« The Warehouse of the World ». A Comment on Rome's Supply Chain during the Empire [1]

Johann Rasmus Brandt

The above quotation used in the title is borrowed from Aelius Aristides, *To Rome*,[2] and which I recently read in an illuminating article by Geoffrey Rickman, where he presented some generic thoughts on storage capacities of imported wares in Rome, Ostia, and Portus.[3] Rickman did not, however, discuss how goods were brought to Rome, a problem which he has previously touched upon.[4] The same problem has been drafted by other scholars, though, more so in relation to the quantity of imports and the capacity of harbours and warehouses, than as to the practical implementation of actually getting commodities to their final destination.[5]

All who want to discuss imports and transport of commodities to Rome walk into a quagmire of uncertain quantifications, recently demonstrated by André Tchernia.[6] Neither the Greeks nor the Romans paid much interest in quantifying numbers, and even less in making statistics. Classical scholars interested in this kind of research on past civilizations must first therefore make an evaluation of the available ancient data, and then discuss the modern calculated data before putting forward their own interpretations. In general the studies on imports have focused upon one commodity, and whenever seldom more than one commodity is discussed, they get treated independently of each other.

As the reader may have understood already, this article shall be about numbers. I do not intend to analyse economic models and market mechanisms, but rather look at the quantity of commodities imported to Rome, the transport routes and the receiving apparatus. What importance did the sea, harbours, rivers and roads play in this system? Where were the weak links in the supply chain. Were there any restrictions on the quantity of supplies the city could receive? In order to approach a more complete picture I will retrace along the way some well discussed arguments.

To again quote Aristides, in his praise of Rome he could tell that « ... so many ships arrive here, conveying every kind of goods from every people every hour and every day... », and further on that « ... the arrivals and departures of the ships never stop, so that one would express admiration not only for the harbour, but even for the sea. »[7] Was this praise of Rome only panegyric exaggerations, or did it contain some self-experienced truth?

The transport infrastructure

« All roads lead to Rome » is a metaphor for an infrastructure which not only included communication over land, but over sea as well. By the Late Republic and Early Empire Rome had turned the Mediterranean into a *mare nostrum* and from every port along its shores ships brought wares to the capital of the empire. At the same time a network of roads had been created, which likewise played an important role in the distribution of wares between producer and consumer. And finally there was the Tiber, which brought local products down the river from the Italian inland and carried overseas products up from the large harbours by the river mouth.[8] It was a complex system that had taken a long time to create and which needed constant maintenance. Its roots went back to the end of the fourth century BC, when Rome started its expansion and the Appian Way was built and Ostia founded. Then now on a central theme in all Roman public building policy was to ensure that the commodities leaving the producer arrived safely to the consumer. Roads and ports had to be built and maintained for land, river, and maritime transport, and adequate storage space for the commodities secured.

The Appian Way was planned and built as a military road in the midst of the Samnite wars, but also became, as all the later long-distance public roads or highways, an important communication route for travellers, the *cursus publicus*, and the transport

[1] The observations in this article were first put forward at a seminar for Classical Norwegian scholars in Rome in 1993, later published in Brandt 1996, and presented in May 1999 in a lecture in English at the British School at Rome. The present article departs from the published article in Norwegian, expands on its arguments, including new material published in recent years. When the present article was ready to go to the editors I came across Aldrete, Mattingly 1999, an article which, in one of its sections, follows a line of arguments in many ways similar to the one I shall do, but has a different aim and conclusion.

[2] Aristid. *Or.* 26.11.

[3] Rickman 2002, p. 361. In this context I prefer Rickman's translation 'warehouse' of the Greek word *ergasterion* to Behr's (1981) literary more correct 'factory'.

[4] Rickman 1980a, pp. 13-20; 1980b, p. 267; 1991; cf. also Pomey, Tchernia 1980-1981, pp. 39-45; Brandt 1996; Tchernia 2000, p. 758; cf. also Zevi 2001a, pp. 276-277; 2001b, pp. 118-119; 2004, p. 216.

[5] See, for example, Rickman 1971; 2002; Fellmeth 1991. Aldrete, Mattingly 1999 is an exception.

[6] Tchernia 2000; cf. also Hesnard 2001, pp. 286-291; Rickman 2002, p. 359: "Any attempts at quantification has of course to rely on sets of assumptions".

[7] Aristid. *Or.* 26.11 and 13.

[8] For the importance of the river, see latest, Patterson 2004.

Fig. 1. Map of Central Italy with the names of places mentioned in the text.

of commodities. These major roads were knit together in a wider network of vicinal roads, giving small villages' access to each other and to markets and towns. The importance of the vicinal roads in the movement of products from producer to consumer can not be underestimated, but the distribution was above all of local character. In Rome's early days the city was supplied mainly by the use of roads from its surrounding *campagna*, but as the city grew supplies had to be transported from further and further away. The drawback of lands transport was slowness and smaller volume. The Tiber was a part of Rome's supply system from early on, and eventually it was the waterways, including the sea, which kept the city alive. It is specifically in this context that the Tiber's *ostium* played an important role.

Ostia was originally established as a military garrison to protect the near-lying saltpans and to control the Tiber as part of the defence of Rome,[1] but was soon turned into the capital's overseas harbour, perhaps already before the institution and the placement of a *quaestor classis* and a naval base at Ostia in 267 BC, during the First Punic War.[2] However, Ostia as a river port was not an ideal harbour.[3] Shifting sand-banks prevented larger ships from docking; they had to anchor at sea, which made unloading difficult and risky. The expansion of trade in the Hellenistic period saw a steady increase in the tonnage of ships in the Mediterranean and resulted in a need for larger and better deep-water harbours. Ostia with its sandy shores lagged behind in this respect and in 194 BC, under an initiative taken by Scipio Africanus, a new port for Rome was built at Puteoli in the Bay of Naples. Thus creating the triangular harbour network Puteoli-Ostia-Rome, this for the following centuries secured the supplies of the capital (Fig. 1).[4] The expensive link in Rome's supply chain was Puteoli. It was also the most vulnerable. Caesar was among the first to realise this.[5] However, it was not until the reign of Claudius that Caesar's plans were put into effect.[6] The planning of a new harbour some 3 km to the north of the mouth of the Tiber was started in AD 42, by AD 46 two canals were built between the river and the sea,[7] and probably by AD 54 the harbour basin was finished. The works, however, continued through improvements to the quays and the adding of storage buildings, and may only have been completed by Nero in AD 64. A beautiful *sestertius* showing the harbour was perhaps struck to commemorate this event.[8]

The site chosen consisted of large sandbanks, which had been dredged and long breakwaters built into the sea and included a lighthouse, to protect the harbour basin. Behind this large artificially created oval-shaped basin, extending for more than 1,200 m, was added the rectangular *darsena* and connections with the two canals. The large basin was created for the anchorage of incoming ships, which could unload their cargo directly to river boats, while the *darsena* was reserved for mooring.[9] The vulnerability of the new harbour, however, was demonstrated in AD 62, when, during a storm, about 200 ships sank inside the harbour basin.[10]

To eliminate this peril a new hexagonal harbour was projected behind Claudius' harbour and built by Trajan in the years AD 106-113,[11] and, as with cities and new city walls, it was built to respond not to the necessities of his own days, but to the possible future expanding needs (Fig. 2). With Trajan no more harbours were built at the mouth of the Tiber; new warehouses were added after his death, but otherwise only maintenance and minor changes were made to his designs.

In his *Panegyricus* (29.2) Pliny the younger wrote that Trajan,

> ... in his wisdom and authority and devotion to his people has opened roads, built harbours, created routes overland, let the sea into the shore and moved the shore out to the sea, and linked far distant peoples by trade so that natural products in any place now seem to belong to all.[12]

It was not without reason that Pliny could boast of

[1] Brandt 2002, with further bibliography.
[2] For a discussion of the date, see recently, Zevi 2002, p. 33.
[3] Dion. Hal. 3.44.3; Strab. 5.3.5.
[4] Zevi 1994, pp. 64-67; 2001a, pp. 271-275; 2001b, pp. 118-119; 2004, pp. 213-216.
[5] Suet. *Claud.* 20.3; Cass. Dio 60.11.1-5; Plin. *nat.* 16.76.201-202; Iuv. 12.75-78.
[6] Plut. *Caes.* 58.5; Suet. *Claud.* 20.1; Quint. *Inst.* 2.21.18, 3.8.16.
[7] *CIL* xiv, 85.
[8] Cass. Dio, 60.11.1-5, followed by Lugli, Filibeck 1935, p. 14, and Testaguzzi 1970, p. 25. Cf. the discussion between Boyce 1966 and Meiggs 1973, pp. 57, 563, and text to pl. xviiia.
[9] Millett *et alii* 2004, pp. 223, 225.
[10] Tac. *ann.* 15.18.3.
[11] On the two harbours, see Lugli, Filibeck 1935; Testaguzza 1970; Meiggs 1973, pp. 51-62, 149-171; Mannucci 1992; Millett *et alii* 2004. – For a more personal interpretation, see Silenzi 1998.
[12] Translation by B. Radice (The Loeb classical library, Cambridge (Mass.) & London, 1975).

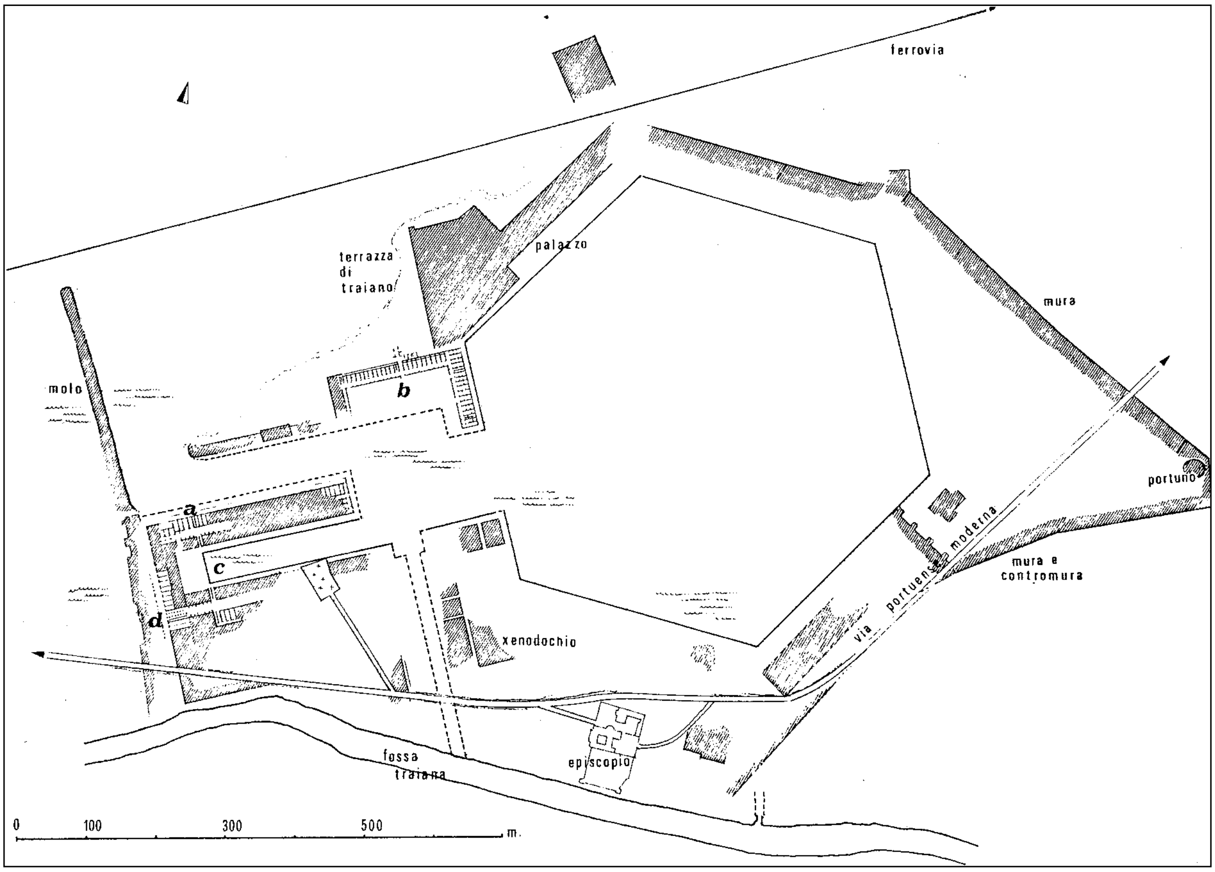

FIG. 2. Map of Trajan's Portus: a) large Trajan storage buildings; b) Severan storage buildings; c) darsena; d) "Claudius' porticus".

his emperor's efforts in this respect, the harbour at Portus was only one of his many undertakings to secure the supply system of Italy and Rome. A look at his many engineering initiatives gives a good insight into the complexities of this system.

