PELAGIC FISH SHOALS IN THE JAVA SEA[1]

D. NUGROHO, D. PETIT, P. COTEL, N. LUONG

ABSTRACT

Two acoustical surveys took place in October 1993 and February 1994, covering the main part of the Java Sea, below 50 m depth. The echo-integration process was performed through a BioSonics 120 kHz Dual Beam echo-sounder. Fish shoal characteristics and their behavioural aspects were observed. The shoals' configurations were extracted from echograms and quantified. This information allows to represent the spatial and bathymetric distribution. An analysis on abundance and distribution of shoals is proposed, as well as their contribution to the global densities and a description of their behaviour during the day and night periods.
KEYWORDS : Java Sea, pelagic fishes, acoustics, shoals.

ABSTRAK

Dua survei akustik telah berlangsung dalam bulan Oktober 1993 dan Februari 1994, meliputi bagian utama dari Laut Jawa, dengan kedalaman dibawah 50m. Proses integrasi - gema dilakukan dengan echo-sounder BioSonics bim ganda 120 kHz. Karakteristik kawanan serta beberapa aspek perilaku ikan telah diamati. Konfigurasi kawanan ikan diekstrasi dari ekogram dan dikuantifikasikan. Informasi ini dapat menggambarkan pembagian menurut tempat dan kedalaman. Dilakukan suatu analisis terhadap kelimpahan dan distribusi kawanan ikan, selain kontribusinya terhadap densitas secara menyeluruh dan deskripsi perilaku mereka pada siang dan malam hari.
KATA KUNCI : Laut Jawa, ikan pelagis, akustik, kelompok ikan.

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The continental shelf of the Java Sea is estimated at 442,000 km^2 (Durand and Petit, 1995) with an average depth of 40 m. The environmental conditions are controlled by a monsoon cycle. The total catch of pelagic fish by seiners was estimated at 485,000 tons in 1991, captured in an area representing 7% of the marine territory of Indonesia (Potier and Sadhotomo, 1995).

Previous studies on the state of exploitation by seiners since 1980, have related that the fishing operations take place with aggregation in areas depending on the season (Atmaja and Sadhotomo, 1985; Nurhakim *et al.,* 1987; Potier and Boely, 1990). To supply information on the importance of the stock and its availability, the estimation of density by acoustics is applied within the framework of the Java Sea Pelagic Fishery Assessment Project.

MATERIALS AND METHODS

The data analysis is based on two parallel acoustic surveys carried out in October 1993 and February 1994, during twelve days (Fig. 1). The data are collected aboard the stern trawler R/V Bawal Putih 1, with biological sampling obtained from pelagic and bottom trawls. The echo-integration was achieved by means of a Dual Beam 120 kHz echo-sounder connected to an interface INES MOVIES, for digitizing, display and integration of the signal.

The basic dimensions of the shoals (distance from the bottom, height and global relative reverberation) were extracted manually from echograms (which give the progress of integration for each ping and the total value by mile). Data postprocessing was performed throughout OEDIPE and SURFER softwares. As it is difficult to attribute a criterion of "pelagic" or "demersal" to the shoals close to the bottom, only the ones situated at more than 5 m from the bottom were taken into account in this study[2]. We selected also the shoals giving a reverberation level more than 50. As the monofrequency systems are unable to discriminate the species, these shoals can not be related to particular species. Nevertheless as Gerlotto (1993) points out, we may consider that aggregations are referred to species having momentarily the same "acoustical behaviour."

The environmental measurements are obtained by vertical profile measurements of temperature and salinity.

