

## An analysis of the size of ships entering Szczecin including oversize vessels

## Analiza wielkości statków zawijających do Szczecina z uwzględnieniem jednostek ponadnormatywnych

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**Key words:** vessel traffic, port of Szczecin, underkeel clearance

### Abstract

The paper presents an analysis of vessels entering the port of Szczecin in 2011 in terms of their size. The analysis comprises such ship parameters as length, breadth and draught. Focus has been put on those ships that require special entrance permission from Harbour Master. The analysis results can be useful in modeling vessel traffic streams and the assessment of traffic intensity on a waterway.

**Słowa kluczowe:** ruch statków, port w Szczecinie, zapas wody pod stępką

### Abstrakt

W artykule dokonano analizy jednostek wchodzących w roku 2011 do portu w Szczecinie, koncentrując się na ich wielkości. Analizom poddano takie parametry jak: długość, szerokość i zanurzenie. Szczególnie skoncentrowano się na jednostkach wymagających indywidualnego pozwolenia na wyjście od kapitana portu z uwagi na swoje gabaryty. Wyniki takich analiz mogą być pomocne w budowie modeli strumieni ruchu statków oraz oceny obciążenia drogi wodnej przez przechodzące nią statki.

### Introduction

The analysis covers vessels that entered the port of Szczecin in 2010 and 2011. Data needed to do the mentioned analysis were obtained from electronic records of the MIS (Management Information System) system. This integrated system of data bases is part of the equipment of VTS Świnoujście – Szczecin operator's stations. The system recorded ships' parameters separated for the analysis:

- ship's name;
- berth;
- length overall;
- draft;
- breadth;
- date of entry.

### Legal regulations for maximum size and oversize vessels

The vessels under consideration are those with a maximum size as provided by local regulations of the port of Szczecin. In Szczecin–Świnoujście Port Regulations from 17 September 2002 with amendments, published in subsequent additional regulations between 10 April 2003 and 4 August 2008, further referred to as the port regulations, the following information can be found [1]:

§ 54

1. Length overall of ships entering and leaving the port of Szczecin (..) cannot exceed 215 m, and breadth overall 31 m.
2. Draft of ships entering and leaving the port of Szczecin cannot exceed 9.15 m with length overall not more than 160 m.

3. The interrelations between maximum length, breadth and draft of a ship with a length overall above 160 m entering the port of w Szczecin are given in a Table, an appendix No. 8 to the directive. (..)
6. Ships that are to be loaded to a draft defined in sections 2, 3, 4 and 5 should report to the competent Harbour Master or VTS centre, not later than 12 hours before completion of loading in Szczecin or lighterage in Świnoujście.
7. Ships with a length overall from 180 m to 200 m are allowed to move in visibility not less than 2 Nm, and at night each time permission shall be granted on conditions defined by Harbour Master upon consultation with the chief pilot.
8. Ships with a length overall over 200 m or draft exceeding 9 m are allowed to proceed only at daytime in visibility not less than 2 Nm.
9. Passenger ships with a length overall over 200 m are allowed to proceed at night on conditions defined by Harbour Master.

## § 72

- 1 Ships underway having abeam the northern head of Kosa Peninsula in Świnoujście proceeding to the port of Szczecin or Police, with a draft more than 7.40 m or length over 160 m, shall exhibit lights and shapes as provided in COLREGs for ships restricted by draft.

## § 126

1. In the port of Szczecin ships are permitted to berth along the following quays:
  - 1) Huk, Mak, Holenderskie, Belgijskie, Angielskie, Polskie, Węgierskie, Greckie, Albańskie, Jugosłowiańskie, Bułgarskie, Noteckie and Gnieźnieńskie and the dolphin island on the Odra River – within a zone up to 24 m wide;
  - 2) Snop, Zbożowe, Rumuńskie, Rosyjskie, Starówka, Czeskie, Słowackie, Parnica and Górnośląskie – within a zone up to 28 m wide.
2. In the port of Szczecin, along the quays not mentioned in point 1), ships can be moored in a zone wider than 28 m upon prior consent of Harbour Master.
3. In exceptional cases, Harbour Master may grant permission for a ship to occupy a wider belt of water than that defined in point 1).