Shortly after Portus he finished also the harbour at Ancona on the Adriatic coast. The event was commemorated by a triumphal arch raised in AD 115.[1] As Nero had done a couple of generations earlier at Anzio (about 45 km south of Rome),[2] Trajan built himself a large villa including a port at *Centumcellae* (Civitavecchia, about 70 km north of Rome), a project Pliny the younger had seen in construction in AD 106.[3] Furthermore Trajan has, in connection with other public works at Terracina (about 100 km south of Rome), also been given the honour for having, if not built, then certainly improving the town's port facilities.[4]

In addition to the harbours Trajan also revised and improved some of the important roads in Italy, best known being a new branch of the Appian Way. Formerly the road went from Benevento via Taranto to Brindisi; the new route passed by Canosa and Bari. The event was immortalized by raising a triumphal arch at Benevento.[5] He further restored the stretch of road called *Decennovium*, or the last 19 miles of Via Appia from *Forum Appii*, through the Pontine marshes, to Terracina,[6] and the continuation of Via Domitiana from Puteoli to Naples, both important stretches of roads in bringing Campania closer to Rome.[7] In Terracina he improved the old via Flacca, which originally followed a breakwater around the high rock of Monte S. Angelo (Pisco Montano). By cutting into the rock he made the route safer, which was very exposed to the sea,[8] thus saving travellers from in bad weather having to climb the 120-130 m high and steep mountain pass *Lautulae*, behind the sanctuary of Jupiter Anxur on the summit of the mountain.

[1] See, for example, SEBASTIANI 1996, pp. 33-36.

[2] SUET. *Ner.* 9. Cf. LEHMANN-HARTLEBEN 1923, pp. 190-191; BRANDIZZI VITTUCCI 2000, pp. 21-31, 153 (the harbour was only completed under Antoninus Pius). Size approximately 60 ha.

[3] PLIN. *ep.* 6.31.15-17. For a modern evaluation and reconstruction of the project, see, for example, LEHMANN-HARTLEBEN 1923, pp. 192-195; BASTINELLI 1954, pp. 15-18, 36-39.

[4] LEHMANN-HARTLEBEN 1923, pp. 205-208; LUGLI 1926, pp. 126-131 (no. 73); MEIGGS 1973, p. 59, n. 3 (a more cautious note). Cf. also FELLMETH 1991, pp. 4-5. For further refs., see ZEVI 2000, p. 509, note 1.

[5] HASSEL 1966; ROTILI 1972.

[6] CANCELLIERI 1990. Cf. also PARIBENI 1927, pp. 121-128 for this and other roads.

[7] FREDERIKSEN 1984, p. 336.

[8] Recently this has been ascribed to Nero in connection with the projected canal Puteoli-Rome, cf. ZEVI 2001a, p. 278; 2004, p. 217.

We also find Trajan active in Rome, where he improved the quays along the Tiber in the south-west end of the city and the storage buildings behind,[1] thus supplementing a scheme laid down nearly 300 years previously by Scipio Africanus and the closely bound *Aemilii*-family, which, with their *porticus Aemilia*, were the first to create adequate storage facilities for imported commodities in Rome,[2] among which grain had a special and important position. Trajan restructured *Forum Boarium* and *Portus Tiberinus* higher up the river,[3] an action commemorated on the arch at Benevento. In one of the sculpted panels we see Roman merchantmen addressing thanks to the Emperor in front of the three most important deities celebrated in Rome's old harbour area: Portunus with an anchor and a snake, Hercules with the lion-skin and club, Apollo with the laurel-wreath.[4] He furthermore built the emporium area near Montetestaccio, a large complex consisting of some 500 m long quays and 90 m deep storage buildings,[5] and he secured the public interest in the Tiber by defining the border between public and private land along its tow-paths between Rome and the sea.[6]

The improvements of *Forum Boarium* and *Portus Tiberinus* were Trajan's first public works. So, from the very start of his reign he had set his mind on the supply of commodities to the city. His interest for the import of goods to Rome can be seen in the *Mercati Traiani*, an ancient supermarket, in which many of the imported goods were sold by retail: this was the last link in the supply chain.

That Trajan had a particular concern for the nutrition of Rome's population may also be seen in another of his initiatives: he reorganised and strengthened the *collegium* of bakers[7] and he gave citizenship to Latins who had a mill in town and who could document that he daily, through a period of three years, had milled at least 100 *modii* (or some 700 kilos) of grain.[8] It should also be added that he built an aqueduct into Rome, *Acqua Traiana* that gave among others Trastevere, as the last region of the city, a secure water supply.[9]

Trajan was not the first to have a comprehensive policy to supplying Rome; as described also Scipio Africanus and Caesar before him had shown a similar interest – all three successful army commanders, who knew how important secure supplies were for an army in rest or on the move.[10] And they all presented projects that within reasonable time with available technology and manpower was accomplished, even if Caesar never lived to see any of his projects put into action. However, Claudius thrown into an unprepared situation of famine in Rome at the beginning of his reign demonstrated that Caesar's plans for a harbour at the Tiber-mouth were not utopian.

The commodities

What volume of commodities did Rome receive each year from overseas trade?[11] With the exception of grain the ancient sources give no figures from which to work out the yearly imports, and for the grain the reliability of the figures is much questioned. The French historian Joël Le Gall considered that the total amount of commodities brought to Rome reached about 800,000 tons annually,[12] his German colleague Ulrich Fellmeth proposed a more modest estimated guess of 400,000-660,000 tons,[13] while Aldrete and Mattingly for grain, oil and wine advanced the figure 423,000 tons.[14] In order to calculate the weight or volume imported we are confronted with a long series of unknown variables. For the calculations I shall make use of some of the already calculated modern figures to see if for these quantities there was a transport capacity and a transport network large enough to get the commodities to the capital.[15] A few new figures, however, will be added to complete the total import of commodities. The point of departure must be the number of Rome's inhabitants, the first unknown variable, but which, for the Imperial times, with a fair degree of acceptability has been stipulated between 800,000 and 1,200,000.[16] I shall use

[1] Le Gall 2005, pp. 227-228; Pisani Sartorio, Colini 1986, especially pp. 195-196 (Colini).

[2] By Zevi 2001a, pp. 272-275; 2001b, p. 117; 2004, pp. 213, 215, coined as a *progetto scipionico*, i.e. the combination of the new harbour at Puteoli in 194 BC and new storage buildings near the river port in Rome.

[3] Rickman 1971, pp. 9, 108-117; Colini 1980, pp. 46-49.

[4] Castagnoli 1980, p. 37; Colini 1980.

[5] Gatti 1936; Meneghini 1985, p. 162, figs. 140.1 and 2, 145.

[6] Attested by a large number of cippi placed along the river by Tiberio Giulio Feroce, *curator alvei et riparum Tiberis et cloacarum urbis*, in the years AD 101 and 103; see Paribeni 1927, pp. 24-25; Le Gall 2005, pp. 161, 183-191; Segarra Lagunes 2004, p. 308.

[7] Aur. Vict. *Caes.* 13.5. Cf. also Sirks 1991a, pp. 311, 313-322; and for Ostia, Lo Cascio 2002.

[8] Gai. *Inst.* 1.34. Cf. also Sirks 1991a, pp. 311-313. – 1 *modius* = 8.8 l, or 6.5-7.0 kg grain, the fluctuations in weight depending on the water content of the grain.

[9] For some recent opinions, see, for example: Evans 1997, pp. 129-133 (for Trastevere) and De Kleijn 2001, pp. 27-28 (served the whole city).

[10] On the vulnerability of Rome's supply system, especially that of the grain, see, for example, Geraci 2003, pp. 625-633.

[11] For a general picture of the variety of commodities, see, for example, Jones 1964, pp. 844-850.

[12] Le Gall 2005, p. 304, followed by Mocchegiani Carpano 1984, p. 47.

[13] Fellmeth 1991, pp. 28-29 (based on an estimated import of grain fixed at 200,000-220,000 tons yearly, which he suggested made up 30-50% of the total tonnage of commodities imported).

[14] Aldrete, Mattingly 1999, pp. 193-196, 198.

[15] As also Hesnard 2001, pp. 286-291, despite her critical remarks on the use of the modern figures.

[16] Tchernia 2000, p. 753. More references in Lo Cascio 2001, p. 185, note 26; see also p. 193 where he puts the population with citizen status at 600,000-700,000, to which shall be added a reasonable number of slaves and visiting foreigners (cf. also Lo Cascio 2000, pp. 39-43, 56-61). For other calculations see, for example, Storey 1997a, pp. 966, 975; 1997b (half a million); Durliat 1990,

both figures to have a minimum and a maximum value. In so doing I will allow for fluctuations in the number of inhabitants, and also in the necessary quantities imported each year.

Grain

The import of grain, because of its vital importance for the nutrition of Rome's population and subsequently its governmental control, is the only trade activity that can furnish some ancient figures useful for the calculation of its amounts. It is also the commodity that has attracted most interest over the years.[1] The discussions, well summarized by André Tchernia,[2] are built on two different approaches:

Approach A: The ancient literary sources that give some idea as to the total consumption of grain in Rome, two referring to the quantities exported from Egypt/North Africa,[3] two to the quantities consumed in Rome.[4]
Approach B: Modern calculations based on an estimation of the population of Rome and of the daily rations or projected calorie needs per inhabitant.

According to Approach A the imported quantities of grain each year appears to have been about 60-63 million *modii*,[5] equivalent to 390,000/420,000-410,000/441,000 tons. The results of the calculations according to approach B show much greater fluctuations, varying from 170,000 tons (= 24 million *modii*) to 350,000 tons (= 50 million *modii*), the first figure based on low calorie needs for a population of 800,000 inhabitants, the second based on high calorie needs for a population of 1,200,000. In a further evaluation of these figures in relation to those of approach A, Tchernia settled for 350,000 tons as a possible yearly import to Rome at the height of the Empire. This is close to the double of the lowest figure. For the sake of convenience I shall adjust the low figure and will for the further calculations

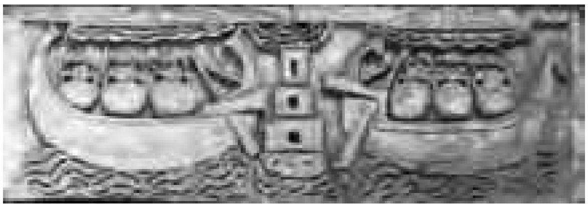

Fig. 3. Relief (3rd century AD) found in the Praetextat catacombs. Two merchant ships with furled sails safely moored in port; between them a lighthouse. Cargo: oil amphorae.

use the figures *175,000* and *350,000* tons as an expression of a possible minimum and maximum import of grain each year.[6]

Oil, wine, and fish products carried in amphorae

The calculations of overseas imports of wine, oil, and fish products have attracted less interest, mainly because we lack ancient information on their quantities. The consumption of oil, even if some data should have been available, cannot be calculated according to calorific needs, because in addition to nutrition oil was also employed for many other purposes, in the preparation of medicines, unguents, and perfumes, for massage and cleansing of the body, and for lighting and lubrification.[7]

For the oil, in one calculation E. Rodríguez Almeida, followed by Tchernia, chose as a point of departure the estimated presence of imported oil amphorae (in early imperial times dominated by the those from Baetica (Fig. 3), by the late 2nd century AD balanced by those from North Africa[8]) dumped at Monte Testaccio, the large mound of pot-sherds in the harbour and warehouse area of Rome. The period of accumulation stretched from the time of Augustus to about 255 AD, or for a period of ca. 270 years. Almeida concluded that the yearly average dumping arrived at ca. 321,000 amphorae, which would have contained about 224,800 hl oil, if the amphorae on average had carried 70 l each.[9] This figure, calculated without

p. 116, followed by Peña 1999, p. 20 (700,000-900,000); Brunt 1971, p. 383 (750,000); Beloch 1886, pp. 411-412 (800,000); Cracco Ruggini 1985, p. 229; Morley 1996, pp. 33-39 (800,000/1,000,000); Coarelli 2000, pp. 296-299 (800,000-1,200,000); Rickman 1980a, pp. 9-13, esp. p. 10 (1,000,000); Aldrete, Mattingly 1999, p. 193, used 1 million inhabitants as a figure for their calculations.

[1] For more recent works see, for example, Brunt 1971, p. 382; Tengström 1974; Rickman 1980a, pp. 231-235, 1980b; 1991; 2002; Haberman 1982; Foxhall, Forbes 1982; Hopkins 1983; Garnsey 1983; 1988, pp. 231-232; Cracco Ruggini 1985; Lo Cascio 1990; Galsterer 1990; Fellmeth 1991; Giovannini 1991; Sirks 1991a; 1991b; Virlouvet 1995; De Romanis 1996; Peña 1999; Tschernia 2000; Hesnard 2001; Marin, Virlouvet 2003. Cf. also Zevi 2001a; 2001b; 2004.

[2] Tchernia 2000.

[3] Ios. *Bell.Iud.* 2.383, 386; Aur.Vict. *Caes.* 1.6.

[4] SHA *Sev.* 23.2; Schol. Luc. *Pharsalia*, 1.318.

[5] The first figure can easily be computed from Josephus' and Aurelius Victor's information; for the second, see the interpretations and calculations by De Romanis 1996.

[6] These figures frame well the other quantities suggested: Garnsey 1983, pp. 118-119: 200,000 tons; Hopkins 1983, p. 88: 200,000-220,000 tons; Foxhall, Forbes 1982, p. 72 (and their cautionary note 104): 212,000-237,000 tons for 1 million inhabitants; Aldrete, Mattingly 1999, p. 193: 237,000 tons (adding that the figure does not include barley, used for animal fodder); Beloch 1886, p. 404: more than 250,000 tons; Rickman 2002, p. 359, "up to 400,000 tons per annum (so as to allow for loss by disease and rodents)"; Zevi 2001a, p. 276; 2001b, p. 118; 2004, p. 216, accepts the figures of Josephus and Aurelius Victor, 60 million *modii* (= ca. 420,000 tons).

