SOUTHWEST FISHERIES CENTER

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SPOTTED DOLPHIN BIOACOUSTICS

By

Sue E. Moore

ADMINISTRATIVE REPORT LJ-90-24C

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SPOTTED DOLPHIN BIOACOUSTICS

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INTRODUCTION

There are two species of spotted dolphins, one endemic to the Atlantic (*Stenella frontalis*) and the other pantropical (*Stenella attenuata*) (Perrin, Mitchell, Mead, Caldwell, Caldwell, van Bree, and Dawbin, 1987). Fisherman in the eastern tropical Pacific (ETP) commonly seek out *S. attenuata* to net yellowfin tuna (*Thunnus albacares*) that aggregate beneath the dolphins (Perrin, Scott, Walker, and Cass, 1985). Such netting results in an annual incidental mortality of dolphins associated with purse-seine net operations (Smith 1983). Considerable effort has been focused on defining geographical stocks of ETP spotted dolphins to better manage the fishery. Perrin et al. (1985) propose three management units, or stocks, for *S. attenuata* in the ETP: the coastal, the northern offshore and the southern offshore spotted dolphins (Fig. 1). Further, Hohn and Hammond (1984) describe patterns of variation within the northern offshore stock that suggest schools west of about 120° W longitude and those near the Equator may be somewhat isolated from those in the major part of the range occurring further north and east. Because differences in the calls of killer whales (*Orcinus orca*) (Awbrey, Thomas, Evans, and Leatherwood, 1982; Thomas, Fisher and Awbrey, 1986a) and humpback whales (*Megaptera novaeangliae*) (Payne and Guinee 1983), from different geographic areas have been described. A preliminary analysis of spotted dolphin whistles was suggested as a means to investigate potential acoustic evidence for stock delineation.

Underwater sounds from dolphins associated with the tuna fishery were recorded intermittently in the ETP between 1978-82 (Awbrey, Duffy, Evans, Johnson, Parks, and DeBeer, 1979; Thomas, 1981; Thomas, Evans, and Fisher, 1982 a-b; Thomas, Fisher and Ferm, 1982c). The goal of these surveys were (a) to record sounds from dolphins and tuna, and those associated with a purse-seine set, and (b) to evaluate the possibility of long range detection of tuna/porpoise. A "signature catalog" of cetacean sounds was developed (Thomas et al. 1982b) and, of note, Thomas et al. (1982c) report that "different stocks of the same species, e.g., eastern and whitebelly spinners, were distinguished acoustically" and conclude that "with appropriate experience" school composition could be identified acoustically. Results of a preliminary analysis concerning these statements relative to spotted dolphin stocks is presented here.

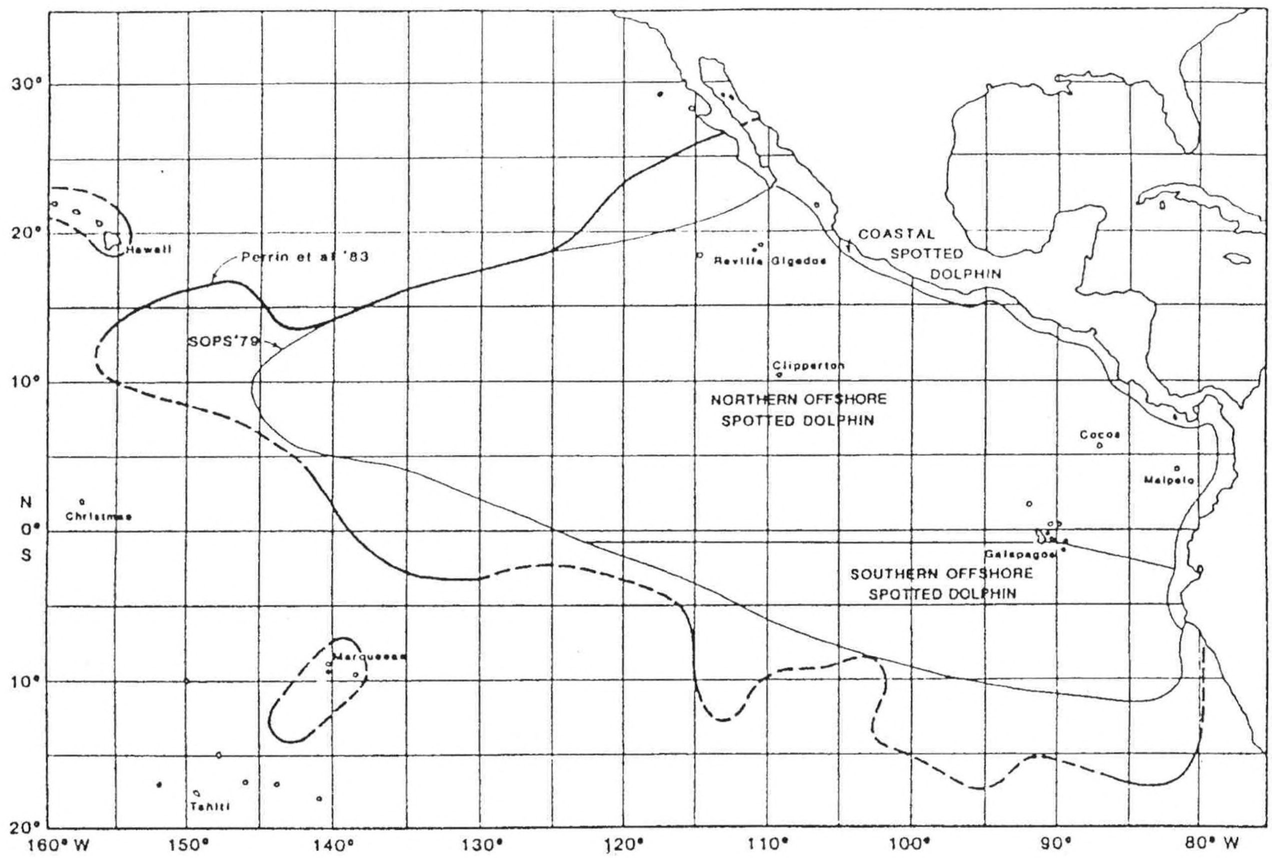

Figure 1. Species range and stock boundaries for *Stenella attenuata* in the eastern tropical Pacific. From Perrin *et al.* (1985).

METHODS

Fourteen tapes containing spotted dolphin sounds were selected for analysis from a catalog of 60 such tapes inventoried at Hubbs Marine Research Center (HMRC),San Diego, CA. Tapes were selected for coastal and northern offshore pantropical spotted dolphins (*S. attenuata*) in the ETP and Atlantic spotted dolphins (*S. frontalis*) when notations on the tape log indicated "good" or "the best" sounds were recorded (Tab. 1, Fig. 2). Analysis of whistles for northern offshore spotted dolphins was emphasized (i.e. 10 of 14 tapes) because stock delineation is least clear for this group. Whistles from Atlantic spotted dolphins (*S. frontalis*) were analyzed to provide a comparison between species.

Whistles were analyzed in real time on a UNISCAN II digital sonograph (Multigon Industries) set at 20 or 40 kHz. The 20 kHz setting was used most often as this was usually the upper limit of the recording equipment. The frequency and time resolution at this setting is +/- 160 Hz and +/- 6 ms, respectively. Whistles were classified based on aurally and visually recognizable shifts in frequency or duration following the method developed by Ford (1987), and adopted by Moore, Francine, Bowles and Ford (1988), for killer whale pulsed calls. It is important to note that whistles and pulsed calls are distinctly different types of phonations, yet features used to differentiate calls such as abrupt frequency shifts and differences in call duration are common to both.

Sonogram examples of whistles from the pantropical coastal and northern offshore spotted dolphins and Atlantic spotted dolphins were cataloged numerically as they were encountered during the analysis. Comparisons of whistles between groups were based on aural characteristics and contour shape as depicted on the sonograms. Quantitative measures of whistle parameters were not performed although approximate values can be read from the sonograms.

RESULTS

Data Quality

Whistles from the pantropical coastal and Atlantic spotted dolphins were recorded from small boats that were within about 200 m of from 5 to 15 animals. In contrast, those from the northern offshore stock were either recorded from large groups (> 300 animals) caught in a seine net, or from a towed hydrophone array at some distance (approx. > 1 km) from the ship. As a result, data for the coastal stock and Atlantic spotted dolphins were generally good with distinct whistles that were clearly distinguishable, while that for the northern offshore stock often had poor signal/noise ratio or were of many animals whistling simultaneously resulting in overlapping signals that could not be clearly distinguished. In addition, the large groups of offshore dolphins often contained a few (about 5%) spinner dolphins (*Stenella longirostris*) that contaminated the sample. Thus, while this preliminary documentation and comparison of whistle types is a useful exercise, it does not represent a thorough sampling of spotted dolphin whistles and underlines the inherent constraints of analyzing data for one purpose when it was collected for another purpose.

Table 1. List of spotted dolphin (*Stenella* spp.) acoustic tapes reviewed for whistle types.

	Tape No.	Date	Location (map #)	Comments
Pantropical *(S. attenuata)*				
coastal stock	404	7/6	Islas Marias Mexico (1)	"control" recordings 5-6 spotted dolphins
	464	5/63	Filibestero Costa Rica (2)	"control" recordings bands 1-3
offshore stock	835 (J)	6/82	ETP (3)	*DS Jordan*: tow 7 & 8
	837	6/82	ETP (4)	*DS Jordan*: tow 9 & 10
	847	6/82	ETP (5)	*DS Jordan*: tow 4 & 5
	835 (Q)	9/81	ETP (6)	*Queen Mary*: "best" data
	839	9/81	ETP (6)	*Queen Mary*
	889	9/81	ETP (6)	*Queen Mary*
	1058	dupe	ETP (6)	
	261	2/78	ETP (7)	*Queen Mary*: 300-500 spotters in net
	297	10/76	ETP (8)	*Elizabeth CJ*: single
	993	10/76	ETP (8)	500-600 spotteds
Atlantic *(S. frontalis)*				
Bahamas	1	6/81	White Sands Bank (9)	5-6 "juveniles"
	2	7/81	White Sands Bank (9)	15+ adult spotteds

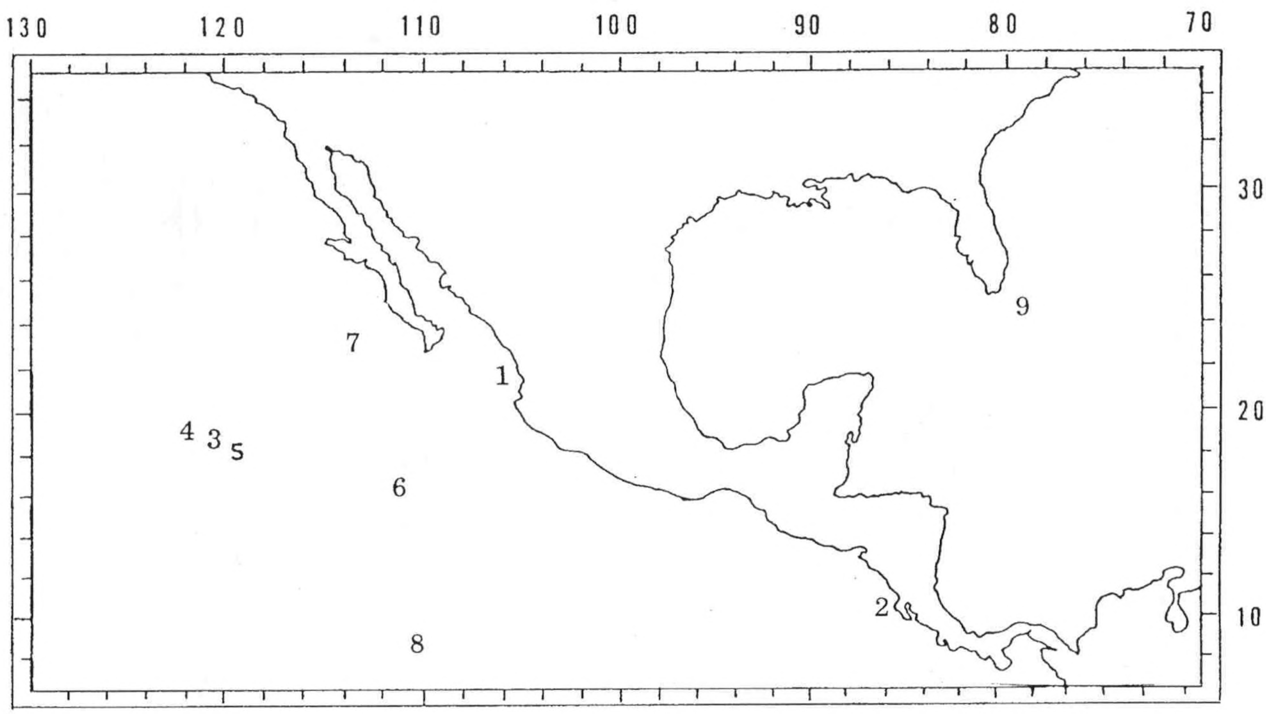

Figure 2. Recording locations for acoustic tapes described in Table 1.

Whistle Types

Thirteen whistle types were identified based upon aural characteristics and contour shape (Table 2; Appendix). Whistles were given brief descriptive names as well as catalog numbers to aid in identifying the salient feature that distinguished them from other whistles. The greater variety of whistles identified for northern offshore spotted dolphins (Table 2) may be the direct result of the larger sample size reviewed for this group, or to the contamination of these data by whistles from other dolphin species. Notably, sonogram examples of whistles attributed to spinner and striped dolphins (*Stenella coeruleoalba*) in Thomas, Fisher, Ferm and Holt (1986b) are very similar to whistle type Sa 1ii, Sa 9i and Sa 10i depicted in the Appendix.

Comparison of Whistle Types

Whistles from Atlantic spotted dolphins (*S. frontalis*) were nearly always some type of 'looped whistle' (i.e. Sa 9i-type). In contrast, the pantropical spotted dolphins (*S. attenuata*) emitted many up swept (i.e. Sa 1i-type) along with a variety of whistles that swept up or down often with 'level' portions to the whistle. Both Atlantic and Pacific pantropical animals produced simple upsweeps (i.e. Sa 1i-type), short whistles emitted in rapid succession (Sa 7i-type), and similar rapid succession sounds with an aural quality of "chirps" (Sa 10 ii-type). The predominant frequency range for both Atlantic and Pacific pantropical animals appeared to be between 8 and 16 kHz.

Sounds from the coastal and northern offshore stocks in the Pacific were aurally very similar. Up and down swept signals were common to both samples. Loop whistles (Sa 9i's) appeared in samples from both groups in about equal proportion, but were relatively rare compared to those in recordings from the Atlantic spotted dolphin.

DISCUSSION

This preliminary analysis of spotted dolphin whistles suggests that while *S. attenuata* and *S. frontalis* may have adopted distinctly different whistling strategies, stocks of the pantropical spotted dolphin in the Pacific produce whistles that are very similar. Similarly, Cass (1987) reported that differences in whistles from Pacific coastal and offshore populations of bottlenose dolphins (*Tursiops* sp.) could not be statistically determined. This does not mean that Pacific common dolphin stocks can not be distinguished acoustically, however, only that such differences are not immediately obvious to a naive listener. If differences in whistles between dolphin stocks can be learned by "experienced operators" (Thomas et al. 1982c) then these differences can probably be identified and catalogued. To use such differences effectively as a tool to distinguish dolphin stocks, a reliable methodology is needed that can separate groups quickly. Recent advances in computer

Table 2. Key to spotted dolphin (*Stenella* spp.) whistle types

WHISTLE TYPE	PANTROPICAL (ETP)		ATLANTIC
	coastal	offshore *	
Sa 1i (simple-up)	x	x	x
Sa 1ii (broken-up)	x	x	
Sa 1iii (up-step)	x	x	
Sa 1iv (long-up)	x		
Sa 1v (hook-up)		x	
Sa 1vi (hook-up-hook)		x	
Sa 2i (down-up)	x		
Sa 2ii (down-up-down)	x		
Sa 3i (down)	x		
Sa 3ii (short-down)	x	x	
Sa 3iii (broken-down)	x	x	
Sa 3iv (warble-down)		x	
Sa 4i (3-way)	x		
Sa 4ii (short 3-way)	x	x	
Sa 4iii (broken 3-way)	x	x	
Sa 4iv (long 3-way)	x		
Sa 4v (missing 3-way)		x	
Sa 4vi (smooth 3-way)		x	
Sa 5i (up-over)	x	x	x
Sa 6i (short-step)	x	x	
Sa 6ii (long-step)	x	x	
Sa 6iii (down-step)	x		
Sa 6iv (step-up)		x	x
Sa 7i (qwik up-series)	x	x	x
Sa 7ii(qwik level-series)	x		
Sa 8i (level)	x	x	
Sa 8ii (long-level)		x	
Sa 8iii (level/chirps)		x	
Sa 8iv (paired-level)		x	
Sa 8v (paired)		x	
Sa 8vi (3 or more)		x	
Sa 9i (loops)	x	x	x
Sa 9ii (uneven loops)		x	x
Sa 9iii (loop-buzz)			x
Sa 10i (U's)		x	
Sa 10ii (U-chirps)		x	x
Sa 11i (chirps)		x	
Sa 12i (3-part)		x	
Sa 12ii (3-part w/ U)		x	
Sa 12iii(broken 3-part)		x	
Sa 13i (pieces)		x	

* northern offshore with 5 % spinner dolphins

processing developed to recognize signatures of man-made devices, may be employed for such applications. Such technology, often called 'neural nets', are based upon sound signature templates established using digitized information from representative acoustic signatures. Incoming data are then compared against the templates and matches scored. Application of neural net capability is probably some years off, although interest in using this technology on killer whale calls has been developed through HMRC.

The pronounced difference in use of loop-type whistles by Atlantic spotted dolphins compared to the pantropical spotted dolphins to the Pacific dolphins is an interesting side light. Caldwell and Caldwell (1971) and Caldwell, Caldwell, and Miller (1973) report individual signature whistles for captive Atlantic spotted dolphins and the stereotypy found in the looped whistles presented in Appendix A for each day's recording support, at least indirectly, the idea that each loop-type was emitted by one individual. The lack of stereotyped loop whistles in the Pacific sample has an interesting, although possibly unrelated, corollary to a similar analysis of common dolphin (*Delphinus delphis*) whistles. Moore and Ridgway (in prep.) describe four predominant whistle types produced by two Pacific captive dolphins, with no evidence of individual signature whistles (i.e. both dolphins produced all whistle types). Conversely, Caldwell and Caldwell (1968) describe signature whistles (except in one case) for four newly captured Atlantic common dolphins.

In summary, whistles from the coastal and northern offshore stocks of the pantropical spotted dolphin sounded and appeared to be very similar. Additional data, particularly for small groups of northern offshore dolphins, would allow a more rigorous comparison and possibly lead to identification of features that could be used (either by a listener, or programmed into a neural net-type device) to differentiate stocks of the pantropical spotted dolphin. Atlantic and pantropical spotted dolphins in the ETP <u>appear</u> to be quite different in their whistling strategies. These differences could simply be a function of recording conditions, group composition, seasonality or a number of other recording-specific differences (as outlined in Thomas et al. 1986b).

ACKNOWLEDGEMENTS

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APPENDIX: Sonogram Index

SPOTTED DOLPHIN (*Stenella* spp.) BIOACOUSTICS

APPENDIX A: SONOGRAM INDEX

SPOTTED DOLPHIN BIOACOUSTICS: SONOGRAM INDEX

Page:	top bottom	Tape No.	tape count	
A-1	Sa 1i (c)	404	20.0	
	Sa 1i (c)	404	11.6	
A-2	Sa 1ii (c)	464	6.5	
	Sa 1ii (c)	464	9.2	
A-3	Sa 1iii (c)	464	2.1	
	Sa 1iv (c)	404	25.7	
A-4	Sa 2i (c)	464	12.0	
	Sa 2i (c)	404	12.5	
A-5	Sa 2i (c)	464	12.4	
A-6	Sa 3ii (c)	464	2.7	
	Sa 3iii (c)	404	16.5	
A-7	Sa 4i (c)	464	7.8	
	Sa 4i (c)	464	8.3	**PACIFIC (coastal)**
A-8	Sa 4ii (c)	464	10.8	
	Sa 4iii (c)	404	21.7	
A-9	Sa 4iv (c)	464	9.0	
	Sa 5i (c)	404	24.5	
A-10	Sa 6i (c)	464	1.5	
	Sa 6i (c)	464	4.5	
A-11	Sa 6ii (c)	464	2.1	
	Sa 6iii (c)	464	13.3	
A-12	Sa 7i (c)	464	10.3	
	Sa 7ii (c)	464	3.0	
A-13	Sa 8i (c)	464	4.4	
	Sa 9i (c)	464	8.7	
A-14	Sa 1i (o)	835 (Q)	548.0	
	Sa 1ii (o)	297	1.3	
A-15	Sa 1iii (o)	297	1.8	
	Sa 1iv (o)	847	939.0	
A-16	Sa 1v (o)	993	2.0	
	Sa 2ii (o)	297	12.5	
A-17	Sa 3i (o)	847	1319.0	**PACIFIC (offshore)**
	Sa 3ii (o)	835 (Q)	58.0	
A-18	Sa 3iii (o)	835 (Q)	406.0	
	Sa 3iv (o)	847	2029.0	
A-19	Sa 4ii (o)	847	890.0	
	Sa 4ii (o)	261	1.3	
A-20	Sa 4iii (o)	847	966.0	
	Sa 4iv (o)	297	0.1	
A-21	Sa 4v (o)	297	11.0	
	Sa 4v (o)	297	4.4	
A-22	Sa 4vi (o)	297	0.7	
	Sa 5i (o)	847	2164.0	
A-23	Sa 6i (o)	847	338.0	
	Sa 6ii (o)	993	1.8	

SONOGRAM INDEX (contd.)

Page:	top bottom	Tape No.	tape count	
A-24	Sa 6iv (o)	847	326.0	
A-25	Sa 7i (o)	847	1028.0	
	Sa 8i (o)	835 (Q)	100.0	
A-26	Sa 8i (o)	847	396.0	
	Sa 8i (o)	847	1496.0	
A-27	Sa 8ii (o)	847	1254.0	
	Sa 8iii (o)	835 (Q)	49.0	
A-28	Sa 8iv (o)	835 (Q)	203.0	
	Sa 8iv (o)	835 (Q)	234.0	
A-29	Sa 8v (o)	835 (Q)	521.0	
	Sa 8vi (o)	847	2209.0	
A-30	Sa 8vi (o)	847	2205.0	
	Sa 8vi (o)	847	2204.0	
A-31	Sa 9i (o)	847	960.0	
	Sa 9ii (o)	847	2027.0	
A-32	Sa 10i (o)	847	687.0	**PACIFIC**
	Sa 10i (o)	847	933.0	**(offshore)**
A-33	Sa 10ii (o)	835 (Q)	26.0	
	Sa 10ii (o)	835 (Q)	153.0	
A-34	Sa 11i (o)	993	1.9	
	Sa 11i (o)	847	2202.0	
A-35	Sa 12i (o)	847	286.0	
	Sa 12i (o)	847	2087.0	
A-36	Sa 12ii (o)	847	315.0	
	Sa 12iii (o)	847	788.0	
A-37	Sa 13i (o)	847	2072.0	
	Sa 13i (o)	847	367.0	
- - -	- - -	- - -	- - -	
A-38	Sa 1i (A)	2	140.0	
	Sa 1i (A)	2	665.0	
A-39	Sa 7i (A)	2	140.0	
	Sa 10ii (A)	2	1245.0	
A-40	Sa 5i (A)	2	840.0	**ATLANTIC**
	Sa 9i (A)	2	700.0	
A-41	Sa 9i (A)	2	1180.0	
	Sa 9i (A)	2	710.0	
A-42	Sa 9i (A)	2	1040.0	
	Sa 9i (A)	2	1160.0	
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	Sa 9i (A)	1	335.0	
A-44	Sa 9i (A)	1	360.0	
	Sa 9i (A)	1	335.0	
A-45	Sa 9i (A)	1	79.0	
	Sa 9i (A)	1	530.0	
A-46	Sa 9i (A)	1	132.0	
	Sa 9i (A)	1	188.0	
A-47	Sa 9i (A)	1	560.0	
	Sa 9i (A)	1	840.0	

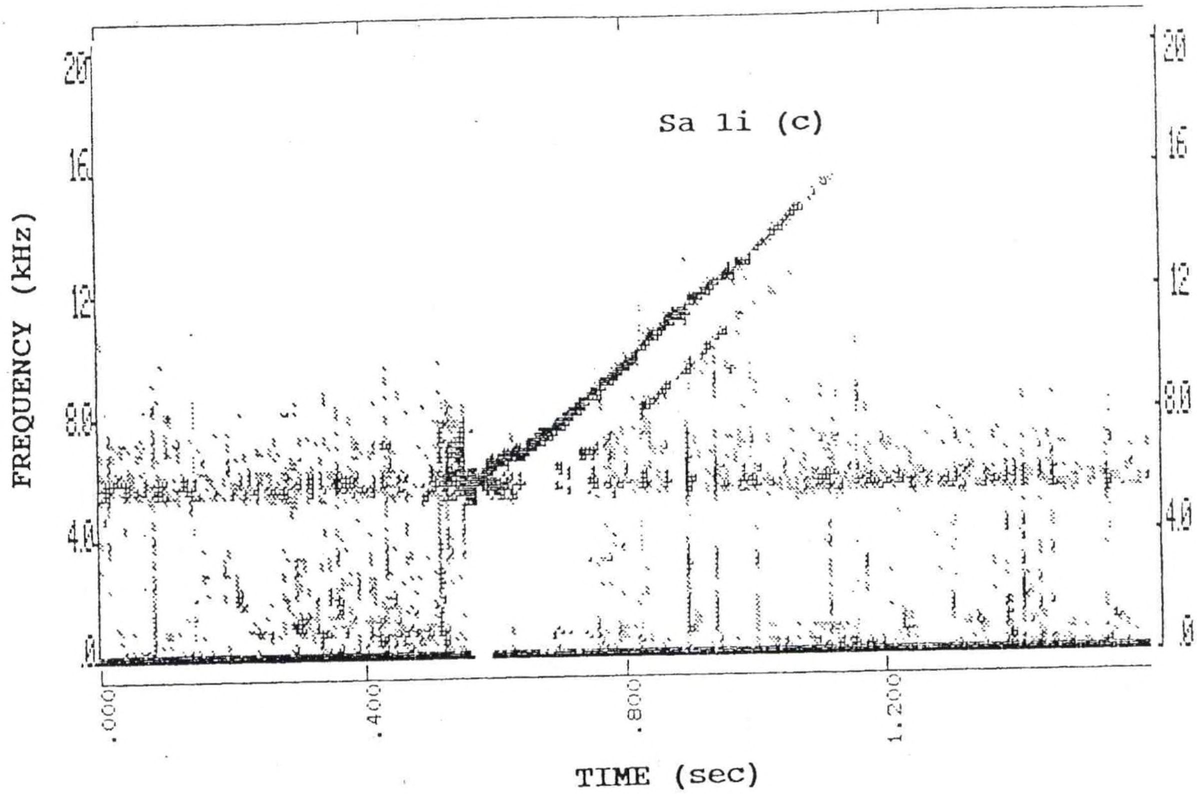
SONOGRAM INDEX (contd.)

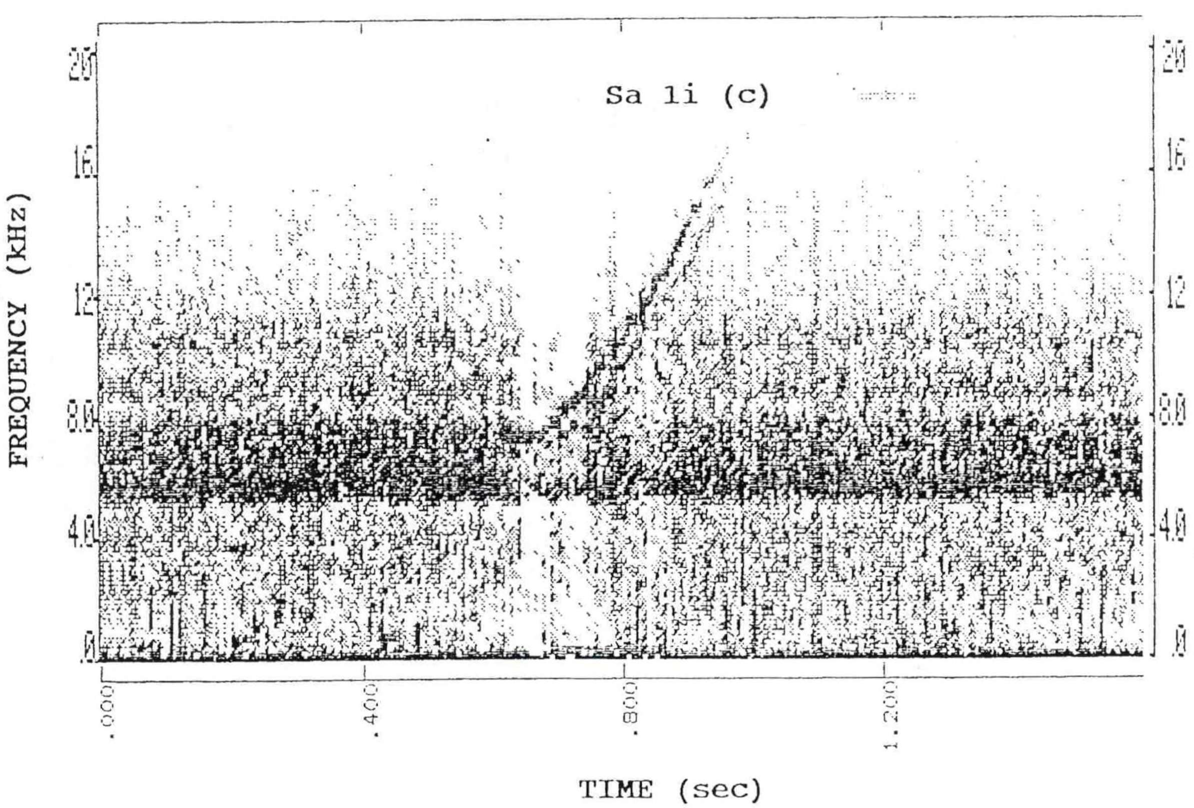
Page:	top / bottom	Tape No.	tape count	
A-48	Sa 9i (A)	1	560.0	
	Sa 9i (A)	1	705.0	
A-49	Sa 9ii (A)	2	830.0	ATLANTIC
	Sa 9ii (A)	1	560.0	
A-50	Sa 9iii (A)	2	1400.0	
	Sa 9iii (A)	2	1930.0	
A-51	Sa 9iii (A)	2	1850.0	
	Sa 9i (A)	3	35.0	

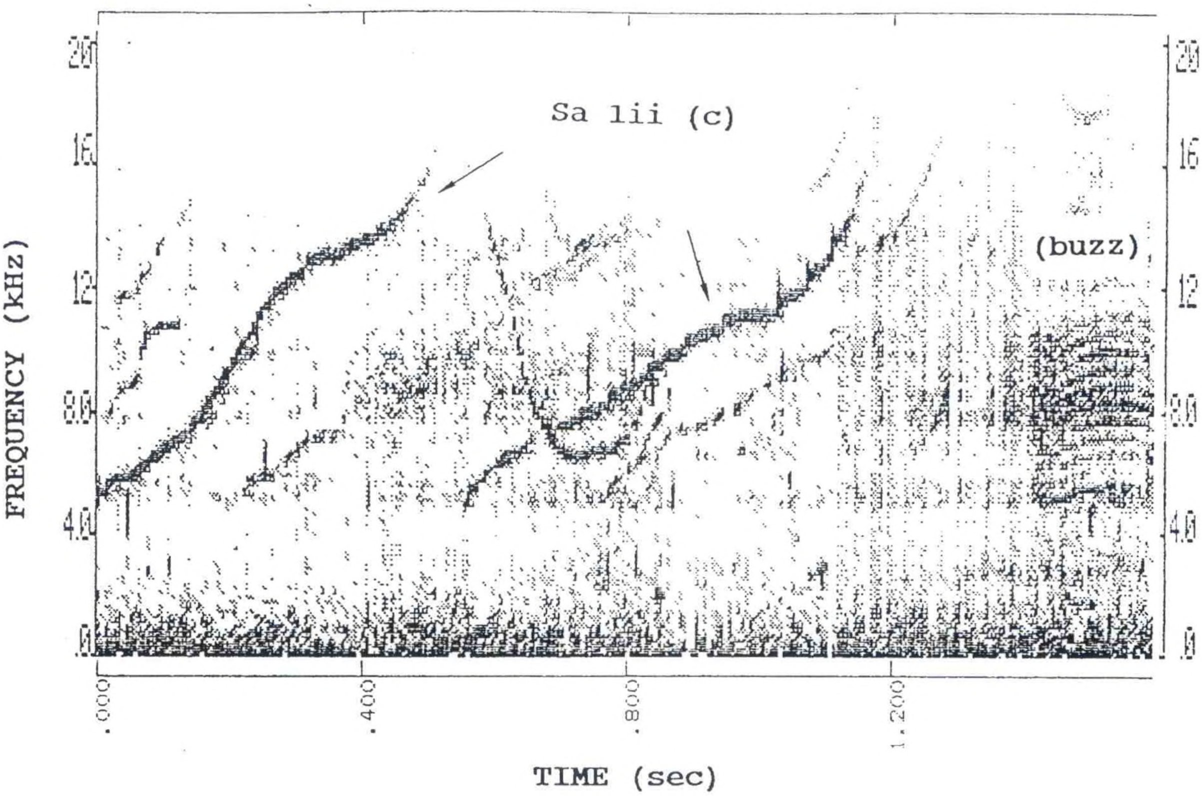
SPOTTED DOLPHIN (*Stenella* spp.) BIOACOUSTICS

APPENDIX A: SONOGRAM INDEX

PACIFIC (coastal)






Sa 1ii (c)
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4.0
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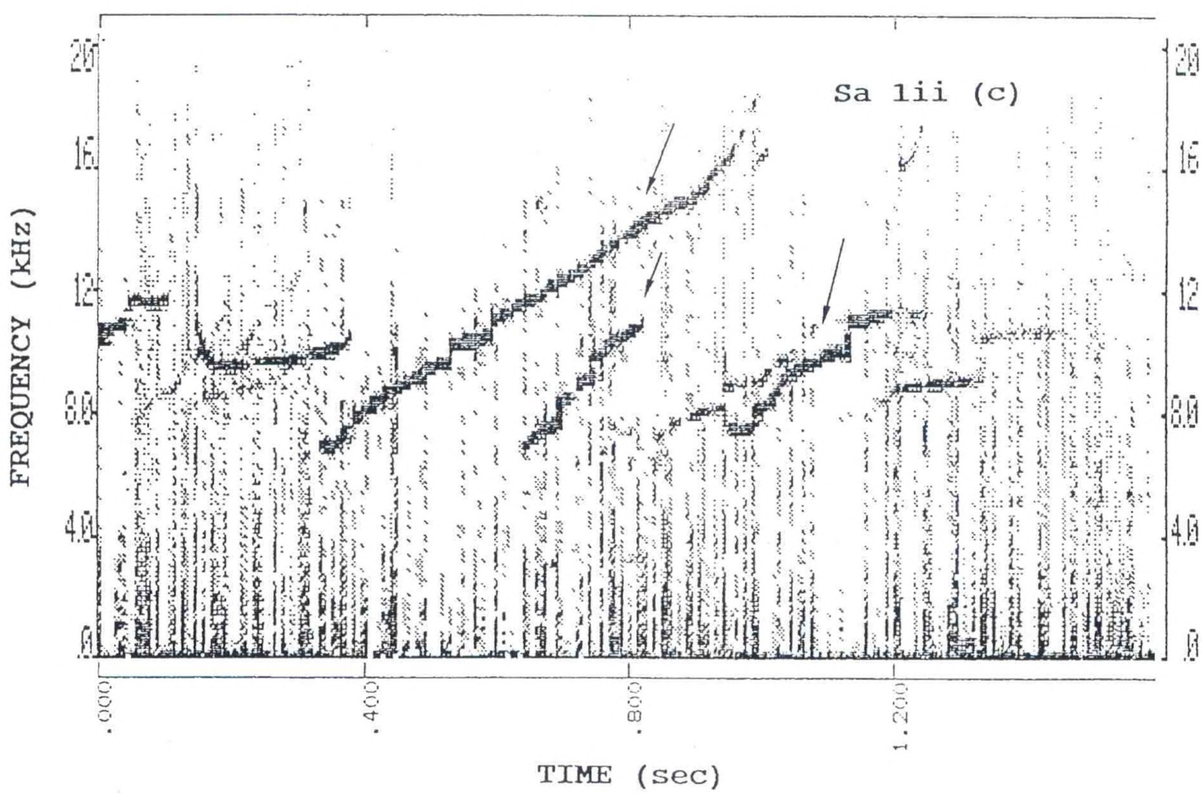
.800
1.200
TIME (sec)


Sa 1ii (c)
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8.0
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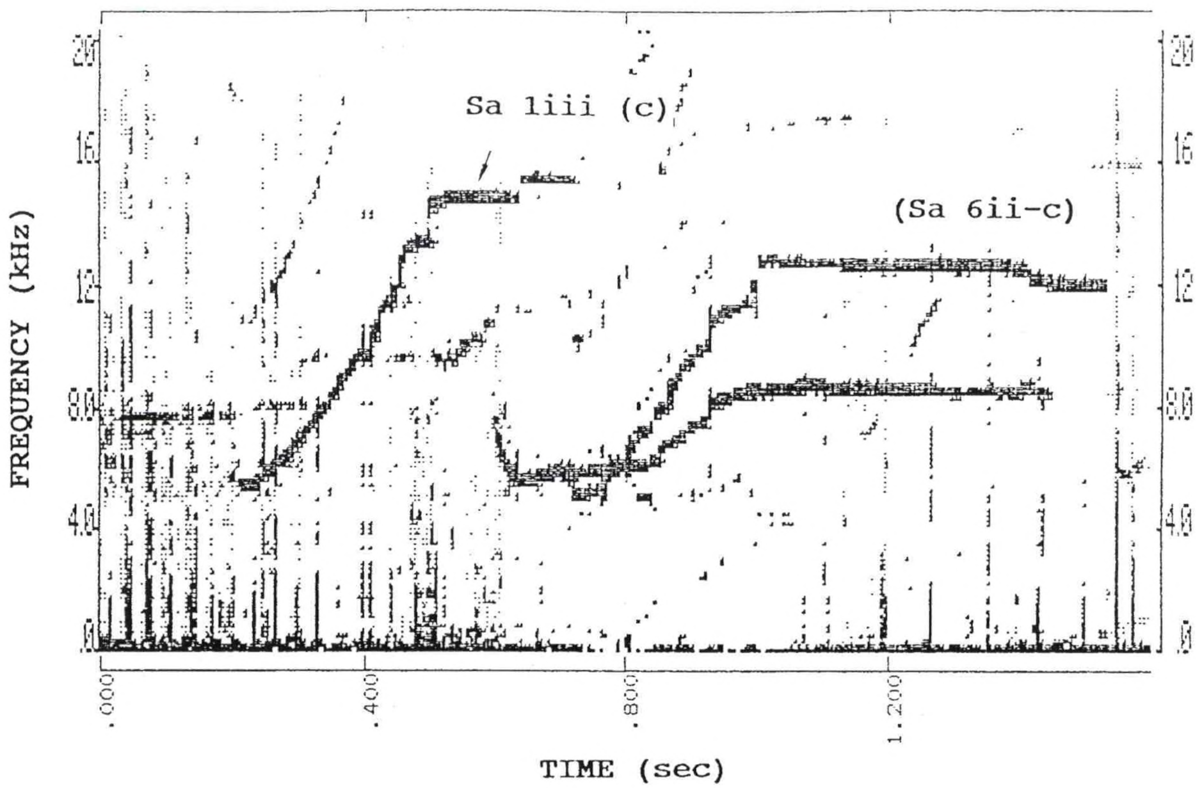
.800
1.200
TIME (sec)