Maximum admissible speed of ships in given sections of waterway can be found in above mentioned Port Regulations.

Oversize vessels are defined as such ships which one of main dimensions ( $L$ ,  $B$ ,  $T$ ) is larger than admissible by Port Regulations.

### Analysis of the sizes of vessels entering the port of Szczecin

The examined samples included:

- 2680 records of vessel entries in 2011;
- 35 records relating to oversize vessels in 2011;
- 3120 records of vessel entries in 2010.

The vessels that entered Szczecin in 2011 were analyzed in detail. A single record includes these data:

- ship's name;
- berth;
- length overall;
- draft;
- breadth;
- date of entry.

This analysis made use of those samples only where the ship's length was more than or equal to 50 m. This was aimed at avoiding distortions due to in-port or near-port traffic. A research sample was processed and verified to eliminate errors that often occur in this type of data records (less than 0.5% record was removed due to unrealistic values). Additionally, the parameters such as underkeel clearance at the berth and in the fairway leading to Szczecin were estimated by using data on maximum depths in these areas. Both water levels and ships' squatting for speeds provided by regulations were taken into account. Squat was calculated with maximal speed of ships on given waterway sections and by Barras I method. Other factors affecting underkeel clearance in the fairway were not considered.

The following parameters of the vessels were analyzed:

- length –  $L$  [m];
- draft –  $T$  [m];
- underkeel clearance at berth – UKCn [m];
- underkeel clearance in the fairway – UKCt [m].

Table 1. Quantitative analysis of selected vessel parameters  
Tabela 1. Analiza ilościowa wybranych parametrów statków

Parameter	$L$ [m]	$T$ [m]	UKCn [m]	UKCt [m]
Sample size	2680	2680	2680	2680
Minimum	50.00	1.05	0.30	0.50
Maximum	221.00	9.20	6.15	8.65
Mean	95.07	5.21	2.51	4.49
Median	88.60	5.25	2.57	4.45
Quartile 1	81.40	4.20	1.25	3.63
Quartile 3	106.99	6.07	3.70	5.50
Standard deviation	26.05	1.55	1.51	1.55
Skewness coefficient	1.48	0.01	0.14	-0.01
Relative kurtosis	3.00	0.75	-1.04	0.75

Table 1 presents selected quantitative statistical parameters of the examined data in the form of measurements of central values, variations, symmetry and concentration.

It can be seen from data in table 1 that mean vessel length is less than 100 m, and mean draft is 5.2 m. The kurtosis values for vessel length indicate significant differences between the normal distribution and the kurtosis estimator, which results from a large number of vessels with a length range of 80–90 m. In most such cases there is a need to use non-parametric tests for further statistical inference due to deviations from distribution normality.

**Analysis of the sizes of vessels entering the port of Szczecin**

**Vessel length**

An analysis of lengths of vessels that called at Szczecin in 2011 is illustrated in figure 1, including a bar chart and empirical distribution function, i.e. values of vessel lengths for the probability  $F(L) = P(L < Li)$ .

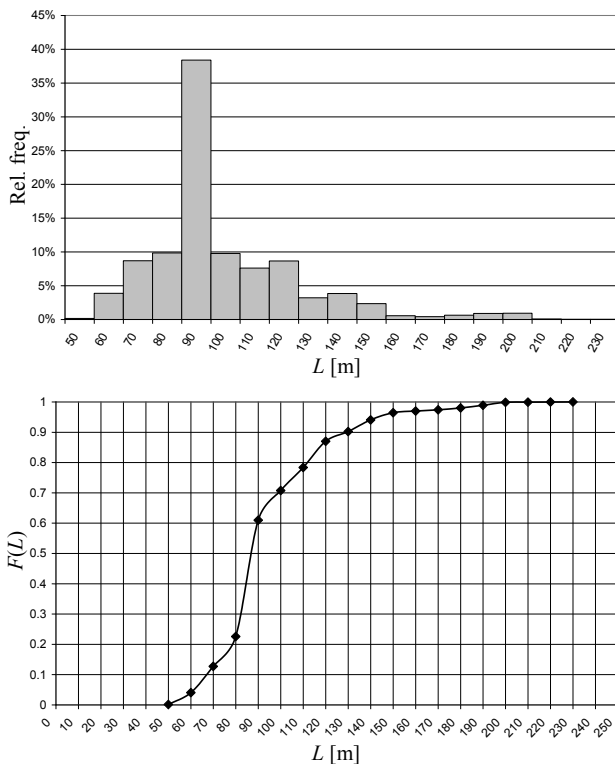


Fig. 1. A histogram and empirical distribution function of vessel lengths for ships entering Szczecin in 2011  
Rys. 1. Histogram i dystrybuanta empiryczna długości statków wchodzących do Szczecina w roku 2011

