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Bibliometric and Qualitative Analysis of Workload Studies in the Maritime Sector

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ABSTRACT

Maritime traffic is a socio-technical system that requires the collaboration of many elements such as stakeholders, equipment, environment, and technology. The workload for stakeholders in marine traffic has increased due to the growing number of monitored ships in coastal areas, as well as the variety and amount of operations. This study aims to conduct a comprehensive analysis of workload studies conducted in the maritime domain, encompassing all stakeholders. In doing so, the goal is to reveal changes over the years, identify collaborative areas, and enhance the understanding of the concept. The Scopus and Web of Science (WoS) databases were used as the data collection tool. A search was conducted with keywords associated with the concept of 'workload in maritime,' leading to the analysis of 372 relevant documents. VOSviewer Bibliometric Data Analysis Tool and MAXQDA Analytics Pro 22 Software were employed in the analyses. After the data from the two databases were combined, it was found that the authors with the most publications (P) and citations (C) in this field are Murai K. (P-41; C-200), Hayashi Y. (P-30; C-196), and Okazaki T. (P-15; C-82). With 56 publications, Japan is in first place, followed by the US (39), China (35), and the UK (27). Additionally, Japan and the US are two countries in collaboration. Among the commonly used terms in this research are mental workload, vessel, safety, performance, human factors, tiredness, simulator, and physiological measuring techniques including heart rate, nasal temperature, Electroencephalography (EEG), and salivary amylase. In workload studies, psychosocial variables were most prominently expressed in 2021. While the analysis of workload studies indicates a focus on “mental workload” studies involving Vessel Traffic Services Operators (VTSOs), research related to seafarers, cadets, marine pilots, and ship masters is seen to dominate this field which is “bridge team”.

Keywords: Maritime, workload, bibliometric analysis, VOSviewer, MAXQDA

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Denizcilik Sektöründeki İş Yükü Çalışmalarının Bibliyometrik ve Nitel Analizi

ÖZ

Deniz trafiği, paydaşlar, ekipman, çevre ve teknoloji gibi birçok unsurların birlikte çalışmasını gerektiren sosyo-teknik bir sistemdir. Kıyı bölgelerinde izlenen gemi sayısının artması, operasyonların çeşitliliği ve miktarı nedeniyle deniz trafiğindeki paydaşların iş yükü de artmıştır. Bu çalışma, denizcilik alanında yürütülen iş yükü çalışmalarının tüm paydaşları kapsayacak şekilde kapsamlı bir analizini yapmayı amaçlamaktadır. Veri toplama aracı olarak Scopus ve Web of Science (WoS) veri tabanları kullanılmıştır. 'Denizcilikte iş yükü' kavramıyla ilişkilendirilmiş anahtar kelimelerle yapılan arama sonucunda 372 akademik yayın elde edilmiştir. Analizlerde VOSviewer Bibliyometrik Veri Analizi Aracı ve MAXQDA Analytics Pro 22 Yazılımı kullanılarak bibliyometrik ve nitel veri analizi yapılmıştır. Buna göre, belirtilen alanda en çok yayın (Y) yapan ve atıf (A) alan yazarların Murai K. (Y-41; A-200), Hayashi Y. (Y-30; A-196) ve Okazaki T. (Y-15; A-82) olduğu görülmüştür. 56 yayınla Japonya birinci sırada, onu sırasıyla ABD (39), Çin (35) ve İngiltere (27) izlemektedir. Ayrıca, Japonya ve ABD bu araştırma alanında iş birliği yapan iki ülkedir. Yaygın olarak kullanılan terimler arasında mental iş yükü, gemi, emniyet, performans, insan faktörü, yorgunluk, simülatör ve kalp hızı, nazal sıcaklık, elektroensefalografi (EEG) ve tükürük amilazı gibi fizyolojik ölçüm teknikleri bulunmaktadır. Psikososyal değişkenlerin en fazla 2021 yılında çalışıldığı görülmektedir. İş yükü çalışmalarında, deniz trafik operatörlerinin "zihinsel iş yükü" çalışmaları olsa da bu alanda gemi insanları, stajyerler, kılavuz kaptanlar ve gemi kaptanları gibi "köprüüstü ekibi" ile ilgili araştırmaların baskın olduğunu görülmektedir.

Anahtar Kelimeler: Denizcilik, iş yükü, bibliyometrik analiz, VOSviewer, MAXQDA

1 Introduction

Workload is generally defined as the ratio of task load and demands in the workplace to the available resources (Altay, 2018). It can be a combination of physical, mental, environmental, positional, and administrative factors. Transportation, distance, etc. constitute the elements of physical workload; calculations, decision-making, communication, memory, and research are the mental factors; temperature, lighting, noise, and vibration are environmental factors; the posture of the back, arms, legs, and head represents positional factors, while organizational factors form administrative workload (Dağdeviren et al., 2005; Özçelik, 2011). However, it can have different classifications based on the specific areas of work. For example, for a teacher, insufficient preparation time, administrative paperwork, school meetings, and lesson plans can contribute to workload factors (Sugen, 2010). On the other hand, for academics, workload components may include time pressure, demands for academic performance, and family factors (Öztürk, 2019).

Workload studies are carried out across various sectors involving human presence, including engineering (Ildız, 2019; Özçelik, 2011; Dağdeviren et al., 2005), education (Sugden, 2010; Öztürk, 2019; Houston, 2006), logistics (Brüggen, 2015), tourism (Atik, 2015), health (Carayon, 2005; Young, 2008), and transportation domains such as air, railway, and maritime (Murai, 2004; Fan and Smith, 2017; Edwards et al., 2017). Numerous variables, including situational awareness (Edwards et al., 2017), job satisfaction (Houston, 2006), performance and well-being (Sugden, 2010; Brüggen, 2015; Bowling et al., 2015; Fan and Smith, 2017), and turnover intention (Araslar, 2021), have all been linked to workload. The data indicates that workload has a negative impact on both physical and psychological well-being (Bowling et al., 2015) and is a strong predictor of occupational stress (MacDonald, 2003).

Furthermore, the literature acknowledges that stress and workload are contributing factors to human errors (human performance) (Lee, 2010; Brookhuis et al., 2010; Fan and Smith, 2017; Tao 2019).

In the maritime industry, it has been found that the human factor accounts for 89.5% of accidents (EMSA, 2022). Therefore, it is true that addressing the human factor is essential to maintaining maritime and navigational safety (IMO, 2023). In the context of maritime studies, it is evident that workload is linked to variables such as stress (Kari et al., 2022), excessive fatigue (Andrei et al., 2020; Remmen et al., 2017; Bal et al., 2015), burnout (Wan et al., 2023), time pressure (Cui et al., 2021), situational awareness (Okazaki et al., 2016), and performance (Barsan et al., 2007; Schuffel et al., 1989; Bal et al., 2015). Similar to various other disciplines such as psychology, business and management, environmental science, medicine, etc. bibliometric studies are undertaken in maritime studies to understand research trends, identification of impactful publications and authors, and analysis of relationships within the field (Başhan, 2022; Podsakoff et al., 2008; Başhan and Çetinkaya, 2022; Tran et al., 2019). For instance, bibliometric studies in the field of maritime research have explored topics such as maritime accidents (Gil et al., 2020; Demirci and Elçiçek, 2023; Cao et al., 2023), autonomous ships (Chaal et al., 2023; Li et al., 2023), seafarer's health and stress (Sharma, 2021; Jiang et al., 2023), port and maritime transport (Chen et al., 2018; Munim and Saeed, 2019) and maritime cybersecurity (Bolbot et al., 2022; Yu et al., 2023). However, there appears to be a lack of bibliometric studies specifically focusing on the concept of workload in the maritime domain.

This study aims to look into how the idea of workload on humans is discussed in the literature in the marine industry, where the human factor holds a significant role. To gain a broader perspective on the studies in this field, bibliometric relationships were analyzed using the VOSviewer program, and textual relationships were conducted using the MAXQDA program. With this study, the goal is to fill the void in the literature by conducting a comprehensive examination of the concept of workload in the maritime sector, encompassing all its stakeholders.

2 Research Methodology

In this study, the Scopus and Web of Science (WoS) databases were used as data collection tools. Searches were conducted using the following keywords to obtain workload studies on all maritime stakeholders:

> *TITLE-ABS-KEY (workload AND (seafarer OR master OR captain OR maritime OR vessel OR ship OR marine* OR bridge OR "vessel traffic" OR VTS OR pilotage OR pilot OR "tug boat" OR "tugboat" OR "helmsman" OR "fisherm*" OR fishery OR fisheries OR "ferry captain")*

It was noticed that the keywords were leading us away from the concept of workload in maritime. This is because the words 'master' and 'pilot' evoke expressions related to both education and aviation industries. Additionally, the word 'vessel' and “port” frequently appears in nursing and computer studies respectively. Therefore, the keywords were finalized by adding some new terms using the AND NOT command, as shown below.

> *TITLE-ABS-KEY (workload AND (seafarer OR master OR captain OR maritime OR vessel OR ship OR marine* OR bridge OR "vessel traffic" OR VTS OR pilotage OR pilot OR "tug boat" OR "tugboat" OR "helmsman" OR "fisherm*" OR fishery OR fisheries OR "ferry captain") AND NOT (aviation OR air* OR aerial OR comput* OR flight OR "pilot stud*" OR "pilot test*" OR nurs* OR education OR "master's degree" OR slave OR "pilot trial" OR "blood vessel" OR patient OR hospital OR "master surgery" OR "pilot project"))*

Additionally, due to the presence of still unrelated publications, irrelevant papers were manually excluded by reading their abstracts from the sample of the study. The study includes all articles, conference papers, reviews, and other publications having English abstracts. As a result, Figure 1 shows data acquisition, the initial stage of the investigation for the search results carried out on 22 April 2023 for Scopus and 25 April 2023 for WoS.