Sa 1iii (c)
(Sa 6ii-c)
FREQUENCY (kHz)
TIME (sec)
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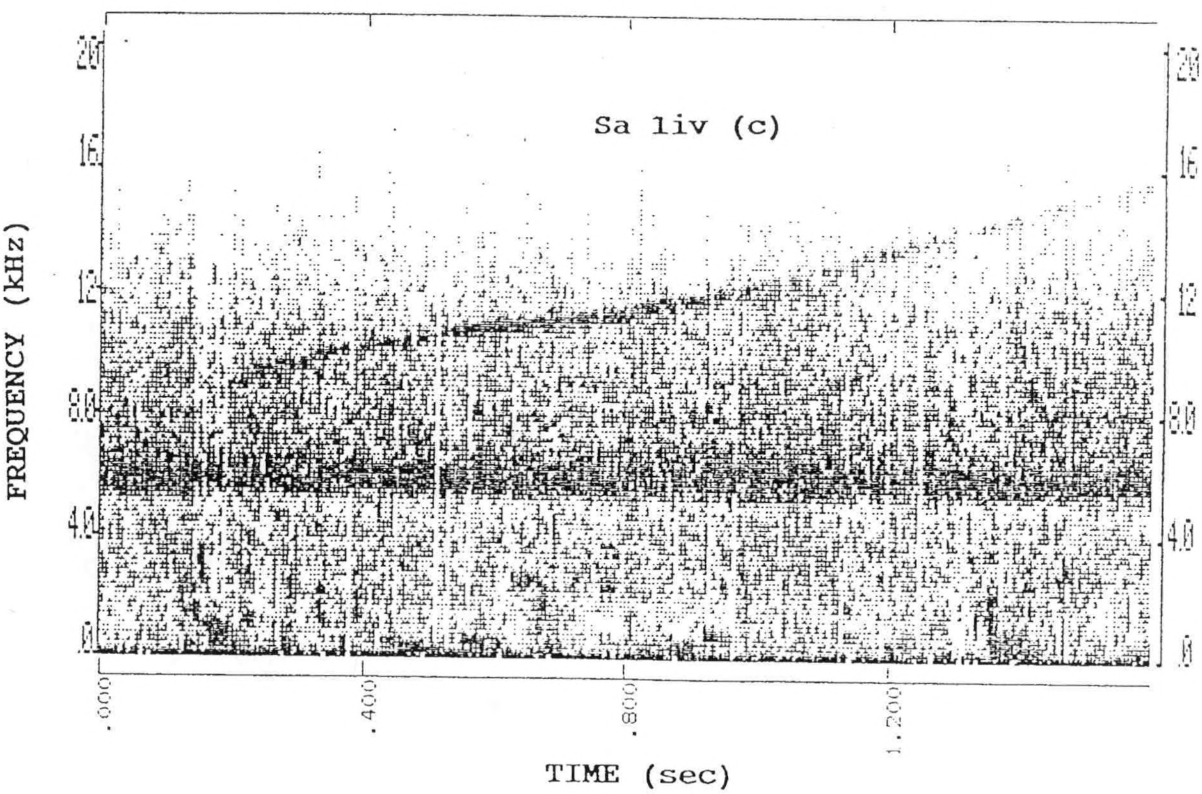
8.0
12
16
20
.000
.400
.800
1.200


Sa 1iv (c)
FREQUENCY (kHz)
TIME (sec)
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4.0
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12
16
20
.000
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.800
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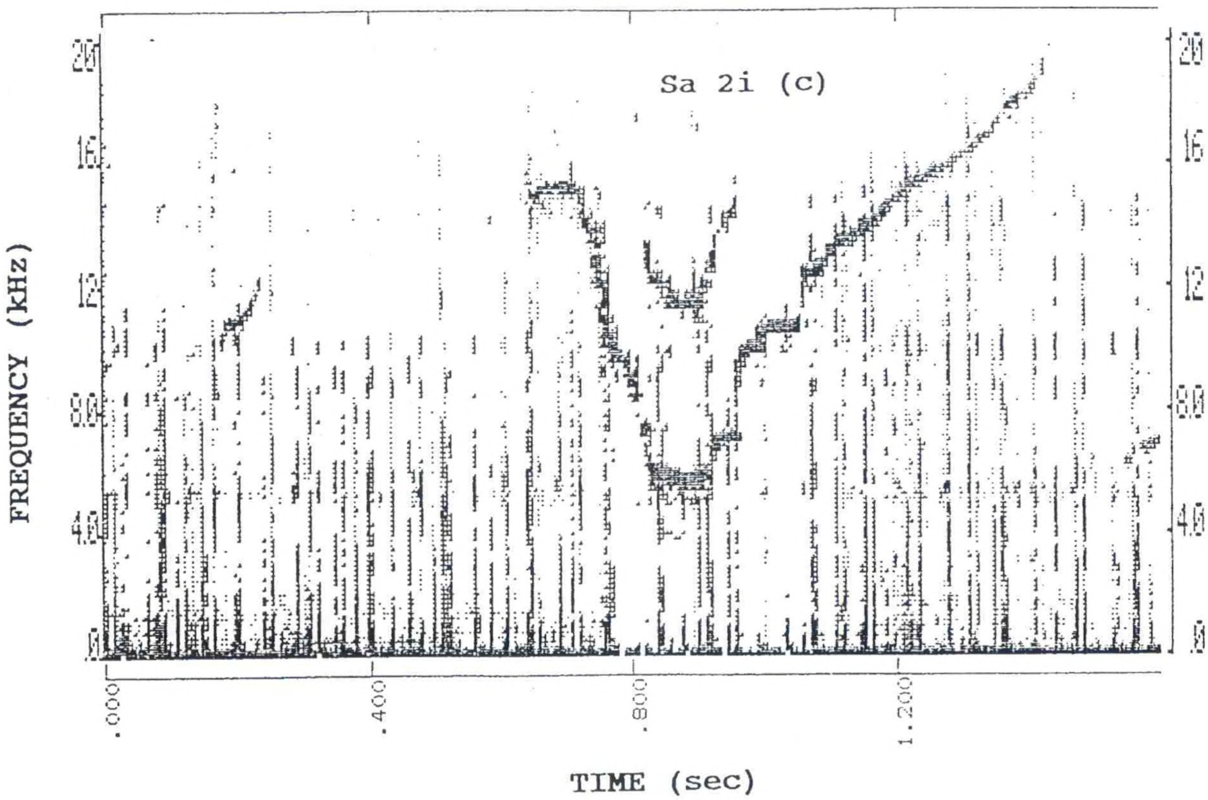
Sa 2i (c)
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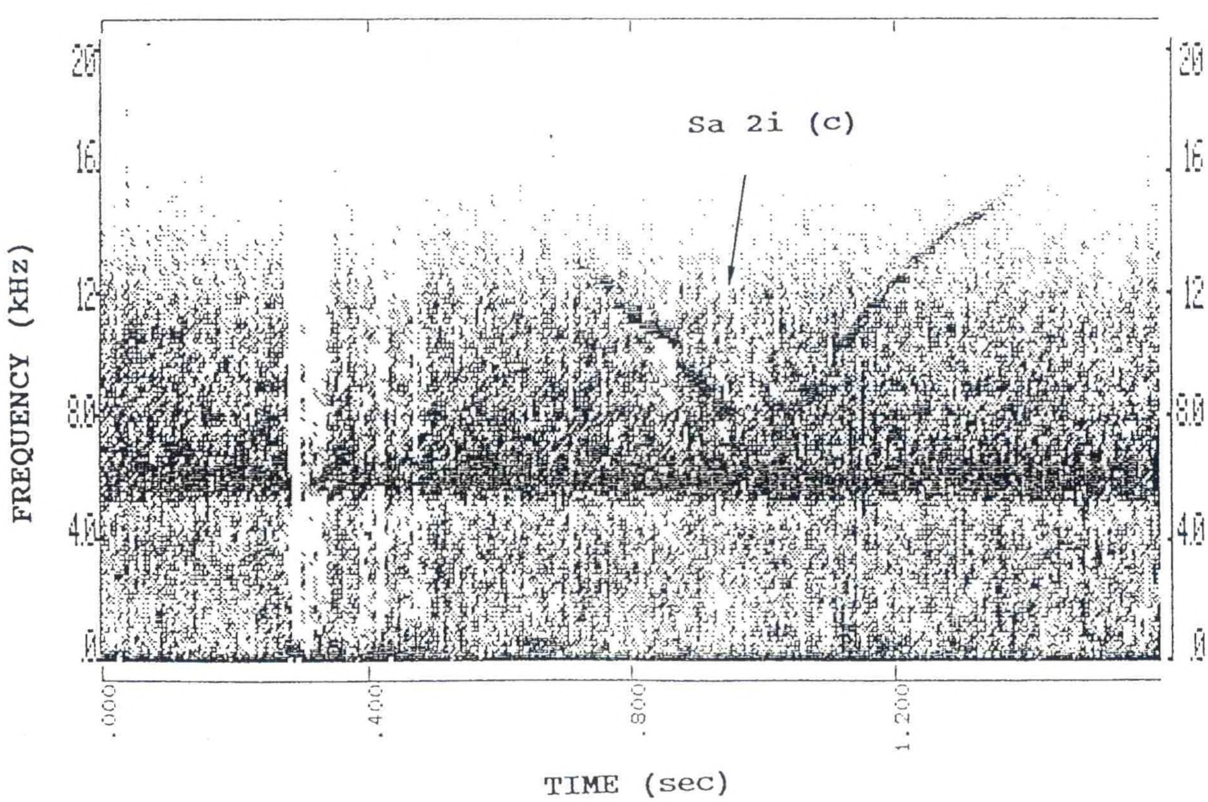
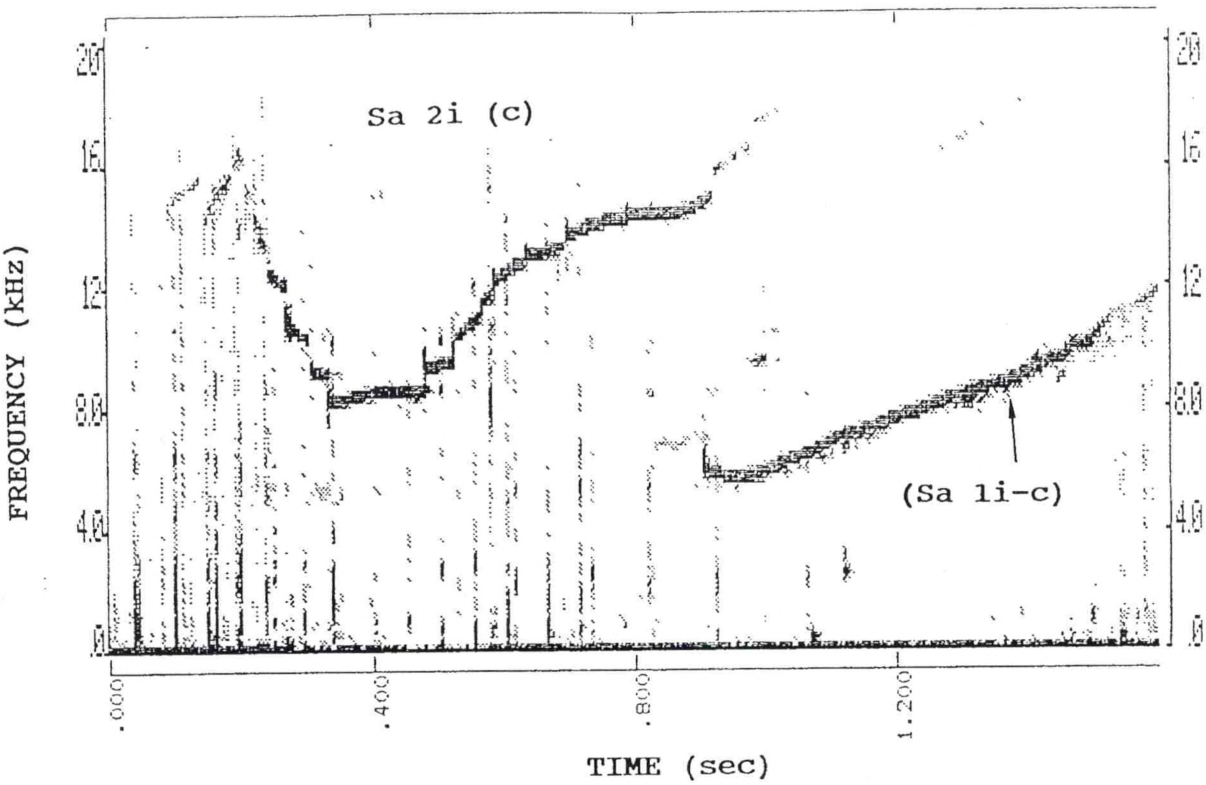
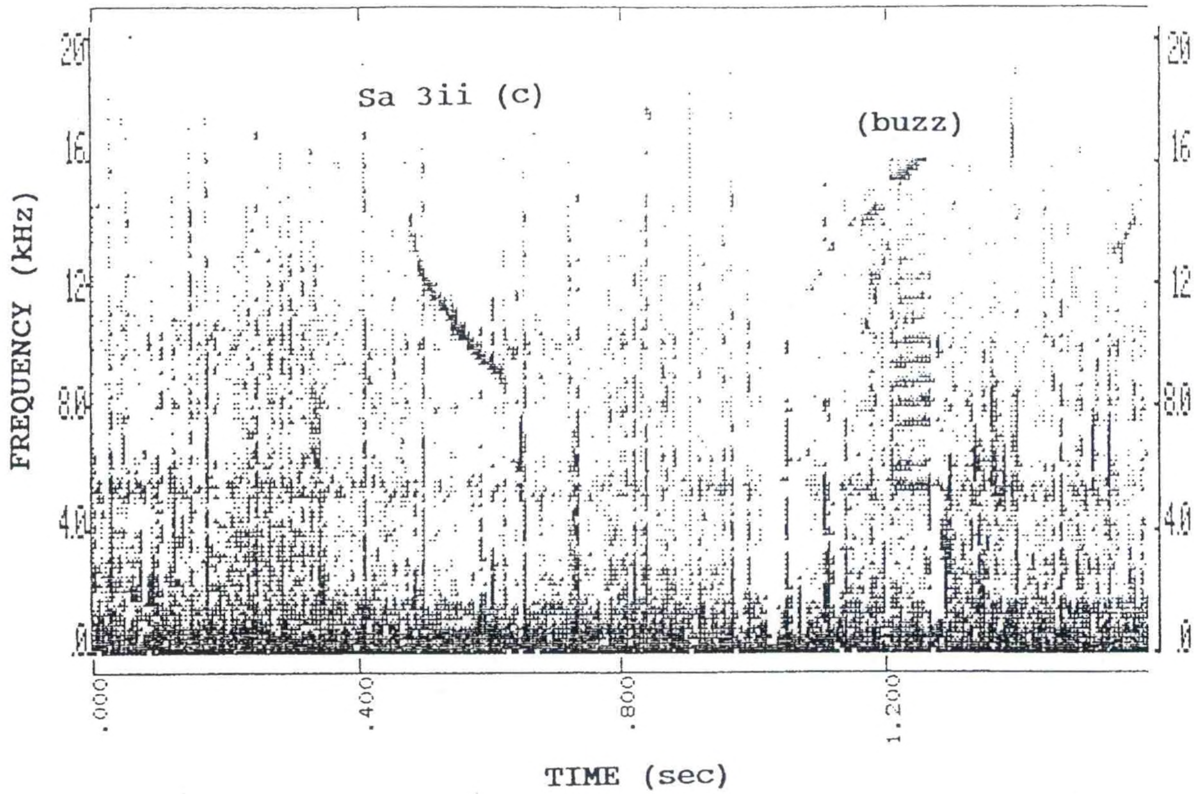
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)


Sa 2i (c)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)



Sa 2i (c)
(Sa 1i-c)
FREQUENCY (kHz)
TIME (sec)


Sa 3ii (c)
(buzz)
FREQUENCY (kHz)
TIME (sec)
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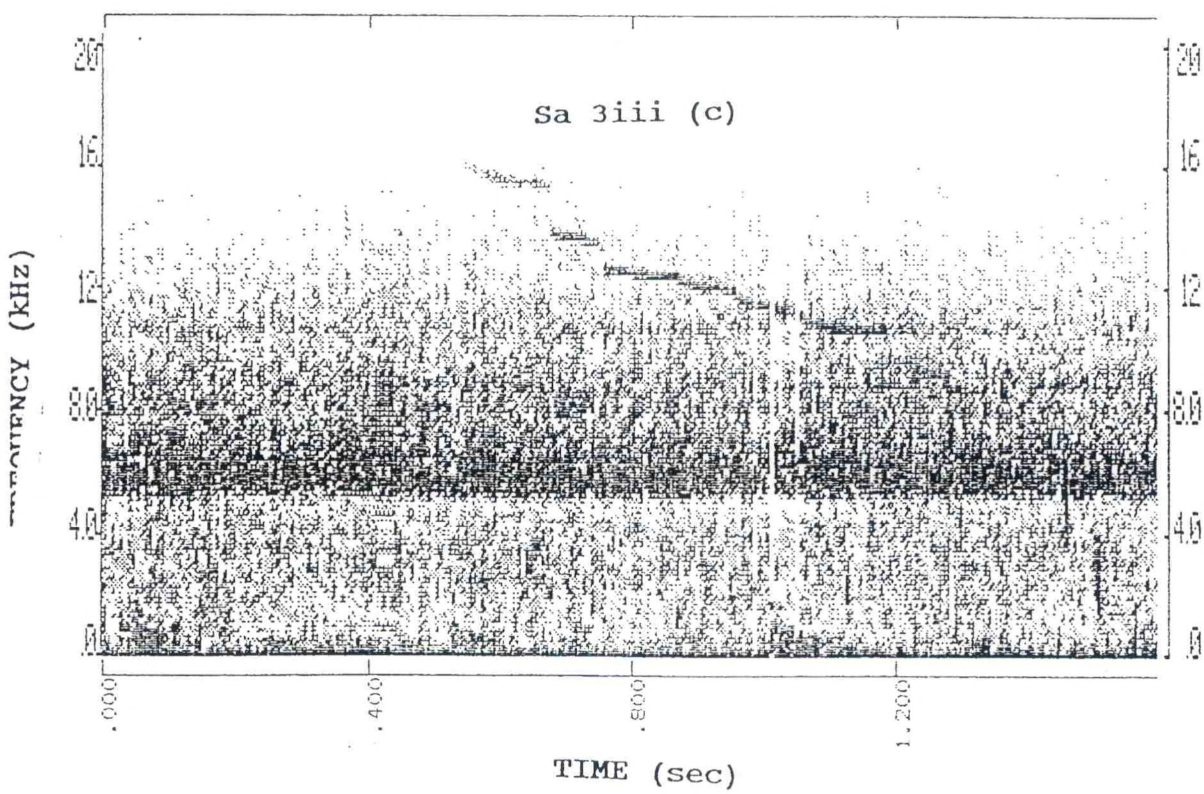
.400
.800
1.200


Sa 3iii (c)
TIME (sec)
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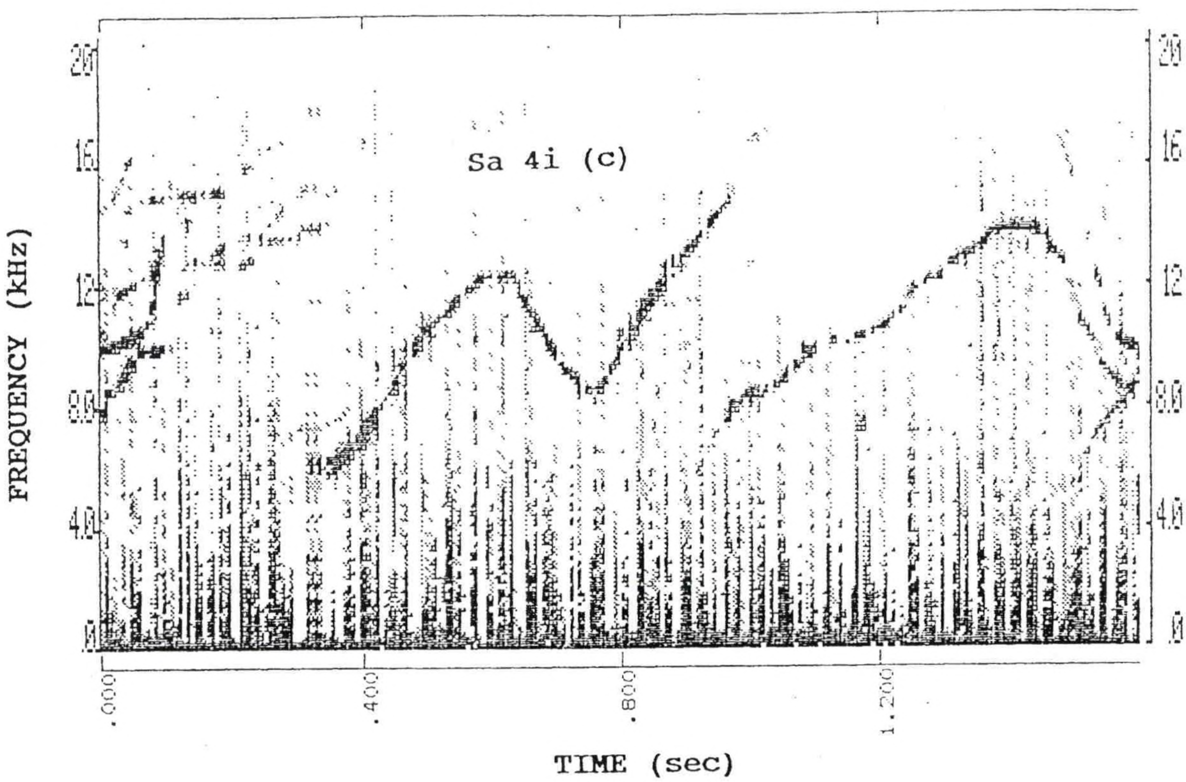
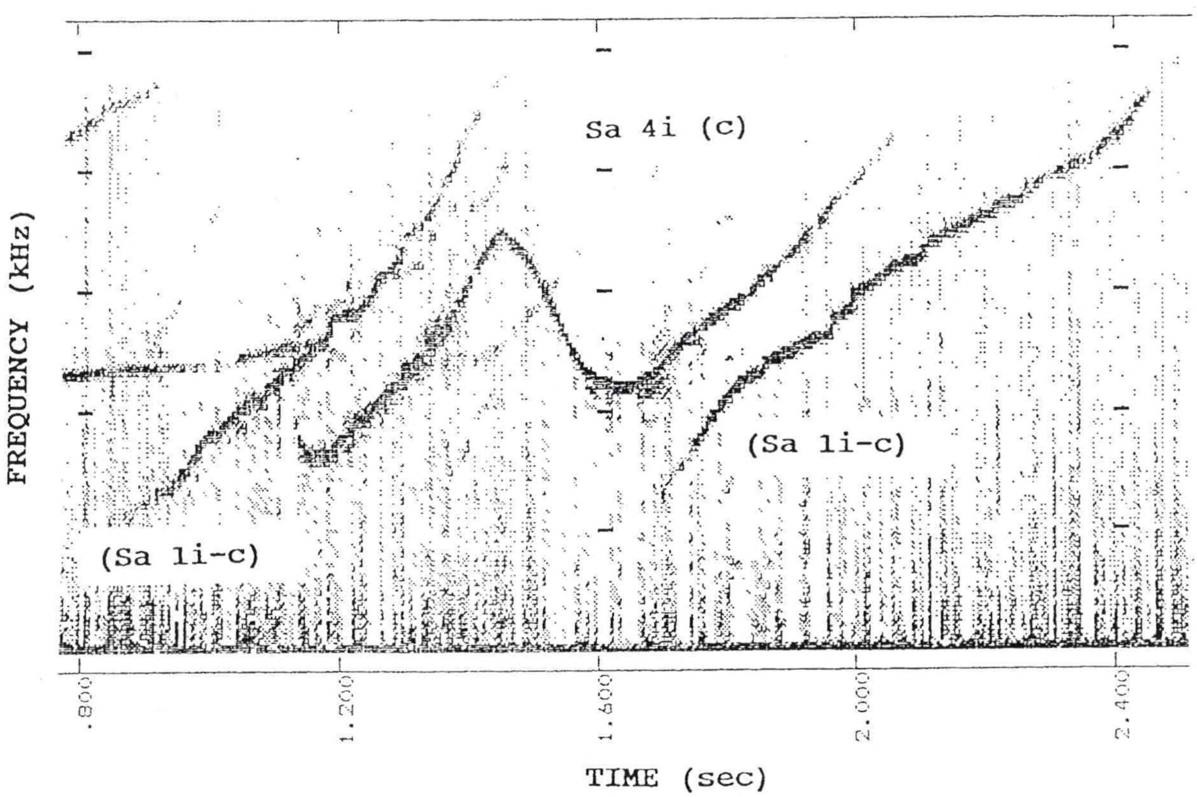
.400
.800
1.200


Sa 4i (c)
FREQUENCY (kHz)
TIME (sec)
20
16
12
8.0
4.0
0
.000
.400
.800
1.200


Sa 4i (c)
(Sa 1i-c)
(Sa 1i-c)
FREQUENCY (kHz)
TIME (sec)
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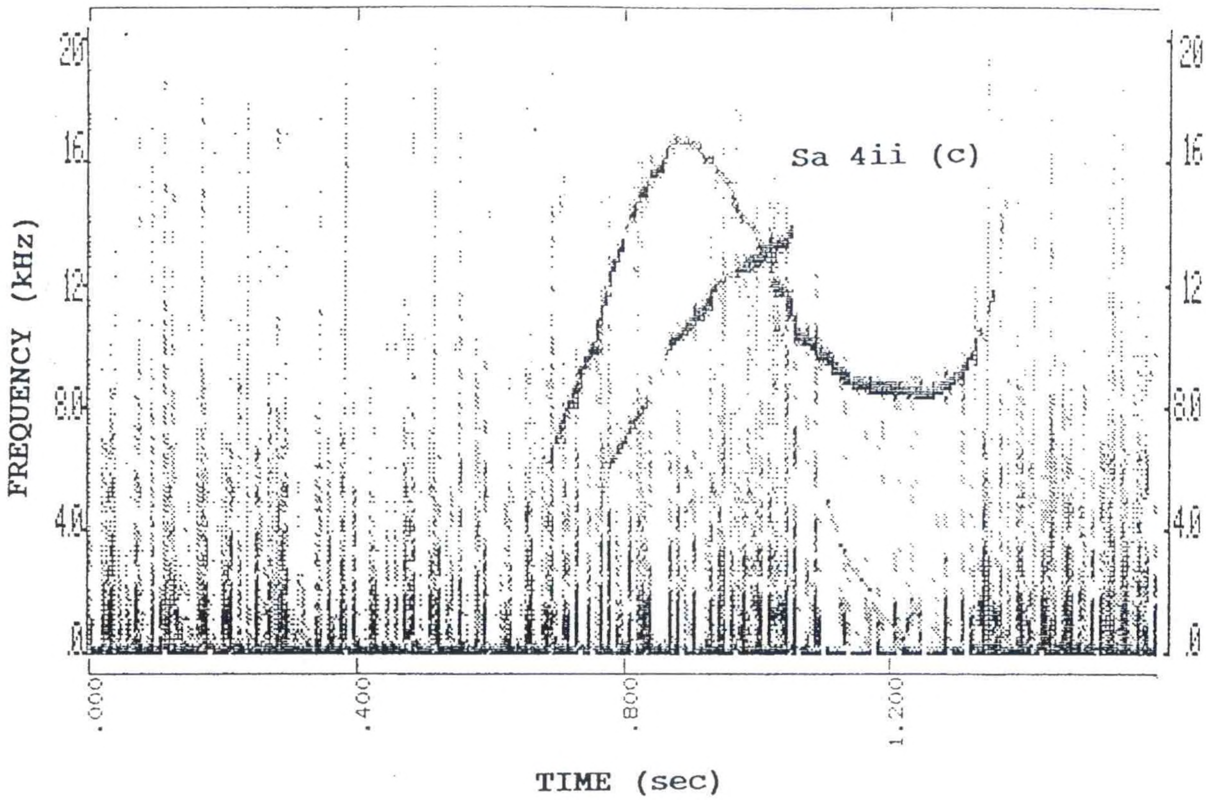
1.200
1.600
2.000
2.400


Sa 4ii (c)
FREQUENCY (kHz)
TIME (sec)
20
16
12
8.0
4.0
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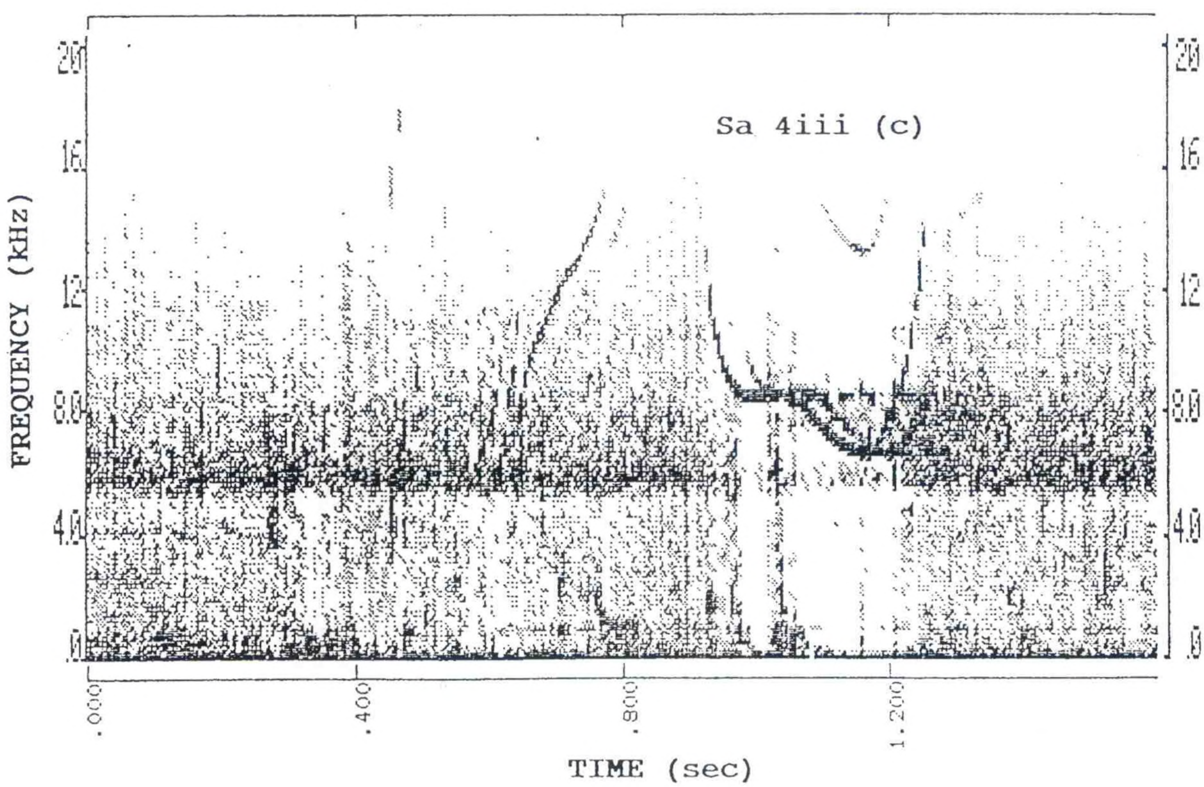
.000
.400
.800
1.200


Sa 4iii (c)
FREQUENCY (kHz)
TIME (sec)
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16
12
8.0
4.0
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.400
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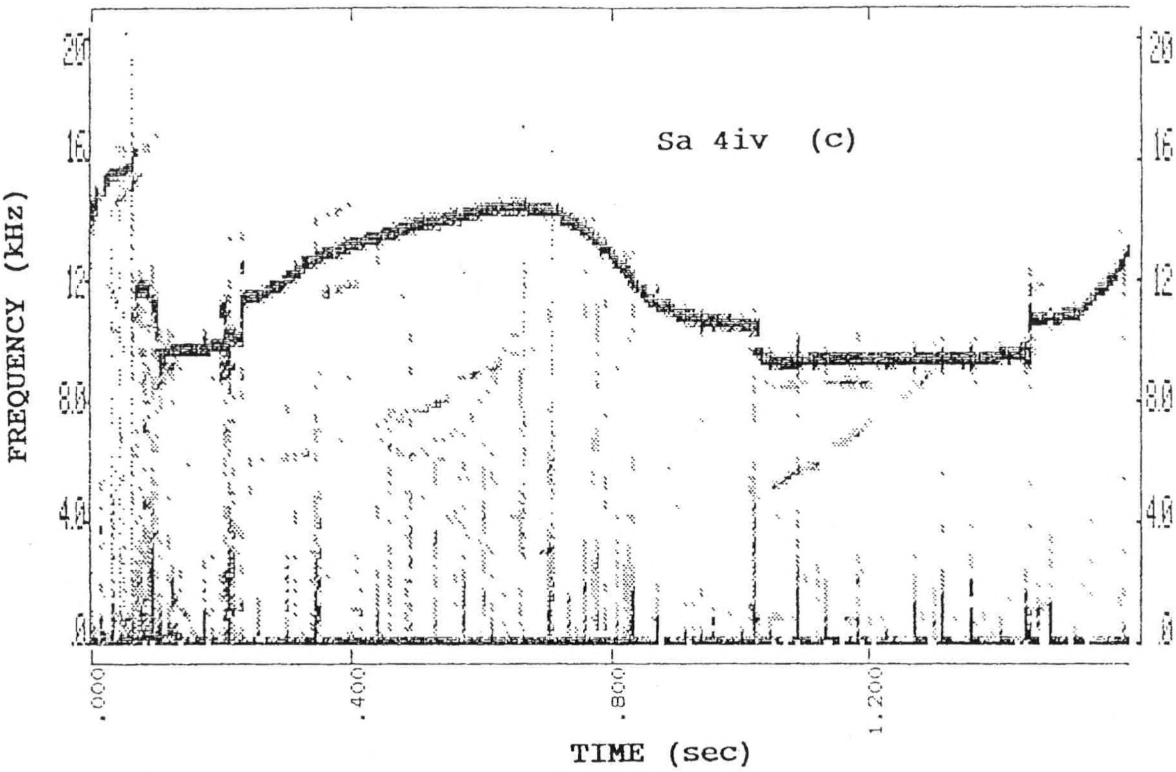
1.200


Sa 4iv (c)
FREQUENCY (kHz)
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8.0
4.0
0
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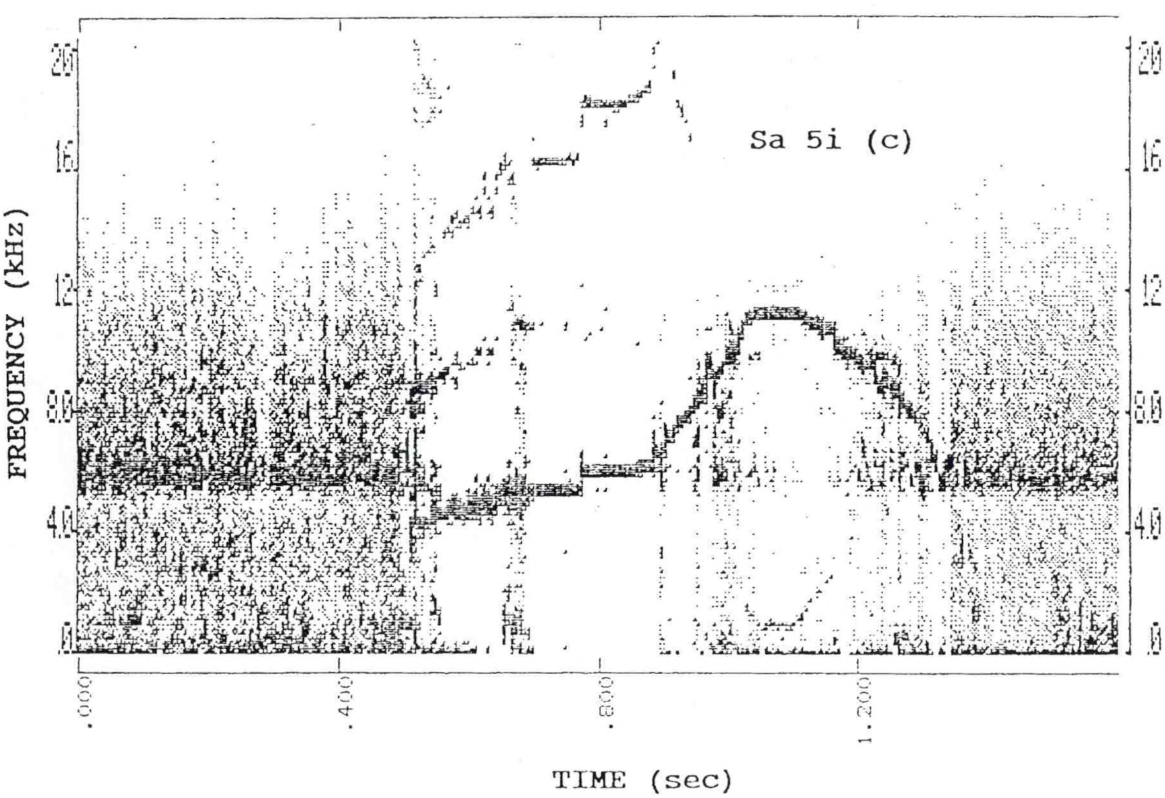
.400
.800
1.200
TIME (sec)


