. China needs lots of raw material for its economy and cheapest logistics plays vital role to ship them into Chinese economy and ship them back to the western countries. It will provide a good opportunity to market their high value-added products to market. In this way, China wanted to add the global value chain to the already existing global supply chain (Esmer, 2016). Chinese companies played an active role in the deepening of Suez. Chinese construction company "CHEC" will build a new container terminal at the port of Ashdod (Sismanyazi, 2017). Again, an agreement was made with the Israeli authorities for the construction of a railway with Israel. Therefore, the initiative is so important for Mediterranean region to support economic development and maritime industry.

For Turkish port industry, the number and capacity of container ports have increased significantly as a result of privatization through the transfer of operating rights and the investments made by the foreign capital thanks to the facilities provided for port investments. They are in well condition in terms of capacity and number and also in terms of ship acceptance facilities, container handling capacities. Some of them are "one stop shop" ports, some of them are 4th generation ports with their logistics infrastructure, port inland connection and coordination with other transportation modes. By the way, China would like to reach the countries on the Black Sea coast, and the Chinese ocean carrier China Shipping (merged with Cosco), which operates increasingly larger Container ships, have chosen Kumport as the most suitable place to enter the Black Sea. Therefore, Türkiye's strategic location at the crossroads of Europe and Asia makes it a natural hub for transportation and trade between the participating countries of the BRI. Türkiye's ongoing infrastructure development projects, such as the construction of the Istanbul Canal, are expected to improve the country's logistics capabilities and further enhance its role in the BRI. However, the chances of getting more demand in Turkish ports also depends on the economic situation and trade dynamics between China and other countries within the BRI, as well as

the effectiveness of Turkish ports to attract more trade and investment.

Methodology

The study has performed the data envelopment analysis (DEA) for measuring the efficiency of Turkish container ports. These seaports are the members of Port Operators Association of Türkiye (TURKLIM) and are operated by major terminal operators. The dataset was taken from the secondary data sources including website of TURKLIM, Turkish Transportation and Infrastructure Ministry and Turkish Port's Web Sites. The data (i.e., total container throughput) belongs to the years of 2018, 2019, 2020 and 2021. The total number of ports is 23, and both models have been explained in details.

SCOR Model

In 1990's, there is a need to measure the efficiency of supply chain and Supply Chain Council found a model named "SCOR". Today, this model is widely used for different researches and continuously updated to version 12.0. It is a categorized process model to develop strategies for process and performance management. It gives useful toolkit to scholars for defining the supply chain configuration. Although traditional supply chain consists of manufacturing process, the port industry does not involve manufacturing and include the business practices in the port industry. It includes five phases: (1) customer demand configuration, (2) port collection, (3) port service, including cargo collection, port handling, port commerce, distribution and warehousing and relevant logistics, (4) water transport to the downstream port and (5) terminal delivery (Wang, 2017). In this study, port collection and port service are very critical as per port internal operational efficiency. Huang et al. (2021) describe the process of SCOR in the port and define the variables and Decision Making Unit (DMU's) of DEA-SCOR based model. Workforce, usage of land and equipment is so critical for container ports (Dowd & Leschine, 1990). These variables can measure the efficiency but it is difficult to reach the cost of data for these type of variables from secondary resources. Huang et al. (2021) advised to use incorporate input variables including quay length, the number of container berths and fixed or mobile gantry cranes. Annual container throughput is approximately related to cargo-related facilities and services, it was considered as an output variable by all prior studies (Thunberg & Persson, 2014). Therefore, annual container cargo throughput is the output variable in this study. All definitions have been in detail in Table 1.

Data Envelope Analysis (DEA)

DEA-based models mostly were mostly inherited from DEA-CCR and DEA-BCC. (Cullinane et al., 2006). The CCR model is used to predict the overall technical efficiency (TE) estimating that returns to scale are constant although the BCC model with the estimation of variable returns to scale is used to predict the pure TE of a decision-making unit (DMU) at a given scale operation. Both models are used in the research since returns to scale of production function of the sample seaports is changeable without exact information. In this method, model orientation can be categorized into input- and output-oriented, which concentrates on minimization for inputs and maximization of output variables (Banker et al., 1984; Banker et al., 2004). For analyzing the port efficiency, this paper can adequately argue that sets of K linear programming envelopment challenges can identify an output-oriented efficiency problem in calculation, with different constraints between CCR and BCC models (Cullinane et al., 2006).

Table 1. The definitions of DMU, output and input variables

DMU, Output/Input(s)	Variables	Definitions
DMU	Ports (N = 23)	Decision Making Unit
Output	Total Container throughput	It represents the movement of a containerized cargo from the ship to an inland carrier or from an inland carrier to the ship, annually.
Inputs	Container Berth	Number of container berth for potential use by container ships primarily loading or discharging of cargoes.
	Wharf Length	It is length of port infrastructure on shore of a harbor.
	Number of Ship-to-Shore (STS) Crane	The number of large dockside crane found at container terminals for loading and discharging intermodal containers.
	Number of MHC Crane	The number of versatile port cranes, suitable for handling containerized cargoes.

Table 2. Summary statistics of sampling

No	Ports (DMU)	2018					2019					2020					2021				
		Input				Output	Input				Output	Input				Output	Input				Output
		Container Berth (piece)	Wharf Length (mtr.)	Number of STS cranes	Number of MHC cranes	Total Container throughput	Container Berth (piece)	Wharf Length (mtr.)	Number of STS cranes	Number of MHC cranes	Total Container throughput	Container Berth (piece)	Wharf Length (mtr.)	Number of STS cranes	Number of MHC cranes	Total Container throughput	Container Berth (piece)	Wharf Length (mtr.)	Number of STS cranes	Number of MHC cranes	Total Container throughput
1	Mersin International Port	21	3370	11	4	1722711	21	3370	12	5	1939029	21	3370	12	5	2009724	21	3370	12	5	2097349
2	Asyaport	4	2010	14	2	1117749	4	2010	14	0	1353409	4	2010	14	0	1437921	4	2010	14	0	1802517
3	Marport	7	2005	10	5	1573600	7	2005	10	5	1679340	7	2005	10	5	1557391	7	2005	10	5	1503254
4	Kumport	4	2174	7	6	1258294	4	2226	9	6	1281850	5	2226	9	6	1210780	5	2226	9	6	1211515
5	Gemport	12	2024	4	6	524652	13	2040	4	7	547190	13	2040	4	6	570427	2	2050	8	6	682064
6	DP World Yarımca	2	922	6	0	575869	2	922	6	0	616749	2	922	8	0	676731	2	922	8	0	666174
7	Evyap Port	6	1270	4	5	464756	6	1270	4	5	499908	6	1270	4	5	509757	6	1270	4	5	599566
8	Yılport Gebze	4	1455	8	0	551726	4	1455	8	0	564531	6	1455	8	0	524065	6	1455	8	0	566447
9	Nemport	6	1080	2	5	390071	6	1080	2	5	430014	6	1080	2	5	484371	6	1080	2	5	544568
10	TCDD Alsancak	4	650	5	3	610908	4	650	5	3	541679	4	650	5	3	531687	4	650	5	3	529131
11	Ege Gübre Aliağa	2	784	2	3	298045	2	784	2	3	380790	2	784	2	3	460297	2	784	3	2	488507
12	Limak İskenderun	8	920	2	5	317.961	8	920	2	5	388328	8	920	4	3	478614	8	920	4	3	476627
13	Socar Aliağa	2	700	3	0	277000	2	850	3	0	311162	2	850	3	0	307250	2	850	3	0	357314
14	Mardaş	3	905	0	9	351849	3	877	0	9	139580	3	877	0	9	114069	3	1073	0	9	222640
15	Assan Port	4	680	0	4	225496	4	680	0	4	248594	4	680	0	4	244643	2	680	0	2	214484
16	Borusan	5	1738	3	9	245499	5	1773	3	8	206395	5	1773	3	8	176117	5	1773	3	8	138491
17	QTerminals Antalya	2	1317	0	6	186290	2	1117	0	6	148750	2	1117	0	6	123983	2	1117	0	6	116786
18	Samsun Ceyport	3	1073	0	9	74129	3	1073	0	9	87840	5	776	1	4	97998	3	1073	0	9	102155
19	Roda Port	3	1200	0	5	86464	3	1200	0	5	99668	3	1200	0	5	82226	3	1200	0	5	92408
20	TCDD Haydarpaşa	4	3413	3	1	56067	4	3413	3	1	45565	4	3413	3	1	41586	4	3413	3	1	27221
21	Limaş	2	405	0	2	16311	2	405	0	2	17914	2	405	0	2	17687	2	405	0	2	25812
22	Akçansa Ambarlı	2	930	0	2	10530	2	930	0	2	26512	2	930	0	2	12522	2	930	0	2	16776
23	Bandırma Çelebi	5	2974	0	3	35695	5	2974	0	3	18581	5	2974	0	3	13340	5	2974	0	3	6981

Note: Source: Input values were collected from TURKLIM Sector Reports (2019, 2020, 2021, and 2022); output values were collected from various information sources, including TURKLIM sector report (2022). Each port is the decision-making unit, which is ranked by total container throughput according to the year of 2021.

The scale efficiency (SE) for the DMU can be calculated by the technical efficiencies derived from the CCR model (TE) and BCC model (PTE), regarding the formula SE (scale efficiency) = TE (technical efficiency)/PTE (pure technical efficiency). Additionally, Lee (2009) commented that the BCC estimates "variable returns to scale", i.e., the scale of output differing. The efficiency value measured in CCR is the "overall technical efficiency", considering that the efficiency value computed by BCC is "pure technical efficiency". If the calculated value is less than "1", this means inefficiency for the decision-making unit (Baran & Górecka, 2015). It may originate from misallocation of inputs, not the factors concerning operational scale.

For this reason, SE means the degree of DMUs' efficiency regarding the optimization of the maximum usage of inputs (Baran & Górecka, 2015). CCR model has been developed by (Charnes et al., 1978) and separated into input-oriented and output-oriented under constant return to scale (CSR). The model has following Eq. 1;

$$\boldsymbol{Maxh_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}}} \quad (1)$$

Subject to;

$$\boldsymbol{\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \; j = 1, \dots, n} \quad (1.1)$$

$$\boldsymbol{u_r, v_i \geq; r = 1, \dots s; i = 1, \dots m} \quad (1.2)$$

Each parameter is identified as follows:

(1) m: input (container berth, wharf length, number of STS crane, and number of MHC crane),

(2) s: output (total container throughput),

(3) n: DMU (number of ports),

(4) y_{rj}: the r. amount of the output of the j,

(5) DMU_{xij}: the i. amount of the input of the j,

(6) DMU_{ur}: the weights of assigned to the output variable,

(7) v_j: the weights assigned to the input variable.

With regard to parameters, the objective function is the rate of the weighted sum of the inputs to the weighted sum of the outputs. The DMU (ports) selects the weights that will make a maximization of the objective function. Constraints provide all weights (u_r and v_i) as a positive or zero, and the objective function takes the value between 0 and 1.

$$\boldsymbol{Maxz = \sum_{r=1}^{s} \mu_r y_{r0}} \quad (2)$$

Subject to;

$$\boldsymbol{\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0} \quad (2.1)$$

$$\boldsymbol{\sum_{i=1}^{m} v_i x_{i0} = 1} \quad (2.2)$$

$$\boldsymbol{\mu_r, v_i \geq 0} \quad (2.3)$$

Linear transformation is used in the model and this transformation is difficult to compare linear programming model, as shown in Eq. 2 (Cooper et al., 2011). A linear programming model in (Thunberg & Persson, 2014) is run n times to determine the efficiency scores of DMU's. The weights that will maximize the efficiency score are determined for each DMU. Once the efficiency score is 1, the DMU is efficient, and when it is lower than 1, it is inefficient (Murat, 2020). Besides, the structure of the output-oriented CCR model is defined as in Eq. 3 (Cooper et al., 2011).

$$\boldsymbol{Minq = \sum_{i=1}^{m} v_i x_{i0}} \quad (3)$$

Subject to;

$$\boldsymbol{\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} \geq 0} \quad (3.1)$$

$$\boldsymbol{\sum_{r=1}^{s} \mu_r y_{r0} = 1} \quad (3.2)$$

$$\boldsymbol{\mu_r, v_i \geq 0} \quad (3.3)$$

Meanwhile, Banker-Charnes-Cooper (BCC) model was developed by the Banker et al. (1984) and the model is divided into input and output-oriented under variable returns to scale (VRS). Apart from CCR, convexity constraint is added to the BCC model (Cooper et al., 2011). Therefore, input-oriented BCC model is created as in Eq. 4 (Banker et al., 1984).

$$\boldsymbol{Maxz = \sum_{r=1}^{s} u_r y_{r0} - u_0} \quad (4)$$

Subject to;

$$\boldsymbol{\sum_{r=1}^{s} u_r y_{r0} - \sum_{i=1}^{m} v_i x_{ij} - u_0 \leq 0} \quad (4.1)$$

$$\boldsymbol{\sum_{i=1}^{m} v_i x_{i0} = 1} \quad (4.2)$$

$$\boldsymbol{u_r, v_i} \geq \in, u_0 \text{ free in sign} \quad (4.3)$$

From this point of view, the output-oriented BCC model is defined as in Eq. 5.

$$\boldsymbol{Minq = \sum_{i=1}^{m} v_i x_{i0} - v_0} \quad (5)$$

Subject to;

$$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} - v_0 \geq 0 \quad (5.1)$$

$$\sum_{r=1}^{s} \mu_r y_{r0} = 1 \quad (5.2)$$

$$\mu_r, v_i \geq \in, v_0 \text{ free in sign} \quad (5.3)$$

As a result, the following prerequisites are fitted for the study. Firstly, the number of variables is at least three times as much. Secondly, the correlation of variables within each cluster is less than 0.70 (Cooper et al., 2011). The study was used to analyze the dataset of the DMU (ports) with the MAXDEA software. This software is very easy to use and most powerful for Data Envelopment Analysis and it includes 15,000 DEA models with most complicated models and no limitations on testing of decision-making units.

In the following section, Table 2 ranks the input and output variables of all container ports in terms of total container throughput, respectively.

Findings: DEA-SCOR Based Model Results

After successfully data collection, the appropriate model (DEA-SCOR model) has been determined and in line with model, the efficiency scores of Turkish container ports were calculated from input and output variables. As the decision-making units (ports) have an effect on the input and output, the study has used both methods: CCR-oriented and BCC-oriented. These methods are called as the input oriented and they aim to maximize the inputs at least given output level. An efficiency performance can range from CCR-focused to BCC-focused methods in policy suggestions. Jaber et al. (2022) confirms that the performance of DMU is better in BCC models compared to CCR models. In this study, the values of TE were calculated with CCR-oriented method and the values of PTE were calculated with BCC-oriented method. With these models, the efficiency scores of container ports were determined and afterward, efficient and inefficient ports were separated. On the other hand, the study presents benchmark scores to be an efficient terminal for inefficient ports in Table 3. Ineffective ports should be referenced to increase their efficiencies as per their benchmarks. For example, the reference ports of Kumport are Assan port, Asya port and Marport. The score of proportionate movement (container berth) for Kumport is the value of -0,74, that is, the port has not enough berth to handle the inward and outward high dense container traffic.

Regarding TE, PTE and SE results, Mersin International Port, Asya Port, Assan Port, and Marport are the most efficient container terminals compared to the other container terminals. Meanwhile, the study also shows that Rodaport, Samsun Ceyport, Yılport Gebze, TCDD Haydarpaşa, Borusan, Bandirma Çelebi, Evyap Port, Mardaş, and Limak İskenderun are the inefficient in terms of TE, PTE and SE results. That is, they do not effectively handle their facilities when they accommodate a number of containers in the inward-outward process due the challenges said in the section of conclusion. Additionally, the SE results of such ports (i.e., Akçansa Ambarlı, Limaş, TCDD Ambarli, etc.) indicates that scale effects are constrains because they have handling problem in the volume of the inward and outward container traffic. In contrast to them, such ports (i.e., Mersin International Port, Asya Port, Assan and Marport) carried out their operational efficiency better on maximum usage of input to handle ship entries and departures.

Table 3. Benchmark scores for inefficient container ports

Ports (DMU)	Benchmark Scores (Lambda)	Benchmark Set
Kumport	0.297958	Assan Port
	0.308293	Asyaport
	0.393748	Marport
Evyap Port	0.062889	Asyaport
	0.430122	Ege Gübre Aliağa
	0.506989	Nemport

From 2018 to 2021 in terms of SE, such ports (i.e., Mersin International Port, Marport, Assanport, and Asyaport) keep their efficiencies stable although efficiencies of these ports including Kumport, TCDD Alsancak, QTerminals Antalya, DP World Yarımca, Ege Gübre get descending. Moreover, Nemport is the only port that has increased its operational efficiency in a four-year period.

The study also measured benchmark scores of inefficient ports so that they can improve themselves on the basis of indicators. The operational result of Turkish ports is given in Table 4 in which TE donates the CCR model technical efficiency, PTE is the BCC model pure technology efficiency, and SE represents scale efficiency.

In terms of findings in Table 4, there are several efficiency gaps that Turkish ports may face, which can include:

a) Limited capacity: Some Turkish ports may not have the necessary infrastructure and equipment to handle large vessels and high volumes of cargo, which can limit their ability to compete with other ports in the region.

Table 4. Efficiency of different ports in Turkish container ports

	Ports (DMU)	2018			2019			2020			2021		
		TE	PTE	SE	TE	PTE	SE	TE	PTE	SE	TE	PTE	SE
1	Akçansa Ambarlı	0.0933941179	1.0000000000	0.0933941	0.2132955743	1.00000000	0.2132956	0.1023695753	1.000000000	0.1023696	0.078215624	1.0000000000	0.0782156
2	Assan Port	1.0000000000	1.0000000000	1.0000000	1.0000000000	1.00000000	1.0000000	1.0000000000	1.000000000	1.0000000	1.000000000	1.0000000000	1.0000000
3	Asyaport	0.9414552315	1.0000000000	0.9414552	1.0000000000	1.00000000	1.0000000	1.0000000000	1.000000000	1.0000000	1.000000000	1.0000000000	1.0000000
4	Bandırma Çelebi	0.2110606544	0.7284429253	0.2897422	0.0996591497	0.66666667	0.1494887	0.0727045804	0.666666667	0.1090569	0.021698588	0.6666666667	0.0325479
5	Borusan	0.2993116935	0.4261526739	0.7023579	0.2925987650	0.40000000	0.7314969	0.2165417617	0.400000000	0.5413544	0.170452219	0.4000000000	0.4261305
6	DP World Yarımca	1.0000000000	1.0000000000	1.0000000	1.0000000000	1.00000000	1.0000000	1.0000000000	1.000000000	1.0000000	0.805700152	1.0000000000	0.8057002
7	Ege Gübre Aliağa	0.7109174779	1.0000000000	0.7109175	1.0000000000	1.00000000	1.0000000	1.0000000000	1.000000000	1.0000000	0.978565509	1.0000000000	0.9785655
8	Evyap Port	0.5897086173	0.6567010379	0.8979864	0.5931322826	0.67300293	0.8813220	0.6333936152	0.645627668	0.9810509	0.779242829	0.7961973113	0.9787057
9	Gemport	0.5946940820	0.6075704132	0.9788068	0.5569485744	0.56355097	0.9882843	0.6101228647	0.613562642	0.9943938	0.756790643	1.0000000000	0.7567906
10	Kumport	1.0000000000	1.0000000000	1.0000000	1.0000000000	1.00000000	1.0000000	0.8918051198	0.963334821	0.9257478	0.853657033	0.9170655534	0.9308572
11	Limak İskenderun	0.6357251530	0.7084572074	0.8973374	0.7388227844	0.80866984	0.9136272	0.7156239417	0.825835301	0.8665456	0.740459613	0.8088751894	0.9154189
12	Limaş	0.1446677546	1.0000000000	0.1446678	0.1441225452	1.00000000	0.1441225	0.1445943681	1.000000000	0.1445944	0.202060138	1.0000000000	0.2020601
13	Mardaş	1.0000000000	1.0000000000	1.0000000	0.7049659705	0.87217365	0.8082863	0.6190418483	0.836414205	0.7401140	0.692017431	1.0000000000	0.6920174
14	Marport	1.0000000000	1.0000000000	1.0000000	1.0000000000	1.00000000	1.0000000	1.0000000000	1.000000000	1.0000000	1.000000000	1.0000000000	1.0000000
15	Mersin International Port	1.0000000000	1.0000000000	1.0000000	1.0000000000	1.00000000	1.0000000	1.0000000000	1.000000000	1.0000000	1.000000000	1.0000000000	1.0000000
16	Nemport	0.7223976191	0.7565621856	0.9548424	0.7362037925	0.77174953	0.9539414	0.8545883769	0.885621123	0.9649593	1.000000000	1.0000000000	1.0000000
17	Port Akdeniz	0.7941901213	1.0000000000	0.7941901	1.0000000000	1.00000000	1.0000000	1.0000000000	1.000000000	1.0000000	0.544497492	1.0000000000	0.5444975
18	Roda Port	0.3758797727	0.7005043045	0.5365845	0.5016710961	0.75163553	0.6674393	0.4461215432	0.740620760	0.6023617	0.287225776	0.6666666667	0.4308387
19	Samsun Ceyport	0.2106841287	0.6666666667	0.3160262	0.4302429929	0.69426582	0.6197093	0.2660821131	0.589267021	0.4515476	0.317521742	0.6666666667	0.4762826
20	Socar Aliağa	0.9620243493	1.0000000000	0.9620243	1.0000000000	1.00000000	1.0000000	0.9971572384	1.000000000	0.9971572	0.925076065	1.0000000000	0.9250761
21	TCDD Alsancak	1.0000000000	1.0000000000	1.0000000	0.9949571718	1.00000000	0.9949572	1.0000000000	1.000000000	1.0000000	0.907750585	1.0000000000	0.9077506
22	TCDD Haydarpaşa	0.1278942619	0.6666666667	0.1918414	0.1017399462	0.66666667	0.1526099	0.0910495323	0.666666667	0.1365743	0.054854050	0.6666666667	0.0822811
23	Yılport Gebze	0.7185566509	0.7197070456	0.9984016	0.6851527730	0.68592087	0.9988802	0.6378053801	0.683369860	0.9333238	0.549943357	0.6659729175	0.8257744

b) Limited investment in port infrastructure: Insufficient investment in port infrastructure could lead to a lack of modern equipment and facilities, resulting in lower productivity and competitiveness.

On the other hand, Turkish ports are actively working on improving their efficiency, and many of the mentioned gaps are being addressed through modernization, investment and automation.

Conclusion and Limitations

This study is used DEA model to describe relative efficiency of ports, which is listed in the members of TURKLIM in the four-year period. An analysis has carried out using DEA – SCOR model. The initial findings involve the optimal efficiency of eight major ports and the tendency of the better port development in numerous ports. Although Turkish port industry may offer good efficiency to BRI, there are some challenges in front of the project. China does not make its game plan for BRI only for Türkiye, and even Türkiye's share is not very large in OBOR. Of course, there are investment plans in Türkiye for Chinese OBOR investments, but they have some challenges to struggle to manage the inward-outward container traffic for Turkish port industry.

Several Turkish ports have been identified as suitable for the Belt and Road Initiative (BRI) due to their strategic location and existing infrastructure. These include:

a) Mersin International Port (MIP) and Assan Port: Located on the Mediterranean coast, they are well-connected to major trade routes and has a large hinterland that includes the countries of the Middle East, Central Asia, and Eastern Europe.
b) Marport: It is the largest port in Istanbul, the largest city in Türkiye, and the main gateway between Asia and Europe.
c) TCDD Alsancak and Nemport: They are major commercial port on the Aegean coast with good connections to major trade routes in the Mediterranean and Europe.
d) Asya Port: It is a deep-water port located on the West Mediterranean coast that offers good connections to the Europe and Asia.

Mersin International Port (MIP) could be a suitable option for China as a sea gateway, as it is well-connected to major trade routes and has a large hinterland that includes countries of the Middle East, Central Asia, and Eastern Europe. Additionally, MIP has been developed as a hub port and has the capacity to handle large vessels and high volumes of cargo. However, it's worth noting that the final decision of which port to choose would be based on the specific needs and requirements of the initiative and the parties involved. The decision may vary according to such challenges. For example, Kumport is important sea gateway for BRI because Chinese companies (China Merchants Holdings International and China Investment Corporation) invested US$920 million to purchase a 65% stake at the Kumport Terminal in the region of Ambarli. As Turkish ports grow in scale and maturity, good cooperation with Chinese giants such as COSCO propose more hopeful collaborations. Although China selected the port of Kumport to reach Black Sea countries, the study shows that Kumport, located in Ambarli, should develop itself to handle the container throughput. However, there is no space to increase the capacity in Ambarli ports that are narrowed in the Istanbul city limits. The port practitioners in the region of Ambarli argue that expropriating the idle storage facility in Haramidere can solve this problem. Especially, container berth of Kumport should be expanded. Another problem is that private ports leased the coastal line from the National Real Estate for 49 years and when the privatization period is over, the state goes out to tender again. The leasing contracts on usage rights of the ports will be ended soon. Many private port operators hinder investments because the contracts will be ended after 49 years.

This study also offered benchmark scores for potential improvements, in other words, the sources of inefficiencies were determined. Each score on average, the greatest potential need for improvement was found in the container berth length (average 60%). That is, container ports achieve efficiency and greater handling capacity by increasing container berth length. In case of expansion of container berth, Turkish ports maybe more competitive as buffers ports for BRI. This is not only the 'efficiency requirement' but also it is an operational necessity. The buffers ports would allow to avoid congestion in the BRI supply chain.

There are certain limitations in this study. Such indexes including the infrastructure, capital, human sources, information and port technology, type of management was removed. Then, this study only focused on the SCOR based approach and different approaches might be combined with data envelopment analysis. Thus, the efficiency evaluation of container terminals is one-dimensional. For the further research, a low sample size will answer how to categorize Turkish container ports according to throughput capacity, and assess the efficiency of each grade of ports to obtain better results. On the other hand, there are several studies

investigating efficiencies of Turkish container ports by recursive and cluster methods. Literature may be extended by including these studies in the future.

Compliance With Ethical Standards

Conflict of Interest

The author declares that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

Data Availability Statements

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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RESEARCH ARTICLE

Green synthesis iron oxide nanoparticles (Fe@AV NPs) induce developmental toxicity and anxiety-like behavior in zebrafish embryo-larvae

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ABSTRACT

The synthesis of nanoparticles and the usage areas of these nanoparticles show a rapid increase. In addition to the beneficial use of nanoparticles, their toxic effects cannot be ignored. In our study, iron oxide nanoparticle (Fe@AV NPs) (mean size: 20.852 nm) was synthesized from *Aloe vera* plant and the developmental toxicity of zebrafish was investigated. Zebrafish embryo-larvae were treated with different concentrations of Fe@AV NPs (1, 10, and 50 mg/L) starting at 4 hours after fertilization and continuing until 96 hours, and different developmental parameters (such as survival rate, hatchability rates, malformations, and behavior) were examined. In our study, it was determined that Fe@AV NPs caused developmental toxicity in zebrafish embryos depending on the dose increase. More than 60% died at 96 hours, especially in the highest (50 mg/L) application group. It was observed that Fe@AV NPs decreased and delayed the success of exiting the chorion depending on the dose increase, and caused various morphological abnormalities (like pericardial edema, tail deformation, and scoliosis) in all application groups except the lowest application group (1 mg/L). While 10 mg/L Fe@AV NPs caused sleep-like behaviors during the daytime by decreasing the daytime motility of the larvae, it caused hyperactivity by increasing their nocturnal motility. The results of thigmotaxis, which is an anxiety parameter, were found to increase anxiety at 10 mg/L Fe@AV NPs exposure.Our findings showed that Fe@AV NPs synthesized from *Aloe vera* plant have in vivo toxicity and their use at concentrations lower than 1 mg/L can be safe in environmental and medical applications.

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Introduction

Synthesis of nanoparticles (NPs) are growing unstoppably in many fields. However, nanotoxicological research is still in its infancy, with the impact of nanoparticles on the environment (Elsaesser & Howard, 2012). Iron oxide nanoparticles (IONPs) are now widely used in drug delivery, water remediation, and medical applications (Choi et al., 2019; Belda Marín et al., 2021; Martin et al., 2022).

IONPs are used in remediation and removal methods against pollutants in aquatic environments (Baruah et al., 2020; Kamath et al., 2020; Monje et al., 2022). This situation has made it important and necessary to investigate the toxic effects of IONPs on aquatic organisms. The toxicity of IONPs in some aquatic organisms is of concern (Sheel et al., 2020; Khoei, 2021; Paulpandian et al., 2022). It has been reported that when carp (*Cyprinus carpio*) is exposed to IONP (size: 20–40 nm) for 21 days, nanoparticles accumulate in the fish liver and intestines and show immunotoxicity in these tissues (Khoei, 2021). Similarly, guppy fish (*Poecilia reticulate*) prolonged (21 days) exposure to IONPs showed high histopathological indices in liver tissues due to circulatory disorders and inflammatory responses (Qualhato et al., 2018). Studies in trout showed that acetylcholinesterase (AChE) activity was decreased in the brain tissues of fish exposed to iron nanoparticles (Fe_3O_4-MNPs) for 96 hours. In addition, it has been reported that there is an increase in lipid peroxidation indicator (MDA values) and the levels of some biochemical parameters (TNF-α, 8-OHdG, and caspase-3) (Ucar et al., 2022). In addition, exposure of zebrafish (*Danio rerio*) embryos to iron nanoparticles (20–30 nm) for 5 days increased mortality, delayed hatchability, and impaired motor abilities (Huang et al., 2019). Still, after zebrafish embryos were statically and semi-statically exposed to IONPs at different doses (21.4 ± 0.39 nm; 0.3-10 mg/L) for 144 hours, it was observed that nanoparticles accumulated in the chorion of embryos and the digestive system of larvae blood accumulation and pericardial edema were observed (Pereira et al., 2020).

It is thought that the natural toxicities of nanoparticles can be used to improve existing cancer treatments through the production of iron nanoparticles, reactive oxygen species (ROS) (Könczöl et al., 2013; Hauser et al., 2016). This idea led to the synthesis of nanoparticles with less toxicity. Green synthesis nanoparticle production offers significant advantages over other nanoparticle synthesis methods as they are cost-effective and do not require the use of highly toxic chemicals (Murugan et al., 2018). Green synthesis nanoparticles are mostly synthesized using plant extracts (Rabiee et al., 2020; Paiva-Santos et al., 2021; Perumal et al., 2021; Kokturk et al., 2022, 2023; Sabeena et al., 2022). Some studies have shown that green-synthesized nanoparticles are less toxic than chemically synthesized NPs (Verma et al., 2020; Anila et al., 2021; Kokturk et al., 2022; Sabeena et al., 2022).

Aloe vera is a perennial and succulent plant whose main components are *Aloe vera* gel and latex (Viljoen et al., 2001). It has been reported that there are many bioactive components in the leaf of the plant (Minjares-Fuentes et al., 2018; Rehman et al., 2019). It has been reported that these components of the plant cause antibacterial, anti-inflammatory, and anticancer effects (Fehrmann-Cartes et al., 2019; Majumder et al., 2019; Medina-Cruz et al., 2021). However, it is very important to investigation the content of some phenolic compounds in *Aloe vera* leaf extract due to their cytotoxicity, and carcinogenicity (Guo & Mei, 2016). Because some studies have shown that *Aloe vera* plant has a toxic effect on living things (Lee et al., 2014; Nalimu et al., 2021; Amri et al., 2022).

In this context, our study aimed to determine the effects of green synthesis iron oxide nanoparticles (Fe@AV NPs) synthesized from *Aloe vera* plant on developmental changes (survival rate, larval hatching rate, and malformations) and behavior (locomotor activity and thigmotaxis) in zebrafish embryos and larvae.

Material and Methods

Chemicals and Instruments

Chemicals were purchased commercially from Merck. In the structural characterization of the samples, SEM (Hitachi Regulus 8230 FE-SEM, 10kV, 100X, 200X), TEM (Hitachi HT7800 TEM, 100Kv, 100000X), FT-IR (Spectrum Two FT-IR Spectrometer), XRD (Panalytical Empyrian, 2θ angle between 10-90o) brand devices were used

Preparation of Aloe vera

Fully grown fresh leaves of *Aloe vera* were washed with ultrapure water. The *Aloe vera* plant was kept in a low temperature (37.5°C) oven for five days. Then the dried plant was ground with the help of a blender. The ground plant was taken up in 100 ml of ethanol and boiled at about 80°C. After boiling, filtration was done. The resulting mixture was filtered using filter paper (Whatman: 1) after cooling. The resulting liquid mixture was stored at +4°C to be used in studies (Ozturk et al., 2022) (Figure 1).

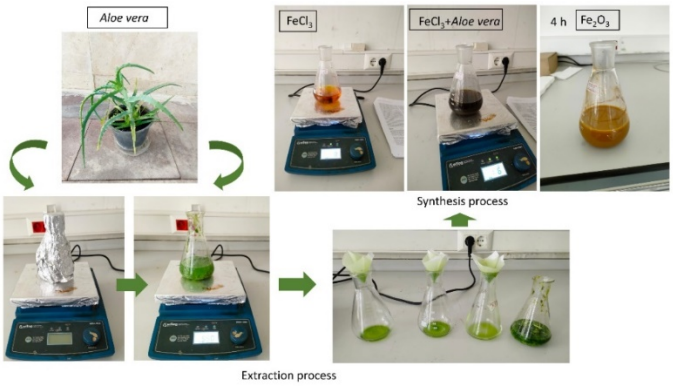

Figure 1. Steps of green synthesis of Fe@AV NPs using leaf extract of *Aloe vera*

Green Synthesis of Fe@AV NPs

0.6 M 100 ml $FeCl_3$ solution was prepared with ultrapure water. The prepared solution was stirred for 15 minutes to completely dissolve in the magnetic stirrer. Then it was mixed with 80 ml $FeCl_3$ solution and 20 ml *Aloe vera*. The resulting solution was left to cool for 2 hours for centrifugation after being subjected to a heating-shaking process in a closed water bath for 4 hours at 60°C. Centrifugation was continued at 4000 rpm for 5 minutes. During the process, the solid material was washed twice with ultrapure water and once with ethyl alcohol and kept in an oven at 60°C for 24 h. Finally, the characterization of the obtained solid material was started (Rautela & Rani, 2019) (Figure 1).

Zebrafish Breeding and Spawning

The adult fish from which the embryos used in our study were obtained, the AB striped zebrafish (*Danio rerio*) were obtained from Oregon State University. Zebrafish are reared at 28±1°C with a photoperiod of 14 h light and 10 h dark, with water circulation. Adult zebrafish are fed twice a day (artemia and flake food). Fertilized eggs were obtained from healthy adult zebrafish, as was done in previous studies (Sulukan et al., 2017).