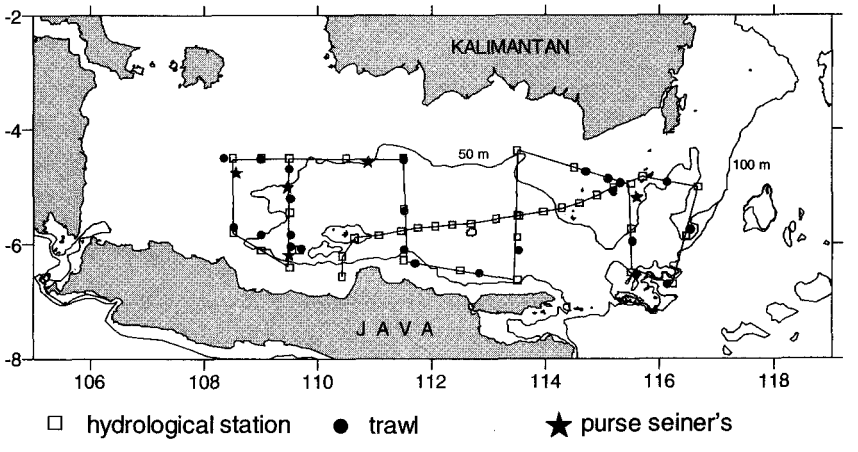

Figure 1 **Survey October, acoustic tracks, oceanographic stations and biological samplings.**

Gambar 1 **Survey bulan Oktober, jalur akustik, stasiun oseanografik dan sampel biologi.**

[2]The shoals, near the bottom, are scarce and uniformaly distributed.

Table 1 The general settings of the equipment.
Tabel 1 Susunan umum dari peralatan.

Frequency	: 120 kHz	Pulse duration	: 0.4 m sec
Power	: -3 dB	Ping rate	: 3/sec
Bandwidth	: 5 kHz	Depth range	: 125
TVG	: 20 log	Speed	: 6 knots
Angle trends	: 7° (narrow beam)		
	18° (wide beam)		

RESULTS

Hydrological conditions during the surveys

The mean saline conditions observed during the surveys are relative to the seasonal conditions and the topography. In October, winds and currents still bring up the oceanic influence throughout the continental shelf; the salinities are near 34‰. In February, winds and currents transport waters of low salinity (rains and outflows) from the western lands; the mean salinities fall to 32‰ (Durand and Petit, 1995; Petit *et al.*, 1995). The more interesting is the spatial location of the maxima between the two seasons : in October, we have a low gradient from West to East (max.); in February, the gradient tends to be opposite because of the bulk of salted water coming along the coast of Kalimantan where the depth is shallower. Consequently, the highest salinities, in February, are in the South West part of the Java Sea. This is well described in Figure 2, where the mean salinities appear more homogeneous in October than in February. In this latter, in the eastern part, the salinities grow only along the last transect. Between the two seasons, the mean temperatures vary only of about 1°C.

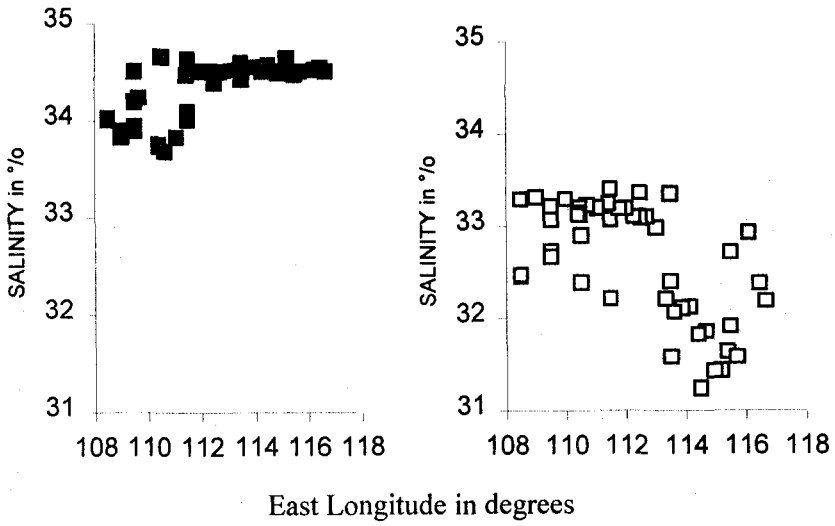

Figure 2 Longitudinal averaged salinity in October (left) and February (right).
Gambar 2 Rata-rata salinitas menurut letak lintang dalam bulan Oktober (kiri) dan Februari (kanan).

Abundance and spatial location of shoals

The total number of shoals recorded in October is 197 and 110 in February. Most of shoal reverberations are low in both seasons. In October, the shoals are distributed almost over the whole area, but the maximum is concentrated in the eastern part around the Matisiri and Kangean Islands (Fig. 3). This abundance tends to decrease through the West, except in the coastal zone of Java.