Sa 5i (c)
FREQUENCY (kHz)
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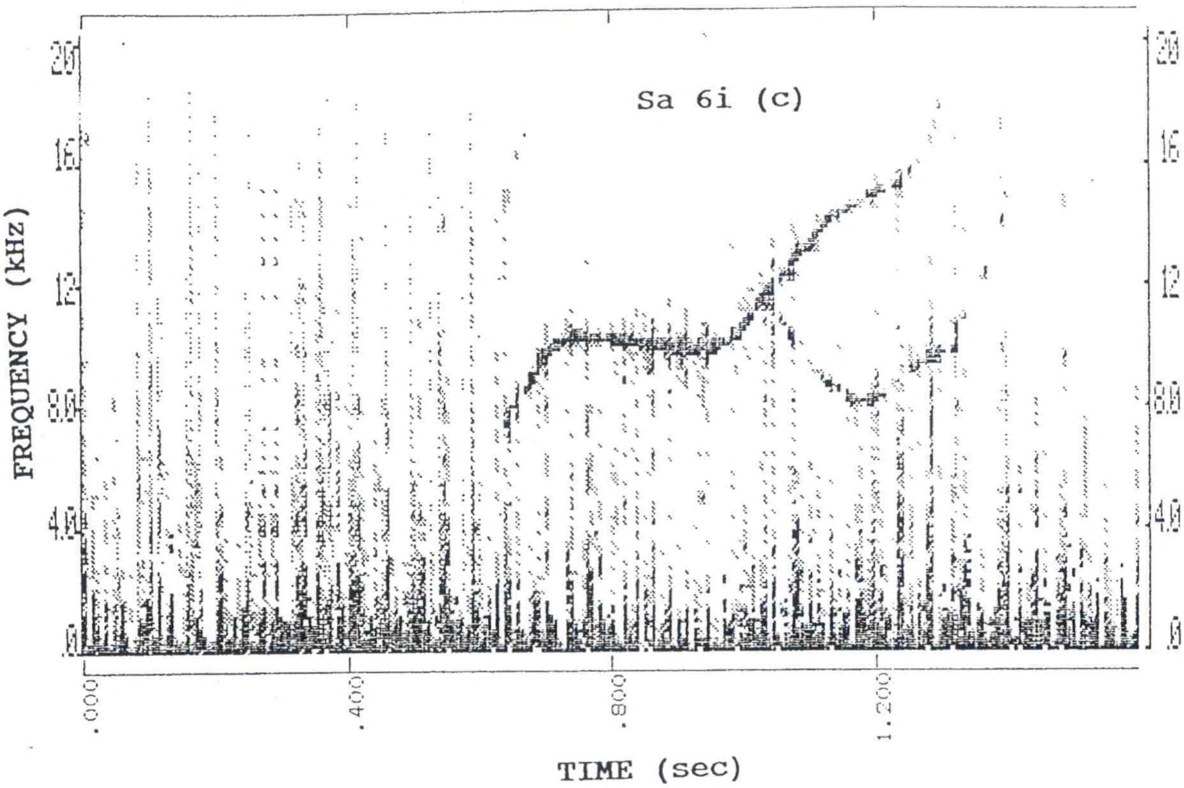
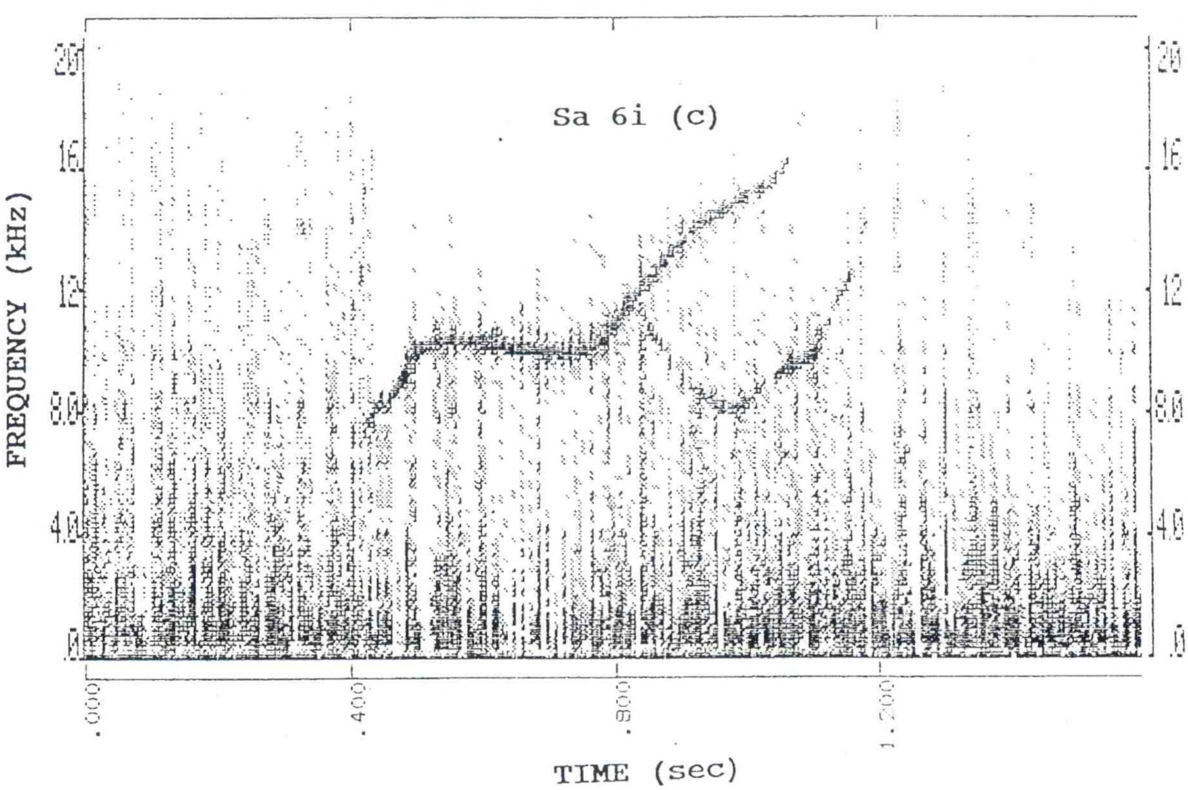
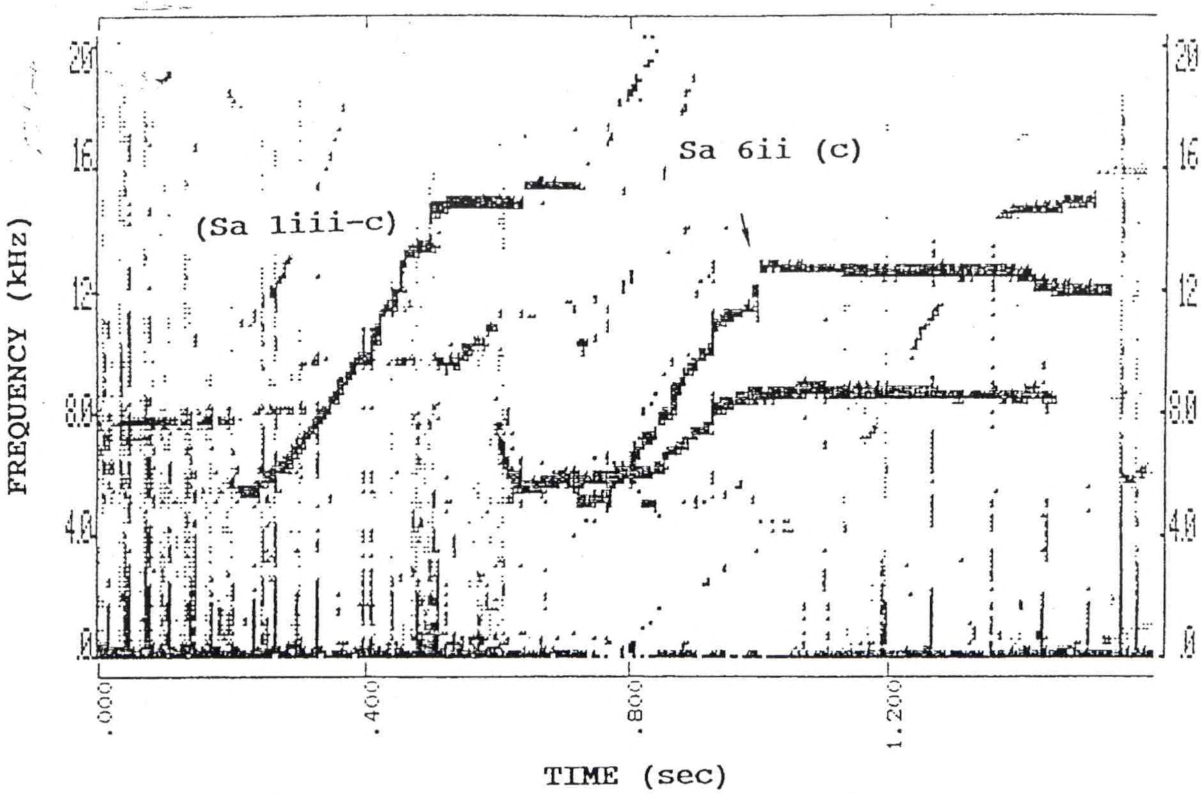
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)



Sa 6i (c)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
TIME (sec)
.000
.400
.800
1.200



Sa 6i (c)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
TIME (sec)
.000
.400
.800
1.200


Sa 6ii (c)
(Sa 1iii-c)
FREQUENCY (kHz)
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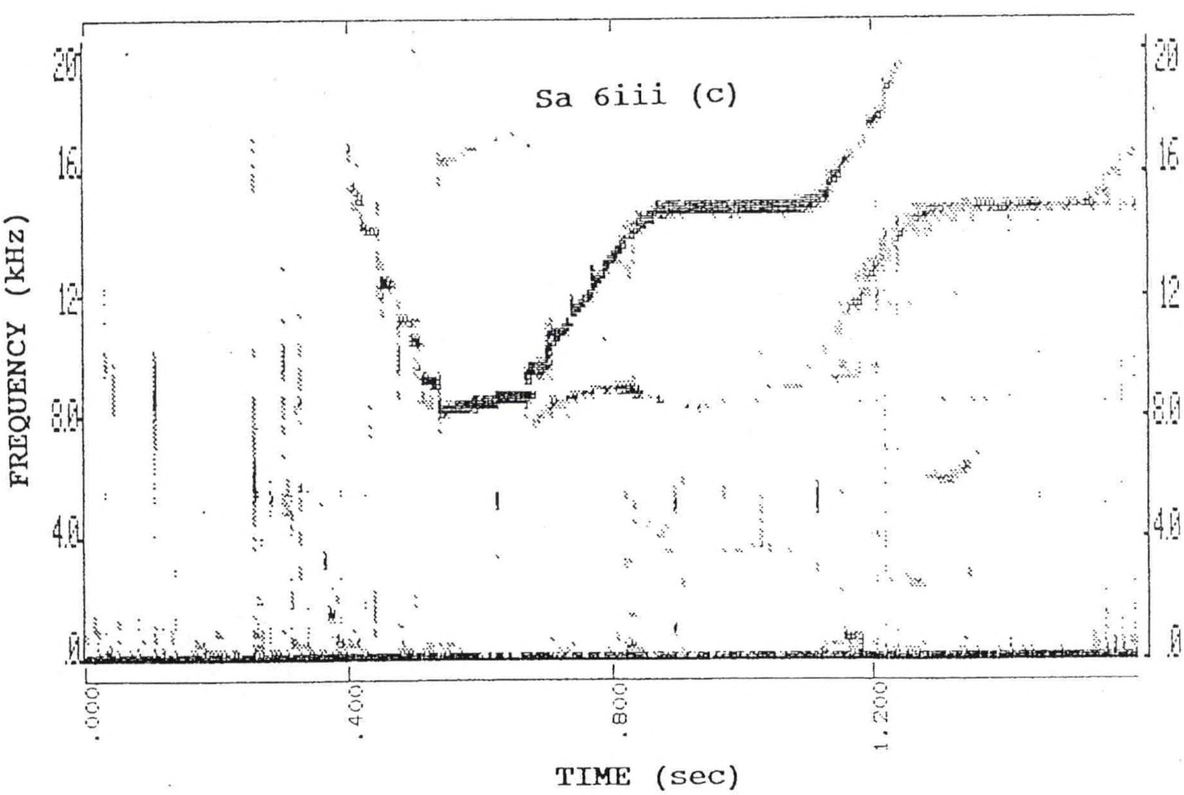
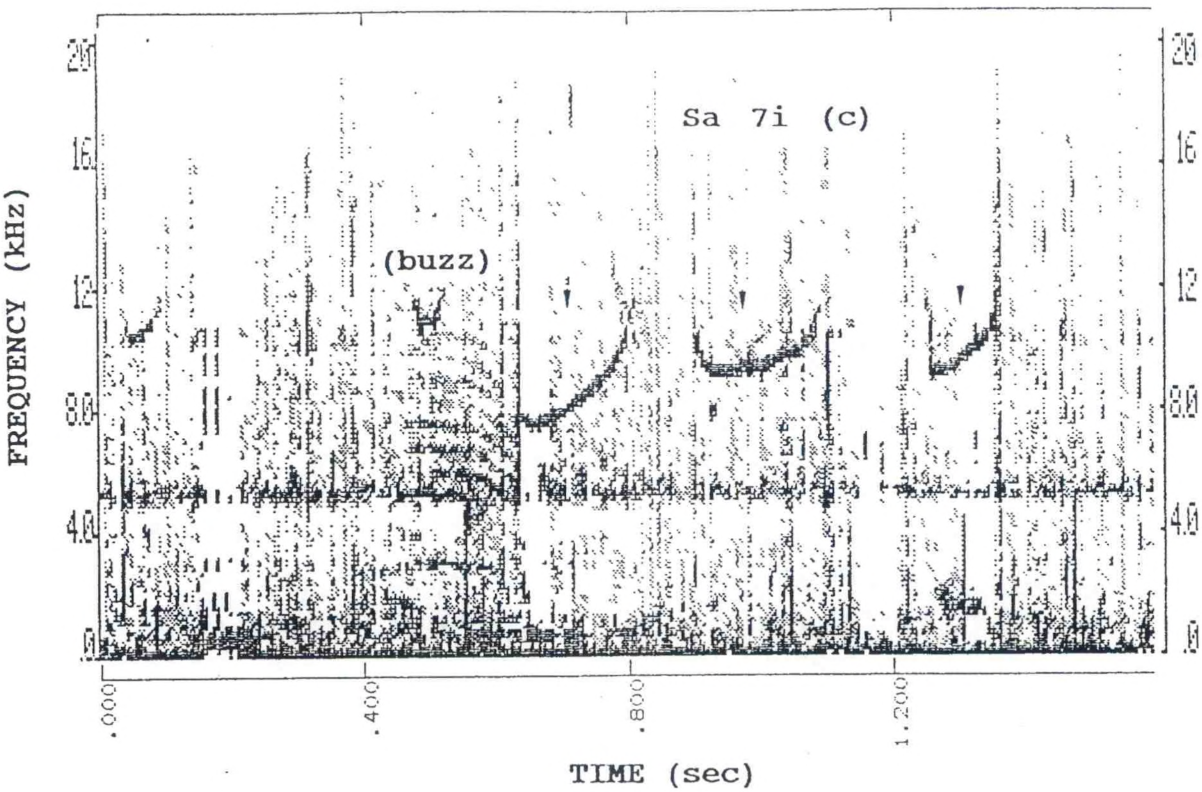
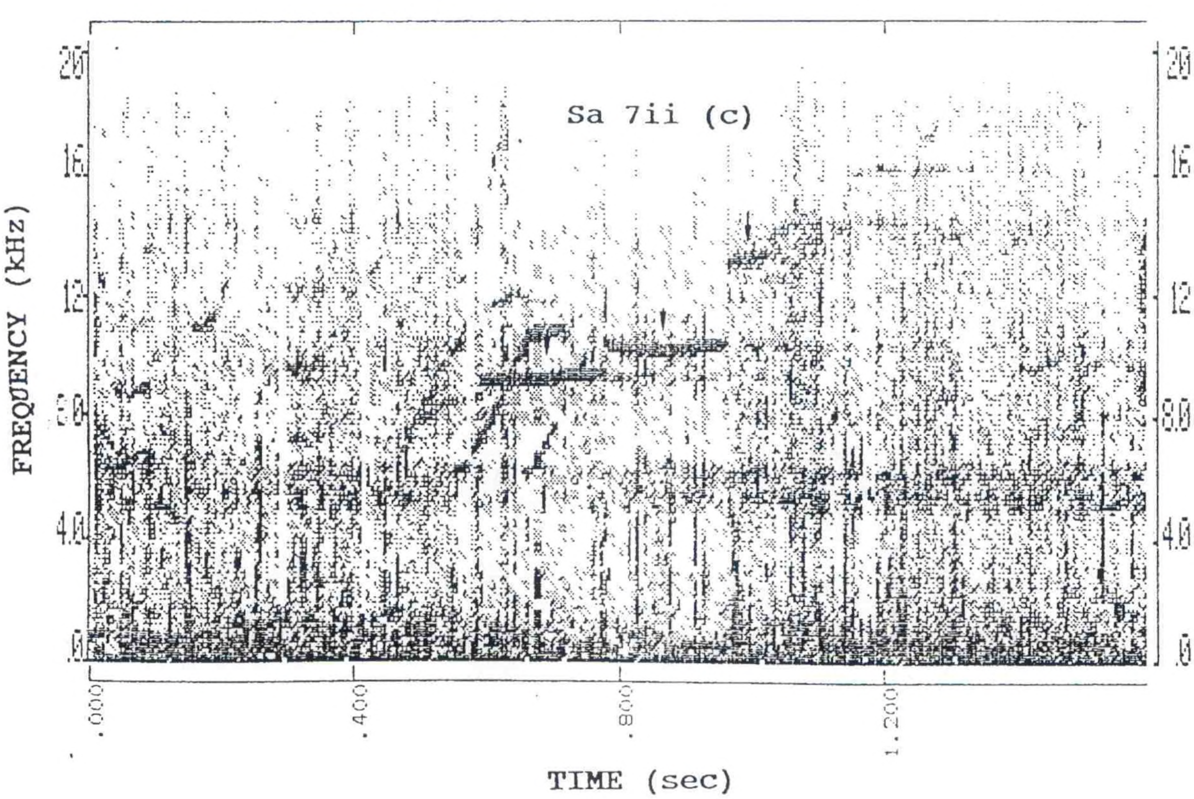
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)

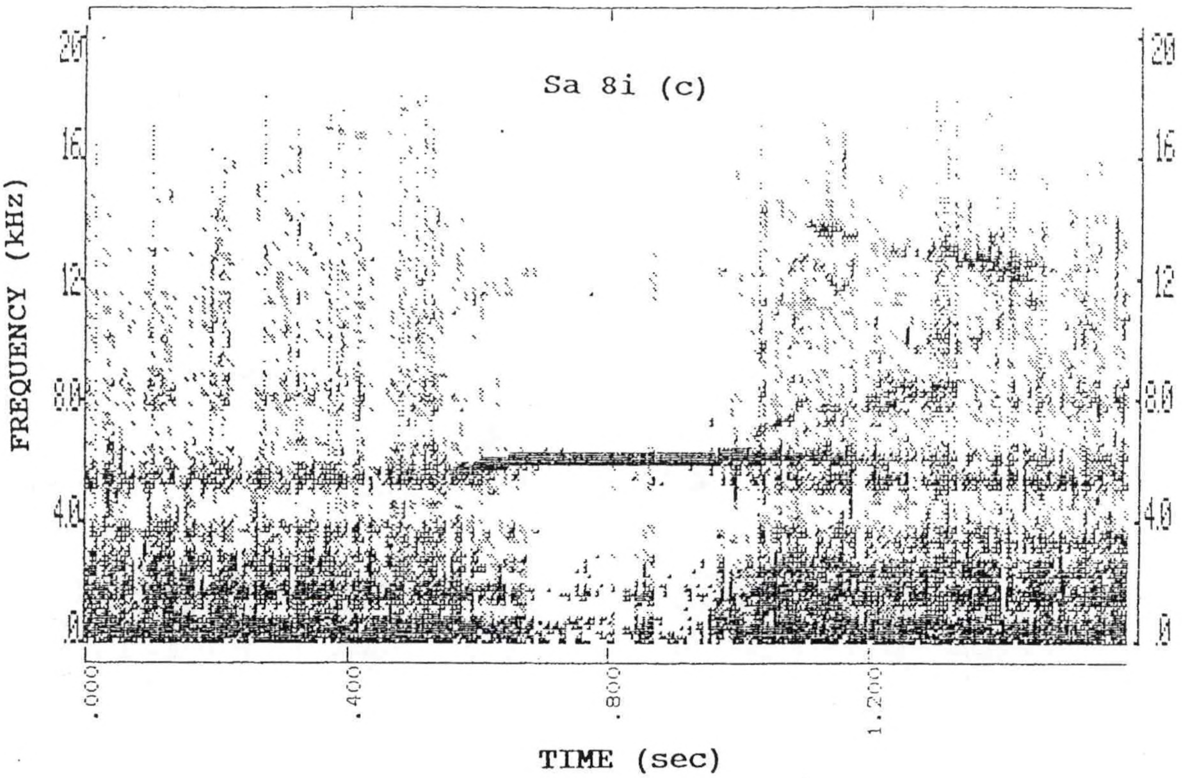

Sa 6iii (c)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)

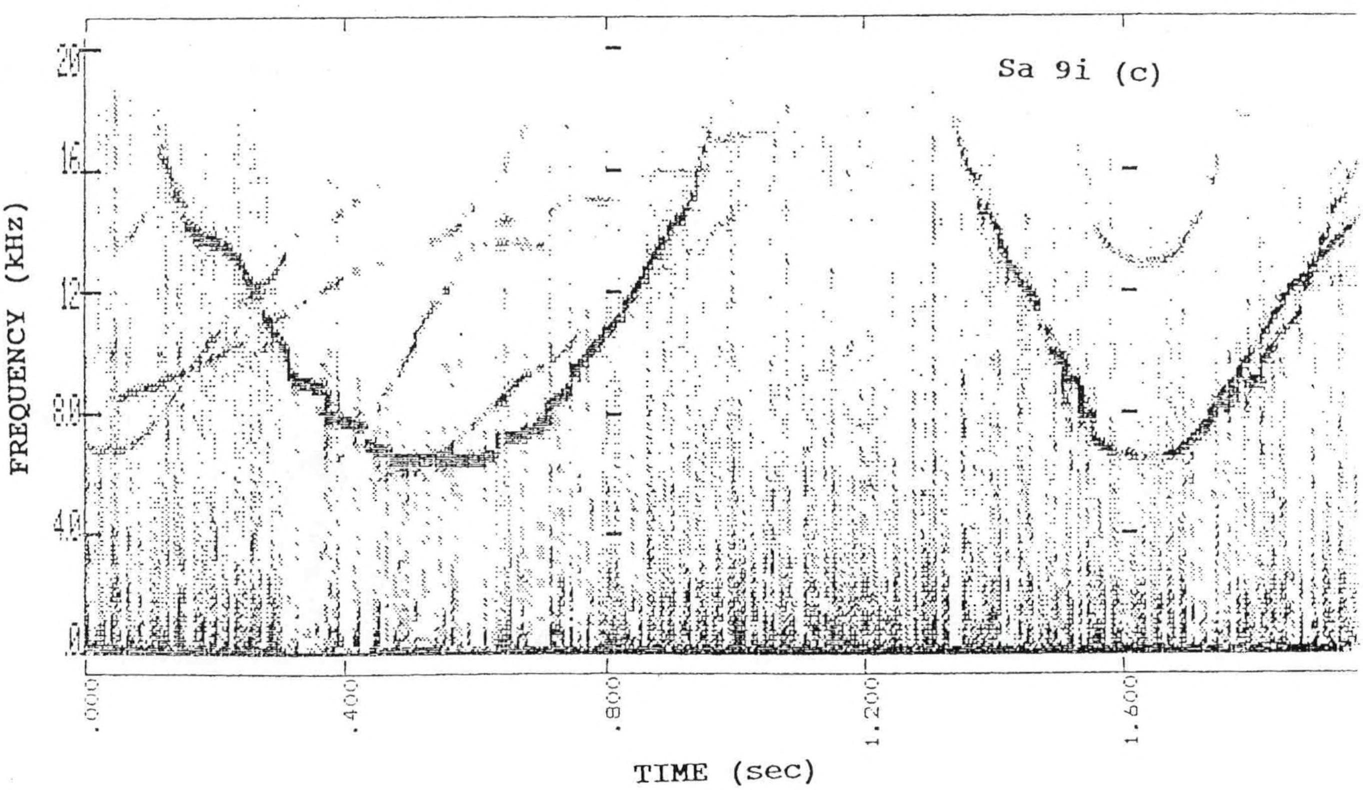


Sa 7i (c)
(buzz)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
TIME (sec)

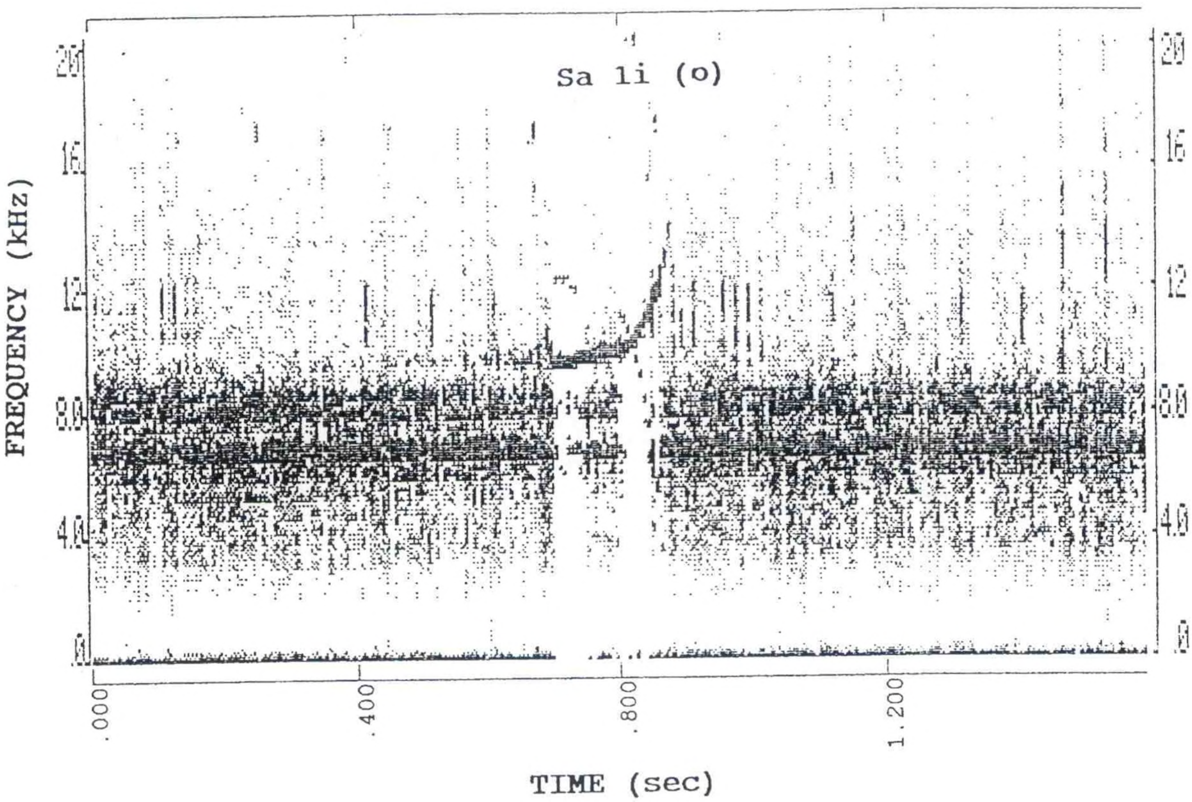


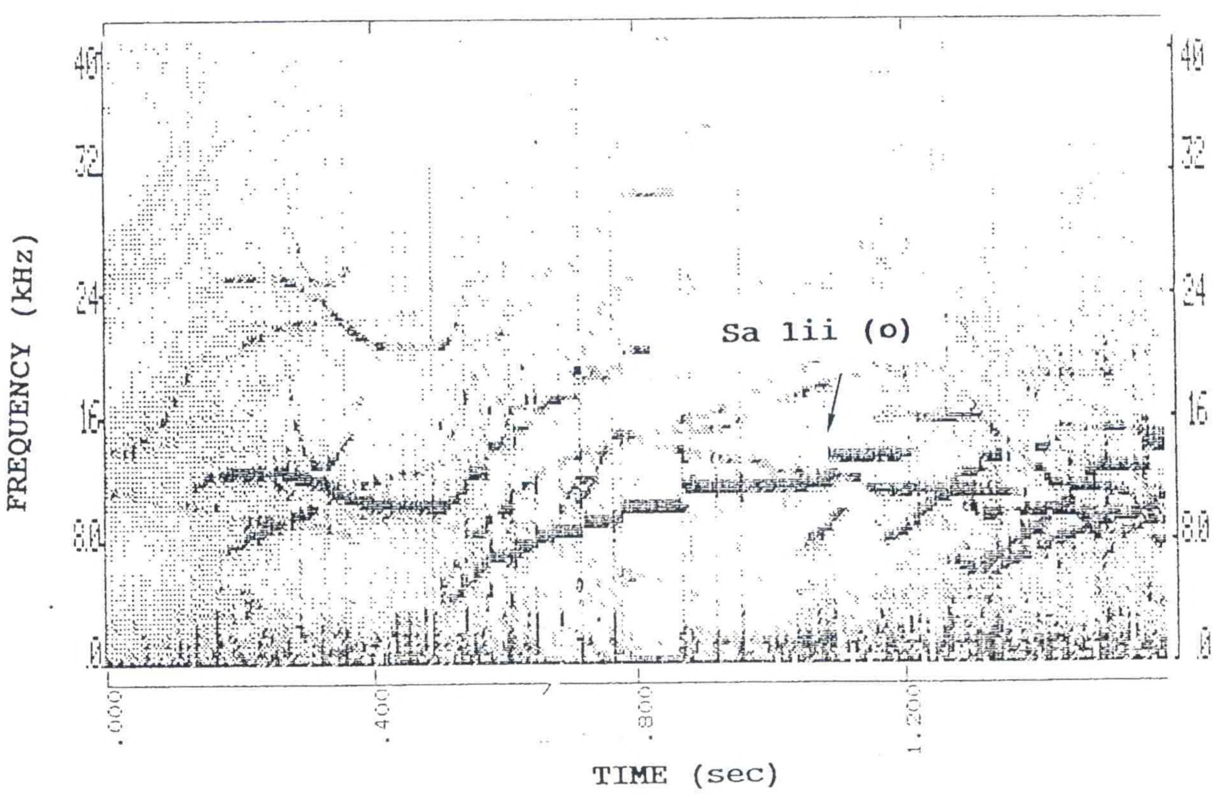
Sa 7ii (c)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
TIME (sec)

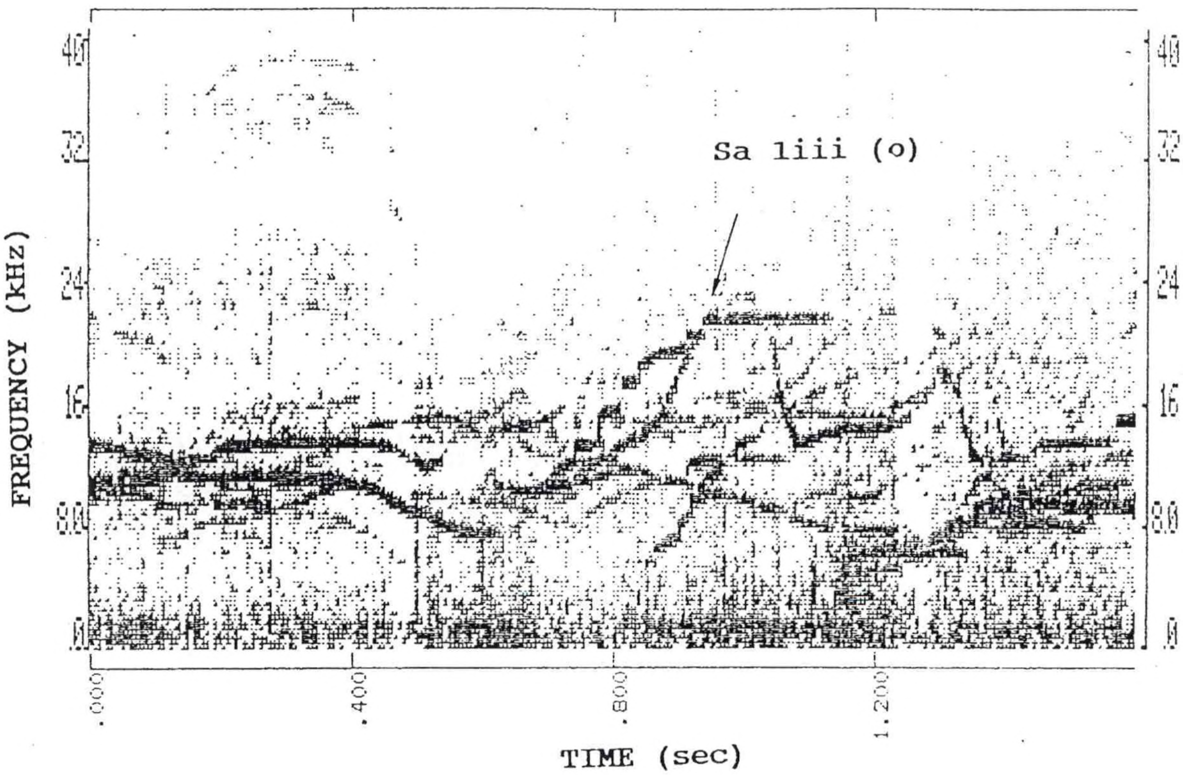

Sa 8i (c)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
TIME (sec)

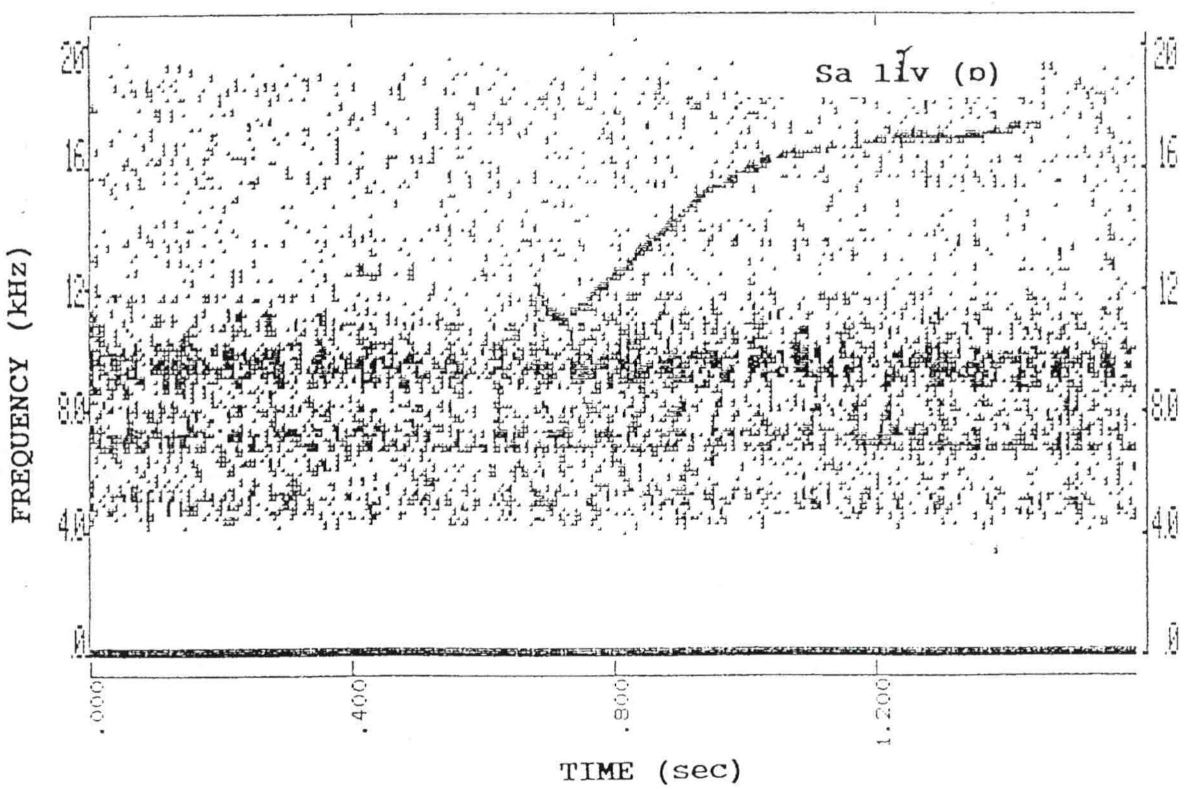

Sa 9i (c)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
1.600
TIME (sec)

PACIFIC (pelagic)






FREQUENCY (kHz)
40
32
24
16
8.0
.0
Sa 1iii (o)
.000
.400
.800
1.200
TIME (sec)


FREQUENCY (kHz)
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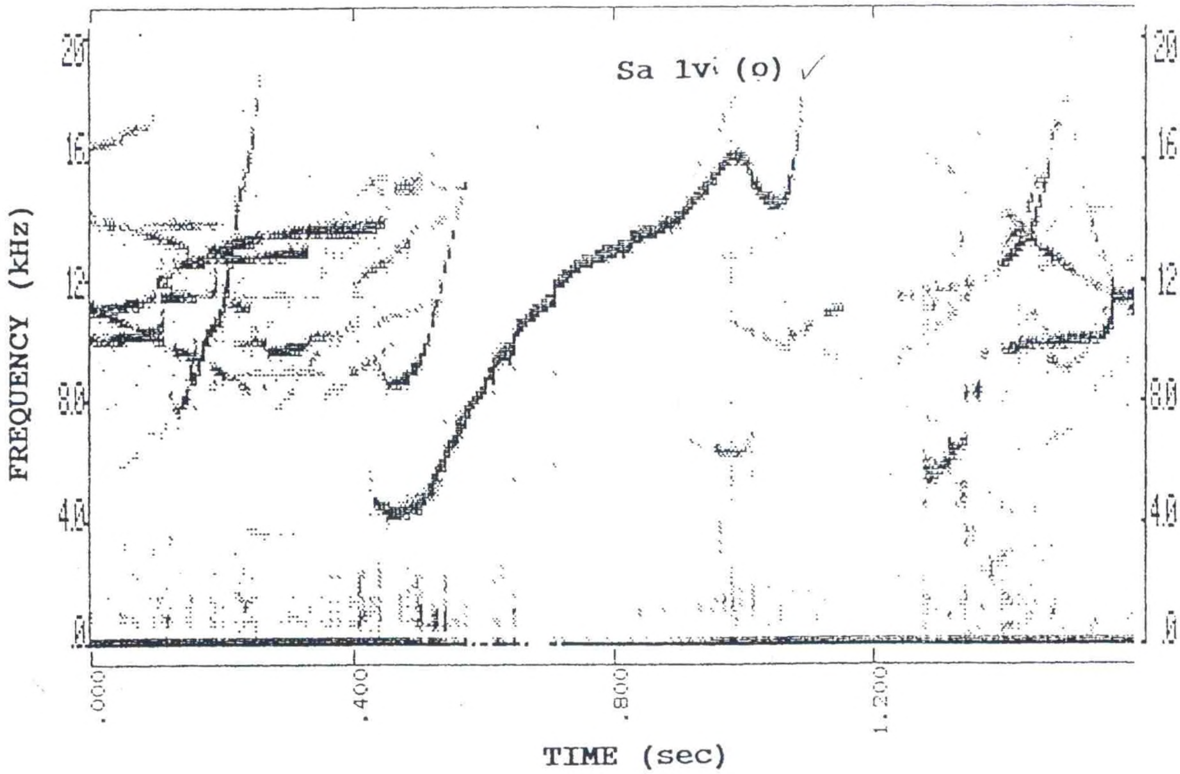
16
12
8.0
4.0
0
Sa 1iv (p)
.000
.400
.800
1.200
TIME (sec)


Sa 1vi (o)
FREQUENCY (kHz)
20
16
12
8.0
4.0
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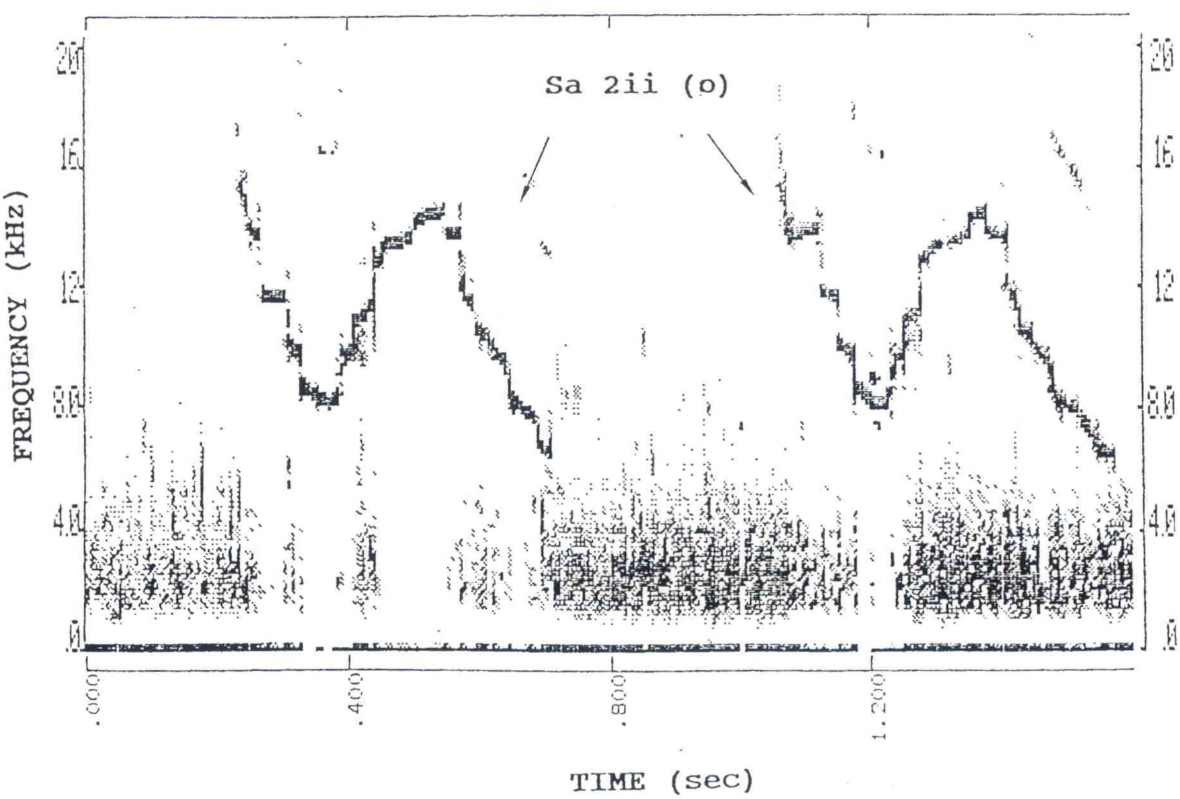
.000
.400
.800
1.200
TIME (sec)


