MANAGEMENT
2025, Vol. 29, No. 2
www.management-poland.com
DOI: 10.58691/man/211512

ROBERT MAREK

The scope and definition of maritime logistics in light of contemporary research

Abstract

Research background and purpose: Maritime logistics has begun to develop more and more rapidly, no less, there is no defined scope of its activities. This study aims to identify the scope of maritime logistics activities.
Design/methodology/approach: This study critically evaluates the scope of maritime logistics, which mainly refers to the area of container handling. Based on a literature review comparing maritime economists and competitors, it attempts to define the scope of maritime logistics.
Findings: The assessment identifies the need to expand the scope of logistics, taking the entire maritime economy and not just a separate part of it as a reference point. In many cases, the proposed scope of maritime logistics focuses on the movement of cargo and/or cargo units between seaports. Literature research has identified a gap in this area, as there are no studies dedicated to this issue.
Value added and limitations: The results of the study highlight the need for further research into the problems of maritime logistics and the preparation of methods and principles to improve its knowledge and efficiency of operations. Defining the scope of maritime logistics is important to understanding the current and emerging features of maritime logistics and the potential impacts it will have along maritime supply chains. This also contributes to the broader discussion on maritime logistics, such as definition and scope covering, in particular, such areas of logistics activity as: the logistics handling of cargo and cargo units, the logistics of people service, the logistics of sea mining, logistics of offshore electricity, logistics of distribution of clean seawater, logistics of breeding, fishing and agriculture, the logistics of water sports, the logistics of marine waste and recycling and method and tools of logistics support.

Keywords: *maritime logistics, cargo and cargo units logistics, offshore electricity distribution logistics, scope of maritime logistics, definition of maritime of logistics*

JEL Clarification: L20, L23, D23

Received: 2025-07-22; **Revised:** 2025-09-24; **Accepted:** 2025-09-30

Robert Marek
Management and Quality Science Department, Gdynia Maritime University, ul. Morska 81-87, 81-225 Gdynia, Gdynia, Poland;
email: r.marek@wznj.umg.edu.pl
ORCID: 0000-0001-8634-9518

1. Introduction

Maritime logistics is a part of logistics, the operational activities of which take place in a specific natural environment, on which human influence is limited. The extent of this limitation is due to the state of technical and technological achievements and the effectiveness of their use. Besides, maritime logistics is closely related to international and global logistics setting directions and trends in technology, service and organization. From the essence of maritime logistics, a number of its specific features emerge. At this point, it is worth considering the phenomenon of the provision and consumption of maritime logistics services and the resulting consequences for its operation.

The service of maritime logistics, being the result of its production, cannot be stored or provided for stock. In maritime logistics we are dealing with a very specific phenomenon, that is, the phenomenon of the simultaneity of the process of providing logistics services and their consumption. The impossibility of providing maritime logistics services for stockpiling and storing them results, on the one hand, in the occurrence at certain periods of its unused logistic capacity residing in resources, which are lost irretrievably in these situations due to the impossibility of storing them and thus creating stocks, and, on the other hand, in the occurrence at certain periods of difficulties in meeting the growing needs of maritime logistics due to the impossibility of creating stocks of logistic services in periods favorable for this.

Not insignificant from the point of view of the specifics of maritime logistics is also its production effect. The activity of maritime logistics boils down to the provision of services at a place and time in relation to the process of moving cargo, cargo units, people and means of transportation. The logistics service does not create a specific product, however, it performs the process of movement, thereby contributing to the creation of new value, and therefore use value in accordance with the principle of economics that there is no value without use value. The movement of cargo, cargo units and people in space and time cause the maritime logistics service to increase their value on the one hand, while on the other hand it is a necessary condition causing the object of movement to have potential use value at the place of manufacture to reach actual use value at the place of delivery (consumption). In other words, use value is created by moving the object of maritime logistics in space and time. A logistics service in this sense creates both use value and new value. This feature of the maritime logistics service is special and distinguishes maritime logistics from other economic areas whose production results in concrete physical goods.

Despite this attention, some research gap still persists. The research focuses mainly on the movement of cargo units and cargoes by vessels between seaports. Therefore, the present paper aims are to identify the scope of maritime logistics activities and review existing definitions of maritime logistics. Consistent with these purposes, the analysis has been developed on based on current scientific literature. This study attempts to comprehensively address the scope of maritime logistics. The study's findings not only provide insight into the broad spectrum of economic activities encompassed within maritime logistics but also offer a discussion on the revision of existing definitions of maritime logistics. Furthermore, this study complements previous analyses of the role of maritime logistics in the domestic and international economy by attempting to present its scope, which may contribute to its further development.

The continued growth of maritime and ocean operations is a significant reason to reassess the existing scope of maritime logistics. Therefore, the following research hypothesis was formulated:

H_1: *Maritime logistics has a broader scope than that related to the handling of cargo and cargo units transported by sea and ocean.*

Therefore, it is reasonable to hypothesize that, given the broader understanding of maritime logistics, it should refer not only to the transport of cargo and cargo units by sea and ocean. Therefore, the following hypothesis was formulated:

H_2: *The definition of maritime logistics must take into account a broader spectrum of maritime activities.*

However, as a result of the evolution of technical and technological progress and the increasing intensity of the exploitation of the seas and oceans, maritime logistics should be looked at in a somewhat broader context, which will be the subject of a later section of this paper. In assessing the development of maritime logistics, it should be said that its development depends on the state of knowledge of maritime logistics. This level of knowledge, is growing faster and faster, and its scope is expanding to include new problems and areas of maritime logistics.

This article is structured in the following way. Section 2 described the literature review. Section 3 describes the methodology whereas Section 4 and 5, respectively, present the results and discussion and summary.

2. Literature review

Starting from the essence of maritime logistics, it seems reasonable to attempt to define its scope, although this is difficult and has not been clearly defined in the literature to date (Caliskan et al., 2016). The literature research was conducted using two methods: narrative review and thematic analysis. The narrative review was conducted based on available research articles on maritime logistics. The literature was selected randomly.

The literature research also utilized thematic analysis to determine how different researchers define the scope and maritime logistics. Traditionally, maritime logistics by many researchers has focused on the handling of cargoes traded by sea, especially cargoes carried in shipping containers (Panayides, 2006; Lee et al., 2012). However, maritime logistics has a direct connection not only with the cargoes handled, or cargo units, but with the entire maritime industry, which is developing very rapidly as a result of the emergence of various innovations in the field of maritime technology (Soares, 2023).