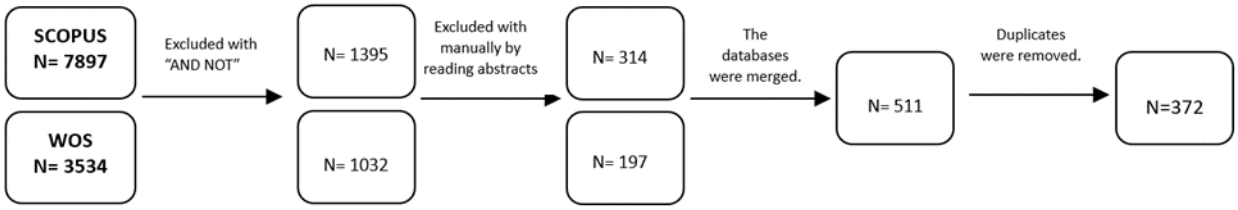

Figure 1: Data Acquisition Steps

After providing descriptive statistics for the merged dataset, it was transferred to VOSviewer for bibliometric analysis and to MAXQDA Qualitative Data Analysis programs for word frequency and relational analysis. VOSviewer is a program designed to facilitate the visualization and analysis of bibliometric maps. It can be utilized to create maps of authors, journals, keywords, and citation networks (van Eck and Waltman, 2010). MAXQDA as the software for both qualitative and quantitative methods allows lots of analysis options such as frequency tables, word coding, crosstables, word combinations, and mapping (MAXQDA, 2023). The analyses conducted with these programs are illustrated as shown in Figure 2.

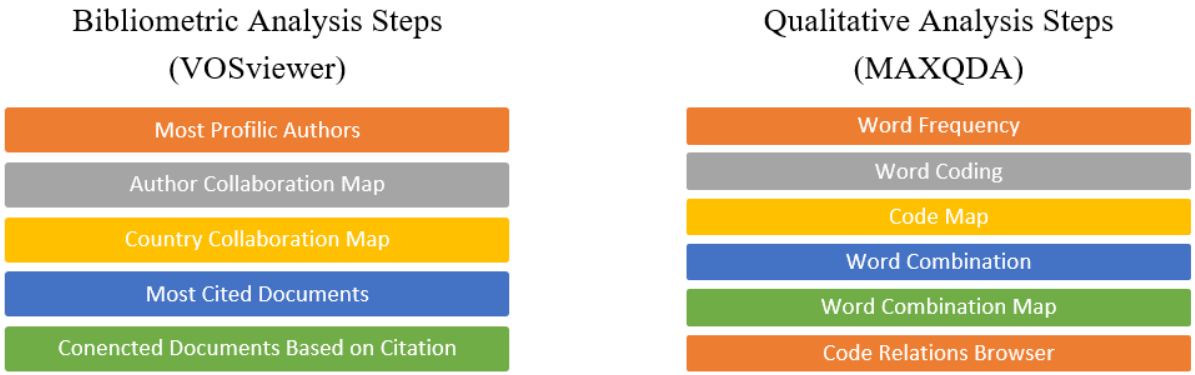

Figure 2: Analysis Steps of the Study

3 Results and Discussion

The first study was carried out in 1973, according to the pattern of investigations by year shown in Figure 3. In the last ten years, over half of the studies conducted during the previous fifty years have been completed. Six workload studies in the maritime industry have been carried out as of the first quarter of 2023.

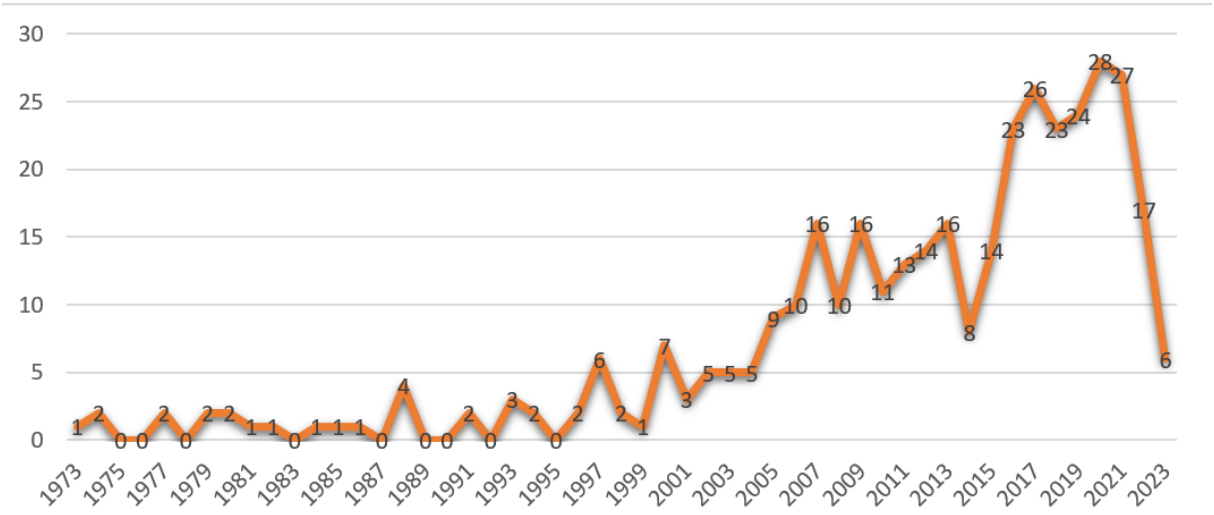

Figure 3: Number of Documents per Year

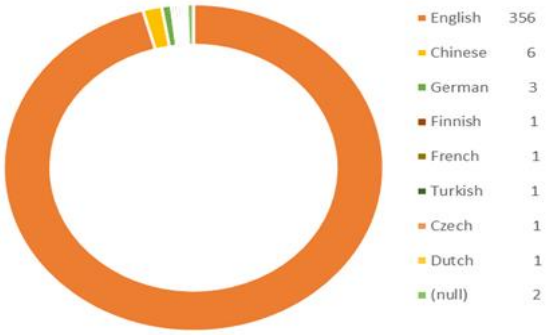

Figure 4: Language of Documents

Figure 5: Type of Documents

When Figures 4 and 5 are analyzed, it is observed that out of the publications obtained, 356 of them are in English, while 6 are in Chinese and 3 are in German. Furthermore, among the documents, 198 are articles, while 155 are conference papers.

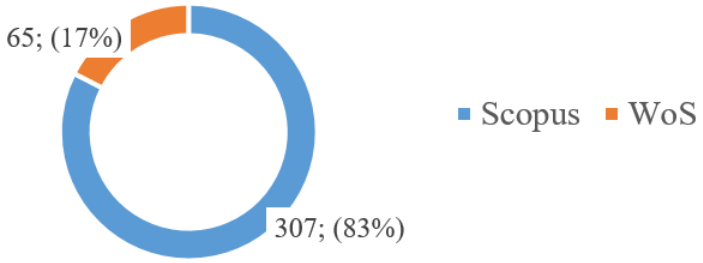

Figure 6: Type of Sources

3.1 VOSviewer Analysis

The VOSviewer tool was used to analyze the data set in the second step of the study for bibliometric analysis. This leads to the observation that 861 distinct authors are included in the studies. With 41 articles, Murai K. is the most prolific author in this discipline, as seen in Figure 7. Hayashi Y. (30), Okazaki T. (15), Kitamura K. (14), Mitomo N. (11), Hikida K. (10), Wakida S. (10), Fuhushi K. (9), Yoshimura K. (9), Miyado T. (7), Stone L. C. (6), Liu Y. (6), and Wang J. (5) are the players who come

behind him. Figure 7 also displays the years during which authors conducted their research. Accordingly, it is evident that Murai K. and Okazaki T. have a predominant concentration of work in the early 2010s, contributing to their highest number of publications.