Sa 2ii (o)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
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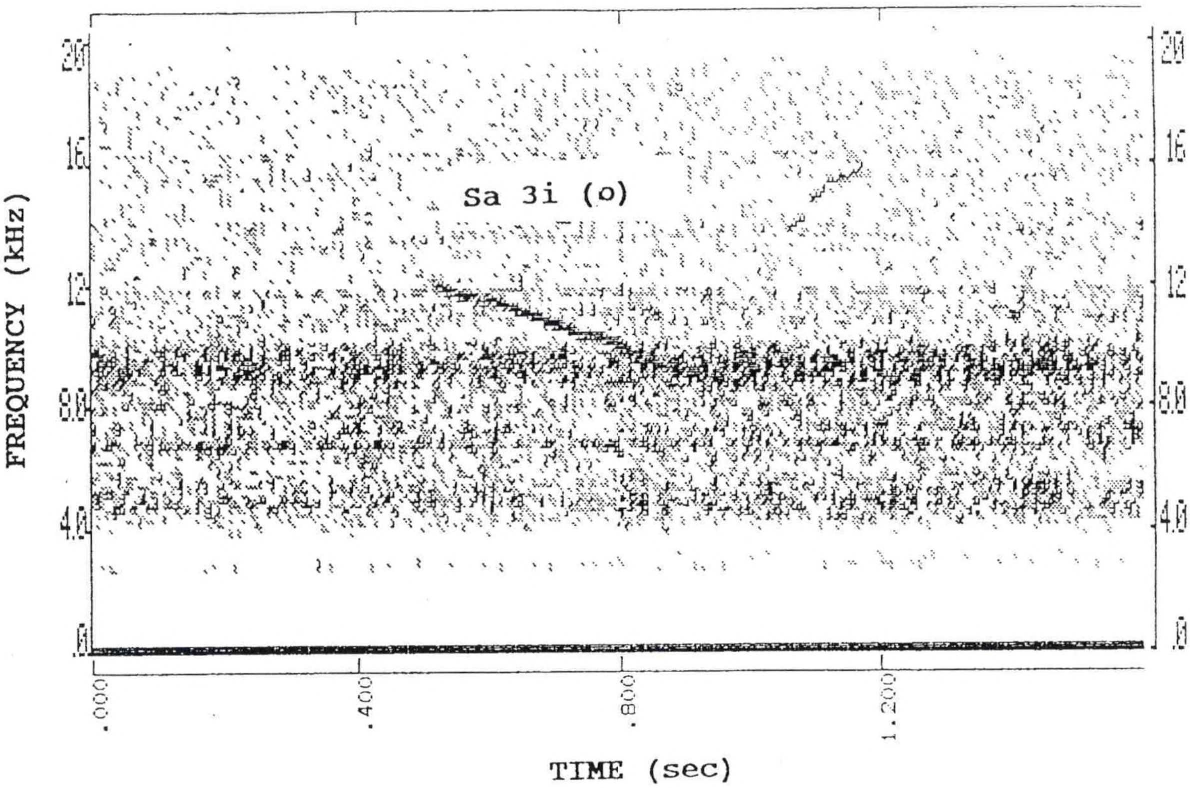
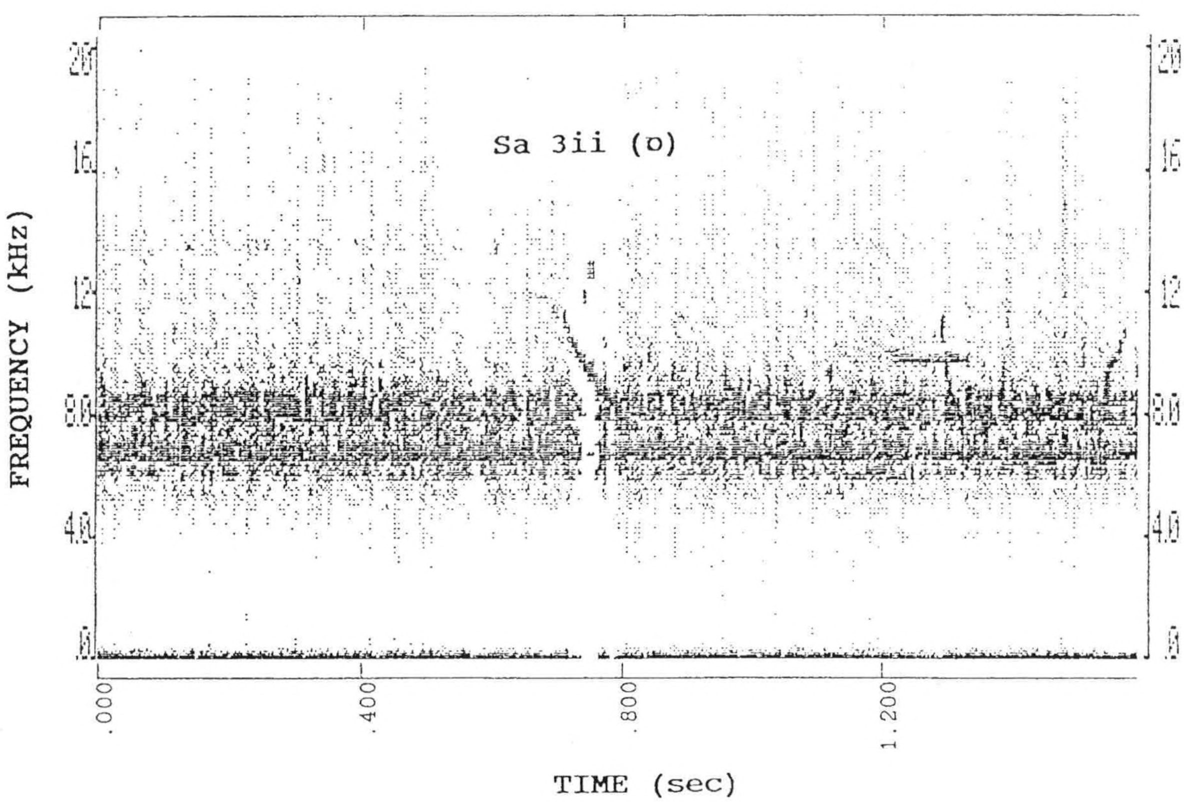
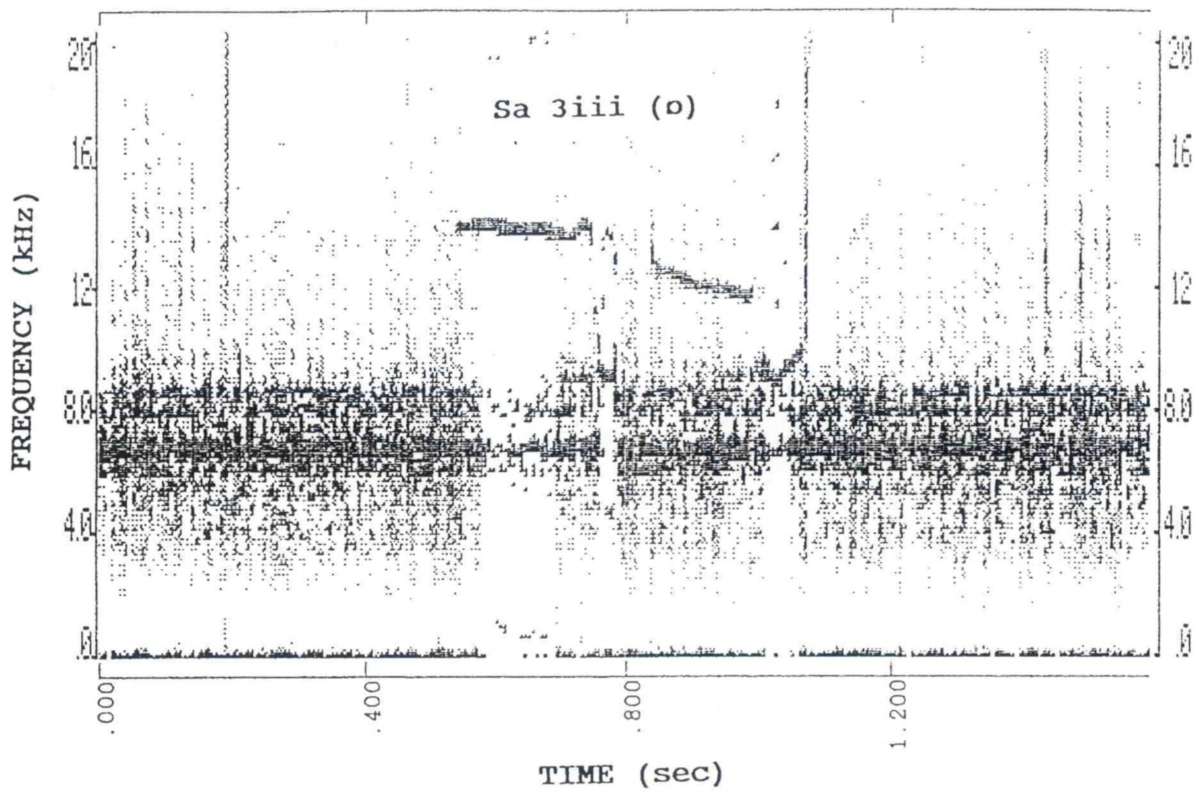
.400
.800
1.200
TIME (sec)

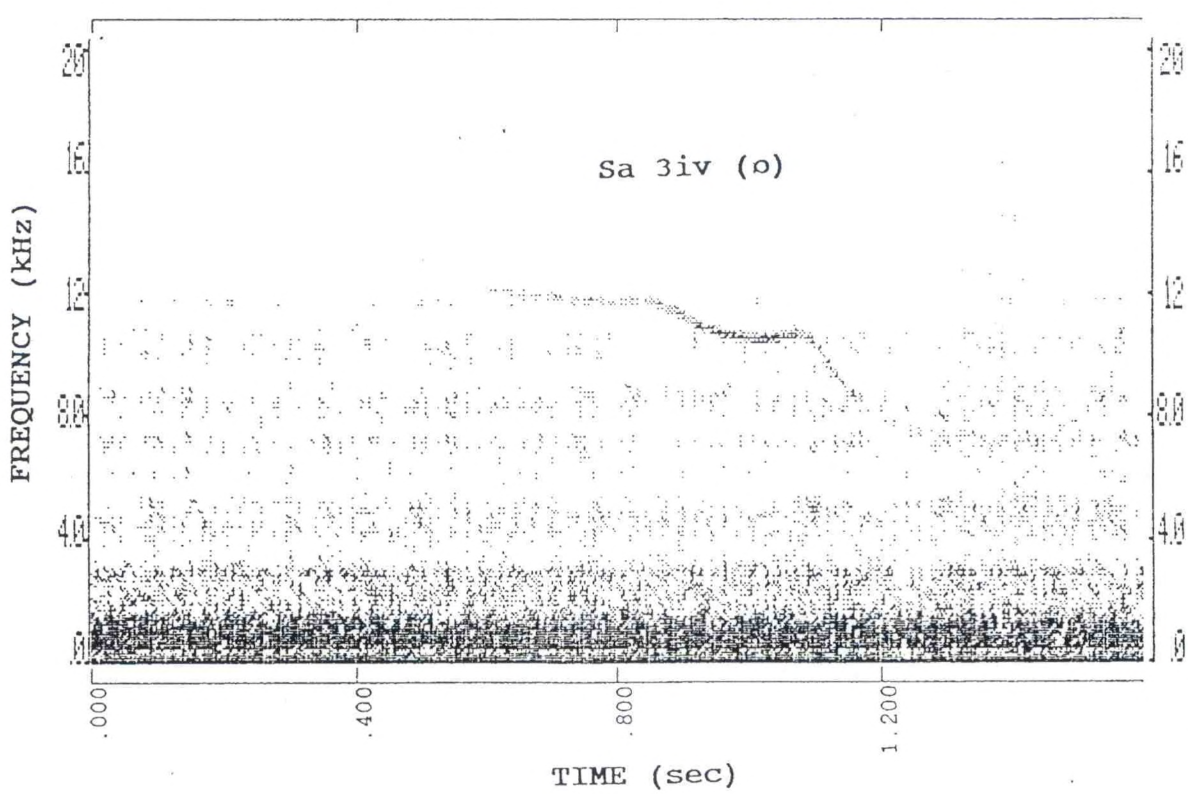


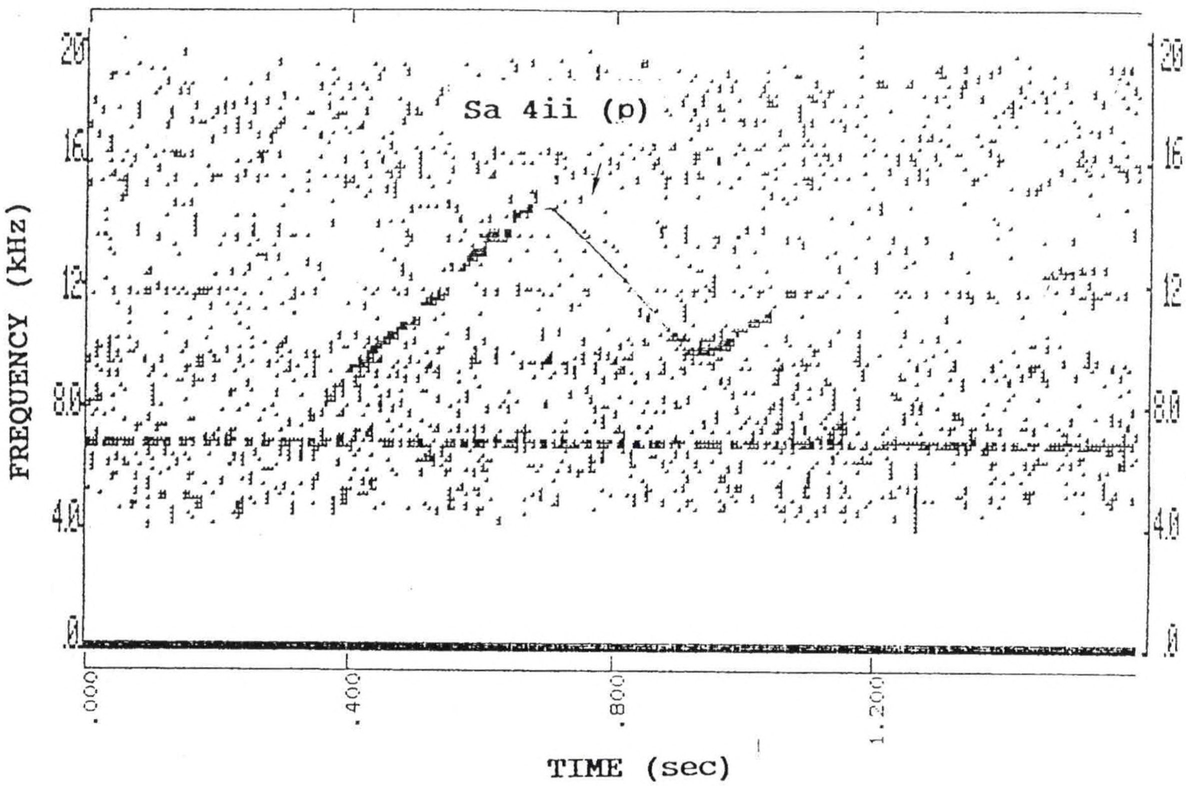
Sa 3i (o)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
TIME (sec)



Sa 3ii (o)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
TIME (sec)


Sa 3iii (o)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
TIME (sec)
.000
.400
.800
1.200


Sa 3iv (o)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
TIME (sec)
.000
.400
.800
1.200



Sa 4ii (p)
FREQUENCY (kHz)
TIME (sec)
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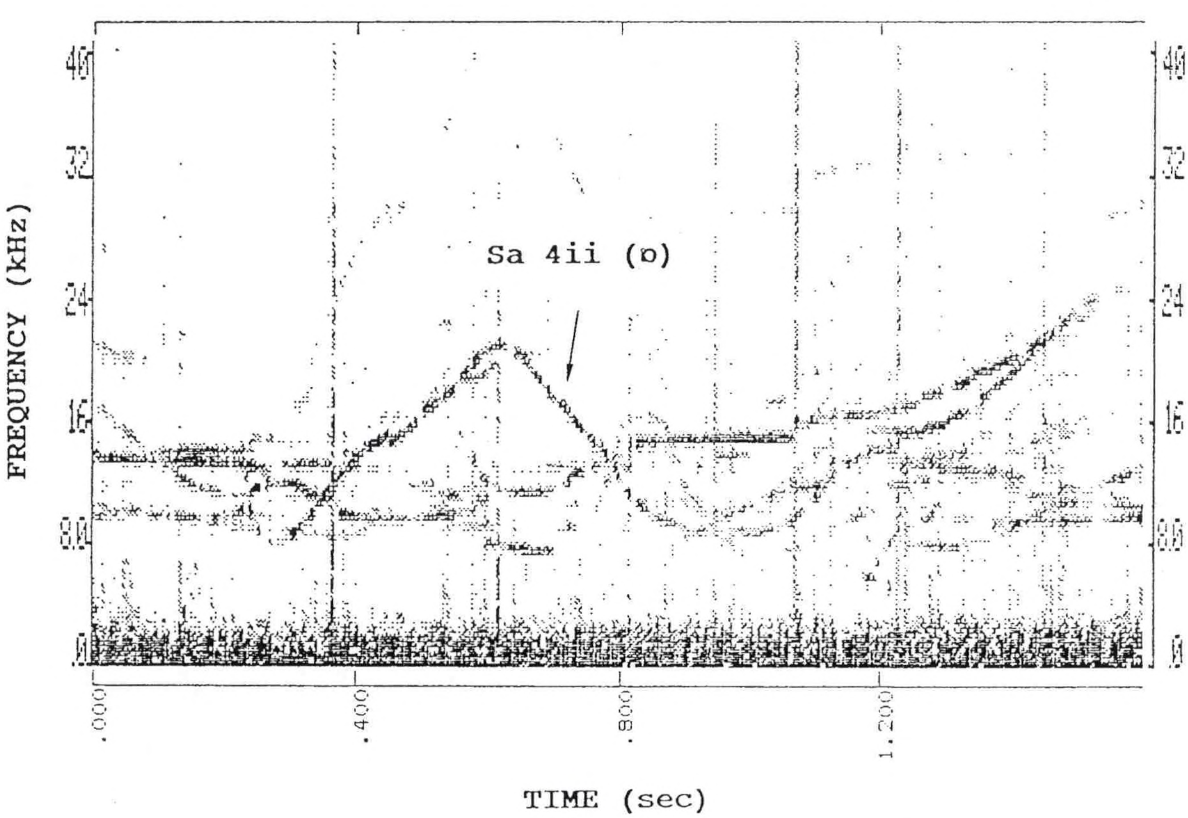
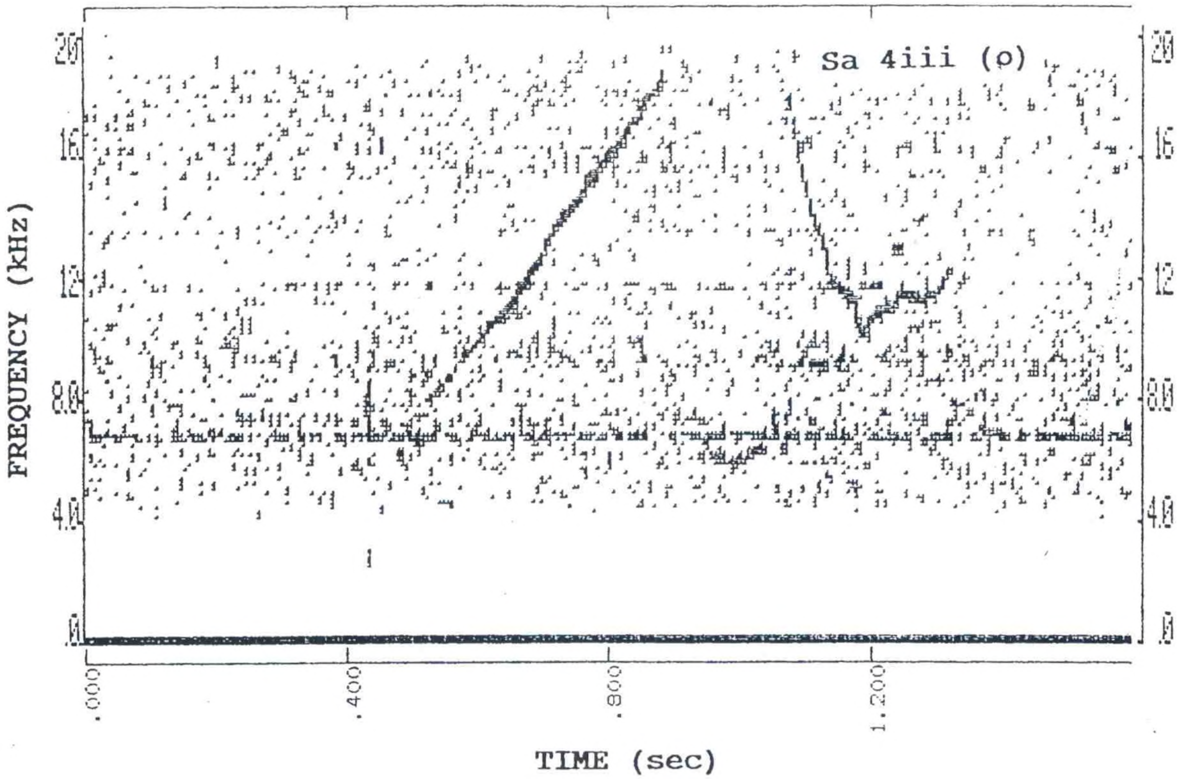
16
12
8.0
4.0
0
.000
.400
.800
1.200



Sa 4ii (p)
FREQUENCY (kHz)
TIME (sec)
40
32
24
16
8.0
0
.000
.400
.800
1.200


Sa 4iii (ρ)
FREQUENCY (kHz)
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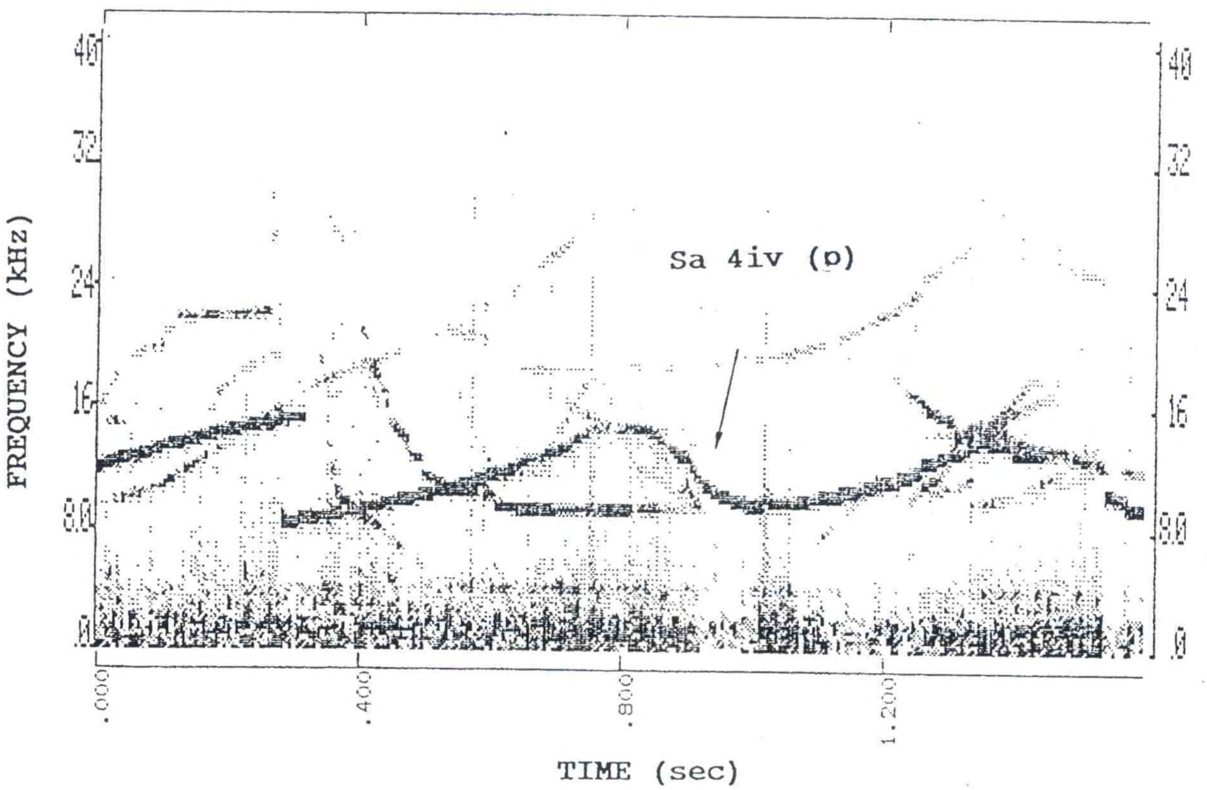
12
8.0
4.0
.0
.000
.400
.800
1.200
TIME (sec)


Sa 4iv (ρ)
FREQUENCY (kHz)
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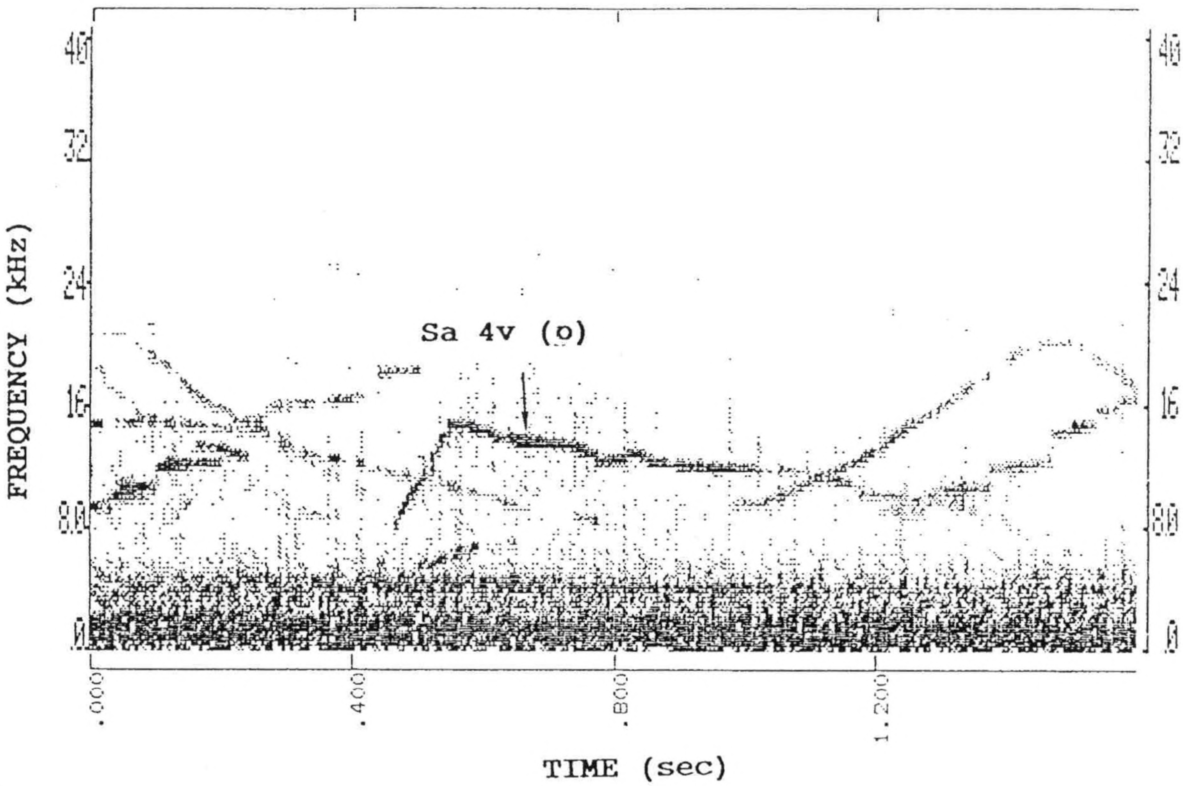
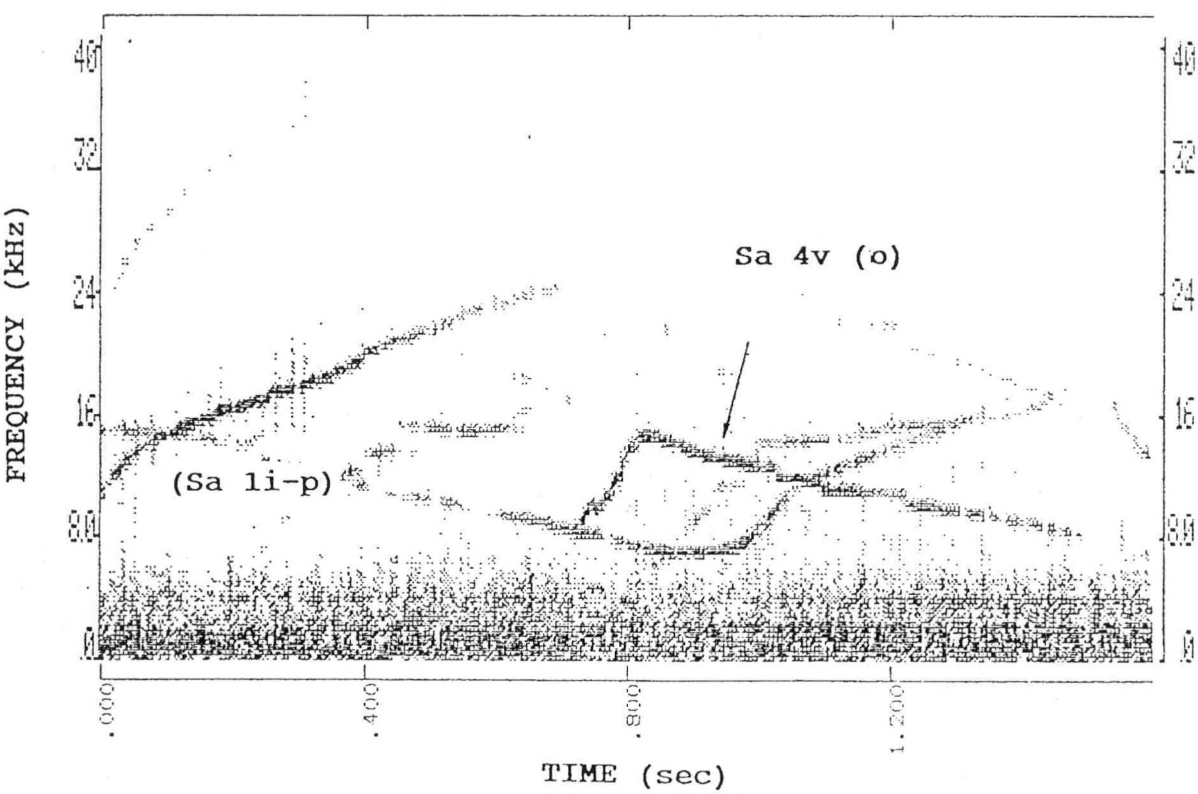
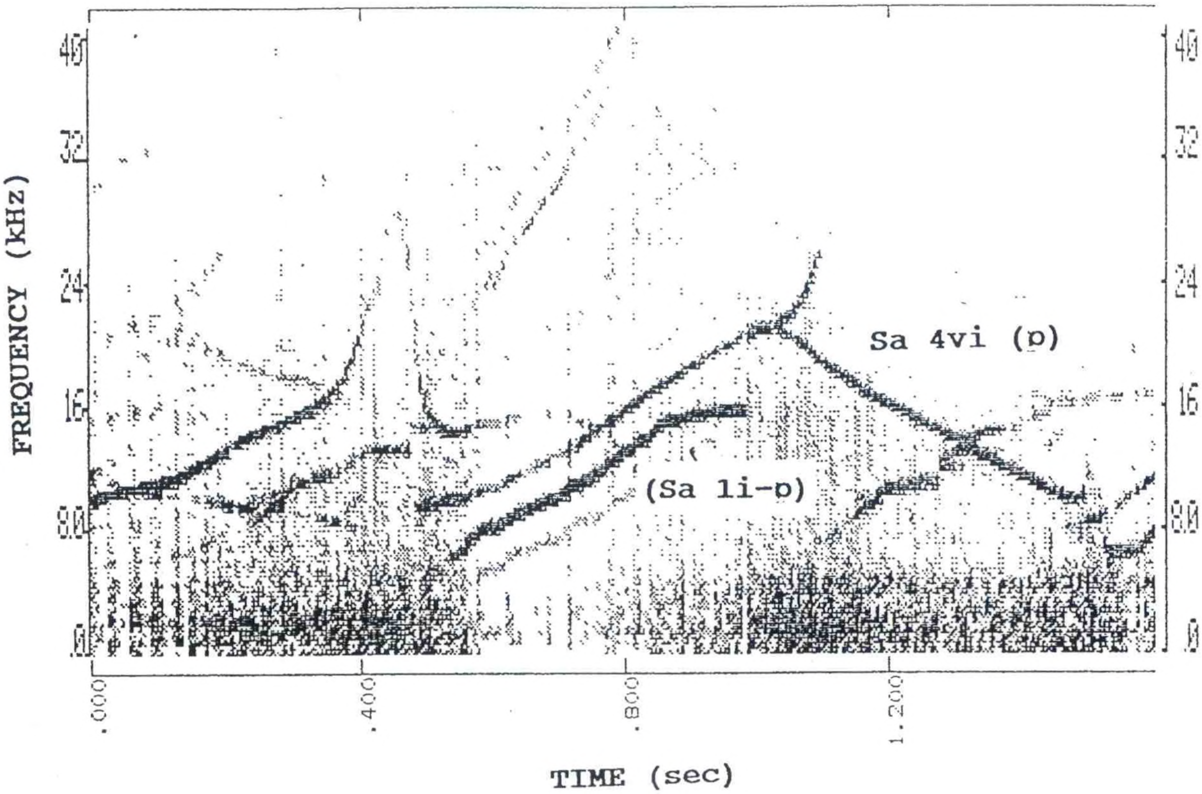
32
24
16
8.0
.0
.000
.400
.800
1.200
TIME (sec)

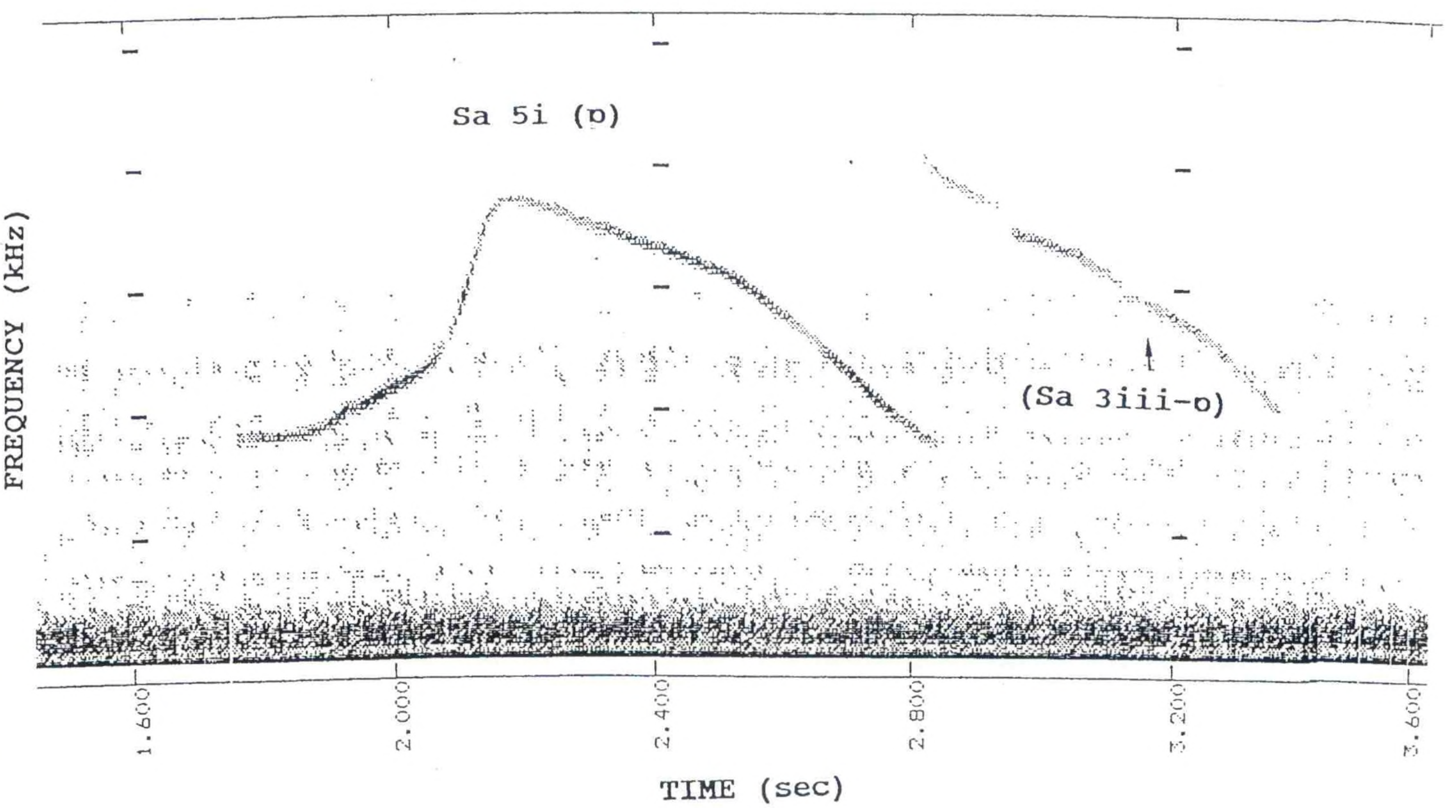


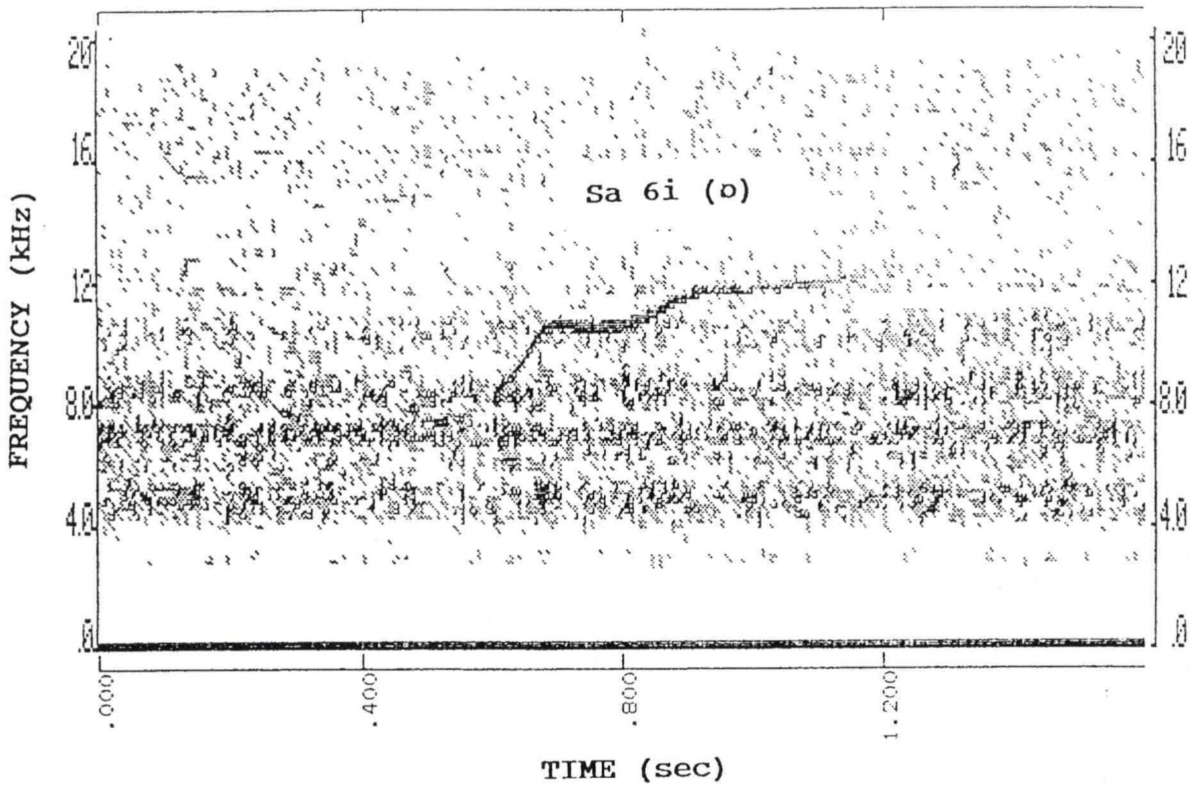
Sa 4v (o)
FREQUENCY (kHz)
TIME (sec)