An analysis of data in figure 1 shows that the most frequently calling vessels were those ranging in length from 80 to 90 metres, as they account for nearly 40% of all vessels. Ships longer than 150 m make up only 0.5% of all arrivals.

**Vessel draft**

An analysis of drafts of vessels that called at Szczecin in 2011 is illustrated in figure 2, including a bar chart and empirical distribution function, i.e. values of vessel drafts for the probability  $F(T) = P(T < Ti)$ .

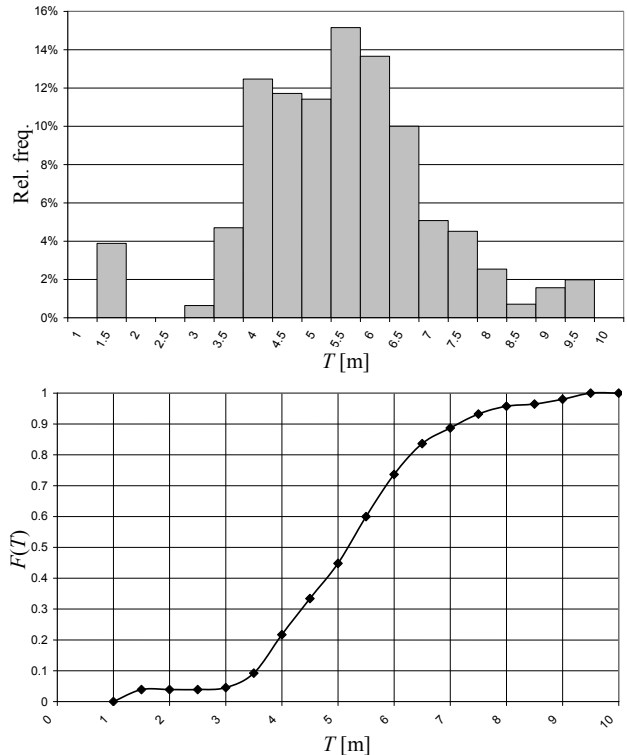


Fig. 2. A histogram and empirical distribution function of drafts of vessels for ships entering Szczecin in 2011  
Rys. 2. Histogram i dystrybuanta empiryczna zanurzeń statków wchodzących do Szczecina w roku 2011

The analysis of data from figure 2 indicates that vessels drawing 3.5 m to 6.5 m make up about 75%. It will be noted that there is a substantial group (4%) of inland vessels with an approximate draft of 1.5 m. Vessels with a maximum draft more than 9 m account for 2% of all entries.

**Analysis of underkeel clearance of vessels entering the port of Szczecin**

**Underkeel clearance at the berth**

An analysis of underkeel clearance (UKC) values at berths of ships calling at Szczecin is given in figure 3, which shows a bar chart and empirical distribution function, i.e. UKC values at the berths for ships for which the probability  $F(UKC_n) = P(UKC_n < UKC_{ni})$ .

An analysis of data in figure 3 allows to state that UKC at the berth shows slight variation (linear distribution function) and oscillates between 0.5 m and 4.5 m for 85% of all considered vessels. It can be noted that there is a group of vessels (14%) that make a maximum use of draft at berths.