Fe@AV NPs Treatment to Zebrafish Embryos-larvae

The iron oxide nanoparticle concentrations were derived from previous iron nanoparticle studies (Zhang et al., 2015; Pereira et al., 2020). Stock solution of nanoparticles was prepared with ultrapure water and kept in the sonicator for 20 minutes. Three different concentrations (1, 10, and 50 mg/L) were prepared with E3 solution (5 mM NaCI, 0.17 mM KCI, 0.33 mM $CaCI_2$, 0.33 mM $MgSO_4$, %0.01 methylene blue) from the stock solution and 40 embryos were used in each treatment group. The experiment was performed in three replications. Embryos were exposed to nanoparticles 4 hours after fertilization and exposure continued for 96 hours. In the experiment, solutions were renewed every 24 hours (semi-static exposure) (von Hellfeld et al., 2020). All developmental changes of embryos and larvae were examined at 24, 48, 72, and 96 hpf (OECD, 2013).

Developmental Toxicity of Fe@AV NPs (survival rate, hatchability rates, and malformation rate)

After the embryos and larvae were exposed to different concentrations of Fe@AV NPs, the survival rate was in the range of 4-96 hpf and the morphological changes were examined under the microscope and photographed. Hatchability rates was carried out between 48-96 hpf (Köktürk et al., 2022).

Effects of Fe@AV NP on the Behavior of Zebrafish Larvae (thigmotaxis and locomotor activity analyzes)

Locomotor activity was made using 16 (2 replicates) 96 hpf larvae randomly selected from each group and placed in a plate. The plate was placed on the DanioVision (Noldus) instrument set at 28.5°C and the behavior of the larvae was recorded for 50 min. (dark and light cycles). Motion records dark and light cycles data and total distance analysis of each larva were evaluated by EthoVision (Noldus) software (Kiziltan et al., 2022).

Thigmotaxis (anxiety index) was determined in larvae by making minor changes according to the method described by Schnörr et al. (2012). The purpose of the thigmotaxis analysis is to determine the larvae in the transition from light to dark by measuring the total distance traveled in the outer region (2.25 mm outer) of the wells in the plates by the ratio between the entire test area. As with locomotor activity, the evaluation of the behavior of their larvae for thigmotaxis analysis was performed with the EthoVision software (Baran et al., 2020).

Data Analysis

Developmental toxicity (survival rate, hatchability rates, and malformations) and behavior parameters were analyzed using ANOVA followed by Tukey post hoc testing. GraphPad Prism 8 software was used for data analysis and preparation of graphs. Results are given as mean±SD. Statistical significance (****$p < 0.0001$, ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$ compared to control) or ns: not significant

Results

Characterization of green synthesis of Fe@AV NPs (FT-IR, XRD, FE-SEM, EDS, and TEM)

FT-IR provides information on the vibrational properties of chemical functional groups. FT-IR spectra of the samples (Perk Marble Spectrum FTIR spectra) were obtained using FT-IR Spectrometers using KBr pellets, in the range of 4000 to 400 cm^{-1} with 4 cm^{-1} resolution. In the spectra of Fe@AV NPs, peaks of 3339 cm^{-1}, 1624 cm^{-1}, 1382 cm^{-1}, 865 cm^{-1}, 670 cm^{-1}, and 496 cm^{-1} were obtained. The peaks obtained in the spectral regions are 3339 cm^{-1} hydroxyl group (OH), 1624 cm^{-1} carbonyl group (O=C), 1382 cm^{-1} aliphatic amine (C-N), 865 cm^{-1} and 670 cm^{-1} (Fe-O), was paired with the 496 cm^{-1} alkane group (C-H) (Herlekar et al., 2014; Xiao et al., 2016; Hussain et al., 2016; Abid et al., 2022) (Figure 2).

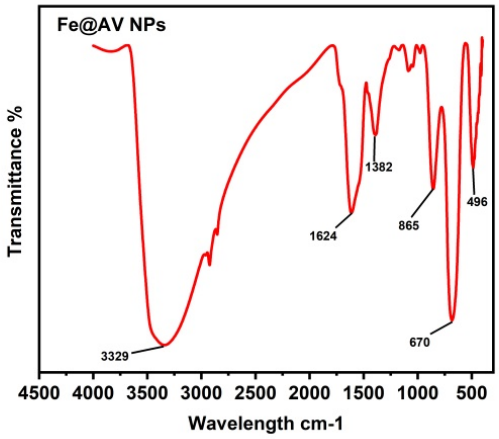

Figure 2. Image of FT-IR spectra of Fe@AV NPs

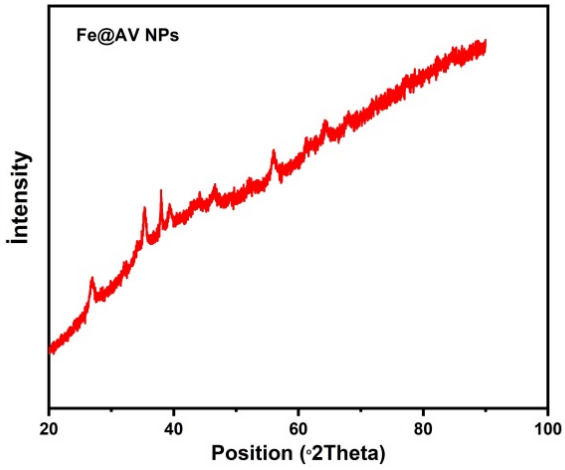

Figure 3. XRD spectra of Fe@AV NPs

With the aid of X-ray diffraction (XRD), the crystal size of the sample was evaluated. Iron oxide formation was confirmed using XRD (peaks obtained at 26.39, 34.89, 37.57, 45.80) (Herlekar et al., 2014; Hussain et al., 2016) (Figure 3).

Normal SEM imaging cannot be performed on iron-bound nanoparticles obtained by green synthesis. Because the magnetic field created by SEM is not preferred because it disturbs Fe-bound nanoparticles and creates agglomeration and stacking. Therefore, the surface morphology and size of the nanoparticles were determined with FE-SEM (Field Emission Scanning Electron Microscopes) and TEM devices. In addition, their elemental compositions were determined with the help of EDS. Figure 4 represents the SEM image of iron-containing nanoparticles with different shapes such as irregular hemispherical and cubic (Mahdavi et al., 2013; Herlekar et al., 2014; Majumder et al., 2019; Abid et al., 2022).

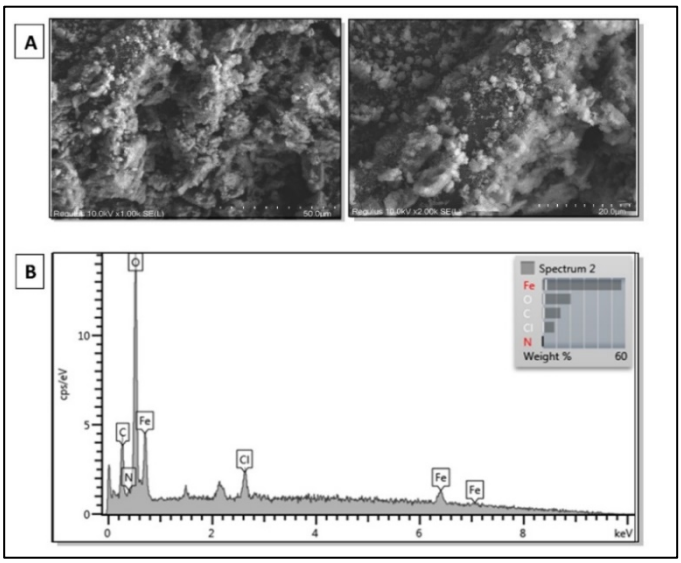

Figure 4. FE-SEM (A) and EDS (B) image showing the morphology of the biosynthesized Fe@AV NPs

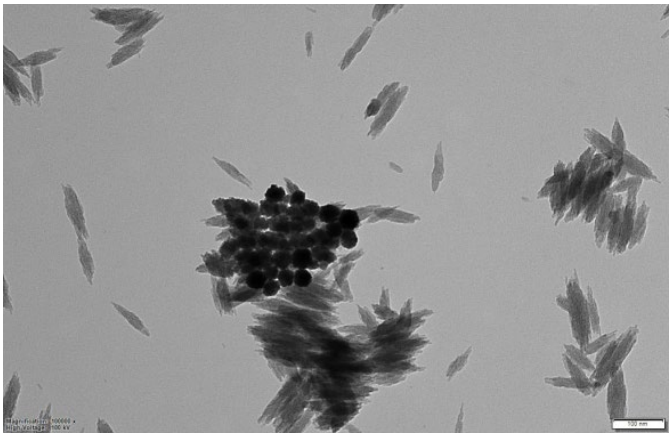

Figure 5. TEM image showing the morphology of Fe@AV NPs synthesized by green synthesis

Figure 5 shows the TEM image of magnetite nanoparticles synthesized using *Aloe vera* extract. The figure shows the image of some spherical or hemispherical and cylindrical

nanoparticles. In addition, the average size of the obtained cylindrical magnetic particles was determined as 20.852 nm from the image program. However, some clusters are noticeable in these images. These clusters sometimes form at the first moment and sometimes within a few days (Herlekar et al., 2014; Xiao et al., 2016; Majumder et al., 2019).

Developmental toxicity of Fe@AV NPs

The survival rate (24-96 hpf) of zebrafish embryos-larvae exposed to Fe@AV NPs is shown in Figure 6. There was a significant dose-dependent difference between the exposed groups (1, 10, and 50 mg/L) compared to the control (Figure 6). The survival rate was decreased in the Fe@AV NPs groups compared to the control (96.7%), and the survival rates for the 1, 10, and 50 mg/L groups were determined as 90.8%, 81.7% and 39.2%, respectively.

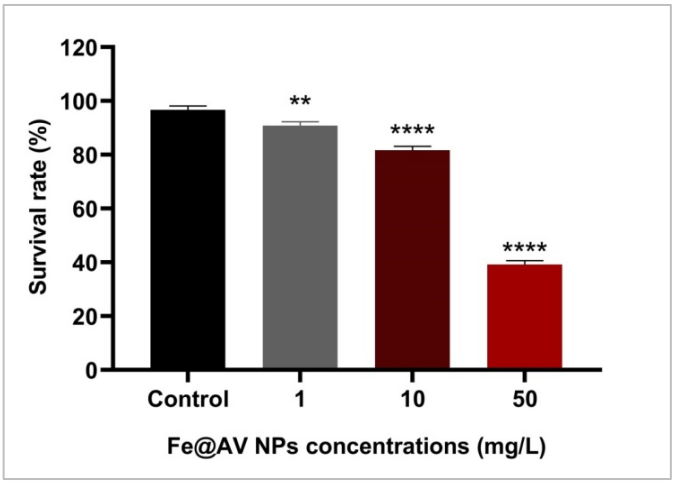

Figure 6. The survival rate of zebrafish embryo-larvae at different concentrations of Fe@AV NPs

Zebrafish embryo and larvae hatching at 48, 72, and 96 hpf were concentration-dependently delayed by Fe@AV NPs (Figure 7). In our study, while the hatching rate of the 48 hpf control group was 63.33%, the hatching rate of the 1, 10, and 50 mg/L concentration groups was 40.83%, 36.67%, and 21.67%, respectively, and significantly decreased compared to the control (Figure 7). Similarly, when the control and Fe@AV NPs application groups were compared at 72 and 96 hours, it was found that there was a significant difference (Figure 7).

The results for the morphological changes showed that there were phenotype distortions in the 1 mg/L concentration group, but there was no significant difference compared to the control group (Figures 8-9). However, phenotype changes such as pericardial edema, tail deformation, and scoliosis in the 10 (13.29%) and 50 (36.11%) mg/L groups of Fe@AV NPs were significantly significant with the control group (Figures 8-9).

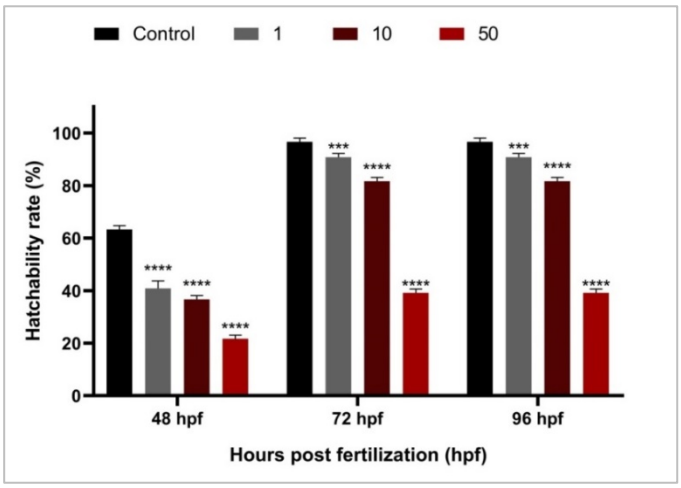

Figure 7. Concentration- and time-dependent hatchability rates for Fe@AV NPs in zebrafish embryos

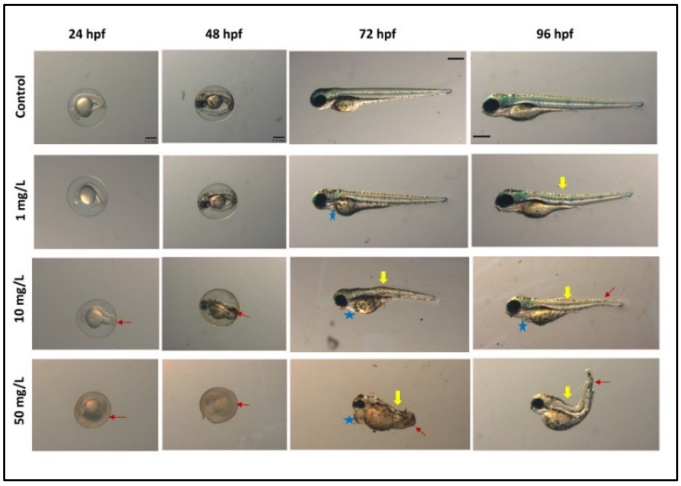

Figure 8. Visual inspection of embryo and larvae at 24, 48, 72, and 96 hpf. Scale bar: 0.5mm

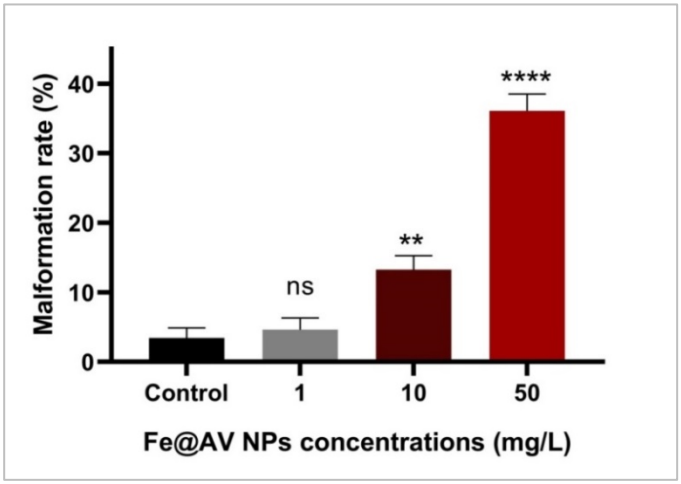

Figure 9. Malformation rate of zebrafish embryo-larvae at different concentrations of Fe@AV NPs

Effects of Fe@AV NPs on the Behavior of Zebrafish larvae

In our study, because the larvae were completely immobile in the 50 mg/L application group at the 96 hours, behavioral testing was not performed in these groups. Thigmotaxis and locomotor activity analyzes were performed to detect the change in behavior of zebrafish larvae exposed to Fe@AV NPs at concentrations of 1 and 10 mg/L for 96 hours (Figure 10). When the change in the distance traveled was examined, it was determined that especially 10 mg/L Fe@AV NPs caused sleep-like behaviors in the larvae during the day by decreasing their daytime mobility and causing hyperactivity by increasing the nighttime mobility (Figure 10A). When the results of thigmotaxis, which is an anxiety and anxiety parameter, were analyzed, it was found that it increased and induced anxiety at 10 mg/L Fe@AV NPs exposure (Figure 10B).

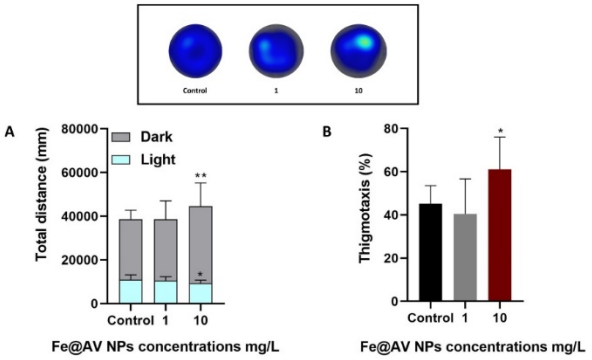

Figure 10. Dark/light locomotor activity (A) and anxiety like behavior (thigmotaxis) (B) of 96 hpf zebrafish larvae.

Discussion

It is thought that the cause of death of embryos in the chorion is that nanoparticles agglomerate on the chorion, increasing the chorion thickness, which in turn blocks the nutrient and oxygen exchange (de Medeiros et al., 2021). Aggregation in iron oxide nanoparticles indicates that these materials tend to accumulate near the bottom and in the sediment rather than in the water column This may make benthic organisms such as zebrafish embryos potential targets of nanoparticles in nature (Zhu et al., 2012). In our study, it was determined that Fe@AV NPs nanoparticles caused death in embryos and larvae depending on the dose increase. It can be said that Fe@AV nanoparticles cause death by accumulating in the chorion membrane of embryos and the pericardial region of larvae with their aggregation tendency. In addition, it is thought that toxic phenolic compounds in *Aloe vera* plant, which is used for the green synthesis reaction, may affect the survival rate of embryos and larvae (Guo & Mei, 2016).

It is known that the size of some iron nanoparticles is smaller than the chorion pore size (500–700 nm), which exposes zebrafish embryos to nanoparticles and even delays their exit from the chorion by clogging the chorion pores (Rawson et al., 2000; Pereira et al., 2020; de Almeida et al., 2021). This may lead to pre-hatching hypoxia changes by closing the chorionic pore channels and reducing gas exchange of embryos (Malafaia et al., 2020). It is also known that metallic nanoparticles adsorb to the surface of the chorion by forming complexes with the thiol group of chorionic proteins (Auffan et al., 2014). The green synthesis iron oxide nanoparticle (Fe@AV NPs) synthesized in our study was found to be large enough to easily pass through the chorion channels and by adhering to the chorion surface, delaying the hatchability of embryos from the chorion in all application groups. It has also been reported that iron oxide nanomaterials inhibit the activity of hatching enzymes and prevent zebrafish embryos from hatching (Zheng et al., 2023).

It has been shown that excessive and sustained iron overload can cause heart damage through ferroptosis (Fang et al., 2019). Again, some studies have reported that nanomaterials (nFexOy) formed with the element iron cause pericardial edema and collection of blood in the heart region in zebrafish embryos and larvae (Thirumurthi et al., 2022; Zheng et al., 2023). In our study, similar to the above studies, it was determined that exposure to Fe@AV NPs caused pericardial edema by affecting cardiac development in zebrafish embryos and larvae.

Swimming movements in larvae constitute behavioral and physiological integrity. Monitoring for differences in swimming movements is an additional and important approach for assessing toxic effects compared to other developmental parameters such as morphological changes and survival rates (Oliveira et al., 2020). In zebrafish larvae, locomotor behaviors are initiated and controlled by the nervous system (Drapeau et al., 2002). Therefore, locomotor activity is used as a sensitive indicator for changes in nerve development in abnormal situations (Liu et al., 2022). Many studies have determined that locomotor activity is somewhat impaired by concentration in zebrafish larvae exposed to nanoparticles such as TiO_2, Au, ZnO and SiO_2 (Duan et al., 2013; Chen et al., 2014; Hu et al., 2017; Xue et al., 2018). According to the results of thigmotaxis and dark/light locomotor activity in our study, it was observed that 10 mg/L Fe@AV NPs caused anxiety-like behaviors in zebrafish larvae and increased locomotor activity,

especially in the dark phase. These observations suggest that Fe@AV NPs exposure may have impaired the coordination between the nervous system and muscle connections (Basnet et al., 2019). It has been reported that light-dark transition increases locomotor activity in zebrafish larvae, while dark-light transition decreases locomotor activity. In zebrafish, increased locomotor activity is related to brain functions and nervous system development, and increased anxiety in larvae is associated with these conditions (Sulukan et al., 2023).

Conclusion

Our results showed that green synthesis iron oxide nanoparticles cause toxicity in zebrafish embryos and larvae. Fe@AV nanoparticles decreased the survival rate and hatchability in zebrafish embryos and larvae, while malformation rates increased.

In addition, it was determined that green synthesis Fe@AV NPs caused hyperactivity and increased anxiety in larvae. Compared to other chemical methods, green synthesis nanoparticles are considered to be less toxic. However, our study showed that green synthesis nanoparticles (Fe@AV NPs) can cause different toxicities depending on the *Aloe vera* used in synthesis. Therefore, it is important to determine safe dose ranges of green synthesis nanoparticles for all living things in the ecosystem.

Acknowledgments

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Compliance With Ethical Standards

Authors' Contributions

MK, AY, & ES: Designed the study.
MK: Wrote the first draft of the manuscript.
MK, AY, and ES: analyses were organized
MK, ES: Performed and managed statistical analyses.
All authors read and approved the final manuscript.

Conflict of Interest

The author declares that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required. Zebrafish larvae younger than 5 days old were used in the study. Therefore, the work does not require any license (Directive 86/609/EEC and EU Directive 2010/63/EU). All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

Data Availability Statements

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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RESEARCH ARTICLE

Sustainability focused maritime studies performed in Türkiye: A literature analysis

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ABSTRACT

Sustainability-related issues have started to occupy the maritime field as well as all other fields in recent years. As elements of huge trade and industrial activities, ports and ships require considering sustainable management and development. The maritime industry has started to take steps within the framework of this requirement. In addition, researchers have been showing interest in maritime sustainability in recent years and conducting studies. This study is a review of maritime sustainability studies conducted in Türkiye. The aim is to reflect what the researchers focus mostly on maritime sustainability, and present a comparison with global studies. The included 50 studies were examined via content analysis. The scope, sustainability dimension, and focused topics of the studies were revealed. The descriptives of the studies were given. As a result, it is found to be that port-related and environmental sustainability studies are more frequent, and sustainability criteria is the most used topic.

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Introduction

Importance of Sustainability

The concept of sustainability has a quite broad meaning. It covers a way of thinking and actions that affect individuals, groups, communities, companies, and even governments, etc. Simply, it can be defined as said in the meeting of the World Commission on Environment and Development; "*to meet the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED, 1987). From this point of view, sustainability points to all the matters like efficient and fair usage of resources, pollution prevention, controlling carbon emissions and fighting climate change, etc., that relate to leaving a livable world to future generations.

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The above definitions may seem to be that the sustainability concept is only about environmental concerns, but it is not true. Sustainability has many aspects, as the United Nations declared with 17 Sustainable Development Goals like *no poverty, gender equality, clean water and sanitation, climate action,* and *peace, justice and strong institutions,* etc. (UN, 2018). Basically, sustainability or sustainable development is made of three main dimensions: *economic*, *environmental*, and *social* (Robert et al., 2005). The economic dimension is about the scarcity of resources (Kuhlman & Farrington, 2010), and the efficient and effective use of those. Environmental sustainability is the "*maintenance of natural capital*" (Goodland, 1995), which points to the correct use of the resources that the planet presents. Finally, the social dimension is good relationships and positive conditions between communities (McKenzie, 2004).

In recent decades, considerable attention has been paid to sustainability elements in also the business. Corporations in any field started preparing sustainability concerned strategies and act accordingly. Sustainability at the corporate level can be defined as meeting the demands of stakeholders, without ignoring the potential needs of future stakeholders (Dyllick & Hockerts, 2002). In this context, corporations have to satisfy their stakeholders economically, they need to establish good relations with the social environment, and while conducting business activities they have to be environmentally sensitive.

The sensitivity to sustainability issues is not only in the management and industrial meaning but also in the academic field. The quantity of research is increasing with a positive momentum day by day. Parallel to this, the context of this research is gradually expanding (Lam et al., 2014). Sustainability is a wide and complex concept, and the researchers conducted various research to identify itself and the importance of the concept in different fields.

Sustainability in Maritime Industry

Similar to other business fields, the maritime industry has been focusing on sustainability issues in recent years. This industry has a wide range of components consisting of ports and port authorities, vessels and ship-owner companies, port and ship users, seafarers and port workers, customers, etc. Processes in this kind of industry containing such a broad frame require taking sustainability seriously indeed. The policies and strategies related to maritime sustainability could be summarized as; reducing shipping distance, carbon emission and energy consumption, besides compliance with labor rights (Asgari et al., 2015). From a view of a wider range, the main subjects that the maritime industry deals with are; reducing the emissions from ports and ships, greening of ports, vessel speed optimization and fuel efficiency, renewable-clean energy usage, and regulations including MARPOL (Shin et al., 2018).

Maritime sustainability could be also separated and examined in three dimensions, as same in other fields. Economic dimension of maritime sustainability covers optimizing operations, cost reduction, and value-added services. Environmental dimension is about reducing negative impacts on nature via efficient use of resources and reducing wastes. Finally, the social dimension aims to push up the welfare of the overall society (Denktaş Şakar & Karataş Çetin, 2012).

Concerns about global warming and climate change directed researchers to examine maritime sustainability. Therefore, research in this context has increased in recent years, in parallel with other academic fields. According to the study of Shin et al. (2018), existing literature indicates that research on maritime sustainability is almost half distributed between *port-related studies* and *shipping-related studies*. Some research apart from these could be categorized under *maritime logistics* topic. With this, it was indicated in the study that research regarding maritime sustainability concentrates on a few concepts; *green ports/shipping*, *carbon emission/climate change*, and *region-specific environmental regulation/management*.

Considering maritime sustainability research on ports, some main topics could be *sustainability indicators* (Shiau & Chuang, 2015; Sislian et al., 2016; Lim et al., 2019), *green ports* (Chang & Wang, 2012; Pavlic et al., 2014), *port management* (Tezcan, 2019; Ashrafi et al., 2020), *port operations* (Kim & Chiang, 2014), etc. At the same time, research on shipping could be grouped as; *fuel efficiency* and *alternative/renewable fuels* (Mak et al., 2014; Zhao et al., 2015; Meng et al., 2016; Atilhan et al., 2021), *shipping emissions* (Bouman et al., 2017; Rehmatulla et al., 2017), *speed optimization* (Kim et al., 2014; Psaraftis & Kontovas, 2014), etc. Economic and environmental dimensions of maritime sustainability are the most examined in these studies.

Motivation and Objectives

There are some studies in the literature that are focusing on reviewing sustainability studies in maritime field. Shin et al. (2018), analyzed sustainability literature in maritime studies via text mining method. The study indicates that sustainability studies in maritime field have significantly increased since 2012. The most mentioned terms in maritime sustainability literature were; *sustainability, management, port, emissions, impact,* and *performance.* Zheng et al. (2020), performed a study

on new research trends in port city sustainability. The study is also indicating that the number of research on maritime sustainability was increased highly in recent years. The studies were categorized into five focus categories, and the most frequent category was *technologies, methods and measures to promote sustainability of port cities*. Mansouri et al.'s study (2015) shows that environmental sustainability studies in the maritime field are in a highly increasing trend in number. The study indicates that the most focused point in this research is operational improvement.

Although these reviewing studies present a broad perspective on the research on maritime sustainability literature under a global frame, a gap in studies reflecting a regional perspective has been noticed. Therefore, it is considered that a study to be carried out on the scale of Türkiye, as a study that reviews the maritime sustainability studies carried out in the regional base, will contribute to filling this gap. The objectives of this study are as follows:

(i) to present descriptive statistics of maritime sustainability studies conducted in Türkiye,

(ii) to expose the scope, sustainability dimension and focused topics of these studies,

(iii) to present an evaluation of the studies and comparison with global literature.

Material and Methods

The research process in this study was performed in two stages. In the first stage, a literature review was made to determine the studies to be included. In this study, maritime research focused on sustainability that is conducted in Türkiye was selected to review. To reach the identified sample, a literature review was performed using EBSCO, Web of Science, Scopus, ULAKBIM TR Dizin, Google Scholar, and Council of Higher Education Thesis Center databases. *Maritime sustainability, shipping sustainability,* and *port sustainability* terms and their Turkish equivalents were used as keywords while performing the search. The database searching process has been conducted in October 2022, and 69 studies were obtained. A preliminary examination was performed by reading the abstracts to determine irrelevant ones to the scope of the study. 19 of these studies were eliminated due to being out of scope. The rest 50 studies (39 articles, 8 master theses, and 3 doctoral theses) were found to be suitable for the second stage to include in qualitative content analysis.

As the literature analyses are generally a qualitative synthesis of data, the qualitative content analysis method was chosen for data analysis in this study. The qualitative content analysis examines the data gathered by means of other than measurement methods and coded and categorized (Forman & Damschroder, 2007). The analysis process can be considered into four steps: material collection, descriptive analysis, category selection, and material evaluation (Seuring & Gold, 2012). The material collection step was performed at the literature review stage. In the second step, descriptive analysis, the descriptive statistics of included studies were determined. At the category selection step, the studies were categorized under two main groups; *scope* and *sustainability dimension*. The scope group is made of three categories; *port, ship,* and *marine*, and the sustainability dimension group is also made of three categories; *economic, environmental,* and *social*. In the last step, material evaluation, the focused topics of the studies were revealed. The findings regarding these steps were detailed in the subsequent section.

Results

In the material collection step, which is the first step of content analysis, the literature review has been made and related studies were revealed. After preliminary evaluation, the studies that did not match the scope of this study completely were eliminated, and the remaining 50 studies were included in the qualitative content analysis process. In the descriptive analysis step, the type and design of the researches and publishing year were revealed in line with the first objective. Descriptives of reviewed studies are given in Table 1, Figure 1, and Figure 2.

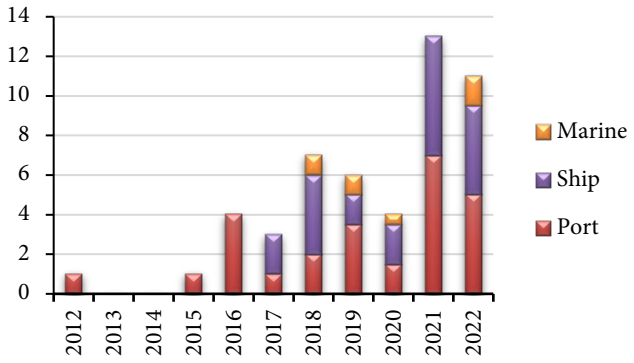

Figure 1. Annual distribution of the studies

In line with the second objective, the studies were examined in depth. Following the review of all included studies, they were categorized under two main groups the scope and dimension of sustainability. In addition, the focused topic of the studies was revealed. The findings of the category selection step are given in the Table 2, Figure 3, and Figure 4.

Table 1. Description of included studies

No	Authors	Year	Type of research	Research design
[1]	Akandere	2021	Article	Mixed
[2]	Akar et al.	2020	Article	Mixed
[3]	Akbayırlı & Tuna	2022	Article	Mixed
[4]	Baştuğ & Esmer	2022	Article	Qualitative
[5]	Bilgili	2021	Article	Mixed
[6]	Bucak	2016	Master thesis	Mixed
[7]	Bucak	2021	Doctoral thesis	Mixed
[8]	Bucak	2022	Article	Mixed
[9]	Canbulat et al.	2019	Article	Mixed
[10]	Cebeci	2017	Master thesis	Quantitative
[11]	Çağlar	2016	Article	Mixed
[12]	Çetin & Söğüt	2021	Article	Quantitative
[13]	Denktaş Şakar & Karataş Çetin	2012	Article	Qualitative
[14]	Durmaz et al.	2017	Article	Quantitative
[15]	Efecan & Gürgen	2019	Article	Qualitative
[16]	Ergin & Ergin	2018	Article	Quantitative
[17]	Fedai	2016	Master thesis	Qualitative
[18]	Gedik & Mugan-Ertuğral	2019	Article	Qualitative
[19]	Genç	2018	Article	Qualitative
[20]	Gültepe Mataracı	2016	Master thesis	Quantitative
[21]	Günaydın	2021	Master thesis	Mixed
[22]	Karakaş et al.	2021	Article	Quantitative
[23]	Karataş Çetin & Denktaş Şakar	2015	Article	Qualitative
[24]	Kaya	2022	Master thesis	Qualitative
[25]	Kılıç et al.	2020	Article	Quantitative
[26]	Büyüksaatçı Kiriş & Yılmaz Börekçi	2018	Article	Qualitative
[27]	Konur	2021	Doctoral thesis	Quantitative
[28]	Konur et al.	2022	Article	Quantitative
[29]	Korucuk & Memiş	2022	Article	Mixed
[30]	Köseoğlu & Solmaz	2020	Article	Qualitative
[31]	Özdemir	2021	Master thesis	Qualitative
[32]	Özispa	2017	Master thesis	Mixed
[33]	Özispa & Arabelen	2018	Article	Qualitative
[34]	Özispa & Arabelen	2021	Article	Quantitative
[35]	Sanrı	2021	Article	Qualitative
[36]	Sürer & Arat	2022	Article	Qualitative
[37]	Şahin et al.	2020	Article	Qualitative
[38]	Şahin et al.	2022	Article	Quantitative
[39]	Tatar & Özer	2018	Article	Qualitative
[40]	Tezcan	2019	Doctoral thesis	Mixed
[41]	Tezcan & Kuleyin	2019	Article	Mixed
[42]	Tezcan & Kuleyin	2021	Article	Mixed
[43]	Tokuşlu	2022	Article	Quantitative
[44]	Uçdu & Kılıç	2022	Article	Qualitative
[45]	Ülker et al.	2021	Article	Quantitative
[46]	Vural et al.	2021	Article	Qualitative
[47]	Yılmaz	2019	Article	Qualitative
[48]	Yigit & Acarkan	2018	Article	Quantitative
[49]	Yiğit	2018	Article	Qualitative
[50]	Yorulmaz & Patruna	2022	Article	Qualitative

Note: Source: Author

Table 2. Theme of included studies

Study	Scope			Dimension of sustainability			Focused Topic
	Port	Ship	Marine	Economical	Environmental	Social	
[1]	*			*	*		Green ports
[2]		*			*		Emissions
[3]			*	*	*	*	Alternative shipping routes
[4]	*			*		*	Sustainability criteria
[5]		*			*	*	Alternative fuels
[6]	*				*		Green ports, Sustainability criteria
[7]	*			*		*	Performance
[8]	*				*		Emissions
[9]	*	*		*	*		Emissions
[10]		*				*	Corporate social responsibility
[11]	*			*		*	Sustainability criteria
[12]		*		*	*		Energy efficiency
[13]	*			*	*	*	Stakeholder relations
[14]		*			*		Emissions, Alternative fuels
[15]		*		*	*		Alternative fuels
[16]		*		*	*		Emissions
[17]	*			*	*	*	Sustainability assessment
[18]			*		*		Marine tourism
[19]			*		*		Marine tourism
[20]	*				*		Emissions
[21]		*		*	*	*	Sustainability criteria
[22]	*				*		Emissions
[23]	*			*	*	*	Corporate social responsibility
[24]	*				*		Green ports
[25]	*	*		*	*		Energy efficiency
[26]	*			*	*	*	Sustainability criteria
[27]		*		*	*		Energy efficiency
[28]		*		*	*		Energy efficiency
[29]	*			*	*		Green ports, sustainability criteria
[30]	*				*		Green ports, sustainability criteria
[31]	*			*	*	*	Sustainability criteria
[32]	*			*	*	*	Sustainability criteria
[33]	*			*	*	*	Sustainability criteria
[34]	*			*	*	*	Sustainability criteria
[35]	*				*		Green ports
[36]		*		*	*		Alternative fuels
[37]		*	*		*		Regulations
[38]		*	*		*		Liquid wastes
[39]		*			*		Emissions
[40]	*				*		Sustainability criteria, management
[41]	*				*		Sustainability criteria, management
[42]	*				*		Sustainability criteria, management
[43]		*			*		Emissions
[44]	*			*	*	*	Green ports
[45]		*			*		Emissions
[46]		*		*	*	*	Sustainable strategies
[47]	*				*		Green ports
[48]		*		*	*		Energy efficiency
[49]		*		*	*		Alternative fuels
[50]		*		*	*	*	Green ports, management

Note: Source: Author

Figure 1 demonstrates the annual distribution of the studies. After first study has been conducted in 2012 an interruption was seen for two years. However, an increasing trend of in the number of studies is seen starting from 2015. The first studies regarding maritime sustainability were port-related. The ship-related studies were started in 2017 and the marine-related ones in 2018.