[7] Amouretti 1986, pp. 183-195; Peña 1999, p. 20; for the organisation of the oil supply to Rome, see pp. 20-28, and also pp. 153-158.

[8] See Rizzo 2003, pp. 220-224, for a discussion on the provenance of the oil. The large amounts of oil amphorae at Monte Testaccio can be due to the presence of a *portus olearis* in its immediate neighbourhood (Peña 1999, p. 20).

[9] Rodríguez Almeida 1984, pp. 116-119: his exact figures were: 53,359,800 amphorae, equal to 37,352,000 hl of oil with an average volume per amphora of 70 l; in addition he considered 25% am-

regard to the size of the population, would give each inhabitant 19-28 l of oil per year depending on the size of the population, as estimated above. Tchernia, using the same figures with some adjustments (195,000 hl carried in 260,000 amphorae of 75 l each), would have arrived at a yearly consumption of 16-24 l per inhabitant.[1]

In another calculation M.-C. Amouretti, followed by D. Mattingly and T. Peña,[2] suggested that each inhabitant on a yearly basis would consume on average 20 l of oil, out of which some would have been made locally. The average yearly consumption for the whole population of Rome would according to these figures have been 160,000-240,000 hl oil carried in about 229,000-343,000 amphorae of 70 l each.[3] With a general decrease in amphora size in the 2nd and 3rd centuries AD the total number of amphorae would have increased.[4] For the further calculations I shall use the last two figures, since they incorporate well the volumes arrived at by both Rodríguez Almeida and Tchernia. With an average weight of 95 kilos per amphora with its oil[5] the total weight of these amphorae would have been about *21,755-32,585 tons*.[6]

For consumption of wine Tchernia returned to his old studies on wine amphorae in which he settled for an annual consumption of 146-182 l *pro capite*.[7] Adapting these figures to the estimated size of Rome's population the consumption by 800,000 inhabitants would have been 1,168,000-1,456,000 hl (or average 1,312,000 hl) per year, that by 1,200,000 inhabitants 1,752,000-2,184,000 hl (or average 1,968,000 hl).[8] Wine was also produced locally, according to Tchernia perhaps making up for half of the total. In a recent study on amphorae found in well-documented excavations in Rome, this appears to be true for the Neronian age if we consider local as Italic (i.e. Italy and Rome), but not later. From the Flavians through the age of the Antonines Italic wine made up only about 40% of the total imported, and of these the wines of the Tiber valley less than 30%.[9] However, wine was also transported in perishable containers and dolia, "the amphora evidence is < thus > capable of providing only a partial and very probably biased picture of the sources of the wine supply".[10] In addition some imported amphorae may also have been recirculated as containers in the local wine trade.[11] Local wine may therefore well have constituted half of Rome's total wine consumption. The total overseas import (including Italian provinces) would thus on average have ranged between 656,000 hl and 984,000 hl, or the equivalent of about 2,523,000-3,785,000 amphorae of an average volume of one *amphora*, or approximately 26 l, each.[12] With an average weight of 40 kilos per amphora filled with wine[13] the total weight of these amphorae would have been *100,920-151,400 tons*.[14]

Many fish products, like different kinds of sauces as *garum*, *liquamen*, *allec*, and *muria*, or in salted condition (*salsamentum*) were transported in amphorae, but our information on these makes it even more hazardous to calculate their quantity. These fish products were popular agents to season food and the dominant producer for the Roman market was Baetica, supplemented to a very small degree by Lusitania.[15] The size of the amphorae carring the sauce was a bit smaller than that of the wine, on average containing 22 l,[16] or

phorae dispersed in the urban market, equal to 13,339,950 amphorae, or 9,338,000 hl oil, and a further 37.5% (1.5:4) finished as building material of different sorts, equal to 20,009,925 amphorae, or 14,007,000 hl oil, for a total of 86,709,675 amphorae and 60,697,000 hl oil. This gives a yearly import over 270 years of 321,146.94 amphorae and 224,803.7 hl oil, which for a population of 1 million would mean an average consuption of 22.5 l *pro capite*.

[1] Tchernia 2000, pp. 757, 758, who, for a period of 250 years ended up with a yearly import of 150,000 hl, to which he added an arbitrarily 30% amphorae dispersed outside Monte Testaccio, bringing the total yearly consumption to 195,000 hl, or 260,000 amphorae with an average volume per amphora of 75 l (or close to 280,000 amphorae with a volume of 70 l).

[2] Amouretti 1986, p. 183 (note, however, that on p. 195 the yearly consumption for a family of four plus three slaves living in town is put at 200 litres, or slightly less than 30 litres each, thus increasing the need for oil); Mattingly 1988, p. 34; Peña 1999, p. 20.

[3] According to the gamma and delta *tituli* inscribed on the Baetican vessels the standard weight of the oil was 216 *librae* of 327.45 g, for a total of 70.7 kilos, which with a density of 0.9 fills 78.6 l, equal to the measure 3 *amphorae* (cf. Peña 1999, pp. 20 (with note 168), 86).

[4] Peña 1999, p. 20; cf. also Rizzo 2003, p. 219, *grafico* 23. The decrease was due to the higher imports of North African oil, carried in amphorae of an average size of 54 l, equal to 150 *librae*, or 49.1 kilo oil (cf. Peña 1999, p. 87, and Rizzo 2003, p. 221, table 34).

[5] Rodríguez Almeida 1984, p. 117, noted that the Beatican amphorae on average contained 73 kilos of oil and the amphora weighed 24-25 kilos, together 97-98 kilos. If the average weight of the oil was 216 *librae* the total weight would have been about 95-96 kilos. Tchernia 2000, p. 758, put the average weight to 90 kilos. With the increased import of North African oil in smaller containers for the same volume of oil the total weight of container and content will be a fraction higher for these amphorae than for those of Baetica.

[6] Aldrete, Mattingly 1999, pp. 195, 199: 26,000 tons, absolute minimum used for consumption only.

[7] Tchernia 1986, pp. 21-27; for the organisation of the wine supply in Rome, see Peña 1999, pp. 11-20, cf. also pp. 153-158.

[8] Tchernia 2000, p. 757. I have used the exact figures, not rounding them off as Tchernia.

[9] Rizzo 2003, pp. 202-220; compare especially *grafico* 23 with the *grafici* 20-22.

[10] Peña 1999, p. 11; Hesnard 2001, pp. 289-290; cf. also Parker 1990, pp. 330-331, and Rickman 2002, p. 358.

[11] Peña 1999, p. 11.

[12] A calculation of the average volume of the 48 amphora types listed by Rizzo 2003, pp. 204-205 (tables 32a-b) gives 25 l. This value seems to become lower in the 3rd century AD, cf. Peña 1999, p. 11, who observed that for the Early Dominate a 2/3 amphora (= 17.5 l) was the most common type.

[13] Peña 1999, p. 202, note 7: two amphorae of a volume 29.1 l and 33.0 l weighed respectively 11.0 and 12.0 kilos. Santa Maria Scrinari 1979, p. 15, suggested an average weight of 45 kilos for container and content.

[14] Andrete, Mattingly 1999, p. 196: 160,000 tons, not distinguishing between imported and locally produced wine.

[15] Rizzo 2003, pp. 225-226, and p. 219, *grafico* 23.

[16] According to the capacities given by Rizzo 2003, pp. 204-205 (table 32a-b) (wine amphorae) and 225 (table 36) (fish sauce), the average wine amphora contained 25 l, the average fish sauce amphora 22 l.

about 5/6 of an *amphora*. G. Rizzo, having calculated both the number of amphorae identified and the total volume of liquids each type of amphora could contain, has furnished us with some useful figures from which to proceed. Comparing the amphorae for wine and for fish sauce the latter made up 13-14% both in numbers and volume. If this figure, rounded down to 10%, reflects the actual ratio between imported wine and "bottled" fish products, then the total import of the latter would be in the region of 65,600-98,400 hl carried in about 298,000-447,000 amphorae per year. With an average weight of 35 kilos per filled amphora the total weight would have been about *10,430-15,645 tons* per year.[1]

Other commodities

The number of commodities arriving Rome each year are impossible to list, but a picture of its magnitude emerges from casual references in ancient texts (as, for example, legumes,[2] meat, seasonings other than fish products, cheese, fruit, honey,[3] fish, wool and textiles,[4] calami, papyrus, metals, marbles and valuable stones, mill – or grinding stones,[5] pottery, glass, timber,[6] wax, incense, ivory, minium,[7] ruddle,[8] etc.[9]), recorded names of storage buildings (like the *Horrea Piperataria, Horrea Chartaria*, and *Horrea Candelaria* in Rome[10]), and excavations on land and at sea. The material can roughly be divided between organics and non-organics, the single products in the first group of commodities in general only possible to extrapolate from the written documents, those in the second group also from excavations.

Reports made during the excavations of the Emporium district in Rome attesting the finds of an elephant tusk in one storage-room,[11] lentils in another,[12] sand used by stone cutters in a third,[13] and amphorae of various sizes, completely filling a fourth, give some evidence of the variety of commodities imported and stored.[14] And at Laurentum south of Ostia was a large animal park where various animals were temporarily housed including camels and elephants (the remains of an *elphas africanus* has been found near Castel Fusano). The area was apparently used as a transit station for wild, imported animals to the amphitheatres in Rome.[15]

However, the most solid data comes from ancient shipwrecks from all periods found scattered around the Mediterranean. In these have been found, in addition to the nearly ever present amphorae containing wine, oil, and fish products, as discussed above, all sorts of ceramic tableware, lamps, dolia, pithoi, louteria, furthermore building material (roof-tiles, tiles, terracotta pipes), metal as ores, ingots and finished products (lead, iron, copper, tin, bronze), stones and marbles as raw blocks or as finished, or nearly finished products (sarcophagi, columns, building stones, grinding stones), pine-cones, resin, glass vessels and objects, etc.[16] To pick one commodity: the variety of stones and marble used in ancient private and public architecture (as seen in excavated and standing buildings, in *spolia* used in later buildings, or in storage areas both at Osia and Rome[17]) brought from Greece, Asia Minor, Egypt, North Africa, Spain, and Gallia, but also from the caves at Carrara in northern Italy, demonstrates well the efforts to which the Romans went to get the best products to their capital.[18] Many monolithic columns of excessive weights from 50 tons upwards were imported and some

[1] Peña 1999, p. 154, for purposes of discussion, considered the volume of consumed fish products to be the double of that of the oil, i.e. 40 l *pro capite* annually. Cf. also the distribution (in percentages of numbers) over time of amphorae carrying wine, oil, and fish products excavated at Ostia, as presented by Tchernia 1986, p. 293: amphorae for oil and fish products fluctuate around the same percentage, but since oil was carried in larger containers than fish products, the weight of oil should presumably be considered more reliable than the weight of the fish products.

[2] See also the wax tablets from Murecine (Pompeii), which mention 4,000 *modii* of Egyptian lentils, emmer(?), and chickpeas stored at Puteoli: Casson 1980, pp. 26-28, 33.

[3] See, for example, Sidon. *Epist*. 1.10.2.

[4] See, for example, Plin. *nat*. 8.190-193; Strab. 5.1.7; *Inschriften griechischer Städte aus Kleinasien*, Bonn, 1972, I.15; cf. also Reynolds 1989, pp. 283-285.

[5] Peacock 1980.

[6] On the timber trade, see Meiggs 1982, pp. 325-370; a lot of timber came also from the Appennines, for the transport of which the Tiber was essential (pp. 336-337); cf. Cic. *rep*. 2.5. See also note 92.

[7] Cf., for example, Le Gall 2005, pp. 300-304.

[8] Red ochre, cf. Wallinga 1964, pp. 8-9; the quantities were very small, cf. Plin. *nat*. 33.118.

[9] For lists of commodities imported to Rome, see Loane 1938, pp. 11-59, and Le Gall 2005, pp. 299-304. These lists make interesting comparisons with duty-levied commodities sailed up the river to Rome in the early 19th century, as published in Segarra Lagunes 2004, p. 353, n. 162. Cf. also the products, many with previniences, listed in Diocletian's price edict 1-34 (Giacchero 1974, pp. 138-220, 271-310, original text and italian traslation).

[10] Rickman 2002, p. 361.

[11] On elephant tusks, see latest, St. Clair 2003, pp. 7-14, 30-37.

[12] On lentils, see also Plin. *nat*. 16.76.201, who informs that 120,000 *modii* were used as ballast for the transport of Claudius' obelisk to Rome. On this, see the comments of Wirsching 2002, p. 143.

[13] For sand used as ballast in ships, see Parker 1992, p. 28; for sand imported by Nero for the imperial wrestlers, see Suet. *Ner*. 45.1.

[14] As referred by Rickman 2002, pp. 361-362, paraphrasing Lanciani 1888, p. 250.

[15] Pavolini 1986, p. 82; Rickman 2002, p. 361; cf. Meiggs 1973, p. 302.

[16] Parker 1992, pp. 17-19.

