

International Conference *The Acoustics of Ancient Theatres*, Patras, 2011

Current Operation of Ancient Greek Theatres: The problem of environmental noise

Nikos K. Barkas

Associate Professor

Nikolaos-Georgios Vardaxis

Architect



Department of Architecture, School of Engineering,
Democritus University of Thrace,
Xanthi, Greece.

I. **Basic principles of acoustic function of the ancient theatres**

- elimination of the external unwanted sounds (noise protection),
- harmonic deployment of the crowd around the theatrical action (architectural forms of open floor plan),
- appropriate sizes according to human vocal and acoustic scales (distribution of direct sound),
- activation of a passive loud speaker (for supporting positive, early sound reflections, as well as decreasing late, disturbing reflections and echo).

II. Critical acoustic conditions

- **reduction of the human voice** by 25 to 33 dB[A] due to the typical size of the existing theatres (up to 37 dB in cases where the third diazoma of the koilon still exists),
- **amplification of the direct sound** by max 6,5 dB with positive contributions from the orchestra, the stage and their combination (the gains are limited by half due to incorrect application or installation of the scenery in performance conditions),
- **acceptable to satisfactory speech intelligibility levels** (effective signal rising of about 20 to 25dB), in circumstances of limited background noise within the limit of the criteria NC-20 / 25.

Previous publications

N. Barkas, Th. Nikaki, D. Sakoulis, "Problems of Reuse and Sound Protection in the Current Operation of Ancient Greek Theatres" 2nd International Conference On Hellenic Civilization (Proceedings under publication) Alexandroupolis, Greece, 2008.

H. Andoniadou, N. Vardaxis, A. Moyses, N. Barkas, "Sound Protection Problems in the Current Operation of Ancient Greek Theatres" (Proceedings under publication) ELINA no5, Athens, Greece, 2010.

III. Survey sample – 14 ancient Greek theatres



Theatre	Use	Kolion	Orchestra	Skene	Environment
A1 Argos	B2	C1	D1	E2	F3
G:	G1 37	G3 43	G5 46		
A2 Delphoi	B2	C2	D2	E2	F2
G:	G1 33	G3 38	G5 47		
A3 Dion	B1	C6	D3	E2	F2
G:	G1 38	G2 43	G4 46		
A4 Dionysus El.	B4	C3	D2	E2	F3
G:	G1 44	G3 54	G5 65		
A5 Dodoni	B3	C3	D2	E3	F1
G:	G1 27	G2 36	G4 34		
A6 Epidaurus	B1	C2		E2	F1
G:	G1 29	G2 36	G3 46		
A7 Eretria	B3	C5	D4	E3	F2
G:	G1 37	G2 41	G5 47		
A8 Thassos	B2	C6	D2	E2	F1
G:	G1 33	G2 37			
A9 Thorikos	B2	C2	D5	E1	F2
G:	G1 34	G4 54	G5 37		
A10 Larisa	B3	C3	D2	E2	F3
G:	G1 43	G3 58 (70)	G5 51		
A11 Maroneia	B2	C4	D3	E2	F2
G:	G1 34	G2 37	G5 46		
A12 Megalopolis	B3	C5		E5	F2
G:	G1 33	G4 37			
A13 Philippi	B1	C3	D2	E2	F2
G:	G1 40	G2 44	G5 52		
A14 Oropos	B2	C5	D2	E4	F1
G:	G1 33	G4 37			

Current Operation of Ancient Greek Theatres: the problem of environmental noise

III. Survey sample – 14 ancient Greek theatres



The Argos theatre

Use; occasional performances.

Koilon; carved in rock.

Orchestra; Roman conversion into water tank.

Skene; damaged building and foundation ruins.

Environment; urban environment – urban activities – traffic.

Noise levels; background noise 37 dB, urban activity noise 43 dB, road traffic noise 46 dB.

III. Survey sample – 14 ancient Greek theatres



The Delphi theatre

Use; occasional performances.

Koilon; full restoration.

Orchestra; Roman coating.

Skene; damaged building and foundation ruins.

Environment; semi-urban environment – rural activities – traffic.

Noise levels; background noise 33 dB, urban activity noise 38 dB, road traffic noise 47 dB.

III. Survey sample – 14 ancient Greek theatres



The Dion theatre

Use; official festivals.

Koilon; damaged by illicit stone traders – partial intervention with wooden gradients.