Figure 3 indicates the sustainability dimension of the studies. While some studies have a theme of containing one dimension of maritime sustainability, some of them contain two or three dimensions at the same time. Almost all studies addressed maritime sustainability in an environmental dimension (n=46, 92%). 28 studies (56%) focus on economic issues and 18 (36%) on social issues.

Figure 4 demonstrates the scope, and the sustainability dimensions mentioned per scope of the studies. The scope of most of the studies (n=27, 54%) is port-related issues. The number of ship-related studies is 22 (44%) and the marine-related studies are 5 (10%). Some of the studies focused on more than one scope. While the studies Canbulat et al. (2019) and Kılıç et al. (2020) focused on port and ship-related issues simultaneously, Şahin et al. (2020) and Şahin et al. (2022) contain ship and marine-related matters. Environmental dimension is the predominant dimension for each scope. All marine-related studies and, almost all port-related and ship-related studies are focused on environmental dimension. More than half of the port-related (59%) and ship-related (59%) studies focused on economic dimension. The number of social dimension studies in ship-related studies (n=5, 23%) is scant relatively to the port-related ones (n=12, 44%).

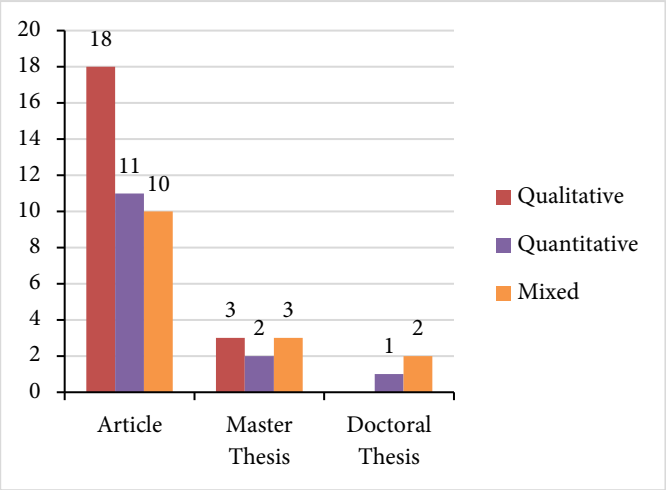

Figure 2. Research type and design of the studies

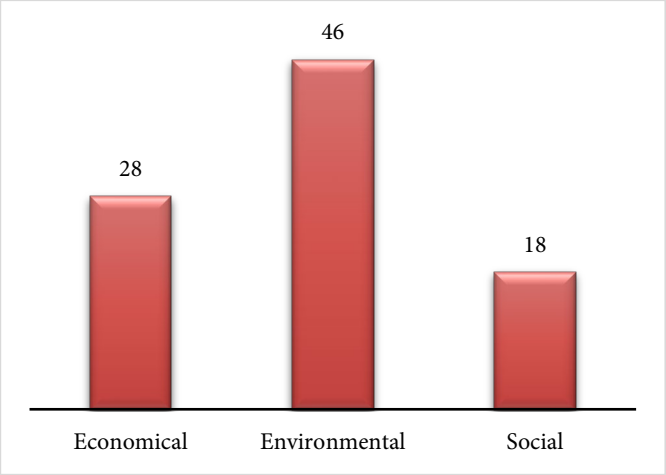

Figure 3. Sustainability dimension of the studies

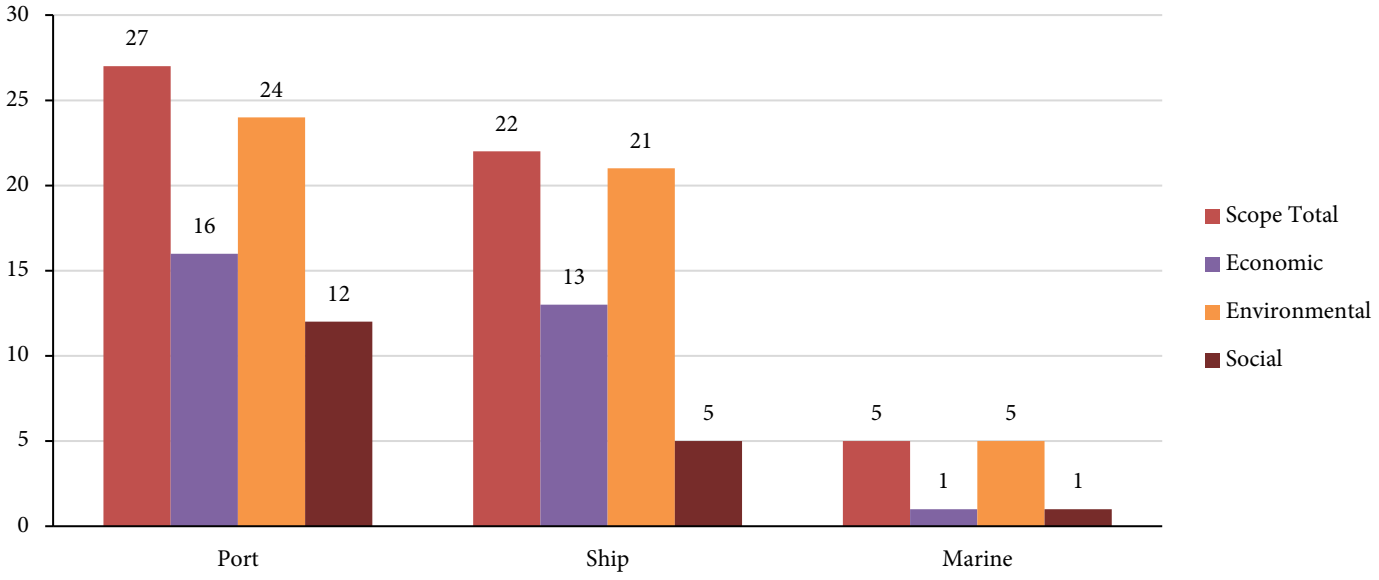

Figure 4. Dimensions per scope

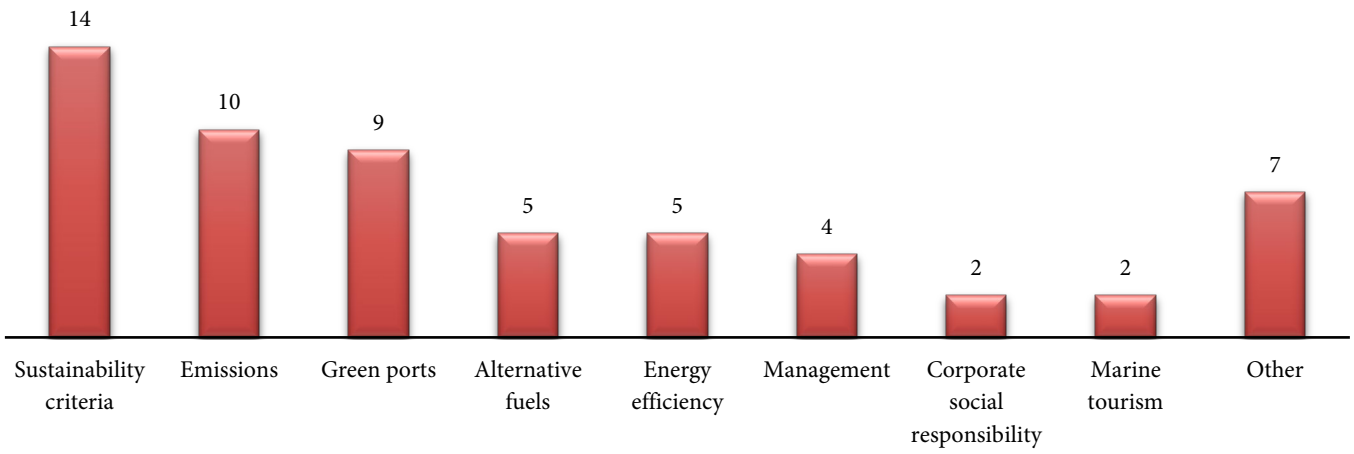

Figure 5. Focused topic of the studies

The last step of the content analysis is material evaluation. In this step, as a result of a deep examination of the studies, the focused topics were revealed. Findings related to the material evaluation step are given in Figure 5. Eight studies have focused on two different topics. The frequency of seven topics is 1, so they are grouped under a topic named *other*. The most focused topic is *sustainability criteria* (n=14, 28%). All but one of the studies focusing on this subject are within the scope of the port. Other prominent topics are *emissions* (n=10, 20%), and *green ports* (n=9, 18%). Some studies focusing on emissions topic are dealt with port emissions, while others are engaged in shipping emissions.

Discussion and Conclusion

Sustainability is a broad concept that is felt increasingly in almost all areas of life day by day. This feeling is also experienced in the maritime field, which includes huge trading and industrial activities. With this reality, researchers included in concerns about sustainability and started studying these matters. Accordingly, the number of studies on sustainability has increased considerably in recent years.

This is a review study that analyses the research performed in Türkiye on the maritime field which focuses on sustainability issues. In line with this analysis, it was desired to reveal the frequency, scope, dimension and topic of the sustainability related maritime studies performed in Türkiye. In this context, 50 studies detected in the literature were included in the analysis. According to the findings, the frequency of the studies has an increasing view in recent years. This indicates the increasing sensitivity of the researchers on sustainability issues. This finding also is in parallel with Mansouri et al. (2015); Shin et al. (2018) and Zheng et al. (2020). The number of the port-related studies is slightly more than ship-related ones as same as Shin et al. (2018). Most of the studies are articles, and the most used research design is the qualitative design. The most touched on dimension of sustainability is the environmental. Almost all studies examined environmental matters in maritime field. This could be a consequence of regulations regarding emissions reduction of IMO (International Maritime Organization) or other national-international authorities. Fuel efficiency could also be another motivation. Shin et al. (2018) found that some keywords like *emission, environmental management, carbon emission,* CO_2 *emission,* and *environmental sustainability* are frequent in maritime studies, supporting this study. In terms of the scope of the studies, it is seen that different dimensions of sustainability are mentioned in each scope. The environmental dimension is predominant for all scopes, however, the scarcity of social dimension in ship-related studies in comparison with port-related ones is quite remarkable.

The focused topic of studies was grouped under 9 main topics. The most frequent one is *sustainability criteria*. These studies determined sustainability criteria regarding effective management, performance, green ports, operations, managers, etc. The next most frequent topic is *emissions*. The studies on this topic examine control and reduction measures of both carbon and other greenhouse gas emissions. Besides, the impact of greenhouse gas emissions on the environment and maritime transportation was also studied. One of the most focused topics is *green ports*. These studies investigated the standards, criteria, and performance measurement of green ports. The green port concept is a topic of very interested in the maritime field (Zheng et al., 2020).

Consequently, the results of this study demonstrates that the maritime sustainability literature in Türkiye tends to

increase in recent years. Although global studies have started to be carried out since the 2000s, it is seen that Turkish researchers have focused on this issue mostly in the last decade. However, the frequency of scope, dimension and topics of the studies are mostly in line with global studies. The environmental dimension either in port-related or in ship-related studies is dominant, in particular. Concerns about emission reduction and energy efficiency require the continuation of work on this topic. Nevertheless, studies focusing on the social dimension are scant, especially in ship-related studies. Studies on sustainable relations between the ship and its stakeholders (ship-owner, port authorities, maritime labors, etc.) can fill the gap in this field.

Compliance With Ethical Standards

Conflict of Interest

The author declares that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

Data Availability Statements

The data that support the findings of this study are available from the author upon reasonable request.

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RESEARCH ARTICLE

Fish spoilage classification based on color distribution analysis of eye images

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ABSTRACT

Fish contains many nutrients beneficial to human health, which makes fish an essential component of a healthy diet. Omega-3 fatty acids, primarily found in fresh fish, can play a critical role in protecting heart and brain health. Freshness is one of the most important quality criteria of the fish to be selected for consumption. It is known that there may be pathogenic bacteria and toxins to human health in fish that are not stored in the right conditions and transferred by wrong logistics methods. One of the widely used approaches for evaluating the freshness of fish is sensory, which would be highly subjective and error-prone. Moreover, sensory analysis is widespread and one of the fastest approaches for evaluating large quantities of fish. At that point, a computer-aided diagnostic system can accelerate the evaluation of the degree of spoilage, reduce the human resources required for this task, and minimize the possibility of spoiled fish consumption. In this study, a fully automated freshness assessment mechanism based on the analysis of digital eye images of fish is proposed. Accordingly, the unsupervised clustering approach was used for feature extraction, and each image was divided into three regions according to their color distribution. The freshness was evaluated according to the intensity difference between these clusters. The results show that the proposed feature extraction approach is highly distinctive for the discrimination of spoilage and can be used to distinguish fresh fish from spoiled fish using machine learning methods without supervision.

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Introduction

Fish is a source of fat, protein, and vitamins such as D and B2, which can be important for human health. Therefore, regular consumption of fresh fish will be an essential component of a balanced diet. One factor that makes the consumption of fresh fish important is the presence of omega-3 fatty acids, which the human body cannot produce but can be taken into the body through fish consumption (Weichselbaum et al., 2013). It is suggested that these fatty acids may reduce the risk of heart disease and stroke (Zhang et al., 1999), and may also be influential in brain development and the protection of health (Uauy & Dangour, 2006). In addition, fish, which is recommended by doctors to be consumed at least twice a week, is also a healthy protein source with low unsaturated fat and cholesterol (Osman et al., 2001).

Although fish is one of the healthiest options in the market, which is recommended for frequent consumption, spoiled fish can be critically dangerous for individuals (Rawat, 2015). Some of the most common bacteria found in spoiled fish are *Vibrio parahaemolyticus* and *Vibrio cholerae*. These bacteria can cause severe food poisoning, nausea, vomiting, diarrhea, dehydration, and death in severe cases (Novotny et al., 2004). In addition, Salmonella bacteria, found in spoiled fish (Sheng & Wang, 2021), can be life-threatening, especially in individuals with weakened immune systems. Moreover, consumption of spoiled fish can lead to histamine fish poisoning, which causes urticaria, hypotension, flushing, and headache (Lehane & Olley, 2000). For this reason, fish that have started to contain harmful bacteria and toxins that may cause food poisoning due to improper storage or waiting should be classified as spoiled, and their consumption should be prevented.

Visual inspection is one of the standard methods of distinguishing spoiled fish from fresh fish (Pons-Sánchez-Cascado et al., 2006). The eyes of a fresh fish should be bright, its general appearance should be shiny and moist, and it should have a non-irritating mild fish odor (Shewan et al., 1953). The fish's texture, appearance, color, and smell provide the necessary information about its freshness. However, the manual inspection would be time-consuming and error-prone due to the subjectivity of different inspectors (Venugopal, 2002; Azeriee et al., 2009). At that point, automation of fish freshness detection may be critical for human health in cases where large amounts of fish are stored or transferred (Vuori, 1992).

Chemical analysis is another preferred method for diagnosing spoiled fish. Accordingly, the number of chemicals such as trimethylamine (TMA) and volatile basic nitrogen (VBN) produced during the putrefaction process is measured (Vuori, 1992). In addition, the pH value of the fish is one of the parameters that can be used as a criterion for spoilage (Vajdi et al., 2019). Although these tests can be a more objective criterion for freshness, they should be performed by experts in a laboratory environment, increasing the cost and the time required for the diagnosis process. Accordingly, an effective computer-aided mechanism would decrease the time and effort required to eliminate spoiled fish, especially in massive transportation and storage cases. Several methods were previously presented for the automation of freshness estimation. For example, in one study, an electrode is used (applied to the fish muscle and skin) for detecting spoilage objectively (Azeriee et al., 2009). Raman spectroscopy is also one of the methods utilized for the assessment of fish quality (Herrero, 2008). Besides the invasive or instrumentation-based methods, digital images of the fish are also analyzed for rapid evaluation of spoilage. For example, in one study, fish gills are automatically segmented for evaluating statistical image features for an efficient fish quality assessment (Issac et al., 2017). Additionally, an investigation of the relationship between RGB (Red, Green, Blue) values of pixels and Quality Index Method scores has revealed that it would be possible to assess spoilage with respect to RGB values. Similarly, Lalabadi et al. (2020) proposed a supervised machine-learning method to classify several color space-based features, including RGB. In addition to RGB-based studies, Jarmin et al. (2012) have compared a fish freshness meter and quantification of RGB color indices. They have revealed that RGB color space-based features effectively detect spoilage after three days. A fuzzy logic-based classification mechanism is implemented by Muhamad et al. (2009) for detecting spoilage of fish. Also, their mechanism performs on RGB color indices.

Digital images of the fish eye are similarly analyzed in this study. An innovative combination of image processing and an unsupervised clustering approach is combined to extract a distinctive visual feature that characterizes spoilage. Accordingly, each eye image is clustered into three regions after preprocessing then the average intensity difference is measured between the most and least dark clusters. The final classification is performed with unsupervised clustering again to assign each image to a class.

Material and Methods

The spoilage process causes a dramatic change in the appearance of the fish eye. Eyes that once appear bright and

clear can become dull, cloudy, and discolored. It was observed that color changes around the pupil increase the gray-level intensity contrast on images of the spoiled fish eye. A few eye images of spoiled and fresh fish are shown in Figure 1.

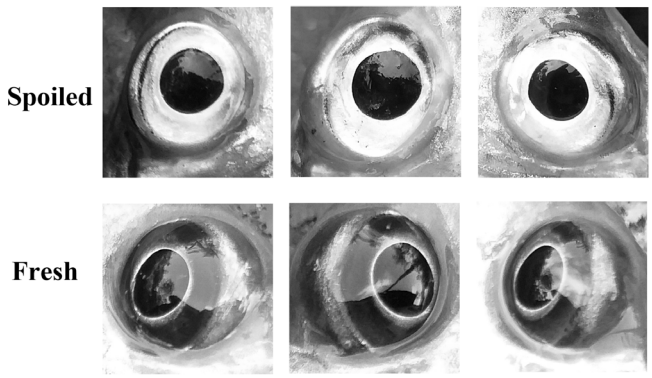

Figure 1. Color change around the pupil caused by spoilage is shown

Gray-level intensity refers to the brightness level of a specific pixel in a gray-level image, which may vary from black (0 intensity, valued with 0) to white (maximum intensity, valued with 255). This study was based on the correlation between gray-level intensity contrast change in the eye region and spoilage. Accordingly, a combination of algorithms, including blurring, was implemented in the MATLAB environment. Each eye image sample was initially preprocessed and then clustered to be divided into three regions with respect to RGB values. Next, each region's average intensity value was calculated to determine the darkest and brightest regions. Accordingly, maximum intensity difference was accepted as a critical feature extracted for final classification. Finally, the data set was clustered again to assign each sample to a class. A block diagram of the implemented mechanism is given in Figure 2.

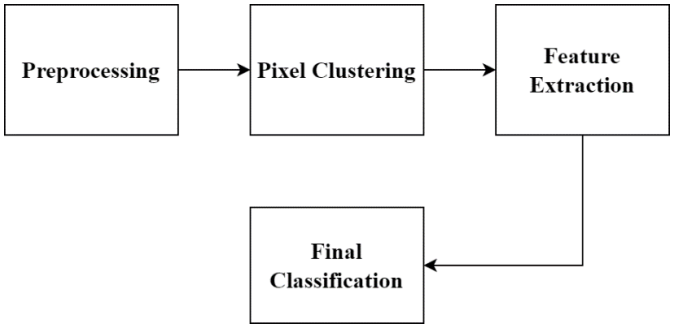

Figure 2. A block diagram showing the stages of the proposed methodology is given

Data-set

All images are taken from the original dataset formed by A. Agustyawan. The dataset includes 40 fish eye images, half of which belong to spoiled fish (Agustyawan, 2021). Sample images are taken from a 10 cm distance with a Samsung A6+ cellphone camera with a 4608 × 3456 pixels resolution (f/1.7, 26mm wide). It should be noted that the camera is focused on the eye pupil, and all eye images are cropped from original data with a 500 × 500 pixels fixed size.

Preprocessing

The main goal of the preprocessing stage was to decrease the complexity of the following clustering task. To achieve that goal, a blurring operation is implemented, reducing the image's sharpness or clarity. It was aimed to suppress high-frequency distortion. Accordingly, a circularly symmetric gaussian lowpass filter averages the colors of neighboring pixels. The result is a smoothed version of the original image, with less high-frequency information and more low-frequency information. The effect of the applied filter is shown in Figure 3.

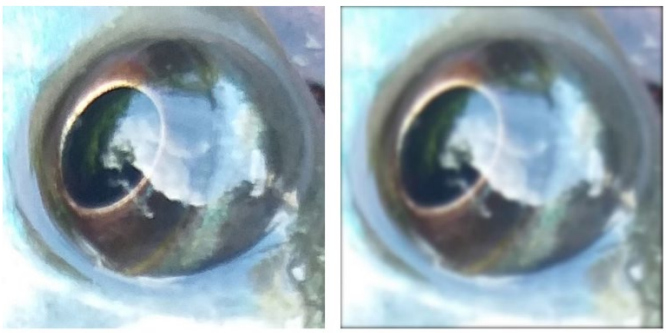

Figure 3. A sample image from the dataset (right) and the output of the blurring process (left) is shown

Clustering Process

Data clustering is grouping similar observations together in a search space. Unsupervised clustering was implemented for two purposes in this study. The first objective was dividing each image into three regions of pixels with respect to RGB values, and the second objective was the classification of extracted features. The K-means approach was preferred for automated clustering. It is a widely used unsupervised machine learning technique based on cluster centroids. It works by dividing observations into k clusters where k is the number of classes determined by the user. The algorithm iterates to minimize the sum of the squared distances between each data point and the centroid of its assigned cluster (MacQueen, 1967). Accordingly, the objective function desired to be minimized defined as:

$$J(V) = \sum_{i=1}^{c} \sum_{j=1}^{c_i} \| x_i - v_j \|^2 \quad (1)$$

Where c_i is the number of observations in ith cluster. c is the number of cluster centroids, and $\|x_i - v_j\|$ is the Euclidean distance between an observation and cluster centroid.

Implemented algorithm first selects random k initial cluster centroids. Then calculates, the distance of each observation to cluster centroids, and each observation assigns to the closest cluster centroid, followed by a recalculation of centroids and distances. The algorithm iterates until no change in centroids are observed. The k-means clustering approach is cost-effective and easy to implement while it can handle large datasets.

In this study, red, green, and blue channel values of each pixel were accepted as an observation than the k-means algorithm was performed to divide each sample image into three regions (Figure 4).

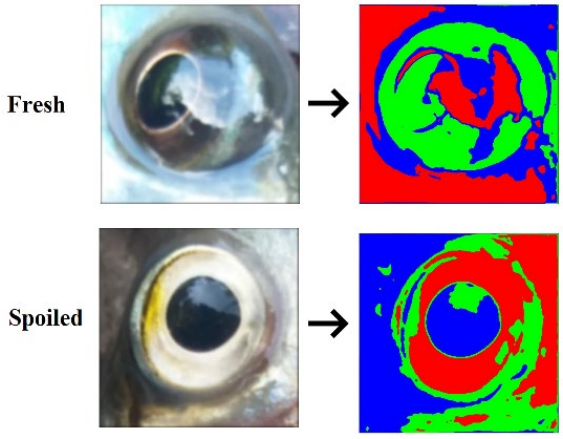

Figure 4. Different regions formed by clustering process is shown in different colors for a fresh and a spoiled sample

Feature Extraction and Final Classification

The calculated feature led us to classify spoiled samples. It was based on significant intensity contrast change. Accordingly, RGB samples were converted to single-channel grayscale. The conversion was based on calculating a weighted average of the three channels to obtain a single intensity value for each pixel. The formula for the conversion process is given below:

$$I = 0.2989 * R + 0.5870 * G + 0.1140 * B \quad (2)$$

Where R, G, and B are the red, green, and blue color channels of a pixel, and the coefficients 0.2989, 0.5870, and 0.1140 represent the luminance sensitivity of the human eye to each color channel.

Three regions were formed previously by assigning each pixel to one of the clusters. After gray-level conversion, the average region intensity was calculated for each cluster. The region with the lowest average intensity was called the darkest region, while the highest average intensity was called the brightest region. Numerical average intensity differences between these clusters were accepted as a key feature for classification. The distinctiveness of the calculated feature was objectively evaluated in the final classification stage.

The final decision stage involves another clustering process. In that stage, each image was accepted as an observation of the search space and represented by a previously calculated feature. Accordingly, each image is assigned to one of the classes as spoiled or fresh with respect to intensity contrast.

Results and Discussion

Fresh fish should have black pupils and clear corneas (Dowlati et al., 2013). It would be possible to observe a discoloration in spoiled fish eyes which most likely causes an increase in the average intensity difference. Three major color regions would be observed in a fish eye image. In most images, the darkest region is the iris area, and the lighter-colored areas include white contours around the iris. Accordingly, the whole image was divided into three clusters. It is also possible to analyze the images with more than three clusters; however, since the average of maximum and minimum areas were considered splitting the image into smaller regions will likely have a limited impact on the final result.

While the region with the highest average intensity value was accepted as the brightest region, the region with the lowest average intensity value was accepted as the darkest region, and the difference between these two regions was taken. The histogram in Figure 5 shows the variance of the intensity contrast in case of spoilage.

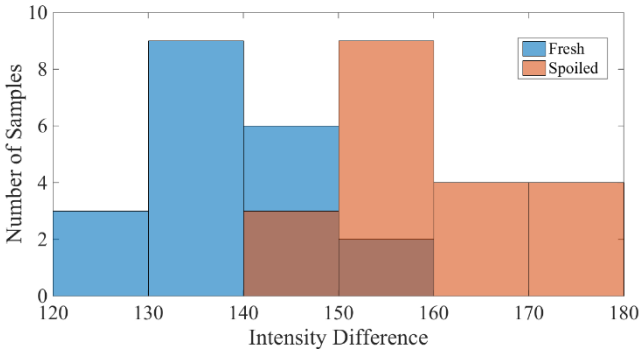

Figure 5. Variance of intensity difference is indicated in histogram form

Table 1. Average results of ten runs are given with standard deviations. Test set1, set2, set3 have 50%, 70% and 80% spoiled images, respectively

Test Sets	Value	F-Score	Accuracy	Sensitivity	Specificity	Precision	Recall
Test Set 1	Mean	0.947	0.950	0.900	1.000	1.000	0.900
	Std	0.000	0.000	0.000	0.000	0.000	0.000
Test Set 2	Mean	0.925	0.940	1.000	0.914	0.880	1.000
	Std	0.121	0.097	0.000	0.138	0.193	0.000
Test Set 3	Mean	0.900	0.940	1.000	0.925	0.850	1.000
	Std	0.161	0.097	0.000	0.121	0.242	0.000

The images used in the data set were not taken at a fixed angle. The presented figure shows that the proposed intensity-based feature changes significantly in the case of spoilage. Based on this, it can be said that the effect of light reflection and angle is relatively small. Moreover, the applied blurring suppresses the effect of reflection and high-frequency local noise.

A novel feature extraction approach is presented in this study. The approach is based on the measurement of contrast change in the eye region as an effect of spoilage. Several studies have tested the significance of average RGB change for spoilage detection. They have revealed a correlation between average RGB indices variation and the deterioration process (Jarmin et al., 2012; Lalabadi et al., 2020). Moreover, Lalabadi et al. (2020) extracted 54 features from the rainbow trout eye images in one study. They have reported that the R/(R+G+B) kurtosis had the highest impact on class prediction. Although a color-based diagnosis was made in this study, the region was divided into clusters and averaged separately instead of examined as a whole.

The significance of the extracted feature for spoilage detection was evaluated by performing unsupervised clustering to classify spoiled fish. Three experimental test sets were formed with randomly selected samples from the original data set for evaluation. 50%, 70%, and 80% of experimental sets were selected from spoiled samples. Classification is performed ten times for each test set. Results are given in Table 1.

The literature on the subject shows that digital images of the fish eye would be an essential resource for the automated diagnosis of spoilage (Muhamad et al., 2009; Lalabadi et al., 2020). The prime contribution of the study is a low-cost, easy-to-implement, unsupervised clustering-based feature. The histogram presented in Figure 5 indicates that spoilage causes a significant variation, which may lead us to conclude that extracted feature would be effective for classifying spoilage. Lalabadi et al. (2020) have reported that 25 samples were diagnosed with %86 accuracy with the features taken from the eye region. Results given in Table 1 indicate that an unsupervised clustering mechanism classified the spoilage with up to %95 accuracy, and the proposed feature is promising.

Conclusion

The potential of a novel intensity contrast-based feature was evaluated to automate the non-destructive detection of fish freshness. The K-means algorithm was implemented to cluster the region without supervision and was also performed to diagnose spoiled fish. Results show that intensity contrast between the darkest and brightest region varies significantly when the spoilage process starts to affect the appearance of the eye. Moreover, it should be possible to conclude that the presented classification scheme is promising for the automated discrimination of spoiled fish. Implementing a supervised machine learning algorithm with the proposed feature is also possible with a more extensive data-set.

Compliance With Ethical Standards

Conflict of Interest

The author declares that they have no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

Data Availability Statements

The datasets analyzed during the current study are available in the "Fresh and not fresh fish dataset" repository, [https://www.kaggle.com/datasets/arifagustyawan/fresh-and-not-fresh-fish-dataset].

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RESEARCH ARTICLE

Quality changes of European eel (*Anguilla anguilla*) stored under refrigerated conditions at 2±1°C

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ABSTRACT

This study aims to determine microbiological, sensory and color changes of whole European eel (*Anguilla anguilla*) aerobically stored at 2.00±1.00°C for 19 days. Samples were analyzed with periodical intervals in terms of Total Mesophilic Aerobic Bacteria (TMAB), Total Psychrophilic Aerobic Bacteria (TPAB), *Psedumonas sp.* and Lactic Acid Bacteria (LAB). For the sensory analysis, samples were evaluated to describe the changes in skin color and mucus, eyes shape and clarity, texture and odor. Description of color changes consisted of *L**, *a**, *b**, ΔE, chroma and hue angle during the storage period. The count of TMAB, TPAB, *Pseudomonas sp.* and LAB were found to be 1.53±0.08; 1.08±0.12; 1.15±0.21 and 1.15±0.21 log cfu/g, respectively. Significant differences were not found for the first 2 days of the storage for any microbiological parameters ($p>0.05$). At the end of the storage time, the counts of microorganisms were significantly increased ($p<0.05$) and reached 8.08±0.65; 7.56±0.08; 7.53±0.76; 2.80±0.14 log cfu/g, respectively. In terms of sensory changes whole European eel samples were resulted unacceptable for consumption after 13 days of storage with an 8.20±0.83 sensory score while 9.75±0.95 was the highest score for the samples on day 19th. The changes in the color of the samples were significant on the first and 5th days of storage ($p<0.05$). ΔE, *L** and *b** values were significantly increased ($p<0.05$) while chroma and *a* values were decreased on day 5. Overall results for this study are proving that *Pseudomonas sp.* could be the indicator microorganism that could be used to determine the shelf life of European eel together with the sensory analysis, linear correlation with storage time was not obtained for ΔE or any other color parameters and whole European eel could be stored at 2.00°C for 13 days based on sensory and microbiological quality changes.

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Introduction

Aquatic products have a significant role in human health as they provide a balanced and healthy diet as high-quality nutrient sources. The consumption of aquatic animals is associated with various advantages for health with their nutrient content such as protein, fatty acids, vitamins and minerals (Parian & Mullin, 2016; Hassoun & Karoui, 2017; Giannakourou et al., 2019). European eel (*Anguilla anguilla*) is a commercially important species in Türkiye as it has been worldwide due to its excellent quality attributes, such as white meat due to its abundance of omega-3 lipids, flavor and high-fat content (El-Obeid et al., 2018; Lambrianidi et al., 2019).

Eels are generally classified as warm-water fish, and they migrate long distances to inland waters for feeding and to the ocean for breeding. They store fat by their nature of spawning migration. Eels are classified under the genus Anguilla which is distributed worldwide (van Ginneken & Maes, 2005; Righton et al., 2016). There are four commercially valuable species in 19 species of the Anguilla genus. *A. anguilla* is distributed in Europe and the relevant Mediterranean coasts. Consumers can purchase eels from the market as fresh products (usually alive or gutted and decapitated). The high-fat content of eels is rich in omega-3 lipids, which expands the potential for eel species, and therefore, eels are attaining worldwide attention (El-Obeid et al., 2018). This attention is important; however, the European eel is listed among the critically endangered species on the International Union for Conservation of Nature (IUCN) red list (Pike et al., 2020). Therefore, eels are under conservation which regulates their fishery, import and export quotes. Efficient use and consumption are also crucial for their conservation, while they are prone to rapid nutritional value losses. The loss of nutritional quality takes place primarily through lipid oxidation, which greatly reduces their estimated shelf life (Küçükgülmez et al., 2013; Yanar et al., 2013; Choulitoudi et al., 2017). Globally, fish losses due to microbiological spoilage account for approximately 10% of the produced fish, whether they are aquaculture or fishery products. In this manner, the expiration date estimates become more important to avoid spoilage and disposal of eels.

The lipid content of European eels is typically higher than most fish species. The nutritional composition of the European eel has been described in many studies. In general, it depends on age, life stage, weight, and time of year (Heinsbroek et al., 2007). The reported ranges for moisture, protein, and lipid ratios in European eels were 60–73%, 15–20%, and 4–30%, respectively (Schreckenbach et al., 2001; Lupatsch et al., 2003; Özogul et al., 2005; Özogul et al., 2014; Gomez-Limia et al., 2021; Tunçelli et al., 2022). Few research reported that European eels accumulate lipids before spawning and that lipid levels increase as the fish grows (Larsson et al., 1990; Saito et al., 2015; van Ginneken et al., 2018). Larsson et al. (1990) also reported that the lipid content of European eel muscle tissue increases while the yellow eel's metamorphosis into silver eels.