In February, the bulk of shoals is concentrated along a curve from the North of Kangean Islands, the continental slope and continuing in the shallow waters, North of Masalembo Islands. In the western part, numerous shoals are remaining in the North of the Java Coast.

Between the two situations, the more emerging event is the disappearance of shoals in the middle and south eastern part of the Java Sea. The mean number of shoals per mile within nine longitudinal strata is relatively low in both seasons (0.047 to 0.325 in October; 0.014 to 0.186 in February, Fig. 4).

The spatial distribution of reverberation levels.

Between February and October, the mean reverberation levels of shoals are the same : 199.4 (October) and 199.8 (February). Taking into account the longitudinal distribution of the number of shoals (Fig. 4), we split the area in two strata; West and East of 112°E. The histogram of relative reverberation (Fig. 5) shows that a common mode (< 200) appears all over the area. The modes 200-500 stay numerous during the South-East monsoon, in the eastern part; the last mode (> 1000) is only in the East.

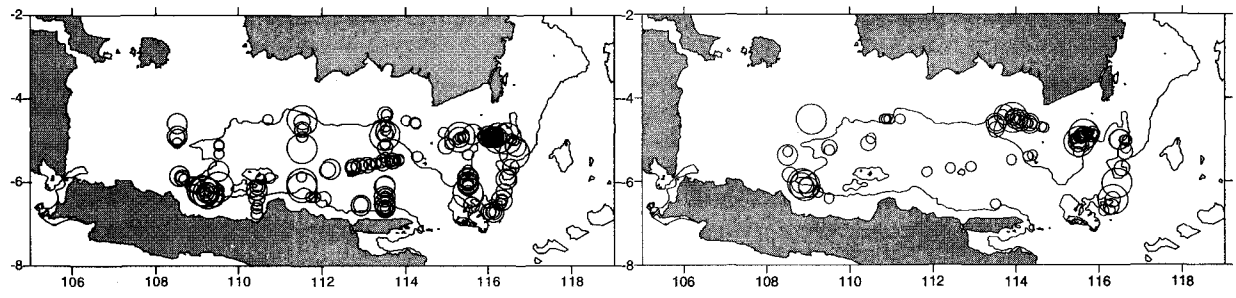

Figure 3 **Geographical distribution of pelagic shoal density in October (left) and February (right).**
Gambar 3 **Distribusi geografis dari densitas kawanan ikan pelagis dalam bulan Oktober (kiri) dan Februari (kanan).**

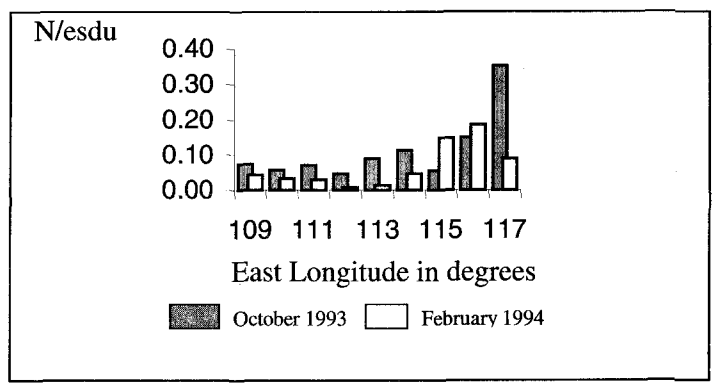

Figure 4 **Longitudinal distribution of averaged number of shoals per ESDU (nmi).**
Gambar 4 **Distribusi rata-rata jumlah kelompok ikan per ESDU (mil laut) menurut letak garis lintang.**

Thus, until now, the study of reverberation levels gives limited information. The mean levels are comparable between the two seasons; the shoals are low reverberating, more numerous in the East during October and February, and almost 40% of the present density have disappeared.

Vertical distribution and day-night variation

The vertical distribution revealed that the shoals are more dispersed during the South-East monsoon : the occupation of the space is better (Fig. 6). The modal vertical location is not the same between the two seasons, *i.e.*, 40 m in October, 20 m in February. The global behaviour changes also : the shoals tend to stay during the night in October, and the mode is going down during day. In February, there is no particular change in location between day and night.