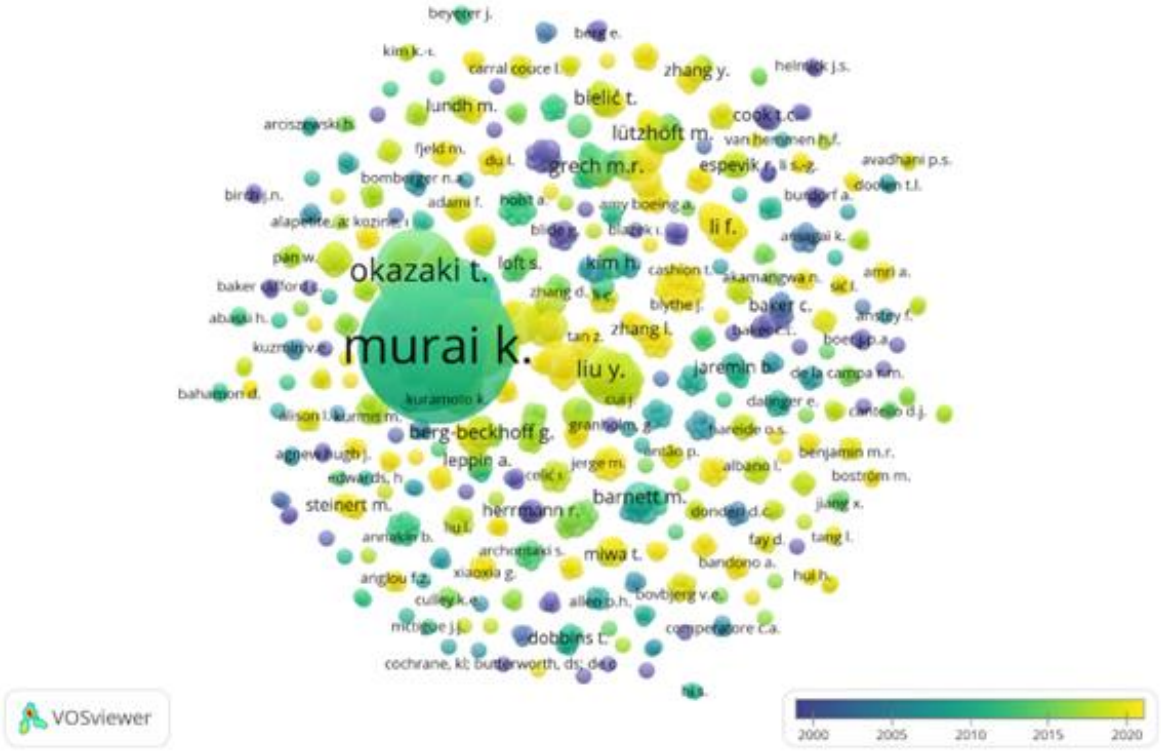

Figure 7: Authors of Documents by Years

Collaborative author groups with at least five publications are shown in Figure 8(a) and Figure 8(b). It is evident that authors who publish frequently also establish cooperative author organizations. We may infer from Figure 8(b) that authors Wang and Nishizaki had more publications after 2018, but authors Hayashi, Murai, and Okazaki had more publications between 2010 and 2016.

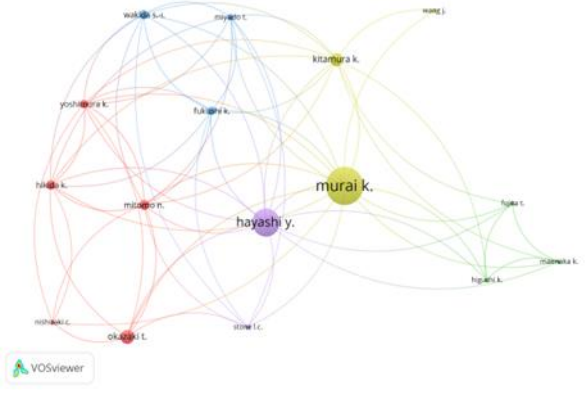

Figure 8(a): Author Collaboration Map

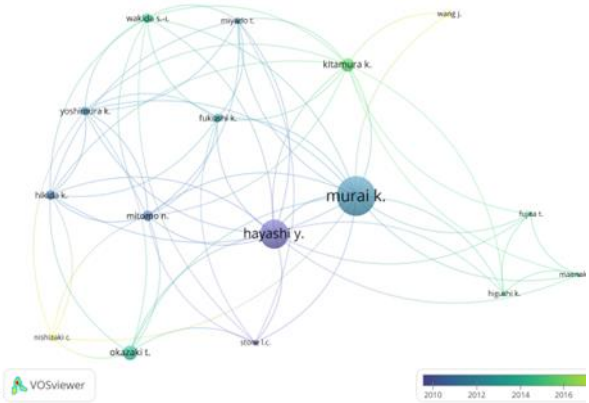

Figure 8(b): Author Collaboration Map by Years

Looking at the affiliations of the authors, Japan comes in first place with 56 publications, followed by the US (39), China (35), UK (27), Norway (20), Australia (16), Sweden (13), the Netherlands (11), Germany (11), Singapore (11), Canada (10), Denmark (10), and Croatia (10). Moreover, Figure 9(a) clearly shows that authors from "Japan and the US", "the UK, South Korea, Turkey", "Australia, Canada, and Singapore," and "China, Denmark, Croatia, Spain, and Finland" have collaborations. As for Figure 9(b), we can state that collaborations, particularly from 2018 onwards, are more prominently led by China, Singapore, and Turkey.

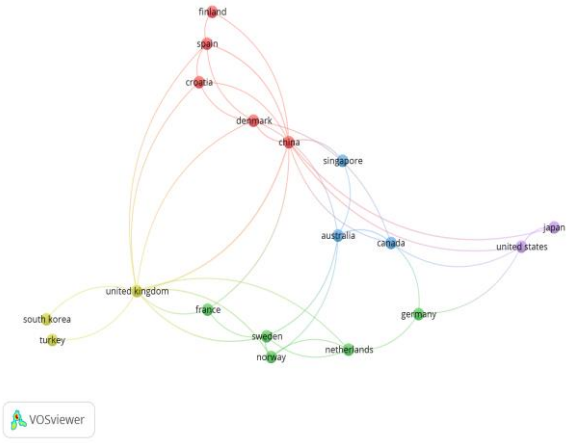

Figure 9(a): Country Collaboration Map

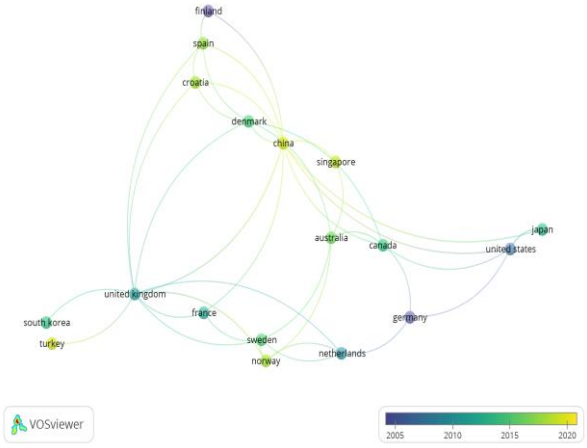

Figure 9(b): Country Collaboration Map by Years

We acquired 170 papers, shown in Figure 10, by identifying publications that received at least 5 citations in order to understand the distribution of citations. Out of all of these, the study on fishing activities by Gislason H. (2000) has garnered the most citations, with 176 references. However, it is clear that Wadsworth's (2008) study, which looks at the health and fatigue status of seafarers, has gotten the most citations when viewing the studies within the context of 372 publications in relation to their citations, as shown in Figure 11. When the titles of other studies in the link are examined (studies by Oldenburg, Akamangwa, Baumler, Andrei, Pauksztat, etc.), it is evident that the research area referenced in the 372 studies revolves around the health, welfare, fatigue, sleep conditions, rest hours, working environment, and their effects on seafarer.

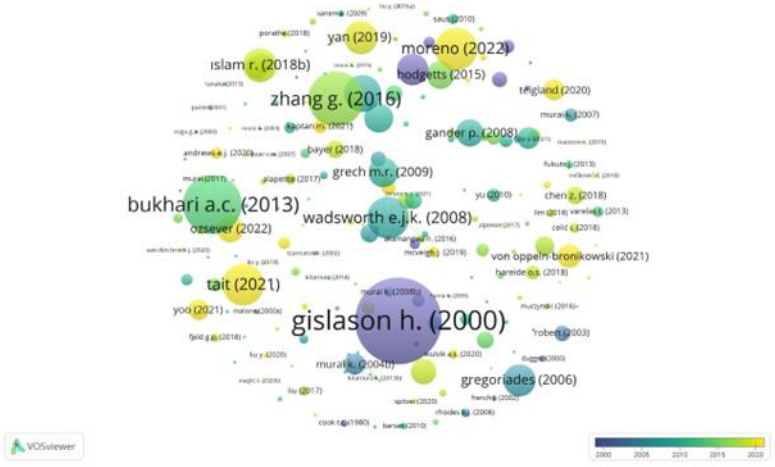

Figure 10: Most Cited Documents

Murai K. is the author with the most citations (C), totaling 200, when the analysis is viewed from the perspective of the authors. Within the context of the 372 documents, the citation count for authors which represents the strength (S) of the author is reaches 115. Following him are Hayashi Y. (C-196, S-105), Okazi T. (C-82, S-6), Kitamura K. (C-38, S-47), and Mitomo N (C-50, S-13).

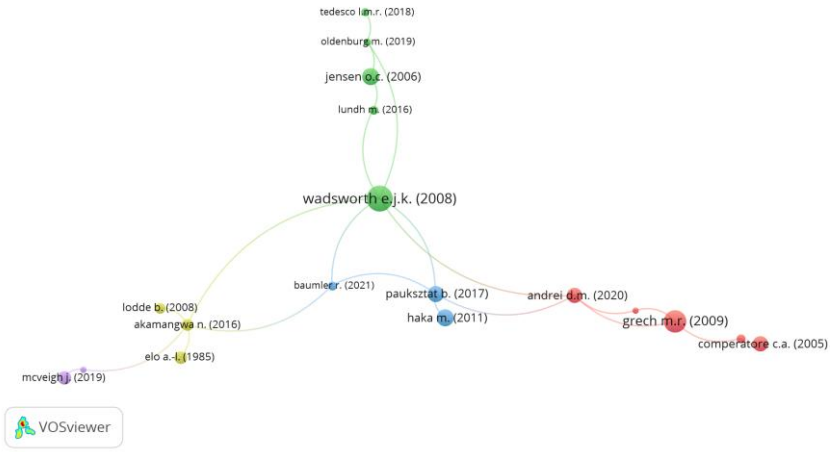

Figure 11: Connected Documents Based on Citation

3.2 MAXQDA Analysis

In the third step of the study, the analysis was conducted using the MAXQDA Qualitative Data Analysis software along with summaries of 372 articles. The abstracts, along with the merged Excel file, were transferred to the MAXQDA, as illustrated in Figure 12. The analyses conducted through this program are explained below under separate headings.