Maritime logistics, like logistics as a whole, in its early days was carried out by individual maritime companies, i.e.: forwarding companies, maritime and ocean shipping operators and ports and marine terminals. As a result, a number of publications have focused on such internal arrangements. The consequence of this is research dedicated to logistics in seaports and marine terminals, shipping and forwarding companies. With the development of the supply chain concept in logistics, maritime researchers have also started to develop this type of concept in relation to maritime logistics (Panayides & Song, 2007; Hameri, el. al, 2014; Seo et. al., 2015; Yuen et al., 2017), and in line with recent trends, orienting it towards green supply chains in maritime logistics (Psaraftis, 2016; Feng, 2025).

Subsequently, research papers began to appear on the strategies implemented in maritime logistics, which started to focus on the strategies of maritime companies (Lorange, 2009; Lorange, 2001; Parola et al., 2015; Marek, 2022).

An important area of research and application is digitisation, which makes it possible, within maritime logistics, to track shipments and automate the various tasks involved in moving them, within a seaport and between its various business stakeholders located on its hinterland, also increases transparency and minimises operational errors in their movement and, through the introduction of electronic documentation, reduces the number of errors involved in completing them and reduces the cost of circulating these documents (de Andres Gonzalez et al., 2021; Ahmed & Rios 2022; Lange & Grafelmann 2022).

An important influence on contemporary research related to maritime logistics is the modern technologies related to digitalisation, the use of bid data, blockchain or artificial intelligence. In the area of maritime logistics, researchers have been exploring the use of blockchain to enable the digitisation and tracking of shipping documents, particularly bills of lading and letters of credit, to ensure data integrity and security, improve efficiency and reduce costs (Ahme &, Rios, 2022; Shirani, 2018; Wagner & Wiśnicki, 2019).

Researchers are also increasingly looking at how artificial intelligence can be used in maritime logistics in the area of optimisation and operations research, with huge opportunities to develop solutions to large-scale optimisation problems in maritime logistics in future research and practice (Dornemann et al., 2020).

3. Research methodology

The state-of-the-art of maritime logistics has been drawn by using two steps of analysis. First, a literature review has been carried out to qualitatively assess the definition and scope of maritime logistics. The review of scientific literature describing maritime logistics used in the article was based on the criterion of the most frequently cited in scientific publications, and these are the precursors of the analyzed issue. The second phase has examined the applicability of various theories in practice, through case studies (interviews with logistics managers of maritime companies) of multinational shippers, sea transport operators, and logistics service providers. The main portion of the research covers 30 persons acting in maritime logistics, belonging to high and middle management level of companies. The research has been conducted in 2024 period. The interview study was characterized by being free, direct and addressed to experts - i.e. people whose companies declare that they deal with maritime logistics. In preparing the questions in interviews, we went in contact with 10 firms, in the Tricity (Poland) area, we found out which marine logistics services they are provided. Additionally, we have included in the direct interviews their opinions on scope and definition of maritime logistics based on the logistic firms they have been working with and their services. Later on, interviews have been applied in 10 firms in the Tricity area, in order to make sure the interview's questions are clearly understood by respondents. As part of the study, the purpose of the interview was defined and potential respondents operating in the declared maritime logistics sector were randomly selected. A set of questions was then developed to understand the respondents' understanding of the concept and scope of maritime logistics. The interview was unstructured and conducted in the companies. All respondents were familiar with the study's purpose and the interview guidelines. Respondents discussed their understanding of maritime logistics and its scope. The face-to-face interviewer strived to maintain a neutral stance, avoiding commentary, but in some unclear situations, questioning the respondent about the precise meaning of their statements. The central issue in these interviews was to explain meanings and scope of maritime logistics. Unfortunately, interview respondents have a poor understanding of maritime logistics, and if they do understand it, it is in a narrow sense, that is, in relation to their core business, and mainly in relation to the cargo or cargo unit they handle. Therefore, this research aims to highlight the importance of maritime logistics in a broader sense, not only in relation to the cargo or cargo unit handled. However, it is important to note certain limitations stemming from the research method used – face-to-face interviews. One of these limitations may be the unconscious influence of respondents' responses when they request guidance or suggestions regarding the response to a question. This occurs particularly in the first stage of the pilot study, where the questions posed to respondents may be unclear or imprecise. Another problem that arose during the study was determining the research sample, and thus the representativeness of the study. In this study, the sample size was set at 30 companies, due to their stated involvement in maritime logistics and their size in the local market – the Tricity area.

4. Research results and discussion

The increasing exploitation of the seas and oceans is due to the fact that maritime logistics encompasses a series of innovations that are designed and made across national boundaries to meet the ever-increasing needs of supplying natural resources "that are in short supply or in short supply on land" of producers operating on a global scale. Maritime logistics can be considered from the point of view of various criteria. Taking the range of influence as a criterion, then we can distinguish domestic, international and global maritime logistics.

Domestic maritime logistics is carried out by entities located within one country at the same time the consumption of logistics services is also satisfied within one country. Examples include maritime logistics involving cabotage shipping service (cargo and passenger), fishing vessel service, auxiliary service carried out for a ship, port, cargo or passengers within a single country.

International maritime logistics is realized when there are at least two maritime countries in the logistics service.

Global maritime logistics, on the other hand, is realized when there are multiple participants located in different maritime states in the logistics service and the object of logistics service is moved intercontinentally.

Undoubtedly, the complexity, variability and unpredictability of logistics processes is shifting from national to global maritime logistics, see Figure 1. In addition, the differences between the two are the differences in the conduct of logistics practice, the scope of decisions of logistics managers, differences in legal systems, restrictions imposed by governments, as well as to the varying availability of resources found in different countries. In addition, the cultural differences that exist between countries lead to the fact that logistics "best practices" in different maritime logistics markets are different but strive to standardize them in order to improve the protection and safety of the movement of people, vessel, cargo and all marine business units involve in supply chain.

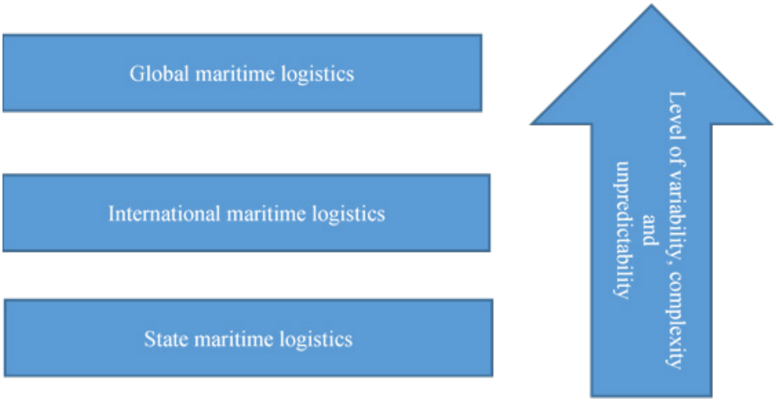

Figure 1. **Relationship among variability, complexity, unpredictability and the maritime logistics**

Source: own study

Taking the object of service as the criterion for the division of maritime logistics, then we can distinguish the logistics handling of cargo and cargo units, the logistics of people service, the logistics of sea mining, logistics of offshore electricity, logistics of clean seawater, logistics of breeding, fishing and agriculture, the logistics of water sports, the logistics of marine waste and recycling. All areas of maritime logistics must be supported by modern methods and tools thanks to which they can function and increase the efficiency and effectiveness of operations, while maintaining all safety areas defined in the maritime industry. The proposed scope of maritime logistics is shown as Figure 2.