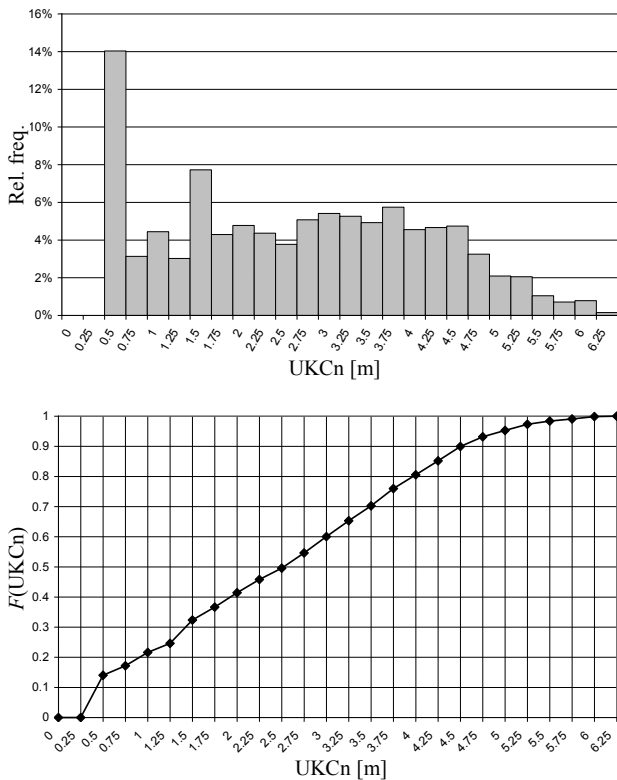


Fig. 3. A histogram and empirical distribution function of UKC at the berth of ships entering Szczecin in 2011  
 Rys. 3. Histogram i dystrybuanta empiryczna zanurzeń statków wchodzących do Szczecina w roku 2011

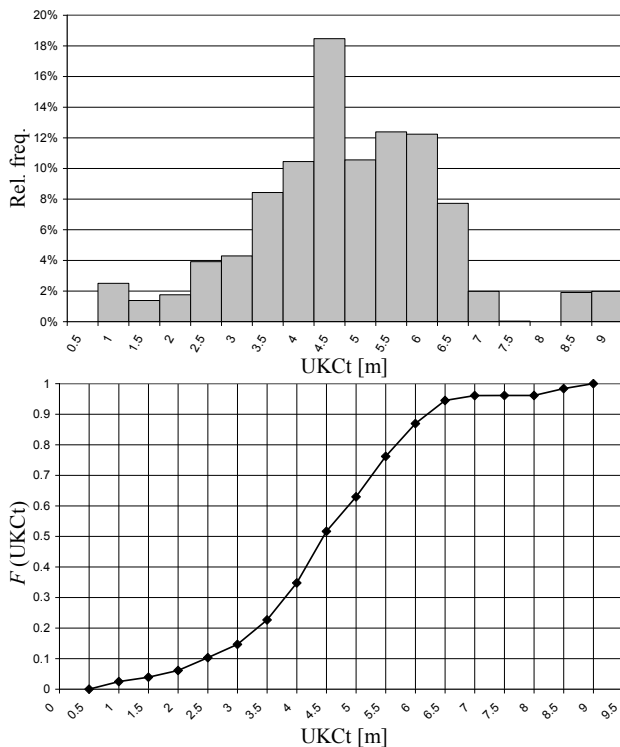


Fig. 4. A histogram and empirical distribution function of theoretical UKC in the fairway for ships entering Szczecin in 2011  
 Rys. 4. Histogram i dystrybuanta empiryczna teoretycznych zapasów wody pod stępką na torze statków wchodzących do Szczecina w roku 2011

**Underkeel clearance in the fairway**

A theoretically calculated UKC for all vessels calling at Szczecin, allowing for squat (calculated by simplified Barras I method) only (no other factors considered) is illustrated in figure 3, including a bar chart and empirical distribution function, i.e. theoretical values of UKC in the fairway for the probability  $F(UKCt) = P(UKCt < UKCti)$ .

An analysis of data in figure 4 allows to observe that UKC in the fairway ranges from 2.5 m to 7.5 m for 90% of vessels arriving in Szczecin. Notably, there is a small group of vessels (less than 3%) that make use of the maximum allowed draft and enter with a theoretical UKC 0.5 m to 1.0 m.

**Comparison of vessels entering Szczecin in 2010 and 2011**

The comparison of the sizes of vessels entering the port of Szczecin in 2010 and the 2012 year does not reveal statistically significant differences. Non-parametric Kolmogorov–Smirnov tests for uniformity were applied in reference to vessel lengths and drafts.