Fish quality parameters are of paramount importance for aquatic animals, as they are directly related to consumer-perceived attributes of appearance, smell, taste, or texture. (Özogul et al., 2005; Hassoun & Karoui, 2017). Freshness is the most important attribute in evaluating fish quality. Consumers can see the organoleptic properties of whole fish. The sensory method is the most satisfying way to assess the quality of freshness, as it best reflects consumer acceptance (Connel, 1995). Quality also depends on internal parameters in addition to external parameters that are important for consumer acceptance. These internal parameters are usually accepted as initial microbial load, microbial activity (Dalgaard, 1995), problematic post-harvest handling, processing conditions (Giannakourou et al., 2023), and microbial spoilage (Ashie et al., 1996), which directly affects the shelf life of fish products (Baklori et al., 2012; Lambrianidi et al., 2019).

The quality of fish becomes progressively worse with post-mortem changes through the chemical attributes, protein and lipid degradations, and microbial spoilage (Ashie et al., 1996). In terms of spoilage, that is the process by which seafood decomposes to the point that it is no longer acceptable for consumption based on the above-mentioned criteria. These events result in reduced sensory quality and nutritional value of fish (Özogul et al., 2006) which makes the product less valuable and buyable by the consumers.

The shelf life of aquatic products is short; therefore, they are often subjected to processing technologies to extend their shelf life. Anyhow, today's consumers prefer high-quality, more "natural" products made with gentle procedures that are microbiologically safe, nutritious, and healthy with minimal additives, seeking fresh or minimally processed foods (Erkmen & Bozoglu, 2016). In this context, quality changes of whole European eel were monitored during the chilled storage under refrigeration conditions and microbiological, sensory and color changes were assessed to determine the shelf life of fresh whole European eels.

Material and Methods

Material

Whole European eel was used in this study. Samples were collected from Muğla province and transferred to the laboratory in an insulated box covered with ice. The average weights of the samples were 355.23±129.13g (WL-2002L) and average lengths were 566.35±55.30 mm. European eel samples were aerobically stored at 2.0±1.0°C for 19 days in pouches to prevent drying of the samples and periodically analyzed in terms of the changes in microbiological, color and sensory quality.

Microbiological Analysis

In each sampling day, 10 g of sample was aseptically removed and homogenized in 90 ml buffered peptone water (Merck, Darmstadt, Germany) in stomacher for 2 min. Serial dilutions were prepared and the counts of TMAB and TPAB were determined on Plate Count Agar (PCA) (Merck, Darmstadt, Germany) with pour plate method, LAB was determined on De Man Rogosa and Sharp (MRS) agar (Merck, Darmstadt, Germany) with double layer pour plate method and *Pseudomonas sp.* was on Cephaloridin-Fucidin-Cetrimide (CFC) agar with CFC supplement (Merck, Darmstadt, Germany) with spread plate method. Incubation time for the microorganisms was 30, 5, 25 and 25°C for 3, 10, 5 and 3 days, respectively. Analyses were performed in 2 replicates and results were represented in log cfu/g (Sallam, 2008).

Color Analysis

The color changes of *A. anguilla* were measured with portable 3NH color meter (Shenzen ThreeNH Tech. China). Calibration was performed with white and black samples and measurements were conducted with 10 replicates of each sample from the head to the tail of the skin of the fish. From the measurements L^*, a^*, b^*, hue angle and chroma values were obtained. The parameter L^* represents the lightness between 0 and 100 which indicates white and black, respectively. For other parameters -/+ a^* for red/green, -/+ b^* for yellow/blue, hue is the angle between 0° and 360° dividing the color space into four place and chroma is the saturation of the color (Cavaco et al., 2021; Karki et al., 2023). Hue and chroma was calculated based on the Eqs. 1 and 2, respectively. From the obtained values of L^*, a^* and b^*, ΔE which represents the total color changes in the sample was calculated in accordance with the Eq. 3 (Oliveira & Balaban, 2006).

$$Chroma = (a*^2 + b*^2)^{1/2} \quad (1)$$

$$Hue = Arctan(b^*/a^*) \quad (2)$$

$$\Delta E = \sqrt{(L_0^* - L_t^*)^2 + (a_0^* - a_t^*)^2 + (b_0^* - b_t^*)^2} \quad (3)$$

Sensory Analysis

Sensory changes of whole eel were evaluated in accordance with the method described by Arkoudelos et al. (2007) with slight modifications. Specimens were tested in terms of the changes in skin color and mucus, eyes shape and clarity, texture firmness and odor. Each parameter ranges between 0 and 2 which is representing good quality and inappropriate for consumption, respectively. Samples were assumed to be spoiled when the total sensory score reached the scores of 8 out of 10. During 19 days of storage 2 to 5 trained panelists were attended for sensory session and results were recorded as mean ± standard deviation (SD).

Statistical Analysis

Results obtained from the duplicate analysis were subjected to variance analysis (ANOVA). Tukey's test was used to compare the mean values at the significance level of $p<0.05$. Statistical tests were performed by using statistical package program IBM SPSS (SPSS Inc., Chicago, 2008). Polynomial quadratic function was used in order to estimate the effect of storage time in color values (El-Gendy et al., 2014; Gunathilake et al., 2019).

Results and Discussion

Microbiological Changes

During 19 days of storage of whole European eel, microbiological changes such as TMAB, TPAB, *Pseudomonas sp.* and LAB were assessed and results were shown in Table 1. The initial counts of TMAB, TPAB, *Pseudomonas sp.* and LAB were found to be 1.53±0.08, 1.08±0.12, 1.15±0.21 and 1.15±0.21 log cfu/g which indicates a good quality for fish as indicated by Scherer et al. (2006). During the storage the counts of bacteria were progressively increased and reach 8.08±0.65, 7.56±0.08, 7.53±0.76 and 2.80±0.14 log cfu/g, respectively at the end of the storage time ($p<0.05$). Statistical differences were not significant ($p>0.05$) for the first two days of the storage for TPAB, *Pseudomonas* sp. and LAB. Among the bacterial groups TMAB has reached the highest count at the end of the storage time followed by TPAB, *Pseudomonas* sp. and LAB. For the acceptable limit of indicated by ICMSF (1986) 7.00 log cfu/g

was exceed on day 13 for TMAB and TPAB and on day 19 for *Pseudomonas* sp. in contrast with the bacteria group tested in here LAB were not exceed the acceptable limit of 7.00 log cfu/g. Moreover, the highest count was obtained on day 13 for LAB. Similar results were reported by Arkoudelos et al. (2007) for TMAB Researchers were reported the initial counts of Total Viable Count (TVC) for farmed eel (*A. anguilla*) stored under different packaging types (air, vacuum and modified atmosphere (MAP)) at 0°C as 2.8 log cfu/g. The counts of TVC were exceeded the acceptable limit of 7.00 log cfu/g after 18 days for air packed samples. For the initial counts of *Pseudomonas* sp. were reported to be less than 10 cfu/g however exceeded the 7.00 log cfu/g after 5 days of storage for air packed samples. In terms of the counts of *Pseudomonas* sp. 5 days of storage at 0°C until the acceptable limit is exceeded is not in agreement with our findings which were 19 days. The differences between the same bacteria could be due to the differences between the strains that naturally occurred in the fish and metabolic activity of the strains (Illikoud et al., 2019).

The growth of LAB in whole chilled European eel is indicating that the LAB is not dominant at the time of spoilage. The highest count was reached 3.21±0.05 log cfu/g on day 13 and slightly decreased to 2.80±0.14 log cfu/g ($p>0.05$). The results were comparable to those reported for European eel (*A. anguilla*) fillets stored at 4°C (Giannakourou et al., 2023). Slower growth of LAB in European eel fillets was reported as the initial count was started 2 log cfu/g and reached 4.6 log cfu/g at day 8. However, in another study the growth of LAB was reported faster in fresh eel fillets stored at 2°C compared to the findings for whole European eel as the numbers of LAB was found to be 6 to 7 log cfu/g on 10th day of the storage (Lambrianidi et. al., 2019). The differences in LAB counts between whole and filleted eel could be the results of filleting process which causes higher exposure of the muscle and thus resulting the higher bacterial growth quality loss during storage (Islami et al., 2015).

Color Changes

The changes in color namely L^*, a^*, b^* and ΔE that are indicating Lightness/darkness (100/0), green/red (-/+), blue/yellow (-/+) and total color changes, respectively (Ünal Şengör et. al., 2018) are shown in Figure 1. Linear correlation was not found between storage time and representative color parameters. But instead, polynomic function was able to explain the regression with the values of R^2 = 0.89, 0.87, 0.89 and 0.88. During 19 days of storage L^*, b^* and ΔE values were increased on day 5 and highest values were found to be 6.12, -4.80 and 3.87 ($p<0.05$) and decreased in accordance with the storage time and reported to be 5.21, -6.75 and 0.93. Significant differences ($p<0.05$) were found for b^* values on the last day of the storage. In contrast to L^*, b^* ΔE values, a^* values were decreased on day 5 ($p<0.05$) and lowest and highest values were found to be 6.44 and 8.44, respectively. Samples were darker and had yellowish and reddish color on day 5. Significant differences were not found between the initial and last day of experiment ($p>0.05$). However, fluctuations in the color values indicates high enzymatic activity. Darker color on the skin of the samples could be the results of the activity of calpains and cathepsins (Haard, 2002). Similar results for L^*, a^* and b^* values were reported by Küçükgülmez et al. (2013) for European eel fillets during refrigerated storage. In the study, no significant differences were reported for chitosan coated and non-coated European eel fillets.

Table 1. Microbiological changes (mean±SD) in whole European eel stored at 2.00°C*

Storage time (days)	TMAB	TPAB	*Pseudomonas sp.*	LAB
0	1.53±0.08^{a}	1.08±0.12^{a}	1.15±0.21^{a}	1.15±0.21^{a}
2	1.38±0.12^{b}	1.45±0.21^{a}	1.00±0.00^{a}	1.00±0.00^{a}
5	2.15±0.21^{c}	2.16±0.12^{b}	2.58±0.15^{b}	2.20±0.03^{b}
8	4.99±0.12^{d}	5.21±0.05^{c}	5.30±0.18^{c}	3.06±0.02^{c}
13	7.41±0.02^{e}	7.52±0.02^{d}	6.23±0.33^{d}	3.21±0.05^{c}
19	8.08±0.65^{f}	7.56±0.08^{e}	7.53±0.76^{e}	2.80±0.14^{c}

Note:*different superscripts representing significant differences ($p<0.05$) in each column. Results were shown in log cfu/g.

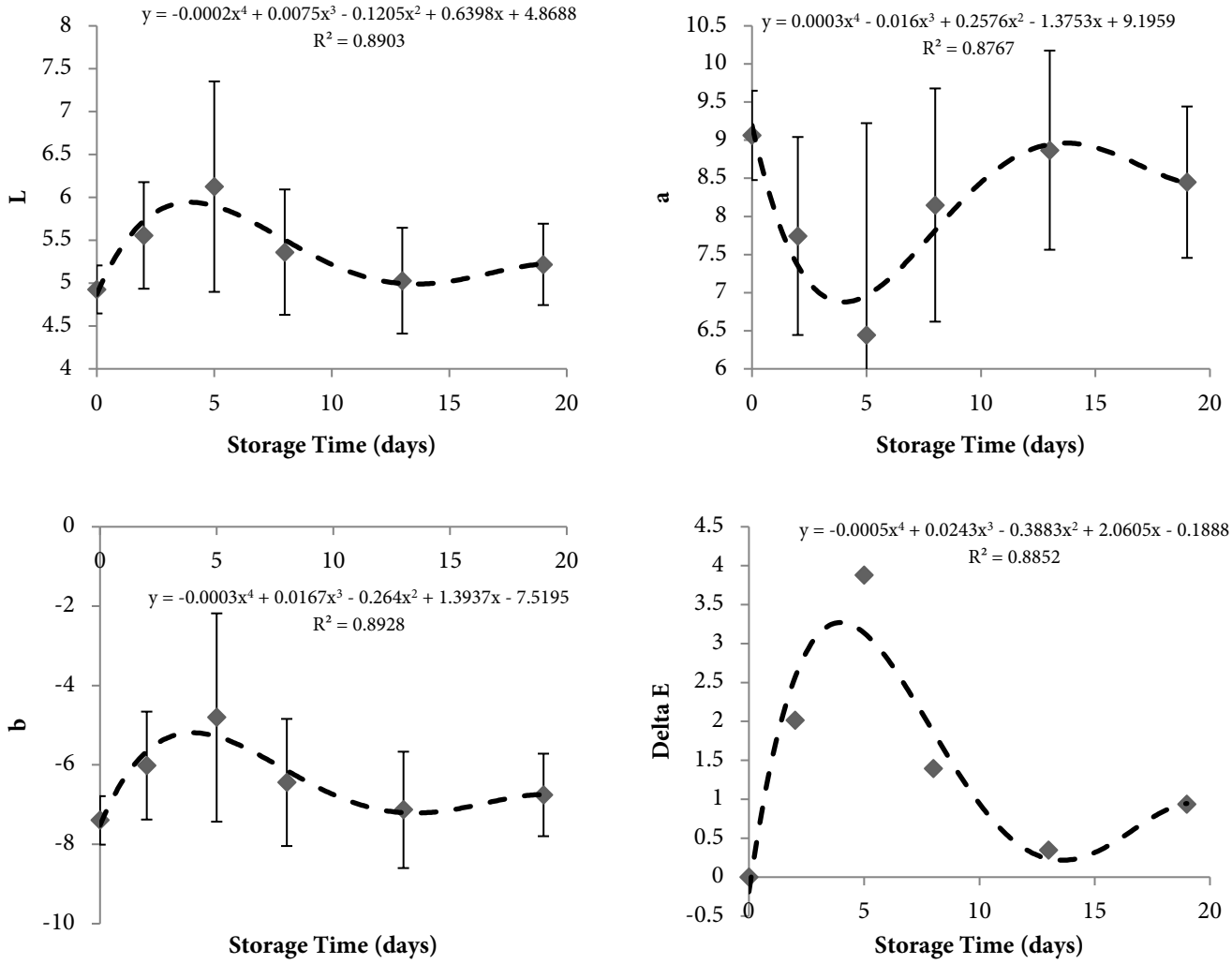

Figure 1. Color changes of whole European eel stored at 2.00°C

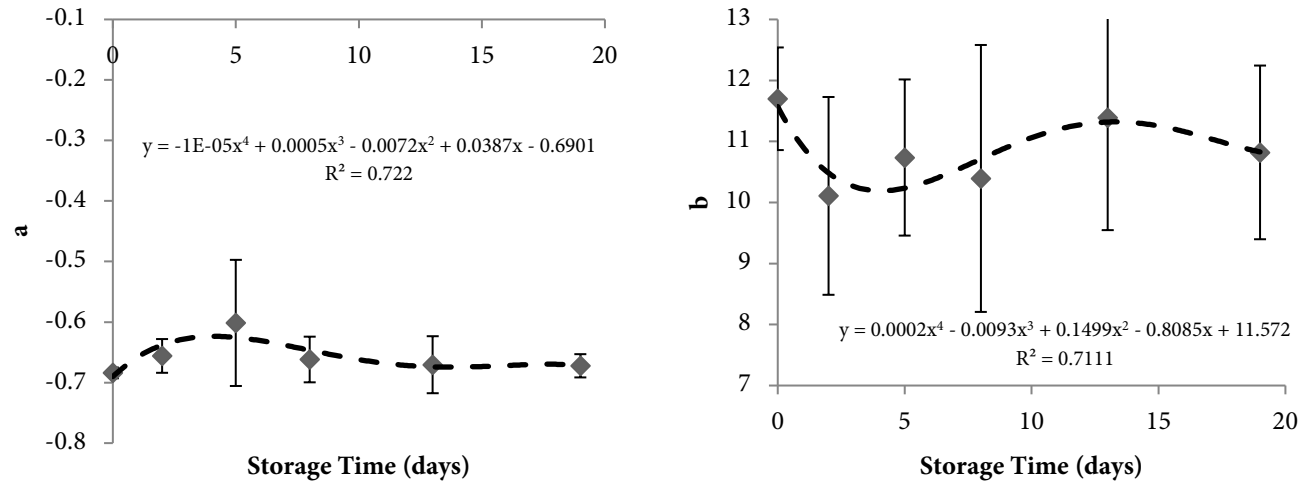

Figure 2. Changes in a. Hue and b. Chroma values for whole European eel stored at 2.00°C

The changes in Hue angle and Chroma in whole European eel stored under refrigerated conditions are shown in Figure 2 a - b. Hue angle is representing the position of the value on the color coordinate system from 0° to 360° in which the positions were divided into 4 area in 90° parts. Moreover, the first 90° area represents red, orange and yellow, the second yellow, yellow-green and green, the third green, cyan and blue and finally the last area of the coordinate system is representing red color in

the system (Cavaco et al., 2021). The changes in Hue angle in this study (Figure 2a) was not significantly changed ($p>0.05$) and remain constant in the second quadrant. The color of whole European eel in terms of Hue angle indicating that the color of the samples was slightly from yellow to yellow green. Hue angle values were found to be -0.68±0.008 on the first day of the storage and slightly changes -0.67±0.01 at the end of the storage time ($p>0.05$) (R^2=0.72). In terms of the Chroma which defines the intensity of the color, the color of the samples was less saturated at the beginning of the storage and in accordance with the storage time the saturation is increased (Figure 2b). The least saturated values were obtained on 2nd day of the storage and found to be 10.10±1.62 and on the last day of the storage Chroma values were found to be 10.82±1.42 (R^2=0.71). In terms of significant changes in Chroma and Hue angle, similar results were reported by Boziaris et al. (2021) for high pressure processed (HPP) Pacific wild pink salmon (*Oncorhynchus gorbuscha*), Alaska pollock (*Gadus chalcogrammus*) and yellow–fin Tuna (*Thunnus albacares*). Researchers reported that no significant ($p>0.05$) changes were found among treated and un-treated samples. In another study the effect of fishing season and storage conditions (vacuum packed or modified atmosphere packed) on the quality of European plaice (*Pleuronectes platessa*) fillets stored at 4°C were investigated. In accordance with the results of the study no significant differences between groups in Chroma and Hue angle were reported (Tsoukalas et al., 2022). As chroma indicates the saturation and hue angle stands for determination of the color itself, these two parameters could give a perspective in terms of quality loss in seafood during storage (Esteves et al., 2021; Setiady et al., 2007; Wade & Glencross 2011). Compared to the results given in the literature it should be noted that during storage time of 19 days no significant effect ($p>0.05$) has been found for *timexchroma* and *timexhue angle* for whole eel stored at 2.00±1.00°C.

Sensory Changes

The changes in total sensory quality in whole European eel stored at 2.00±1.00°C are shown in Figure 3. Total sensory score is obtained by summing the individual parameters namely the score of skin color and slime, eyes shape and clarity, texture firmness and odor of the samples. During each session panelists were recorded the changes in mentioned attributes in terms of their description. In accordance with the records of the panelists skin color, eyes shape and texture firmness were not significantly changed during 19 days of chilled storage. However, the changes in skin slime, eyes clarity and odor were significant ($p<0.05$). The initial total sensory score was 0.00±0.00 which indicates that the samples were in good quality. During 19 days of storage significant increases ($p<0.05$) were found in total sensory score and reached 9.75±0.95 at the end of the storage time. Additionally, linear correlation is obtained between storage time and total sensory score for whole European eel (r=0.97). In this study samples were stored fresh under chilled conditions. In this context storage time together with the microbiological changes to explain the storage time and spoilage of European eels could be the major factors that affects the quality of the samples (Mchazime & Kapute, 2018; Shabani et al., 2019). The sensory shelf life of whole European eels was found to be 13 days in accordance with the results of sensory analysis in this study. Similar results were reported for gutted European eel (*A. anguilla*) stored with and without ice at +3±1°C for 19 days. The shelf life of the samples stored in ice were found to be 12-14 days and for those stored without ice the shelf life was reported for 5-7 days (Özogul et al., 2005). In another study, Özogul et al. (2014) determined the effects of natural antioxidant (laurel and myrtle) on the quality of vacuum packed European eels (*A. anguilla*) stored under refrigerated conditions. Researchers reported the sensory shelf life of the samples as 12 days for control group (vacuum packed and untreated), 16 and 20 days for the group that treated with laurel and myrtle. Küçükgülmez et al. (2013) evaluated the effect of chitosan on quality changes of European eel (*A. anguilla*) fillets under refrigerated temperatures (+4±1°C) and reported that all the groups in the study namely treated samples with different concentrations of extracted and commercial chitosan were rejected in terms of the sensory quality on 15th day of storage.

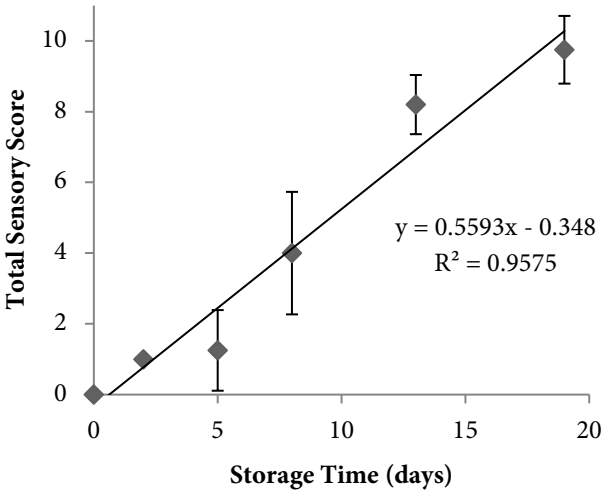

Figure 3. Sensory score changes in whole European eel stored at 2.00°C

Conclusion

The quality attributes of whole European eel stored at 2.00±1.00°C were monitored in terms of the changes in microbiological, color and sensory scores. At the beginning of the storage the TMAB, TPAB, *Pseudomonas* sp. and LAB were slightly higher than 1.00 log cfu/g which indicating that European eel samples were in good quality. After 13 days of storage TMAB and TPAB were exceeded the acceptable limit of 7.00 log cfu/g while the counts of *Pseudomonas* sp. were 7.53±0.76 log cfu/g on day 19. The counts of LAB were not reached the acceptable limit at the end of the storage time and thus decided not suitable for the decision on shelf life of the samples. Color parameters such as L^*, a^*, b^* and ΔE were not followed a linear increase/decrease during 19 days of storage time. The samples were slightly darker, yellowish and reddish at the end of the storage time. As for the sensory quality changes, the score of total sensory changes were significantly different ($p<0.05$) at the end of the storage time compared to the initial sensory scores of the samples. Overall results of this study indicating that the shelf life of whole European eel at 2.00±1.00°C were found to be 13 days. For the determination of the shelf life of samples microbiological changes such as TMAB, TPAB and *Pseudomonas sp*. together with total sensory scores should be used. Additionally, it could be suggested that combination of lower storage temperatures (i.e., storage in the ice) and usage of natural antimicrobials would have positive effect on prolonging the shelf life of whole European eel.

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Compliance With Ethical Standards

Authors' Contributions

İYG: Laboratory work, design of the study and manuscript, statistical analysis.
EB: Field work, sensory analysis, contributing to manuscript writing
All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

Data Availability Statements

All data generated or analyzed during this study are included in this published article.

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RESEARCH ARTICLE

Growth strategy preferences of Turkish tramp shipping companies: A qualitative research

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ABSTRACT

Tramp shipping has played an important role in world seaborne trade since the 19th century. Shipowner companies operating in tramp shipping, which is a mean of maritime transport associated with bulk cargoes that make up three-quarters of all maritime trade, also provide an important economic power to the sector. These shipowners need to grow by making profitable investments in order to survive and maintain their competitive advantage in such a dynamic and competitive market. Based on this, in the exploratory study, fifteen interviews were made with the managers of the fifteen shipowner companies operating in the field of tramp shipping sector, and their opinions were taken about the concept of growth, growth in terms of quality-quantity, the reasons for growth, the factors considered, and the problems encountered in growth process. The data obtained as a result of the interviews were analysed with *MAXQDA* 2020, a computer-aided qualitative data analysis program. According to the results of the research, it has been determined that the shipowner companies mostly grow by expanding their fleet; market conditions and economic situation of maritime sector play an important role in the decision to grow, and financing, economic crises and government policies and laws are barriers to growth.

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Introduction

World shipping has been dominated by a limited number of bulk commodities transported over all of the world's oceans and seas since the final third of the nineteenth century (Harlaftis & Theotokas, 2004). Tramp shipping is a means of sea transport associated with bulk cargoes, which account for three-quarters of all maritime traffic. This demonstrates that

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the tramp shipping model is used to carry out the majority of maritime transport activities (Erol & Dursun, 2016).

In 2020, the global commercial shipping fleet grew by 3 per cent, reaching 99,800 ships of 100 gross tons and above. However, global maritime trade decreased by 3.4% on a tone basis (UNCTAD, 2021). In the world, tanker, bulk cargo, container, dry cargo, and passenger ship types accounted for 1,829,113 DWT in 2021. Bulk Cargo ships have the biggest DWT share among these ship classes, accounting for 48.2 percent (DTO, 2021). When it comes to the Turkish merchant fleet, ships of 1000 GT and above is 6.4 million DWT. Bulk Carriers (30%), Oil Tankers (22.5%), Container Ships (16%), Dry Cargo Ships (11.1%), and Chemical Tankers (9.9%) make up the majority of Turkish merchant fleet (DTO, 2021). Shipping companies are reforming to meet new operational and economic demands and to manage their renewed fleets more efficiently (Demirel, 2015). They need to improve their organization and management systems in order to adapt to the constantly and rapidly changing environmental conditions.

Today, organizations are faced with rapidly changing technologies, globalization and increasing competition. In order to be successful and maintain their existence in such a dynamic environment, it is inevitable for organizations to be more competitive than ever before. Businesses cannot grow in a stable environment; thus, they must learn to adapt in order to exist in a dynamic and changing world (Wang & Li, 2013). Dynamic capabilities enable firms to adapt to an uncertain environment, maintain operations, ensure competitiveness, and improve resilience (Bathke et al., 2022). In this regard, shipowners seek strategies to cope with the high degree of competition in the tramp shipping market, and aim to grow their companies in order to differentiate themselves from their competitors.

Tramp shipping is a branch of sea transportation that is particularly susceptible to market forces such as supply and demand for shipping services, as well as strong rivalry. The dynamic and unstable market is the most important component of tramp shipping; demand for shipping services is impacted by the state of the global economy. Therefore, it is of great importance to reveal how Turkish shipowners have grown their businesses in this competitive environment. From this point of view, this research aims to reveal the growth strategy preferences of shipowner companies engaged in tramp shipping in Turkey. Semi-structured interviews were conducted to Turkish shipowners for exploring the growth strategy preferences and other related subjects. When the dynamic capabilities, growth and maritime literature are examined, it is seen that the number of studies on these issues is not very large. There are studies in the field of liner shipping, but the scarcity of studies in the field of tramp shipping draws attention. Considering these situations, the subject discussed and research field show the originality of this study.

The following section introduces the theoretical background and relevant literature based on dynamic capability and growth in tramp shipping. The third section describes the methodology of the study. In the fourth section, findings of the qualitative study are presented. In the fifth and the last section, the findings of the study are discussed and the conclusion part is given.

Dynamic Capabilities and Growth Concept

In the strategic management literature, it is seen that resources play a huge and important role in achieving growth and competitive advantage (Penrose, 1959; Rumelt, 1984; Wernerfelt, 1984; Porter, 1985; Barney, 1991). Firm resources comprise all assets, capabilities, organizational processes, company attributes, information, knowledge, and so on that a company controls and that enable the company to devise and implement strategies that increase its efficiency and effectiveness (Barney, 1991).

It has been very important for businesses to develop their management and organizational skills to survive and enhance the competitiveness in dynamic environment that increases with the effect of globalization. To confront the difficulties of globalization, it is apparent that businesses must create dynamic capacities to alter current resources, skills, and ability (Augier & Teece, 2009; Wang & Li, 2013). This situation highly depends on the growth and expansion attempts of the companies.

Growth is viewed as an uneven and discontinuous process characterized by uncertainties related to market dynamics, external factors, and the traits and skills of entrepreneurs and enterprises (Vickers & Lyon, 2014). According to Teece & Pisano (1994), a business's competitive advantage is based on dynamic capabilities anchored in high-performance routines that operate within the organization, are ingrained in its processes, and are conditioned by its history. Dynamic capabilities are higher-level activities that can enable an enterprise to direct its ordinary activities toward high-demand uses, develop new capabilities, and effectively coordinate (or orchestrate) internal and external resources to address and shape shifting business environments (Henderson & Cockburn, 1994; Teece et al., 1997; Eisenhardt & Martin, 2000; Teece, 2016).

This situation is of great importance for companies in the maritime sector, as it is in all sectors. The maritime sector frequently experiences quick and severe business cycles, emphasizing the importance of dynamism and flexibility in strategic management (Saarni, 2013).

As being one of the maritime transport types, tramp shipping is particularly vulnerable to the rules of supply and demand for shipping services, as well as to fierce competition in the market. The product is homogenous; entry barriers are minimal; multiple enterprises compete for business (each ship, perhaps, is a distinct competitive unit); and information flows make markets transparent. Depending on market conditions, the freight prices that may be obtained in these marketplaces are quite variable (Clarkson Research Services Limited, 2004). This situation naturally pushes the ship owners to take precautions (Erol & Dursun, 2016).

Businesses' survival and long-term competitive advantage are dependent on growth and development activities in an increasingly competitive environment caused by globalization.

When the growth and maritime sector literature is analyzed, it is discovered that the studies are largely focused on liner shipping sector and are few in number. Midoro & Pitto (2000), after examining the major features of strategic alliances in liner shipping, discovered that the major elements driving instability are the alliance's growing organizational complexity and the formation of a certain amount of intra-alliance rivalry. Slack et al. (2002) analyzed trends in container shipping in light of several of the leading companies in the sector forming strategic alliances. The findings confirmed the decade-long increase in the number of services and intensity of service frequency. In their study, Song & Panayides (2002) sought to find the reasoning for cooperation (or non-cooperation) in liner shipping. The present types of cooperation, such as shipping alliances, shipping consortia, and mergers and acquisitions demonstrate the market's complexity.

Brooks & Ritchie (2006) investigated the general pattern of maritime transport-related mergers and acquisitions on a global scale using a database of all mergers and acquisitions worldwide. According to the findings of this study, the maritime transport sector does not exhibit a significantly different pattern than other sectors of the transportation business. Solesvik & Westhead (2010) investigated how a maritime firm's competitive advantage might be strengthened by selecting the suitable partner through a strategic partnership. The findings indicated that strategic partnerships were effective when partners were properly chosen.

When the literature is examined, very few studies have been found that combine dynamic capabilities and maritime transport (especially in tramp shipping).

Tsekouras et al. (2011) identified the existence of strong linkages between organizational and process innovation and dynamic capabilities in the small companies in a traditional service sector. In the research, the case study method was applied in three Greek tramp shipping companies. The findings showed that organizational and process innovations are critical aspects of a dynamic strategy in small service companies. In terms of family businesses and dynamic capabilities perspective, Jones et al. (2013) investigated a family-owned shipping company in Liverpool to see how multigenerational ownership, entrepreneurial cognition, and dynamic capacities are linked in family businesses. In the setting of a failed firm, the study highlighted the relevance of entrepreneurial cognition. Saarni (2013) explored the dynamic capabilities in Finnish maritime industry during the years of weak demand and uncertainty. The results showed that half of the firms have reflected dynamic capabilities already in 2009 and their share has increased by 2012. The findings also revealed that the acts that are most typically lacking from maritime companies are observation and identification of business opportunities, as well as collaboration in R&D. Similarly, Bathke et al. (2022) examined container shipping firms' attitudes to build resilience through developing dynamic capabilities in turbulent times. This study investigated scenarios for container shipping businesses' macro environment using a Delphi-based scenario analysis. Glyptis et al. (2021) identified how dynamic capabilities emerge in connection to family resources in order to help family businesses thrive. The findings revealed the effect of the controlling family on management accounting's seeking, seizing, and reconfiguring processes in order to enable the reconfiguration of family resources in the business across product strategy, governance, networking and personnel, and finance. During the coronavirus pandemic, Dovbischuk (2022) investigated the connections between various innovation-oriented dynamic capabilities, dynamic resilience, and firm performance among logistics service providers (LSPs) and internal logistics departments of industrial businesses. In their study, Hussein & Song (2022) made an effort to forecast the competencies needed in marine sector for the next ten years by critically analyzing a few significant global and industry-based obstacles and, concurrently, identifying possibilities in a creative and forward-looking way. They found out that particularly in view of the dynamic and disruptive global events, it is thought vital to understand the key factors that affect the

present and future state of maritime sector. Additionally, it was appeared that developing a sustainable and stable corporate entity depends on having a broad understanding of the fundamental and required abilities for positions in the sector in the future.

In the light of this information and due to the gap in the literature, this study aimed to reveal the growth strategy preferences of shipowner companies engaged in tramp shipping in Turkey. To identify the reasons that trigger the growth of Turkish Tramp Shipping Firms, to determine which growth strategies they prefer and how they apply these strategies, and to discover the problems they encounter during the growth process are the main research subjects of the study.

Material and Methods

Sample of the Study

This study aimed to reach shipowners operating in tramp shipping along with other fields within and outside the maritime sector to identify the growth strategy preferences and other related subjects as concept of growth, factors that are important when determining a growth strategy, barriers of growth and reasons of growth. The study utilized a purposive sampling approach, which is a form of non-probability sampling method. Non-probability sampling, is a method in which the sample is determined not by the probability with which a unit can join the sample, but by other factors such as the sampler's common sense, experience, intention, and competence (Acharya et al., 2013; Etikan & Bala, 2017). Purposive sampling is a method of discovering and selecting instances that will efficiently employ limited research resources by selecting respondents who are most likely to provide acceptable and meaningful information (Sharma, 2017; Campbell et al., 2020).

Turkish Shipowners Association member list was analysed initially to define the population of the study. The list of 136 member firms was scrutinized, and member companies that do not provide tramp shipping services were eliminated. Since 20 of the remaining 60 companies couldn't be contacted because of unanswered phone numbers and inactive website and email addresses, the number of companies operating as shipowners in tramp shipping has been found to be 40. 15 shipowner companies provided feedback and participated in the research.

Figure 1 depicts the process of defining the research population. Furthermore, information about the interviewees and their companies are shown in Tables 1 and 2.

As seen in Table 1, all of the participants hold top senior executive positions. The participants in the sector have a range of experience varies between 7-47 years. Therefore, all of the participants have the necessary know-how to convey their views on the issue, both in terms of their expertise in the sector and their firms, as well as their positions.