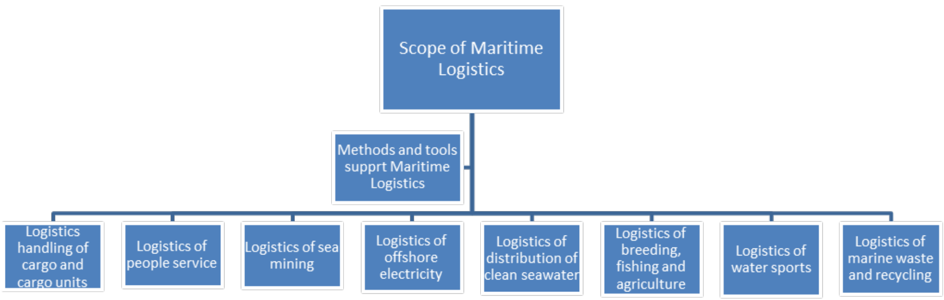

Figure 2. **Propose Scope of Maritime Logistics**

Source: own study

Unfortunately, to date, scientific studies have failed to define the scope of maritime logistics, merely pointing to the existing difficulties in defining it. This appears to be a consequence of the evolutionary and interdisciplinary nature of maritime logistics, which makes it difficult to define its scope. Therefore, an important contribution of this study is to attempt to define the scope of maritime logistics and, on this basis, to propose its definition. It should be said that the scope of maritime logistics depends on a variety of conditions. Part of it comes from traditional maritime services and the rest from technical and technological advances, in the areas of mechanics, automation, robotics, computer science, marine biology, commodity science, transportation systems, cybernetics, operations research, management and quality sciences, economics and many other system sciences and specific disciplines. Based on the above, it can be concluded that the enormous progress in technological innovation creates ever greater opportunities to understand and use the resources found both in sea and ocean water itself and beneath their bottom.

4.1. Logistics handling of cargo and cargo units

Cargo and cargo unit handling logistics is the core of maritime logistics, as it is estimated to be responsible for handling 92% of world trade in goods in 2016 (Grzelakowski, 2018). As previously mentioned, in the traditional sense, maritime logistics is reduced to the handling of cargo and cargo units between seaports, using various modes of transportation directly involved in or supporting the transportation process. The complexity of logistics handling by sea of cargo and cargo units is due, on the one hand, to the huge volume of their diversity in terms of physical and chemical characteristics of the cargoes handled, and, on the other hand, to the greater degree of integration, coordination and accuracy of planning of logistics processes. As a result, we distinguish cargoes: conventional "non-containerized" and containerized general cargo, palletised, pre-slung, temperature-sensitive, heavy, oversized, project, dry and wet bulk, semi-mass, rolling (ro-ro). In addition to this division, there are non-hazardous and hazardous cargoes in the handling of maritime logistics. Particularly complicated is the process of handling dangerous cargoes, the transportation of which by sea is defined in detail by the conventions of their carriage, in maritime transport applies the IMDG code, the provisions of which also apply within the administrative boundaries of the seaport for the manipulation and transportation of dangerous cargoes

This subject diversity of the logistics handling of cargo by sea, gets further complicated when one takes into account their additional characteristics, such as: (Misztal, 2010):

- specific odor (e.g., leather);
- ease of absorbing foreign odor (e.g., tea, eggs);
- not changing weight during the transportation process (machinery);

- hygroscopic and easily soaking up water (grain, salt, sugar);
- reducing their weight (charcoal);
- self-igniting (coal, grain);
- explosive (dynamite; ammonal; ammunition);
- poisonous (various chemicals);
- readily ignitable (gasoline, kerosene);
- emitting noxious gases (sulphur, petroleum);
- emitting dust (cement); etc.

The divisions of cargo and cargo units used are mainly due to the need to determine the technology of carriage, handling, manipulation and storage, and are aimed at separating groups of possibly homogeneous cargoes for which the basic technological conditions of carriage and handling are or can be similar. The grouping of cargoes is aimed at determining technological and organizational framework solutions for them and, as a result, optimizing the logistical processes of their movement within the maritime logistics chain.

An additional element in the complexity of the logistics process in the shipping area is the use of an appropriate transport unit - a vessel. Here, as in other transport industries, carriers strive to adapt the means of transport to the transportation requirements of the cargo and cargo units. As a result, vessels vary in both size and type. If we consider the size of the vessel, here we distinguish handy, handymax, malaccamax, panamax, suesmax, aframax. In turn, if we take the type of vessel for our considerations, we distinguish the following ones: general cargo vessels, multipurpose vessels, bulk carriers, tankers, combination vessels, semi-container vessels, container vessels, product vessels, car carriers, crawlers, heavy cargo vessels and oversize heavy lift vessels, towing sets "full-sea tug with barge or pontoon", and many others. At the same time, the basic shipping and production activities of ocean-going and seagoing vessels are supported by other ones such as: tugboats, pilot boats, fire-fighting vessels, bunker boats, lightships, floating harbour cranes, salvage vessels, hydrographic vessels, training vessels, icebreakers, research vessels, oceanographic vessels, exploration vessels, experimental vessels, floating hotel vessels. Undoubtedly, shipping has a significant impact on the processes and total costs of maritime logistics (Stopford, 2009).

It should be noted that recently, a shadow fleet (grey fleet, dark fleet) has appeared in maritime transport, which uses various tactics to circumvent the export sanctions imposed on the country - mainly crude oil. Such vessels turn off AIS within the loading port and then transport the cargo to a seaport not covered by sanctions but also being an oil exporting country, in this port they replenish the cargo, thus cleaning the cargo's origin documents, and sell it legally on the market.

Another important area creating complexity in maritime logistics is operations related to the handling of vessels, cargo and cargo units at ports and marine terminals. Ports and marine terminals are also characterized by varying degrees of technical and technological development depending on their location, and thus their geographic position on transportation routes and importance within logistics supply chains. The complexity of today's transportation and logistics systems and the increasing level of specialization in the handling of cargo units, cargo, passengers and even electricity have contributed to the emergence of different terminals in the market (Marek, 2019).

This complexity of terminals is justified by the fact that they are not homogeneous in their technical and operational structure, economic functions, importance in land-sea supply chains and in the international exchange of goods by sea, hence they are often grouped according to different criteria. As a result, we can divide maritime terminals according to the following criteria: ownership, specialisation, customer accessibility, location, object of service, type of transport mode served, degree of automation (Marek 2015; Marek, 2021).