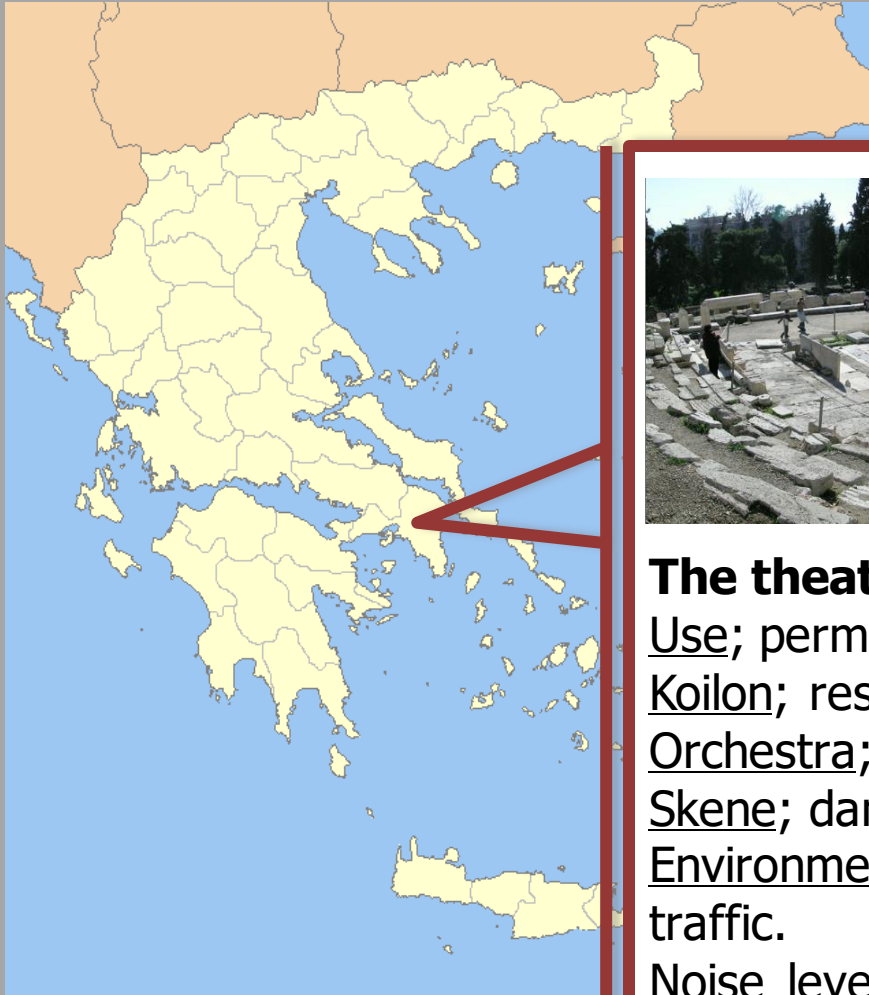
Orchestra; authentic form, soil.

Skene; damaged building and foundation ruins.

Environment; semi-urban environment – rural activities – traffic.

Noise levels; background noise 38 dB, natural sounds 43 dB, rural activity noise 46 dB.

III. Survey sample – 14 ancient Greek theatres



Theatre	Use	Koilon	Orchestra	Skene	Environment
A1 Argos	B2	C1	D1	E2	F3
G:	G1 37		G3 43		G5 46
A2 Delphi	B2	C2	D2	E2	F2



The theatre of Dionysus Eleftherus

Use; permanent performance prohibition.

Koilon; restoration including Roman interventions.

Orchestra; Roman coating.

Skene; damaged building and foundation ruins.

Environment; urban environment – urban activities – traffic.

Noise levels; background noise 44 dB, urban activity noise 54 dB, road traffic noise 65 dB.

III. Survey sample – 14 ancient Greek theatres



Current Operation of Ancient Greek Theatres



The Dodoni theatre

Use; temporary ban due to restoration works.

Koilon; full restoration including Roman interventions.