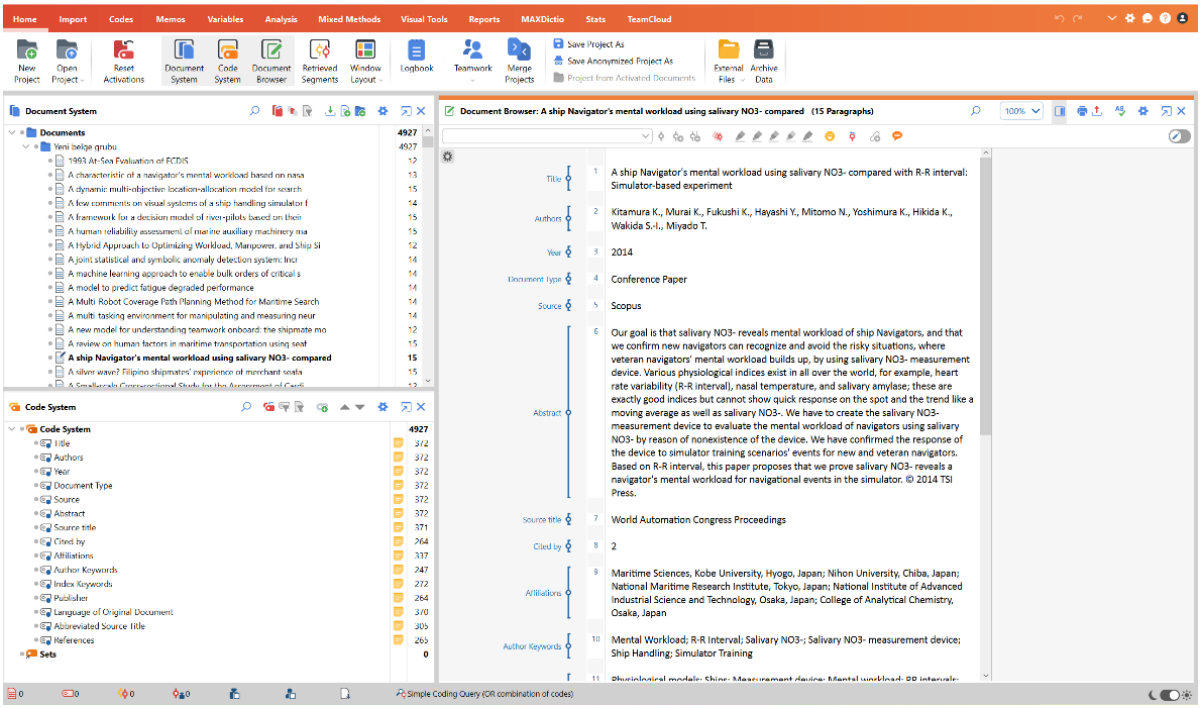

Figure 12: MAXQDA Interface

3.2.1 Word Frequency

At this stage of the study, word frequency analysis has been conducted to identify the most frequently recurring words. Using a stop list, 832 terms that don't have any real substance were eliminated, including "and, or, other, I'm, have, here vs." Afterwards, a separate list was produced using terms from the 37,968 words that appeared at least ten times. The initial 37 words prior to editing are seen in Figure 13.

Word	Length	Frequency	%	Rank	Documents	Documents %	1993 At-Sea	A characteris...	A dynamic mult...	A few comment...	A framework fo...	A human reliab...	A Hybrid Appro...	A joint statistic...	A machine lear...
workload	8	682	1,80	1	319	85,75	2	4	1	2	3	1	1	1	2
ship	4	505	1,33	2	174	46,77	1	0	0	8	0	2	1	0	0
mental	6	323	0,85	3	104	27,96	0	4	0	2	8	0	0	0	0
maritime	8	291	0,77	4	139	37,37	1	0	1	0	0	0	0	2	0
human	5	270	0,71	5	101	27,15	0	2	0	0	0	8	1	1	0
performance	11	252	0,66	6	127	34,14	4	2	3	0	0	0	0	2	1
work	4	229	0,60	7	109	29,30	0	0	0	0	0	0	0	0	0
factors	7	218	0,57	8	99	26,61	1	0	0	0	0	0	0	0	0
fatigue	7	215	0,57	9	48	12,90	0	0	0	0	0	0	0	0	0
safety	6	206	0,54	10	103	27,69	1	0	0	0	0	0	0	0	0
seafarers	9	194	0,51	11	55	14,78	0	0	0	0	0	0	0	0	0
data	4	193	0,51	12	105	28,23	0	0	0	0	0	0	0	1	1
based	5	184	0,48	13	121	32,53	0	2	0	1	1	0	0	0	2
systems	7	179	0,47	14	85	22,85	0	0	0	1	2	1	1	0	0
vessel	6	168	0,44	15	71	19,09	0	0	1	0	0	1	0	0	0
navigation	10	161	0,42	16	81	21,77	5	0	0	0	0	0	0	0	0
ships	5	156	0,41	17	90	24,19	0	0	0	0	0	2	1	0	0
simulator	9	153	0,40	18	69	18,55	0	0	0	2	0	0	0	0	0
bridge	6	146	0,38	19	66	17,74	0	0	0	0	0	0	0	0	0
stress	6	138	0,36	20	59	15,86	0	0	0	0	0	0	0	0	0
information	11	133	0,35	21	87	23,39	2	0	0	0	2	0	0	1	0
crew	4	126	0,33	22	70	18,82	0	0	0	0	0	0	2	0	0
sea	3	125	0,33	23	65	17,47	0	0	1	3	0	0	0	0	0
working	7	122	0,32	24	59	15,86	0	0	0	0	0	0	0	0	0
training	8	121	0,32	25	74	19,89	0	0	0	5	0	0	0	0	0
control	7	119	0,31	26	52	13,98	0	0	0	0	0	0	0	0	0
rate	4	119	0,31	26	71	19,09	0	1	0	1	0	0	0	0	0
time	4	119	0,31	26	82	22,04	1	0	1	0	0	0	0	0	0
marine	6	114	0,30	29	57	15,32	0	0	0	0	0	1	0	0	0
risk	4	111	0,29	30	50	13,44	0	0	0	0	0	0	0	0	0
management	10	110	0,29	31	62	16,67	0	0	0	0	0	0	0	0	0
model	5	109	0,29	32	51	13,71	0	0	4	0	9	0	0	0	0
task	4	108	0,28	33	56	15,05	0	0	0	0	0	0	0	0	0
traffic	7	107	0,28	34	39	10,48	0	0	0	0	0	0	0	0	0
navigator	9	105	0,28	35	40	10,75	0	4	0	0	0	0	0	0	0
vessels	7	105	0,28	35	66	17,74	0	0	2	0	0	0	1	0	2
sleep	5	101	0,27	37	25	6,72	0	0	0	0	0	0	0	0	0

Figure 13: Word Frequency – Before Editing

At this point, terms that were believed to communicate the same idea were combined with plural-singular expressions and words that came from the same root (automated, automated, automatically, automation, etc.). A selection of the combined words is shown in Table 1.

Table 1: *Merged Words in the Word Frequency*

Original Words	Merged Words
Officer	OOW
Worker	Personnel, Employees
Port	Harbor
Cadet	Trainee
Nasal	Noise
Naval	Navie, Military
Seafarer	Seamen, Crew, Mariner, Rating
Workforce	Manpower
Questionnaire	Survey
Wellbeing	Welfare

As a result, Figure 14's first 50 words were obtained. Workload, ship, seafarer, maritime, and vessel are the most often used terms when searching in the Scopus and WoS databases, leading the way.

Nevertheless, terms that are not among our keywords - such as mental, human, safety, performance, fatigue, operation, simulator, and stress - give some indication as to the focus of research in these areas.