The complexity, multifunctionality of marine terminals and the resulting scale of tasks in the area of operation, resulting from the demand for logistics services, mean that in the area of maritime logistics, it is necessary to operate many different entities providing a range of logistics services both in relation to the main process and logistics support processes. These entities - marine terminals - offer handling of cargo and cargo units with a large diversity of infrastructure and superstructure in terms of size, type and availability - time, space and economic, causing a high level of complexity of maritime logistics processes (Pluciński, 2013).

4.2. Logistics of people service

Another important area of functioning of maritime logistics are services provided in connection with the logistic service of passengers "external logistics" and the logistic service of employees "internal logistics", see Fig. 3. It's important to note here that people transport both internal or/and external is not logistics, but rather a series of activities related to management their movement across land and water. Logistics services related to people movement represent a new approach, unlike the traditional definition of logistics, which referred to raw materials, semi-finished products, and finished goods (Council of Supply Chain Management Professionals, 2016). In the first case, the subject of logistic service are passengers who have various needs for moving and spending free time on sea and ocean vessels. In order to meet the diverse needs of passengers, carriers have adapted various types of maritime transport, which is reflected in the following vessels: white fleet (water trams, hydrofoils, coastal ships), ferries, passenger liners and cruise vessels. Terminal operators, on the other hand, have created marinas, stations or passenger terminals to provide passenger logistics services. The increase in the number of passengers served transforms into an increase in the complexity of logistics processes. Taking into account the level of complexity of logistics processes, it seems that the simplest is servicing passengers using the white fleet and the most complex is servicing cruise vessel passengers.

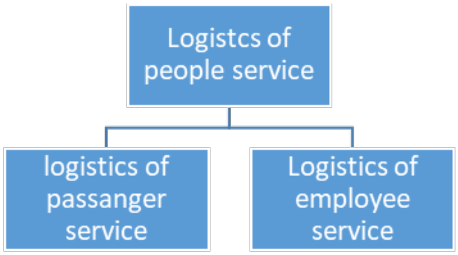

Figure 3. **Logistics of people service in maritime logistics**

Source: own study

In turn, the movement of people for internal needs is related to logistic support for the processes of the main maritime shipping operators - regular and irregular. The movement of people for the internal needs of maritime logistics is carried out by the organizational units of sea carriers or is entrusted to specialized entities - crewing (manning) companies "they play the role of employment agencies at sea". For a crewing company, the logistics of moving people will be the main process, while for a sea carrier it will be an auxiliary but extremely important process because without appropriate human resources, the implementation of the main process is impossible - there must be full staff on the ship or other facilities operating at sea, for example "drilling platforms" - in accordance with the regulations maritime conventions regulating the work of seafarers at sea -STCW Convention (International Maritime Organization, 2001).

As a result, crewing companies are engaged, on the one hand, in the transfer of persons from their place of residence to a vessel, or "drilling rig", or off-shore wind farms located in seaports or at sea or in the ocean in various parts of the world, and in transferring persons from a vessel, or "drilling rig", or off-shore wind farms to their place of residence – repatriation. The movement of people within maritime logistics also includes people employed on oil platforms, as well as flying shipyards or riding gangs - people who do not have the status of a seafarer but are occasionally delivered to a vessel, an oil platform or another maritime facility (e.g. marine wind turbine or offshore transformer station) in order to carry out repairs and maintenance of electrical, mechanical, communication and navigation equipment, or simple painting of elements ships or cleaning holds. The increasing number and demands of people moving by sea or ocean make maritime logistics even more socially important and complex in terms of logistical challenges.

4.3. Logistics of sea mining

Until now, most offshore mining activities have focused on extracting sand, zinc, amber and diamonds from shallow coastal waters. Most often, this mining was associated with dredging of the seabed in coastal areas to a maximum depth of approximately 200 m (Norman et al., 2020). Minerals typically extracted from these depths include sand, silt, mud, manganese, nickel, copper, zinc, and cobalt. Currently, the field of experimental extraction of various natural resources from the seabed is deep sea mining, which involves the extraction of minerals and deposits from the ocean floor found at a depth of 200 meters or more (Vysetti, 2023). Currently, the most exploited deposits lying under the seabed and oceans are: crude oil and natural gas, extracted using offshore drilling platforms. There are three types of deep mining that arouse great interest but also require different logistical processes for their extraction and distribution: polymetallic nodule (Sitlhou & Chakraborty, 2024), polymetallic sulfide (Van Dover et al., 2020) and cobalt-rich ferromanganese shells (HeinJames et al., 2009) Most deep sea mines are located near polymetallic nodules - active or extinct hydrothermal vents located at depths of 1,500 to 3,700 meters below the ocean surface (Herzig & Hannington, 1995). "Since 2010, the International Seabed Authority which is responsible for writing the rules for mining in seabed areas beyond national jurisdictions, issued exploration study permits mostly to explore manganese nodules, seafloor massive sulfides, and ferromanganese crusts to many exploration companies across the global oceans". As of December 2022, the ISA had issued 31 exploration contracts for seabed mineral resources" (Issues brief: Deep-sea mining, 2024) and it means that we have a deep sea mining, which is gradually developing (Ma, 2019). It should be noted that there are currently many technical and systemic challenges in the area of deep sea mining, in particular: development of deep-sea mining systems, seabed mineral collection system, subsea mining vehicle (SMV), subsea lifting system, surface system support (Zenghui et al., 2023). Currently, due to the lack of major, in-depth studies on the effects of deep sea mining, the side effects are unknown (World Bank, 2016). As a result, there is a threat from the consequences of sea mining. It can be presumed that mining, i.e. drilling, depth and exploitation, may cause damage to the marine environment, and some may even cause emergencies. This is still an embryonic area of maritime logistics operation, but with a great future.

4.4. Logistics of offshore electricity

With the increasing demand for electricity from the natural environment, a policy of renewable energy sources from offshore wind farms is being implemented. Therefore, the concept of maritime logistics for offshore wind farms should be planned in the context of the new development of a decision support system. Unlike other maritime logistics items, electricity is moved here. In this case, maritime logistics activities focus on three levels.

The first stage of logistic activities consists in activities related to the construction and installation of elements of an offshore wind farm (offshore wind turbines, an offshore transformer station and undersea cables laid by robots under the surface of the seabed at a depth of approximately 1.5-2,0 meters - these cables most often have a copper core thickness of 10 to 14 cm), all these works require enormous logistic preparation, starting from the planning of construction elements in production companies, up to their delivery without any damage to the port offshore, until they are finally placed in designated areas of the offshore wind farm.