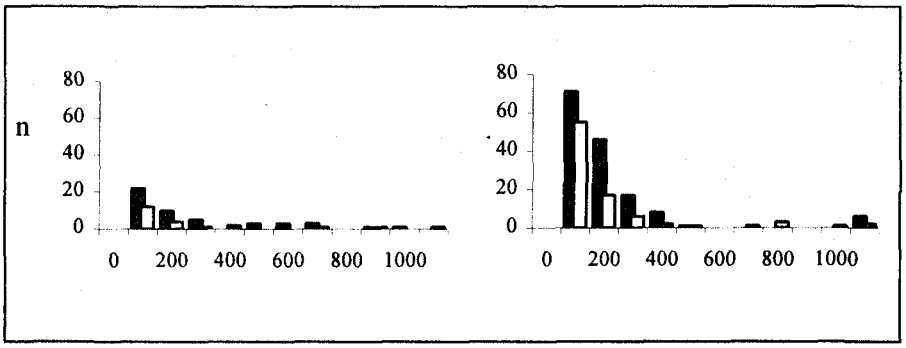

Figure 5 **Frequency histograms of shoal density on both areas (left, West of Long. 112°E, right, East of Long. 112°E).**
Gambar 5 **Histogram frekuensi densitas kawanan ikan di kedua area (sebelah kiri : area barat bujur 112 T, dan sebelah kanan : area timur bujur 112 T).**

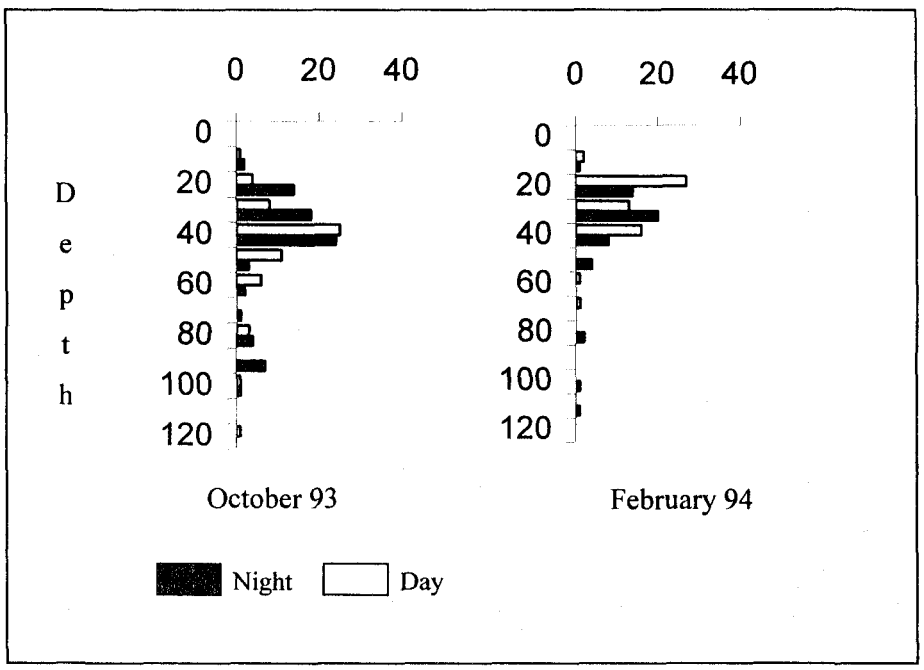

Figure 6 **The number of shoals vs depth.**
Gambar 6 **Jumlah kawanan ikan menurut kedalaman.**

The more interesting information seems to be that the number of shoals is more important during the night in October, although the pelagic populations are usually scattered by night (Tab. 2). An evaluation on the mean levels of reverberation shows that the highest reverberation levels appear by day in October when the small ones are found by day and night. In average the situation is inverted : the mean level is highest in February; the phenomenon could be in relation with the lunar cycle (February : full moon; October : new moon).

Table 2 Density of shoals by day and by night.
Tabel 2 Densitas kawanan siang dan malam.

	October 93		February 94	
	day	night	day	night
N	76	121	72	38
Minimum	50	50	50	50
Maximum	2474	1527	1151	3177
Mean	262	160	172	253
Variance	162620	41164	51857	300307

DISCUSSION

On this study, various results have been extracted :

- proportion, relatively low, of pelagic (or semi pelagic) stock able to aggregate,
- identity of the reverberation mean level of shoals between the seasons,
- big relative abundance of small shoals everywhere in dry season and more located in wet season,
- occurrence of bigger shoals in depth and in the eastern part in October,
- permanence of shoals in the extreme west part, particularly near the Java Coast,
- difference of behaviour for the global population between the two seasons.