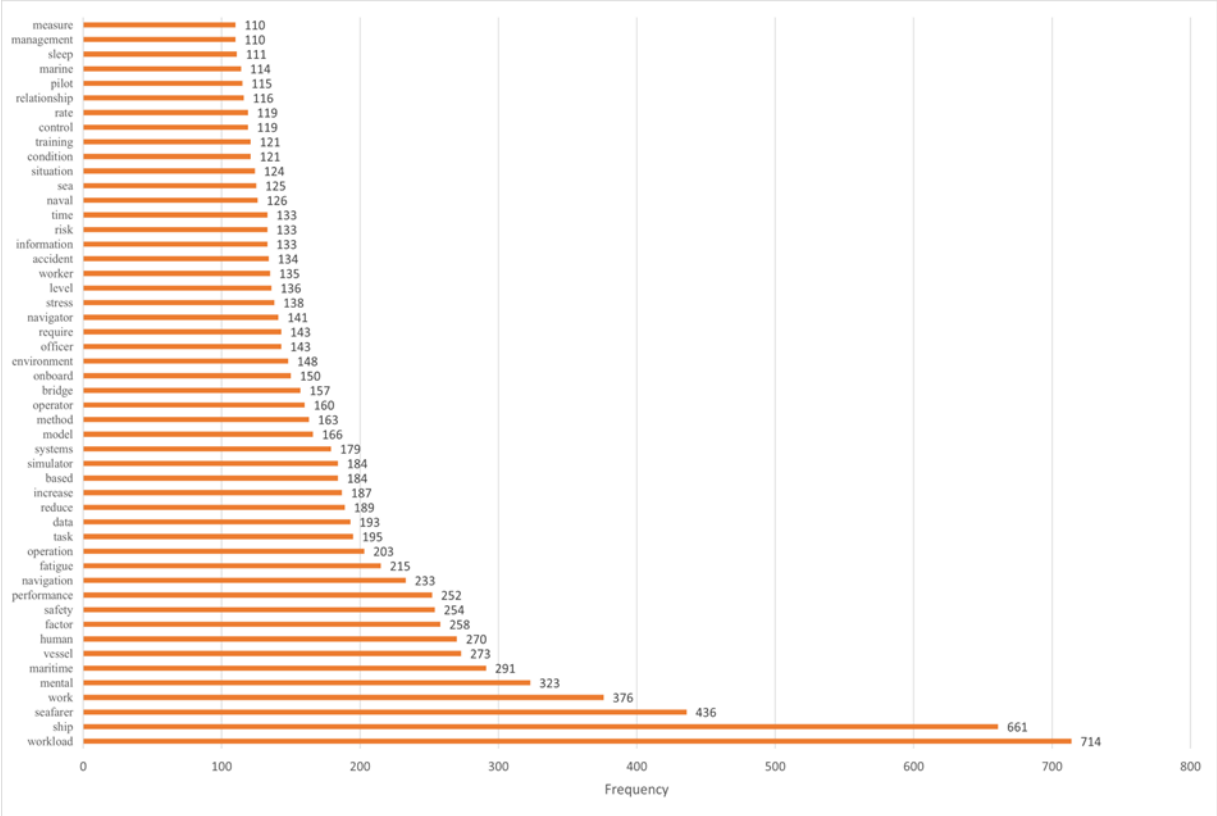

Figure 14: The Top 50 Frequently Words

3.2.2 Word Coding

For relational analyses, the top 200 words from the word frequency analysis have been coded. A core code structure of 160 words has been formed throughout this coding process; it is shown in Figure 15. Terms that do not have substantive significance, such as presented, subject, applied, result, confirm, increase, capable, useful, critical, and reduce, have been left out.

According to this, some important words in the code structure are as follows: workload (437), ship (379), work (218), seafarer (204), maritime (186), performance (170), factor (165), safety (153), mental (144), operation (139), vessel (138), human (136), navigation (130), data (127), method (118), task (117), simulator (114), systems (111), environment (106), time (103), onboard (101), information (98), bridge (96), officer (94), relationship (94), operator (91), …, wellbeing (25), interface (25), ergonomic (23), social (23), device (23), track (22), algorithm (21), radar (18), score (17), shift (20), phase (19), NO_3 (16), Electronic Chart Display and Information System - ECDIS (13).

Figure 15: Code Cloud – 160 Words

3.2.3 Code Map

After examining the co-occurrence frequencies of the codes, the code maps were reviewed. The locations of the codes in the code clustering map are established using a similarity analysis employing the Classic Multidimensional Scaling Method (MAXQDA, 2022). As seen in Figure 16, 5 clusters have been obtained based on the similarity of words being used together.

The code "mental" is more commonly addressed in research conducted in simulated environments, whereas studies pertaining to seafarers are mostly concentrated on the areas of accidents, safety, and human factor, according to the code clustering map. Based on the green-highlighted cluster, it can be deduced that physiological measurements, including NO3, heart rate, saliva, and body temperature, are part of experimental research carried out on captains, trainees, and bridge teams. The terms "Manning," "sleep," "stress," and "fatigue" are used more frequently alongside the expressions "operator" and "worker," indicating that these codes are more commonly associated with studies where data is collected through questionnaires.

The last set of codes, which are marked in light blue, focuses on the tools used during navigation. These terms include "ECDIS, Vessel Traffic Services (VTS), radar, ergonomic, EEG, tool, interface, visual, communication, automation, collision, fishery." There appears to be an analysis of the connection between workload and collision incidents, the significance of communication, and the concurrent evaluation of decision support instruments in marine traffic, including VTS variables. Furthermore, the relationship between VTS and local traffic is implied to be connected to the fishing included in this group.

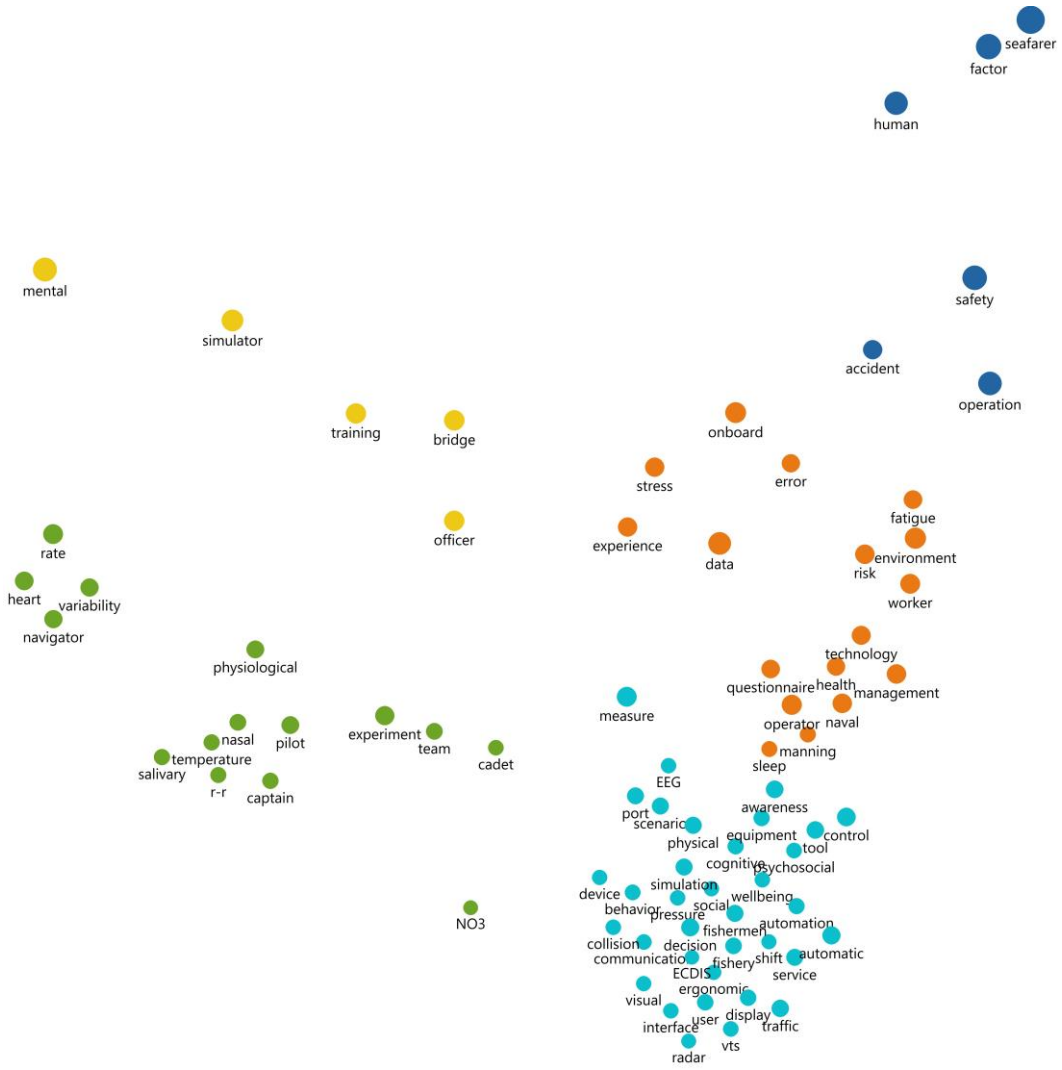

Figure 16: Code Map

3.2.4 Word Combination

While examining word co-occurrence frequencies frequently produces insightful results, understanding the relations can occasionally be difficult. For example, it becomes crucial to look at the contexts in which keywords like "environment" or "port" when exploring the meanings behind them. By using word combinations to explore particular topics or ideas, we can gain a deeper comprehension. By examining these situations, we can see how words are employed in combination with one another and gain insight into their meanings.

When looking at word combinations that are repeated ten times or more, Figure 17 displays the word cloud for the first 81 of those combinations. The combination "Mental workload" stands out with 264 instances, suggesting that assessing mental workload is a major component of the workload concept in marine situations. It may be concluded from these findings that the primary goal of these investigations is to evaluate mental effort. Among the most often used terms are those that deal with human factors, human errors, situational awareness, and maritime safety.

The term "bridge simulator" is frequently mentioned in these studies, often incorporating physiological measurement techniques like heart rate, eye tracking, body temperature measurements, and salivary analyses. Notably, the term "environment" is found to relate to the “work environment”, while "port" specifically refers to the port coordinator”. Additionally, studies delve into areas that may not prominently emerge in word analyses, such as "retirement pension", "social support", "food hygiene", and "noise exposure" suggesting research into factors impacting the well-being of maritime workers.