The second stage of logistics activities consists in maintaining offshore wind turbines in high technical efficiency, so that the distribution of electricity from the wind farm (offshore transformer) to the marine installation terminal located on land (within the sea port) is uninterrupted and efficiently distributed deep into the land territory. However, in order for the logistics of electricity distribution to function, an installation terminal must be built in the seaport, which receives electricity sent from the sea and further distributes it inland, as well as a designated service site to ensure efficient maintenance and repair of offshore windmills.

The last third stage is related to the dismantling of offshore wind turbines for technical or economic reasons (replacing worn-out turbines with new ones). This stage is both labor-intensive and cost-intensive.

Offshore wind farms are to generate energy of 5.9 GW in 2030, and up to 11 GW in 2040, thus clean energy (free of CO2 emissions) will power thousands of households in Poland (Ministerstwo Klimatu i Środowiska, 2024).

4.5. Logistics of distribution of clean seawater

With climate change, more and more areas are deprived or have limited sources of access to drinking water. Due to this limitation, in the future, industrial-scale seawater purification plants will be built, which will purify salty sea water from physiological saline to the level of 99%, (Dreizin et al., 2008) and then the purified water will be distributed inland to meet the needs of people, agriculture and industry. Agriculture, in particular, may gain the opportunity to become independent from rainwater here. In order to use the available seawater resources, it is necessary not only to build infrastructure for its collection and distribution of purified drinking water, but also to make efforts to clean seawater from garbage lying at the bottom of the sea basin.

4.6. Logistics of breeding, fishing and marine agriculture

Another important area of development of the maritime industry is breeding, fishing and marine agriculture. These three areas also require a number of logistic activities related to breeding, fishing and plant cultivation under the sea. A good example of breeding is fish and shellfish farming (Food and Agriculture Organization of the United Nations 2020). For example, salmon is farmed in Scotland and Norway and then distributed to various parts of the world. In turn, within fishing we distinguish industrial fishing "carried out using specialized vessels - trawlers, purse seiners "trawlers and purse seiners can also perform processing and freezing functions", luggers, cutters, fishing boats, shrimp vessels, and recreational fishing - coastal and high seas, where the owner of the fishing boat provides organization and transport the clients to the fishing area and they participate in the fishing themselves using your own or rented fishing equipment.

Each of these fishing areas requires a different approach to the process of logistics handling of the obtained catches. Another area of the developing maritime industry is the agriculture of plants under sea waters, in particular the cultivation of "macro and micro algae" seaweed. Cultivated seaweed is increasingly used as: biomass for electricity production; as biomass for the production of biofuel; specialized chemicals for food, cosmetic and pharmaceutical processing, fertilizers for soil and animal feed, as well as for nutritional needs, as algae are rich in proteins and vitamins (Okinawa, 2016; Quinn et al., 2011; Dębowski et al., 2013). Algae are cultivated in a marine environment, for example in Zanzibar, and then distributed to various commercial destinations. All these applications require a different approach to logistics processes.

4.7. Logistics of water sports

Another important industry related to maritime logistics is sports and recreation, most often practiced in coastal areas of the sea or ocean. The wide spectrum of human needs related to sports and water recreation has resulted in the separation of many activities, in particular: regattas, surfing, kitesurfing, yachting, SUP board, kayaking, wakeboarding, diving, snorkelling, windsurfing, water skiing, parasailing, sailing, flyboarding, diving, freediving, jet surfing, fishing and cage diving. Each of these collective and individual sports requires a different approach to maritime logistics services.

4.8. Logistics of marine waste and recycling

Pollution of sea waters, including port waters, is a challenge for modern maritime economy and is a serious problem of modern civilization in the field of environmental protection. With economic and technical development, humans have contributed to the pollution of sea waters, including microplastics (Upendra & Kaur, 2023). However, apart from this relatively new pollution of sea waters, a significant threat still comes from petroleum waste generated by the operation of engines, after washing cargo tanks, oil-water emulsions, or after cleaning exhaust gases in the exhaust manifolds of seagoing ships. In order to neutralize various pollutants related to the functioning of the maritime economy, activities are carried out based on new technologies, as a result of which waste is collected and then processed mechanically, chemically and biologically, along with disinfection and ozonation, which comprehensively ensure effective neutralization.

Ballast water received from the ship is neutralized by disinfection using ozonation and the use of a UV reactor, which effectively sterilizes the water so that it does not pose a threat to the marine environment. This diversity of marine waste and the activities undertaken in the field of recycling require a number of different logistics processes typical of maritime logistics. In addition, sea waters are polluted by: municipal sewage, industrial pollution, chemical fertilizers, including pesticides, detergents, remains of weapons, including chemical ones left after World War II, leaks of fuel and other chemicals from shipwrecks lying on the seabed and abandoned or broken fishing nets. In the near future, there will be additional pollution related to unmanned underwater vehicles, which will be increasingly used for military purposes by various countries, i.e. they will be used for espionage, provocative activities and warfare.

Unmanned vehicles of this type mean that even countries significantly distant from their enemies can no longer feel safe and must create systems enabling them to neutralize this type of offensive or military activities. In the latter time, unmanned underwater vehicles will be equipped with explosives, which means an additional risk of pollution for the oceans and seas, as well as for global maritime trade. Unfortunately, underwater and surface unmanned vehicles can be used as terrorist weapons by terrorists or pirates, which may negatively impact the security of maritime supply chains (Klimek & Marek, 2011). This means that there will be no need to kidnap crews or ships, as it has been the case so far, and it will be enough to terrorize sea and ocean carriers with the destruction of their ships to achieve the same effect.

This may have consequences for maritime trade and therefore world trade. Such actions may contribute to an increase in freight rates to cover the costs of ransoms paid to terrorists, an increase in insurance prices, expenses related to changes in ship routes, and expenses for the purchase of direct protection measures against attacks by sea robbers. Owners of offshore wind farms, sea ports and rich seaside towns that rely on tourist resources will also face a similar problem. In order to overcome the upcoming problems with the development of technology enabling the use of surface and underwater unmanned vehicles, a system should be created to neutralize this type of terrorist and military acts and to cleanse their elements from the bottom of various sea and ocean waters, in close future.

5. Proposed definition of maritime logistics

Maritime logistics is becoming more and more important, more and more complex, an unpredictable variable and, as a result, more and more interesting due to the fact that the world economy is subject to a process of permanent changes - globalization - deglobalisation "process of near-shoring, near-sourcing, reshoring", lengthening, shortening, dilution, narrowing, interruption, construction of a new configuration of supply chains and many other trends and changes, the most important of which is considered to be digitalization, automation, robotisation, climate change, changes in behaviour on the labour market, changes in the availability of resources and their distribution, fuel challenges, economic and management challenges and international regulations regarding environmental protection. A number of these factors affecting maritime logistics make it difficult to clearly define this concept.