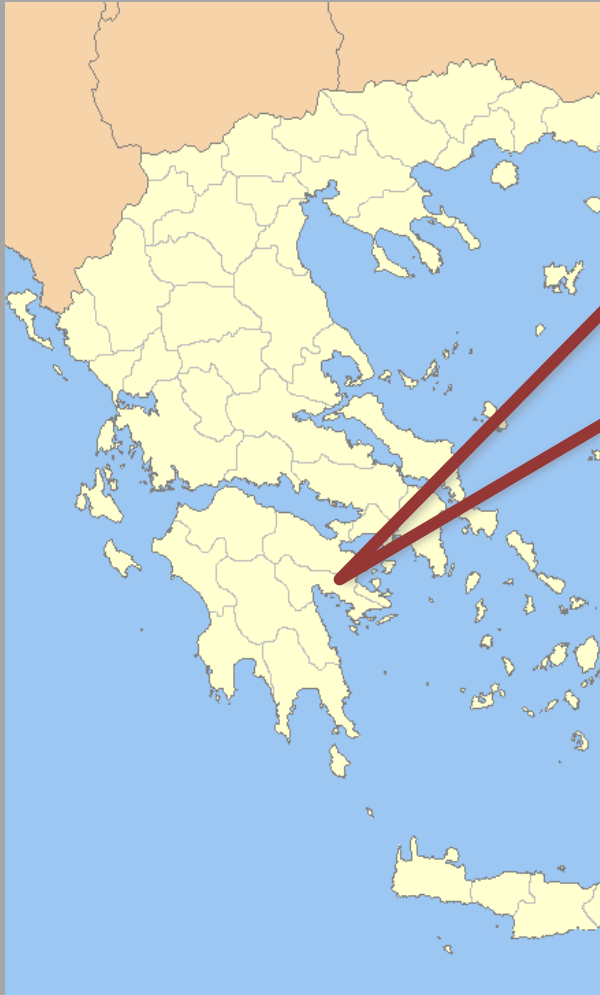
Orchestra; Roman coating.

Skene; yposcenum ruins.

Environment; natural environment with minimum activity.

Noise levels; background noise 27 dB, natural sound 36 dB, rural activity noise 34 dB.

III. Survey sample – 14 ancient Greek theatres



The Epidaurus theatre

Use; official festivals.

Koilon; full restoration.

Orchestra; authentic form, soil.

Skene; damaged building and foundation ruins.

Environment; natural environment with minimum activity.

Noise levels; background noise 29 dB, natural sound 36 dB, urban activity noise 46 dB.

III. Survey sample – 14 ancient Greek theatres



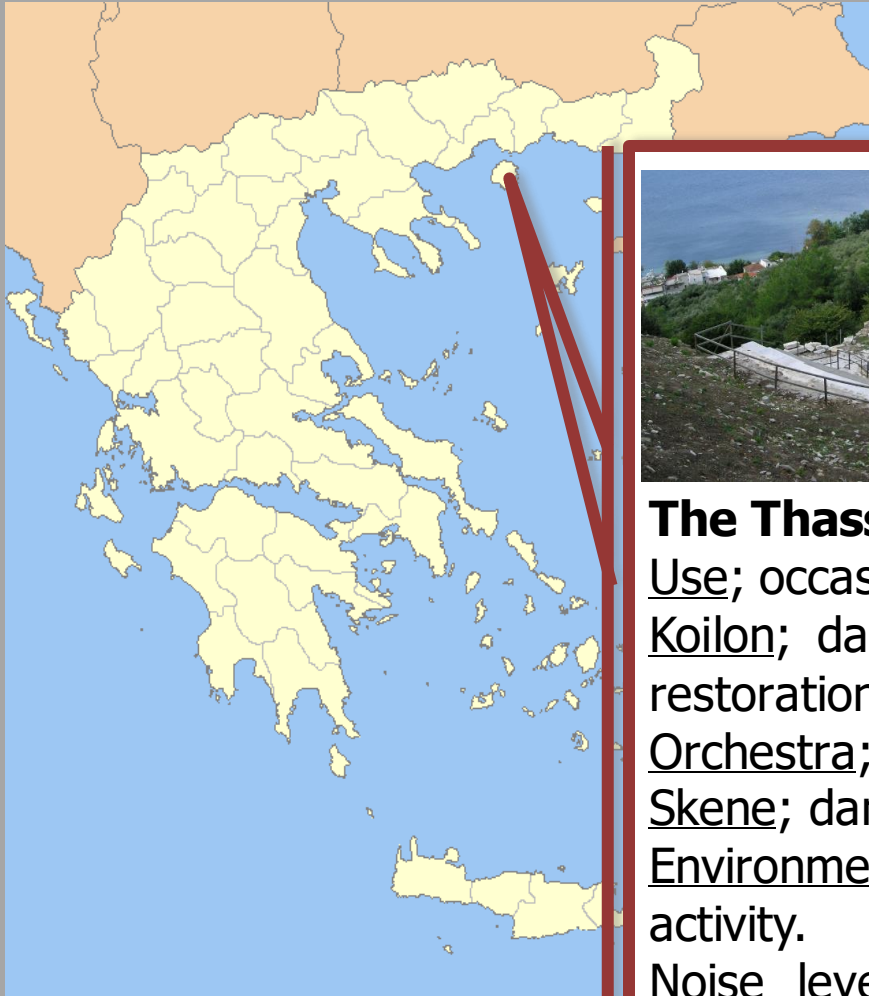
Theatre	Use	Koilon	Orchestra	Skene	Environment
A1 Argos	B2	C1	D1	E2	F3
G :	G1 37		G3 43		G5 46