[17] Until the age of the Flavians shipped to the storage areas at the foot of the Aventine Hill, in the area called Marmorata, later stored at Claudius' harbour, and later still at Trajan's harbour; see latest, Pensabene 2002, p. 27.

[18] For a description and distribution map of the caves, see recently, Lazzarini 2002, and map on p. 264. Frank 1940, p. 222, calculated that for Trajan's forum 50,000 tons of marble alone was imported. For a calculation of the marbles used for the two restoration periods of the Colosseum in the 3rd century AD (i.e. for the *porticus in summa cavea* and the seats), see Bianchi *et alii* 2003: 80 column bases: 112.8 tons (p. 38); 80 column shafts: 828.48 tons (table 3, p. 40); 80 capitals: 205.6 tons (p. 42); 48 rows of seats: 8,514.45 tons; total: 9,661.33 tons.

may have been transported in specially made ships, as were obelisks.[1]

Many ships carried more than one cargo, but few more than five.[2] From a sample of 98 fairly well documented shipwrecks A.J. Parker has noted the distribution of trading commodities found aboard each ship, the commodities listed one by one independent of the number of ships (TABLE 1).[3]

Commodity	Wrecks	%
Amphorae	92	54
Pottery	26	15
Tiles	5	3
Metal & ore	17	10
Stone	4	2
Other	27	16
TOTAL	171	100

TABLE 1. The distribution by number and percentages of trading commodities in 98 ship-wrecks.

The table demonstrates a close parity (54%/46%) between ships carrying amphorae with wine, oil, and fish products and ships carrying other non-organic commodities. Unfortunately the table only presents number of products and not their relative weights. In another table each type of amphora and each category of other products are listed according to the numbers of shipwrecks in which they were found out of a total of 1,259 recorded wrecks.[4] The amphorae had 1,360 registrations (some wrecks having more than one type of amphorae), other products 610, the latter in this case making up only 45% of the amphorae. Since amphorae dominate in shipwrecks, and because their presence in each shipwreck is generally more plentiful than other products, the weight of the other products was certainly much less than that of the amphorae – perhaps, despite the flourishing trade in stone, this category did not make up more than a third of the total weight of the filled amphorae. I shall for the further calculations use this as a key for the distribution of weights between the two sets of commodities, knowing well that this is an arbitrary figure.

The total weight of filled amphorae transported to Rome each year, according to the figures calculated above, amounts to 21,755-32,585 tons amphorae filled with oil, plus 100,920-151,400 tons amphorae filled with wine, plus 10,430-15,645 tons amphorae filled with fish sauce, for a total of *133,105-199,630 tons*. The total weight of other non-organic commodities should then amount to *44,368-66,543 tons*.

FIG. 4. Mosaic (end of the 2nd century AD) from *Piazza delle corporazioni* at Ostia. Two merchant ships of different types under sail; above a lighthouse. The inscription refers to shipowners (*navicularii*) from the coastal town Sullectum in modern Tunisia.

For organic material like timber,[5] legumes, vegetables and fruits (conserved, dried, or perhaps some even fresh), salted meat, ivory, wild animals for the amphitheatres, horses for the elites, etc. no quantities are available from which to make even educated guesses. In order to have the organic material visible as a factor in the further calculations, as a sheer guess, I shall consider the organic material making up a very modest one third of the total non-organic material, or *14,789-22,181 tons*.

MARITIME TRANSPORT

For maritime transport we have to distinguish between ocean going (*naves onerariae*) (FIG. 4) and coastal ships (FIG. 5), even if their sizes would overlap each other. Many coastal ships were presumably also of a size that they could sail up rivers, thus saving reloading costs in coastal harbours. What were the sizes and loading capacities of these different types of ships?

Two ships are often cited when tonnages are concerned, Hieron IÌs *Syrakosia*[6] and the *Isis* of Alexandria, which Lucian saw in the harbour at Pireus.[7] The tonnage of the first has been calcu-

[1] For the transport of the obelisks, see recently, WIRSCHING 2002.

[2] PARKER 1992, pp. 20-21: 30% carried one cargo, 20% two cargoes, 17% three cargoes, 11% four cargoes, 12% five cargoes, and the remaining 11% from 6 to 13 cargoes.

[3] PARKER 1992, p. 20. The sample covers ships dating between 400 BC and 400 AD. The table gives a total picture for all trade in the Mediterranean in this period, but since 75% of the wrecks are datable between 100 BC and 400 AD with 52% covering the first two centuries, the table strongly reflects the Roman trade, even if not all the wrecked ships had Rome as their final destination.

[4] PARKER 1992, pp. 17-19 (note that many wrecks carried more than one cargo, thus the total number will exceed that of the wrecks).

[5] CASSON 1965, p. 31 (imported since 192 BC); MEIGGS 1980, pp. 189-194 (difficult to quantify, but [p. 192] "from such evidence as I have been able to find I feel very reluctant to accept extreme views without more explicit evidence"); cf. also MEIGGS 1982, pp. 354-355. In the late second century AD the importance of the tree trade may have given the *navicularii lignarii* the opportunity to achieve a portion of the great colonnade behind the theatre at Ostia and signal their presence with a mosaic sign. See also note 75.

[6] ATHEN. 5.206-209.

[7] LUKIAN. *Navigium* 5-6.

lated to 1,940 tons d.w.,[1] the second to about 1,200 tons d.w.,[2] but it is a general opinion that these two ships were extraordinary – the first one was also docked after one trip.

In order to establish an average tonnage for seagoing vessels two sources of information are available: imperial law texts and excavated shipwrecks found scattered around the Mediterranean, both at sea and in later silted-up coastal areas. However, it is worth noting that also here the average size of the ships will be an arbitrary figure, but even so indicative.[3]

In a decree issued by Claudius the emperor offered Roman citizenship to Latins who built big vessels.[4] Gaius informed that sea-going ships should have a carrying capacity of not less than 10,000 *modii* of grain (65-70 tons), and that in order to be eligible for citizenship the Latins concerned had to carry grain to Rome for 6 years.[5] In another decree, perhaps from the latter part of the second century AD, ship owners who, for the transport of grain, built *one* ship with a carrying capacity bigger than 50,000 *modii* of grain (i.e. 325-350 tons), or more (perhaps five?) ships bigger than 10,000 *modii*, were offered exemption from public duties.[6] It is very possible that the emperor in this way tried to encourage an increase in tonnage in order to reduce the number of ships sailing and mooring in the harbours. The average size of the vessels may therefore have been lower than those given in the decrees.[7]

The two sizes mentioned in the decrees most likely refer to two different functions. The first decree was issued in connection with a famine in Rome in AD 51 during Claudius' reign.[8] The size presumably referred to coastal and river boats (*naves codicarii*) used in the traffic between Puteoli, where the grain arrived at the time of Claudius, and Rome. The figure 10,000 *modii* is well below the maximum size for sailing on the Tiber, which could receive ships with a carrying capacity of up to 3,000 amphorae,[9] or 150 tons d.w., equal to max. 23,000 *modii* grain.[10] Three of the four boats excavated at Claudius' port at Ostia were considerably smaller.[11] In a recent study it has been suggested that the average tonnage of the Roman merchant fleet in general could have been as low as *60 tons* d.w. (or 1,200 amphorae).[12] I shall in this study instead use this figure as an average tonnage for coastal and river boats. The figure will most likely be well above the real average tonnage of coastal and river boats, thus giving us for the further calculations a *minimum* number of boats needed for the transport of commodities.

FIG. 5. Relief (3rd century AD) found at Ostia, now in the Torlonia collection. A coastal(?) ship under sail.

The larger carrying capacity of 50,000 *modii* (or 7,000 amphorae), equal to 325-350 tons, should therefore refer to ocean going ships. Ships of this size and above have been found among Roman shipwrecks in the Mediterranean, but ships of high tonnages appear to be common for the 1st century BC and 1st century AD; later there is a slight decline in the average size.[13] An analysis of ancient ship wrecks distinguishes three classes: 1) boats under 75 tons dead weight, the most common; 2) boats 75-200 tons d.w.; 3) boats above 250 (*sic*) tons d.w.[14] Modern

[1] CASSON 1971, pp. 185-186; cf. also POMEY, TCHERNIA 1980-1981, pp. 52-53; ZEVI 1994, pp. 62-64; 2001a, pp. 269-271; 2001b, pp. 116-117; 2004, pp. 214-215.

[2] CASSON 1971, pp. 186-188; POMEY, TCHERNIA 1980-1981, pp. 45-55 (esp. p. 50); ZEVI 1994, p. 62; 2001a, pp. 269-271; 2001b, p. 116; 2004, p. 214.

[3] On the caution needed when using modern calculations of tonnages, see, for example, POMEY, TCHERNIA 1980-1981, p. 29; ERICSSON 1984, p. 73. See also the warning of WALLINGA 1964, p. 26.

[4] SUET. *Claud.* 18.2, 19.

[5] GAI. *inst.* 1.32C.

[6] *Dig.* 50.5.3 (Scaevola).

[7] Note that in a late rescript (AD 439), in the eastern provinces, a minimum tonnage of 2,000 *modii* (= 14 tons) was established: *Nov. Th.* 8 (= Pharr 1952, p. 495). In AD 450 the capacity was set at no less than 40 *cupae* (or barrels): *Nov. Val.* 29.2 (= Pharr 1952, p. 541), which according to ROUGÉ 1966, p. 72, equalled 1,040 *modii*, or about 6 tons. See also TENGSTRÖM 1974, p. 37.

[8] ROUGÉ 1952, p. 318; 1966, p. 359; POMEY, TCHERNIA 1980-81, pp. 43-44; GARNSEY 1988, p. 223.

[9] DION. HAL. 3.44.3.

[10] An amphora with content in this context is generally considered to weigh about 50 kilos. See, for example, POMEY, TCHERNIA 1980-81, pp. 32-35; cf. also WALLINGA 1964. LE GALL 2005, p. 146, considered the ships only of 78,6 tons d.w. based on the weight of an *amphora* wine. Cf. also CASSON 1965, p. 32, note 10, who refers that in modern times 190 tons was the maximum capacity of boats sailing on the Tiber.

[11] SANTA MARIA SCRINARI 1979, pp. 15, 56-57: Oneraria maggiore I: 50/60 tons; II: 50/80 tons; oneraria minore I 22/28 tons; II 28/31 tons, the calculations made according to the formula used by, for example, POMEY 1978; POMEY, TCHERNIA 1980-81, pp. 30-31, 48. Using Scrinari's measurements and the same formula I arrive at the following tonnages for the four Ostian ships: 123 tons, 173 tons, 21 tons, 32 tons. Cf. also BOETTO 2001, p. 126, for a corrected size of Oneraria maggiore I, bringing its carrying capacity down to 58 tons.

[12] HOUSTON 1988, pp. 558-560.

[13] ROUGÉ 1952, p. 72; PARKER 1992, p. 26.

[14] PARKER 1992, p. 26.

scholars have for ocean going ships suggested an average carrying capacity of 250-350 tons;[1] considering the observations of the ancient shipwrecks, the lower tonnage is perhaps closer to the truth than the higher. In comparing ships from pre-industrial societies it has been suggested that, if the Roman merchant fleet was similar, the number of ships above 100 tons would have been limited.[2] I would therefore for sea going vessels opt for an average tonnage of *150 tons* d.w. The tonnage is much lower than what has normally been considered, but has the advantage of giving us for further calculations a possible *maximum* number of boats needed for the transport of commodities. The reason why I for sea going ships prefer a maximum number and for coastal and river boats a minimum number will become clearer in the course of the further analyses.

Let us start with the ocean going vessels. How many ships would have called each year at Portus from when Trajan's harbour was fully operational? In Tables 2 and 3 are listed the total weights of imported commodities and the number of calls of ships with an average dead weight tonnage of 150, according to respectively the low and the high estimate. The number of ship calls will give an impression of the traffic in the harbours at Portus, which is of interest us, rather than the total number of ships calling at Portus each year. However, to calculate the total number of ships sailing to Rome we may use Tchernia's model: the grain ships from North Africa and Egypt would have managed two deliveries each year, while for ships carrying other commodities one could consider three deliveries.[3] However, it is important to remember that not all ships in the Mediterranean sailed to Rome.

Commodity	Weight in tons	% commodities	Nos. of calls seagoing ships	
Grain	175,000	48	1,167	
Oil	21,755	6	145	= 1,283
Wine	100,920	27	673	
Fish sauce	10,430	3	70	
Other non-organic	44,368	12	296	
Other organic	14,789	4	99	
TOTAL	367,262	100	2,450	

Table 2. The total weight and percentage of each commodity, and number of calls of seagoing ships of a carrying capacity of 150 tons at Portus each year. Low estimate.

Using Tchernia's model above, the total number of ships needed to carry these commodities to Rome would have been (1,167 : 2) + (1,283 : 3) = 1,011 ships.

Commodity	Weight in tons	% commodities	Nos. of calls seagoing ships	
Grain	350,000	55	2,333	
Oil	32,585	5	217	= 1,922
Wine	151,400	24	1,009	
Fish sauce	15,645	2	104	
Other non-organic	66,543	10	444	
Other organic	22,181	3	148	
TOTAL	638,354	99	4,255	

Table 3. The total weight and percentage of each commodity, and number of calls of seagoing ships of a carrying capacity of 150 tons at Portus each year. High estimate.