Defining the concept of maritime logistics by many scientists mainly refers to the transport of containers by sea carried out within the triad of enterprises "sea freight forwarders - container terminal operators - sea carriers". This triad of companies is mainly responsible for the smooth flow of containerized units, cargo and information throughout the entire container logistics chain. This approach and understanding of maritime logistics can be found both among its precursors and successors who attempted to clarify it. To confirm this argument, it seems justified to quote several important definitions of maritime logistics:

1. According to Panayides (2006, p. 3), "maritime logistics is a concept that applies the principles of logistics and supply chain management to maritime transport, including ports".
2. Gudehus and Kotzab (2012) state that the operational task of maritime logistics is to transport cargo by ships on rivers, canals and seas with the minimum possible costs, fuel consumption and emissions. To achieve this, optimal shipping networks and maritime transport chains.
3. Maritime logistics as a concept has evolved following the development of multimodal and intermodal transport, and in particular the physical integration of different modes of transport, which occurred after the emergence of container intermodality (D'este, 1993).
4. In turn, Nam and Song (2011) state that maritime logistics concerns maritime transport (i.e. forwarding and ports), traditional logistics functions (e.g. warehousing, warehousing and offering distribution center services) and integrated logistics activities (e.g. value value-added services including labelling, assembly and repair). Based on the above, research will fall within a maritime logistics perspective if it (i) applies the theoretical context of logistics and/or supply chain to maritime transport and/or (ii) adopts a supply chain perspective that includes the maritime section and/or port operations as unit of analysis.

5. Song and Lee (2012, p. 15)define maritime logistics as "the process of planning, implementing and managing the movement of goods and information related to ocean transport".
6. According to K. Ficoń (2013, p. 5), maritime logistics is "the process of managing a logistic supply chain covering a section of a sea route using sea transport means and port technologies for reloading operations".

Based on the above-mentioned definitions of maritime logistics, the following definitions can be proposed: *Maritime logistics is the process of planning, organizing, directing, controlling and coordinating the flow of material goods, cargo units and services carried out by maritime companies in order to ensure the efficient, effective and safe flow of material goods, cargo units and services, as well as related information and logistics support methods necessary for the operation of the green maritime logistics chain*.

In this definition, the concept of a material good was deliberately introduced, since consumer goods are not only moved in cargo units but are also transported in bulk. An example would be coal.

At the same time, in the definition, the flow of material goods is supposed to be efficient in terms of customer service for maritime logistics entities. This refers to the organizational aspect and the efficiency aspect, that is, optimizing the level of costs of moving material goods from the point of shipment to the point of receipt while maintaining the accepted level of quality of customer service. In addition, the movement must be carried out in a safe manner for both people, material goods, the vessel and the environment. Safety and security of the movement of material goods in maritime logistics are ensured by existing laws, regulations and international conventions.

Also, the specificity of information and its carriers in the form of documentation is characteristic of maritime transport, which can be an additional contribution to its emphasis. Such peculiarities may include: the different types of charters used in maritime transport, documents accompanying the cargo and the ship, during the sea voyage.

Logistics support methods are designed to ensure its the operational availability, reliability, efficiency, effectiveness, safety and security of maritime logistics subsystems.

In the proposed definition, the concept of a green maritime supply chain is present, as it is crucial to look for logistics solutions that are environmentally friendly. The search for optimal solutions between efficiency in the movement of material goods, cargo units and the provision of services and the protection of the natural environment is currently a huge challenge, both in terms of image and regulation. The regulatory ones stem from regulations established by the IMO (Caliskan, Ozturkoglu, 2016) and the ESG reporting directive adopted in the European Union (Directive EU 2022/2464).

The multiplicity of areas and aspects of considering the concept of maritime logistics makes it difficult to identify its key characteristic features. All in all, the main emphasis is on the flow of material goods at one time, services at another, and people (e.g., seafarers, platform workers, repair brigades, ship passengers) along with the information pertaining to them. The goal of maritime logistics is to optimize the flow according to a number of criteria: time, place, cost, safety and security (of people, vessel, cargo, marine environment), quality, etc. Finding the optimum for these assumed parameters is not a simple task, especially since there are no reference points for these parameters in maritime logistics. The inability to create reference parameters is due to the fact that it is not possible to conduct comparable experiments under ceteris paribus conditions, since both the object under study, such as seaports, and its environment change in a turbulent and unique way. This means that the smooth flow obtained under baseline conditions will prove unreliable in the near unpredictable future, such as interference due to the covid-19 pandemic that has occurred, Russia's war in Ukraine, or the armed conflict between Israel and Palestine. Consequently, the search remains for general formulations that enable a smooth flow in the maritime supply chain. This smooth flow of material goods, services and people should translate into stability and security, and consequently into economic efficiency for maritime logistics participants.

The presented approaches to maritime logistics, focus on the object-oriented view, which includes the physical processes of the movement of goods between companies operating in the sphere of the maritime supply chain and the accompanying flows of information. It seems at this point, to draw attention to the fact that the movement of goods within the framework of maritime logistics, increases the utility value of the place and time of the goods moved and in no way contributes to their value as a result of processing - utility of form - simply does not occur here. In other words, within the framework of maritime logistics we are not dealing with the traditional logistics system found in the sphere of production, where production entities move goods in a system of three logistics subsystems - procurement, production and distribution.

However, maritime logistics should be viewed in the context of the rapidly growing maritime industry, which has a wide area of activity, as it encompasses central, regional and maritime administration; classification, surveillance, survey and certification institutions; marine and transportation insurance; production, repair and scrap yards; ship and port equipment manufacturers; ship equipment and container repair facilities; maritime trading companies; shipping companies; ports and port service companies; maritime logistics and shipping companies; maritime agents and brokers; customs agencies and offices; the dockside industry and hydrotechnical construction; fishing and marine fish processing; crew agents and seafarer placement companies; maritime yachting; scientific research and training institutions; design, IT, consulting, legal and promotional companies; publishing houses, newspapers, cultural and educational institutions; professional and social organizations. Within the framework of the aforementioned areas of maritime and oceanic activity, new ones are emerging, which as a result of technical and technological progress is becoming an increasingly complex economic and thus logistical subsystem.

6. Conclusion

In recent years, a clear increase in interest in maritime logistics has been observed. Studies have appeared on the scientific market presenting the issues of maritime logistics in various theoretical contexts, and in each of them this concept has a different meaning, although in many cases it focuses on the logistic service of cargo and cargo units - sea containers. The literature on maritime logistics is becoming more and more extensive and contains many different definitions that more or less precisely define the concept of maritime logistics, concisely or broadly defining its scope, role and functions in the mutual relations between the entities of the maritime triad and in relation to ecology. Their content, the phrases used and the emphasis may depend on the field of science it represents and in the name of which researchers deal with the issues of maritime logistics. Of course, these definitions, despite their different approaches, have common features. In each case, we are talking about the logistics process, logistic objects - ship, handling and transport devices, cargo, loading unit" and the relations between these objects - these are important elements of the concept of maritime logistics.