**Analysis of oversize vessels**

In this analysis oversize vessels are understood as vessels whose one parameter even slightly exceeds defined values. Such vessel has to get a permission from Harbour Master each time it intends to enter. The port of Szczecin has the so called dynamic definition that takes into account the relationships between draft, length and breadth of the ship [2]. The decision to grant permission to enter strongly depends on the vessel’s draft and length, and to a large degree on breadth. In port regulations these parameters are strongly correlated, so that as the length and breadth increases, the maximum allowed draft of the vessel rapidly decreases. Therefore, apart from restrictions of maximum draft at approach channels and at the berth, there is a restriction concerning length and breadth. In one year there were 40 such cases where breadth was the critical parameter. According to the regulations, maximum breadth of ships entering Szczecin is 31 m, and more than 30% of oversize ship entries refer to ships over 31 m in breadth.

From the above data on oversize vessels one can observe that the limit draft of 9.15 m was not exceeded. Occasionally the maximum draft was larger than the admissible draft at the berth, which was due to low water level during the vessel entry, but these values ranged from 5 to 7 cm.

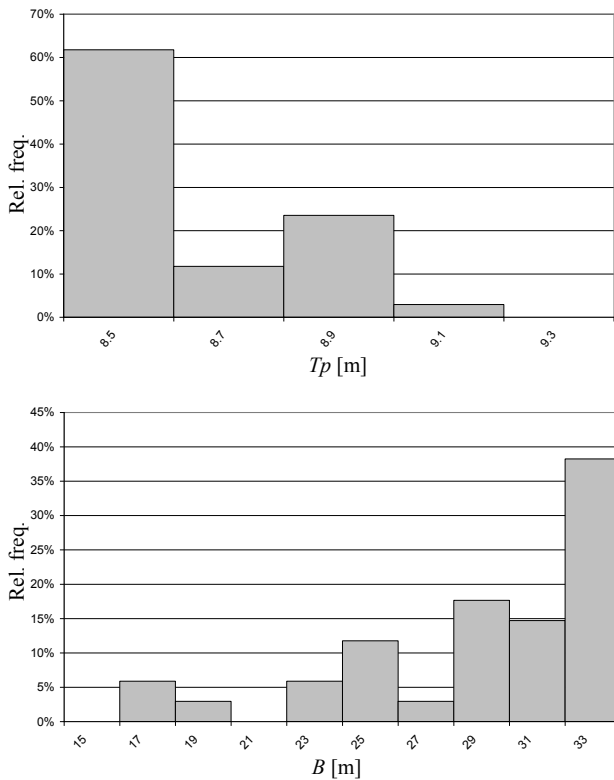


Fig. 5. Histograms of over-standard drafts and breadths of ships entering Szczecin in 2011

Rys. 5. Histogramy ponadgabarytowych zanurzeń i szerokości statków wchodzących do Szczecina w roku 2011

## Conclusions

At present all over the world there is a growing demand for handling increasingly larger vessels in ports. In many cases local harbour regulations impose restrictions that result from excessive safety

margins. An example of this is the determination of a maximum draft of an entering vessel strongly related with its breadth. Port regulations, supposed to minimize the risk of dangerous incidents, are generally based on experience of port users to date. Fast technological progress and development of marine traffic engineering methods will probably necessitate reconsideration of these issues to maximize the port potential.

This article presents analyses of the parameters of ships entering the port of Szczecin. It follows from the available data that the parameters of the existing waterway are exploited to a small degree, which has mainly economical reasons.

One essential factor, the squat of a ship in motion, mainly depends on ship speed and should be thoroughly examined and determined dynamically. The relevant system may bring substantial savings in expenditure on waterway dredging.

The relations between ship's length, breadth, draft and speed should be considered comprehensively for ships en route, at port approaches and along the berth with an aim of developing an advisory system for ships allowed to enter the port.

The performed analyses are vital in reference to plans of modernizing the waterway leading to Szczecin by increasing its depth to 12.5 m.

## References

1. Świnoujście-Szczecin Port Regulations from 17 September 2002 ([www.ums.gov.pl](http://www.ums.gov.pl)).
2. HAJDUK J.: Termin „statek maksymalny” w inżynierii ruchu morskiego. *Inżynieria Morska i Geotechnika*, 5, 1998.