According to Table 2, except for one, the base of all companies interviewed is Istanbul. The companies are corporations and limited companies as legal status with a total employee number ranging from 4 to 550, representing shipowners of different sizes. Since, the majority of the companies interviewed are family businesses, and the companies are managed by the founder entrepreneur and second-generation family members. All of the companies have been serving in the tramp shipping sector for many years and are in a position to provide sufficient information on the growth strategies of the companies throughout these years.

In terms of ship type, the majority of the company's fleets consist of dry cargo ships, followed by general cargo and tankers. The presence of container-type ships in the fleet indicates that companies are diversifying on the basis of their field of activity.

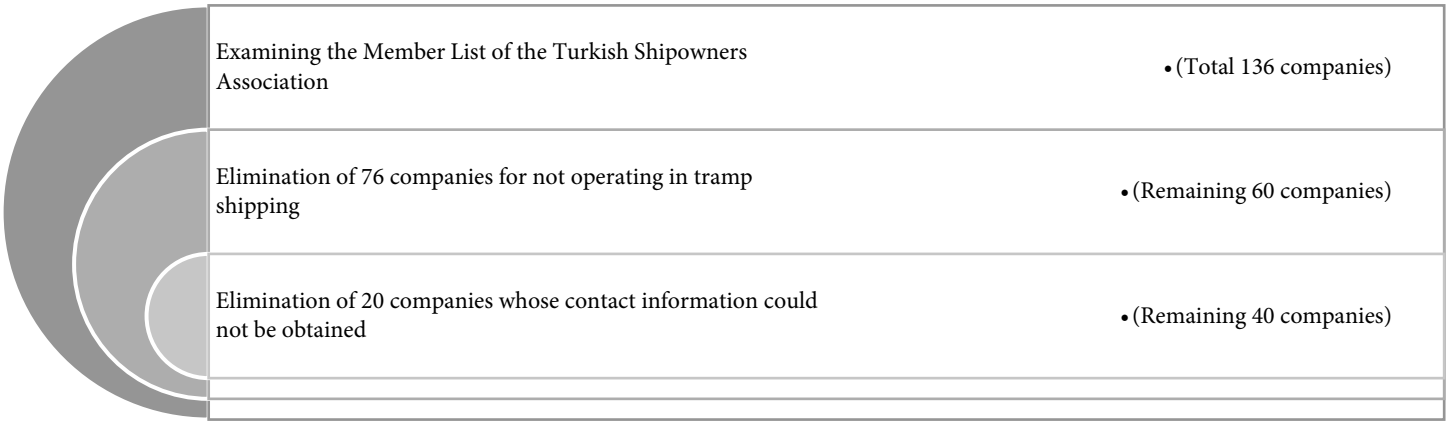

Figure 1. Determination of the study population

Table 1. Profile information of the participants

Participants	Age	Education	Position	Total Experience in Company	Total Experience in the Sector
1.	51	Master	CEO	34 years	34 years
2.	39	University	Board Member	17 years	17 years
3.	35	Master	General Manager	12 years	12 years
4.	48	University	General Manager / Owner	16 years	23 years
5.	50	University	Chartering Manager	5 years	25 years
6.	43	University	Chartering Manager	24 years	25 years
7.	43	Master	Operation & Insurance Manager	15 years	20 years
8.	65	University	Chairman of the Board	37 years	45 years
9.	31	University	Chartering & Fleet Manager	7 years	7 years
10.	60	University	Chairman of the Board	31 years	31 years
11.	60	University	DPA & Technical Manager	28 years	39 years
12.	49	University	Chartering Manager	14 years	24 years
13.	73	Master	Chairman of the Board	42 years	47 years
14.	46	University	Chairman of the Board	21 years	21 years
15.	51	University	Executive Manager	31 years	35 years

Table 2. Profile information of the companies

Firm	Foundation Year	Legal Status	Ownership Structure	Employee Number	Company Manager
A	1968	Corporation	Family Business	500	Founder Entrepreneur
B	1968	Corporation	Family Business	75 and above	Foun. Entrep. and 2nd Gen. Fam. Member
C	1972	Corporation	Family Business	300	2nd Gen. Fam. Member
D	2005	Limited Co.	Equity Partnership and Foun. Entrep.	4 (except ship personnel)	Founder Entrepreneur
E	1989	Corporation	Family Business	5	2nd Gen. Fam. Member
F	1989	Corporation	Sole Proprietorship	150	Foun. Entrep. 2nd Gen. Fam. Member
G	1960	Limited Co.	Family Business	550	2nd Gen. Fam. Member
H	1985	Corporation	Sole Proprietorship	18	Founder Entrepreneur
I	1990	Limited Co.	Family Business and Sole Proprietorship	100	4th Gen. Fam. Member
J	1990	Corporation	Family Business	88	2nd Gen. Fam. Member
K	1971	Corporation	Family Business	320	Foun. Entrep.
L	1977	Limited Co.	Family Business	50	2nd Gen. Fam. Member
M	1980	Corporation	Found. Entrep.	70	Foun. Entrep.
N	1999	Corporation	Family Business	170	Foun. Entrep.
O	1990	Limited Co.	Family Business Found. Entrep.	50	2nd Gen. Fam. Member

Data Collection Method

The study employed the qualitative research method in order to identify, through exploratory research, the viewpoints of shipowner companies on growth-related issues and how they expand their businesses. As one of the qualitative research methods, interviews provide a useful way for researchers to learn about the world of others (Qu & Dumay, 2011). The possibility of previously unknown information emerging is a big advantage of semi-structured interviews. Participants can be considered experts based on their expertise; so, when ample chance to speak freely is allowed, fresh and original knowledge might emerge (O'Keeffe et al., 2016).

In the research, semi-structured interviews were conducted with 15 shipowner companies operating in the tramp shipping sector. The semi-structured interview method was preferred in the study in order to research the subject in depth, to learn the perspectives of the participants about growth strategies, and to benefit from their knowledge and experience. Interview questions were prepared by examining studies in similar fields in the literature, and then they were finalized by taking the opinions of experts from the sector and academia. Interview question form consists of five parts. The form, which starts with the profile information section of the interviewee and the business, continues with the sections of the business's growth strategy and strategic alliance and ends with the section of diversification measure of the business. The findings of those sections were not included in the study due to the number of businesses engaged in strategic alliance and operating outside the maritime sector is not high.

There are studies on tramp shipping that employ the interview method also in the literature. For instance, Thai et al. (2014) aimed to develop and verify a service quality model in tramp shipping. Emphasizing that tramp shipping is a labor-intensive sector, Holmgren & Pritschau (2015) tried to explore how people in the tramp shipping sector perceive and manage 24/7 work availability by applying boundary theory, and they conducted semi-structured interviews with thirteen professionals. Demirel (2015) in his study intended to conduct a SWOT analysis of Turkish shipping companies based on their organizational and management systems. Data for organizational and management systems are gathered from open sources such as information on corporate websites, printed materials, and interviews with company personnel, including ex-workers (both liner and tramp shipping firms).

Data Collection Process and Analysis

Semi-structured interviews to collect research data were conducted between August 2021 and February 2022. In order to increase the validity and reliability of the research, the question form was checked by experts from academia (4 people) and sector (3 people) before the interviews were conducted.

The Turkish Shipowners Association was contacted, and support from the General Secretariat was received, in order to reach the relevant shipowners and increase the number of participants in the research area. Furthermore, contact information was acquired from companies' websites and social media platforms (LinkedIn), and efforts were made to reach relevant experts by phone and e-mail.

The data obtained from the interviews were analyzed with MAXQDA 2020, a computer-aided qualitative data analysis program. In the analysis process, first of all, a project on MAXQDA 2020 was created and the data was transferred to this project. In the context of the questions asked to the participants, each interview was individually coded and categorized by the authors. Then, the data were reported based on descriptive analysis.

Results

First, the participants were asked what the term "growth" meant to them. Participants expressed different remarks about the idea of growth, which has a variety of definitions and aspects in the literature. The expressions for the concept of growth are shown in Figure 2.

As it can be seen in Figure 2, the participants mostly focused on the increase in the number of ships in their definitions of the concept of growth, and they associated the growth of the company with the increase in their fleet. After the increase in the number of ships, the most repeated growth concept is the increase in the number of employees. Being a corporate business, having a younger fleet, increase in different business lines, investments and business volumes are other factors often included in the definitions. Growing through ships, one of the most valuable assets for shipowners, means growth for the majority of companies. This situation shows that shipowner businesses prefer organic (internal) growth as growth strategy.

The second question posed to the participants was about how their businesses have grown quantitatively since its establishment. Figure 3 shows the statements of the participants about quantitative growth.

According to Figure 3, the majority of the participants stated the quantitative growth of their businesses as the increase in the number of ships. Increase in business lines, profitability, investments, business volume, number of employees and DWT capacity are other quantitative growth expressions stated by the participants. When analyzing quantitative growth, it becomes clear that shipowners place a heavy emphasis on financial indicators when determining growth.

The third question posed to the participants was about how their businesses have grown qualitatively since its establishment. Figure 4 shows the statements of the participants about qualitative growth.

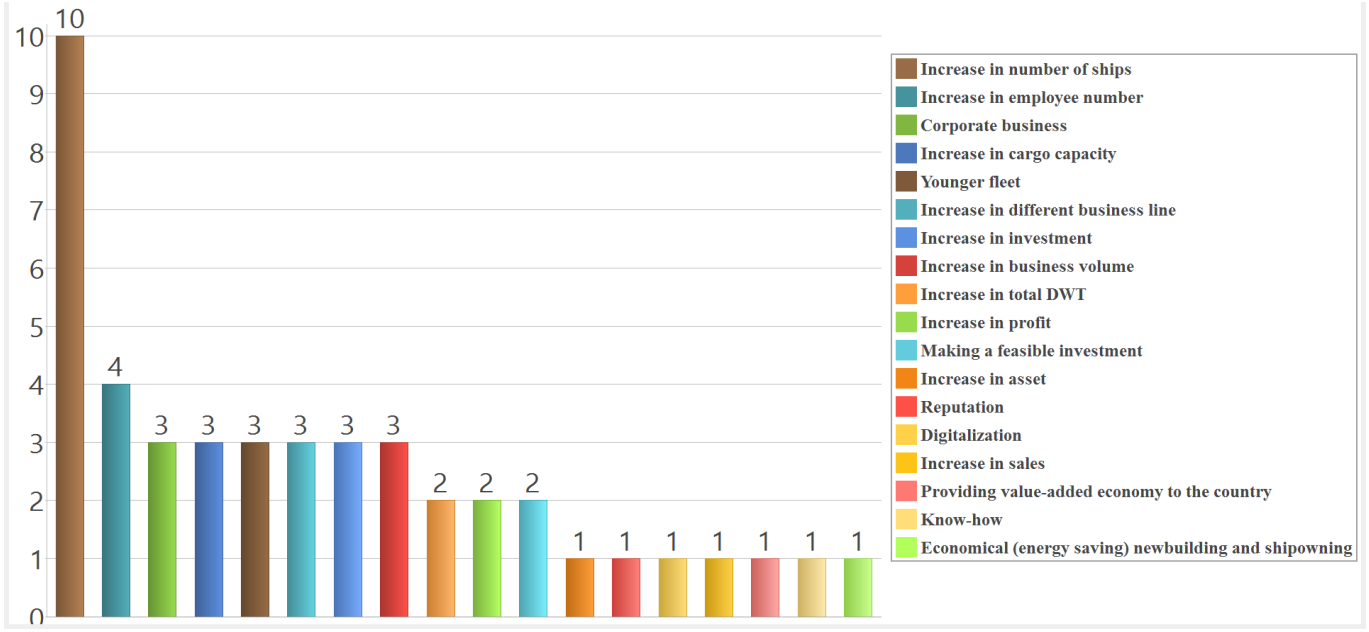

Figure 2. Concept of growth

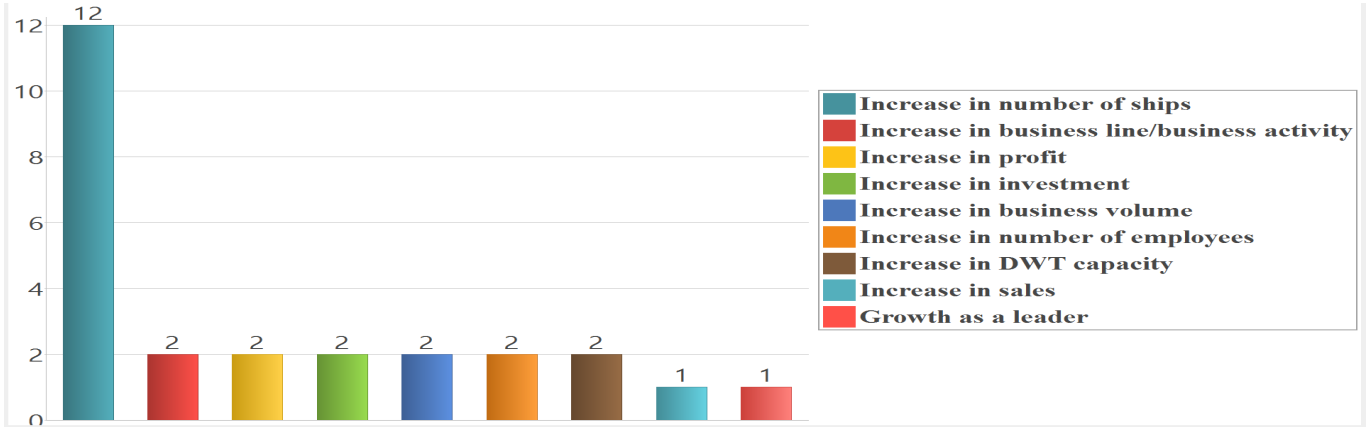

Figure 3. Quantitative growth

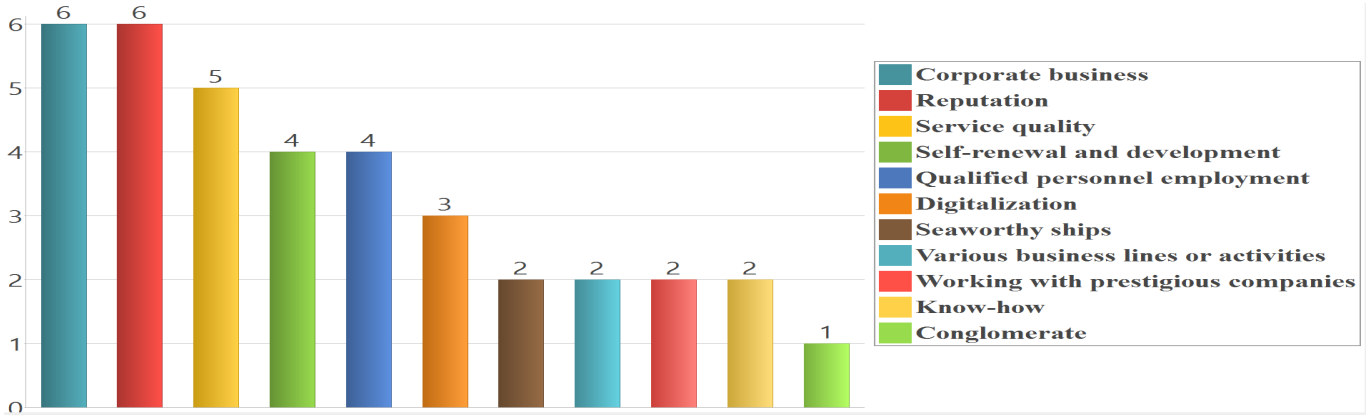

Figure 4. Qualitative growth

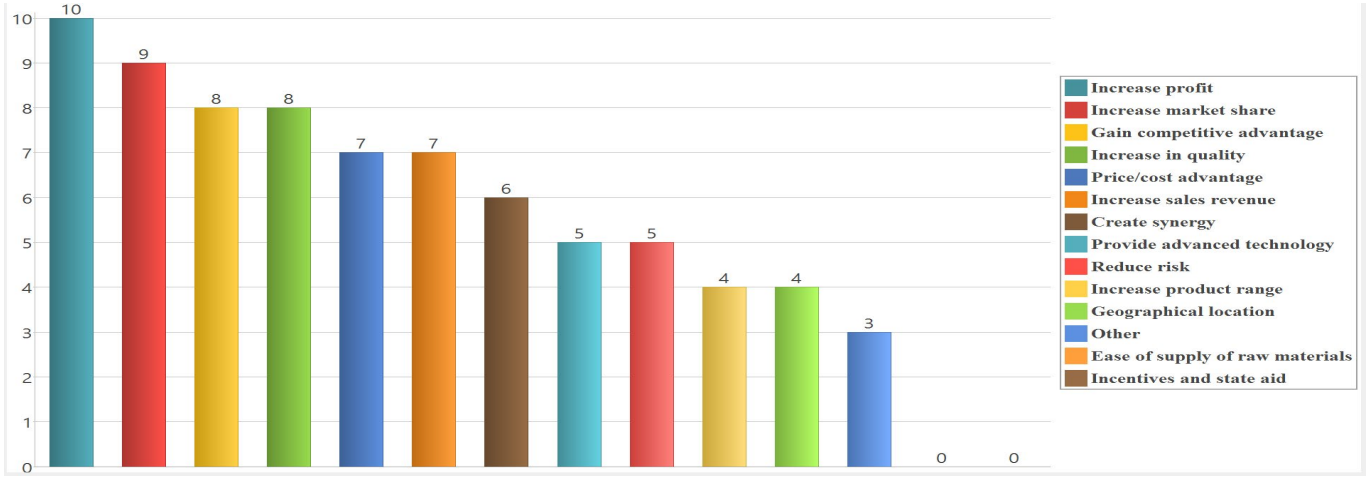

Figure 5. Reasons for growth

Figure 6. Growth strategy determinants

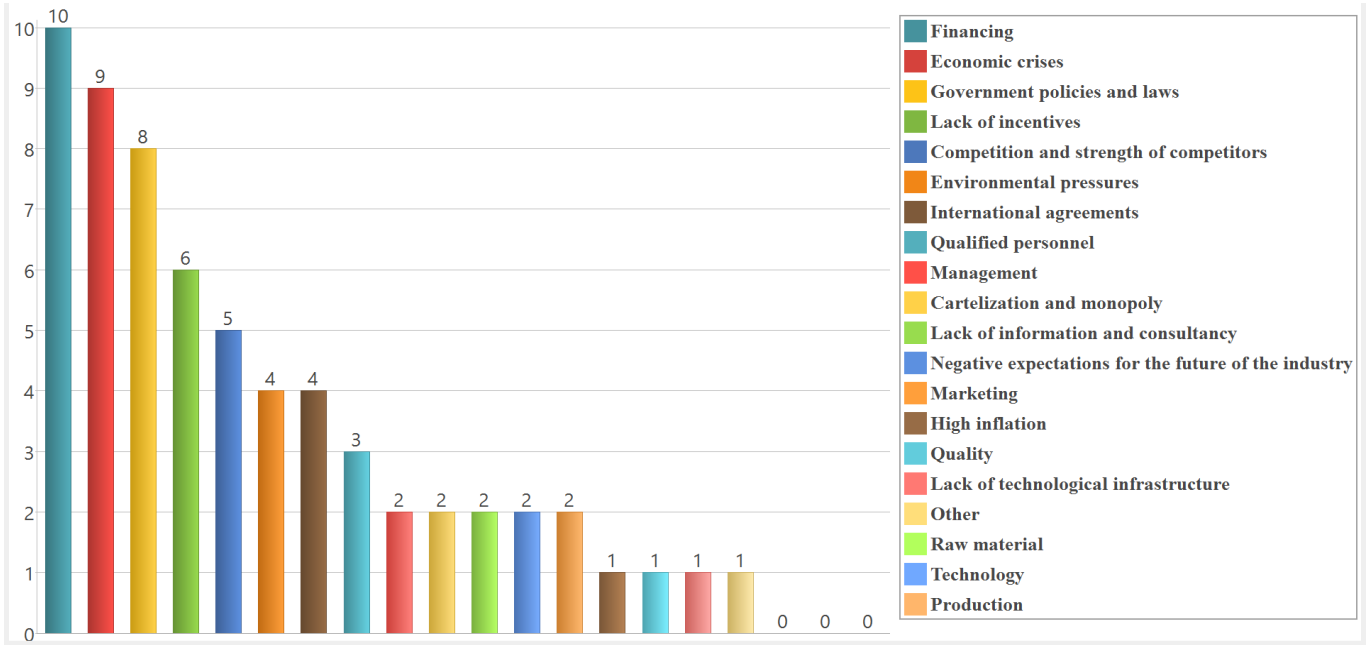

Figure 7. Difficulties in growth process

According to Figure 4, the majority of respondents indicated the qualitative growth of their businesses as becoming a corporate company and gaining a reputation. Providing quality service, self-renewal and development, employing qualified personnel and digitalization are other qualitative growth expressions stated by the participants. It is hardly unexpected from a qualitative standpoint that shipowners prioritize corporation and building a reputation. The transformation of operations into a corporate structure, improvement of service quality, and permanent customer satisfaction and loyalty with the reputation gained as a result are of utmost importance for shipowners operating in a global and competitive industry with so many parties and stakeholders.

In another question, participants were asked to explain the reasons that drive their companies to grow. Responses of the participants are shown in Figure 5.

The results show that increasing the profit and market share are the main reasons that trigger the shipowners to grow. In addition to these, factors such as gaining competitive advantage, increasing quality, providing price/cost advantage, increasing sales revenues, creating synergy, providing advanced technology and reducing risk are among the reasons that encourage growth. These findings led to the conclusion that financial variables account for the majority of the causes of growth. This is hardly unexpected given that the main objective of corporations is to generate a profit. Shipowners go to the path of growth in this highly competitive industry for reasons including being better than their rivals, gaining a bigger market share, and raising the quality of service.

The participants were asked which factors they considered while determining the growth strategy, and the answers given are shown in Figure 6.

According to Figure 6, market conditions, economic developments and financing opportunities are among the factors that shipowners frequently consider while determining their growth strategy. Profitability of investment, political developments in the country, younger fleet and ship investments, company structure, investment opportunities and growth expectations in the sector are among the other growth strategy determinants. Due to the volatility and unpredictability of the tramp shipping sector, shipowners must consider economic and market trends while deciding how to growth. Shipowners must continually monitor changes, detect bad circumstances such as crises, etc., and additionally they must respond appropriately in order to handle such dynamic and unpredictable market structures.

Finally, the participants answered the question of what kind of difficulties their companies faced during the growth process. The answers of the participants regarding the growth barriers are given in Figure 7.

Discussion

Organizations' heightened vulnerability to geopolitical and technical shocks, shifting consumer preferences, and the protracted consequences of the economic slump all result in organizational shocks and disruptions as a result of globalization. In order to survive and grow, the maritime sector must manage issues with both internal and external disruptive occurrences (Akpınar & Özer Çaylan, 2022).

The purpose of this study is to look into the growth strategy preferences of Turkish shipowners engaged in tramp shipping sector. Therefore, it has been attempted to determine the views of Turkish shipowners operating in the tramp shipping sector on issues such as the concept of growth, the factors affecting growth, and the problems encountered while growing.

When asked to explain the concept of growth, the participants tended to emphasize the increase in the number of ships, and it was found that they connected the growth of their businesses with the expansion of the fleet. This situation exemplifies the resource-based approach, which emphasizes the importance of resources in the growth of firms and gaining competitive advantage (Rumelt, 1984; Wernerfelt, 1984; Barney, 1991). The increase in the number of ships, which is one of the most important assets for shipowners, is an important indicator for the growth of the company.

The majority of the participants stated the quantitative growth of their organisations as the increase in the number of ships. This situation can be given as an example of the change-in-amount perspective. According to this perspective, growth can be measured using a variety of different measures, with sales, employment, assets, physical output, market share, and profits being the most frequently recommended (Delmar, 1997; Weinzimmer, et al., 1998; Wiklund, 1998). More precise measures (Bolton, 1971) such the number of seats in restaurants or theaters, may be taken into account in within-industry studies as in this study. Growth in terms of quality has been associated with corporate business, gaining reputation and improving service quality.

According to the results of the study; the reasons for the growth of the companies were determined as increasing the profit, increasing the market share, gaining competitive advantage and increasing the service quality. These results are not surprising because for all businesses, the basic objective is

to generate a profit in order to maintain their competitive advantage. Some of the findings concur with those reported in the literature. Indicators such as increased number of employees, increased sales, increased profits, increased market share, and continued growth/competitive advantage are examples of findings in the literature (Flamholtz & Randle, 1990; Holmes & Zimmer, 1994; Howard, 2005).

When the participants were asked about which factors they took into account while determining their growth strategy, factors such as the market conditions, economic developments and the availability of financing opportunities were the factors that came to the fore. The dynamic and uncertain market structure of the tramp shipping sector leads shipowners to follow market conditions and economic developments while making growth decisions. At this point, the elements of the dynamic capabilities approach come into play and the effect of environmental conditions manifests itself. Such dynamic and uncertain market structure requires managers to constantly follow developments, to sense negative situations such crisis etc., and to take precautions to these situations. Moreover, it forces them to look for and seize opportunities and resources such as financing to make the most profitable investment. Lastly, these opportunities and resources are reconfigured according to changing market and environmental conditions (Henderson & Cockburn, 1994; Teece et al., 1997; Eisenhardt & Martin, 2000; Augier & Teece, 2009; Saarni, 2013; Teece, 2016; Hussein & Song, 2022).

Finally, the participants were asked about the barriers they faced during growth. The vast majority of respondents cited financing, economic crises, and government policies and laws as barriers to growth. In the literature, capital availability, provision of external debt and equity capital appear as growth barriers (Orser et al., 2000; Becchetti & Trovato, 2002). In Wilson's study, it is stated that economic crises do not create a growth barrier for small-scale companies; however large-scale companies continue to take defensive actions in times of economic crisis (Wilson & Eilertsen, 2010). Gupta et al. (2013) categorized the growth barriers as institutional and financial. Issues such as the enterprise's interactions with the government, as well as matters of legality, taxation constitute institutional barriers. Financial difficulties will include a shortage of financial resources (Gupta et al., 2013).

Conclusion

The vast majority of maritime traffic is made up of bulk goods, which are transported by tramp shipping. This illustrates that the majority of maritime transport operations are conducted using the tramp shipping activities. In the tramp shipping sector, which is a dynamic and uncertain sector affected by many environmental variables, it is of great importance for shipowners to survive and grow.

In the light of the interviews, it has been observed that the majority of shipowners' businesses are family businesses and managed by the founding entrepreneur or second-generation family member. Shipowners that engage in tramp shipping sector must make the best use of their resources to thrive, continuously scan the market for opportunities and threats, and take appropriate action in response. Many elements, from economic to political, are at play in determining the growth strategy. Additionally, they should adjust their investment strategies and resources in accordance with the external environment and look for methods to develop a competitive advantage by growing in this competitive sector. In addition to the factors affecting growth, the problems experienced by shipowners while growing are also discussed. While the majority of the shipowners mentioned the difficulty of accessing finance, they also emphasized the external environmental factors. Economic crises and government policies and laws are also among the problems that hinder growth.

The opinions of businesses engaged in tramp shipping sector on growth were investigated as part of this exploratory research. It is anticipated that this study will lead the future researches in this field and contribute to the sector and related literature in these respects. In future studies, it is thought that it will be useful to expand the sample and repeat the studies on shipowner companies in the tramp sector, to compare the results according to variables such as company structure and managerial characteristics and the practices in different sectors of maritime, and to get the opinions of other stakeholders in the sector.

The research has some limitations. Due to the pandemic conditions and the busy schedule and time constraints of the managers in the shipowning companies, there were difficulties in reaching key people, and this led to a limited number of meetings. Again, depending on the increase in the number of samples, quantitative methods can be added for future studies and compared with the results of this study.

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Compliance With Ethical Standards

Authors' Contributions

İAD: Conceptualization, Methodology, Collection of the data, Data analysis, Writing - Original Draft, Writing – Review and Editing.

GDS: Supervision, Methodology, Writing – Review and Editing.

Both authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

Ethical approval received for semi-structured interview from Dokuz Eylül University, Social and Human Sciences Research and Publication Ethics Committee, 26.05.2021, E-87347630-640.99-59302.

Data Availability Statements

The authors confirm that the data supporting the findings of this study are available within the article.

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RESEARCH ARTICLE

The bibliometric analysis and visualization mapping of research on maritime accidents

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ABSTRACT

The purpose of the study was to assess the output of research on maritime accidents and citations from 2000 to 2022 through a bibliometric analysis. Utilizing the visualization and mapping program VOSviewer 1.6.18, the relevant data was extracted from the Web of Science (WoS) database and analyzed. The findings indicated important study fields, country contributions, productive journals, as well as the most cited authors' articles. The primary findings were as follows: The most influential journal was Safety Science. One of the most common topics of study for maritime accidents was the human factor. The most productive country was the People's Republic of China. The findings of the study can assist researchers in conducting their studies more effectively by providing information about the journals they may use, the authors who contributed to it, current research trends, countries, and keywords.

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Introduction

Since the beginning of shipping, maritime accidents, which is unwanted anomalous occurrences aboard a ship that frequently cause fatalities, serious injuries, and different sorts of property damage, have been a significant problem for the global maritime community (Luo & Shin, 2019). Marine accidents constantly happen, causing significant harm to both people and the environment, despite ongoing advancements in maritime technology and safety management (Shi et al., 2021). Over the years 2014 to 2021, there were 21,173 reported marine accidents and incidents, with 2,647 occurring on average per year (EMSA, 2022).

Numerous studies have been conducted on marine accidents in an effort to reduce them and improve maritime safety. Examining the studies on maritime accidents reveals that various types of accidents, particularly grounding and collision, are the subject of research. Graziano et al. (2016) have proposed

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a new approach by analyzing grounding and collision incidents and integrating the Technique for the Retrospective and predictive Analysis of Cognitive Errors (TRACEr) with the accident analysis technique of CASMET. A statistical analysis of AIS data and marine accident data from Norwegian waters was also carried out by Bye & Aalberg (2018) to determine the factors that led to collision and grounding accidents. In collision and contact accidents on passenger ships, human factor analysis has been carried out by Uğurlu et al. (2018).

Whereas numerous studies have highlighted the significance of human and organizational factors in marine accidents (Hetherington et al., 2006; Schröder-Hinrichs, 2010; Chen et al., 2013; Qiao et al., 2020), others focus on risk analysis (Awal & Hasegawa, 2017; Fan et al., 2020a, 2020b; Kulkarni et al., 2020). There are also studies utilizing methods like root cause analysis, HFACS and Bayesian networks (Hänninen & Kujala, 2012; Montewka et al., 2014; Kum & Sahin, 2015; Kececi & Arslan, 2017; Akyuz, 2017; Batalden & Sydnes, 2014; Soner et al., 2015; Yıldırım et al., 2019).

Hetherington et al. (2006) carried out a literature review on the topic of ship safety, focusing on three key areas: common accident causes, human error, and efforts to improve maritime security. Fatigue, stress, health, situational awareness, teamwork, decision making, communication, automation, and the prevalence of a culture of safety were all factors in their analysis. In their research, Chen et al. (2013) also proposed a Human and Organizational Factors (HOFs) framework for the investigation and analysis of maritime accidents. But Qiao et al. (2020) claims that because there is a paucity of data concerning human factors in the shipping industry, evaluating the role of human factors in maritime accidents is challenging.

According to Kulkarni et al. (2020) accidents can be avoided by assessing the risk in waterways and maritime areas and linking it to preventive actions that improve navigational safety. Fan et al. (2020b), similar to Kulkarni et al. (2020), stated that, because the majority of marine accidents have a low likelihood but serious consequences, risk assessment is important for shipping operations. However, Awal & Hasegawa (2017) state that while risk analysis is frequently employed in the maritime context, its usage is restricted to risk control options. According to the research of Fan et al. (2020a), 'ship age', 'ship operation', 'voyage segment', 'information', and 'vessel condition' are the key risk influencing factors for different types of marine accidents.

Kum & Sahin (2015) have carried out root cause analysis for accidents that occurred in the Arctic Region between 1993 and 2011. Kececi & Arslan (2017) proposed a new taxonomy in their study that incorporates root cause taxonomies that have been applied up to now in the examination of maritime accidents (Kołakowski et al., 2022).

There have been several studies on various accident types using a variety of methodologies in a number of different countries, so research is required to better comprehend the arrangement of information on maritime accidents. Therefore, this study attempts to improve the contribution of all previous studies by conducting a bibliometric analysis of the maritime accident literature.

It has been noted that bibliometric analysis studies are conducted in the maritime industry on various subjects (Mao et al., 2010; Lau et al., 2017; Munim et al., 2020; Meyers et al., 2021; Bolbot et al., 2022; Büber & Köseoğlu, 2022; Kołakowski et al., 2022). Utilizing bibliometric analysis, Mao et al. (2010) have analyzed the global scientific output of risk assessment research over the previous sixteen years and provided insight into the study's characteristics and trends. Lau et al. (2017) have examined the collaborative and semantic patterns in container shipping articles published between 1967 and 2013 in the journals of transportation, supply chain management, economics, geography, regional planning, and operations research. Munim et al. (2020) have conducted a bibliometric analysis of 279 research on the uses of big data and artificial intelligence (AI) in the marine sector, which were published in 214 academic journals from the Web of Science database. Meyers et al. (2021) have conducted a Scopus-based bibliometric analysis of marine research that included the Automatic Identification System. Büber & Köseoğlu (2022) conducted a bibliometric study of oil spill response research output and citations from 2000 to 2022. Kołakowski et al. (2022) have applied a bibliometric method to a sample of 234 scientific papers indexed in the SCI-EXPANDED collection of Clarivate Analytics' Web of Science Core Collection in order to critically analyze the research trends concerning the active methods for reducing the negative environmental impact of shipping. Bolbot et al. (2022) have performed a bibliometric analysis of maritime cybersecurity-related papers using several metrics and analytical techniques to determine academic research topics, methodologies, and major research concerns and directions.

Although significant bibliometric analysis studies have been conducted in diverse fields, there are few bibliometric analyses focused on marine accidents (Kulkarni et al., 2020; Gil et al., 2020; Dominguez-Péry et al., 2021; Fu et al., 2021; Wróbel, 2021). A bibliometric study of risk management studies with a focus on the Baltic Sea region has been presented by Kulkarni

et al. (2020). Similarly, Fu et al. (2021) conducted a bibliometric study of the scholarly literature on the risk management of Arctic shipping. Gil et al. (2020) have conducted a bibliometric analysis and systematic evaluation of shipboard decision support systems for accident prevention. Dominguez-Péry et al. (2021) performed a bibliometric analysis of human error-related marine accidents. In order to confirm the widely held opinion that humans are responsible for about 80% of accidents and to determine their origins, Wróbel (2021) has conducted a literature review. Even if there are a few bibliometric analysis studies on marine accidents in the literature, a comprehensive bibliometric study appears to be necessary. We believe that our research will fulfill this gap in the literature.

The structure of this paper is as follows: The second section describes the study's methodology and provides a concise explanation of bibliometric analysis. The third section gives the results of a bibliometric study of papers on marine accidents and displays the many viewpoints on network structure based on bibliographic matching, citation, and keyword concurrence. The fourth section discusses the outcomes and provides information for future studies.