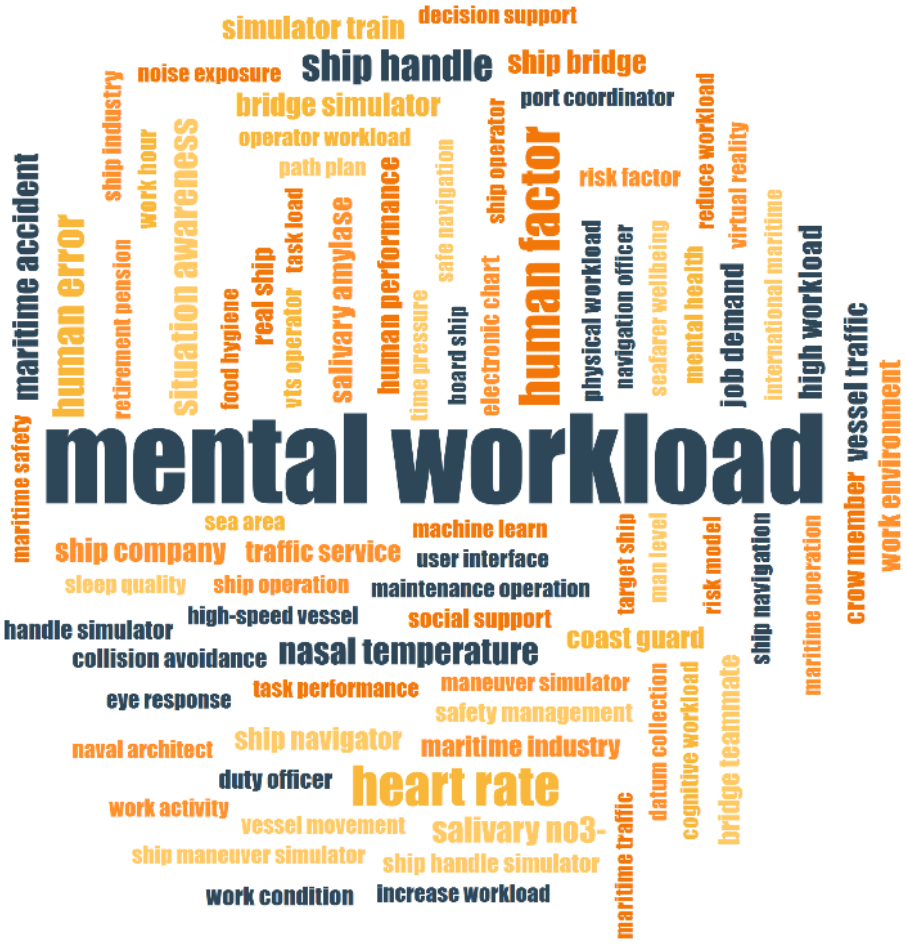

Figure17: Word Combination Cloud

3.2.5 Word Combination Map

After encoding the locations where the most frequently repeated word combinations are found in the text, a relationship map of these word combinations has been created. Figure 18 presents the word combinations whose locations on the map are based on similarity ratios. It is evident from the green cluster that research linking human error, human performance, and human factors to marine accidents is prioritized. When looking at the light blue cluster, it is evident that studies mostly involve the concurrent use of high workload, job demands, mental health, working conditions, seafarer well-being, work environment, and physical workload. Furthermore, within the same cluster, we also notice the inclusion of studies related to maritime traffic, vessel traffic services, operators' workload, decision support tools, user interface, conflict avoidance, navigation safety, and situational awareness. The yellow cluster encompasses studies involving physiological measurements conducted in simulators focused on ship navigator, duty officer, and bridge teammate. The appearance of mental workload as a separate cluster in this visual does not indicate its lack of connection with other studies. On the contrary,

according to the connectivity map provided in Appendix 1, the intense relationships of mental workload with all clusters may be a reason for its exclusion from any specific cluster.

3.2.6 Code Relations Browser

This tool provides a matrix table that shows which codes are frequently used together in a text, making the relationships between codes easily visible. In this section of the study, a relational analysis of the coded areas has been conducted over the years. The coded areas have been examined in four separate tables, categorized as follows:

- maritime stakeholders,
- analysis technique,
- psychosocial variables such as stress and fatigue, and
- maritime domains such as port, VTS, fishery.

In order to prevent any misleading impression due to the repeated occurrence of the same code within a document, counts have been taken by considering each code only once per document.

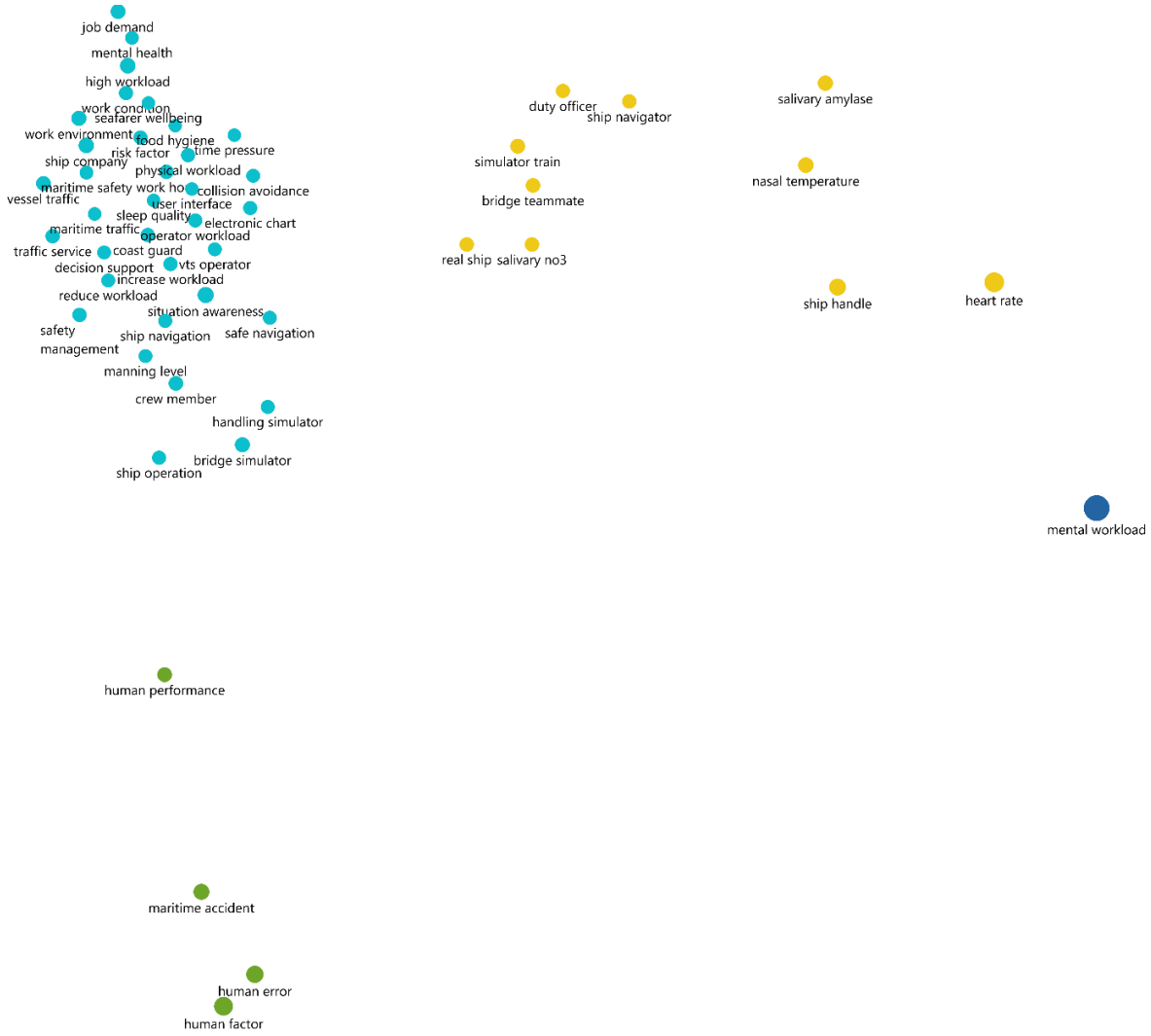

Figure 18: Word Combination Map

3.2.6.1 Maritime Stakeholders by Years

It is noted that the phrases "officer" and "navigator" have been less common in recent years when looking at the maritime stakeholders in past research. "Vessel traffic service operator" is the term that is often understood when we use the term "operator," and since 2017, study on this term has received increased attention. Remarkably, comparatively speaking, there doesn't seem to be as much attention focused on examining the workload of cadets, captains, and fisherman. In Figure 19, it is observed that the maritime stakeholders provided are coded a total of 643 times within the relevant 372 documents. As mentioned at the beginning of the section, these codings have been counted once per document. For example, the code 'seafarer' appears in 139 documents, while 'fisherman' and 'cadet' each appear in 20 documents.