As shown in the article, the scope of maritime logistics is much broader and does not focus only on the handling of cargo and transport units transported by sea. The scope of maritime logistics is expanding as a result of technical and technological progress in the field of mechanization, automation, autonomisation, robotisation, computer science, artificial intelligence and marine biology. The scope of maritime logistics, as shown in the article, is wide, although in many areas not yet researched: "logistics of rare resources, logistics of recycling waste located at the bottom of the oceans and seas, logistics of electricity distribution, logistics of distribution of sea drinking water, logistics of sea crops". At the same time, there are more and more new challenges affecting maritime logistics in the form of environmental protection requirements, including zero greenhouse gas emissions in the form of the EU directive ETS-2 - CO2 emission allowance trading system (ETS EU). Based on the extended scope of maritime logistics, a new definition was proposed, which presents a broader approach to the concept of logistics, i.e., it focuses not only on the movement of cargo and cargo units but also on services related to the handling of people within maritime logistics. The division of the scope of maritime logistics is of a conventional nature and only expresses certain directions of integration of the maritime industry, which requires a specific logistics approach.

Another approach to addressing the lack of consensus definition is to search for consensus in the "sub-disciplines" related to maritime logistics, or the disciplines that contribute to the body of knowledge in maritime logistics, and attempt to quantify these by category. It should also be noted that not only has maritime logistics as a discipline failed to reach consensus, other disciplines, such as information systems, have gone through similar struggles for identity and definition.

Future research should provide more detailed information on the scope and role of maritime logistics in contemporary international and global logistics. Assuming that the survey participants were familiar with maritime logistics due to their declared business activities, each defined it through the lens of their operational activities rather than in a broader context. Therefore, the results of the face-to-face interview should be interpreted as a prelude to further research on the state of knowledge about maritime logistics and its scope. Furthermore, future research should develop more differentiated approaches to determining the attitudes of maritime logistics companies and the types of services they provide.

Declaration of Generative AI and AI-assisted technologies in the writing process

While preparing this work, the author did not use any tool/service.

References

Ahmed, W.A.H., & Rios A. (2022). Digitalization of the international shipping and maritime logistics industry: a case study of TradeLens. In B.L. MacCarthy & D. Ivanov (Eds.), *The Digital Supply Chain* (pp.309-323). https://doi.org/10.1016/B978-0-323-91614-1.00018-6

Caliskan, A. & Ozturkoglu, Y. (2016). Maritime Logistics. In A. Ochoa-Zezzatti, J. Sánchez, M.G. Cedillo-Campos, & M. de Lourdes (Eds.), *Handbook of Research on Military, Aeronautical, and Maritime Logistics and Operations* (pp. 377-384).

Council of Supply Chain Management Professionals. (2025). Supply chain management definitions and glossary of terms. Retrieved June 20, 2025, from https://cscmp.org/CSCMP/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms.aspx

D'Este, G. (1996). An event-based approach to modelling intermodal freight systems. In D. A. Hensher, J. King, & T. H. Oum (Eds.), World transport research: Proceedings of 7th World Conference on Transport Research (Vol. 4, pp. 3-14). Pergamon/Elsevier Science.

De Andres Gonzalez, O., Koivisto, H., Mustonen, J. M., & Keinänen-Toivola, M. M. (2021). Digitalization in just-in-time approach as a sustainable solution for maritime logistics in the Baltic Sea region. *Sustainability, 13*(3), 1173. https://doi.org/10.3390/su13031173

Dębowski, M., Zieliński, M., Grala, A., & Dudek, M. (2013). Algae biomass as an alternative substrate in biogas production technologies—Review. *Renewable and Sustainable Energy Reviews, 27*, 596–604. https://doi.org/10.1016/j.rser.2013.07.029

European Parliament and Council of the European Union. (2022). Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting. *Official Journal of the European Union, L 322*, 15–64. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022L2464

Feng, X., Liu, M., Zhang, W., Yin, W., & Chao, Y. (2025). The impacts of pilotage planning on green maritime logistics. *Regional Studies in Marine Science, 55*, 102748. https://doi.org/10.1016/j.rsma.2024.103989

Ficoń, K. (2013). Logistyka morska. Statki, porty, spedycja [Maritime logistics: Ships, ports, forwarding]. Bel Studio.

Food and Agriculture Organization of the United Nations. (2020). Economic value of ecosystem services from the deep seas and the areas beyond national jurisdiction (No. 1210 FIAF/C1210 (En), pp. 1–117).

Grzelakowski, A. S. (2018). Transport conditions of the global economy. *Transport Economics and Logistics, 80*, 75-84. https://doi.org/10.26881/etil.2018.80.08

Gudehus, T., & Kotzab, H. (2012). *Comprehensive logistics* (2nd ed.). Springer.

Guri, R., Copping, A., Huesemann, M., Forster, J., & Benemann, J. (2008, March 31). Techno-economic feasibility analysis of offshore seaweed farming for bioenergy and biobased products. PNWD-3931. Pacific Northwest National Laboratory. https://www.marineagronomy.org/sites/default/files/Roesijadi%20et%20al.%202008%20Techno-economic%20feasibility%20of%20offshore%20seaweed%20farming.pdf

Hameri, A-P., Borg, A., & Eloranta, E. (2014). Vendor-management in a global maritime supply chain – The case of a Brazilian pulp producer. *Maritime Economics & Logistics, 16*(2), 207–227.

Hein, J. R., Conrad, R. T., & Dunham, R. E. (2009). Seamount characteristics and mine-site model applied to exploration- and mining-lease-block selection for cobalt-rich ferromanganese crusts. *Marine Georesources & Geotechnology, 27*(2), 160-176. https://doi.org/10.1080/10641190902852485

Herzig, P. M., & Hannington, M. D. (1995). Polymetallic massive sulfides at the modern seafloor:A review. *Ore Geology Reviews*, 10(2), 95–115.

International Maritime Organization. (2001). *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978: As amended 1995 and 1997*. International Maritime Organization.

IUCN. (2024, November 24). Deep-sea mining. https://iucn.org/resources/issues-brief/deep-sea-mining

Karaś, A. (2020). Smart port as a key to the future development of modern ports. *TransNav: The International Journal on Marine Navigation and Safety of Sea Transportation, 14*(1), 27–31. https://doi.org/10.12716/1001.14.01.01

Klimek, H., & Marek, R. (2011). Żegluga morska wobec zagrożeń piractwem i terroryzmem [Maritime shipping in the face of piracy and terrorism threats]. *Studia i Materiały Instytutu Transportu i Handlu Morskiego, Zeszyty Naukowe Uniwersytetu Gdańskiego*, 8, 91–92.