Materials and Methods

Bibliometric analysis is a method of document analysis technique that involves of bibliometric theory to examine related material using mathematical and statistical techniques (Zou et al., 2018). Bibliometric techniques are being utilized more often to research various scientific topics and to evaluate institutions and universities globally (Ellegaard & Wallin, 2015). By understanding the meaning of massive amounts of unstructured data in a systematic manner, bibliometric analysis is valuable for unraveling and charting the cumulative scientific knowledge and evolutionary subtleties of established domains (Donthu et al., 2021). By examining the production of publications, keywords, authors, institutes, and nations, bibliometric approaches offer a means to pinpoint development patterns or future research directions (Chen et al., 2016; Li et al., 2015). Web of Science (WoS), Scopus, Science Direct, and Google Scholar are just a handful of the academic databases and search engines that are readily available, and they all make it much easier to find and retrieve scientific papers for bibliometric research (Wong et al., 2020). The world's most popular platform for searching and analyzing scientific citations is the Web of Science (WoS), and it is utilized as a research tool to support a wide range of scientific activities across many knowledge areas as well as a dataset for extensive investigations involving massive amounts of data (Li et al., 2018). Consequently, bibliometric analysis was performed with the data obtained from the WoS database in this study.

This article describes the outcomes of bibliometric analysis and visualization of a variety of scholarly works. Therefore, the purpose of this article is to identify the global research trends for the terms "maritime accident* or marine accident*" as well as the most productive authors and publications. This study makes a methodological contribution to the field of maritime accident by presenting a bibliometric mapping that allows for the evaluation of scientific presentation as well as its visual analytics using five bibliometric mapping techniques (co-occurrence keyword analysis, abstract keyword analysis, author citations analysis, citation country analysis, and citation source analysis). This allows for a better understanding of the field's structure and evolution. Despite extensive research on bibliometric analysis from a range of disciplines, there are only a limited number of publications on the application of bibliometric studies to marine accidents.

On November 24, 2022, the whole data set—limited to English and the article document type—was retrieved from WoS. Book Chapters or Early Access or Proceeding Papers were excluded from the dataset. The terms "Maritime Accident*" or "Marine Accident*" are used in the WoS search engine. This search found 570 studies on the topic that were published between 2000 and 2022.

The bibliometric analysis in this study was carried out using the VOSviewer (version 1.6.18) software. The software VOSviewer enables the creation and visualization of bibliometric maps (Md Khudzari et al., 2018).

The objectives of this study are to: 1) provide a thorough overview of the evolution of research on maritime accidents; 2) identify the distribution of the most productive journals and contributing countries; 3) identify the most common relevant keywords; and 4) identify the authors who have contributed the most.

Results

Table 1 displays the top 10 articles by search query that were cited the most throughout the specified duration, with Chauvin et al.'s (2013) article leading the list with 287 total citations. The significance of bridge resource management for pilot-on-board navigation in restricted waterways is the focus of this most-cited paper. In the article, collision accidents were examined and HFACS was used as a method. It can be seen that the most cited article was published in the Accident Analysis and

Prevention journal, which has Q1 as its category quartile and Elsevier as its publisher.

Figure 2 presents a network map of cited authors linked by grouped citation links. While creating the map, we included the authors with a minimum of three documents in the analysis and 7 clusters were formed. The analysis revealed that Pentti Kujala had the highest citation weight, while Jin Wang had the highest total link strength weight. The paper, co-authored by Jin Wang and focusing on the potential effects of AIS on maritime navigation safety, comes in second place among the top 10 most cited articles (see table 1) with 213 citations. According to their study, a number of stakeholders, including regulatory agencies, must take additional measures for the AIS to achieve its stated aims and objectives. The paper, co-authored by Pentti Kujala, is ranked third among the top 10 most cited articles (see Table 1) and focuses on creating a systematic and proactive framework for assessing risk. Their study has produced a comprehensive model of risk for the marine transportation system.

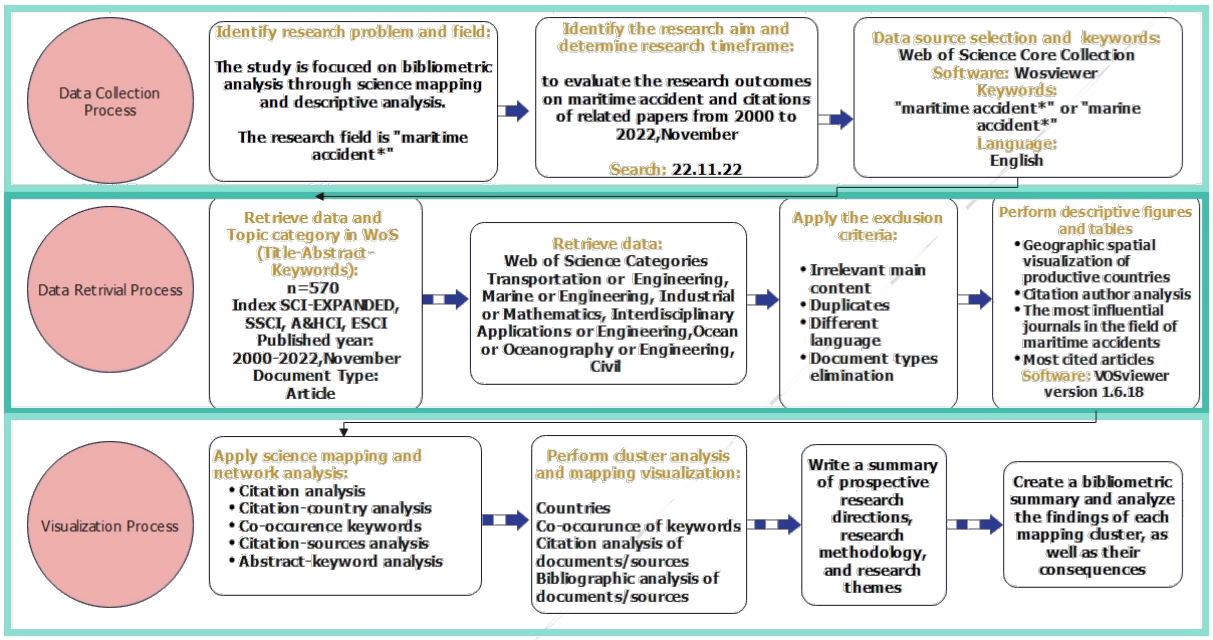

Figure 1. The conceptual framework of methodology

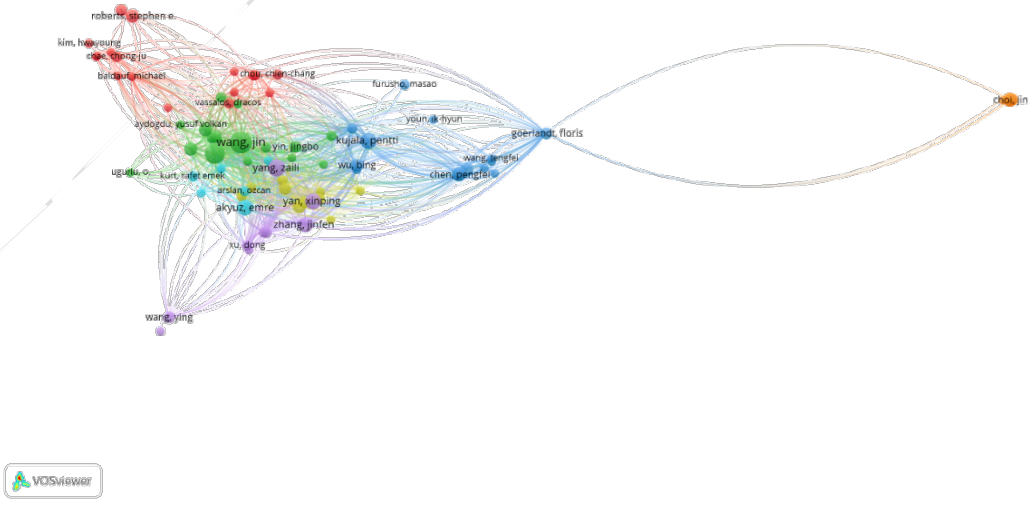

Figure 2. Maritime accident studies network map of citation-authors analysis

Table 1. Top-cited articles with information related to searching query ("marine accident*" or "maritime accident*")

ID	Authors and Publication Year	Source Title	Publisher and WoS Category	Total Citations	Scientific Contribution	Aim of the Study	Methodology	Research Sample	Category Quartile	Impact Factor
1	Chauvin et al. (2013)	ACCIDENT ANALYSIS AND PREVENTION	Elsevier; Transportation	287	This study demonstrates the significance of bridge resource management for pilot-on-board navigation in narrow waterways.	to classify accident types with various patterns of human and organizational factors in order to present a methodical and multifactorial analysis of collisions at sea.	Human Factor Analysis and Classification System (HFACS).	Collision Accidents	Q1	6,376
2	Harati-Mokhtari et al. (2007)	JOURNAL OF NAVIGATION	Cambridge University Press; Engineering, Marine	213	According to this study, a number of stakeholders, including regulatory authorities, need to do more for the AIS to achieve its stated goals and purposes.	to investigate the AIS's (Automatic Identification System) implementation on ship bridges and any potential effects on marine navigation safety.	"Swiss Cheese" Model	AIS studies	Q2	2,647
3	Montewka et al. (2014)	RELIABILITY ENGINEERING & SYSTEM SAFETY	Elsevier; Engineering, Industrial	159	This study establishes a holistic risk model for the maritime transportation system.	to develop a systematic and proactive framework for determining the risk.	Bayesian Belief Networks	Open Sea Collision Involving a Ro Pax	Q1	7,247
4	Hänninen & Kujala (2012)	RELIABILITY ENGINEERING & SYSTEM SAFETY	Elsevier; Engineering, Industrial	143	The model demonstrates that altering direction during an encounter is the most important component, followed by aspects like the officer of the watch's activity, situational evaluation, threat detection, personal condition, and incapacity.	to determine the elements that significantly affect the probability of ship collisions in the Gulf of Finland.	Bayesian network	Collision Accidents in the Gulf of Finland	Q1	7,247
5	Chen et al. (2013)	SAFETY SCIENCE	Elsevier; Engineering, Industrial	132	This study suggests a new HFACS analogy for examining and evaluating marine accidents. This study suggests a new HFACS analogy for examining and evaluating marine accidents.	to provide a particular Human and Organizational Factors (HOFs) framework for the investigation and evaluation of maritime accidents.	Human Factors Analysis and Classification System for Maritime Accidents (HFACS-MA)	Herald of Free Enterprise	Q2	6,392
6	Wróbel et al. (2017)	RELIABILITY ENGINEERING & SYSTEM SAFETY	Elsevier; Engineering, Industrial	130	The findings indicate that as autonomous ships become more common, navigational accidents should become less common. But it's likely that accidents on unmanned ships will have a lot more serious effects than on regular ships, especially if they don't happen while the ship is in navigation.	to evaluate whether the accident would have occurred if the ship had been unmanned and whether the consequences of the accident would have been different if it had.	HFACS-MA and What-If Analysis	100 Maritime Accident Reports	Q1	7,247
7	Eleftheria et al. (2016)	SAFETY SCIENCE	Elsevier; Engineering, Industrial	123	The study shows that, even though there have been more ship accidents in general over the past ten years, the safety level of different types of ships has not changed much, and neither has the average severity of their effects.	To evaluate the safety of all fundamental categories of merchant ships in terms of accidents' occurrence, initial frequencies, and fundamental outcomes. To quantify the risk level of the operating world fleet by statistical analysis of historical data.	Formal Safety Assessment	Maritime Accidents in the Period 2000–2012	Q2	6,392
8	Kum & Sahin (2015)	SAFETY SCIENCE	Elsevier; Engineering, Industrial	121	The development of crew training manuals, competency standards, and the establishment of Arctic navigation training facilities can all benefit from the findings of this study.	to conduct a root cause analysis investigation into the marine incidents that the Marine Accident Investigation Branch (MAIB) has documented as happening north of 66°33′ between the years of 1993 and 2011.	Root Cause Analysis (RCA) and Fuzzy Fault Tree Analysis (FFTA)	Arctic Marine Accidents from 1993 to 2011	Q2	6,392
9	Zhang et al. (2016)	OCEAN ENGINEERING	Elsevier; Engineering, Marine	120	In this study, an improved approach for identifying near misses between ships using AIS data is provided and demonstrated to be effective in decreasing the frequency of near misses requiring additional expert analysis.	to analyzing maritime traffic data for near misses between ships, especially in open water and coastal restricted sea areas.	A new technique based on the principles of the traffic conflict technique	AIS Data from the Northern Baltic Sea	Q1	4,372
10	Fowler et al. (2000)	RISK ANALYSIS	Wiley; Mathematics, Interdisciplinary Applications	119	The Commission of the European Communities (CEC) project "Safety of Shipping in Coastal Waters" (SAFECO) outcomes are presented in this article.	to determine the influences that could increase the safety of shipping in coastal waters.	Marine Accident Risk Calculation System (MARCS)	The case study area is the North Sea area in the Lloyd's Maritime Information System casualty database.	Q1	4,302

The distribution of publications on maritime accidents by country is shown in Figure 3. People's Republic of China tops the list with 1800 citations, followed by England with 1354 citations, Türkiye with 1274 citations, Finland with 1019 citations, and Norway with 757 citations. People's Republic of China also possessed the greatest number of documents. South Korea is in the second place in terms of the number of published documents, while it is in the fifth place in the citation ranking. Also revealed were that Poland had 495 citations with 25 publications, the USA had 398 citations with 24 citations, and France and Sweden had 484 and 462 citations, respectively, with 13 publications each. Of the 196 countries in the world, we noted that just 55 have written papers on the topic. Nonetheless, current findings indicate that "maritime accidents" are a growing field of study in the majority of countries.

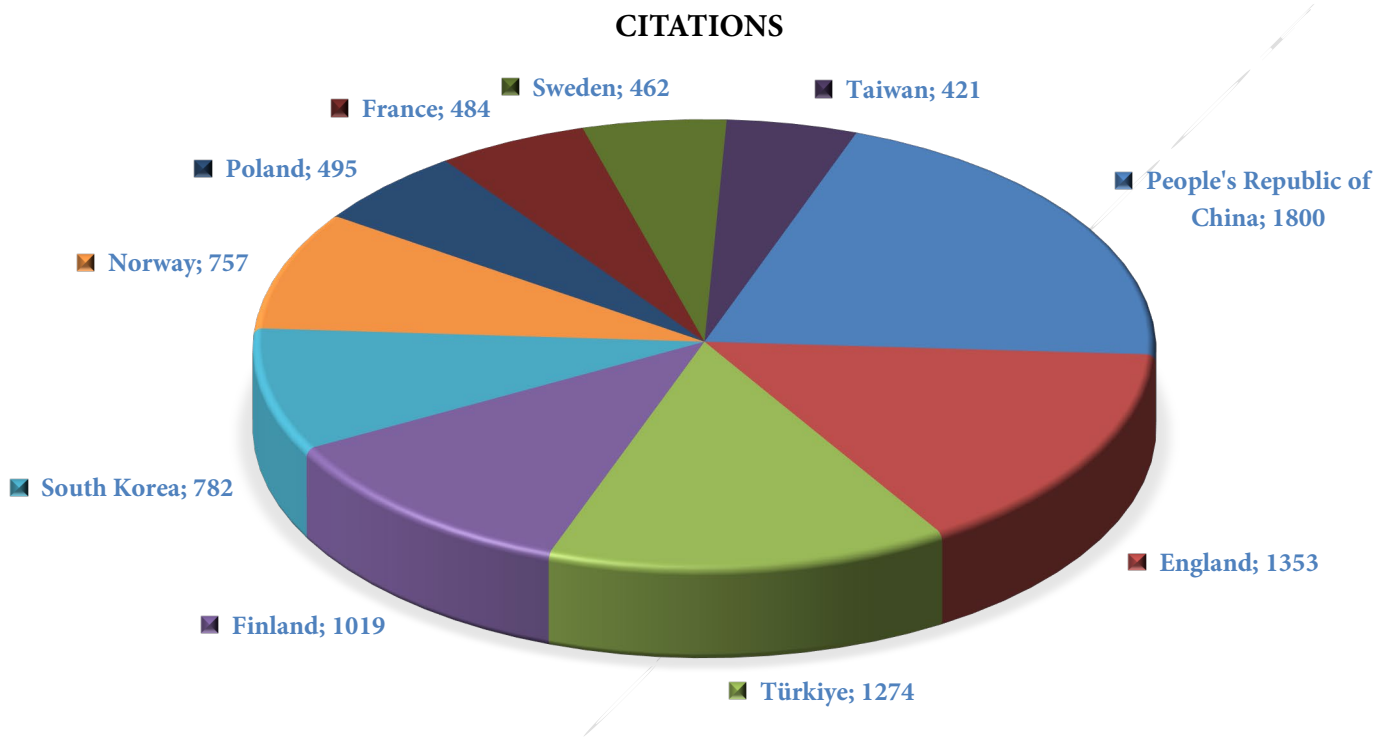

Figure 3. The distribution of publications cites on maritime accidents by country

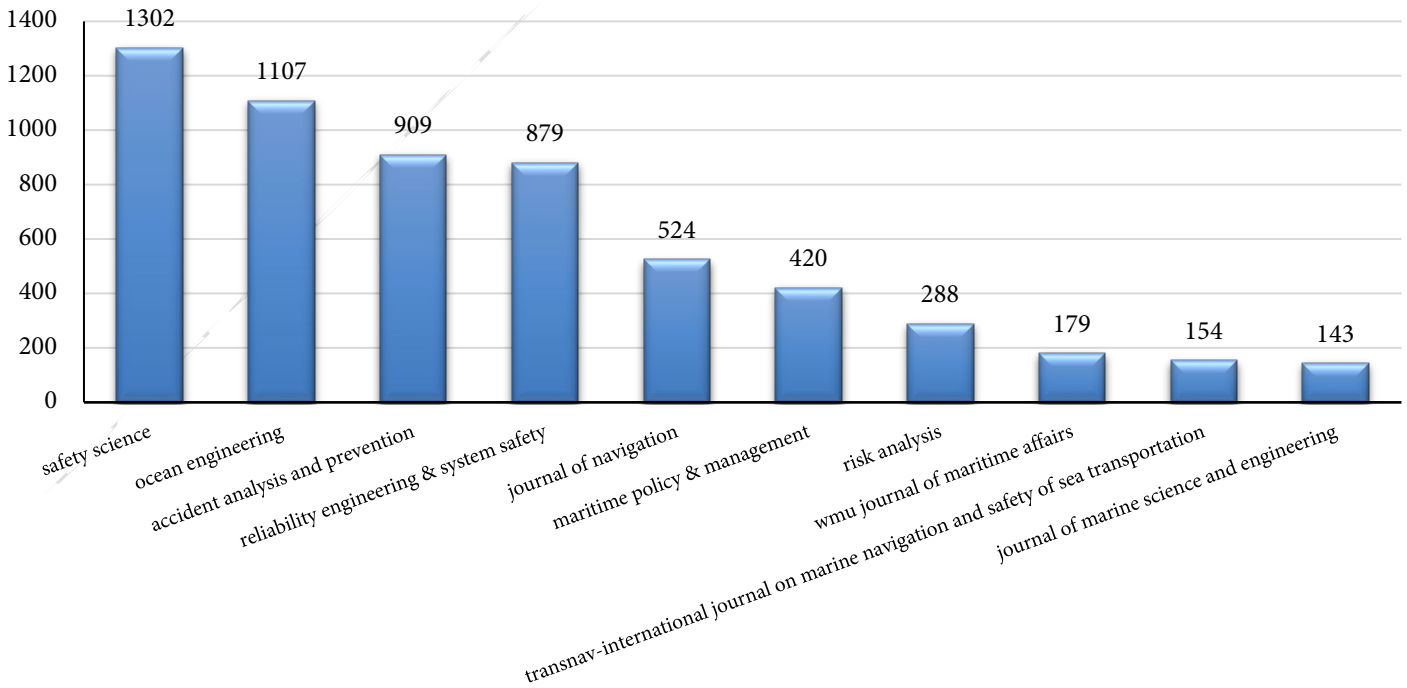

Figure 4. The most influential journals in the field of maritime accidents

By conducting research on high-quality journals, academics may have a deeper understanding of the academic preferences of each journal on the topic of maritime accidents, allowing them to be more selective when subscribing to journals and submitting papers. As a result, as seen in Figure 4, we ranked the top 10 journals whose papers on maritime accidents have received the most citations. The number of articles in a total of 186 journals that are focused on at least three publications was examined. The most influential journals, as seen in Figure 4, are Safety Science, Ocean Engineering, and Accident Analysis and Prevention.

A network map of keywords based on searching query on "maritime accident", "marine accident" literature was drawn in Figure 5.

According to Figure 5, more than 1724 keywords were extracted from the 570 publications. After applying a minimum three number of occurrences, 96 keywords were ranked by the number of occurrences. These keywords showed the main content of studies on field of maritime accident. These keywords were classified into twelve cluster. The size of each cluster shows the publication weight of each keyword. When the authors' most frequently used words are evaluated, it becomes clear that the most frequently used keywords are maritime accident, maritime safety, marine accident. There are connections between the keywords Bayesian network, maritime risk, risk assessment, fatigue, seafarers and Istanbul Strait when looking at the pink, purple, green and yellow clusters with the keywords maritime accident and marine accident. The relationships between the keywords human factor, Bayesian network, and human error are noticeable when we look at the blue clusters associated with the maritime safety keyword. Examining at the orange and red clusters reveals connections to the first-appearing risk analysis and collision accident keywords as well as the Bayesian belief network, AIS data, decision-making, and data mining keywords. According to Figure 5, it can be concluded that the Bayesian network is one of the popular methods in studies on maritime accidents, risk assessments connected to accidents are conducted, human factor studies related to marine accidents are prominent, AIS data is used in research, and the Istanbul Strait is one of the important regions for accident studies.

Figure 6 displays a map of the most popular keyword group distribution in abstracts. As can be observed, "human factor", "safety", and "human error" are some of the popular keywords here. Our finding that studies on marine accidents tend to concentrate on human factor and human error is supported by Figure 6.

Discussion and Conclusion

In this study, which analyzes search queries on (maritime accident* or marine accident*), some significant worldwide research trends were gathered from publications from WoS from 2000 to 2022, November. This study evaluated the geographical distributions of publications related to searching query, maps of the author and citation, linkages of cooccurrence and author keywords, the evolution of research priority themes through time, and the underlying journals and articles.

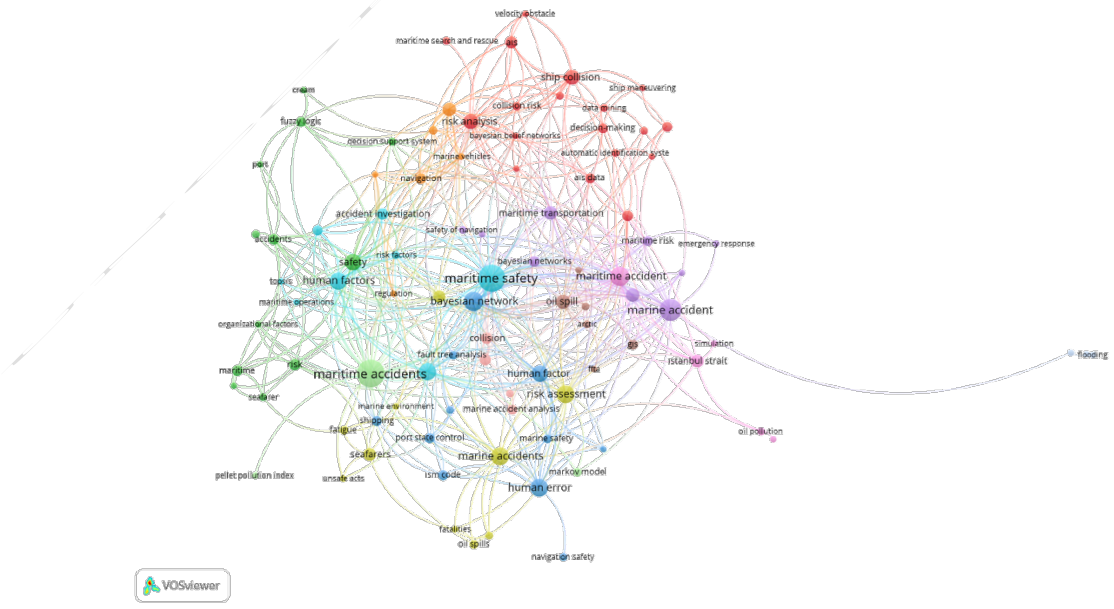

Figure 5. A network map of keywords based on searching query on maritime accident, marine accident literature

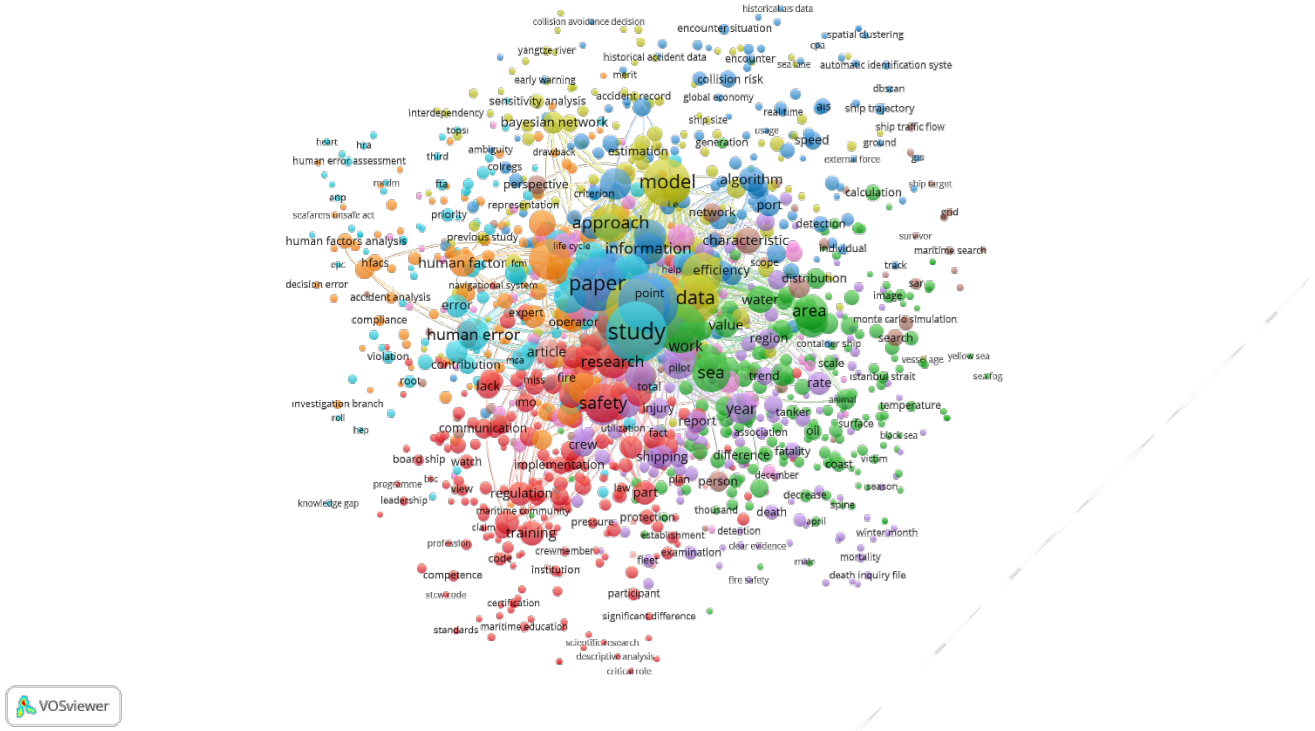

Figure 6. The map of keywords that are used in abstracts

Dominguez-Péry et al. (2021) conducted a bibliometric analysis under the umbrella of human error in their study; and Gil et al. (2020) focused on the decision support system in their study. While Fu et al. (2021) performed the analysis for the Arctic region, Kulkarni et al. (2020) performed the analysis for the Baltic Sea. We conducted a comprehensive bibliometric analysis of maritime accidents, unrestricted by region. We were able to demonstrate the prominent methods, trends, and analyses in maritime accident studies since we analyzed all maritime accident studies without focusing on specific approaches such as risk assessment or decision support systems. We believe that our comprehensive bibliometric analysis has filled a significant gap in the literature.

This research provides a significant addition to the field since the bibliometric approach is a modern tool for analyzing publishing activity. This research covers the outcomes of bibliometric analysis and visualization of a variety of academic publications. This article identified the global research trends for the search terms "maritime accident* or marine accident*" as well as the most productive authors and publications. This study makes a methodological contribution to the field of maritime accident by presenting a bibliometric mapping that allows for the evaluation of scientific presentation as well as its visual analytics using five bibliometric mapping techniques (co-occurrence keyword analysis, abstract keyword analysis, author citations analysis, citation country analysis, and citation source analysis). This allows for a better understanding of the field's structure and evolution.

We discovered that the most influential publication was Safety Science. The country with the highest level of production was the People's Republic of China. We found that the most frequently used keywords are maritime accident, maritime safety, and marine accident. We concluded that the Bayesian network is one of the popular methods in studies on maritime accidents, risk assessments connected to accidents are conducted, human factor studies related to marine accidents are prominent, AIS data is used in research, and the Istanbul Strait is one of the important regions for accident studies.

The following contributions were made by this study: it provided a thorough overview of the evolution of research on maritime accidents, and as a result, prominent approaches in maritime accident studies were identified. The distribution of the most productive journals as well as the most cited authors in research on marine accidents were identified. It has been determined which countries around the world have conducted extensive research on the subject.

Since we only examined English-language publications from a certain time period, the consistency of our findings depended on the search terms we selected. These are the limitations of our study. In the future, the contribution of

articles written in languages other than English and those published over a wider period of time can be analyzed. Choosing "article" as the only document type is one of the limitations of this study. In future research, the study could be expanded by including additional document types. Furthermore, while the data for the present study were taken from WoS, future research can utilize a variety of bibliometric techniques and additional databases as well. The current study is also limited to using a single database.

The outcomes of this study can help researchers by providing insight on how to conduct their research in terms of journal selection, authors who contributed, research trends, countries, and keywords. Various databases, including scientific collections, might be used as data sources in future studies. In future research, the search can be broadened to include terms such as "incident".

Compliance With Ethical Standards

Authors' Contributions

AY: Conceptualization, Software, Resources, Investigation, Methodology, Visualization, Formal analysis, Writing – review and editing.

CS: Conceptualization, Writing – review and editing, Resources, Supervision, Investigation, Visualization

Conflict of Interest

The authors declare that they have no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

Data Availability Statements

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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RESEARCH ARTICLE

Biochemical composition of different sex and body parts of blue crabs (*Callinectes sapidus*) caught from the middle Black Sea coast

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ABSTRACT

This study was carried out to determine the nutritional composition of blue crabs (*Callinectes sapidus*) caught on the Fatsa (Ordu) coasts of the Middle Black Sea of Türkiye. The nutritional value of various edible body parts (carapace, right and left claw, and legs) of the blue crabs were evaluated, and the proximal biochemical compositions of crabs belonging to different sexes were compared. The average protein content in male and female blue crabs was 18.79% and 19.11%, respectively. The highest amount of protein in female crabs was determined in the carapace, while the highest amount in males was determined in the legs. The quantity of fat in male crabs ranged from 0.46 to 0.69%, whereas the amount in female crabs ranged from 0.63 to 0.92%. The mean fat in female crabs was higher than in male crabs ($p<0.05$). The moisture and ash content in all of the body parts of male and female crabs varied between 78.62-76.73% and 2.29-2.39%, respectively; however, the difference between these values was statistically insignificant. The lowest and highest energy values for 100 g of crab meat were determined to be 78.27 kcal and 88.00 kcal, respectively. This study suggests that the blue crab, with its high protein and low-fat content, may be an alternative nutrient-dense species for the rural population.

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Introduction

This study was carried out to determine the nutritional composition of blue crabs (*Callinectes sapidus*) caught on the Fatsa (Ordu) coasts of the middle Black Sea of Türkiye. The nutritional value of various edible body parts (carapace, right and left claw, and legs) of the blue crabs were evaluated, and the proximal biochemical compositions of crabs belonging to different sexes were compared. The average protein content in male and female blue crabs was 18.79% and 19.11%, respectively. The highest amount of protein in female crabs was determined in the carapace, while the highest amount in males

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was determined in the legs. The quantity of fat in male crabs ranged from 0.46 to 0.69%, whereas the amount in female crabs ranged from 0.63 to 0.92%. The mean fat in female crabs was higher than in male crabs ($p<0.05$). The moisture and ash content in all of the body parts of male and female crabs varied between 78.62-76.73% and 2.29-2.39%, respectively; however, the difference between these values was statistically insignificant. The lowest and highest energy values for 100 g of crab meat were determined to be 78.27 kcal and 88.00 kcal, respectively. This study suggests that the blue crab, with its high protein and low-fat content, may be an alternative nutrient-dense species for the rural population.

As a result of population growth in the world, people's food requirements are increasing day by day. Effective use of currently available food sources and the availability of substitute food sources are required to meet these demands.

When used effectively, seafood contains many nutritional sources in terms of human health. However, the availability of these resources is prone to decline owing to climate change, inappropriate human overuse, and poor policy. These consumption patterns led to a decline in endemic species and an increase in the alien invasive species (AIS) population. Although this condition may initially seem alarming, it has been shown that invasive edible species may be used to acquire nutritional and economic advantages, at least in part (Piras et al., 2019). The increased water temperature due to deep water currents and climate change makes the environmental conditions more suitable for Mediterranean-origin species in the Black Sea. In addition, increased human activities and maritime transport play a critical role in the transferring species to other regions. For these reasons, it was recently discovered that the Black Sea has a large number of AIS (Shefer et al., 2004; Şahin et al., 2009; Sağlam et al., 2011; Turan et al., 2016, Ceylan, 2020). One of these invasive edible alien species is the blue crab, first discovered in Europe in the early 20th century and the Mediterranean in 1949. The blue crab is thought to have originated in the western Atlantic (Enzenroß et al., 1997) and is processed locally in the Mediterranean region and exported to European countries with a high economic return (Türeli et al., 2000). It was initially recorded in 2017 in Ordu province in the Middle Black Sea area of Türkiye (Aydın, 2017). Numerous studies have been undertaken on the nutritional profile of different species of crab across the world (Tsai et al., 1984; Siddiquie et al., 1987; Barrento et al., 2010; Bayraklı, 2021; Shaeik et al, 2021; Tufan, 2022). Although there are certain studies on the nutritional composition of different crab species including blue crab in Mediterranean coasts of Türkiye (Türeli et al., 2000; Gökoglu & Yerlikaya, 2003; Çelik et al., 2004), no such study has been conducted on blue crabs in the Middle Black Sea coast. For this purpose, this aimed to determine the nutritional compositions such as protein, fat and mineral content among the sex and different body parts of the blue crab.

Material and Method

Captured individuals were sampled at 2-10 m depths in a Trammel net with 48 mm mesh set up close to the creek mouth for demersal fish sampling (Aydın, 2017).