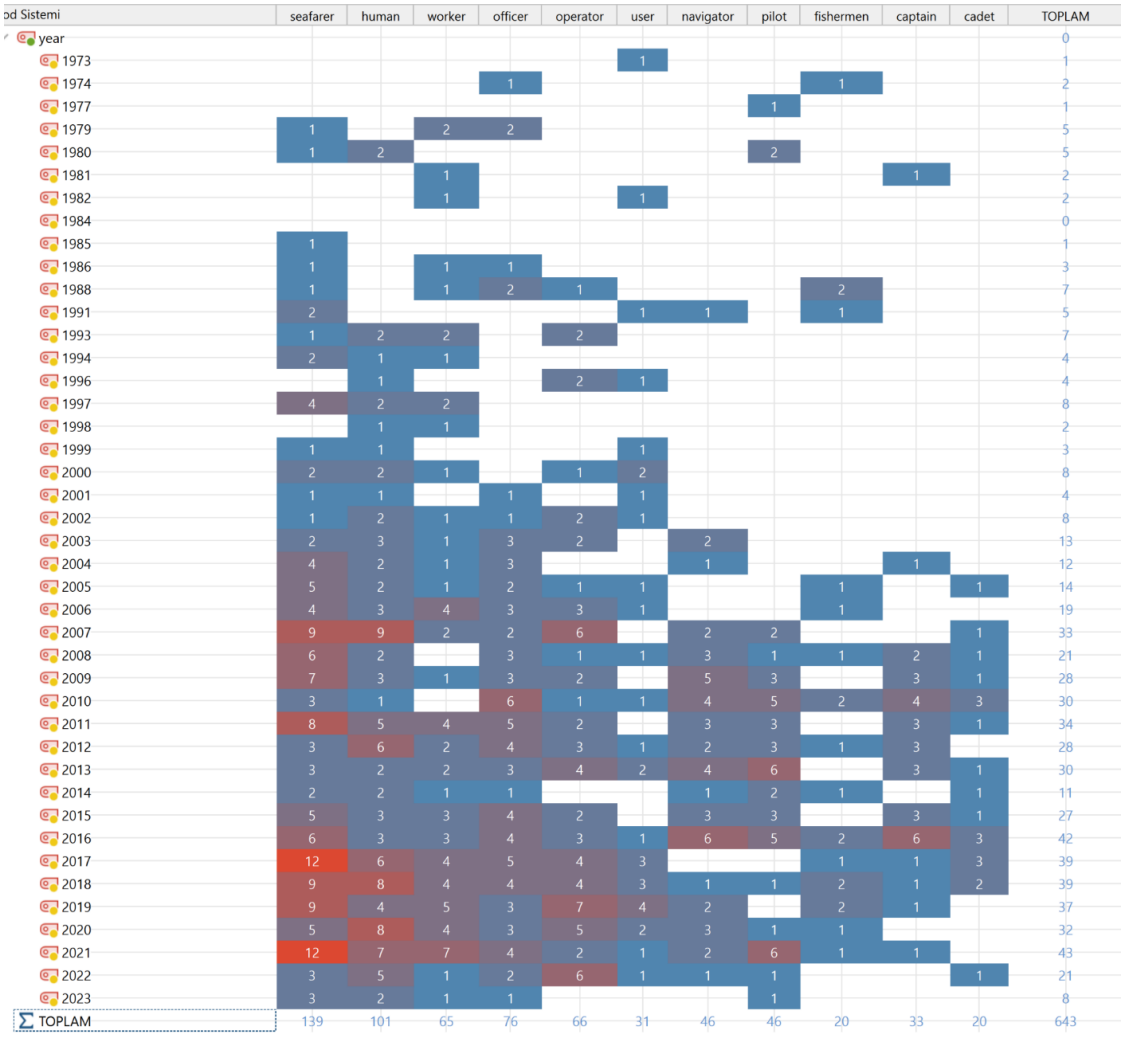

Figure 19: Code Relations Matrix - Maritime Stakeholders by Years

3.2.6.2 Analysis Techniques by Years

When examining the techniques shown in Figure 20, it is evident that the utilization of techniques like salivary measures, body temperature, and heart rate has decreased since 2014, although scenario-based simulator studies have increased.

The provided methods have been coded a total of 620 times across the 372 documents. Among these, 'simulator' is the most frequent, occurring 79 times, followed by 'experiment' with 71 occurrences. The NO_3 measurements, which we started to observe from the year 2012, have the least repetition with 10 occurrences. Following this, EEG measurements, which started to be underutilized in studies from 2016, follow with 15 occurrences. It should be mentioned that starting in 2020, there appears to be less of a tendency to adopt questionnaire approaches.

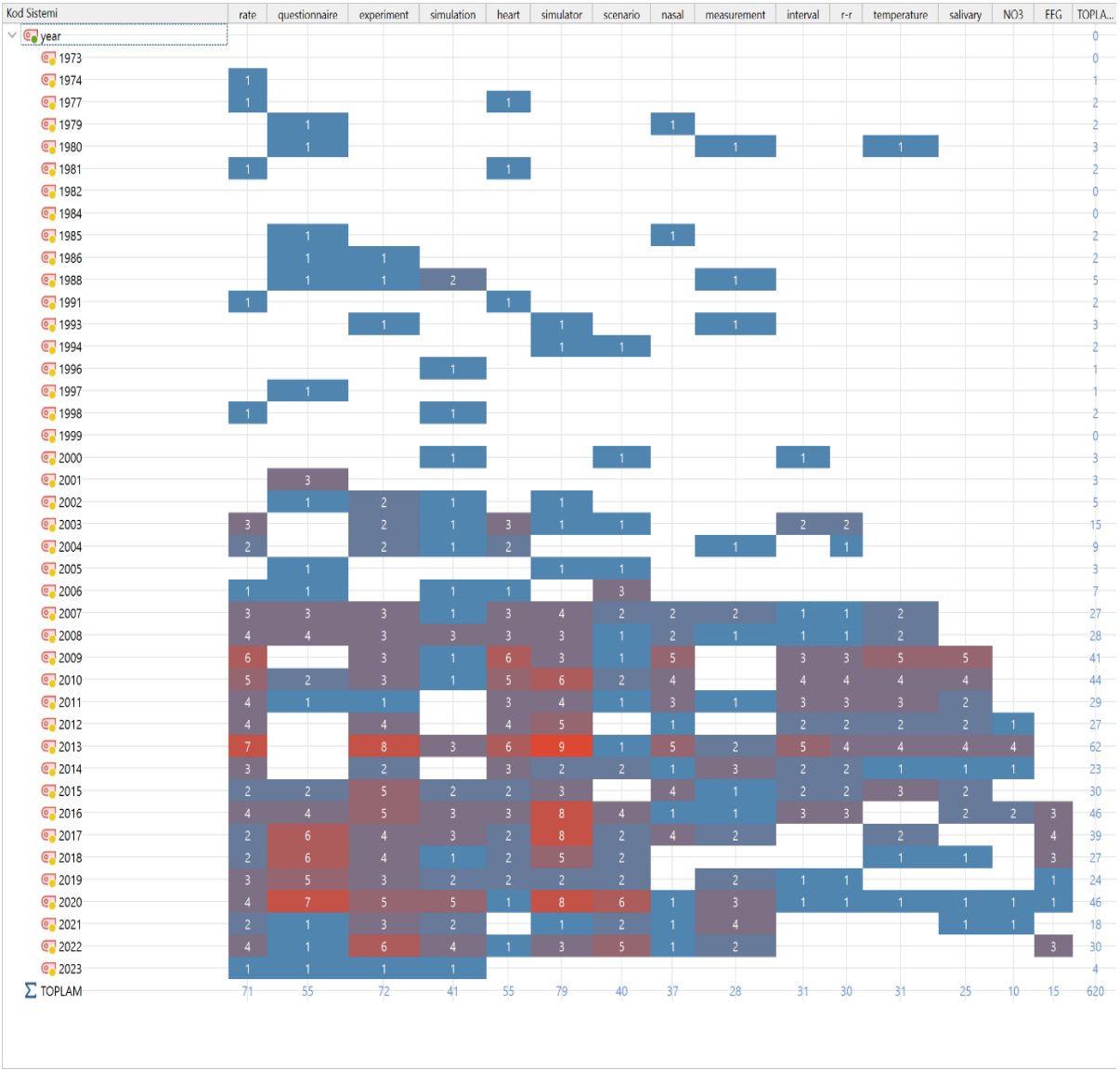

Figure 20: Code Relations Matrix - Analysis Techniques by Years

3.2.6.3 Psychosocial Variables by Years

Regarding emotional experiences centered on workload-related studies in the marine sector, as shown in Figure 21, a total of 287 section codes have been awarded. Only 21 codes were found in investigations done prior to 2000; however, in the recent ten years, there appears to have been a greater concentration in this area. Studies on psychosocial emotions such as "stress," "fatigue," and "well-being" have increased, despite a decline in codes pertaining to human physiological aspects since 2017. In comparison to previous years, there are more studies conducted in this field, particularly in 2021. The psychosocial difficulties encountered during the pandemic period may be the cause of this. Furthermore, a noteworthy result is the lack of significant research conducted on the specified topics in the 1990s.