Lange, A-K., & Grafelmann, M. (2022). Digitalization of maritime logistics systems. In M. Grafelmann & A-K. Lange (Eds.), *Digitalization of Maritime Logistics Systems* (pp. 95–116). Springer.

Lee, E-S., Nam, H-S., & Song, D-W. (2012). Defining maritime logistics and its value. In D-W. Song & P. M. Panayides (Eds.), *Maritime logistics: A complete guide to effective shipping and port management* (pp. 9-21). Elsevier.

Lorange, P. (2001). Strategic re-thinking in shipping companies. *Maritime Policy & Management, 28*(1), 23–32.

Lorange, P. (2009). *Shipping strategy: Innovating for success*. Cambridge University Press.

Ma, W. (2019). Sustainability of deep sea mining transport plans [Doctoral dissertation, Delft University of Technology]. TRAIL Research School. https://doi.org/10.4233/uuid:19f390f7-1814-4c28-b01e-a1ff84f20415

Marek, R. (2015). Globalne alianse strategiczne w żegludze kontenerowej [Global strategic alliances in container shipping]. *Studia i Materiały Instytutu Transportu i Handlu Morskiego, Zeszyty Naukowe Uniwersytetu Gdańskiego*, 12, 11-37.

Marek, R. (2019). Marine container terminal complexity. In M. Vinogradova, A. Cuic Tankovic, & G. Pavelin (Eds.), *Economic and Social Development: 45th International Scientific Conference on Economic and Social Development – XIX International Social Congress*, Moscow, 17–18 October 2019. Book of proceedings (pp. 139–153). Varazdin Development and Entrepreneurship Agency

Marek, R. (2021). Changes in the technology of moving containers inside sea container terminals: From conventional to automated technology. In Proceedings of the 37th International Business Information Management Association (IBIMA), Cordoba, Spain (pp. 12249–12257).

Marek, R. (2022). A proposal to define and classify the logistics strategies of maritime container terminal operators. In *Research in Business Innovation, Management, and Performance: 40MGT 2022* (Article 4024322). IBIMA Publishing.

Ministerstwo Klimatu i Środowiska. (2024, November 12). Program rozwoju morskich farm wiatrowych [Offshore wind farm development program]. https://www.gov.pl/web/morska-energetyka-wiatrowa/program-rozwoju-morskich-farm-wiatrowych

Misztal, K. (2010). Organizacja i funkcjonowanie portów morskich [Organization and functioning of seaports]. Wydawnictwo Uniwersytetu Gdańskiego.

Nam, H-S., & Song, D-W. (2021). Defining maritime logistics hub and its implication for container port. *Maritime Policy & Management, 38*, 269–292.

Norman, T., Robles, P., & Jeldres, R. I. (2022). Seabed mineral resources, an alternative for the future of renewable energy: A critical review. *Ore Geology Reviews, 126*, 125–134.

Okinawa Institute of Science and Technology Graduate University. (2016, August 9). Okinawa mozuku – the treasure under the sea. https://www.oist.jp/news-center/press-releases/okinawa-mozuku-%E2%80%93-treasure-under-se

Panayides, P.M. (2006). Maritime logistics and global supply chains: Towards a research agenda. *Maritime Economics & Logistics, 8*, 3–18.

Parola, F., Satta, G., & Panayides, P. (2015). Corporate strategies and profitability of maritime logistics firms. *Maritime Economics & Logistics, 17*(1), 52–78.

Pluciński, M. (2013). Polskie porty morskie – w zmieniającym się otoczeniu zewnętrznym [Polish seaports in a changing external environment]. CeDeWu.pl.

Psaraftis, H. N. (2016). Green maritime logistics: The quest for win-win solutions. *Transportation Research Procedia, 14*, 133–142.

Quinn, J. C., Catton, K., Wagner, N., & Bradley, T. H. (2011). Current large-scale US biofuel potential from microalgae cultivated in photobioreactors. *BioEnergy Research, 4*, 41–53. https://doi.org/10.1007/s12155-011-9165-z

Sitlhou, L., & Chakraborty, P. (2024). Comparing deep-sea polymetallic nodule mining technologies and evaluating their probable impacts on deep-pollution. *Marine Pollution Bulletin, 183*, 114038.

Soares, C. G. (2023). Intelligent shipping technology and development trend. In Proceedings of the 1st World Conference on Navigation Science and Technology, Qingdao, China.

Song, D-W., & Lee, E-S. (2012). Coopetitive networks, knowledge acquisition and maritime logistics value. *International Journal of Logistics Research, 15*, 15–35.

Stopford, M. (2009). *Maritime economics* (3rd ed.). Taylor & Francis.

Upendra, S., & Kaur, J. (2023). Microplastic pollution in seawater: A review study. *Nature Environment and Pollution Technology, 22*, 1635–1641.

Van Dover, C. L., Colaço, A., Collins, P. C., Croot, P., Metaxas, A., Murton, B. J., Swaddling, A., Boschen-Rose, R. E., Carlsson, J., Cuyvers, L., Fukushima, T., Gartman, A., Kennedy, R., Kriete, C., Mestre, N. C., Molodtsova, T., Myhrvold, A., Pelleterr, E., Popoola, S. O., Qian, P-Y., Sarrazin, J., Sharma, S., Suh, Y. J., Sylvan, J. B., Tao, C., Tomczak, M., & Vermilye, J. (2020). Research is needed to inform environmental management of hydrothermally inactive and extinct polymetallic sulfide (PMS) deposits. *Marine Policy, 121*, 104183

Vysetti, B. Deep-sea mineral deposits as a future source of critical metals, and environmental issues - a brief review. *Minerals and Mineral Materials, 2*(2), 5. http://dx.doi.org/10.20517/mmm.2022.12

Wagner, N., & Wiśnicki, B. (2019). Application of blockchain technology in maritime logistics. *Dubrovnik International Economic Meeting, 4*, 155–164.

World Bank. (2016). Precautionary management of deep sea mining potential in Pacific Island countries. https://cer.org.za/wp-content/uploads/2016/08/World-Bank-Precautionary-Management-ofDeep-Sea-Mining.pdf

Young-Joon Seo, Y.-J., Dinwoodie, J., & Roe, M. (2015). The influence of supply chain collaboration on collaborative advantage and port performance in maritime logistics. *International Journal of Logistics Research and Applications, 19*(6), 133–142.

Yuen, K. F., & Thai, V. (2017). Barriers to supply chain integration in the maritime logistics industry. *Maritime Economics & Logistics, 19*, 551–572.

Zenghui, L., Kai, L., Xuguang, Ch., Zhengkuo, M., Rui, Lv, L., Changyun, W., & Ke, M. (2023). Deep-sea rock mechanics and mining technology: State of the art and perspectives. *International Journal of Mining Science and Technology, 33*, 1085–1098.