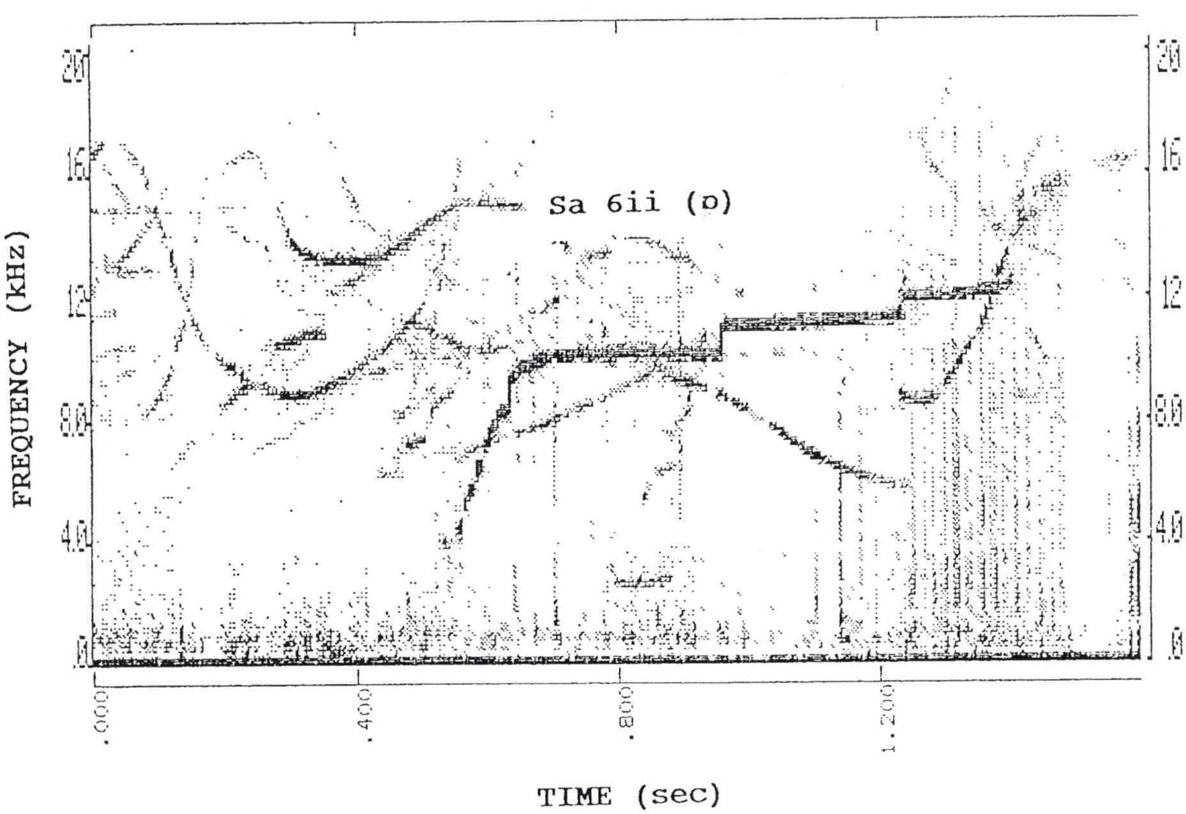
Sa 4v (o)
(Sa 1i-p)
FREQUENCY (kHz)
TIME (sec)


FREQUENCY (kHz)
40
32
24
16
8.0
.0
Sa 4vi (p)
(Sa 1i-p)
.000
.400
.800
1.200
TIME (sec)

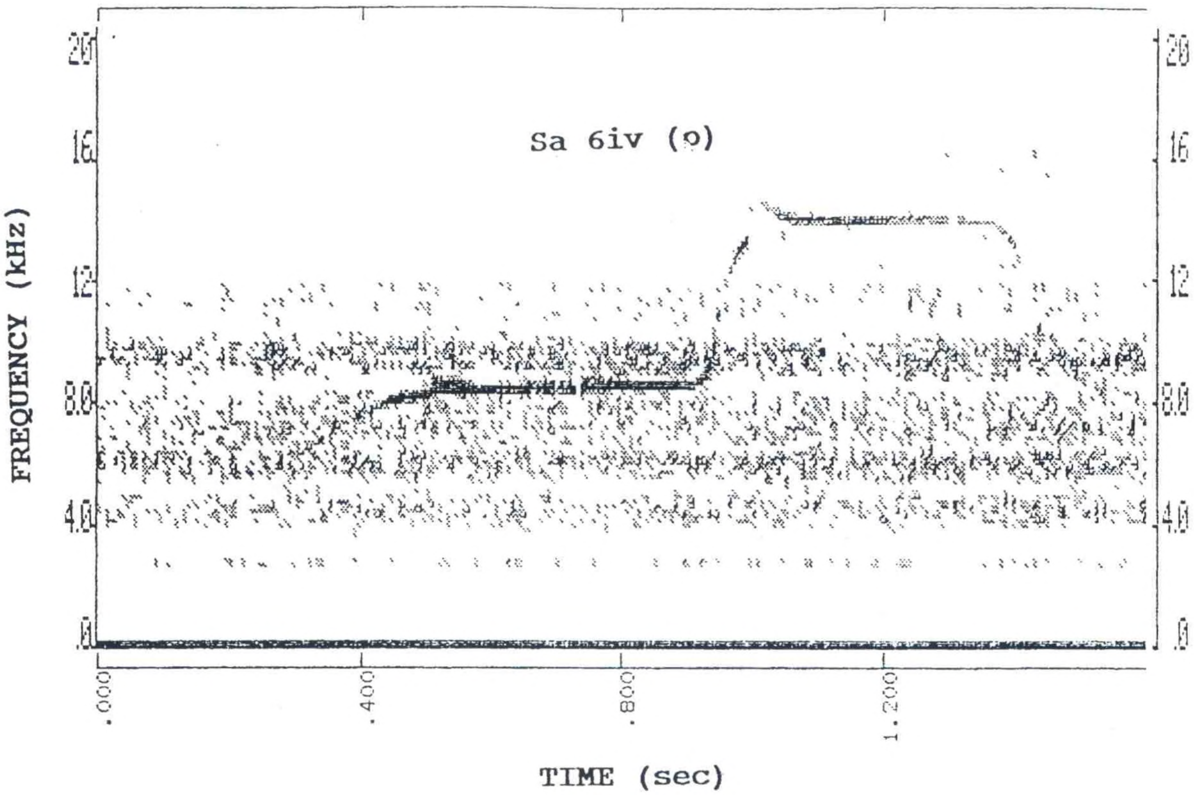

Sa 5i (p)
FREQUENCY (kHz)
(Sa 3iii-p)
1.600
2.000
2.400
2.800
3.200
3.600
TIME (sec)

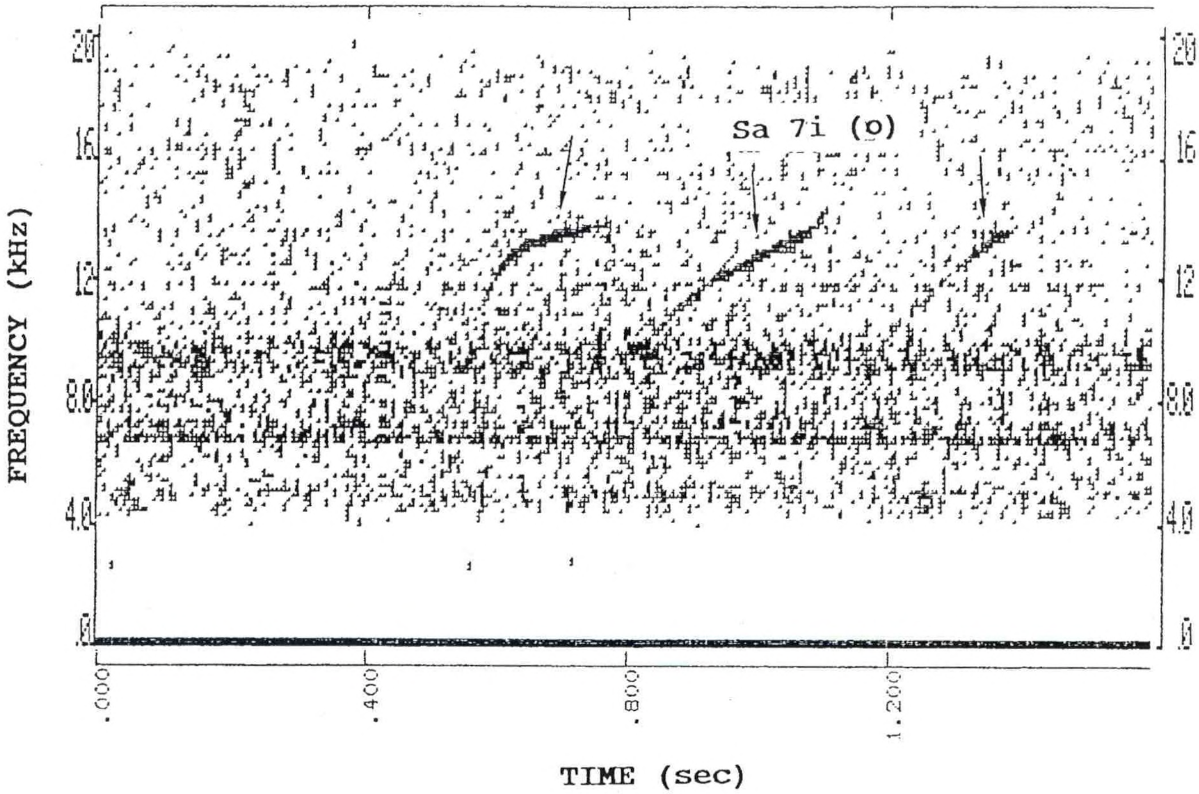


Sa 6i (ɒ)
FREQUENCY (kHz)
TIME (sec)



Sa 6ii (ɒ)
FREQUENCY (kHz)
TIME (sec)


Sa 6iv (♀)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
TIME (sec)



FREQUENCY (kHz)
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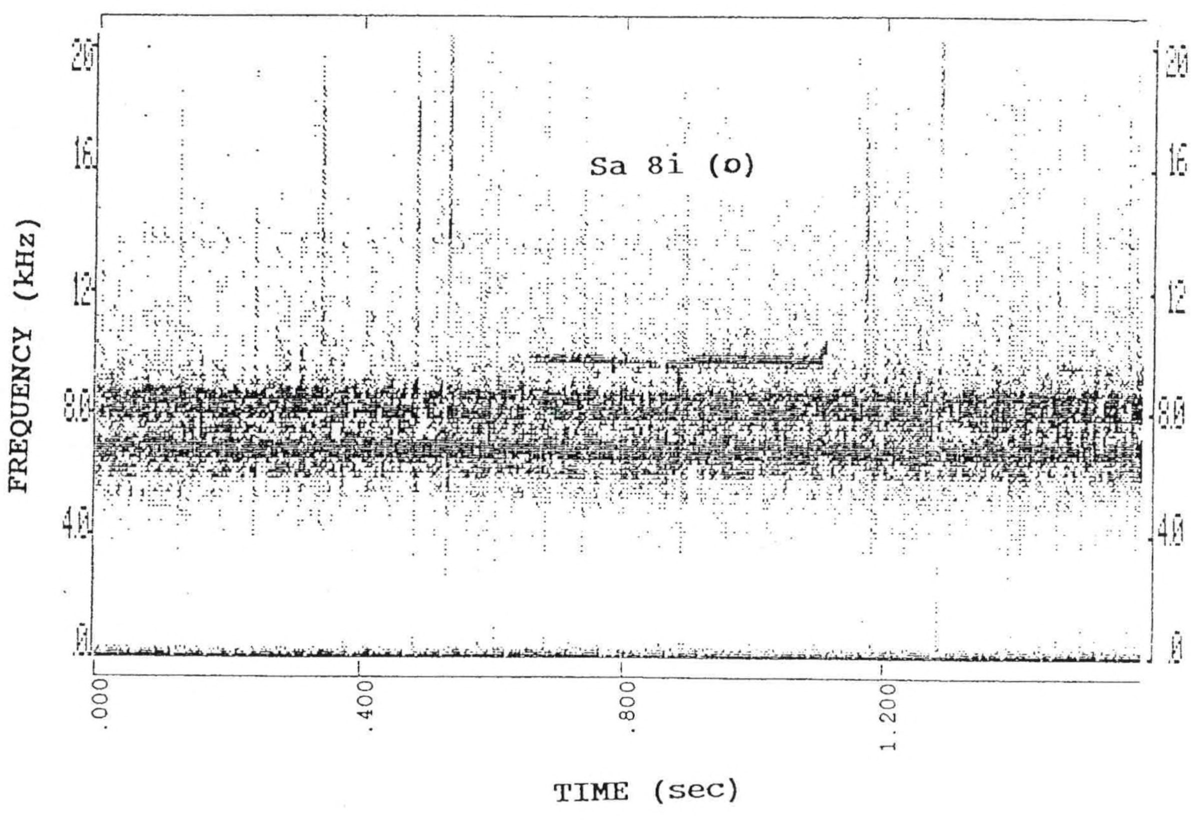
16
12
8.0
4.0
.0
Sa 7i (o)
.000
.400
.800
1.200
TIME (sec)



FREQUENCY (kHz)
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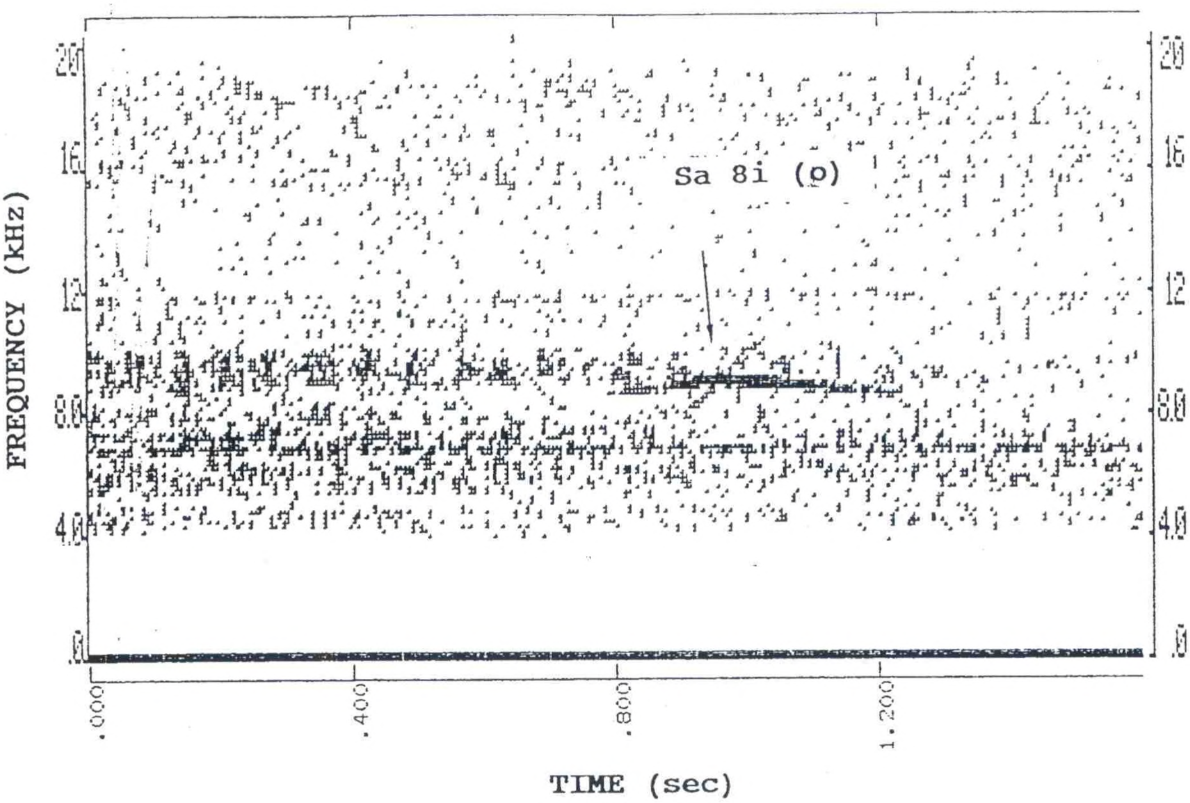
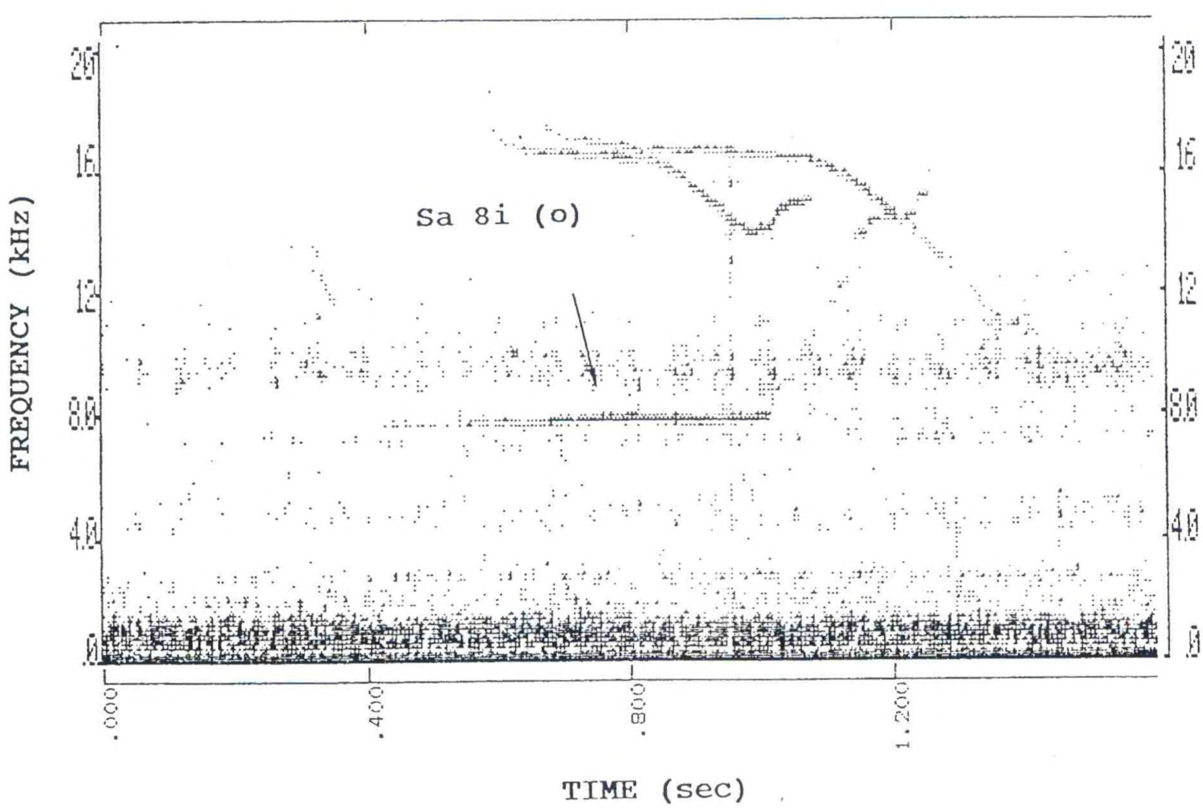
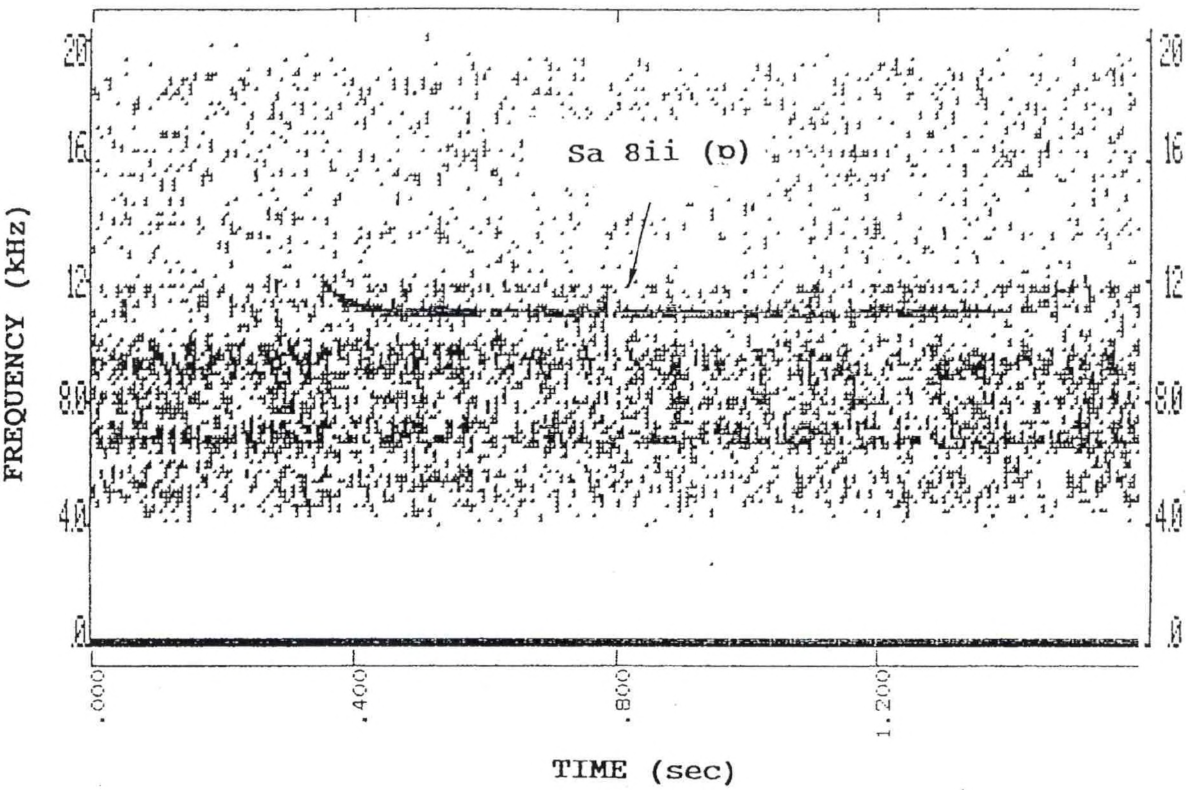
16
12
8.0
4.0
.0
Sa 8i (o)
.000
.400
.800
1.200
TIME (sec)



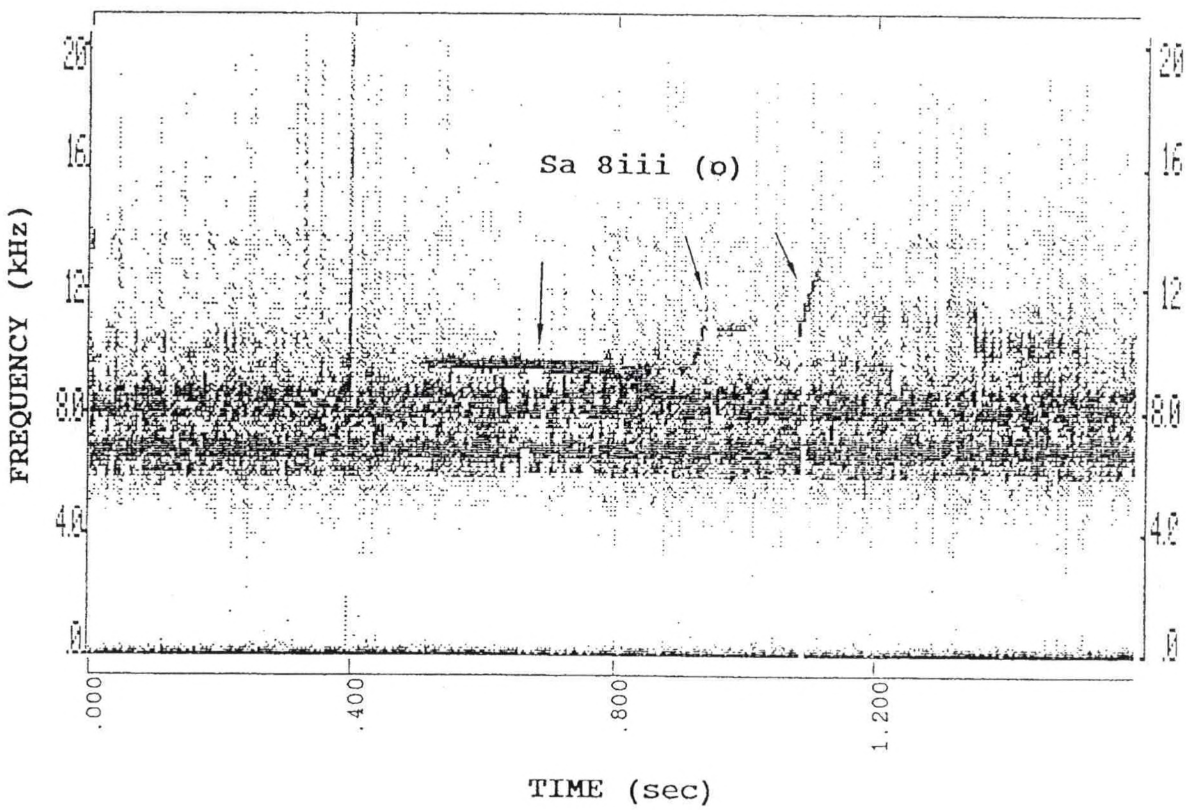
Sa 8i (o)
FREQUENCY (kHz)
TIME (sec)



Sa 8i (o)
FREQUENCY (kHz)
TIME (sec)



FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
Sa 8ii (o)
.000
.400
.800
1.200
TIME (sec)



FREQUENCY (kHz)
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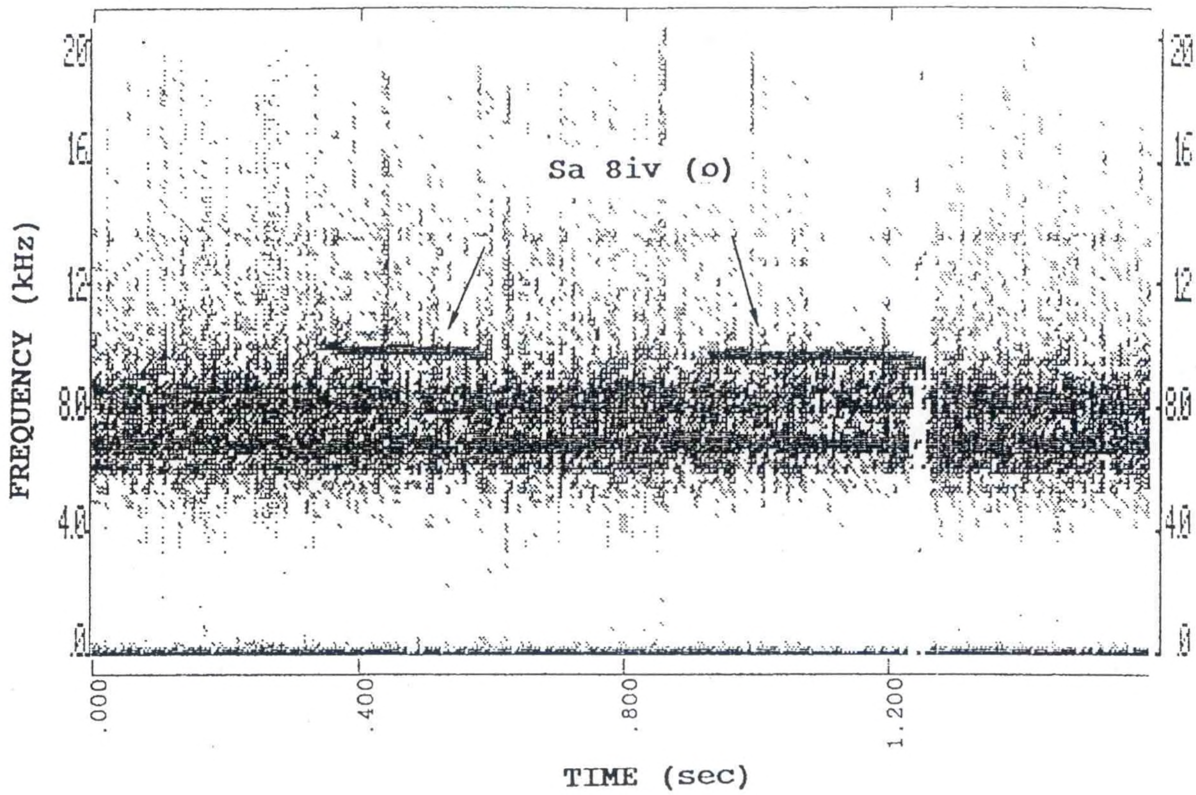
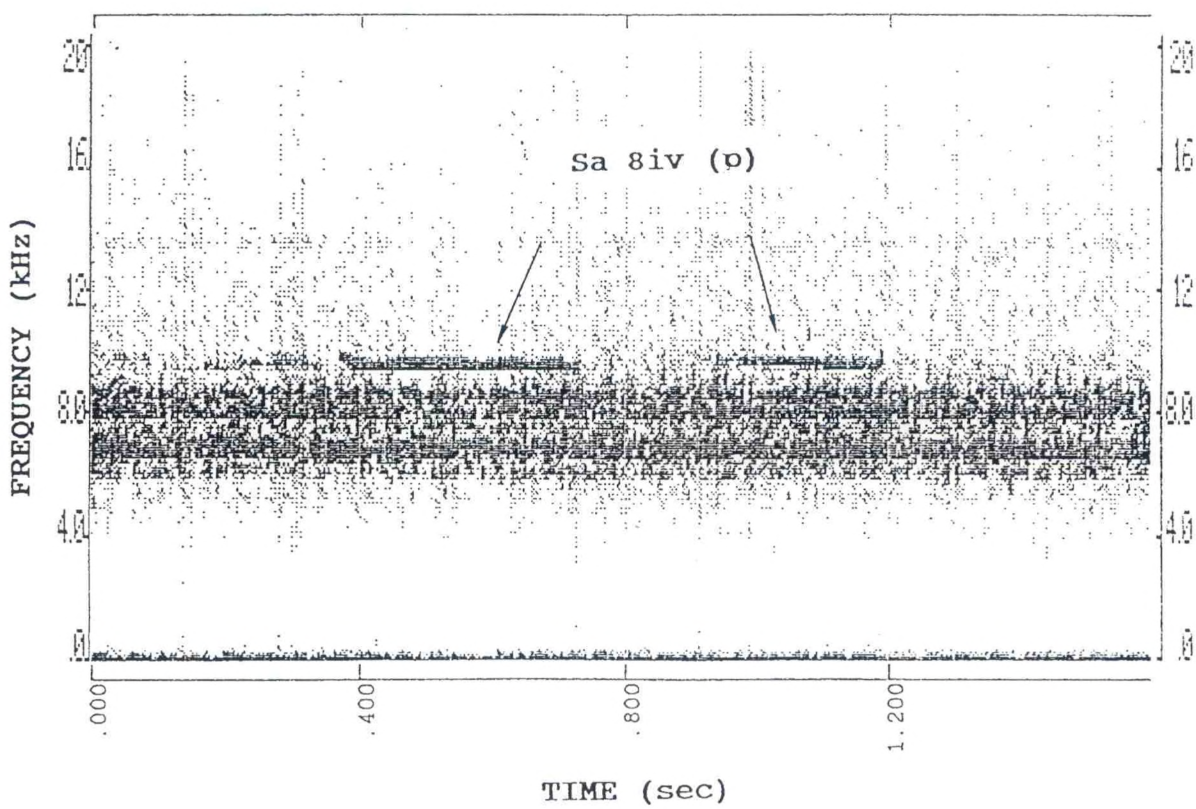
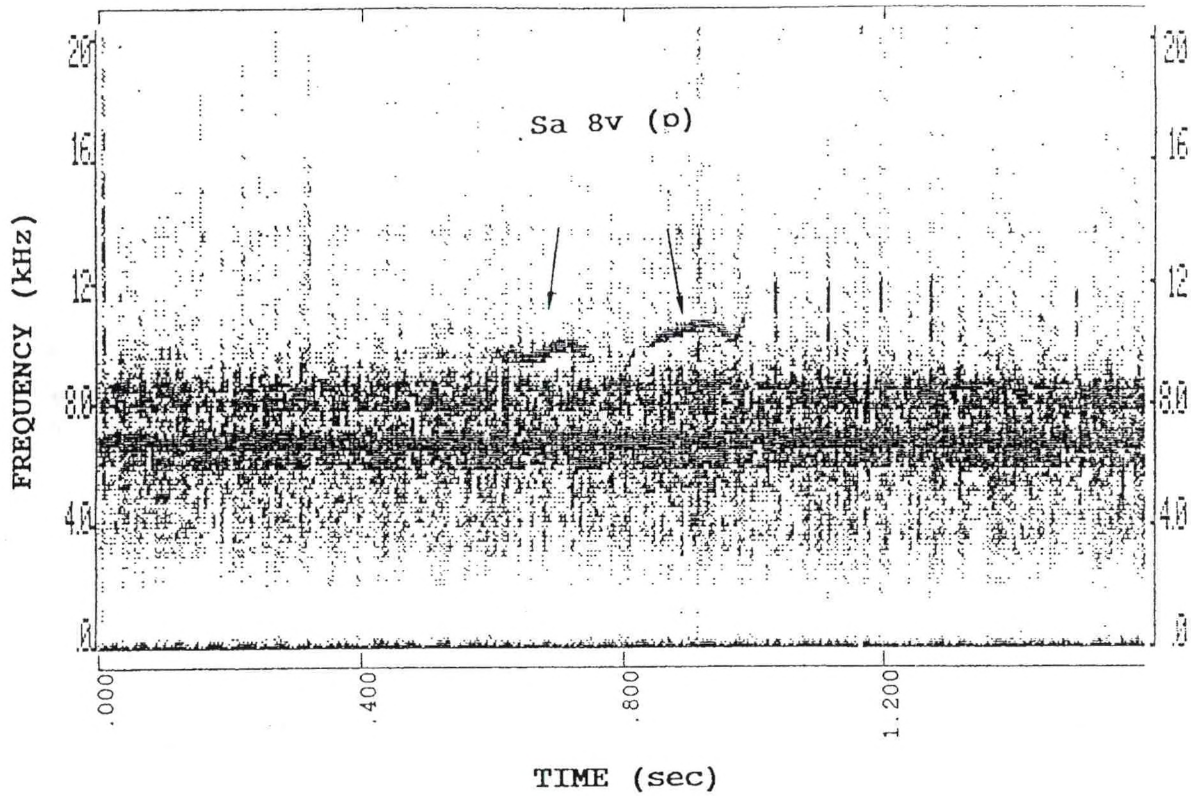
16
12
8.0
4.0
.0
Sa 8iii (o)
.000
.400
.800
1.200
TIME (sec)


Sa 8iv (o)
FREQUENCY (kHz)
TIME (sec)
.000
.400
.800
1.200


Sa 8iv (p)
FREQUENCY (kHz)
TIME (sec)
.000
.400
.800
1.200


Sa 8v (p)
FREQUENCY (kHz)
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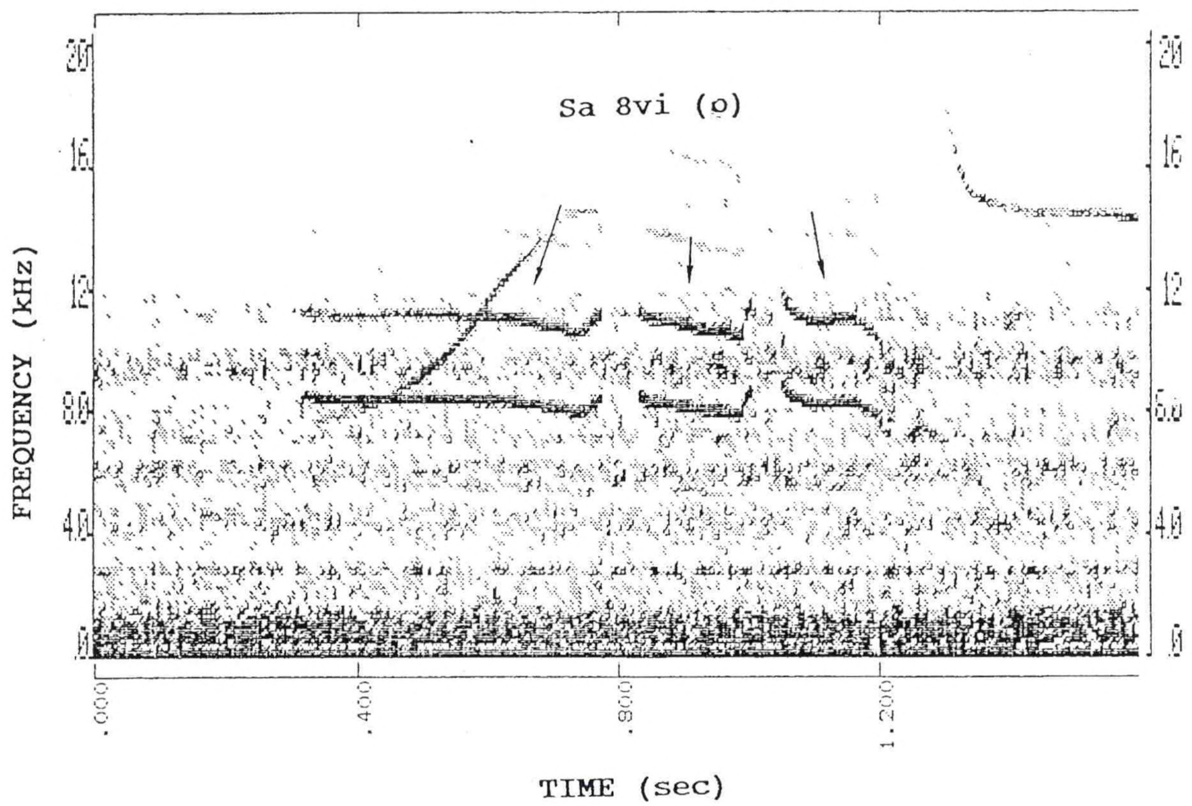
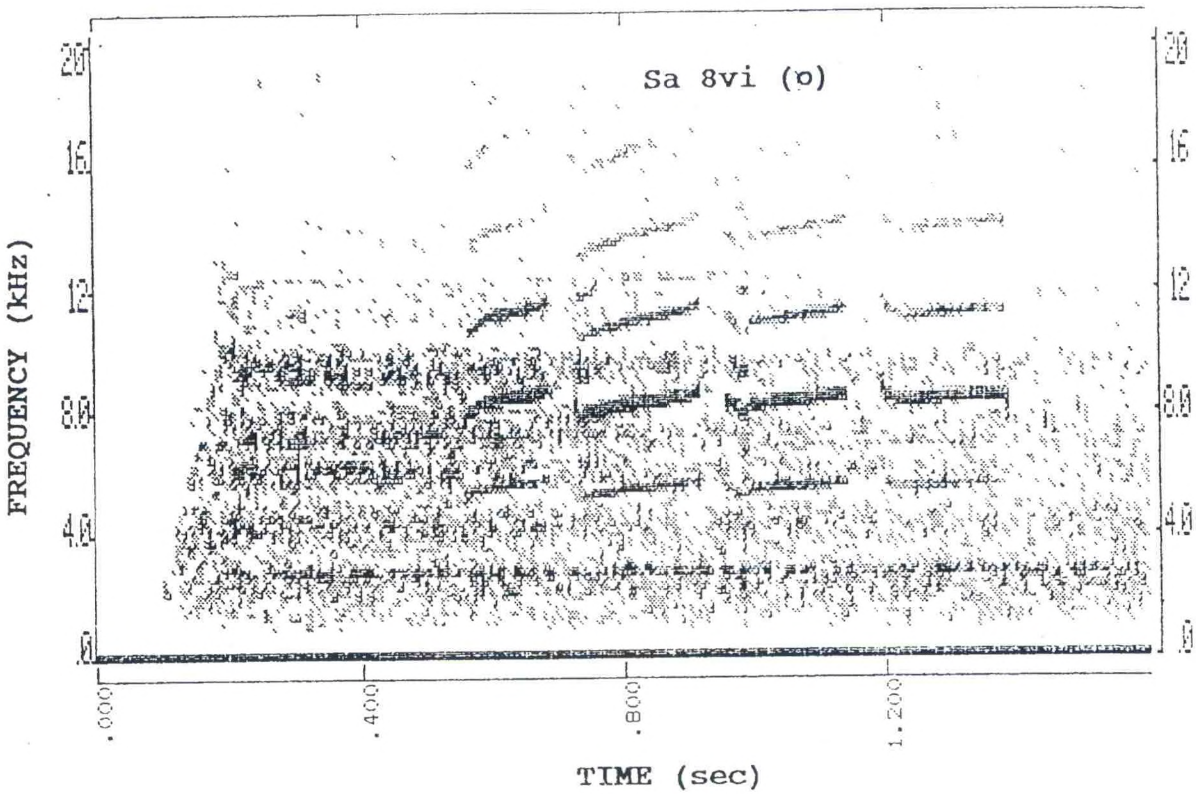
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)