The Eretria theatre
Use; temporary ban due to restoration works.
Koilon; damaged by illicit stone traders.
Orchestra; preserved charoneion passage.
Skene; yposceniun ruins.
Environment; semi-urban environment – rural activities – traffic.
Noise levels; background noise 37 dB, natural sound 41 dB, road traffic noise 47 dB.

A14 Oropos	B2	C5	D2	E4	F1
G :	G1 33		G4 37		

III. Survey sample – 14 ancient Greek theatres



Theatre	Use	Koilon	Orchestra	Skene	Environment
A1 Argos	B2	C1	D1	E2	F3
G:	G1 37		G3 43		G5 46
A2 Delphi	B2	C2	D2	E2	F2



The Thassos theatre

Use; occasional performances.

Koilon; damaged by illicit stone traders - partial restoration with wooden gradients.

Orchestra; Roman coating.

Skene; damaged building and foundation ruins.

Environment; natural environment with minimum activity.

Noise levels; background noise 33 dB, natural sound 37 dB.

III. Survey sample – 14 ancient Greek theatres



The Thorikos theatre

Use; occasional performances.

Koilon; full restoration.

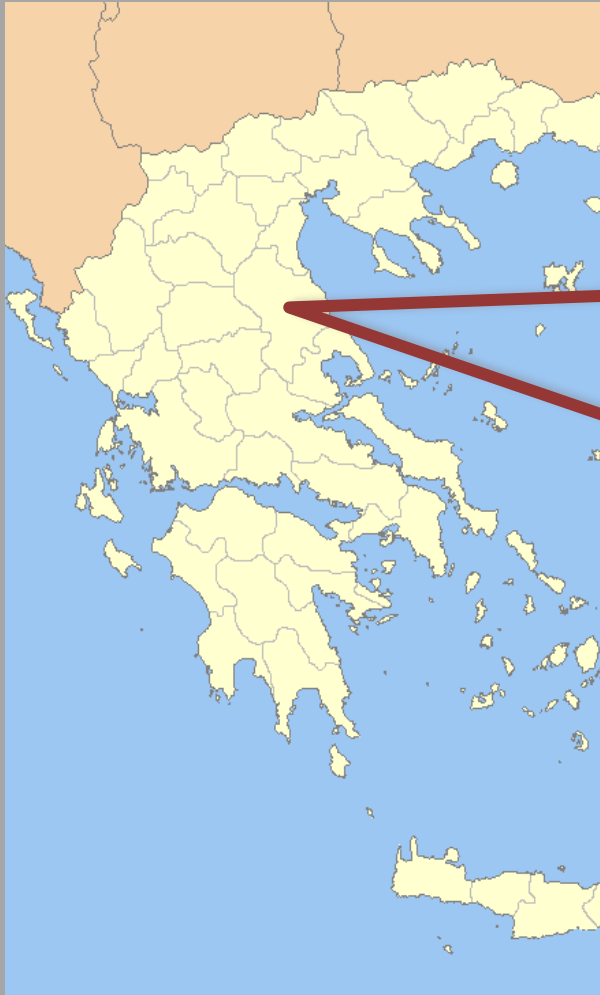
Orchestra; incomplete configuration.

Skene; without any kind of building.

Environment; semi-urban environment – rural activities – traffic.

Noise levels; background noise 34 dB, rural activity noise 54 dB, road traffic noise 37 dB.

III. Survey sample – 14 sites in Greece



The Larisa theatre

Use; temporary ban due to restoration works.

Koilon; restoration including Roman interventions.