Using Tchernia's model above, the total number of ships needed to carry these commodities to Rome would have been (2,333 : 2) + (1,922 : 3) = 1,807 ships.

In order to simplify the weights, I shall in further calculations use 370,000 tons as the low estimate, 640,000 tons as the high estimate, only the high estimate lying inside Fellmeth's fork of 400,000-660,000 tons.

The ports: Puteoli and Portus

The calls in the ports could not be made all year round. The safest period for sailing was between May 27 and Sept. 14 (= 111 days), but those daring it could extend the season by a couple of months at each end. From Nov. 12 to March 9, however, the sea was considered closed and not fit for sailing (*mare clausum*).[4] That is why Claudius, when he discovered the shortage of grain in Rome in the first year of his reign, offered to cover all losses, ship and cargo, for the ship owners who, that winter, were willing to sail and bring grain to the city. This means that the sailing season at a maximum lasted 8 months, for most skippers presumably not more than 7, or about 200 days and less.[5]

A low estimate says that, when Portus had taken over all the shipments of commodities directed towards Rome, it would receive on average 2,450 ships : 200 days = 12-13 ships per day; at a high estimate it would receive 4,255 ships : 200 days = 21-22 ships per day.[6] The same number of ships, on

[1] Haberman 1982, pp. 47-48: 120-150 tons; Hopkins 1983, p. 98: 200-350 tons; Torr 1897/1964, p. 25: 250 tons; Fellmeth 1991, p. 20: 250 tons; Lo Cascio 1993, p. 53: 250 tons; Aldrete, Mattingly 1999, p. 196: 250 tons (following Panella 1985, p. 181, fig. 159); Casson 1965, p. 31; 1973, pp. 171-172, notes 23, 25: 340 tons; Tchernia 2000, p. 758: 350 tons. For Late Antiquity, see Jones 1964, p. 843, and Tengström 1974, p. 37, who considered a tonnage as low as 2,000-10,000 *modii*, i.e. 14-70 tons d.w.

[2] Houston 1988, p. 556. Cf. Cic. *fam.* 12.15.2, who tells that Donabella in 47 bc collected merchant ships, all with a capacity above 2,000 amphorae (= 100 tons d.w.), the figure apparently mentioned to underline their big sizes (cf. Meiggs 1973, p. 291).

[3] Tchernia 2000, p. 758. Cf. also Lo Cascio 1993, p. 52.

[4] Veg. *mil.* 4.39; cf. also Hes. *Op.* 618-694; *Cod. Theod.* 13.9.3 (= Pharr 1952, p. 399). For modern authors see, for example, Rougé 1966, pp. 32-33; Casson 1973, p. 270, and note 2.

[5] Aldrete, Mattingly 1999, p. 196, following Panella 1985, p. 181, considered a sailing season of only 100 days.

[6] For grain, oil and wine only Panella 1985, p. 181, fig. 159, calculated 19,5 daily calls; Aldrete, Mattingly 1999, p. 196, 17 daily calls.

FIG. 6. Sarcophagus (mid 3rd century AD), found near Porta Latina, Rome, now in the Vatican museums (inv. 927). Harbourscene, two ships entering the harbour, five rowing boats. Behind the city with temples, triumphal arches, an amphitheatre and other buildings. In the centre husband and wife awaiting to receive their portraits, here deified in the guise of Liber and Venus.

a strict rotational basis, would at the same time leave the port. Presumably, in the height of the sailing season, the ships calls were more frequent (FIG. 6). Since the grain harvest in North Africa was normally April-May, the trickle of boats would have started not earlier than late May. This would in turn reduce the sailing period to 3-5 months for these ships and increase the number of daily calls.

In periods the harbour, whether at Portus or earlier at Puteoli,[1] must certainly have been full of ships, especially when the first ones with grain from Alexandria arrived in early June.[2] Their arrival would have been eagerly awaited for a long time, as Seneca experienced it at Puteoli (*Ep.* 77.1):

> Suddenly there came into our view to-day the 'Alexandrian' ships – I mean those which are usually sent ahead to announce the coming of the fleet; they are called 'mail-boats'. The Campanians are glad to see them; all the rabble of Puteoli stand on the docks, and can recognize the 'Alexandrian' boats, no matter how great the crowd of vessels, by the very trim of their sails.[3]

The arrival of the Alexandrian fleet meant not only the end of a possible spring shortage of grain, it also meant jobs for the seasonal workers, and in the hull of the ships were hidden many values that soon should exchange hands and honour many IOUs and mortgage deeds, in the way we can, for example, read it on some wax tablets found at Pompeii.[4]

The unloading of moored ships took time because the numbers of dock workers (the *saccarii*), depending on the size of the ships and the docks, would be restricted. The time would be dependant on the number of workmen available and the time it would take to carry the wares from the ship to the storerooms and return for a new load. A papyrus tells that the unloading of a ship carrying grain took 12 days.[5] Fellmeth considered this to have been a rather large ship, perhaps one with a dead weight tonnage of 350; one with a tonnage of 150 would then have taken some 5-6 days to unload. Other calculations consider 2-4 days sufficient to unload a ship of 130-150 tons d.w.,[6] but this may be a bit optimistic. Let us make another calculation to see the amount of work needed. It is based on the assumption that a docker on average carries maximum 40 kilos of load (or one amphora of wine or sack of grain) at the time and that he can take 5 loads off the ship per hour:[7]

[1] On the port at Puteoli, see, for example, PIROMALLO 2004.

[2] See GERACI 2003, pp. 643-655, for the export of grain from Alexandria.

[3] Translation by R. M. Gummere (The Loeb classical library, New York & London 1953). In AD 384, during a famine, SYMM., *Relat.* 9.7, immagined "how the people and the senate would be standing on the banks of the Tiber estuary welcoming the convoy and its cargo of Egyptian corn"; cf. TENGSTRÖM 1974, pp. 47-48.

[4] CASSON 1980, pp. 24, 26-28, 33; RICKMAN 1980a, pp. 236-238; FREDERIKSEN 1984, pp. 327-328; GERACI 2003, p. 642, with further references.

[5] FELLMETH 1991, p. 21, note 65, with further references; cf. also GERACI 2003, pp. 645-646.

[6] ROUGÉ 1952, p. 325; POMEY, TCHERNIA 1980-1981, p. 40, note 40.

[7] ALDRETE, MATTINGLY 1999, p. 197, using slightly different figures and point of departure.

FIG. 7. Relief (late 2nd century AD) found at Portus, now in the Torlonia collection. Scene from Portus showing unloading of North-African amphorae. At the table three supervisors, one giving a counting ticket(?) to the docker, another notes in a protocol what the third dictates.

150,000 kilos of commodities : 40 kilo per load = 3,750 loads
3,750 loads : 5 loads per hour = 750 hours of work
750 hours of work : 10 hours effective work per day = 75 days of work

To empty a ship in 5 days one would then need: 75 : 5 = 15 workmen, which could work well if the commodities were handed from man to man, perhaps less so if each docker carried his own load from ship to storeroom (the gangplank and the points of registering the wares leaving the ship and entering the store-rooms being possible places of queuing[1]) (FIG. 7).

If we consider 5 days as standard to unload a ship of 150 tons, then on a low estimate, some 60-65 ships (12-13 ships for 5 days) would be in port at the same time, on a high estimate 105-110 ships (requiring 1,140-1,235 dockers daily at a low estimate, 1,995-2,090 at a high one[2]). With a higher average tonnage the days in port would have been more, but the total number of ships carrying commodities less, whilst the number of workmen would not have changed considerably.

However, many ships remained in port after unloading; some waiting for new loads, others having repairs made and securing provisions for a new voyage. In addition, unstable weather conditions may have prolonged some stays in the harbour, as well as bureaucratic difficulties. In the papyrus just referred to we can read that the ship had arrived on June 30, unloading had finished on July 12, but by August 2 the skipper was still waiting for orders to sail. Circumstances like these made it necessary to design the size of a harbour based on other needs than simply what the volume of imported goods would dictate. Considering 10 days as an average time in port for the sea-going vessels, then each mooring/anchorage space could receive up to 20 ships in the course of the season.[3] At a low estimate, with such a rapid average rotation time in port, the minimum need of mooring/anchorage space for sea going vessels would have been:

370,000 tons of yearly commodities : 150 tons d.w. ships: 20 calls = 123-124 ships

At a high estimate the minimum need would have been:

640,000 tons of yearly commodities : 150 tons d.w. ships: 20 calls = 213-214 ships

Did the two harbours at Portus have such a capacity?

Both harbours had a maximum depth of 4-5 m, hus limiting the size of the seagoing vessels putting into port.[4] The sides of Trajan's hexagonal basin measured 358 m in length, its harbour inlet 118 m,[5] for a total length of quays 2,030 m.[6] Holed mooring blocks of travertine were bricked into the quay sides and placed 15 m apart.[7] If we consider one boat for each block the minimum number of ships that could be moored would total 135, but in practice more ships could use the same mooring block, thus increasing the number of ships.[8] Between the two harbours was a transition area with quays and storage buildings, including a rectangular basin referred to as the *darsena*, measuring 45 x 240 m and built already under Claudius.[9] This area had quays running for approximately 1,950 m,[10] making room for another 130 boats, in all minimum 265 boats. The Claudian harbour was not made primarily for mooring. Its long piers stretching into the sea, far away from the nearest storage buildings,[11] functioned more as break waters, at best for the mooring of inactive ships or ships waiting for sail-

[1] ALDRETE , MATTINGLY 1999, p. 197, note 72.
[2] ALDRETE, MATTINGLY 1999, p. 197, for half the length of the sailing season arrived at ca. 3,000 dockers needed daily.
[3] FELLMETH 1991, p. 22, considered 30 calls at each mooring/anchorage place through the sailing season.
[4] TESTAGUZZA 1970, pp. 69, 163; cf. also RICKMAN 1985, p. 108, and 1991, p. 106, who states that a ship of 250 tons d.w. "would have needed a depth of little more than 3 m of water".
[5] CALZA 1925, p. 55; TESTAGUZZA 1970, p. 161; FELLMETH 1991, p. 17. According to CALZA 1925, p. 55, the quays measured 357.77 m. If the the sides were projected to measure 1,200 Roman feet, the foot would in case have been 0.2981 m, slightly longer than normal (on the variability of the actual length of the foot, cf. BRANDT 1985). If the inlet was projected to measure 400 Roman feet, the width, with the use of the long foot above ought to have measured 119.25 m.
[6] TESTAGUZZA 1970, p. 161: 2,028 m; FELLMETH 1991, p. 29: 1,850 m.
[7] CALZA 1925, p. 55; MEIGGS 1973, p. 163; TESTAGUZZA 1970, p. 162; FELLMETH 1991, pp. 17, 20-22. I should think the mooring blocks were planned to be 50 feet apart (= 14.79 m).
[8] TESTAGUZZA 1970, p. 161, followed by RICKMAN 1991, p. 111, gave room to more than 200 ships of an average width of 10 m, while FELLMETH 1991, p. 29, gave room to 154 ships of a width of ca. 12 m.
[9] TESTAGUZZA 1970, p. 173.
[10] TESTAGUZZA 1970, p. 161.
[11] RICKMANN 2002, pp. 256-357; MILLETT *et alii* 2004, pp. 223, 230.

ing orders. The large basin, however, served well for anchorage of ships and reloading directly to river boats, as had been the custom for large ships putting anchor at sea outside Ostia before the harbour was built.[1] In addition came another 2,000 m of quays along the canal joining the harbours with the Tiber, the so-called *Fossa Traiana*,[2] and the river port at Ostia. In all, the harbour should be able to have at least 500 ships, split between sea going vessels and river boats, operating at the same time, and still have space for inactive vessels of both sorts for mooring and/or at anchorage. Portus was thus built more than large enough to both unload and reload commodities destined for Rome, even if the seagoing armada of merchant ships should have been of a low tonnage. But did it have storage facilities for the large quantities of commodities arriving each year?

We may wonder why the new harbours at the Tiber mouth did not take in the Alexandrian grain fleet as soon after they were ready. Instead the fleet continued to unload at Puteoli. One reason may have been established trading networks that were difficult to change. Another, and perhaps more pertinent, may have been the availability of storage buildings. From the time of Claudius few have been registered and when Trajan's harbour was inaugurated the storage buildings were still under construction. From available data there appears to be a parallel development of building activities at Portus and the raising of new or the refurbishing of old storage buildings at Ostia.[3] For only the grain it has been calculated that up to 500,000 cubic metres of storage space, or half a kilometre of storage buildings, was needed.[4] However, Portus/Ostia was only a station on the way to Rome and nearly all storage was for wares in transit. The transit in its turn was dependent on available shipment up the Tiber, and of available storage space in Rome. This means that the total storage space at Portus, Ostia and Rome had to be large enough to receive all commodities arriving in the course of a year, in addition it needed a certain percentage of additional storage space for commodities that had not yet been distributed when the new sailing season started. We have no overview of the number of warehouses, nor their total capacity, nor even the total storage requirement. However, generically the excavated and/or surveyed buildings at Ostia and Portus, as well as fragments of the *Forma Urbis* in Rome, demonstrate that warehouses made a strong impact on the townscape in all three places, most of them lying close to the quays and dominating the waterfront.[5] And Portus could not have received the grain fleet from Egypt and North Africa until it had secured adequate storing capacity.