Studies on abundance and distribution of fish through acoustics have been done in the past around Kangean Islands (Barus and Rumeli, 1982) and in the middle part of the Java Sea (Boely and Linting, 1986; Boely *et al.*, 1991). During this latter cruise, the same dispersed small shoals have been discovered. But these surveys were very limited. Since the end of 1970, investigations have pointed out high rates of pelagic fish exploitation in the middle of Java Sea (Sudjastani, 1978). After 1980, an active development of new fishing tactics has been followed by the increase of the total catch (Sadhotomo and Widodo, 1992; Potier and Petit, 1995).

Recent investigations suggest the presence of 3 groups of fish inhabiting the waters of the Java Sea (Petit *et al.*, 1995) : a coastal one, living close to the Java Coast; a neritic one covering the whole of the continental shelf, and an oceanic one that might have semi demersal behaviour. Even though analogy cannot be made totally between global data of density and shoals, we have to consider that the small shoals participate to the group 2, as the bigger from the eastern part could participate to the group 3.

Acoustic evaluation reveals that the mean density drop is 58% by night and 48% by day between October and February. For the aggregated part, the decreasing is 49% and 38%. The migrating populations do not belong exclusively to the shoals; or from an other point of view, an important part of the "pelagic" population does not aggregate. Even though the fleets of big seiners are not operating on shoals with their new tactic (light attraction), the behaviour of the part of pelagic fish staying aggregated by night in October, could encourage attraction and aggregation.

In February, the percentage of total catch in central Java Sea represents only 9%; then, the most part of big seiners operates in the Makassar Strait (Potier and Sadhotomo, 1995). This seems related to the disappearing of the big densities in the eastern part. But, as revealed by the apparent change of behaviour, the catch ability could be less favourable : deleted waters in wet season may be more turbid and this may disturb the light attraction. Potier and Boely (1990) and Boely *et al.,* (1991) suggest that the seasonal changes of fishing grounds could be related to the ones of environmental conditions, particularly the salinity. Obviously, the disappearance of shoals in the eastern part (Fig. 7) seems to coincide with the low salinity (less than 33‰, Fig. 2).

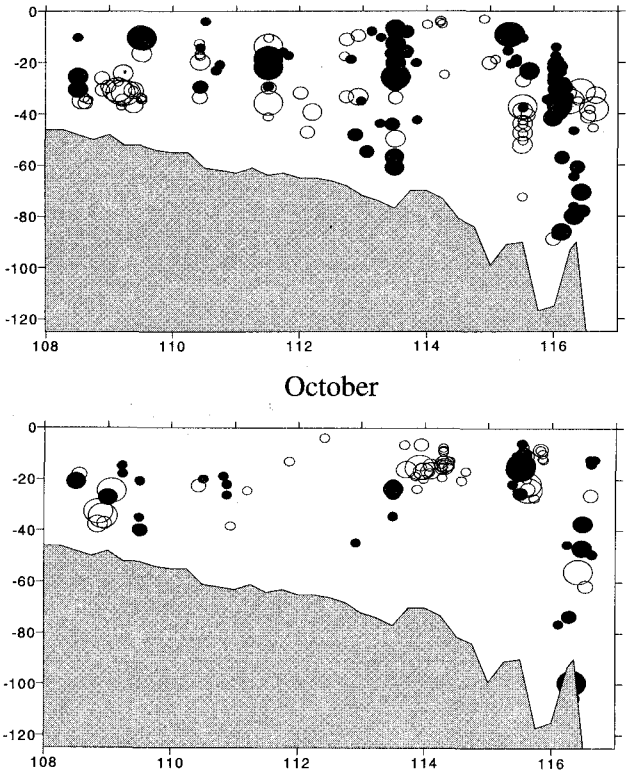

Figure 7 **Longitudinal day (white) and night (black) variability of shoals density (depth in metre).**

Gambar 7 **Keragaman densitas kawanan menurut bujur pada siang (putih) dan malam hari (hitam) (kedalaman dalam m).**

Five exploited species live in the Java Sea. *Decapterus macrosoma* represents the bulk of the catch during the dry season in the eastern part. It is sure that this species is migrating out of the continental shelf in wet season. But, does this species participate or not to the shoals? What are the ecological affinities of the other species? (*D. russelli, Selar crumenophtalmus, Rastrelliger kanagurta, Ambligaster sirm* and *Sardinella gibbosa).* In wet season, we met the "highest" salinities in the south western part of the Java Sea; we met also in the same area, relative big densities and shoals. But another group of shoals appears in shallow water, South Kalimantan ($29 < S‰ < 31‰$). Experimental samplings and further investigations will be necessary for satisfactory interpretation.