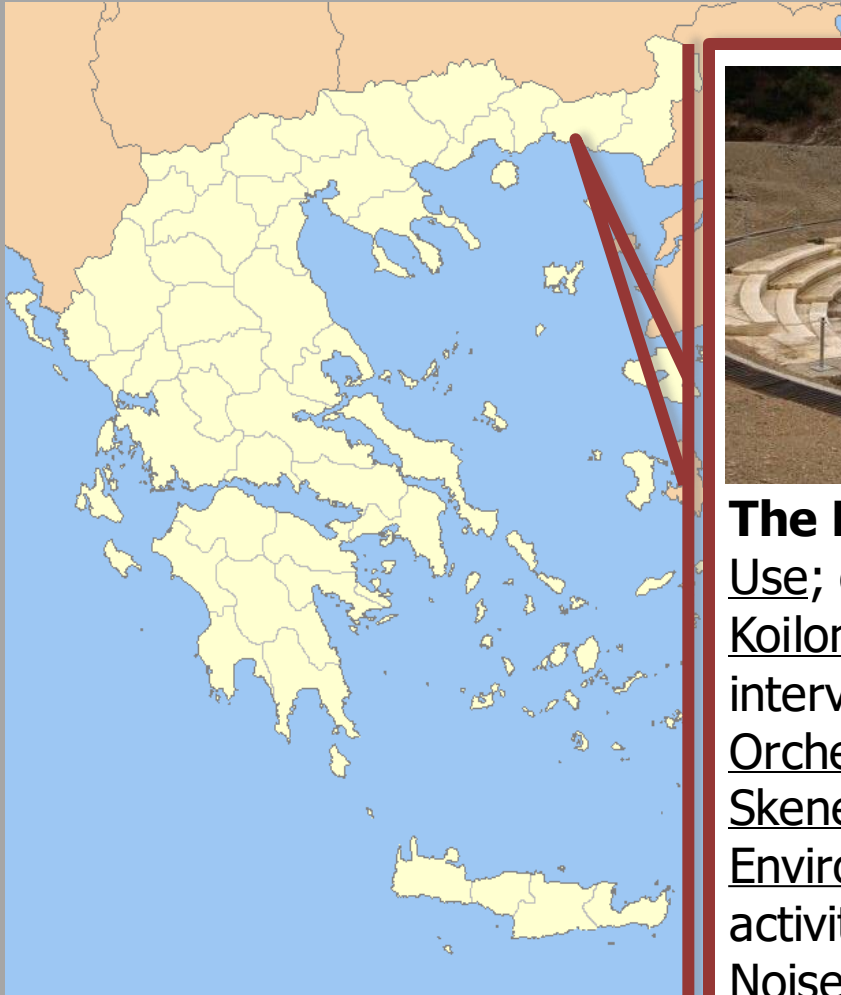
Orchestra; Roman coating.

Skene; damaged building and foundation ruins.

Environment; urban environment – urban activities – traffic.

Noise levels; background noise 43 dB, urban activity noise 58 (70) dB, road traffic noise 51 dB.

III. Survey sample – 14 ancient Greek theatres



Theatre	Use	Koilon	Orchestra	Skene	Environment
---------	-----	--------	-----------	-------	-------------



The Maroneia theatre

Use; occasional performances.

Koilon; partial restoration including Roman interventions.

Orchestra; damaged.

Skene; damaged building and foundation ruins.

Environment; semi-urban environment – rural activities – traffic.

Noise levels; background noise 34 dB, rural activity noise 37 dB, road traffic noise 46 dB.

III. Survey sample – 14 ancient Greek theatres



The Megalopolis theatre

Use; temporary ban due to restoration works.

Koilon; damaged by illicit stone traders.

Orchestra; authentic form, soil.

Skene; scenea ductilis (mobile stage).

Environment; semi-urban environment – rural activities – traffic.

Noise levels; background noise 33 dB, rural activity noise 37 dB.

III. Survey sample – 14 ancient Greek theatres



The Philippi theatre

Use; official festivals.

Koilon; full restoration including Roman interventions.

Orchestra; Roman coating.

Skene; damaged building and foundation ruins.

Environment; semi-urban environment – rural activities – traffic.

Noise levels; background noise 40 dB, natural sounds 44 dB, road traffic noise 52 dB.

III. Survey sample – 14 ancient Greek theatres



The Amphiarraion theatre at Oropos

Use; occasional performances.

Koilon; damaged by illicit stone traders.

Orchestra; Roman coating.

Skene; colonnade of the proscenium.

Environment; natural environment with minimum activity.

Noise levels; background noise 33 dB, rural activity noise 37 dB.