Transport over land

Before Trajan's harbour was built the Alexandrian fleet, and perhaps also most other large seagoing vessels, delivered their commodities at Puteoli. From here the commodities could be sent to Rome by road, or by smaller ships along the coast and up the Tiber. If sent by road what kind of organisation would have been needed? Since we already have started a game of calculations, let us continue. If we assume that all the grain travelled from Puteoli to Rome by road, certainly the safest way, the following calculations can be made. The use of the low estimate of grain imports, 175,000 tons, will suffice to illustrate the problem.[6]

1. The shortest route Puteoli-Rome went by Via Domitiana[7] and Via Appia, along the coast, length ca. 210 km. The inland route along Via Cassia was longer, ca. 230-240 km, and it was more strenuous.
2. The average speed of a loaded ox-cart was 15 km per day.[8] If donkies or mules were used, the speed would perhaps have been slightly more.[9] Donkies/mules could have been used both as ordinary pack animals and as draught animals.[10]
3. The average load for an ox-cart, according to the Diocletian price edict from AD 301, was 1,200 *librae*, or a bit less than 400 kilos (1 *libra* = 0.32745 kilo).[11] If donkies (or mules) were used as pack-animals, the most common transport animal,[12] their load could not have exceeded 125 kilos.[13]

[1] DION. HAL. 3.44.3; STRAB. 5.3.5.

[2] TESTAGUZZA 1970, p. 161. Recently a new canal, about 40 m wide, joining Trajan's harbour with the Tiber has been detected with more storage buildings along its sides, see MILLETT *et alii* 2004, p. 227. The new discovery will add more quay space to what is already known and make old calculations obsolete. See also KEAY *et alii* 2005, published when the present article was already in print.

[3] RICKMAN 2002, pp. 355-358; cf. also VITELLI 1980, fig. 3, p. 60 and fig. 8, p. 64.

[4] GALSTERER 1990, pp. 32-33; RICKMAN 2002, pp. 359-360; GERACI 2003, p. 637. – On storage at Ostia, see also HERMANSEN 1981, pp. 227-237.

[5] RICKMAN 1971, pp. 15-86 (Ostia), 87-122 (Rome); cf. also 1980a, pp. 134-143; 2002; ZEVI 2002, pp. 54-58.

[6] Cf. also POMEY, TCHERNIA 1980-81, p. 40.

[7] This new road, reducing the travelling time to Rome, was only built under Domitian in AD 95 and praised by STAT. *Silv.* 4.3. See MAIURI 1983, p. 130; FREDRIKSEN 1984, p. 336; ZEVI 2000, p. 511, note 6.

[8] YEO 1946, p. 255; FORBES 1965, p. 159; HOPKINS 1983, p. 104. JONES 1964, p. 842, followed by TENGSTRÖM 1974, p. 31, and RICKMAN 1980, pp. 13, 121, used 2 miles, or a bit more than 3 kms per hour, thus implying a slightly higher daily speed. Note also the comment by FINLEY 1973, p. 126: "oxen, mule, donkey are slow and hungry".

[9] JONES 1964, p. 842, "man's walking pace", which RICKMAN 1980, p. 14, translated into 3-4 miles (5-6 kms) per hour.

[10] The carrying weight for mules are not given in the Diocletian edict; cf. LE GALL 1994. For draught animals *Cod. Theod.* 8.5.8 (= PHARR 1952, p. 196), mentioned 8 mules for summer transports, 10 for winter ones.

[11] GIACCHERO 1974, p. 17.3; MOMMSEN 1893, comments on p. 145. – In *Cod. Theod.* 8.5.8 and 8.5.17 (= PHARR 1952, pp. 196, 197) this figure is reduced to 1,000 *librae* (c. 330 kilos) for ordinary transport wagons (*raedae*), but remained 1,500 *librae* for post wagons (*c.* 495 kilos) (cf. *Cod. Theod.* 8.5.28 and 30 (= PHARR 1952, p. 199). The last weight seems to have been rather standard in the antiquity, cf. BURFORD 1960, p. 2, note 2.

[12] So according to VARRO *rust.* 2.6.5.

[13] YEO 1946, p. 225; cf. also WHITE 1975, p. 52. In the Diocletian edict a maximum weight is not given.

4. A return journey Puteoli-Rome along the shortest route would then have taken: 2 x 210 km: 15 km per day = 28 days. If we add a couple of days for loading, unloading and rest, a return journey would have taken ca. 30 days, i.e. an ox-cart could have made max. 12 trips a year, excluding days for repairs of equipment and recovery from fatigue and sickness of animals and men.

5. The daily quantity of grain to leave Puteoli would have been 175,000 tons : 365 days = ca. 480 tons, or 480,000 kilos.

6. In terms of transport this means that 480,000 kilos : 400 kilos per ox-cart = 1,200 ox-carts would have to leave Puteoli every day, or alternatively 480,000 kilos : 125 kilos per donkey/mule = ca. 3,840 donkies/mules per day.

7. The total number of animals needed for a 30 days round trip would accordingly have been: 1,200 ox-carts per day x 30 days = 36,000 oxen (using one oxen per cart – the number of men would have be the same calculating one man per ox-cart), or alternatively 3,840 donkies/mules per day x 30 days = 115,200 donkies/mules (but not so many men as more donkeys/mules tied together could have been handled by one man). In these numbers are not considered replacement animals.

8. The traffic density along the road would accordingly have been: 15 km per day : 1,200 ox-carts per day = c. 12.5 m road space per ox-cart, or alternatively : 15 km per day : 4,380 donkies/mules per day = c. 4 m road-space per donkey/mule – or the double if they walked two side by side.

9. Since two roads lead from the Bay of Naples towards Rome (see the first point above) the traffic could have been eased by using both, the distance between the ox-carts/mules increasing to the double.

10. I shall not try to calculate the number of resting places needed along the roads[1] nor how much "fuel" in terms of fodder, food and water would have been needed for animals and men, nor try to imagine how the animal (and human) excrements might have transformed the sight and smell of the roads.

It should not be necessary to comment what traffic problems transport on this scale would have caused and what infrastructure would have been needed – the numbers are self explanatory.[2] It is worth noting that here we are only talking about grain, and not of other commodities which also had to be transported to Rome. Even if only the grain from Egypt, that covered one third of Rome's needs, should have been carried along the road from Puteoli, serious traffic jams would have occurred along the route. Furthermore, if the grain transported from Puteoli had followed the land route, Horace would certainly have given a completely different description of his journey along Via Appia from Rome to Brindisi than the one we can read in his first book of *Satires*.[3] And the important service of the *cursus publicus* would have been confronted with serious problems of inefficiency.

There is general agreement among historians that transport by land in Antiquity was much more expensive than that by sea. A. H. M. Jones, for example, once remarked that it was cheaper to ship a load of grain "by sea from one end of the Mediterranean to the other than carting it 75 miles <= 120 km>".[4] And Keith Hopkins, using the Diocletian price edict, calculated the difference between various transport systems as follows: the costs of sending one ton of commodities would increase by the figure of 6 if shipped along rivers instead of by sea, and by the figure of 55 if sent by road.[5]

Confronted with these figures not only would an organisation of transport on the scale presented above have been impossible, but the price of grain would also have multiplied. This leaves the sea as the only way to bring the commodities from Puteoli to Rome.

Transport along the coast

It was argued above that the tonnage of coastal and river boats on average could have been maximum 60 tons d.w.[6] The low average tonnage was presumably partly determined by the river – by bringing the grain directly to Rome one would eliminate an expensive reloading stop at Portus. Since we know little about which commodities went directly to Portus before Trajan's harbour was built, except perhaps grain, let us consider what it would take to move 175,000 tons of grain (or the double if we use the high estimate) from Puteoli to Rome:

175,000 tons of grain : 60 tons d.w. = 2,916 ship loads (or the double)

Only five months passed from the first ships with grain arrived at Puteoli in late May/early June un-

[1] Holmberg 1933, p. 74, distinguished between *mutationes*, for the change of animals, lying 8 Roman miles (= *c.* 8 km) apart, and *mansiones*, with lodging accommodation, lying 25 Roman miles (= *c.* 36 km) apart.

[2] Cf. also Pomey, Tchernia 1980-1981, pp. 39-40.

[3] Hor. *sat.* 1.5, who at *Appii Forum* was more concerned about gnats and frogs of the fens that drove off sleep and a singing boatman soaked in wine.

[4] Jones 1964, pp. 841-842; followed by Finley 1973, p. 126; Rickman 1980, p. 14, with note 29.

[5] Hopkins 1983, p. 104. Carreras Monfort 1999, p. 93, using the same edict arrived at the following ratios between the following means of transport: 1 sea shipping: 3.4 river boats (downstream): 6.8 riverboats (upstream): 43.4 pack animals : 50.72 wagons. Cf. also Duncan-Jones 1974, p. 368, who, from the edict, stipulated that a wagon load of grain carried 100 Roman miles would increase its price by 36-73%; Schneider 1982; Fellmeth 1991, p. 3; Lo Cascio 1993, p. 54. On water and land transports see also Meiggs 1982, pp. 335-346. On the costs cf. also Plin. *ep.* 10.41.

[6] See p. 33.

til the autumn storms started in November, and before when all the grain should have arrived in Rome, or at least in Ostia. That means that the number of ships leaving Puteoli each day would on average have been:

2,916 ship loads : 150 days = ca. 20 ships per day (or the double)

The voyage along the coast could, with favourable wind and weather conditions, be done in two days, but only one way, the return would then have taken more time, let us say three days. Up the Tiber it took another three days,[1] but down again only one. If we add two days for loading and unloading respectively, a roundtrip from Puteoli to Rome and back would last ideally 13 days.[2] If we use the last figure, it means that hardly more than 12 trips could be done per season, weather and repairs permitting. To carry all grain form Puteoli to Rome one would then have needed minimum:

2,916 ship loads : 12 trips = ca. 243 coastal boats (or the double).

This would mean that some 38 boats would be sailing up the coast, 57 up the Tiber, 38 unloading in Rome, 19 sailing down the river, 57 sailing south to Puteoli and 38 loading there every day in the sailing season (or the double) – numbers that do not seem terribly excessive. However, the transport along the coast contained a risk the skippers perhaps did not always want to take in uncertain weather conditions,[3] and Monte Circeo was an area always with unpredictable currents. Therefore the coastal transport was the weak link in the grain supply chain – and the more boats that were involved the weaker the link.

In 39 AD, one would expect in the middle of the summer when the sea was calm, Caligula constructed a ca. 4 km long road,[4] "fashioned in the manner of the Appian Way", across the bay from Puteoli to Baiae, "by bringing together merchant ships from all sides and anchoring them in a double line".[5] The exploit would have taken weeks rather than days to complete. The number of boats requisitioned for the occasion must have been in the hundreds,[6] and the pace and rhythm of the seagoing trade severely disturbed. If the famine in the winter 40/41 AD, in the first year of Claudius' reign, can be connected to this event,[7] then the weakness of the Puteoli harbour, as well as that of the Puteoli-Ostia link, in Rome's supply chain was well demonstrated. Claudius' initiative of building a new harbour at Ostia did not solve the problem, as already explained,[8] and Nero, instead of bringing the Alexandrian fleet to Rome by improving his uncle's efforts, chose to bring Rome to the Alexandrian fleet. Like Claudius' port, also Nero's project, a canal, had been one of Caesar's ideas.

Many of the engineering projects described by the ancient authors astonish us now, bordering on disbelief; and if we did not know that many of the projects were actually started or even brought to completion, we would probably have labelled them unrealistic designs of folly. One example of such completed project was Claudius' Portus.

Caesar's plans to build a new harbour at Ostia demonstrated his special care for shipping and its importance in securing a safe and steady supply of commodities to Rome. The same care lay behind his plans to build a canal through the Corinthian isthmus (so that boats should be spared from sailing round the weather exposed rocks of Peloponnese), as well as behind his plans to build from the Tiber a deep canal south of Rome through the Pontine marshes to Terracina. In that way the boats could avoid sailing round Monte Circeo; at the same time the marshes could be drained for cultivation and a granary obtained at the doorsteps of Rome.[9]

Nero, with his two favorite architects, Severus and Celer, carried this project a step further, prolonging the projected canal from Terracina to Puteoli.[10] Tacitus wrote ironically about the project, saying that there was no need to build the canal, but he may have missed the point. Nero, who was not unaware of Rome's fragile supply system (his construction of a port and villa at Anzio is a clear sign in this direction), most certainly had the transport of grain in mind.[11] Claudius' Portus had not been built to direct the Alexandrian fleet to Rome, the fleet continued to unload grain in the deep-water port at Puteoli.[12] The projected canal could keep the important transport route

[1] So according to Philostr., *V A* 7.16. Cf. Le Gall 2005, p. 314. In the 19th century, before the introduction of steamships, the towing took 2-3 days depending on the sailing conditions on the river; see Segarra Lagunes 2004, p. 355, n. 166.

[2] Pomey, Tchernia 1980-1981, p. 41, suggested 15 days; cf. also Zevi 2001b, pp. 118-119.

[3] On a shipwreck at Misenum, see Tac. *ann.* 15.46.

[4] The exact length is impossible to establish. For a discussion, see Barrett 1989, pp. 211-212.