Sa 8vi (p)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)


Sa 8vi (o)
FREQUENCY (kHz)
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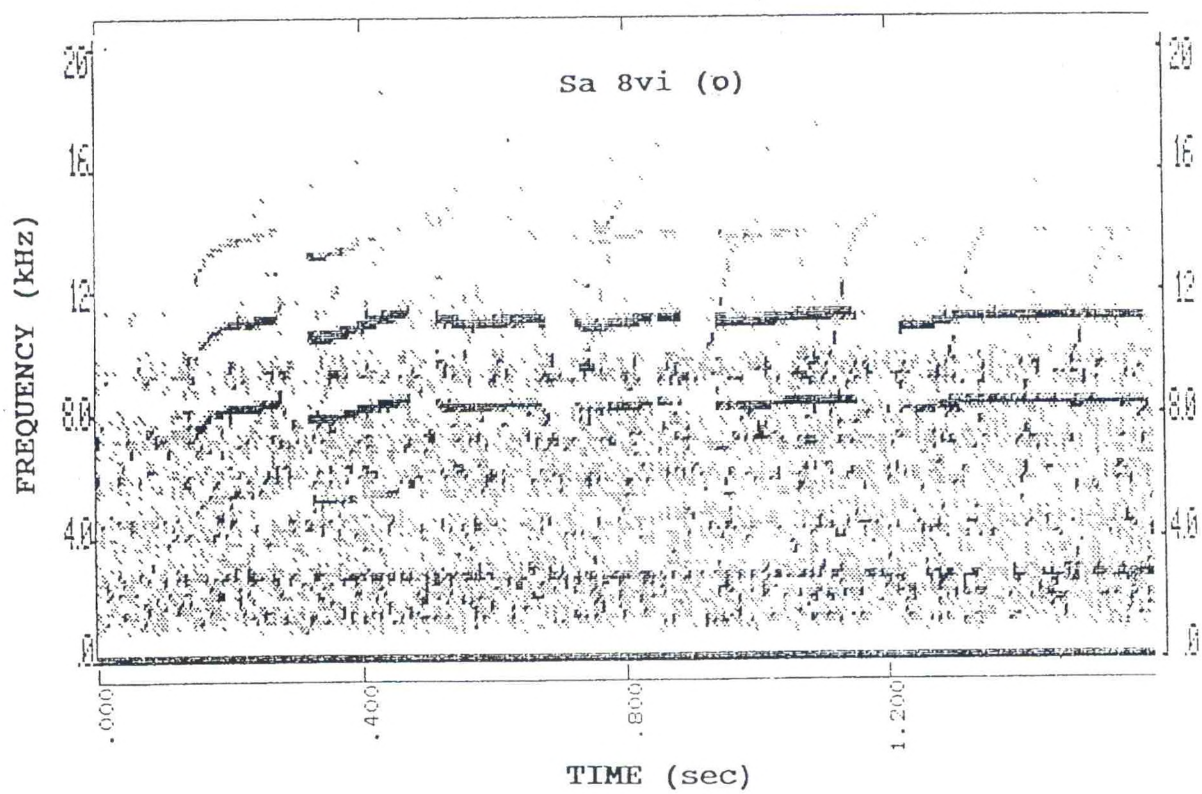
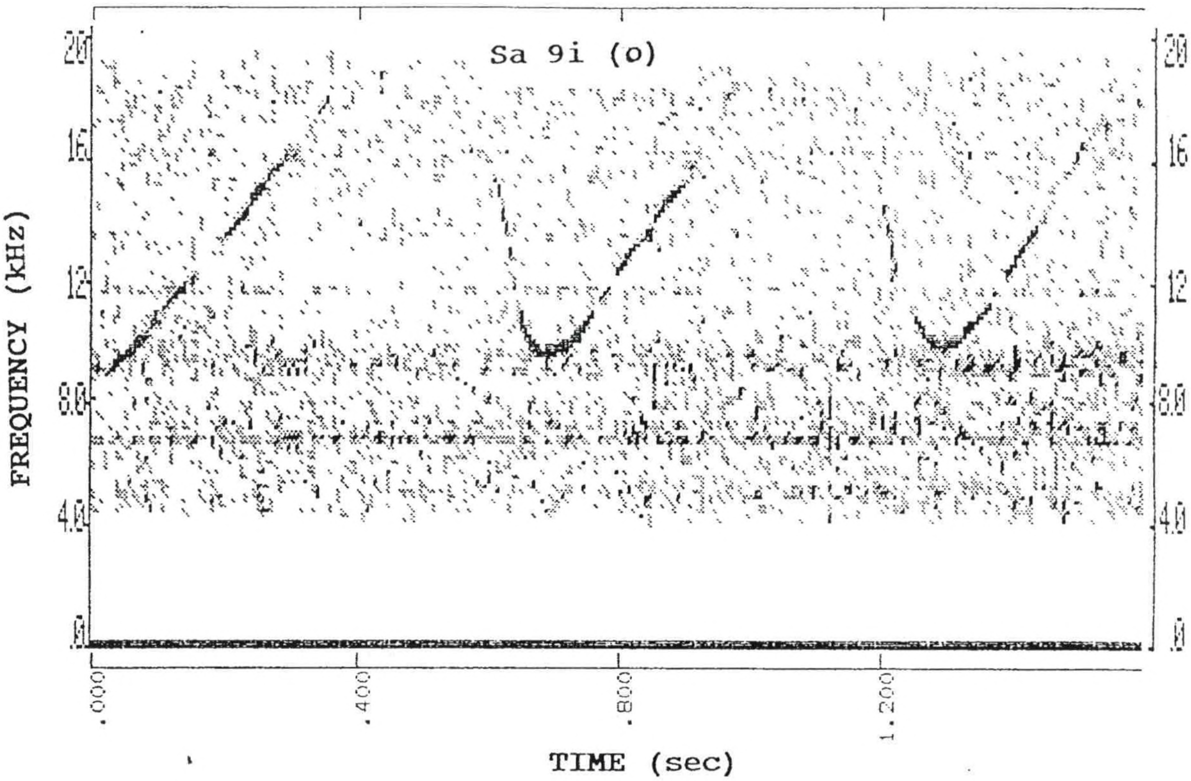
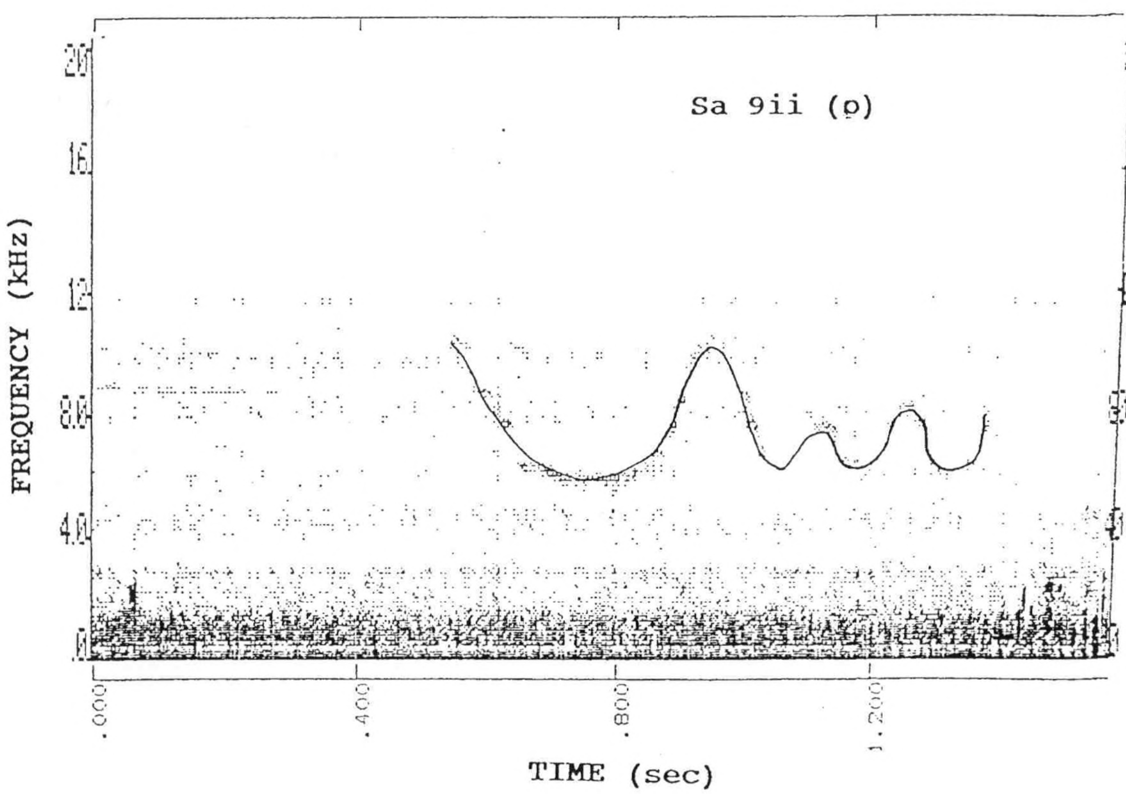
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)

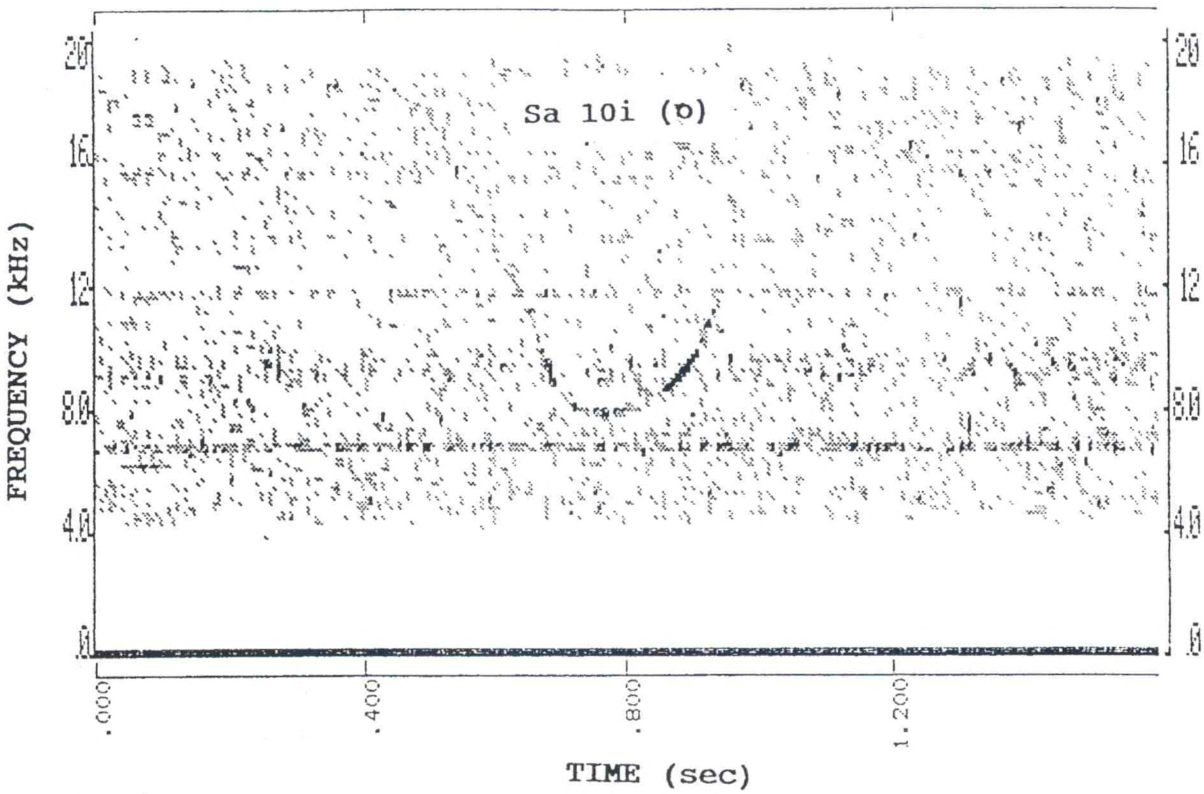

Sa 8vi (o)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)

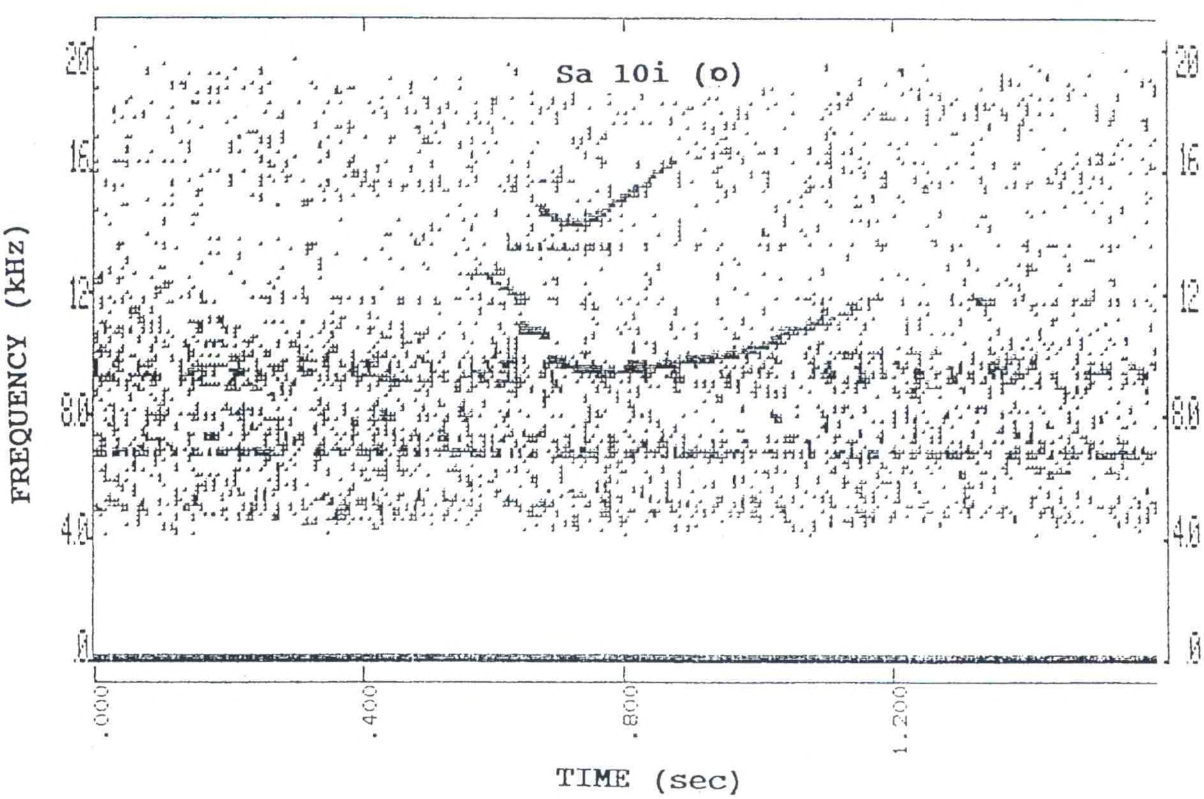


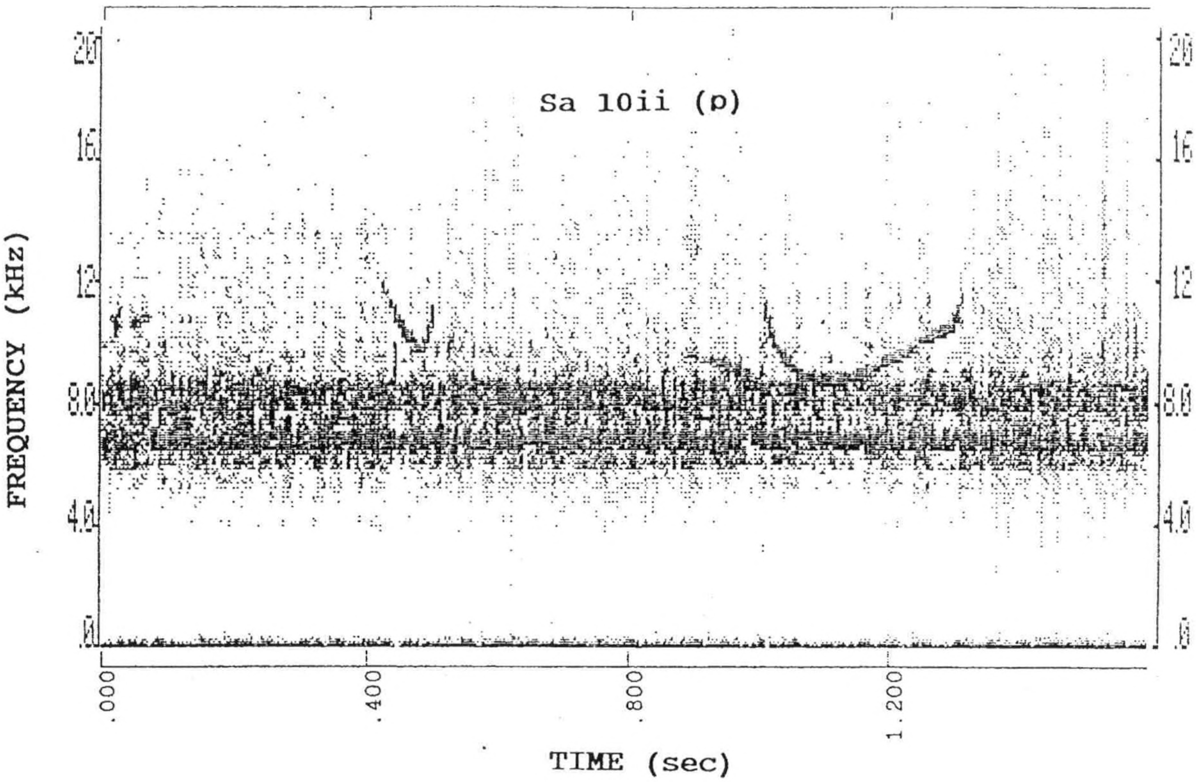
Sa 9i (ρ)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
TIME (sec)

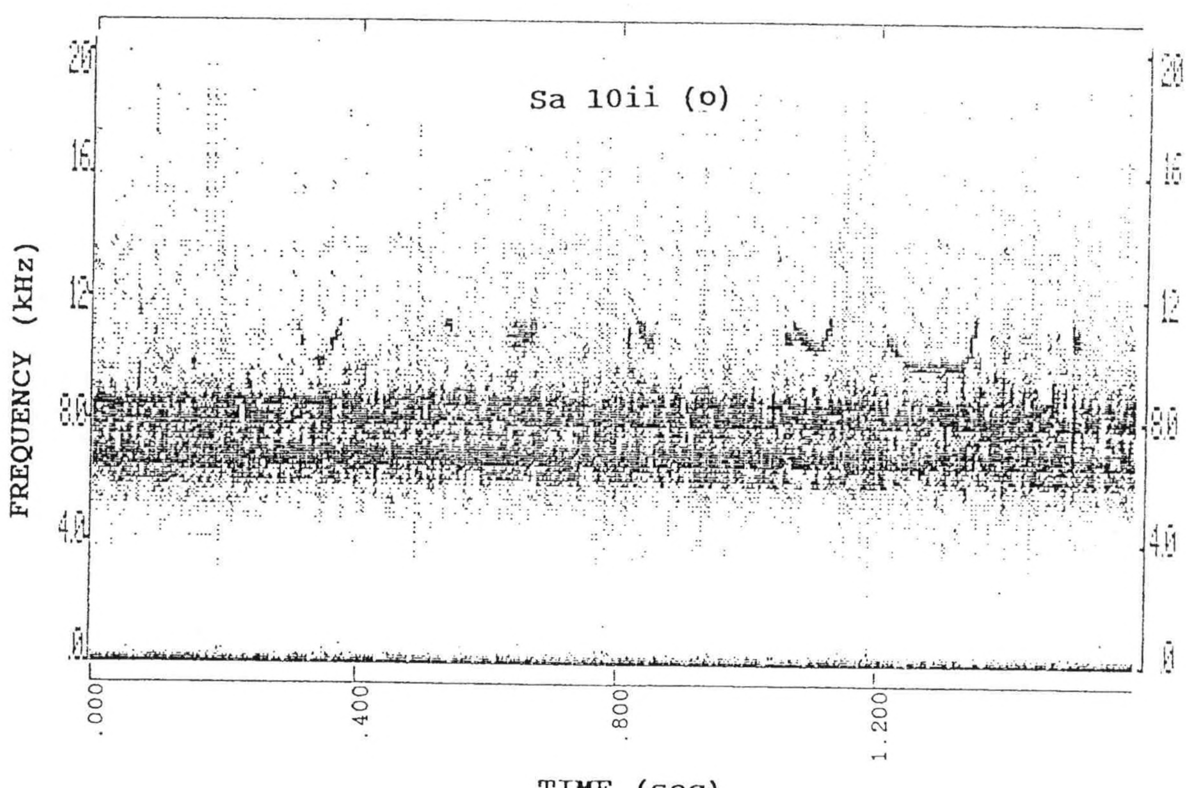


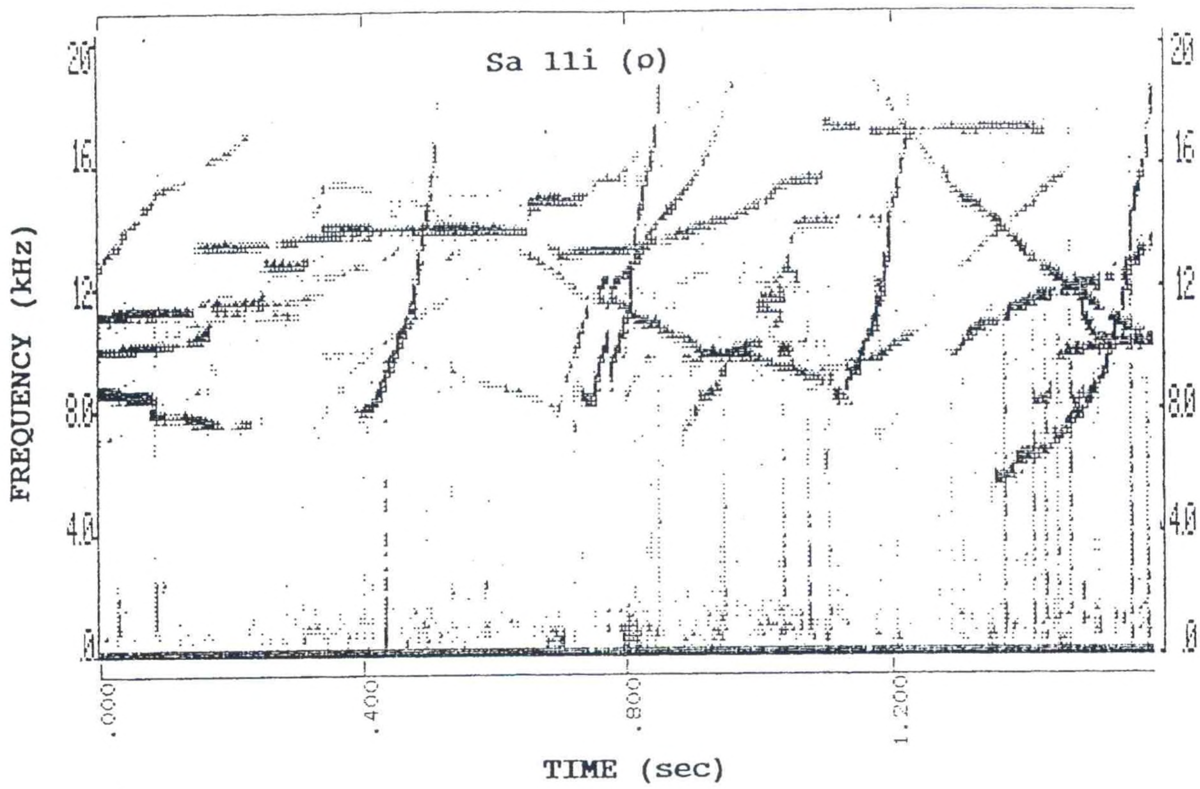
Sa 9ii (ρ)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
TIME (sec)

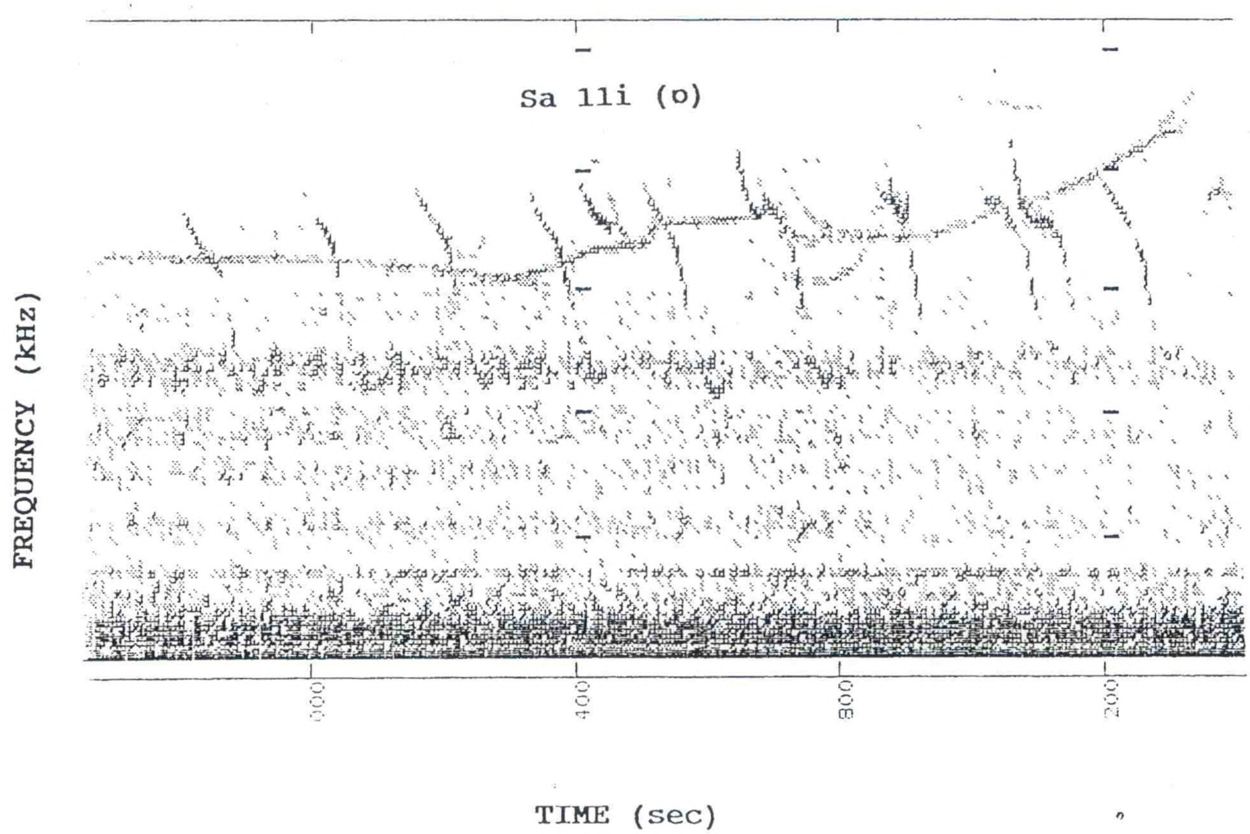

Sa 10i (o)
FREQUENCY (kHz)
TIME (sec)

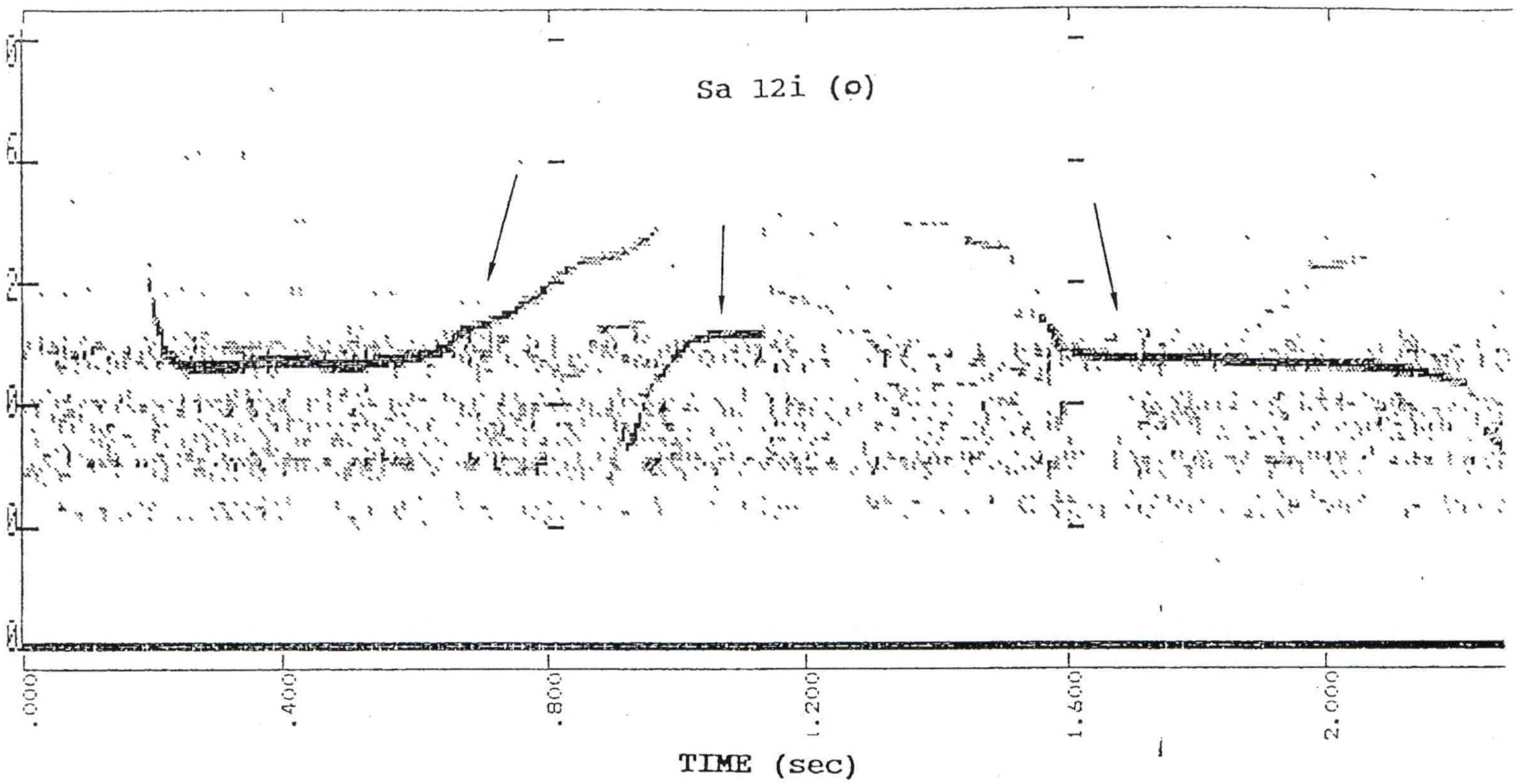

Sa 10i (o)
FREQUENCY (kHz)
TIME (sec)

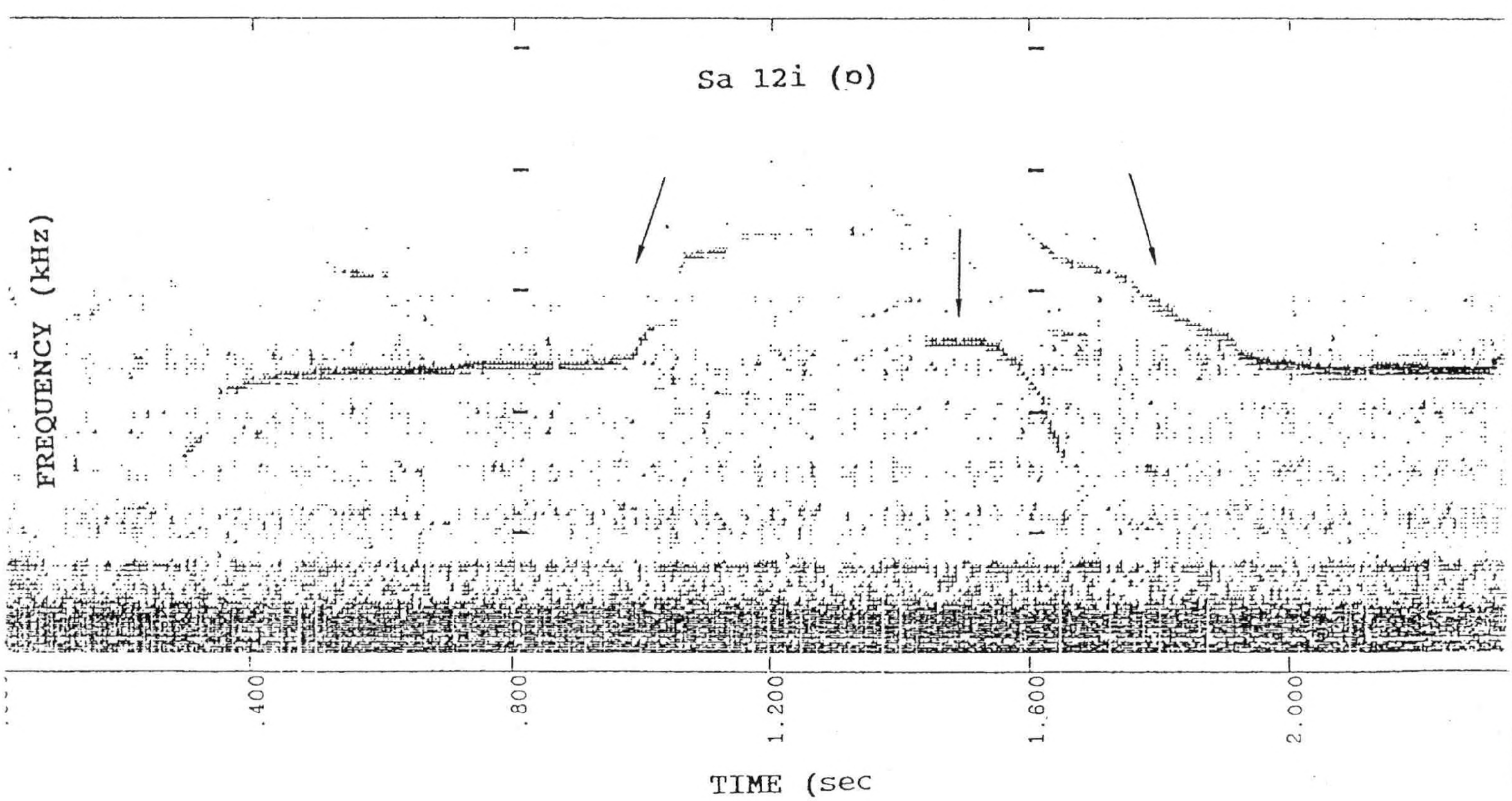

Sa 10ii (p)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
TIME (sec)

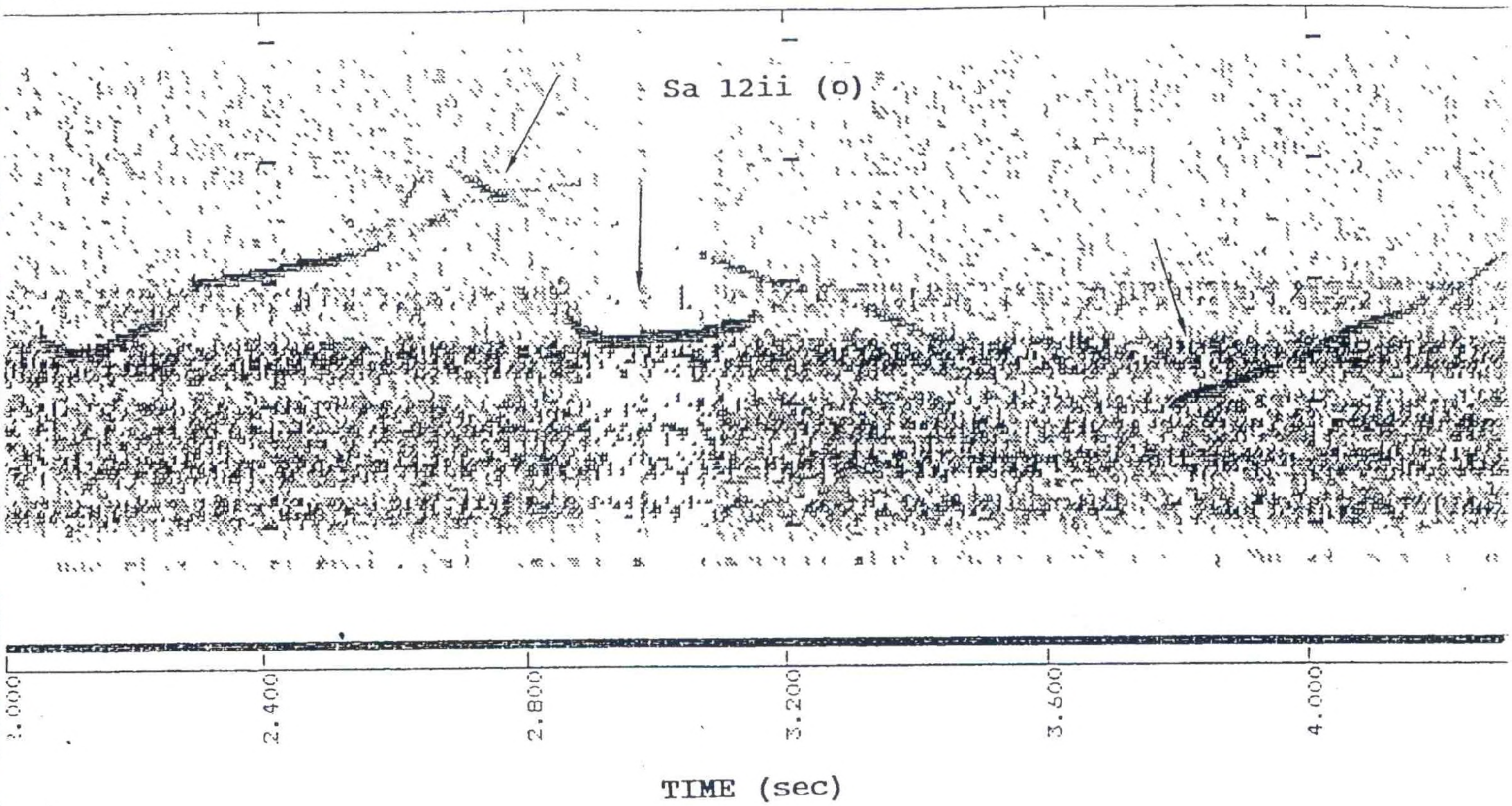

Sa 10ii (o)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
TIME (sec)