Environment

F3

F2

F2

F3

F1

F1

F2

F1

F2

F3

F2

F2

F2

F1

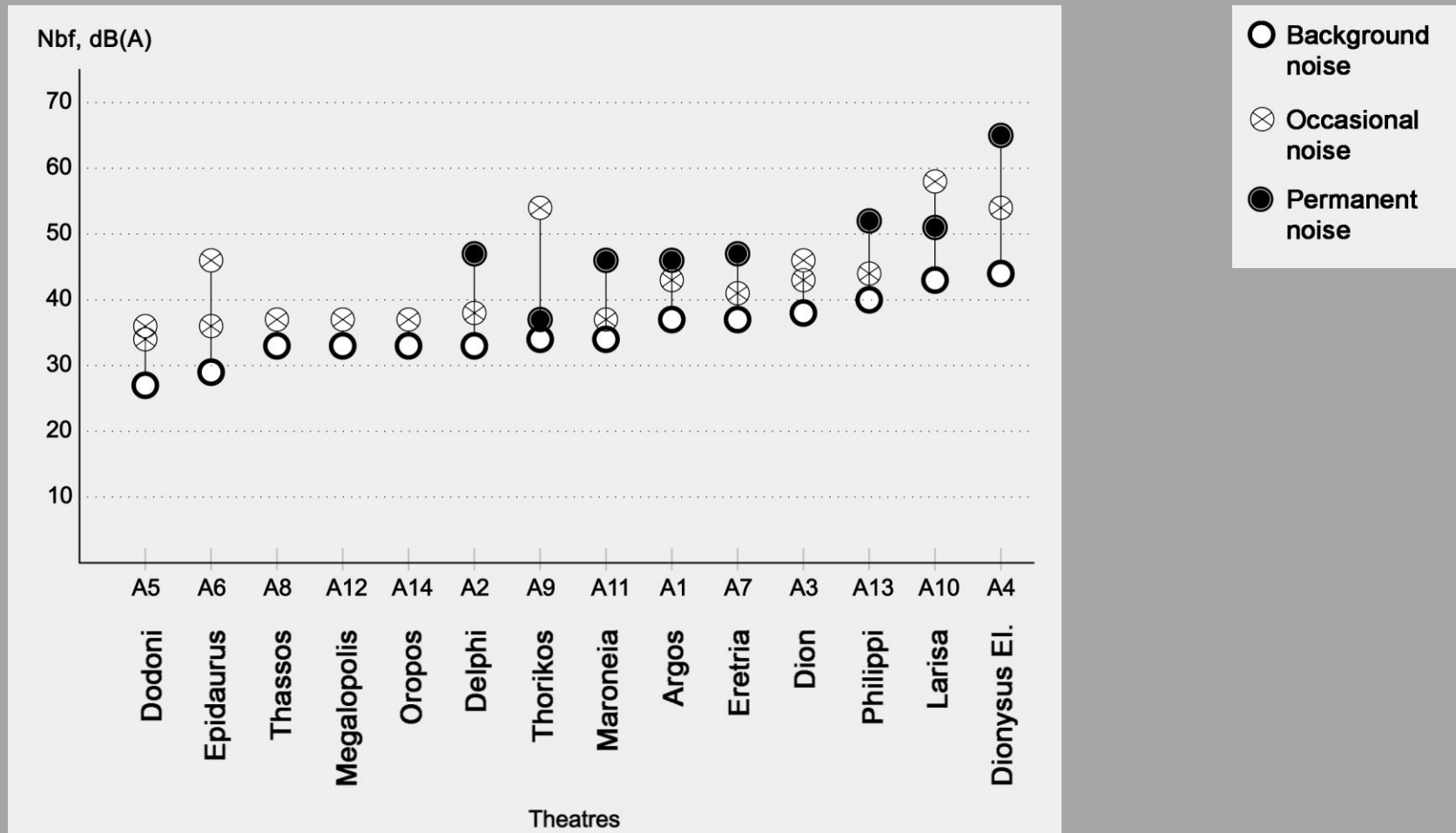
VII. Data Process – Numerical model

- the actor is at the back of the orchestra (at the crossing point of possible scenery with the central axis of the koilon, 1, 7 m above the level of the orchestra),
- the initial intensity of the human voice **Lo** is 87 dB[A] (at 1m) with spherical wave conditions (without any electrical gains),
- the viewer is at a maximum distance of 36 to 45m from the actor (i.e., lateral or central positions for 90 - 95% of the seats of the koilon, except for the third diazoma cases, 1,1 m above the level of seat),
- the decrease of the direct sound due to the distance, **Ld**, is 31 to 33 dB[A],
- the **orchestra** as a perfect reflector (gain of **+3** dB, without sound absorption),
- any background noise **Nbf** is amplified (**+5** dB) due to the presence of the crowd during the performance,
- the rising **Ra** of the effective signal is min 20dB,
- the final rising signal values are given in rounded decibel values according to the formula;