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DISCUSSION

(Chairman Dr. PASARIBU)

Dr.NURZALI

Q : - Why do fish schools disappear between October and February, which are both in the same season ?

A : - Maybe, during 1993, the dry season was longer than before; thus, October is still representative of the South East monsoon. If you look at the salinity, the high one is present during the South East monsoon in the Java Sea and not in the West monsoon. Consequently, February and October have not the same conditions. The phenomenon is different : in February, the schools are less in number and stay close to the surface; in October, greater number of fish schools, higher density. Between both seasons, in the eastern part, there are still some schools, but in the western part, they have disappeared. Maybe, they are composed of different species. Here are still preliminary results from sampling quite few data from purse seine, collected during our acoustic surveys. If you compare the area North of Tegal, Kariwono, at about 108 ° East longitude, according to the time, and the ones where species belong, you can see that *Macrosoma* has disappeared in the western part of Bawean. But, to discriminate between February and October, we have to look at more carefully. I have not answered your question, but there are some data which can define that difference. If you ask me where are the schools in February, it is quite tough to work with. It is still at the beginning and if we have some other project, maybe we could get more details such as these ones.

Q : - Based on your own experience, which are the species the most dominant ? What accuracy do you estimate about schooling size, their weighting, etc. ? Personally, I did it on demersal species, on prawns and shrimps in the Java Sea and I predicted that, from a first estimate of 200 kg, our error was 5 to 10 kg; that is to say : my confidence on the estimate was 25%. What is your estimated percentage ?

A : - Actually, it is very difficult to say. One of the reasons is that it is the first time I work with an acoustic team and I discovered that there are a lot of variables to correct in the same time. If you did your estimation by guessing like in the old fashioned ways before 1990, it is not the case nowadays and we must be careful about these predictions. Mr. Gerlotto will give you some more explanations on school estimate. I assume, here, that the school is a cylinder; in fact, it is still questionable about this cylinder. But, it remains the easiest way to express what a school is, and, from echograms, to use the Johannesson's formula. If you ask me : how many tons ? Maybe, we can combine average size of school fish sampled and the Target Strength values from Dr. Cotel's results.

About the dominant species, the areas have already data on species. The aggregated fishes data, shown before, were collected from light fishing. If we work on natural schools, we will have differences. Are the schools below the purse seiners the same as the ones below the transducer ? We have some data from the sampling but, mainly from the Target Strength measurements.

Mr. NAHMULIN

Q : - How many variables did you use to support your conclusion ?

A : - I only used the salinity and temperature parameters. But I did not correlate them in a statistical approach with the school parameters, until now. It was just done to show the difference between both seasons, October and February, characterized by a difference in salinity and temperature. I have not yet worked on the relation between schools and these variations of environment.

Q : - Have you observed any difference along these 5 years ? You, also, do not mention anything about the currents whose acting is very important.

A : - Personally, I only used temperature and salinity, in my study. There are maybe data about the currents in the Project archives.

Dr. MERTA

Q : - Are there any differences in school size between East monsoon and West monsoon ?

A : - If you look at the estimated diameters between both seasons, on the first figure, you can see that in the south-east monsoon, the presence of schools of broader scales, with large and small diameters. The small diameter ones occur in both seasons. If the Johannesson's formula is valid, there is a difference in diameters. If we look at the echograms, about their behaviour, it is still confusing. Are they more scattered, small but many ? Or, do they stay more compact ?

By playing back echo-integration files, using the Movies B software from IFREMER, we could define more precisely the shape, the size and the parameters of the schools through different threshold settings.

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PROCEEDING OF ACOUSTICS SEMINAR AKUSTIKAN 2

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