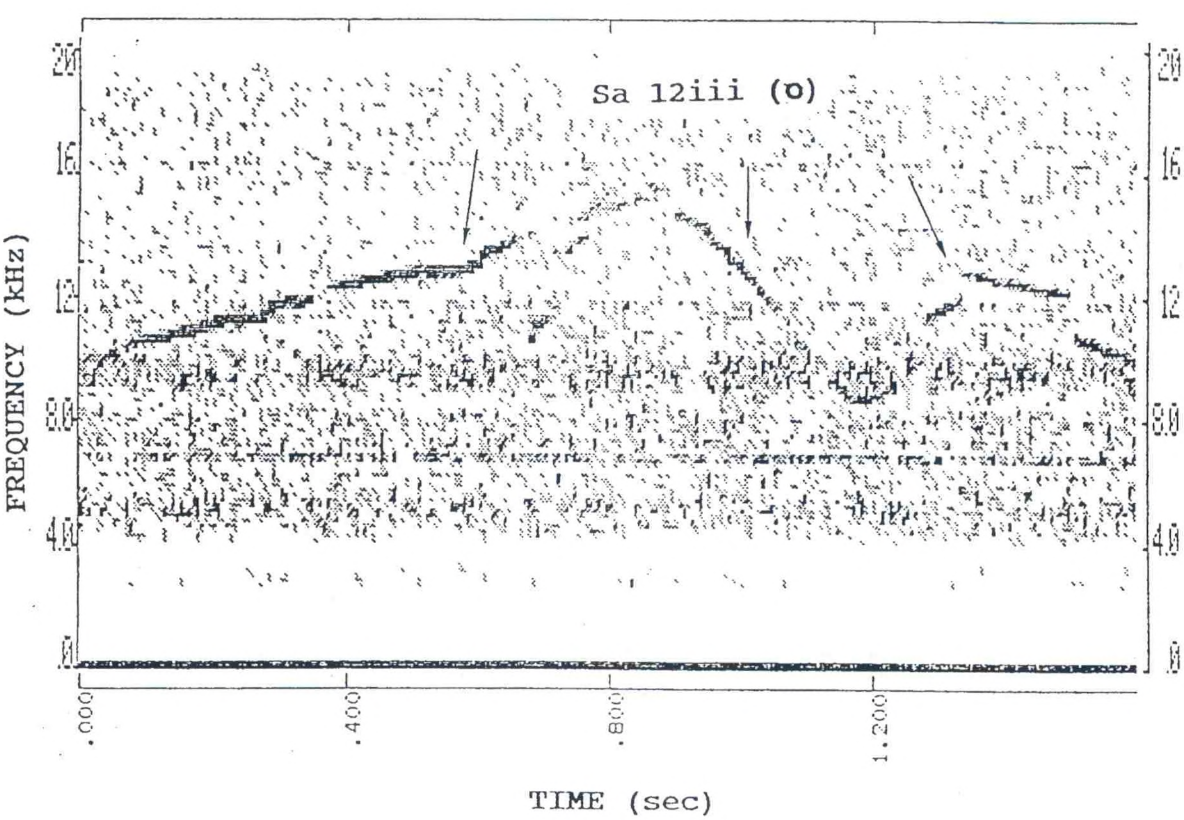

Sa 11i (ρ)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
TIME (sec)

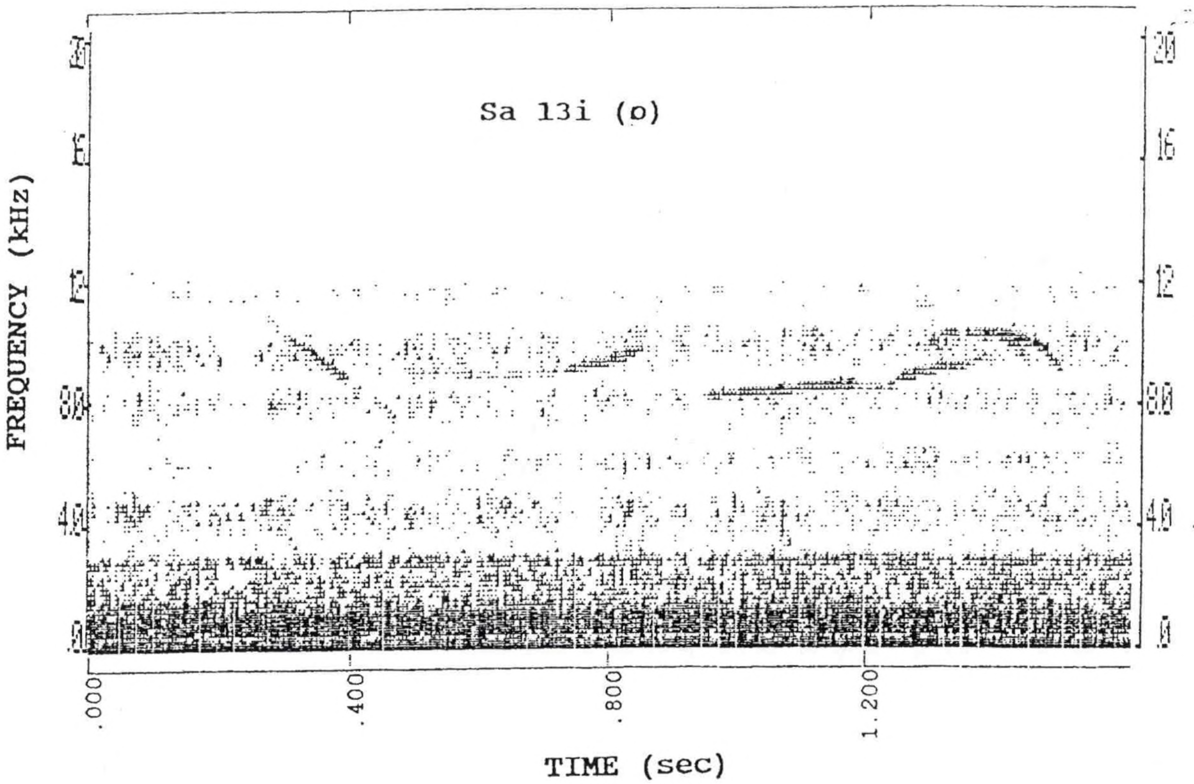

Sa 11i (ρ)
FREQUENCY (kHz)
.000
.400
.800
1.200
TIME (sec)

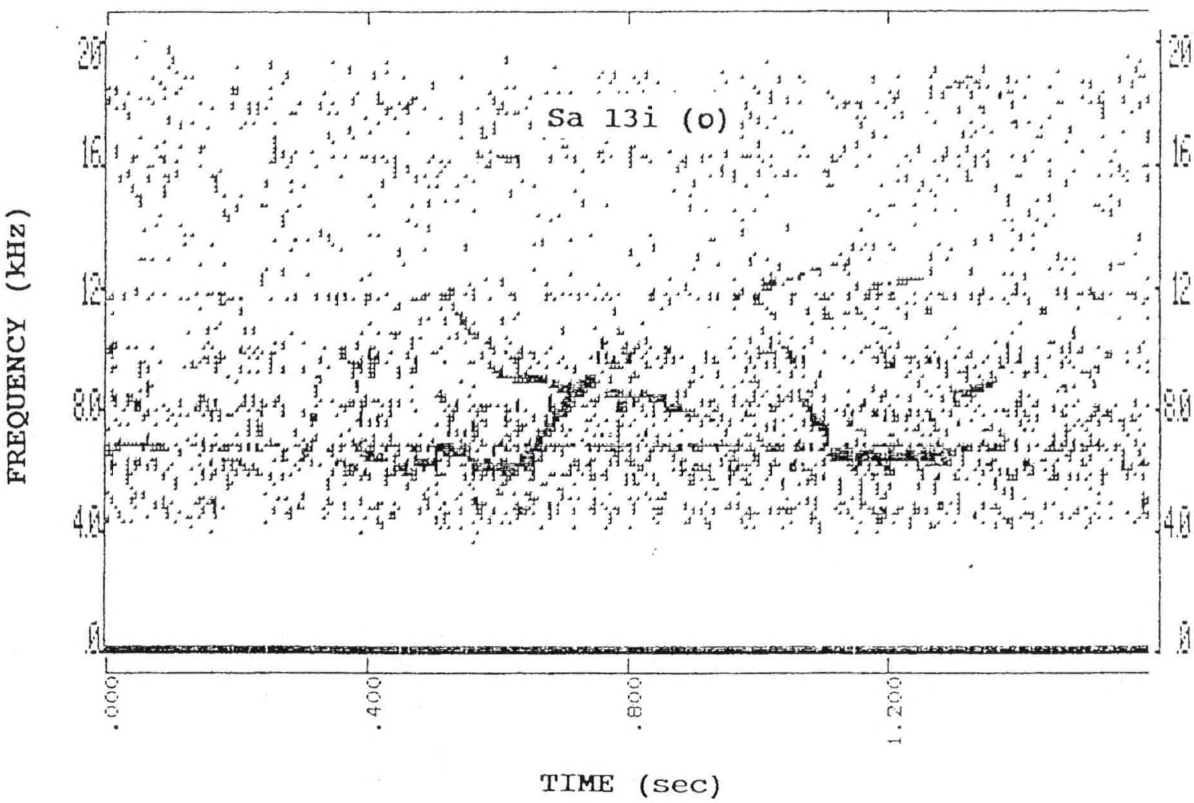

Sa 12i (o)
.000
.400
.800
1.200
1.600
2.000
TIME (sec)


Sa 12i (o)
FREQUENCY (kHz)
.400
.800
1.200
1.600
2.000
TIME (sec

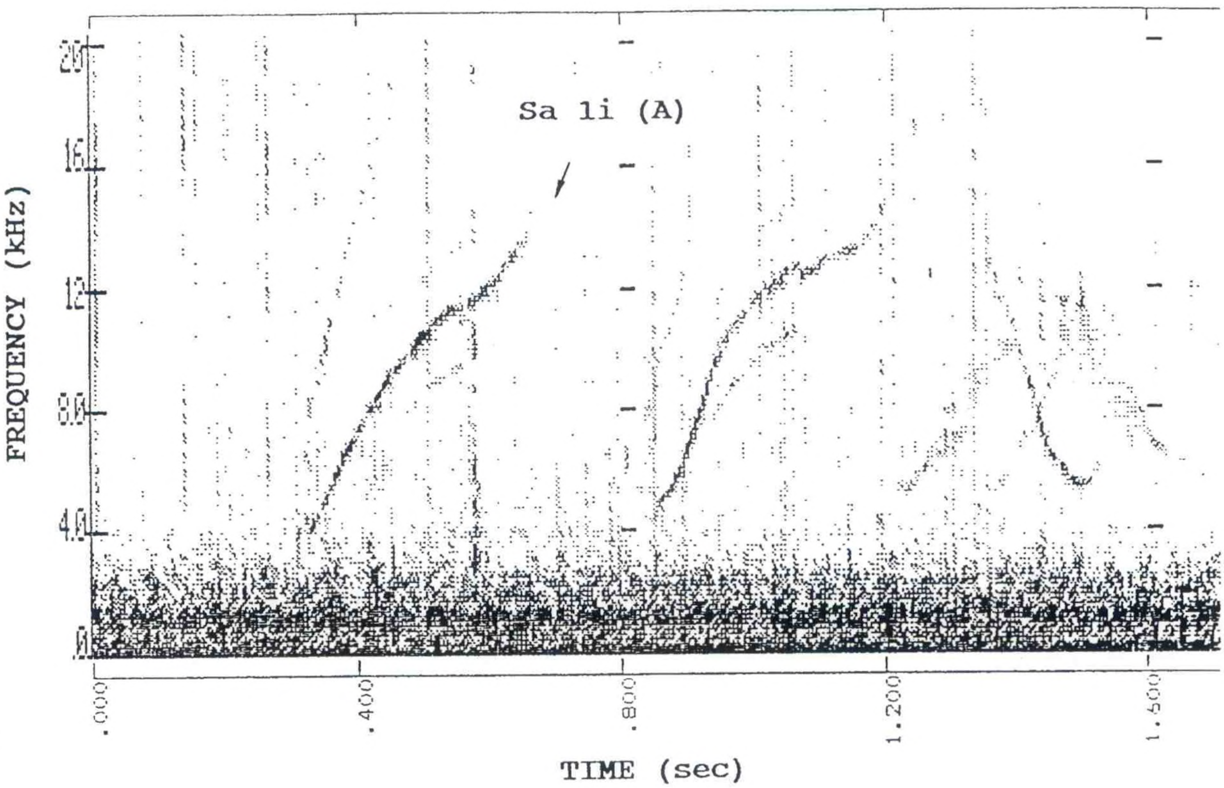

Sa 12ii (o)
2.000
2.400
2.800
3.200
3.600
4.000
TIME (sec)

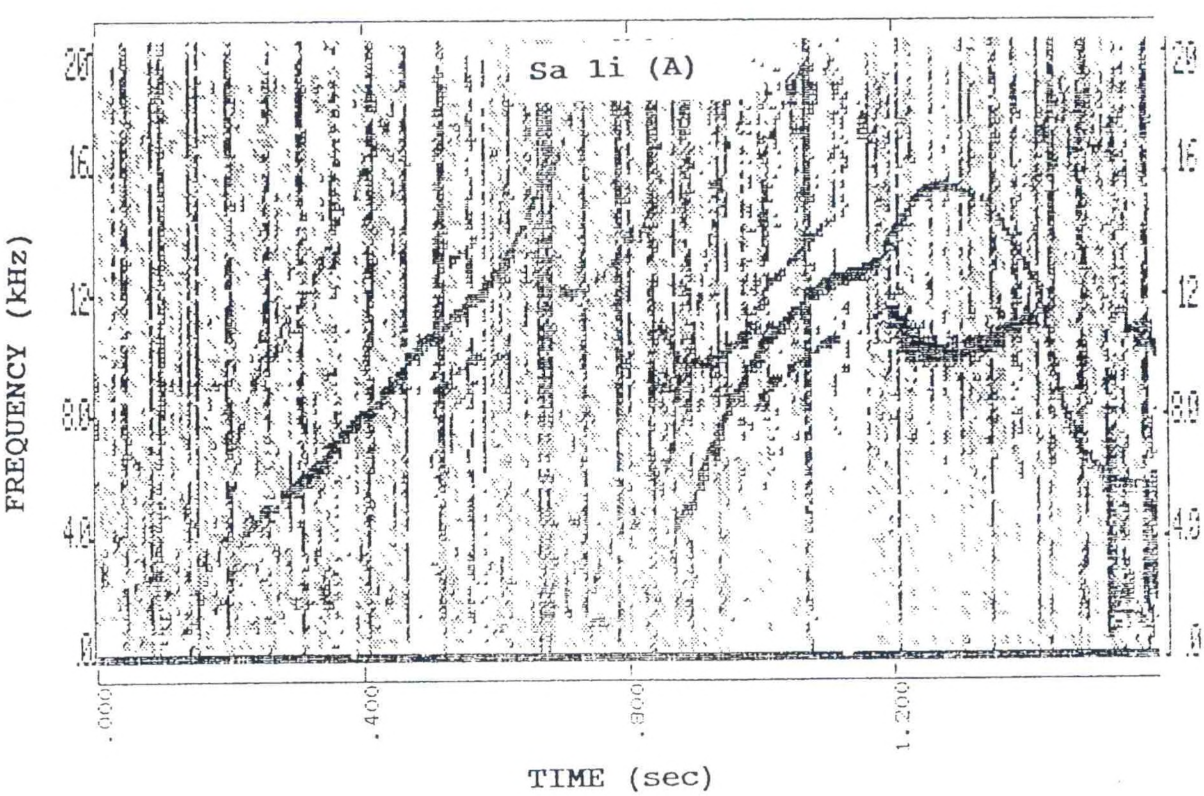

Sa 12iii (o)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
TIME (sec)

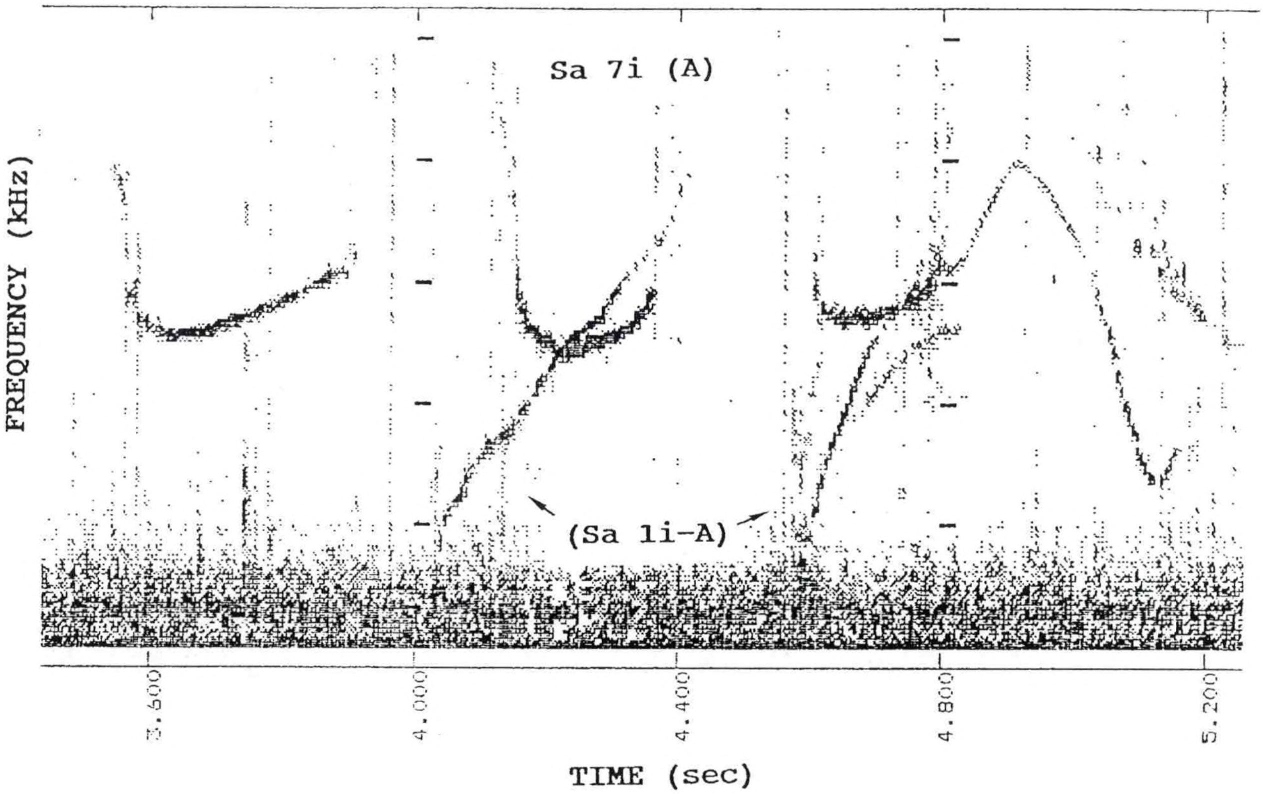

Sa 13i (p)
FREQUENCY (kHz)
TIME (sec)
.000
.400
.800
1.200

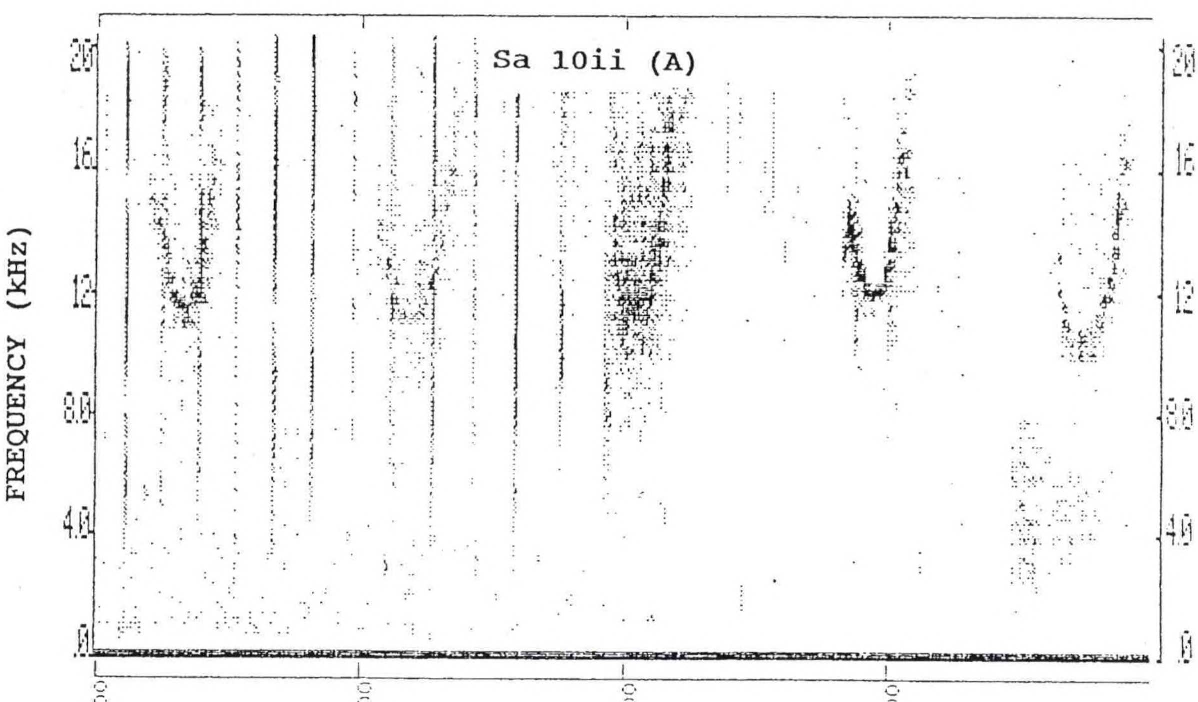

Sa 13i (o)
FREQUENCY (kHz)
TIME (sec)
.000
.400
.800
1.200

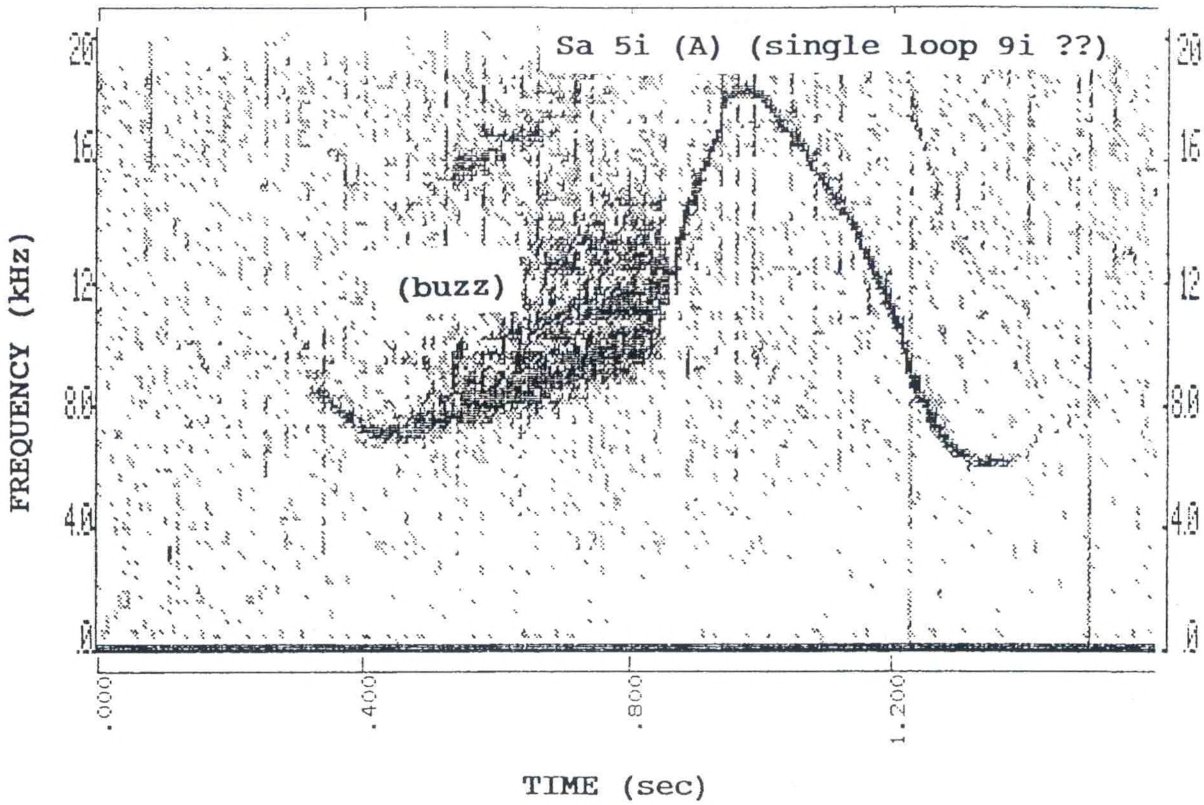
ATLANTIC

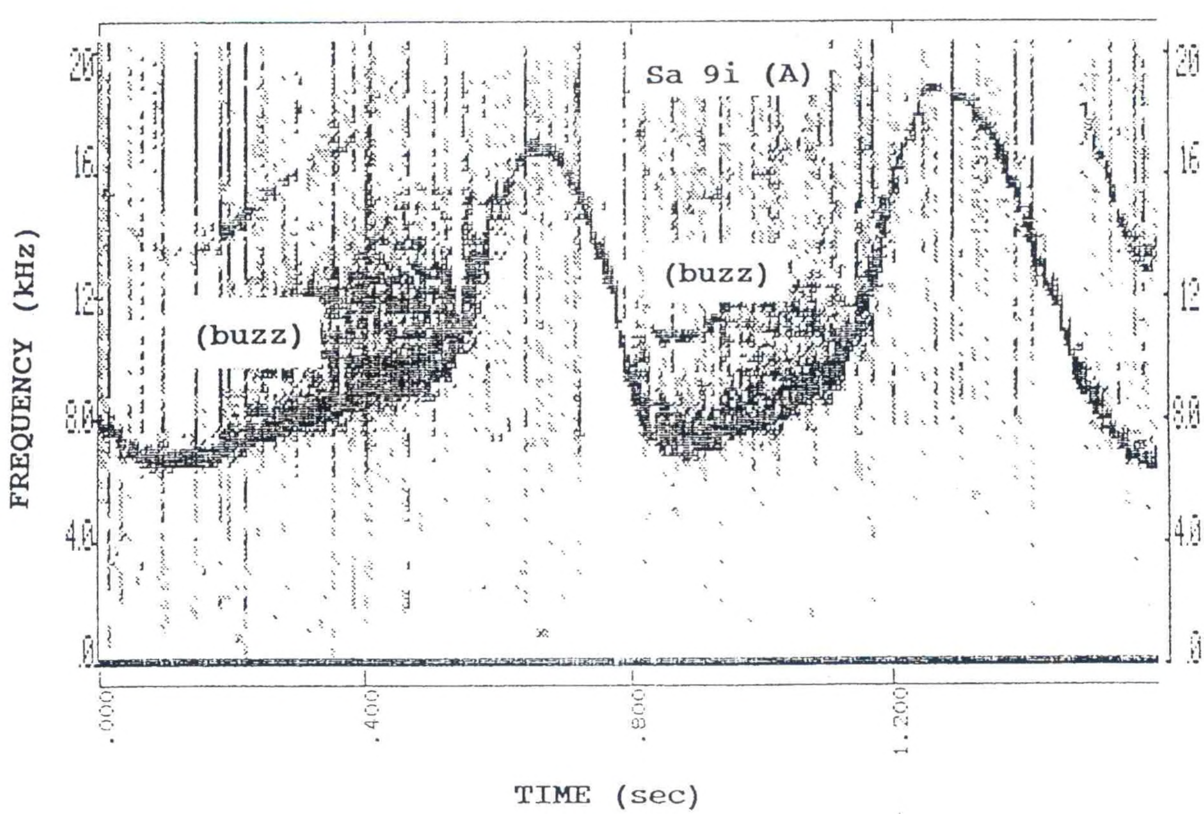

Sa 1i (A)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
.000
.400
.800
1.200
1.600
TIME (sec)

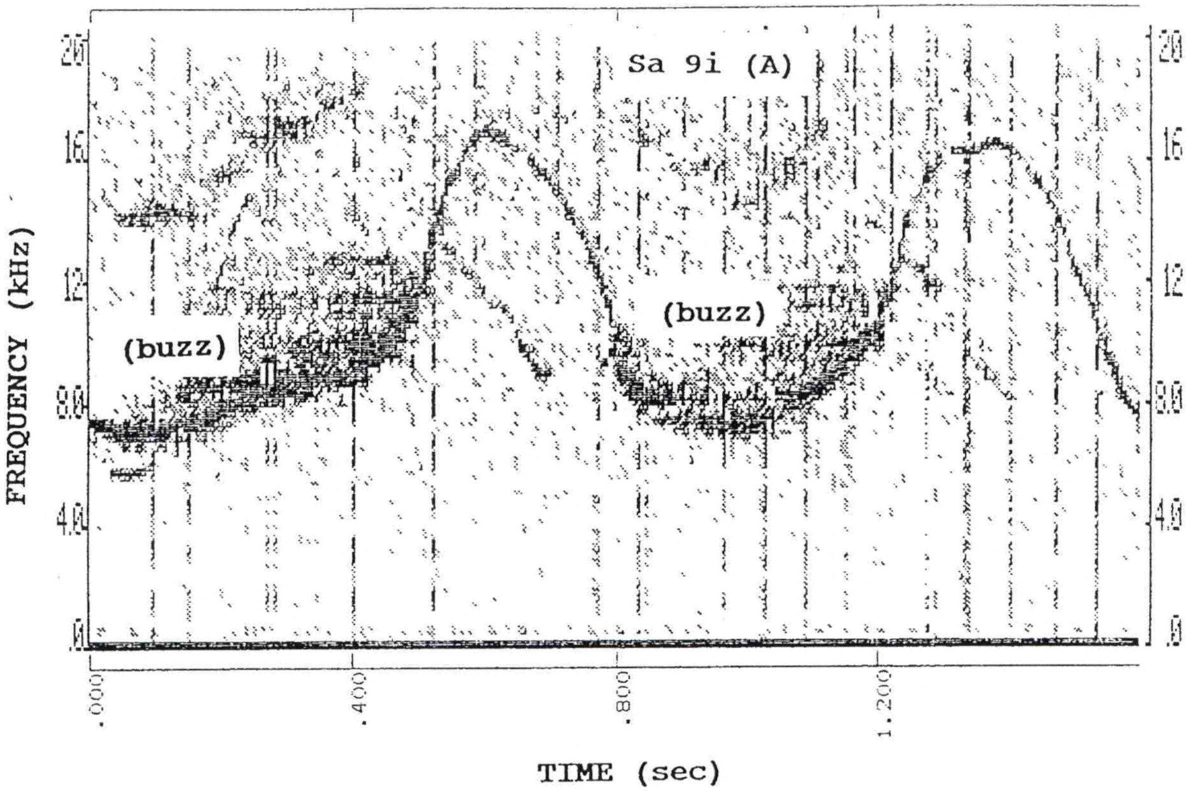

Sa 1i (A)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)

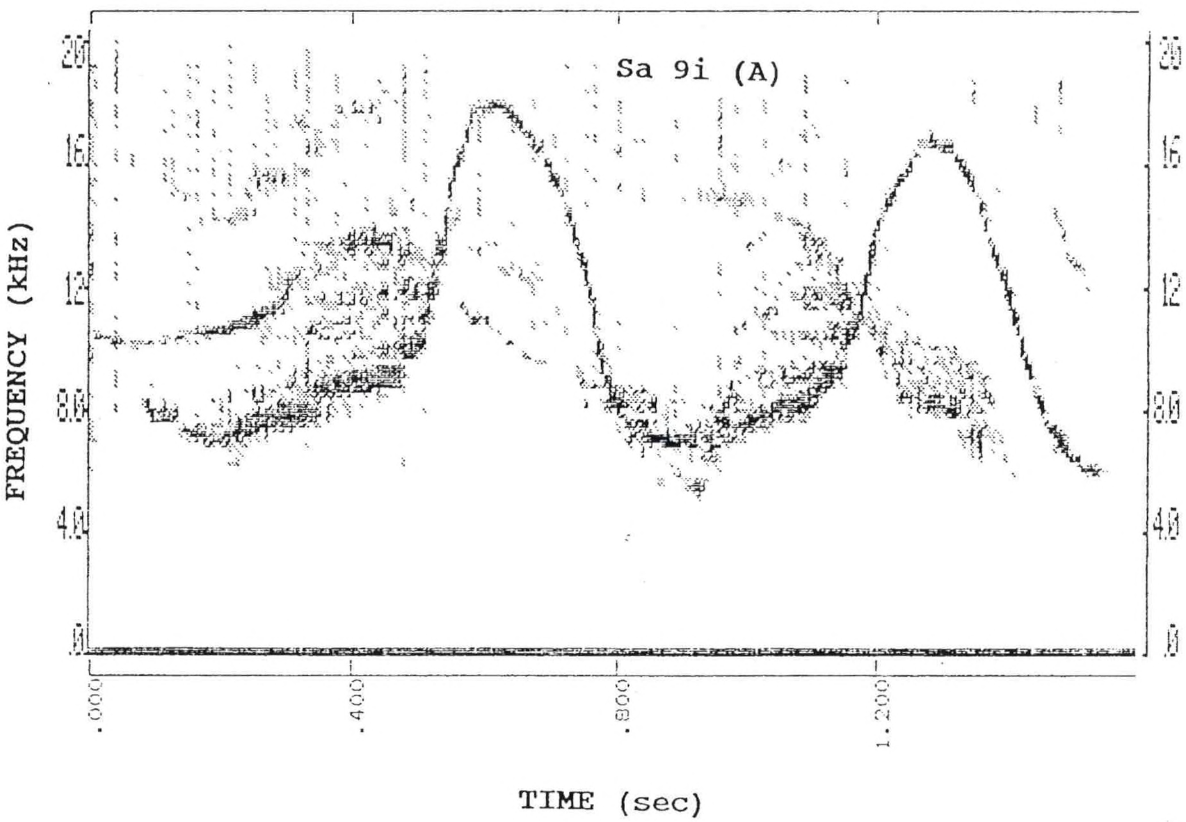

Sa 7i (A)
(Sa 1i-A)
FREQUENCY (kHz)
3.600
4.000
4.400
4.800
5.200
TIME (sec)

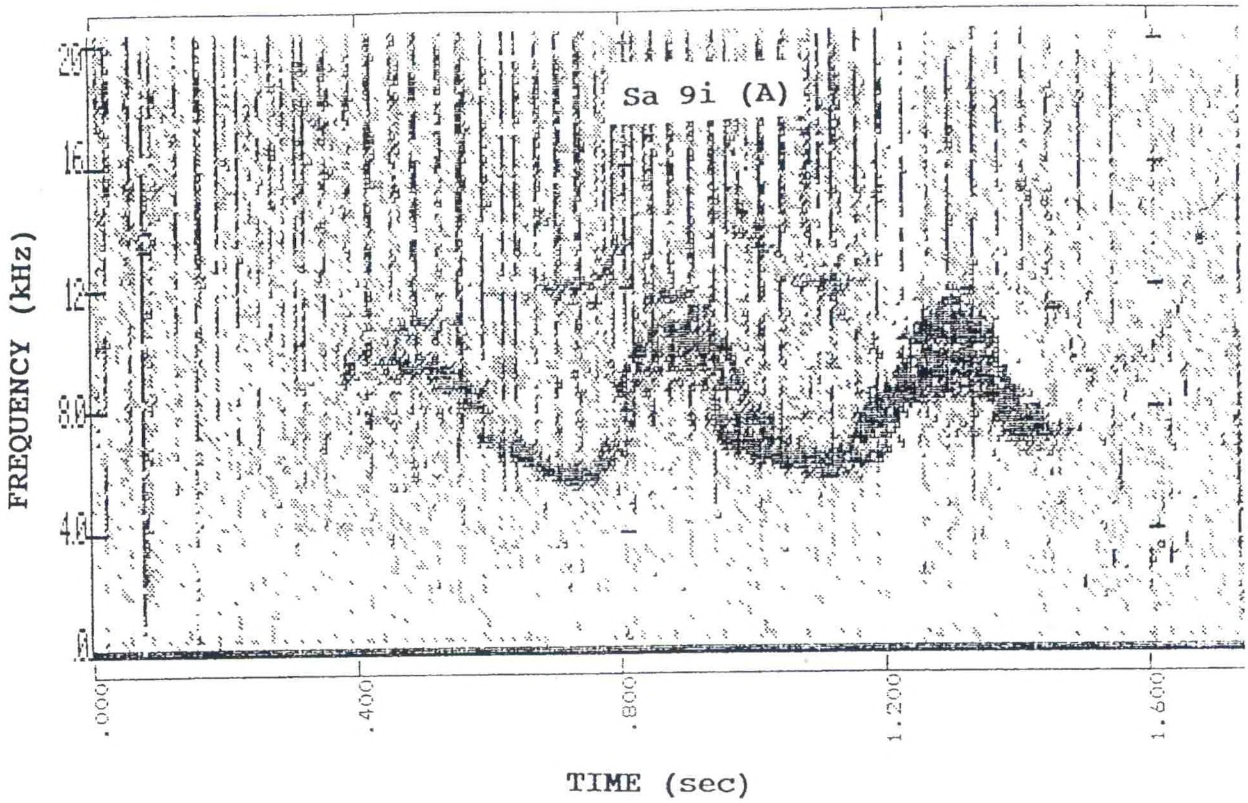

Sa 10ii (A)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)

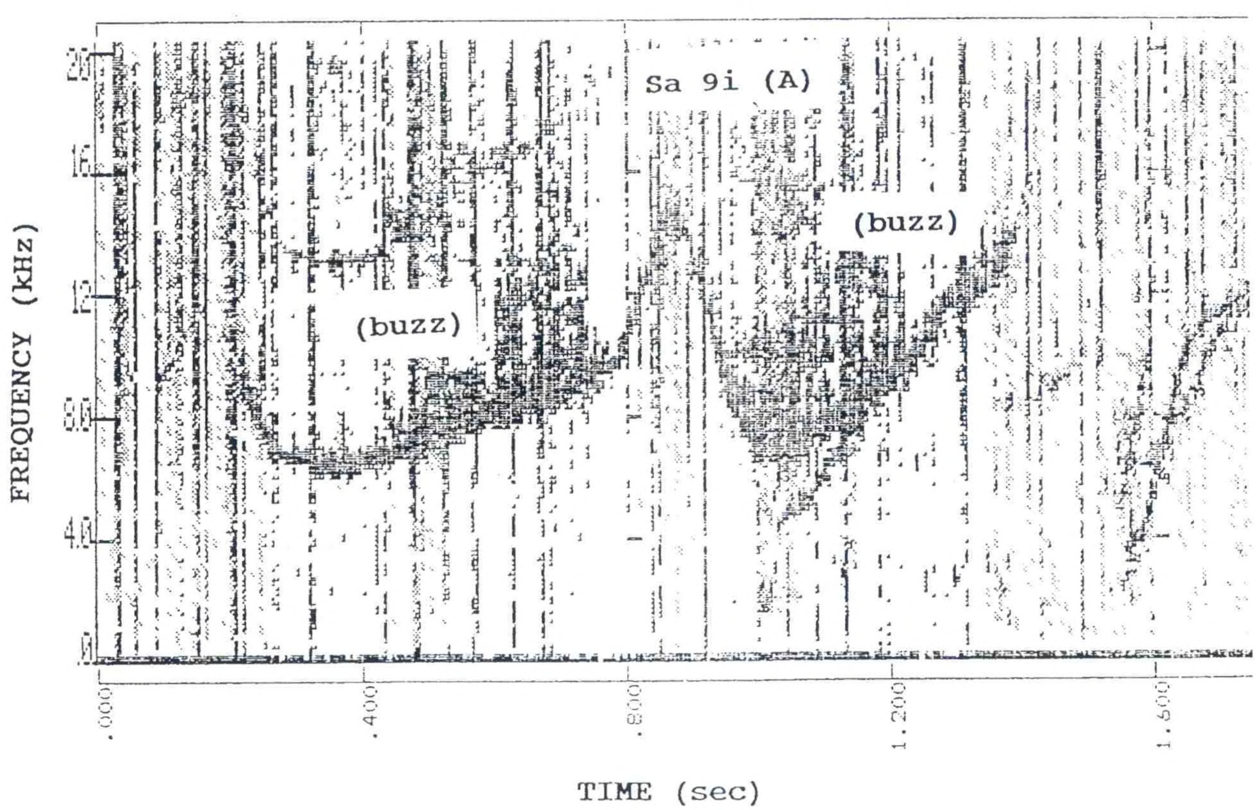

Sa 5i (A) (single loop 9i ??)
(buzz)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)