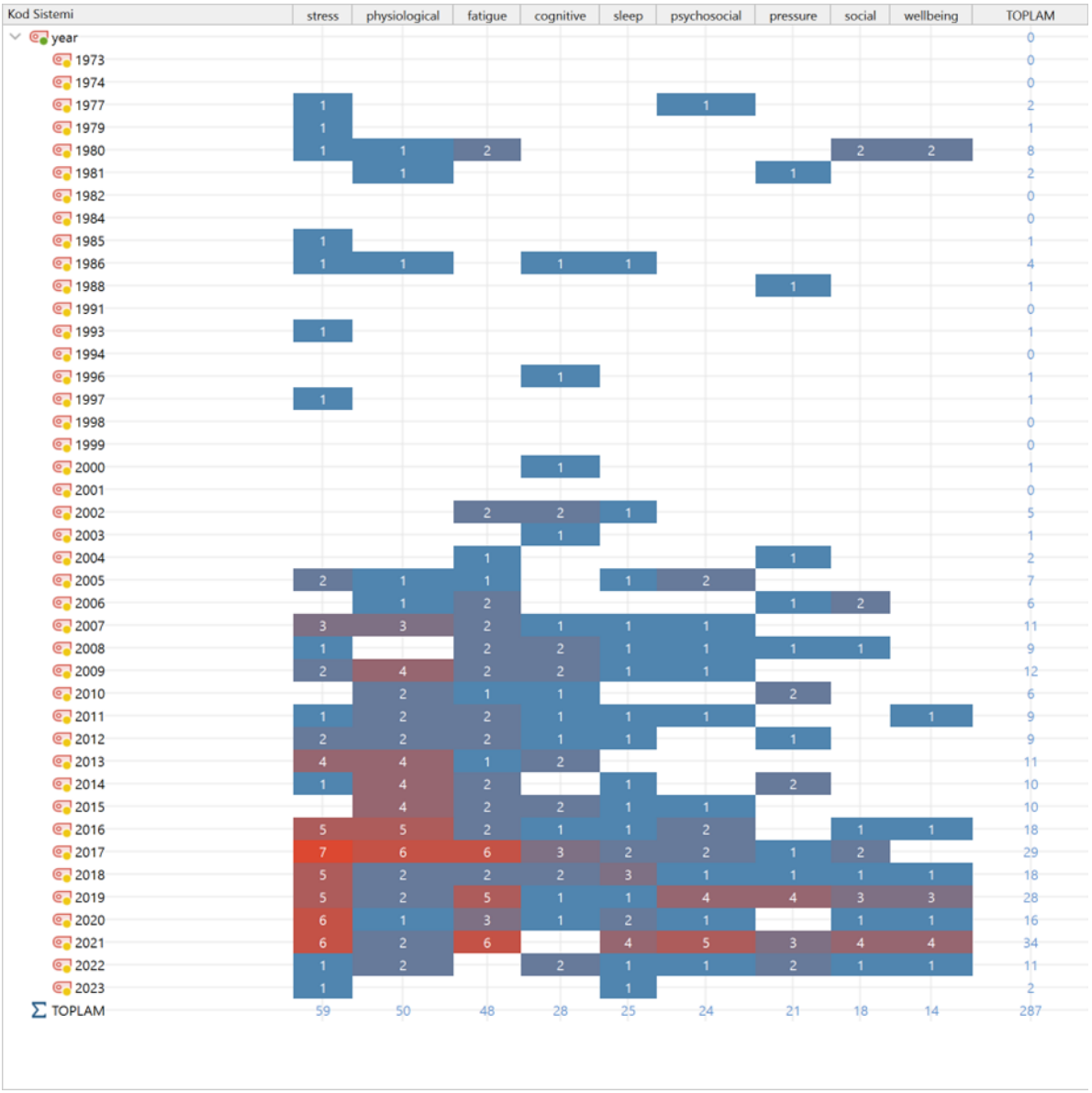

Figure 21: Code Relations Matrix - Psychosocial Variables by Years

3.2.6.4 Maritime Domains by Years

Figure 22 indicates that while there have been few research on Vessel Traffic Service, there has been a more steady trend since 2019. It was noted that from 1996 to 2011, there were more research studies on "manning." In total, the relevant codes have occurred in 831 instances, with VTS and ergonomic keywords being the least frequently encountered research areas, each with 17 repetitions. The years with the highest number of occurrences for the relevant codes are respectively 2019 (63), 2020 (62), 2021 (61), and 2018 (60). The increase in studies related to fishermen from 2016 onwards might be due to the evaluation of the connection with VTS in the studies. The most frequently mentioned codes at that part are “maritime”, "vessel," "onboard," and "bridge." This suggests that most research on workload in the maritime industry focuses on ship crew members.

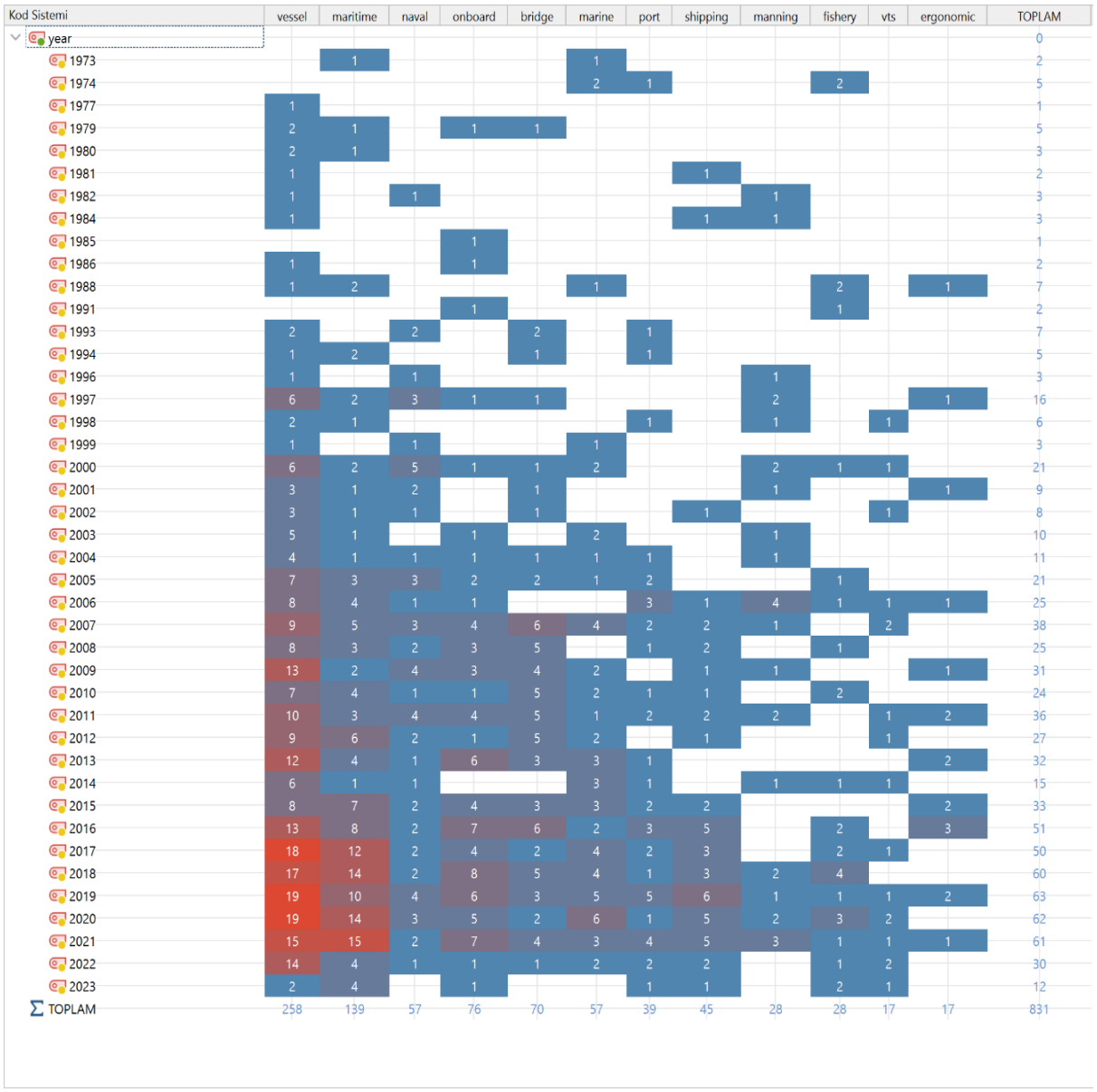

Figure 22: Code Relations Matrix – Maritime Domain by Years

4 Conclusions

In the discipline of marine studies, maritime accidents and their causes have long been a popular and extensively explored subject. The likelihood that these incidents may cause large financial and environmental damages is the main factor contributing to their prominence. Studies on the causes of accidents conducted in the past few years have often brought attention to the human factor. The literature frequently addresses topics like seafarer burnout, fatigue, and well-being. The idea of workload has also received more attention in the marine literature. This research aims to investigate the way in which the concept of workload is seen in the marine industry.

It is seen that the field of workload studies in maritime has a history spanning 50 years. Out of the examined 372 academic studies, 41 belong to Murai K., and 30 to Hayashi Y. In terms of international collaborations, European countries such as Finland, Spain, Croatia, Denmark, along with China, are observed to collaborate, while Japan collaborates with the United States, and Turkey collaborates with the United Kingdom and South Korea. Wadsworth's (2008) study, which examines the health and fatigue

condition of seafarers, is the most cited among other works, indicating a focus on seafarers in the field. The other highly cited studies also revolve around seafarers' welfare, sleep status, rest hours, and working environment. In the section of word analyses, another significant finding of the study emerges. It is evident that workload studies in the maritime domain are more focused on 'mental workload". Human factor, safety, performance, fatigue, simulator, and physiological measuring methods including salivary amylase, nasal temperature, EEG, and heart rate are the expressions most commonly linked with it.

About 80% of incidents between 2014 and 2021 happened in internal, territorial, and inland waters, according to accident statistics (EMSA, 2022). This understanding leads to the belief that workload analyses for vessel traffic services, which include informational services for ships, assistance with navigation, control maritime traffic, and coordination of services such as search and rescue and piloting in coastal areas, may be helpful in maintaining maritime safety. Research pertaining to cadets, marine pilots, and ship masters is perceived to dominate this subject, even if bibliometric analysis of workload studies reveals a focus on mental workload studies using VTSOs.

Remote control represents a transitional stage as ships approach becoming autonomous. Therefore, investigating the factors influencing the workload of VTSOs providing remote assistance to vessels and understanding how these factors may evolve in the future will enhance our comprehension and preparedness for upcoming operational processes to ensure maritime safety.

5 Limitations

Publications not indexed in Scopus and Web of Science were excluded from the scope of this research. Although a comprehensive keyword analysis has been conducted to include studies related to all stakeholders in maritime traffic, it is possible that some workload-related studies were still omitted. In bibliometric analyses, collaborative and interdisciplinary research may complicate authorship patterns. So, changes in authorship trends over time can affect bibliometric analyses.

6 Declarations

6.1 Funding source

There is no funding source in this study.

6.2 Competing Interests

There is no conflict of interest in this study.

6.3 Authors' Contributions

Elif ARSLAN: Conceptualization, organizing and reporting the data, taking responsibility for the explanation and presentation of the results, and writing.

Serim PAKER: Conceptualization, supervision, and editing.

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Appendix I – Word Combination Connectivity Map