[5] Suet. *Calig.* 19; translation by J.C. Rolfe (Loeb Classical Library, Cambridge [Mass.] & London 1913). Cf. also Sen. *De brevitate vitae* 18.5; Ios. *AJ* 19.5-6; Cass. Dio 59.17; Aur. Vict. *Caes.* 4.3.

[6] According to Wardle 1994, p. 190, L. Casson shall have estended the number of ships to 560, but his reference is wrong; Virlouvet 1985, p. 52, note 46, suggested 2,000 boats, a number most likely much too high.

[7] Pomey, Tchernia 1980-1981, p. 41. Cf. also Rickman 1980a, pp. 74, 75; Zevi 2001a, pp. 277-278; 2001b, p. 119. Contra: Garnsey 1988, pp. 222-223; Barrett 1989, p. 195; Wardle 1994, pp. 189-190; Williams 2003, p. 241. Cf. also Lo Cascio 1993, p. 58.

[8] See pp. 26-27.

[9] Plut. *Caes.* 58.4-5; Suet. *Iul.* 44.2-3; Cass. Dio 44.5.1. For modern interpretations, see, Henderson 1903/1905, p. 247; Maiuri 1983, pp. 123-139; Meiggs 1973, pp. 57-58; Griffin 1984, pp. 107-108.

[10] Suet. *Ner.* 31.3; Plin. *nat.* 14.8.61; Tac. *ann.* 15.42.

[11] See, for example, Fellmeth 1991, p. 4; Zevi 2004, pp. 216-217.

[12] On the deep-water port, see Frederiksen 1984, p. 324; Zevi 2001a, pp. 278-279; 2001b, pp. 119-120; 2004, pp. 214-215.

between Puteoli and Rome open all year round and reduce seasonal traffic congestions in harbours and on the Tiber. And why should not Nero manage to accomplish such a project (it was actually initiated north of Puteoli, but never completed[1])? Had not his limping and stuttering uncle, in addition to the harbour at Portus, a few years earlier in the Appennines east of Rome, also cut a more than 5 km long tunnel through the mountain, emptied a third of the lake *Fucinus* and transformed 5,000 ha of lake bottom into fertile land?[2] This project, by the way, was also one originally proposed by Caesar,[3] again I should suggest, in an effort to gain land for cultivation of grain in the neighbourhood of Rome.[4]

Transport up the Tiber

The final link in the supply chain was the Tiber between the sea and Rome.[5] From the large seafaring ships, *naves onerariae*, the commodities were brought up the river by coastal boats or boats particularly built for river traffic, the *naves codicariae*, the size of which, as argued above, could perhaps have had an average tonnage of maximum *60 tons d.w.*[6]

The Tiber was a capricious river with marked changes of the water table and the speed of its currents from one season to another. The river was at its lowest in August making it difficult for bigger boats to reach the city, at its highest in April in connection with spring rain and the thaw of the snow in the mountains.[7] The higher the water table the stronger the current, and the more strenuous it would be to travel upstream, though quicker, but less safe downstream. During heavy rain, mainly in the winter months, the river easily flooded and all traffic slowed down or came to a complete halt, at times causing lack of supplies and creating famine in Rome.[8] In those periods of a high water table and stronger currents, even if it was navigable, the river could still be dangerous, due to floating tree trunks and other objects that could cause damage to the hulls of the boats. Accordingly the river was not navigable every day of the year. For the calculations I shall consider *330 days* as a maximum sailing period. The calculated figures will only give an average situation, which perhaps only could be reached in shorter periods of the year; due to the nature of the river, in periods the traffic had to slow down, in others, when the sailing conditions were optimal the traffic was intensified. The average figures therefore have to give room for variations in the volume of traffic. Intensified traffic would increase congestion and incidents along the transport route. With these preliminary statements let us turn to the last round of calculations.

The total weight of the commodities that arrived at Portus and destined for Rome was, using a low estimate for a population of 800,000 inhabitants, established at 370,000 tons, with a high estimate for a population of 1,200,000 inhabitants at 640,000 tons.[9] To these numbers should also be added salt extracted from the saltbeds by the rivermouth, only at this point being a commodity that has to be taken into consideration. With an average daily need of 10 grams of salt per day, 800,000 inhabitants would have needed 8 tons per day, or 2,920 tons per year; a population of 1,200,000 would have needed 4,380 tons. The corrected numbers are thus ca. 373,000 tons for a population of 800,000, and ca. 645,000 tons for one of 1,200,000.

To carry all these commodities it would require:

373,000/645,000 tons of commodities : boats of 60 tons d.w. = 6,217/10,750 boat trips per year

With this number of trips Rome would have to receive:

6,217/10,750 trips : 330 days = ca. 19/33 boats per day.

A riverboat of 60 tons d.w. could be loaded or unloaded in a couple of days. Due to its strong currents and winding course it was not possible to sail up the river,[10] instead men and/or oxen were used to pull the boats, a trip that took three days upstream to Rome.[11] The return voyage lasted only one day.[12] All together a roundtrip Portus-

[1] Johannowsky 1990; cf. also Zevi 2004, pp. 216-217.
[2] Suet. *Claud.* 20.2; Cass. Dio 60.11.5, cfr. 61.33.3-5; Tac. *ann.* 12.56-57.
[3] Suet. *Iul.* 44.3; *Claud.* 20.1; Plin. *nat.* 36.124.
[4] For the drainage of the lake in the 19th century, see, for example, the more or less contemporary publications, Brisse 1876; De Filippis 1893.
[5] Meiggs 1973, pp. 289-298. – On the Tiber, see also Le Gall 2005; *Tevere* 1986; Tchernia 2003, pp. 46-51.
[6] See p. 49.
[7] On the changing flow of the Tiber, see Le Gall 2005, pp. 12-17. Note that many authors (see, for example, Mocchegiani Carpano 1984, p. 48) referring to Plin. *epist.* 5.6.12, consider that the river was not fit for sailing in the height of the summer, due to its low water table; cf. Tengström 1974, p. 58. Pliny wrote about the situation near his villa in Tuscany, not in Rome. The water table of the lower part of the Tiber was never so low that boats could not sail on the river, only larger ships may have met some difficulties.
[8] For floods in Rome, some of which may also have damaged foodstuff in the warehouses, cf. Suet. *Otho* 8 and Tac. *hist.* 1.86 (in AD 69, causing lack of supplies and famine); Plin. *epist.* 8.17 and *CIL* VI, 964 (under Trajan). For a more complete picture of the floods, see Le Gall 2005, pp. 34-42.
[9] See p. 50.
[10] Prok. *Goth.* 1.26.11.
[11] See note 152. – Mocchegiani Carpano 1984, p. 49, mentioned two overnight stays for which mooring was necessary. It shall not be excluded that the towing teams of men/oxen had to be changed at regular intervals during the day. For this the presence of 'service' stations and fresh towing power would have been needed (cf. Rickman 2002, pp. 360-361).
[12] Sirks 1991a, p. 266, said half a day. Holland, Holland 1950, p. 91, indicated an average speed of three miles per hour for a modern raft.

Rome-Portus including loading and unloading would have taken 8 days. If this traffic had moved continuously, as on a conveyor belt, the total number of boats necessary for this operation would have been:

38/66 boats loading in Portus every day + 57/99 boats sailing up the river + 38/66 boats unloading in Rome + 19/33 boats sailing down the river = total 152/264 boats.[1]

Shuttle traffic like this would perhaps not have required so much harbour space in Portus and Rome. At Portus the river boats could either be moored by the quay to get loaded from the storage buildings, or alongside moored ships to be loaded directly. As at Portus, also in Rome, in the emporium area, mooring blocks were cemented in the quays at every 15 m,[2] which means, with the boats moored along the quays (only possible way due to the currents of the river), that on average only 570/990 m quay space, split between the two sides of the river, would have been needed (or even less, if the boats were moored alongside each other, as visible on many a print and photograph of mooring boats in the same area from the 16th-20th century).

However, the traffic on the river would have been rather intense. The Tiber, with all its bends, between Portus and Rome measured about 34 km,[3] which means that the distance between the boats going up the river would have been:

34,000 m length of Tiber : 57/99 boats going up = 596/343 m between the boats; for boats going down the river the distances would have been tripled.

The boats were towed by men and/or oxen,[4] and both sides of the river were used. By the 6th century AD the left side, apparently employed by boats leaving from Ostia, was overgrown and out of function.[5] This implies that the traffic along the right side of the Tiber, on which side Portus was situated, was the side most used for towing. However, since the large storage buildings in Rome stayed on the left side of the river, at a certain point during the upward journey most of the boats from Portus had to shift to the other side. This would have required an operation that slowed down the speed of the boats, opening a possibility for congestions in periods of intense traffic for the upgoing vessels, and a nuisance for the downgoing ones. The permanent services such an operation required would also have created the necessity for small river stations, unless the area with extended quays and buildings below the Aurelian walls also could have served for this purpose.[6]

The size of the towing teams is not known, but a comparison with modern data for the Tiber may give a small clue: for boats of 38 tons 8 *bufali* (or water buffalos, generally considered stronger than ordinary oxen, introduced into Italy in the seventh century AD) were needed, for those of 95 tons, 10 were used, and for those of 140 tons, 12.[7] For a full tour each team would use three days up the river and perhaps no more than two days back again, in all five days.[8] Considering an average of 8 oxen per boat, the minimum total number of animals needed to keep this service going every day the year round would be:

8 oxen per team x 19/33 boats being towed per day x 5 days per tour = 760/1,320 oxen; for teams of men the minimum number would have been tripled or quadrupled, and with an average lower tonnage of the boats the number of towing power would have to be increased.

Many attempts have been made to quantify the traffic up the river, but strangely enough the numbers suggested have never been evaluated in their full and proper contexts.[9] Most of the figures presented above seem to be reasonable and manageable for the work to be performed, but it shall be remembered that the calculations presuppose that there were no delays in the traffic, that the boats were on the move continuously with no time for repairs or rest days for boats and crew.[10] The total number of boats

[1] Aldrete, Mattingly 1999, p. 198, with the use of boats of 70 tons d.w. and a week to make a round trip arrived at 6,043 trips per year for a total of 166 boats per day to carry grain, oil, and wine only. Cf. also note 184.

[2] As preserved in the quays in the Marmorata/Testaccio area. Cf. Gatti 1936, pl. i.

[3] Strab. 5.3.5: 190 stades; Cass. Dio ed. Dindorf I, p. 55: 180 stades (text corrected); Prok. *Goth.* 1.26.4-5: 126 stades, from Trajan's canal along the river to the sea: 15 stades. Apparently the two authors had different views of the length of a *stadium*: on this see Bauslaugh 1979, esp. p. 5, note 22. For modern measurements, see Le Gall 2005, p. 313: 35,020 m from Torre Bovacciana to Ponte Palatino in Rome, but since the voyage started from Trajan's harbour, the length for our calculations would have been closer to 34,000 m.

[4] Mart. *Spect.* 4.64.22: *helicarii*; Prok. *Goth.* 1.26.11-12: oxen; for the 17th and 18th centuries, see *Tevere*, pp. 157-158.

[5] Prok. *Goth.* 1.26.13; 2.7.6; cf. also 1.26.11: oxen stood ready near the harbour in Portus, in no small number, on the right side of the river.

[6] On these areas, cf. Jacopi 1943; Le Gall 2005, pp. 219-222; Mocchegiani Carpano 1984, pp. 34-37. Cf. also Tengström 1974, p. 59, who suggested that the harbour at Pietra Papa, near S. Paolo fuori le mura, could have served as a station for boats waiting their turn to be unloaded in Rome

[7] Casson 1965, p. 39, note 69.

[8] For the sake of convenience I calculate here as if the teams followed the boats all the way from Portus to Rome, which they, according to the arguments presented above, in most cases did not.

[9] To give some figures that has appeared in print: Le Gall 2005, p. 304, followed by Mocchegiani Carpano 1984, p. 47, estimated the total import of commodities to 800,000 tons, for which 12,000 ship loads (of ca. 67 tons d.w.) were necessary to bring the commodities to Rome; Zevi 2001, pp. 118-119, considered that all 60 million *modii* grain went to Rome, which, brought with riverboats of 50 tons d.w. each, would have required some 10,000 (*sic*) (in addition would have come all other commodities); Rickman 1980a, p. 19 (followed by Cracco Ruggini 1985, p. 231) considered that even if 60 million *modii* grain left for Rome, only 40 million *modii* arrived safely, which for riverboats of an avereage tonnage of 68 tons would only require some 4,500 ship loads; cf. also Rickman 1991, p. 112. Cf. also note 176. On the river traffic, see also Pavolini 1986, pp. 104-108.