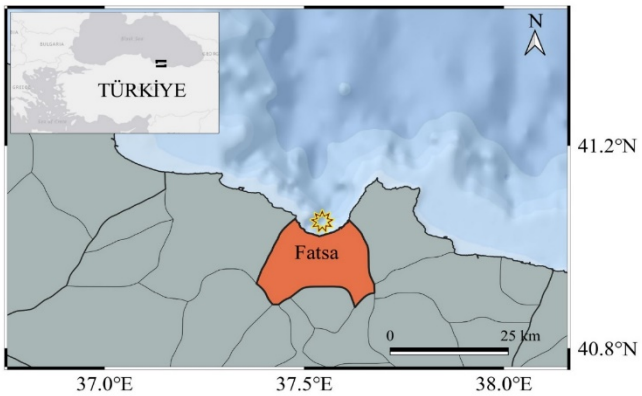

Figure 1. Sampling area of blue crab (Fatsa, Ordu, Türkiye)

After the captured samples (n_{male}:9, n_{female}:8) were frozen at -18°C, they were brought to Sürmene Faculty of Marine Sciences by the cold chain in a styrofoam box. The sampled individuals were taken to the laboratory and their height and weight measurements were performed. The carapace width of the female individual sampled with one claw missing was 19.6±0.6 cm, the carapace length was 7.83±0.7 cm, and the total weight was 269.39±14.22 g. The carapace width of the male individual was 19.4 cm, carapace length was 8.40 cm and the total weight was determined as 449.19±17.32 g. After length and weight measurement, sex was determined in blue crabs (Figure 3; Millikin & Williams, 1984, as male and female). After sex determination, the flesh meat on the carapace, right claw, left claw and legs of female and male crabs were removed and prepared for analysis separately (Figure 4). The removed flesh meats obtained from the same sex and the same body part representing the same season were mixed with a homogenizer (Arçelik; K-1631 P Valso Plus, 2.2 L capacity, Türkiye).

Analysis of Proximate Composition

Moisture analyses were conducted according to the oven drying method. 5 g wet sample was taken from each blue crab body part sample, and the moisture content was determined by removing the water content between 14-16 hours at 105°C (AOAC, 1995, Method 985.14). The total ash amount was

determined with the gradual combustion method, with the final temperature in the muffle furnace at 540-560°C (AOAC, 2005a). Crude fat analyses were carried out on dry matter using the Soxhlet method (Velp SER 148/6, Velp Scientifica, Milano, Italy) by petroleum ether and hot oil extraction method (130°C), and the results were calculated as g/100 g by converting to wet sample amount. The crude protein amount (nitrogen content) was determined according to AOAC Method 2.507. The analysis was made on dry matter, and the protein amount was calculated by converting to the amount of wet-weight samples as a result of the analysis (AOAC, 2005b). The Atwater method was applied to calculate the total energy value of the soup (Merrill & Watt, 1973).

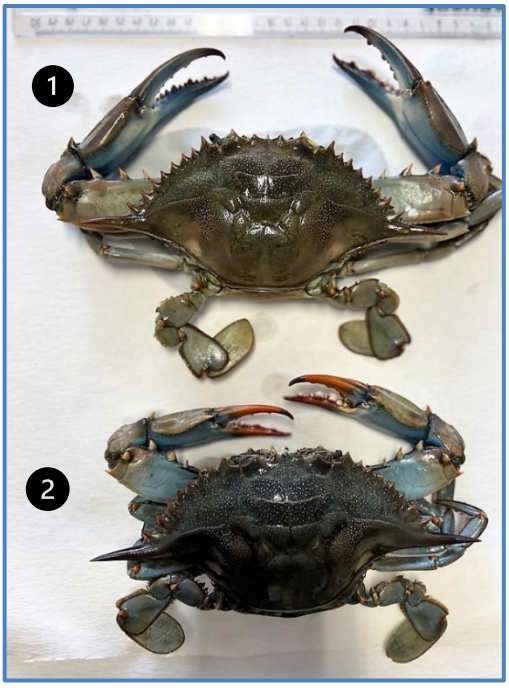

Figure 2. Male (1) and female (2) blue crab

Statistical Analysis

The data obtained were analyzed by analysis of variance (One-Way ANOVA) and when significant differences were found, comparisons among means were further analyzed by using a TUKEY and Mann-Whitney U test (data not provided in the normality of assumptions) under the JMP 5.0.1 program (SAS Institute. Inc. USA) and SPSS (SPSS Inc., Chicago, IL) (Sokal & Rohlf, 1987). A significance level of 95% ($p<0.05$) was used throughout the analysis.

Results

The nutritional composition of the analyzed blue crab meat is given in Table 1. According to these results, protein values in body parts (carapace, right claw, left claw and legs) of male individuals were found to be 18.26-19.22%. The amount of protein in female crabs was found to be the highest (19.93%) in carapace and the lowest in right claw (18.05%). The total crude fat in the body parts of male crabs was found to be in the range of 0.46-0.69%. The amount of fat in female crabs was found to be the highest in carapace (0.92%) and the lowest in legs (0.63%). It was determined that the lowest and highest moisture content in female (in carapace) and male (in right claw) crabs varied between 76.73-78.58%, respectively. The lowest amount of ash was determined in the carapace of female crabs (2.29%), while the highest in the carapace of male crabs (2.39%). When the energy amounts in 100 g crab meat were calculated, the highest amount was found as 88.00 kcal/100 g in the carapace of female crabs, and the lowest was found as 78.27 kcal/100 g in the right claw of male crabs.

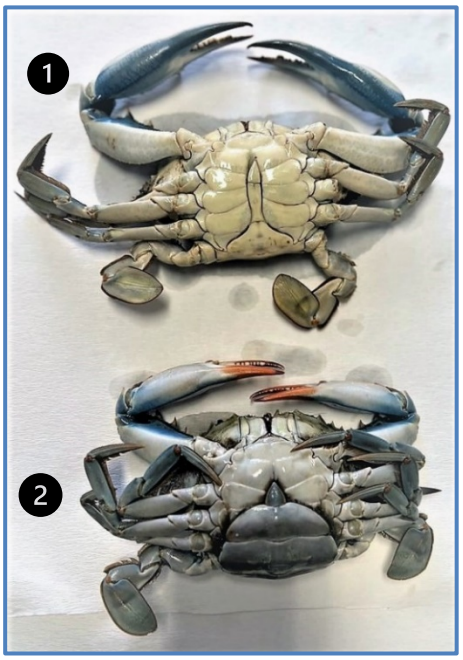

Figure 3. Male (1) and female (2) blue crab bottom view

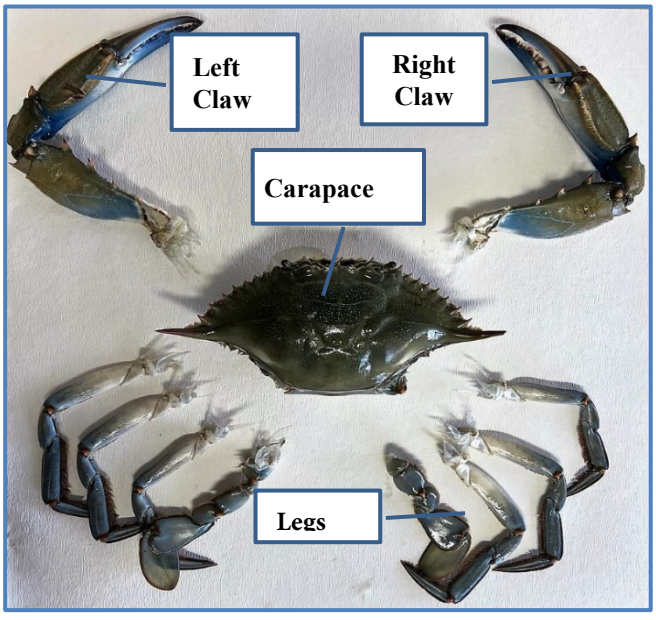

Figure 4. Analyzed body parts of blue crab

Table 1. Proximate composition in body parts of male and female blue crabs (*Callinectes sapidus*) (g/100 g)

	Body Parts	Protein	Fat	Moisture	Ash	Energy (kcal/100 g)
MALE ♂	Carapace	$18.97\pm0.09^{a}{}_{A}$	$0.69\pm0.03^{a}{}_{A}$	$77.69\pm1.23^{a}{}_{A}$	$2.39\pm0.21^{a}{}_{A}$	$82.08\pm1.23^{ab}{}_{A}$
	Left Claw	$18.69\pm0.07^{a}{}_{A}$	$0.59\pm0.02^{a}{}_{A}$	$78.32\pm0.96^{a}{}_{A}$	$2.38\pm0.15^{a}{}_{A}$	$80.10\pm1.41^{ab}{}_{A}$
	Right Claw	$18.26\pm0.05^{a}{}_{A}$	$0.58\pm0.03^{a}{}_{A}$	$78.58\pm1.14^{a}{}_{A}$	$2.35\pm0.18^{a}{}_{A}$	$78.27\pm0.85^{bc}{}_{A}$
	Legs	$19.22\pm0.06^{b}{}_{A}$	$0.46\pm0.04^{b}{}_{A}$	$77.49\pm0.84^{a}{}_{A}$	$2.34\pm0.21^{a}{}_{A}$	$81.03\pm0.96^{a}{}_{A}$
	Mean	$18.79\pm0.23_{A}$	$0.58\pm0.06_{A}$	$78.02\pm0.68_{A}$	$2.37\pm0.14_{A}$	$80.37\pm0.77_{A}$
FEMALE ♀	Carapace	$19.93\pm0.15^{a}{}_{B}$	$0.92\pm0.04^{a}{}_{B}$	$76.73\pm0.97^{a}{}_{A}$	$2.29\pm0.28^{a}{}_{A}$	$88.00\pm0.69^{a}{}_{B}$
	Left Claw	$18.75\pm0.31^{b}{}_{A}$	$0.79\pm0.08^{b}{}_{B}$	$77.85\pm0.45^{a}{}_{A}$	$2.32\pm0.36^{a}{}_{A}$	$82.14\pm0.48^{b}{}_{B}$
	Right Claw	$18.05\pm0.45^{b}{}_{A}$	$0.77\pm0.06^{b}{}_{B}$	$78.62\pm1.01^{a}{}_{A}$	$2.31\pm0.21^{a}{}_{A}$	$79.17\pm0.98^{d}{}_{A}$
	Legs	$19.72\pm0.09^{a}{}_{B}$	$0.63\pm0.02^{c}{}_{B}$	$76.98\pm1.12^{a}{}_{A}$	$2.30\pm0.11^{a}{}_{A}$	$84.51\pm1.32^{bc}{}_{B}$
	Mean	$19.11\pm0.14_{A}$	$0.78\pm0.07_{B}$	$77.54\pm0.89_{A}$	$2.31\pm0.17_{A}$	$83.45\pm1.04_{B}$

Note: n=3, ±: standard deviation (SD). Different superscript letters in the same column (a, b, c and d) indicate significant differences amongst different body parts of the same sex ($p<0.05$). Different subscript letters (A and B) in the same column indicate significant differences between the same body parts of different sexes (male and female) ($p<0.05$).

Discussion

In the study conducted by Gökoğlu & Yerlikaya (2003) on the blue crabs (*C. sapidus*) caught from the Mediterranean region, the protein, fat and ash amount in claw meat were found to be 15.00, 0.64, 1.39, and 14.71, 0.79, 1.89 g/100g in carapace meat respectively. Oramadike & Kolade (2015) examined the proximate composition of blue crabs they bought from the local fish market in Nigeria, and they reported that. The study's results reported that the protein, fat and ash values, respectively, were 19.18, 0.43, and 2.18%, in male crabs, and 20.21, 0.72, and 2.30% in female crabs. In another study, the protein and fat contents of male blue crabs obtained from Akyatan Lagoon in the Mediterranean were 30.31% and 1.64% in carapace, respectively, and 31.03-1.22% in claws. In female crabs, the amount of protein in carapace and claw was 26.51-29.59% and, the amount of fat was 1.62-1.12%, respectively (Kuley et al., 2008). It was concluded from the findings of previous studies that the nutritional composition analysis results of crabs were roughly in agreement with our study data. However, certain differences were identified between the sexes. These differences are thought to be due to the height and weight differences (male and female) and reproductive period of the crabs (Balogun & Talabi, 1985; Nettleton et al., 1990; Silva & Chamul, 2000; Baklouti et al., 2013). In the present study, the lowest amount of protein (18.05%) in both male and female crabs was found in the right claw; however, the highest amount of protein (19.93%) was determined in the carapace. While the amount of protein in the carapace of female crabs was similar to that in the legs, significant differences were found among other body parts ($p<0.05$). The amount of protein in the carapace of female individuals was statistically different from both among other body parts of the same sex (except legs) and from the carapaces of male crabs ($p<0.05$). Also, statistical differences were found between the amount of protein in the legs and other body parts of male blue crabs ($p<0.05$).

The low fat content of crabs (Table 1) is a feature of carapace, reported as <2% in several studies (Gökoğlu & Yerlikaya, 2003; Kuley et al., 2008; Ayas, 2011). The lowest and highest amount of fat in male blue crabs was found in the legs (0.46%) and carapace (0.69%), respectively. Statistically significant differences were found between the amount of fat in the legs and other organs ($p<0.05$). The amount of crude fat in the body organs of female crabs was found to be between 0.63% and 0.92%. The lowest fat was found in the legs, while the highest was in the carapace like in male crabs. While the amount of fat in the right claw and left claw of female crabs is similar, the amount of fat among the other body parts was significantly different ($p<0.05$). In addition, statistically significant differences were found between the amount of fat in all body part of male and female crabs ($p<0.05$). The lowest moisture content in the male and female crab species was 76.73% in the carapace of females and the highest was in the right claw of female crabs. In addition, there was no statistical difference between both the body parts and sexes. The highest amount of ash in female and male crabs was determined as 2.39% in the carapace of male crabs and the lowest (2.29%) was in carapace of female crabs.

On the other hand, like the amount of moisture, there were no significant differences between the different body parts and sexes. The energy values of crab meat were in the range of 78.27

and 88.00 kcal/100 g. The highest energy value was found in carapace of female crabs, while the lowest was found in the right claw of male crabs. In addition, the average amount of energy in the meat of female crabs was statistically different from that of male crabs ($p<0.05$).

Conclusion

The nutritional values of the edible meat of the blue crab caught in the middle Black Sea coast of Türkiye were analyzed and it was determined that both male and female individuals of this species have a high protein and low-fat content. Thanks to this feature of blue crabs, it can be beneficial for the people of the region as an alternative aquatic product. It has been observed that invasive species can migrate to different regions such as the middle Black Sea due to changing climatic conditions, so this study raises awareness of the existence of this species in the Black Sea region. It is believed that the use of foreign invasive species such as blue crabs as food will partially prevent the over-spreading of the species.

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Compliance With Ethical Standards

Conflict of Interest

The author declares that they have no conflict of interest.

Ethical Approval

For this study, all applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

Data Availability Statements

The data that support the findings of this study are available from the author upon reasonable request.

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RESEARCH ARTICLE

Determination of fish diversity in the northern coasts of Cyprus (eastern Mediterranean) by visual census method

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ABSTRACT

The present study aims to determine fish assemblages spreading between 0 and 40 m depth on the northern coasts of Cyprus. During the study, Underwater Observations (UO) have been conducted in 54 locations and photographed the fish species. The hourly imaging figures of the recorded species were determined by using the Time-Transect Method (TTM). Also, dominance Analysis (DA) and Incidence Frequency Analysis (IFA) of the identified species were performed. As a result, 72 different fish species belonging to 26 families were found to occur in the studied area. After the evaluation of identified species, 56 of them were determined as native species of the Mediterranean and 14 of them as Indo-Pacific origin. Additionally, we provide two new records (*Dasyatis chrysonota* and *Gobius fallax*) from Cyprus.

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Introduction

Cyprus, the third largest island in the Mediterranean Sea, is located in the Levantine Sea. It is one of the keystone areas of the biological invasions of the Mediterranean Sea due to its location which is very close to the Suez Canal, and being exposed to heavy ship traffic (Iglésias & Frotté, 2015). Recent studies on marine biodiversity are mainly concentrated on the southern coasts of Cyprus (Moullec et al., 2019). In contrast, there are only a few studies from the north coasts of Cyprus.

The Suez Canal which connects the Mediterranean and the Red Sea is one of the most important and effective transit lines in the world. The canal was opened in 1869 with the initiatives of French Diplomat and engineer Ferdinand de Lesseps. After that, constructing the Aswan Dam on the Nile River have been removed the geographical barriers between the Red Sea and the Mediterranean, and then some Indo-Pacific species started fluxing the Mediterranean via the Suez Canal. As a result of the expansion and extension works on the Suez Canal from 1956 to

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2010, at the present time, the channel length reaches 193.3 km, with a depth of 24 m. Also, the 2nd channel was put into operation in parallel with certain parts of the existing channel on August 6, 2015 (Ergüden & Turan, 2013).

Thanks to its high endemism, the Mediterranean has become a hotspot of marine bio-invasions (Mannino et al., 2017). Although there are limited invasions from the naturally occurring Gibraltar Strait in the Mediterranean, most of the biological invasions in the region are carried out through the Suez Canal, which was formed artificially (Galil et al., 2015). In addition to the species that pass through the canal to the Mediterranean Sea, species that are carried by fouling and ballast waters through intensive ship traffic have also accelerated this invasion.

Benli et al. (1999, 2003) conducted studies in 1997 and 2003 with the aim of contributing to the determination of macro biodiversity with its dispersal in the North Cyprus coastal zone. Biotopes resulting from interaction of living and non-living parameters were evaluated ecologically. In the first study, a total of 82 fish species were determined during a bottom trawl operation between the depths of 20 and 600 m (Benli et al., 1999) and 84 fish species were caught between the depths of 25-840 m (Benli et al., 2003).

An investigation was carried out between 1995 and 1996 by Torcu et al. (2001) for the determination of fish species living on the coasts of Northern Cyprus. In this study, 49 fish species belonging to 2 classes and 32 families were collected. Çiçek (2006) conducted a study using the underwater visual census (UVC) technique and photography in Northern Cyprus.

The first project to record the spread of the Red Sea immigrants of Cyprus was initiated in 1967 during a joint program (Biota of the Red Sea and the eastern Mediterranean) by the Smithsonian Institution. A total of 140 alien species were listed which are known to reach to the Mediterranean Sea via the Suez Canal (Steinitz, 1970). Katsanevakis et al. (2009) presented an updated inventory of alien marine species from the coastal and offshore waters of Cyprus based on a thorough compilation of existing information, and provided a baseline information on the current situation of the island. A survey carried out around Cyprus during September 2014 documented the occurrence of 25 alien fishes, increasing the number of recorded alien fishes to 35 (Iglésias & Frotté, 2015).

The aim of this study is to provide an up-to-date list of the native and non-native fish species on the northern coast of Cyprus and to provide the opportunity to the relevant scientist to determine changes about the fish fauna of eastern Mediterranean.

Material and Methods

The study area is located in the northern part of the Cyprus Island (Levantine Sea – Eastern Mediterranean) between Koruçam and Esentepe (Figure 1). The survey was carried out from 0 to 2 nautical miles to the land, between the depths of 0 - 40 m. using the Time-Transect Method (TTM). Between 07.11.2015 and 28.09.2016, data were collected by completing the underwater observations (UO) with devices for an average of 70 hours of dives at 54 stations on the Northern Cyprus coasts (Figure 2).

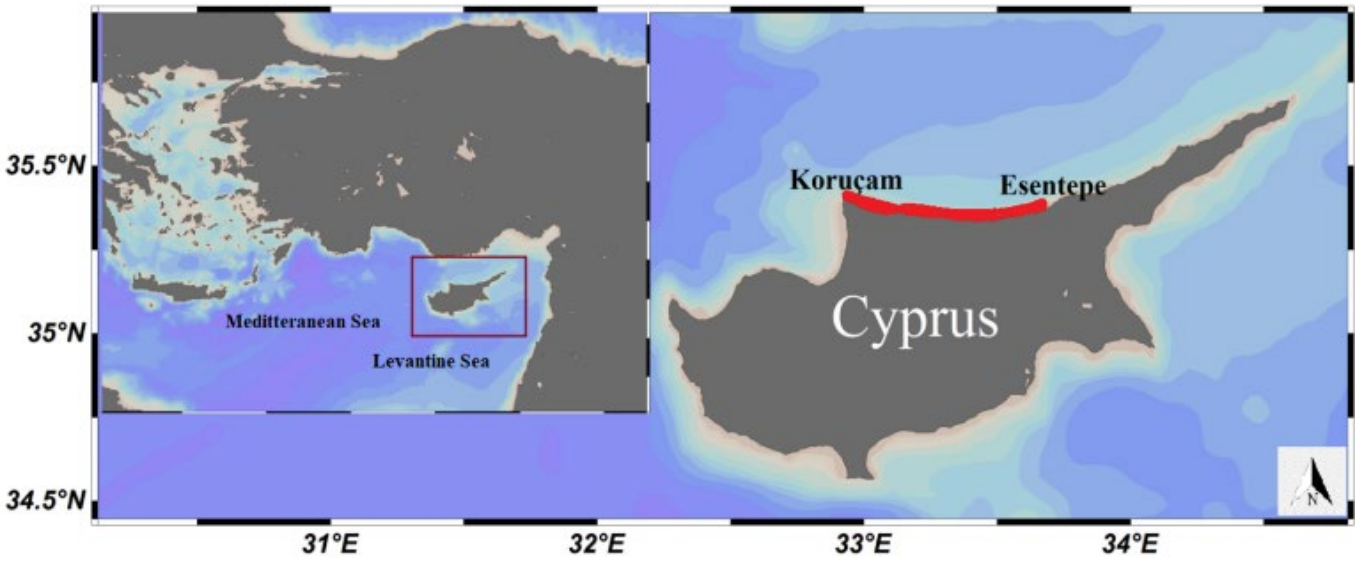

Figure 1. Study area

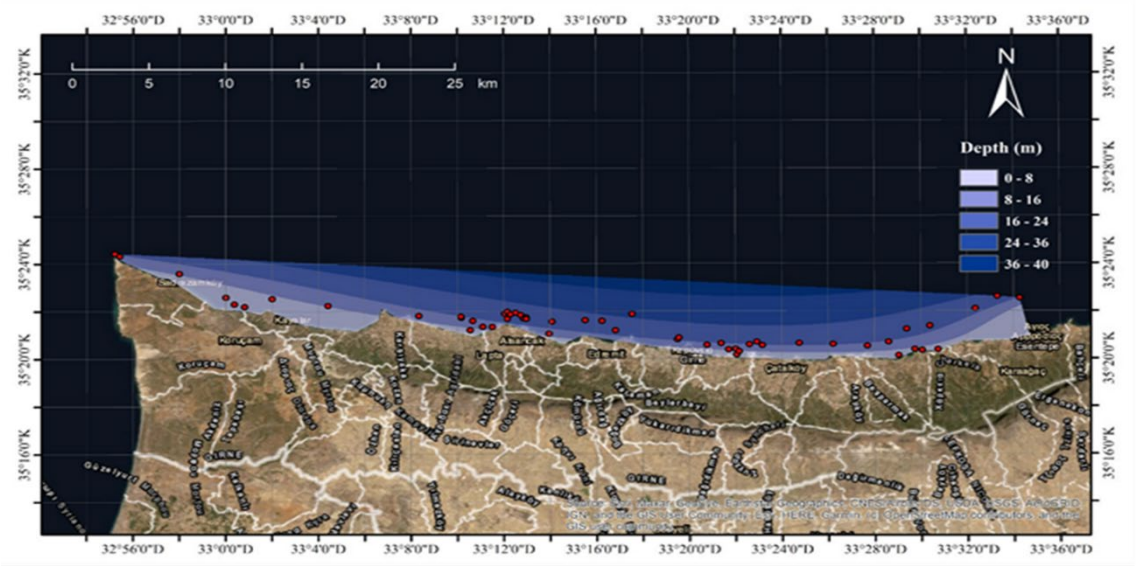

Figure 2. Sampling stations

The stations were determined according to the following items:

- Anthropological impact (the intensity of maritime traffic due to the presence of the harbour, the presence of a power plant, the supply of oil to the island from this point of the area and TRNC's hotels are out-numbered).
- The presence of underwater structures built to meet the water needs of the island in the study area.
- The distance of the mooring port of the boat to be used for field works to the stations.
- Sampling stations including areas where both anthropological effects are intense and not.

Special diving programs were formed for each sampling station. US NAVY and Deco 2000 dive tables were used for dive planning. The coordinates of the dives were determined using marine GPS or handheld GPS (Garmin GPSMAP 66s). And at every time, the first diving was performed around 10.00 and the second at 13.00. Table 1 provides detailed examinations conducted at the studied stations.

The shootings were performed by providing land and sea transportation to the pre-determined stations, divers were used the free diving and/or SCUBA diving method for shooting (Canon EOS Dd200 camera, Sea & Sea MDX-series housing, Sea & Sea YS-D2 J Flash and X-Adventurer 3000 Lumens and their components) and video-camera (Go–Pro Hero 3 and Go–Pro Hero 5) equipment.

Nevertheless, marine biodiversity based on UO are practically limited in terms of maximal depth and duration of diving because of physiological and technical constraints. In TTM using UO, the species recorded between the time when the underwater imaging starts and the time when the imaging ends are taken as basis. The aim was to complete the study without giving any damage to any of the habitats, using only imaging methods at the dive points in the designated stations. The field studies were based on the time-transect method following instruction by Engin et al. (2016). According to this method: descent from the surface and ascent to the surface times were subtracted from the total dive time. Number of individuals/species observed during a dive time was proportioned to an hour (60 min) (ind/hour). The abundances of each species were calculated at each station of the whole study area. After the dives, the images obtained were recorded digitally on a daily, weekly basis. The number of individuals in the stations and sight stations were recorded by analysing the obtained images. through the collected data, Imaging Frequency Analysis (IFA) and Dominance Analysis (DA) were performed. IFA is a method used to determine the incidence frequency of the detected species in different habitats. According to this method, it provides the expression of the observation frequency of the species percent (%) in the habitats (Kocataş, 1994). DA is a method used to determine the total ratio of individuals of a certain species to all the species determined (Kocataş, 1994).

The taxonomic classification of the species obtained from underwater imaging performed at the determined stations were based on Catalog of Fishes online database and validation of the scientific names of the species was done following Fricke et al. (2019).

Table 1. Study area station details (StN: Station Number; StCoo: Station Coordinates; BoT: Bottom time; ImT: Imaging time; DMax: Maximum depth; DAver: Average depth; BoStr: Bottom Structure; UnV: Underwater Vision; WT: Water Temperature)

Time	StN	StCoo	BoT (min)	ImT (min)	DMax (m)	DAver (m)	BoStr	UnV (m)	WT (°C)
7.11.2015	45	35°20'43.35" N 33°28'35.99" E	77	74	15.6	13	Sandy-Posidonia	12-15	24
7.11.2015	51	35°21'23.54" N 33°30'23.24" E	67	64	12.6	8.8	Sandy-Posidonia	10-12	24
8.11.2015	41	35°20'35.33" N 33°23'9.54" E	62	58	16.1	11.9	Rocky	10-13	24
14.11.2015	47	35°21'15.57" N 33°29'23.21" E	57	54	17.4	13.1	Posidonia	15-18	23
15.11.2015	12	35°21'14.26" N 33°10'33.27" E	87	85	4.1	2.1	Rocky-Posidonia	15-18	18
28.11.2015	35	35°20'24.88" N 33°21'42.10" E	43	41	37	25.3	Sandy-Posidonia	18-20	22
28.11.2015	36	35°20'26.19" N 33°22'0.23" E	67	65	7.8	5.7	Rocky	15-20	22
12.12.2015	49	35°20'23.97" N 33°30'44.61" E	-	-	Surface	Surface	Rocky-Posidonia	-	16
19.12.2015	48	35°20'21.97" N 33°30'3.39" E	-	-	Surface	Surface	Rocky-Posidonia	-	18
20.12.2015	15	35°21'22.26" N 33°11'30.61" E	57	55	7.6	4.3	Rocky-Posidonia	4-5	18
26.12.2015	15	35°21'22.26" N 33°11'30.61" E	68	66	11.2	5.8	Rocky-Posidonia	7-8	17
13.02.2015	46	35°20'9.01" N 33°29'2.61" E	23	21	4.2	2.9	Rocky-Posidonia	-	18
10.01.2016	50	35°20'24.43" N 33°29'44.30" E	57	55	5.3	2.1	Sandy	8-10	17
28.02.2016	37	35°20'12.00" N 33°22'3.08" E	76	74	6.4	2.8	Sandy-Rocky	5-7	17
2.04.2016	36	35°20'26.19" N 33°22'0.23" E	57	53	12.2	10.7	Rocky-Posidonia	8-10	18
2.04.2016	37	35°20'20.47" N 33°22'9.48" E	67	64	12.3	10.5	Rocky-Posidonia	8-10	19
3.04.2016	38	35°20'20.47" N 33°22'9.48" E	63	59	15.2	12.7	Rocky-Posidonia	8-10	19
3.04.2016	39	35°20'37.62" N 33°22'35.85" E	45	42	16.9	13.2	Rocky-Posidonia	8-10	18
3.04.2016	40	35°20'44.30" N 33°22'54.93" E	42	39	17.4	13.1	Rocky-Posidonia	8-10	18
16.04.2016	24	35°21'46.28" N 33°12'58.00" E	57	51	27.8	18.7	Rocky	12–15	20
16.04.2016	24	35°21'46.28" N 33°12'58.00" E	56	50	30.2	17.2	Rocky	12-15	21
17.04.2016	22	35°21'44.00" N 33°12'50.93" E	48	42	25.8	18.6	Rocky	12-15	20
23.04.2016	22	35°21'44.00" N 33°12'50.93" E	58	52	27.7	18.9	Rocky	8-10	20
24.04.2016	23	35°21'42.50" N 33°12'58.36" E	52	46	29.3	18.9	Rocky	7-8	21
24.04.2016	14	35°21'22.69" N 33°11'6.06" E	84	82	5.2	3.2	Rocky	10-12	20
30.04.2016	24	35°21'46.28" N 33°12'58.00" E	51	45	27.3	18.2	Rocky	-	-
30.04.2016	15	35°21'22.26" N 33°11'30.61" E	55	53	6.5	3.9	Rocky	5-8	21
1.05.2016	23	35°21'42.50" N 33°12'58.36" E	38	32	29	20.5	Rocky	8-10	22
1.05.2016	23	35°21'42.50" N 33°12'58.36" E	78	76	6.5	3.2	Rocky	8-10	21
4.06.2016	16	35°21'55.76" N 33°12'2.43" E	57	51	22.1	16.1	Rocky–Sandy-Posidonia	8-10	25
4.06.2016	26	35°21'35.80" N 33°14'4.77" E	62	59	13.6	9.7	Rocky-Posidonia	8-10	25
18.06.2016	16	35°21'55.76" N 33°12'2.43" E	52	46	21.8	14.2	Rocky–Sandy-Posidonia	12-14	26
18.06.2016	25	35°21'5.31" N 33°13'57.17" E	63	59	18	11.8	Rocky–Sandy-Posidonia	12-14	27
19.06.2016	23	35°21'42.50" N 33°12'58.36" E	43	37	31.4	19.6	Rocky-Posidonia	8-10	26
16.07.2016	27	35°21'39.22" N 33°15'30.69" E	47	41	23	16.3	Rocky–Sandy-Posidonia	8-10	29
16.07.2016	28	35°21'37.31" N 33°16'14.66" E	46	43	18.7	14.4	Rocky–Sandy-Posidonia	8-10	30
17.07.2016	29	35°21'13.51" N 33°16'49.28" E	47	41	28.9	20.2	Rocky–Sandy-Posidonia	6-8	26

Table 1. continued

Time	StN	StCoo	BoT (min)	ImT (min)	DMax (m)	DAver (m)	BoStr	UnV (m)	WT (°C)
17.07.2016	17	35°21'42.26" N 33°12'9.31" E	64	62	13.4	5.7	Rocky–Sandy-Posidonia	6-8	30
30.07.2016	21	35°21'52.51" N 33°12'43.34" E	46	40	28.6	18.7	Rocky-Posidonia	10-12	30
30.07.2016	17	35°21'42.26" N 33°12'9.31" E	77	75	3.8	2.5	Rocky-Sandy	10-12	30
31.07.2016	20	35°21'57.98" N 33°12'30.29" E	43	37	34.2	19.4	Rocky–Sandy-Posidonia	6-8	30
31.07.2016	14	35°21'22.69" N 33°11'6.06" E	54	51	19.2	15.8	Rocky–Sandy–Posidonia	6-8	30
6.08.2016	30	35°21'54.67" N 33°17'32.12" E	42	36	29.2	19.8	Posidonia	8-10	30
6.08.2016	15	35°21'22.26" N 33°11'30.61" E	65	59	20.9	15.5	Sandy-Posidonia	10-12	31
20.08.2016	34	35°20'40.85" N 33°21'22.80" E	57	52	19.5	13.5	Rocky–Sandy-Posidonia	10-12	33
20.08.2016	33	35°20'36.73" N 33°20'46.05" E	46	54	18.9	12.5	Rocky–Sandy-Posidonia	10-12	31
21.08.2016	53	35°22'37.35" N 33°33'18.13" E	75	43	20.5	7.4	Rocky–Sandy-Posidonia	10-12	30
21.08.2016	54	35°22'32.80" N 33°34'16.13" E	67	69	9.7	3.9	Rocky–Sandy-Posidonia	10-12	30
22.08.2016	18	35°22'0.37" N 33°12'9.59" E	54	64	25.6	17.4	Rocky–Sandy-Posidonia	12-15	30
22.08.2016*	19	35°21'54.04" N 33°12'17.13" E	62	48	24.8	16.9	Rocky	Night diving	30
23.08.2016	52	35°22'6.64" N 33°32'20.98" E	46	56	22.6	16.8	Rocky–Sandy-Posidonia	12-15	30
23.08.2016	44	35°20'33.41" N 33°27'41.26" E	52	40	22.6	13.4	Sandy-Posidonia	12-15	30
24.08.2016	31	35°20'50.68" N 33°19'29.96" E	59	46	30.6	18.4	Sandy-Posidonia	8-10	31
24.08.2016	32	35°20'54.85" N 33°19'33.35" E	43	53	19.6	14.6	Rocky–Sandy-Posidonia	10-12	33
25.08.2016	17	35°21'42.26" N 33°12'9.31" E	54	40	21.3	15.8	Rocky–Sandy-Posidonia	12-15	30
4.09.2016	43	35°20'38.20" N 33°26'12.64" E	47	48	30.8	20.2	Posidonia	10-12	30
4.09.2016	42	35°20'40.31" N 33°24'44.70" E	59	41	24.4	15.2	Posidonia	8-10	29
17.09.2016	11	35°21'45.60" N 33°10'10.14" E	48	53	24.9	19.3	Posidonia	8-10	28
17.09.2016	10	35°21'48.22" N 33°10'9.11" E	62	42	9.6	6.8	Posidonia	8-10	29
18.09.2016	13	35°21'37.51" N 33°10'39.58" E	54	59	27.3	19.4	Rocky-Posidonia	10-12	28
18.09.2016	9	35°21'50.36" N 33°8'20.40" E	73	48	8.4	4.1	Rocky–Sandy-Posidonia	10-12	30
26.09.2016	1	35°24'26.33" N 32°55'12.69" E	43	71	32.3	17.7	Sandy-Posidonia	10-15	28
26.09.2016	2	35°24'19.98" N 32°55'25.72" E	68	37	13.7	6.4	Rocky–Sandy-Posidonia	12-15	26
26.09.2016	3	35°23'35.92" N 32°58'0.18" E	59	65	6.8	2.3	Rocky–Sandy-Posidonia	12-15	26
27.09.2016	8	35°22'15.48" N 33°4'25.20" E	46	57	24.3	17.3	Sandy-Posidonia	10-12	26
27.09.2016	7	35°22'32.80" N 33°2'0.50" E	62	40	9.1	4.9.	Rocky–Sandy-Posidonia	12-15	27
28.09.2016	4	35°22'36.46" N 33°0'0.70" E	48	60	31.6	21.1	Sandy-Posidonia	10-12	27
28.09.2016	6	35°22'12.60" N 33°0'49.24" E	49	42	8.1	5.9	Rocky–Sandy-Posidonia	12-15	27
28.09.2016	5	35°22'19.36" N 33°0'22.74" E	46	47	7.8	4.9	Rocky–Sandy-Posidonia	12-15	27
19.08.2016	14	35°21'22.69" N 33°11'6.06" E	58	44	24.4	17.1	Sandy-Posidonia	6-8	30
10.12.2016	54	35°22'32.80" N 33°34'16.13" E	52	48	24.6	15.4	Rocky–Sandy-Posidonia	10-12	30
11.12.2016	15	35°21'22.26" N 33°11'30.61" E	68	66	11.4	7.8	Rocky	5-8	21

Note: *Night dive

Results

A total of 72 fish species belonging to 26 families has been identified at the sampled 54 stations. *D. chrysonota* and *D. pastinaca* were the cartilaginous fish species observed during the study. In detail, 56 species were determined as native species and 23% (13 species) of them were non-native species. As a result of this study, the list of the species observed in the stations and the total number of individuals sighted are showed in detail (Table 2).