$$Ra = Lo - Ld + 3 - (Nbf + 5) \geq 20 \text{ dB}$$

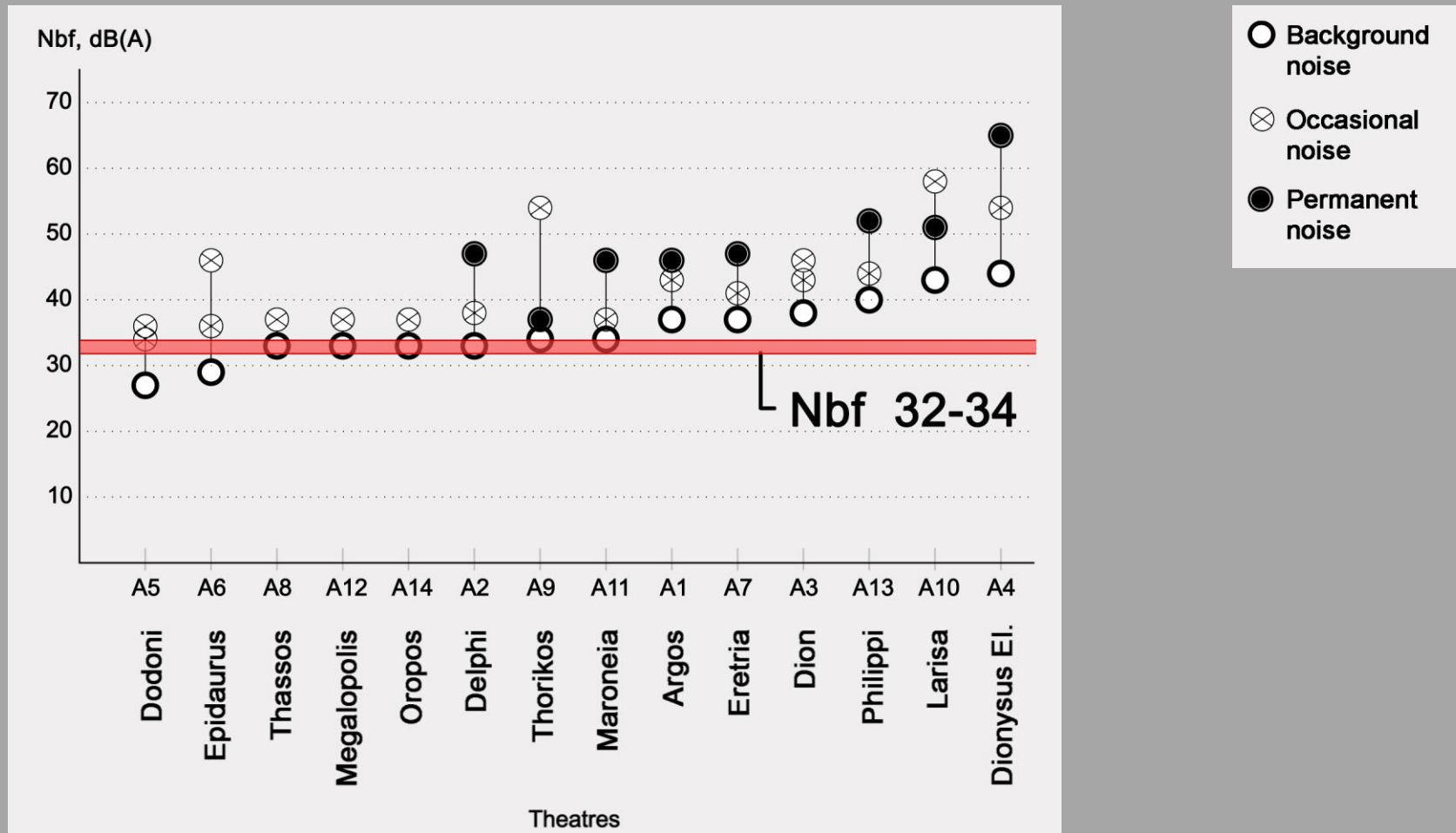
VII. Data Process – Figure 1

Theatres in ascending order of background noise levels



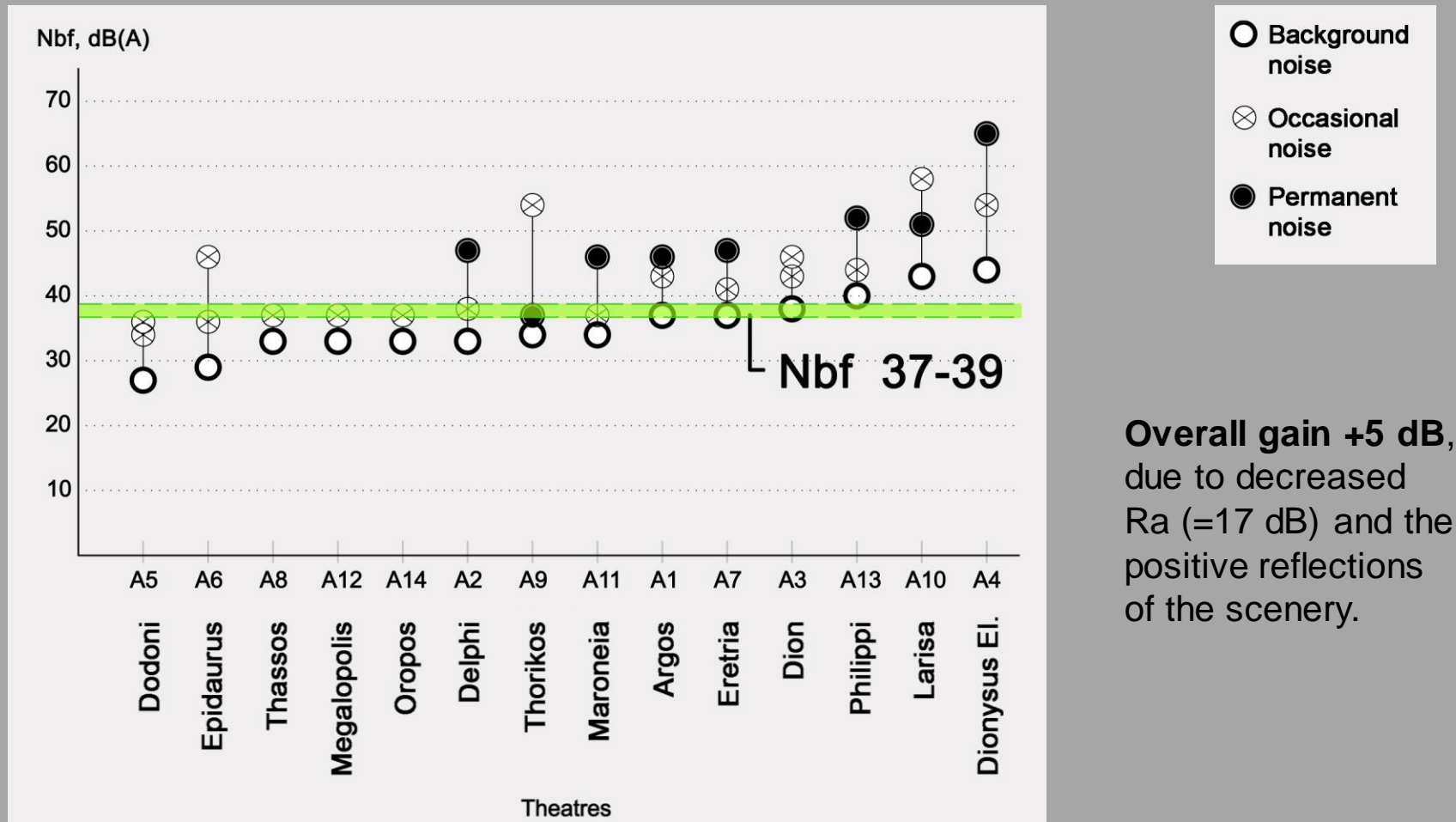
VII. Data Process – Figure 2

Classification of the theatres



VII. Data Process – Figure 3

Alternative application of the model for limited acoustic conditions



Overall gain +5 dB,
due to decreased
Ra (=17 dB) and the
positive reflections
of the scenery.

VIII. Conclusion

- The contemporary acoustic environment of the ancient Greek theatres does not allow proper operation under distinctive nuisance conditions ($>35\text{dB[A]}$).
- Confirmation of international sound limits (NC-25 curve).
- Demand for mandatory **sound protection measures** against urban or any other activity.
- **Destruction of the skene** of the ancient Greek theatres;
Suggestion for use of revocable backgrounds (reflectors – sound barriers) during the performances.