[10] We should perhaps not exclude that various sorts of corruption and speculation in grain and other wares, in which skippers and towers may also have been involved, could have conditioned the steady flow of commodities up the river; on this cf. Geraci

therefore has to be increased, as well as the quay space needed to moor active and inactive boats. There is also reason to believe that the average tonnage of the boats were actually lower than the one considered here. In the year 218 BC the senators passed a law (the *lex Clodia*) that forbade them to own ships with a capacity of more than 300 amphorae (= 15 tons d.w.), considered enough to transport their own agricultural produce from the fields.[1] The implication, as Meiggs once noted, is that "men were trading with ships not much larger".[2] By using a high average tonnage the calculations give a *minimum* solution. With a lower average tonnage the number of ships would be higher and their internal distances up the river less, thus increasing the possibility of congestions.[3] Furthermore, some transports of heavy material, like monolithic columns, would have taken longer time to bring up the river, thus slowing down also other traffic. Likewise, the maintenance of tow paths, bridges,[4] and the riverbeds (in particular after floods), the responsibility of which was given to a special office, the *Curatores alvei Tiberis et riparum*,[5] were other factors that could interfere with the river traffic. And finally, much of the wares that arrived in Rome were also distributed to its hinterland,[6] the volume of which (not possible to generate) has not been included in the above calculations. By adding all these observations, the traffic must have been much more intense than the calculations demonstrate: we can easily imagine the many traffic problems that may have occurred.[7]

It is difficult to state with precision how many trips the river boats could perform per year, but from the present calculations I should say that the saturation point would stand below 10,000. This explains why first Claudius and later one of the emperors of the second century AD, perhaps Marc Aurelius, encouraged skippers to build bigger boats, not only the seagoing vessels, perhaps more important the riverboats.

In 60 BC a terrible storm made many boats sink in Rome and by the rivermouth,[8] and in AD 62, during another strong storm, more than 200 vessels sank in Claudius' harbour. At this last occasion some 100 vessels also burnt on the river,[9] presumably because they were amassed together in one place (most likely in Rome). Such events must have created serious blows to the river transport, since many of the vessels which sank certainly were river boats, and they demonstrate well the fragility of this link in Rome's supply chain. In Late Antiquity Rome's fishermen were joined with the *codicarii* in one *corpus*,[10] perhaps to strengthen the river transport system, but this was presumably more a sign of a system in crisis, than of an over-heated system in full speed.

Concluding reflections

When Trajan had finished his supply chain program for Rome, the Tyrrhenian coast on either side of the mouth of the Tiber could muster four safe ports over a distance of some 150 km of sandy shores: Terracina, Anzio, Portus and Civitavecchia.[11] In his classical book on Roman Ostia Russell Meiggs claimed the three smaller ports, and especially the one at Civitavecchia, to be harbours of refuge in case of bad weather, or as auxiliary harbours in case Portus should be too crowded with ships.[12] Ulrich Fellmeth, however, sustained that the ports at Civitavecchia and Terracina were absolutely not necessary and regarded them as competitors to the ones at respectively Portus and Puteoli.[13]

Did all the four ports close to Rome really have a function in the capital's supply chain, and if so, were they all strictly necessary? An answer perhaps lies with the numbers above. However, before answering, it is important to remember that statistics (even modern ones) never fully represent the reality. But from what the numbers are worth (and much patching can certainly be done on single calculations), the results may at least tell us something:

1. Transport by land is expensive and the load capacity of ancient vehicles was so low that the transport of large quantities of goods would have caused severe traffic congestions, if all commo-

2003, p. 641, and for modern times Segarra Lagunes 2004, pp. 347-355. A suspect rise in the price of grain in the late Republic may be one example on ancient speculation, see, Cic. *leg. man.* 44.

[1] Liv. 21.63.3-4.

[2] Meiggs 1973, p. 291.

[3] By reducing, for example, the average tonnage to 50 tons d.w. the number of ships needed daily would increase from 19/33 to 23/39 and reduce the distances between them up the river from 596/343 m to 493/291 m.

[4] In a document issued in 1760 under Pope Clemens XIII we are told that 17 bridges along the towpath Fiumicino-Rome were repaired, giving a minimum number which may not have been much dissimilar to the ancient situation; see Segarra Lagunes 2004, p. 329.

[5] Le Gall 2005, pp. 155-208 (especially pp. 202-203), 377-378.

[6] On Rome and its hinterland, see Morley 1996.

[7] Many of the recorded disfunctions and irregularities in the transport of commodities to Rome in the 16th and 17th centuries (see, for example, Segarra Lagunes 2004, pp. 346-350) may also have occurred in Roman times, even if the the controls set by the public administration were perhaps more severe.

[8] Cass. Dio 37.58.3.

[9] Tac. *ann.* 15.18.

[10] Cf. *Cod. Theod.* 14.21.1 (year AD 364) (= Pharr 1952, pp. 420-421), and the inscription published in «NS», 1925, pp. 226-228, dated to ca. AD 400; cf. also Le Gall 2005, p. 385, note 16.

[11] Here should also, perhaps, be added the small non-commercial harbour at Astura, south of Anzio, only useful for shelter, cf. Piccarreta 1977, pp. 62-66.

[12] Meiggs 1973, pp. 59-60; supported by Rickman 1991, p. 109, with some additional observations on emergency storage; cf. also Rickman 2002, p. 360. Note also that Anzio was used for incoming ships when the Goths in AD 537 blocked Portus, but because of scarcity of men it was difficult to bring the cargoes thence to Rome, see Prok. *Goth.* 1.26.18.

[13] Fellmeth 1991, pp. 5, 30-31.

dities to Rome were to be unloaded in one port and brought to the capital by land. However, in cases where canals and rivers fit for sailing were not available, the roads were the only other transport possibility.

2. The Tiber was the quickest and cheapest way of bringing commodities to Rome, but the river was a potential bottleneck – the number of boats sailing on the river at any time must have been restricted, and the total number of boat trips through the year could presumably not have exceeded 10,000. The rivers strategic importance for Rome was well exemplified during the Civil War when both Marius and later Sulla, returning respectively from Africa and the East, had as their first objective to take Ostia, from where they could «hope to starve Rome into submission».[1] In the Gothic Wars Vitigis seized Portus in AD 537 with the same intent.[2]

3. Therefore, in order to secure a safe supply of commodities to Rome it was important that many supply routes were used, both on water and on land, even if land transport may have caused an increase in the price of each commodity. I think it is within such a framework we must see Nero's harbour at Anzio and later those of Trajan at Civitavecchia and at Terracina. Along roads from these harbours goods could be brought to Rome's hinterland, and, if necessary, also to the city itself in 3-7 days. These harbours were not superfluous, nor in completion with the harbour at Portus, as Fellmeth surmised, nor were they primarily shelter-or auxiliary-harbours, as suggested by Meiggs,[3] they were essential parts in Rome's and its hinterland's system of supply routes, as attested by Appian in his account of Marius' seizure of Anzio, and the inland towns Ariccia, Lavinio, and other localities, where commodities for Rome were kept in stockage.[4] Puteoli could have maintained a similar function, even after the grain traffic was directed to Portus.[5] However, a precision must here be made: the smaller ports near Rome were created not to relieve quay space in Portus, but the bottleneck Tiber.

During the Gothic wars, when Portus was blocked, Anzio was used for the import of wares to Rome.[6] However, due to a scarcity of men, the Romans found great difficulty in carrying the cargoes to the city. But this was an immediate bureaucratic problem, not the result of a deficient or non-existent infrastructure. Examples of such bureaucratic difficulties were not uncommon. At Antiochia, for example, during a famine in the year 362/3 AD grain could not be supplied from nearlying towns, perhaps because of bureaucratic or market regulations.[7]

4. As some emperors before him Trajan was much concerned about providing a reliable and safe supply of commodities to Rome, but he differed from many of his predecessors on one important point. Instead of expensive, time consuming and sometimes even utopian engineering projects, he solved the problems with few and feasible projects. With Trajan Rome seems to have reached an acceptable balance in the supply of commodities (including fresh water). After him long forgotten proposals stayed forgotten and were no longer aired by engineers looking to solve eternal problems. Neither did anyone later find it necessary to improve the supply routes strengthened by Trajan. Hereafter only patching was made to the system on which he had laid the final stone.

5. By focusing on the imports of grain the requirements of other commodities have often been overlooked (even if grain was the heaviest and most important). I find it difficult to accept that Rome received as much as 60 million *modii* from overseas. Rickman turned the information round, saying that only 40 million *modii* arrived, the rest was lost due to theft (despite the strict controls[8]) and negligent care in transportation and storage (decay and attacks by insects, vermin infestations and rodents),[9] to which should be added also shipwreck.[10] A second explanation could be that the Romans imported more than necessary to have sufficient stockage in case of a supply crisis.[11] A third explanation could be that Josephus' and Aurelius Victor's sources for the export were of Egyptian and/or North African origin and only gave the quantity leaving for Rome's main harbour at the time, at Puteoli. The figures do not tell how much ended up in the stomachs of Rome's inhabitants.[12] Campania, which was an exporter of grain to Rome and other places in the Middle and Late Republic, lost this position when Augustus annexed Egypt and started to import

[1] Liv. *epit.* 79; App. *civ.* 1.67 and 1.88; Meiggs 1973, p. 34.
[2] Prok. *Goth.* 1.26.7-13; Meiggs 1973, p. 99.
[3] Rickman 1991, p. 109, called them 'satelites', and Hesnard 2001, p. 292: 'depot ports'.
[4] App. *civ.* 1.67 and 1.69.
[5] See, for example, Tchernia, Viviers 2000, pp. 781-782.
[6] Prok. *Goth.* 1.26.17-18.
[7] Jones 1964, pp. 445-446; Hopkins 1983, p. 105.
[8] For these, see, for example, Tengström 1974, pp. 34-39, 43, 45-47, 50-52, 91-92, who analysed the Late Antique situation.
[9] Rickman 1991, p. 111; 2002, p. 359; Galsterer 1990, pp. 31-32; Geraci 2003, p. 637, and note 33 with further references: up to 30 % loss.
[10] Rememberì Paulus who once sailed with a grain ship, which in an autumn storm was wrecked at Malta (*Acts of the Apostles* 27). For other stories on the hazards of sailing, see, for example, Ios. *Vit.* 15 and Synesius, *Epistolae* 5.
[11] Geraci 2003, pp. 633-637.
[12] As also noted by Geraci 2003, p. 636, where he distinguishes clearly between the volumes of grain imported, the ones distributed to the population, and the ones actually consumed. For a different way of estimating the size of the grain imports, cf. De Romanis 2003.

cheap grain from there. The production in Campania sank and the region soon became itself an importer.[1] Even if the cultivation of grain did not come to a complete stop,[2] it is very likely that the densely populated areas around the Bay of Naples in the Imperial period received their grain from the same sources as Rome, especially since Puteoli, the receiving port, was not only a port for Rome, but also for Campania.

6. And finally, even if the harbours at Terracina, Anzio, and Civitavecchia were essential elements in Rome's supply system, the bottleneck of the Tiber was by far the most important one. The river had a maximum carrying capacity and was perhaps the element which, in demographic terms, in the last instance determined Rome's point of saturation and stabilised the number of inhabitants at a certain number through the Imperial period.[3] The Tiber served as a brake block on the expansion of the capital, the quantity of supplies brought to the city by way of the river had a limit. In the introduction to the calculations above Rome's population was established within the fork 800,000-1,200,000 inhabitants. In these numbers must also be included its *suburbium*,[4] the definition of which is rather vague.[5] In a recent study on the density of the population in Rome G. R. Storey concluded that people living inside the Aurelian walls could not have superceded half a million.[6] Even if we should disagree with Storey's methods and results,[7] we should take a warning from his conclusion, that his «data should give pause to the claim that ancient Rome had one million inhabitants». The supply chain seems to confirm this observation. I should say Rome had definitely less, even when its near-lying *suburbium* was included.

The drawback of the present and similar calculations is that we heap uncertainties upon uncertainties, but for whatever the figures are worth they demonstrate the enormous logistic and administrative task it must have required to nurish a metropolis like Rome.[8]

To return to Aristides, quoted at the beginning of this article, the calculations also show that the ancient author was right in his observations – that Rome may well have received ships «every hour and every day» and that «the ships never stopped» – but the Tiber had a limit capacity overlooked by some modern scholars, to the extent that without realising it their praise of the city and its size might have been taken to a point not supported by the reality of the system governing it.

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[1] Frederiksen 1981, pp. 6-12; cf. also Lo Cascio 1993, p. 57.

[2] Cf. the discussion Jongman 1988; Andreau 1994; Ciarallo 1994.

[3] As also suggested by Morley 1996, p. 185. On the stable population, cf. Peña 1999, p. 10.

[4] Lo Cascio 2001, pp. 186-187.

[5] Cf., for example, Champlin 1982, p. 110 ("the suburb is... not only ambiguous, it is a paradox"); Lafon 2001; *Lexicon Topographicum Urbis Romae. Suburbium* I, Rome, 2001, p. 1 (A. La Regina). Morley 1996, p. 85, considered the maximum extension of the *suburbium* to be 30 km, bordered by the Monti Sabatini, Sabini, Tiburtini and the Colli Albani (see pp. 83-107 for the transformation of this area).

[6] Storey 1997a, pp. 966, 975; 1997b.

[7] Lo Cascio 2001, p. 186.

[8] On this cf. also Aldrete, Mattingly 1999, pp. 192-193.

Referenze grafiche e fotografiche: Fig. 2: copied from Mannucci 1992, p. 56, fig. 63; Fig. 3: photo German archaeological institute, Rome, neg. no. 68-1007; Fig. 4: photo German archaeological institute, Rome, neg. no. 69-2904; Fig. 5: photo German archaeological institute, Rome, neg. no. 34-7082; Fig. 6: photo German archaeological institute, Rome, neg. no 31-1138; Fig. 7: photo: German archaeological intitute, Rome, neg. no. 33-1329.

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