When considered the minimum and maximum observed species according to biotopes, *C. chromis* was the most observed species in all biotopes except for Posidonia and Sandy-Rocky bottom type. *S. mediterraneus* (15 individuals) and *B. boops* (616 individuals) were mostly observed on sandy-rocky and *Posidonia* biotopes, respectively. In addition, the species mostly displayed in term of diving hours for all biotopes was *C. chromis*.

The results revealed that, aside from the species observed only once or twice during the whole field studies, other species were encountered 56 and 53 times during the 72 dives performed in 54 stations. The observed individuals in the stations were evaluated with the total observed species, the species living in schooling form and distributed in large areas showed dominant character in the dominance analysis. The frequency of observation was determined to be low and at a lower percentage, as a result of the dominance analysis made on the species that do not live in schools as expected. The IFA and DA results of the observed species are given in detail in Table 3.

In our study 14 non-native species (*A. forskalii*, *S. rubrum*, *F. commersonii*, *P. miles*, *P. forsskali*, *U. pori*, *P. vanicolensis*, *P. trispilus*, *T. pavo*, *O. petersii*, *S. luridus*, *S. rivulatus*, *S. diaspros* and *T. flavimaculosus*) were also observed. Considering these species according to the biotopes, more species were observed in the biotopes with hard ground. The numbers of native/ non-native species relative to biotopes, together with their trophic level, are given in Figure 3. Trophic levels were calculated for each species according to Fishbase (Froese & Pauly, 2000). Non-native species preferred living quarters in highly Sandy-local *Posidonia* biotopes. It is observed that the non-native species show similar distribution characteristics in the biotopes other than rock-sand (Figure 3).

First Records

During the dives made on the island of Cyprus; two new species have been reported with their detailed information given below.

Between the hours of 12:00 - 13:00 on December 11, 2016 in coordinates (35°22'37.35" N, 33°33'18.13" E), *G. fallax* (Figure 4) was observed in the SCUBA dive performed at 30°C at an average depth of 20 m. On December 10, 2016 between the hours of 15:00 - 16:00; in coordinates (35°22'32.80 "N, 33°34'16.13" E) *D. chrysonota* (Figure 5) was observed in the SCUBA dive performed at 30°C at an average depth of 15 m.

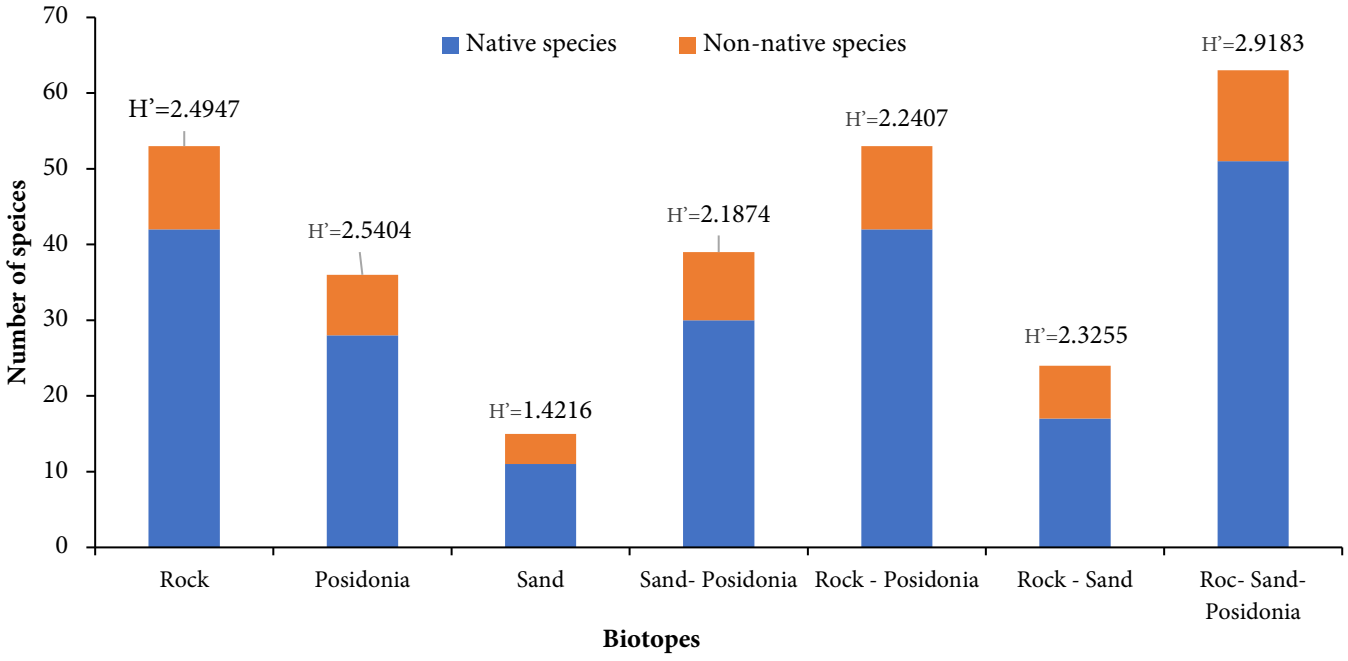

Figure 3. Number of native/lessepsian species according to biotopes with the Shannon diversity index value (H')

Table 2. The list of observed species in stations (TNIO: Total Number of Individuals Observed; DA: Dominance Analysis, NIS: Number of Imaging at the Station, IFA: Imaging Frequency Analysis, TL: Trophic Level, *: non-native species)

Species	Observed Stations	TNIO	DA%	NIS	IFA%	TL
Dasyatidae						
Dasyatis pastinaca	18,23	57	0.1	2	3.70	4.1
Dasyatis chrysonota	54	1	0.0	1	1.85	3,8
Muraenidae						
Gymnothorax unicolor	7,43,54	23	0.0	3	5.56	3.4
Muraena helena	10,20,44	74	0.2	3	5.56	4.2
Atherinidae						
*Atherinomorus forskalii**	9,11,12,14,15,17,18,23,25,30,35,45	3199	6.4	13	24.07	3.3
Holocentridae						
*Sargocentron rubrum**	2,7,10,16,19,21,22,23,24,27,29,30,32,33,36,38,39,41,43,54	1753	3.5	20	37.04	3.6
Fistulariidae						
*Fistularia commersonii**	2,15,16,19,23,33	169	0.3	6	11.11	4.3
Scorpaenidae						
**Pterois miles*	16,19,21	112	0.2	3	5.56	3.7
Scorpaena maderensis	2,7,21,54	171	0.3	4	7.41	4.1
Scorpaena scrofa	2,19,24,44	54	0.1	4	7.41	4.3
Serranidae						
Epinephelus aeneus	8,13,14,15,20,22,31,36,37,38	19	0.0	10	18.52	4.0
Epinephelus caninus	14,22,23,24,26	89	0.2	5	9.26	3.8
Epinephelus costae (Steindachner, 1878)	14,19,21,24,27,33,40,41,44,53	496	1.0	16	29.63	3.9
Epinephelus marginatus	4,5,8,10,14,16,17,20,27,31,33,41 ,54	441	0.9	19	35.19	4.4
Mycteroperca rubra	16,21,22,23,27	182	0.4	5	9.26	4.1
Serranus cabrilla	6,10,15,16,19,20,23,24,29,32,34,37,39,42,43,44,47,50,54	328	0.7	19	35.19	3.4
Serranus scriba	2,6,7,9,10,12,15,16,19,24,27,29,30,32,33,36,39,41,42,43,45,47,54	282	0.6	29	53.70	3.8
Apogonidae						
Apogon imberbis	3,5,8,9,10,14,15,17,19,22,23,27,31,32,33,38,39,41,43,44,53,54	468	1.0	22	40.74	3.4
Echeneidae						
Echeneis naucrates	23,36	8	0.0	2	3.70	3.7
Carangidae						
Caranx crysos	19,21,27,36,52	245	0.5	42	77.78	4.1
Pseudocaranx dentex	2,6,21,36,38	41	0.1	5	9.26	3.9
Trachinotus ovatus	2,6,7,22,23,24,36,43	36	0.1	6	11.11	3.7
Sparidae						
Boops boops	4,5,9,11,15,17,22,23,30,34,35,45 ,47,51	1580	3.2	14	25.93	2.8
Dentex dentex	22,23,30,42	28	0.1	4	7.41	4.5
Diplodus annularis	4,5,9,12,14,15,17,28,34,42,47,50	100	0.2	14	25.93	3.6
Diplodus puntazzo	1,8,14,15,22,23,52	32	0.1	7	12.96	3.2
Diplodus sargus	3,4,5,9,12,14,17,21,25,27,36,37,38 ,50	318	0.6	21	38.89	3.4
Diplodus vulgaris	1,3,4,5,8,10,14,15,16,17,20,22,23,24,26,32,33,36,37,39, 43,44,52	991	2.0	23	42.59	3.5
Lithognathus mormyrus	6,7,44	20	0.0	3	5.56	3.4
Oblada melanura	2,6,7,9,10,12,15,16,21,23,24,27,29,33,34,36,37,39,42,47,50,54	846	1.7	22	40.74	3.4
Pagellus bogaraveo	2,9,19,22,23,32,41	45	0.1	7	12.96	4.2
Sarpa salpa	2,6,7,9,10,12,23,44,50	395	0.8	9	16.67	2.0
Centracanthidae						
Spicara maena	7,9,10,15,16,22,23,24,29,41,42,47	841	1.7	12	22.22	4.2
Sciaenidae						
Spicara smaris	7,9,10,15,16,20,24,27,29,41,42,45 ,47	962	2.0	16	29.63	3.0
Sciaena umbra	15,21,22,35,44	90	0.3	5	9.26	3.8

Table 2. continued

Species	Observed Stations	TNIO	DA%	NIS	IFA%	TL
Mullidae						
Mullus barbatus	27,42,43	74	0.2	13	24.07	3.1
Mullus surmuletus	2,7,9,10,12,15,16,21,23,29,32,33 ,43	262	0.7	3	5.56	3.5
*Parupeneus forsskali**	2,6,10,21,33	72	0.1	5	9.26	3.5
*Upeneus pori**	10,15,23,27,44	169	0.3	5	9.26	3.5
Pempheridae						
*Pempheris vanicolensis**	2,9,15,44,50,54	445	0.9	6	11.11	3.5
Pomacentridae						
Chromis chromis	4,5,6,8,11,13,19,21,28,30,33,35,45 ,47,50,51,53	17703	37.7	43	79.63	3.8
Mugilidae						
Mugil cephalus	12,22,32	97	0.2	3	5.56	2.5
Labridae						
Coris julis	1,3,4,5,7,19,22,24,30,32,45,47,51 ,53 ,54	1293	2.6	5	9.26	3.4
Labrus mixtus	6,16,22,23,24	73	0.1	3	5.56	3.9
Labrus viridis	16,24,29	110	0.2	5	9.26	3.9
*Pteragogus trispilus**	15,23,29,30,34,36,45,47	11	0.0	8	14.81	3.4
Symphodus doderleini	6,7,10,12,15,19,23,24,32,35,36,38 ,47,50	127	0.3	14	25.93	3.4
Symphodus mediterraneus	2,5,6,7,9,10,15,16,19,21,24,27,29,32,33,36,39,41,43,45,47	621	1.3	25	46.30	3.2
Symphodus ocellatus	2,6,10,15,16,23,24,32,33,36,42,44 ,45,54	140	0.3	14	25.93	3.5
Symphodus roissali	7,12,19,21,23,24	202	0.4	6	11.11	3.5
Symphodus rostratus	2,6,9,12,15,16,23,24,36,41,42,47	60	0.1	12	22.22	3.5
Symphodus tinca	2,6,7,12,15,16,21,23,24,29,30,32,33,36,39,54	294	0.6	16	29.63	3.3
*Thalassoma pavo**	2,5,6,7,9,10,12,15,16,19,24,27,29,32,33,35,39,41,43,47,50	1684	3.4	28	51.85	3.5
Xyrichtys novacula	2,9,44,54	135	0.3	4	7.41	3.5
Scaridae						
Sparisoma cretense	2,6,7,9,10,12,14,15,16,19,24,27,29,30,32,33,36,39,42,43,44,50,54	2130	4.3	29	53.70	2.9
Tripterygiidae						
Tripterygion delaisi	22,23,24,36,43	104	0.2	5	9.26	3.4
Tripterygion melanurus	2,7,9,29,54	89	0.2	5	9.26	3.5
Tripterygion tripteronotus	6,10,16,20,33,43,50	93	0.2	7	12.96	3.4
Blenniidae						
Parablennius gattorugine	12,15,33	18	0.0	3	5.56	3.6
Parablennius rouxi	16,33	22	0.0	2	3.70	3.0
Gobiidae						
Gobius bucchichi	2,6,10,16,22,24,32,43,44,47,50,54	153	0.3	12	22.22	3.1
Gobius fallax	15	3	0.0	1	1.85	3.3
Gobius geniporus	2,7,9,10,15,21,22,24,33,36,37,38 ,47 ,50,54	212	0.4	15	27.78	3.3
Gobius paganellus	24	15	0.0	1	1.85	3.3
Gobius xanthocephalus	54	2	0.0	1	1.85	3.2
Gobius vittatus	33	2	0.0	1	1.85	2.9
*Oxyurichthys petersii**	6,24,32,44	39	0.1	4	7.41	3.7
Siganidae						
*Siganus luridus**	2,6,7,10,12,15,16,19,24,32,33,36 ,42 ,50,54	1913	3.8	19	35.19	2.0
*Siganus rivulatus**	2,6,7,9,10,12,15,16,19,24,27,32,33 ,36,39,42,43,44,50,54	6032	12.1	26	48.15	2.0
Balistidae						
Balistes capriscus	16,22,52	117	0.2	3	5.56	4.1
Monacanthidae						
*Stephanolepis diaspros**	19,21,22,27	231	0.5	4	7.41	2.8
Tetraodontidae						
*Torquigener flavimaculosus**	10,15,27,43,44	93	0.2	7	12.96	3.3

Figure 4. First record of *Gobius fallax* Sarato, 1889 in Cyprus

Figure 5. First record of *Dasyatis chrysonota* (Smith, 1828) in Cyprus

Discussion

In the study, UO method was performed in order to determine the fish species distributed from 0 to 2 miles, in the northern part of Cyprus Island. The UO method has advantages and disadvantages over other sampling methods. The method can provide detailed information about the biotope diversity of the studied region and these biotopes. Unlike the other methods (trawl, resistance and other fishing tools), the UO method allows us to make samples without giving any harm to the area. One more advantage is that hard substrata is difficult to sample by trawling or nets, and easier by UO. The UO method also allows us to have detailed information about the behaviours of the studied animals/organisms inhabiting the study area; it may be asserted that these are the most advantageous characteristics of the used method when compared to other methodologies. Considering the disadvantages of the UO method, it may be described as the limitation in the study area and working depth when compared to other sampling methods. The area and depth scanned with trawl and similar catching vehicles is incomparably large. In the studies carried out with such tools it is possible to perform sampling in much larger areas in a shorter period of time. Field surveys carried out by UO method may not be performed for various reasons (unsuitable weather conditions, sampling depth, etc.). Although the ratio of the imaging of species living in the coastal zone is high with the UO method, it remains insufficient in the detection of cryptic species. The UO method allows the identification of morphologically similar species at the genus level since the method is under the control of the individual performing the sample. Despite the disadvantages of the UO method, it is the one mostly used on biological inventory studies in the Mediterranean (Harmelin, 1987; Garcia & Zabala, 1990; Harmelin et al., 1995; Marconato et al., 1996; Borg et al., 1997; Fasola et al., 1997; Charton & Ruzafa, 1998; Mazzoldi & Girolamo, 1998; Vacchi & La Mesa, 1999; Condal et al., 2012). The UO method used in our study was applied to heterogeneous substrata. These substrata were categorized as Sandy-local *Posidonia,* Sandy, Sandy - Rocky, Rocky-*Posidonia*, Rocky, *Posidonia,* Rocky – Sandy -*Posidonia* and Sandy - *Posidonia*. O. petersii was reported frequently between 1982 and 2021 in the eastern Mediterranean region (Langeneck et al., 2022). In our study, in April, August and September 2016; it was recorded in 5 different dives in 4 different regions during dives between 6 - 30 m. D. pastinaca was observed multiple times from the coastal waters of Cyprus between 2015 and 2019 (Giovos et al., 2021). In our study, in April, May, June and August 2016; it was recorded 5 times during dives between 3 - 32 m in April, May, June and August. considering Mediterranean records of P. forsskali, it was recorded 5 times from 2014 to 2018 in South Cyprus and North West region of Cyprus Island (Evagelopoulos et al., 2020). In our study, in July, August and September 2016; it was recorded during dives between 6 - 19 m in 5 different regions. Çiçek (2006) determined a total of 83 fish species 37 different biotope types using the same method. the study was performed with, 400 SCUBA dives and snorkelling, at 31 stations along 70 km of coastline. Field research was conducted between July 2002 and July 2005. In addition, seven lessepsian fish migrant are reported in this study (*A. nigripinnis, F. commersonii, S.rubrum, S. luridus, S. rivulatus, S. diaspros* and *P. vanicolensis*). We observed all of these non-native fish species in our study except for *A. nigripinnis*. In order to determine the diversity of fish in the same region, Benli et al. (1999) identified a total of 82 fish species by using bottom trawl between 20 and 600 m depth. Also, a survey continuation of this study conducted by Benli et al. (2003) documented the occurrence of 84 fish species between 25-840 m depth. Torcu et al. (2001) conducted a study between the years 1995 and 1996. They determined a total of 49 fish species belonging to two classes and 32 families. *P. vanicolensis* which is a lessepsian immigrant is a new record for Northern Cyprus. Sampling in trawl studies

can be carried out down to a depth of 840 m even though the field studies carried out with UO method are limited to 42 m so, when compared to the other studies, there are significant differences in depths. Although this the results are parallel to each other. The limited scientific activities on the coasts of the island of Cyprus, impose restrictions on the comparison of our available data. Benli et al. (1999, 2003) studies may be shown as a milestone of the scientific activities carried out in the Cyprus Island. Due to the prohibition of trawling and seine-haul fishing in the territorial waters of Northern Cyprus, the identification of alien species entering the region remains insufficient. Levant Basin, in which Cyprus Island is located, is considered as a species poor region due to its oligotrophy, high salinity and high sea water temperature. The deepening and widening studies carried out in the Suez Canal and the increasing shipping have gradually been increasing the number of alien species entering the Mediterranean (Galil et al., 2015). For these reasons, it is necessary to keep the current biodiversity inventory up to date the biodiversity inventory of systematic taxa performed in the region. Consequently, it would be more accurate to carry out these monitoring by using different methods in simultaneous to determine the biological diversity of the marine ecosystems.

Conclusion

In conclusion, due to the aforementioned reasons, it is necessary to keep the current biodiversity inventory date the biodiversity inventory of systematic taxa performed in the region. However, it would be more accurate to carry out these monitoring by using different methods simultaneously to determine the biological diversity of the marine ecosystems considering each fish species has a different distribution area and characteristic.

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Compliance With Ethical Standards

Authors' Contributions

FY, AT: Designed the study.
FY: Wrote the first draft of the manuscript.
FY: Carried out the proposal studies of the study.
AT: Directed the thesis in which the study was carried out.
FY, AT: Performed and managed statistical analyses.
Both authors read and approved the final manuscript.

Conflict of Interest

The authors declare that they have no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

Data Availability Statements

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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SHORT COMMUNICATION

A new maximum size record of striped red mullet *Mullus surmuletus* Linnaeus, 1758 from the coast off Benghazi, Libya (Southern Mediterranean)

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ABSTRACT

A specimen of *Mullus surmuletus* with 33.6 cm in total length and 398.3 g in total weight was captured with trammel nets along with other Striped red mullet fish by fisherman off the coast of Benghazi, Libya (Southern Mediterranean) on November 14, 2022. It had the longest length and heaviest weight ever recorded for a Striped red mullet in the Southern Mediterranean off the coast of Libya.

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Introduction

Libya is regarded as one of the least explored regions of the Mediterranean (Coll et al., 2010; Elbaraasi et al., 2019); its ichthyofauna is poorly known (Quignard & Tomasini, 2000; Elbaraasi et al., 2022); and information on length and weight studies on fish is very limited and scarcely done. Striped red mullet *Mullus surmuletus* (Linnaeus, 1758) is a commercially important Mullidae species. The species is found Northern part of West Africa from Gibraltar to Dakar. Along the coast of Western Europe up to the English Channel; also, in the Mediterranean and Black Seas. (Froese & Pauly, 2023). It can grow up to 40 cm tall and live for up to ten years but the common size range from 10 – 25 cm. It occurs on rough grounds but also found over sand and soft bottoms at depths less than 100 m, usually from 5-60 m. Feeds predominantly on small bottom-living invertebrates such as crustaceans, worms, mollusks (Froese & Pauly, 2023).

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The body *M. surmuletus* is slightly compressed. A pair of barbels under the chin that are longer than the pectoral fins; an opercle without a spine; a less steep snout; small villiform teeth in the lower jaw; the upper jaw is toothless (see remarks); teeth on the roof of the mouth (vomer and palatines). The first minute has 7-8 spines on the dorsal fin; the second minute has I + 8 soft rays and 33-37 scales on the lateral line. Color is reddish, with a darker red longitudinal stripe from the eye to the caudal fin and three yellow-brown lines on the lower sides; first dorsal fin has dark markings (Ben-Tuvia, 1990; Froese & Pauly, 2023).

Length and weights of fishes are very important tool for fisheries science. Furthermore, biologists and ecologists need precise estimates of the maximum size of fish in a population because biological rates and ecological functions are size-dependent (Peters, 1983; Cengiz, 2020). For instance, the relationship between metabolic rate and body size is inverse, whereas the relationship between total food intake and body size is positive. The maximum size of a fish is proportional to its size at hatch, its size at sexual maturity, its maturity, and its longevity (Freedman & Noakes, 2002; van der Veer et al., 2003; Cengiz, 2020). Many fishery models, such as the von Bertlanffy and Gompertz growth models, rely heavily on maximum length or weight (Cengiz et al., 2019). The maximum length and weight of *M. surmuletus* for the coast off Benghazi, Libya, in the southern Mediterranean is presented in this study.

Material and Methods

A single specimen of *M. surmuletus* along with other fish of Striped red mullets was caught with trammel nets by a fisherman on November 14, 2022, off the coast of Benghazi, Libya (Figure 1). Immediately after capture, the fish were kept in ice and transferred to the Aquaculture and Fisheries Laboratory of the Department of Zoology, Faculty of Science, University of Benghazi (Libya). Upon arrival to the lab, fish was photographed, sexed, aged based on growth lines on scales of fish, and some of morphometric and meristic analyses were performed. As a result, the specimen was measured to the nearest cm and weighed to the nearest 0.1 g (see Table 1).

Results and Discussion

A single specimen of *M. surmuletus* with a total length of 33.6 cm and a weight of 398.3 g (Figure 2) was obtained off the coast of Benghazi, Libya. Table 1 also contains some of the specimen's morphometric and meristic data. According to the number of growth lines on the scales, the specimen was female and eight years old. *M. surmuletus* can grow to be 40 cm long and live for up to ten years, but the typical size range is 10 to 25 cm (Froese & Pauly, 2023). However, if a fish population in any ecosystem is overfished, its size will gradually decrease (Cengiz, 2020).

Table 1. Morphometric and meristic data of the large size *Mullus surmuletus* caught off coast of Benghazi (Libya).

Parameters	Value (cm)
Morphometric Measurements	
Total length	33.60
Forked length	28.00
Standard length	25.50
Head length	7.00
Predorsal length	9.60
Preanal length	17.90
Eye diameter	1.60
Length of first dorsal fin base	3.60
Length of second dorsal fin base	4.00
Length of pelvic fin	2.50
Length of pectoral fin	5.70
Weight (gr)	398.3
Meristic Counts	
First dorsal fin	8 spines
Second dorsal fin	I + 8 rays
Scales in lateral line	37

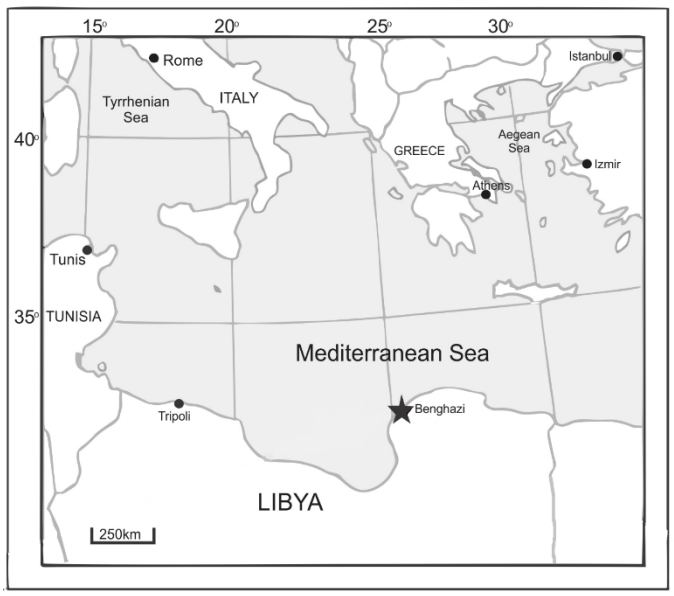

Figure 1. Map showing where the specimen of *Mullus surmuletus* was collected off coast of Benghazi (Libya).

Table 2. The maximum lengths for *Mullus surmuletus* recorded in different areas (TL, Total Length; FL, Fork Length).

Area	References	Length (cm)	Length Type
Aegean Sea, Greece	Papaconstantinou et al. (1993)	24.40	FL
Evvoikos, Greece	Petrakis & Stergiou (1995)	20.10	TL
Majorca Islands (N.W.Med.)	Reňones et al. (1995)	32.00	TL
East Adriatic, Croatia	Dulčić & Kraljević (1996)	30.90	TL
Balear Islands, Spain	Merella et al. (1997)	16.70	TL
Canary Islands	Pajuelo et al. (1997)	33.00	TL
Eastern Mediterranean	Labropoulou et al. (1997)	23.00	TL
Alexandria coasts, Egypt	Abdallah (2002)	20.80	TL
Aegean Sea	Moutopoulos & Stergiou (2002)	32.00	TL
Spain (East coasts)	Valle et al. (2003)	25.40	SL
Babadilli Bay (Mediterranean)	Cicek et al. (2006)	22.20	TL
East Adriatic, Croatia	Dulčić & Glamuzina (2006)	28.50	TL
Aegean Sea (North)	Karakulak et al. (2006)	29.90	TL
Izmir Bay	Ozaydın & Taskavak (2007)	21.90	FL
Izmir Bay	Ilhan et al. (2009)	22.60	TL
Benghazi, Libya	This study	33.60	TL

Consequently, individuals that are not subject to overfishing may attain this length. Growth may be affected by nutrient availability, feeding, light regime, oxygen, salinity, temperature, pollutants, current velocity, nutrient concentration, predator density, intra-specific social interactions, and genetics. (Helfman et al., 2009; Acarli et al., 2018). As a result of these findings, it is reasonable to conclude that regional differences in maximum length and weight are influenced by ecological factors and overfishing pressure (Cengiz et al., 2019).

Figure 2. Striped red mullet *Mullus surmuletus* (TL: 33.6 cm, W: 398.3 g) caught on 14 November 2022 off coast of Benghazi (Libya).

Furthermore, the maximum length of the species was previously reported as 33.00 cm (TL) in the Canary Islands (Pajuelo et al., 1997). Nevertheless, several maximum length reports have also been documented for different locations by several authors (Table 2). For instance, Dulčić & Kraljević (1996) noted that the maximum total length was 30.9 cm (TL) in the East Adriatic coast of Croatia. Moutopoulos & Stergiou (2002) documented that the maximum total length was 32.0 cm for the Aegean Sea. Abdallah (2002) reported the maximum total length as 20.80 cm in the Alexandria coasts, Egypt. Ozaydın & Taskavak (2007) found the maximum fork length as 21.90 cm for Izmir Bay, Turkey. The present paper, however, reports the maximum length not only for the Libyan coast of Benghazi but also for the south Mediterranean Sea.

In fish life history research and fisheries science, maximum length and weight are crucial parameters. These measurements are necessary for population dynamics and stock assessment studies. Consequently, recording such data may be advantageous for scientific databases pertaining to the study of life histories and fisheries. This discovery will be crucial for the management of fisheries.

Conclusion

This paper reported a new size record of striped red mullet *Mullus surmuletus* along the Libyan coast of Benghazi, southern Mediterranean. This finding expends the knowledge of the biology and ecology of this species. Furthermore, this finding will help fisheries scientists for future studies on its populations and may also help to enforce regulations on commercial fisheries concerning landing size restrictions.

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Compliance With Ethical Standards

Authors' Contributions

MS: Collected the data, Wrote the first draft of the manuscript.
HJ: Collected the data.
HE: Designed the study, wrote the manuscript, Performed and managed.
All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

Data Availability Statements

All data generated or analysed during this study are included in this published article.

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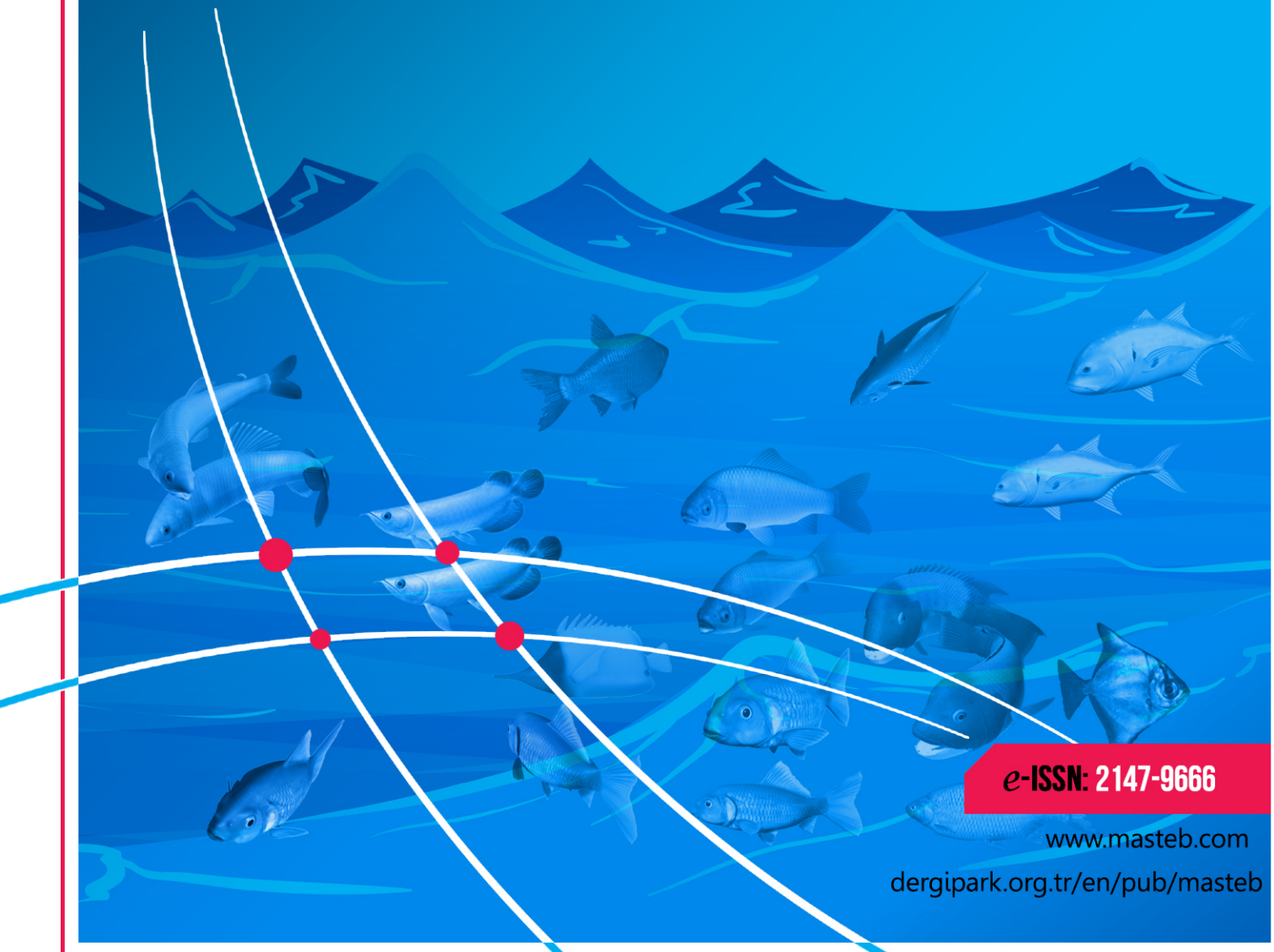

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