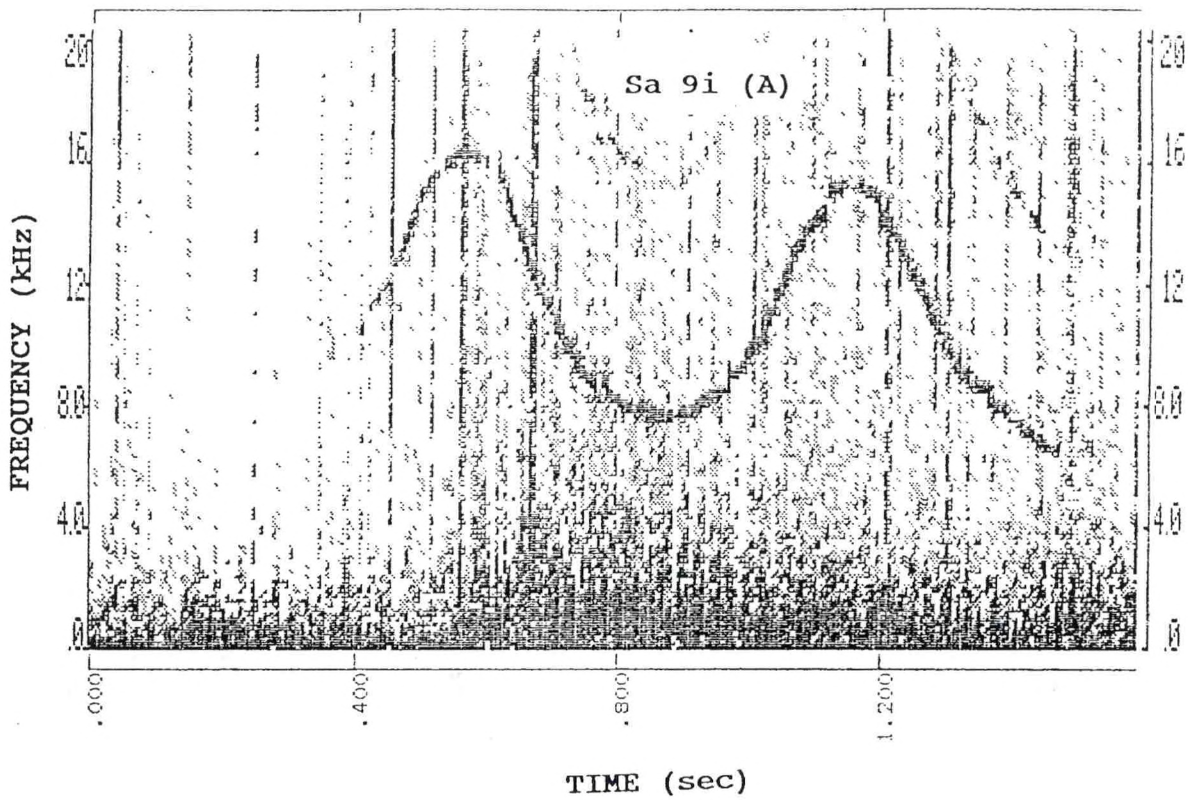

Sa 9i (A)
(buzz)
(buzz)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)

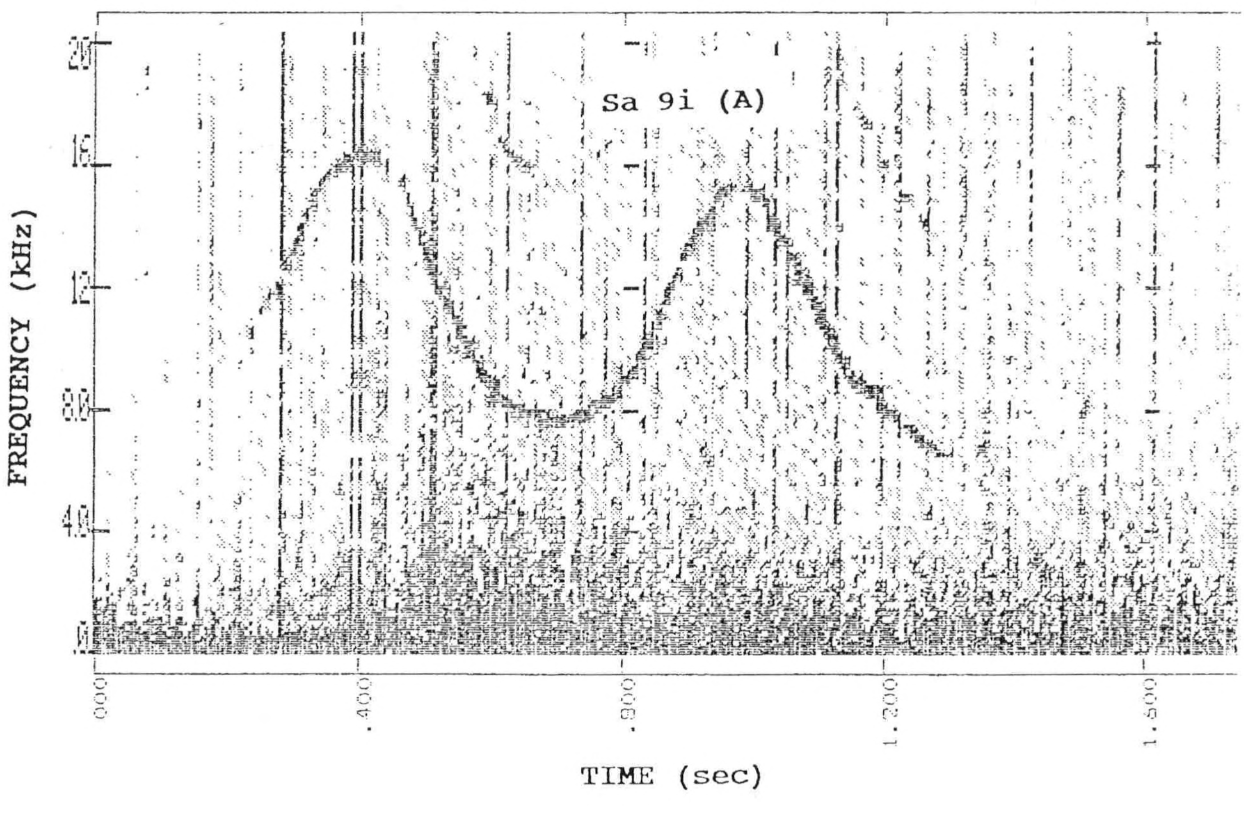

Sa 9i (A)
(buzz)
(buzz)
FREQUENCY (kHz)
TIME (sec)

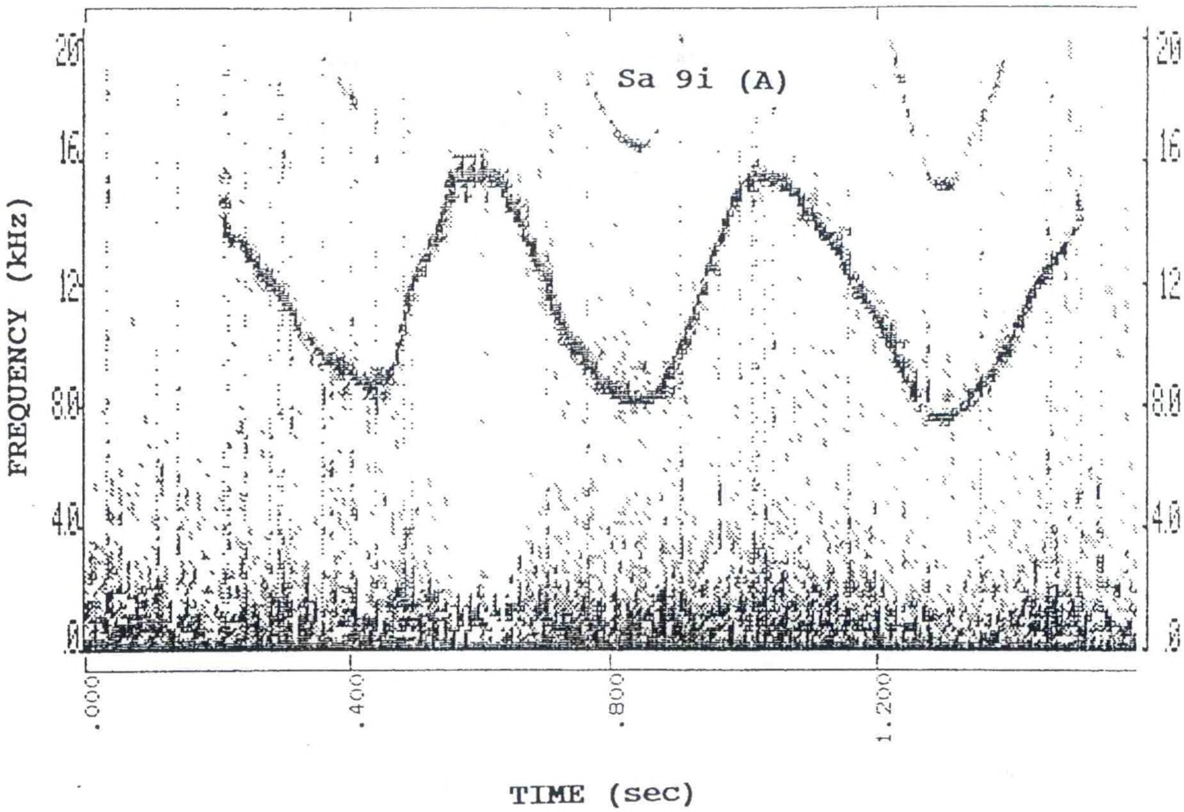

Sa 9i (A)
FREQUENCY (kHz)
TIME (sec)

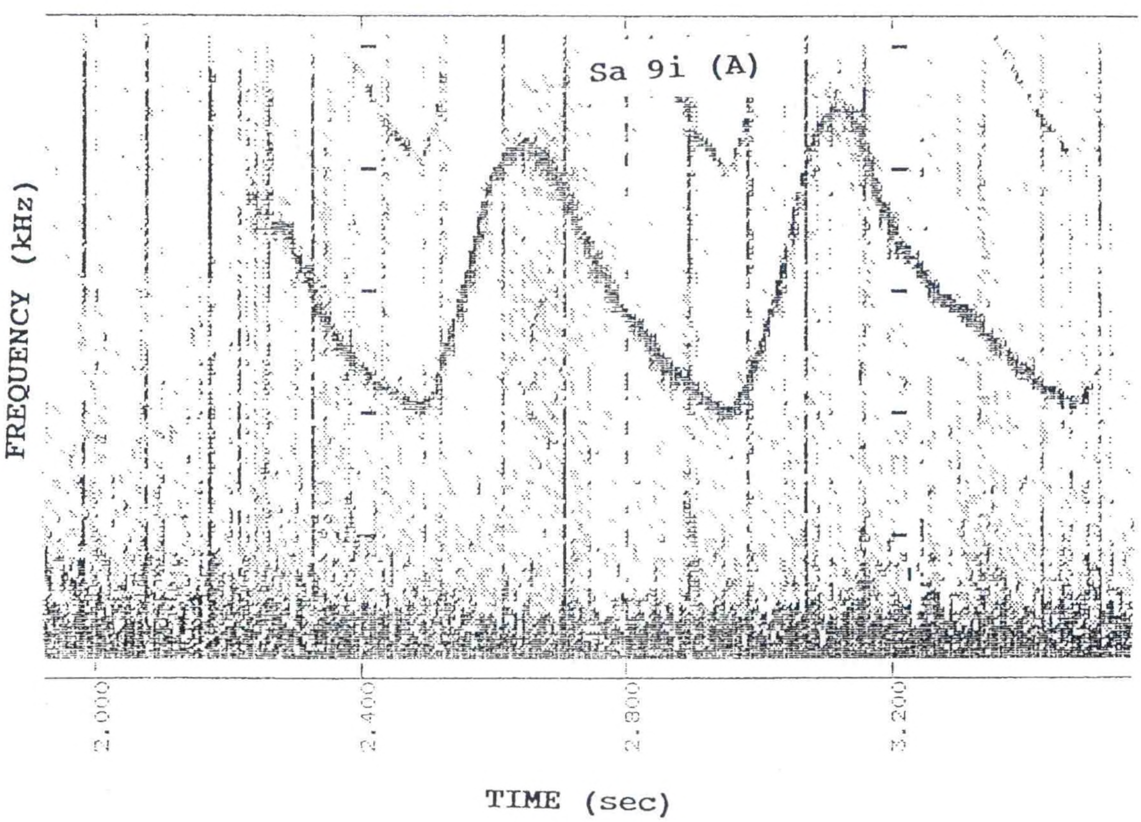

Sa 9i (A)
FREQUENCY (kHz)
0
4.0
8.0
12
16
20
.000
.400
.800
1.200
1.600
TIME (sec)

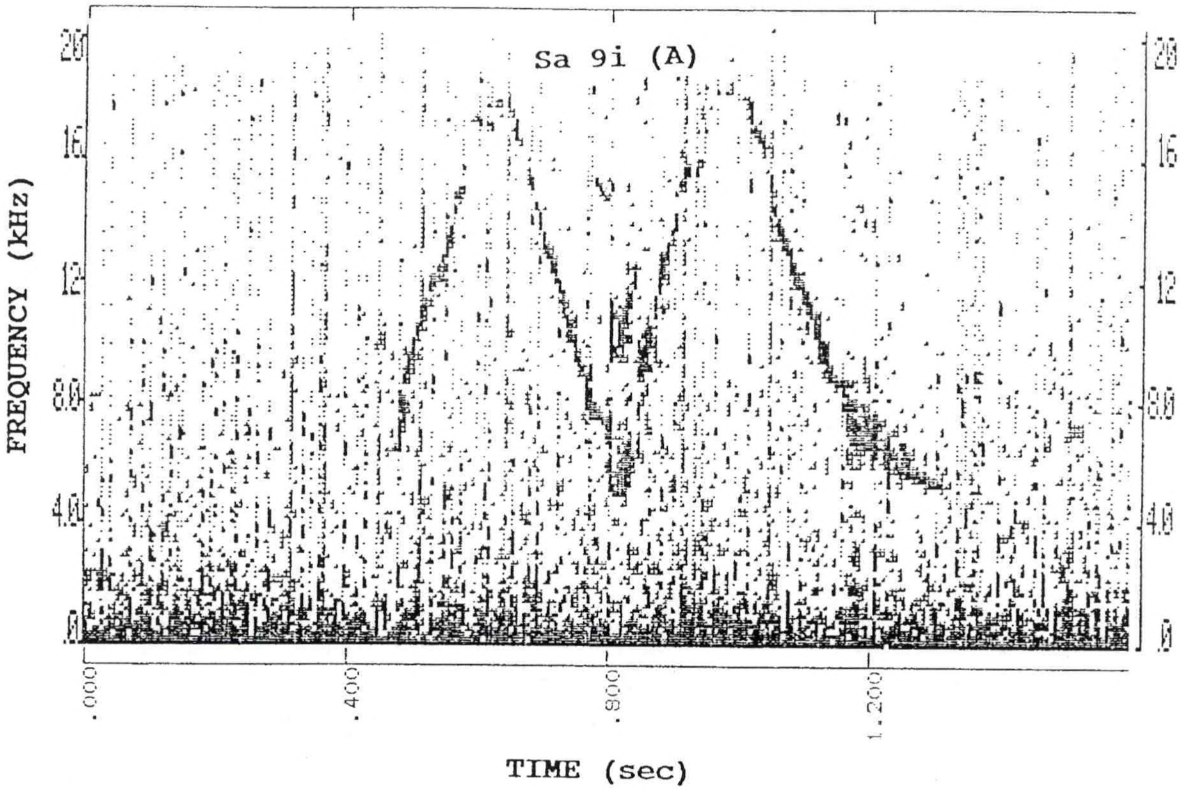

Sa 9i (A)
(buzz)
(buzz)
FREQUENCY (kHz)
0
4.0
8.0
12
16
20
.000
.400
.800
1.200
1.600
TIME (sec)

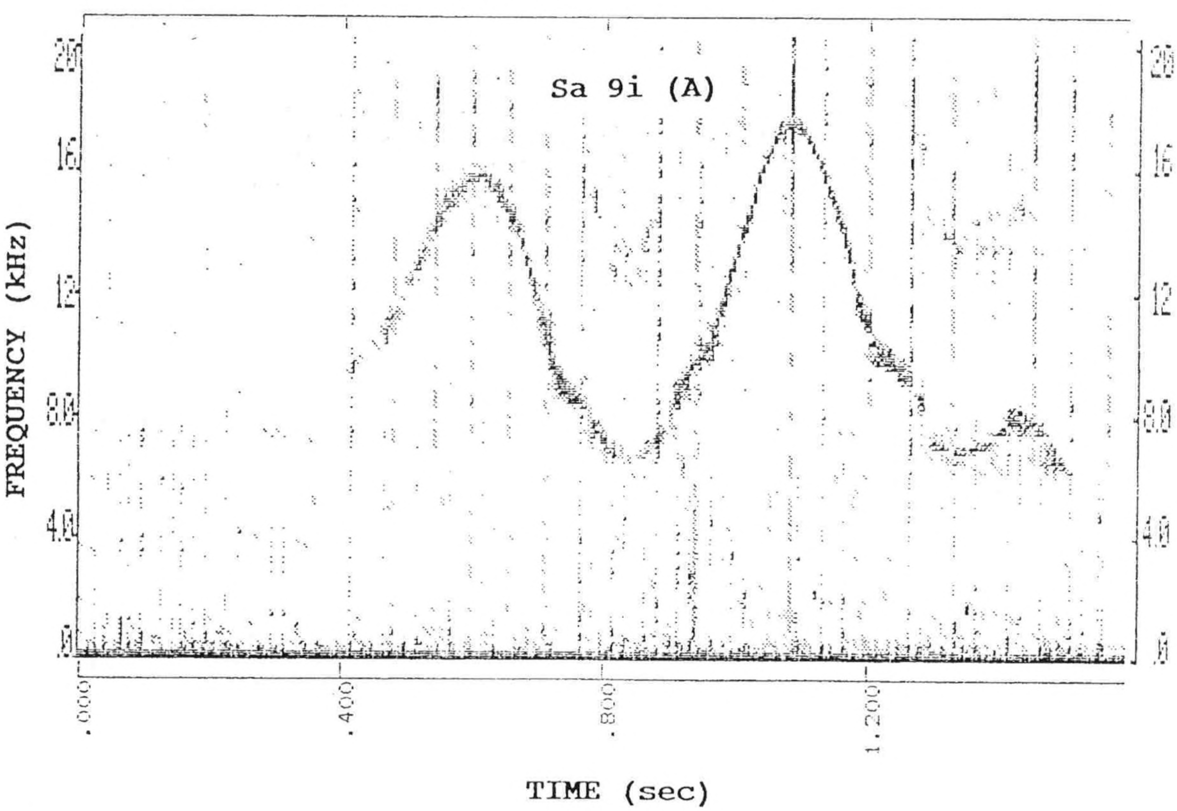

Sa 9i (A)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
TIME (sec)

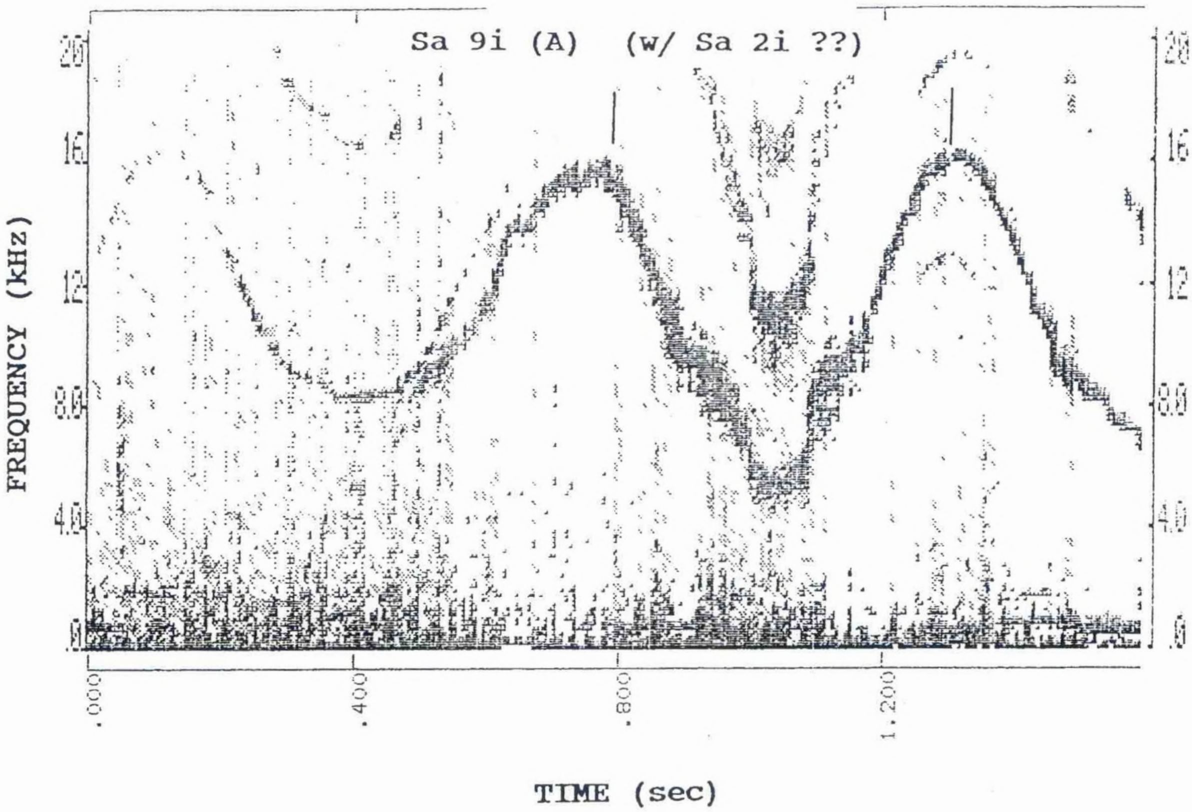

Sa 9i (A)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
1.600
TIME (sec)

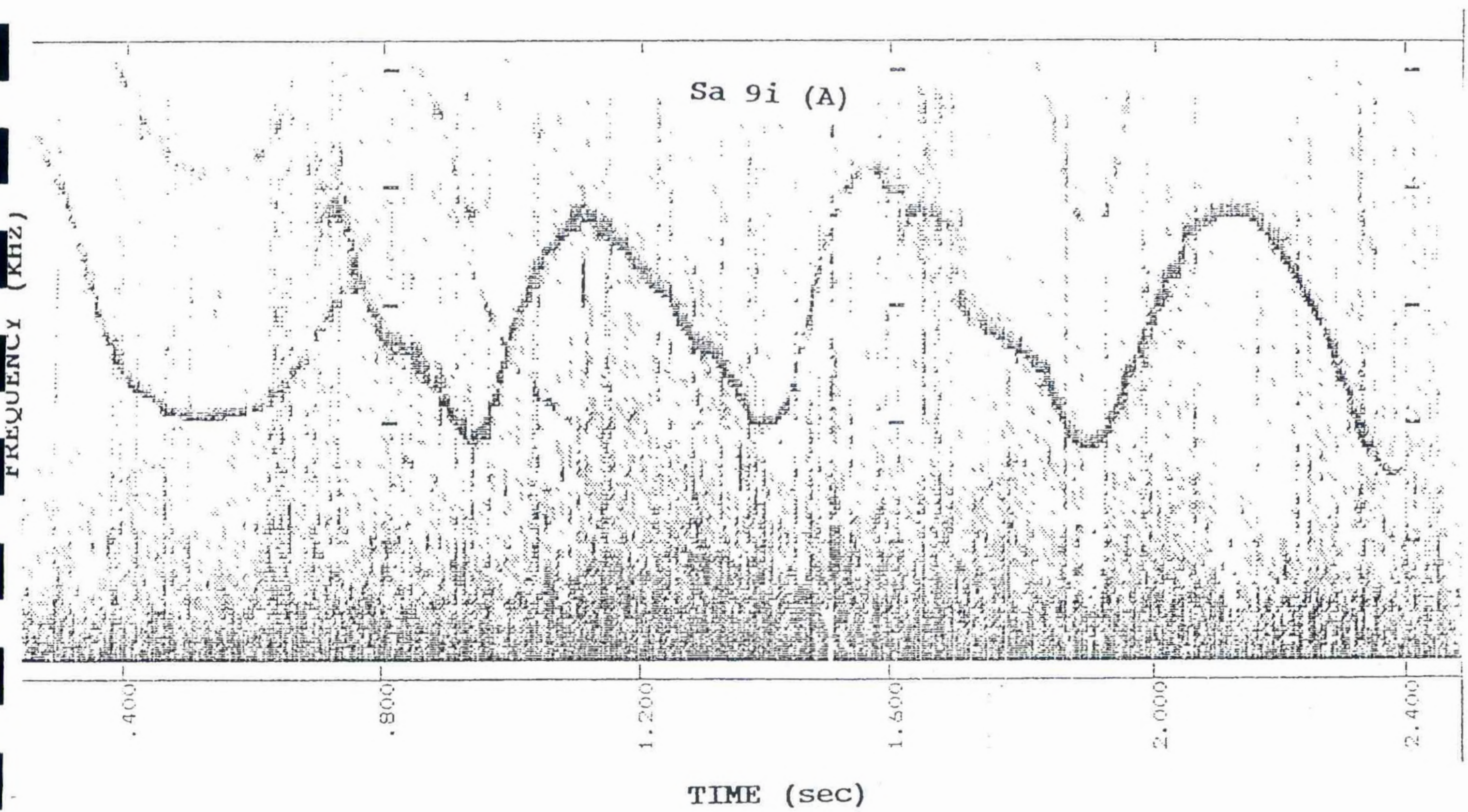

Sa 9i (A)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
TIME (sec)

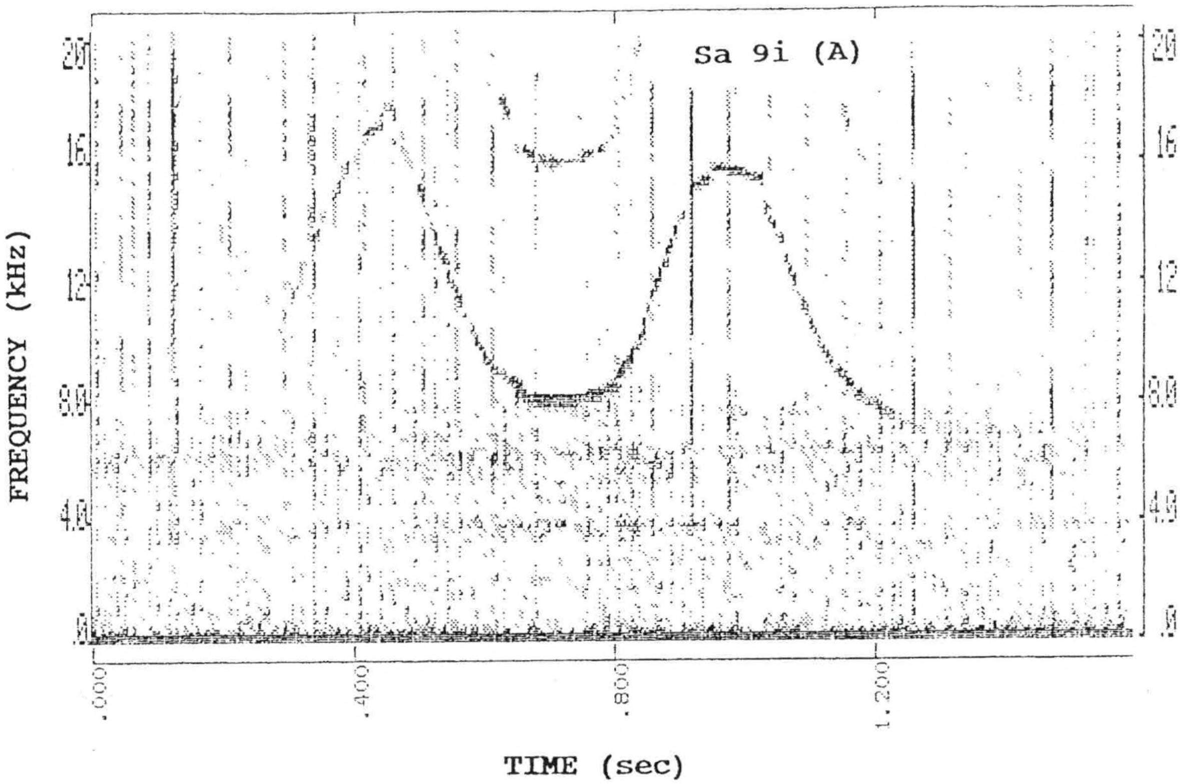

Sa 9i (A)
FREQUENCY (kHz)
2.000
2.400
2.800
3.200
TIME (sec)

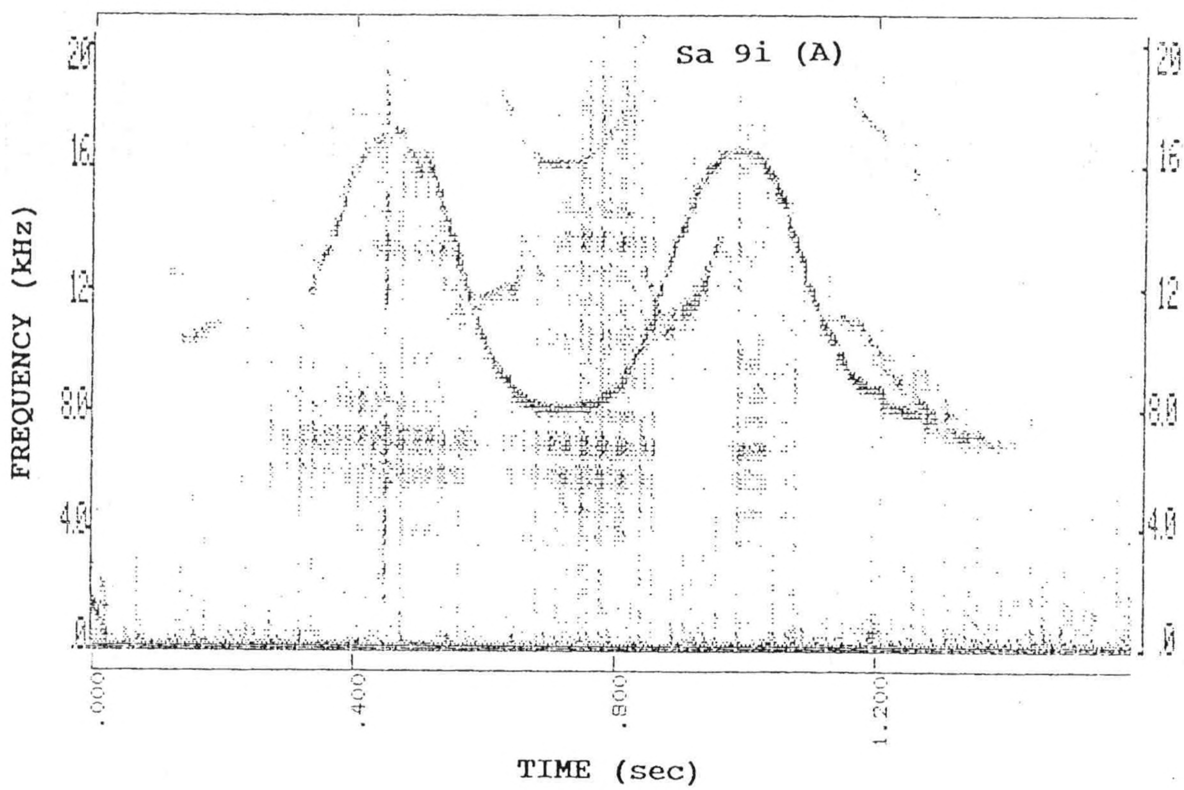

Sa 9i (A)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)

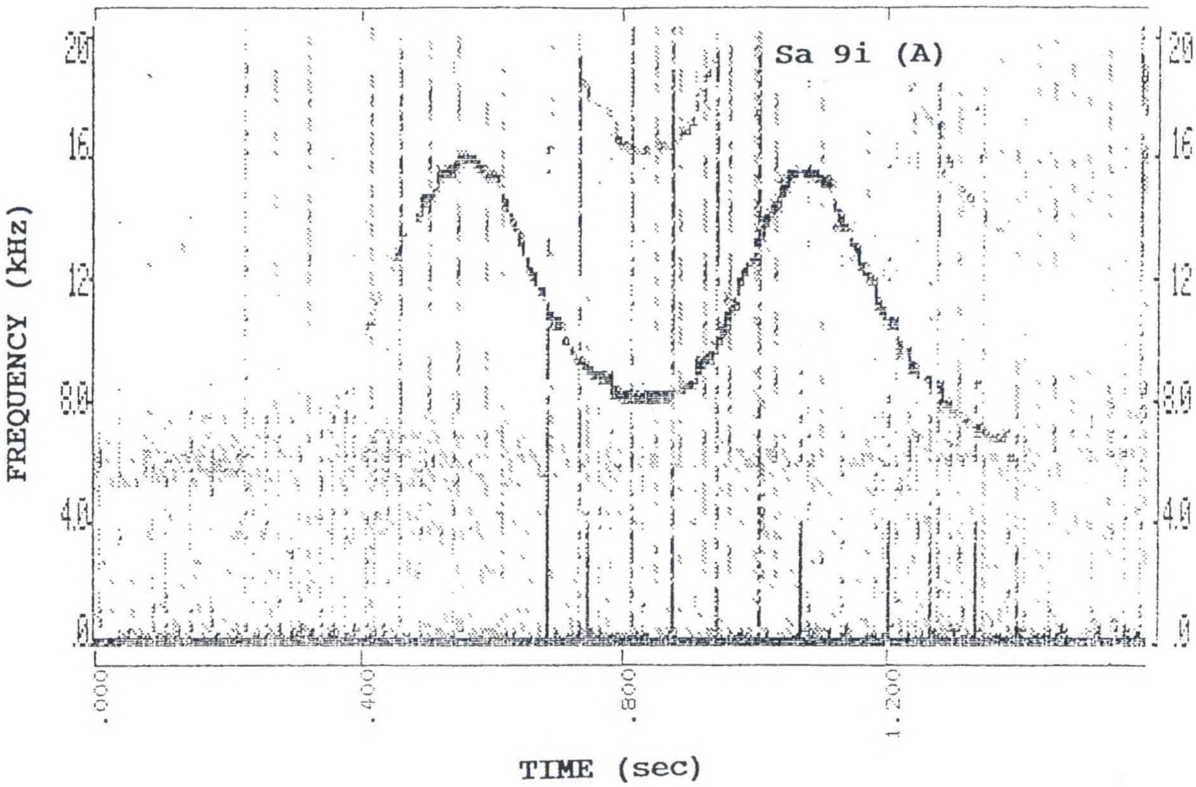

Sa 9i (A)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)

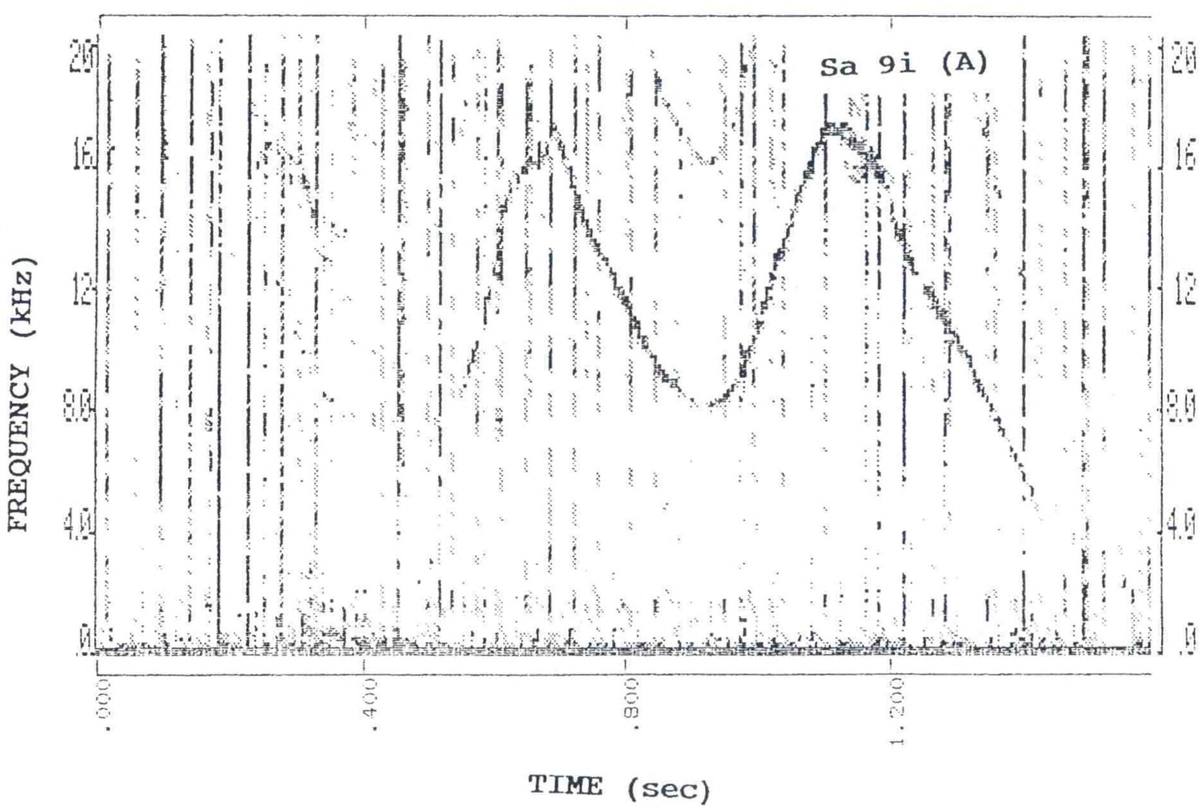

Sa 9i (A) (w/ Sa 2i ??)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)

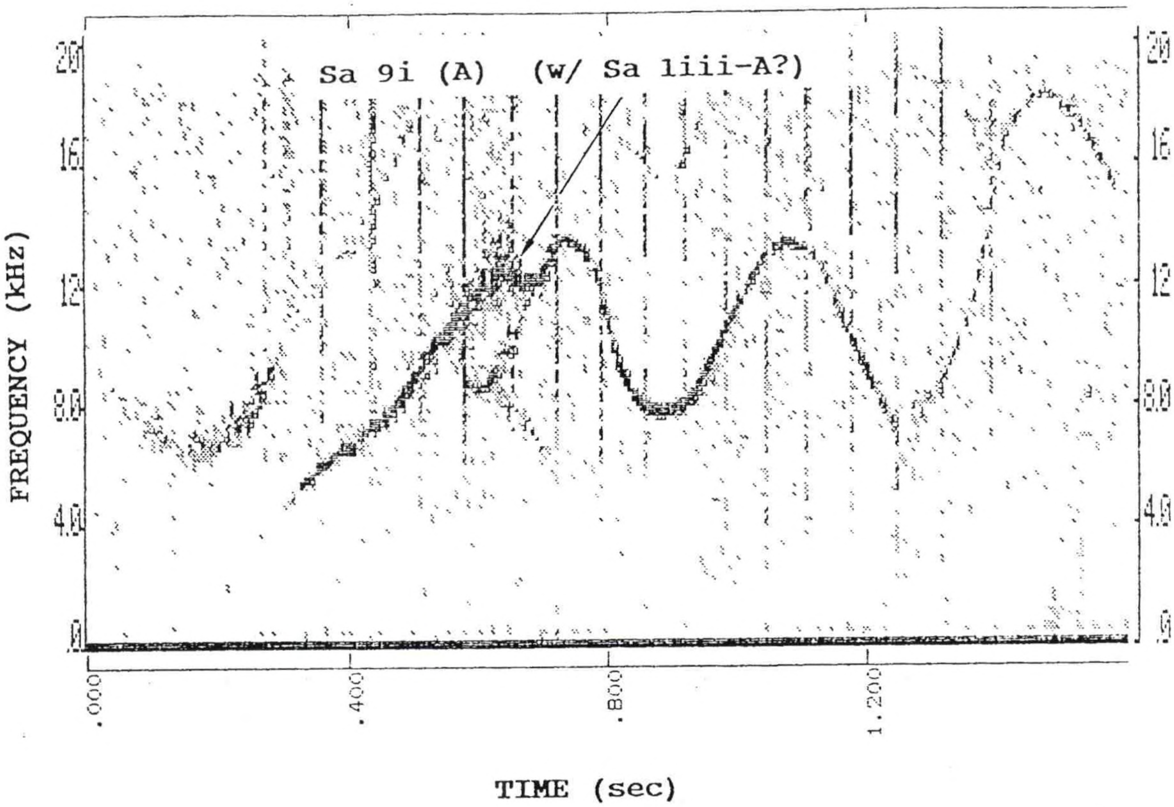

Sa 9i (A)
FREQUENCY (kHz)
.400
.800
1.200
1.600
2.000
2.400
TIME (sec)

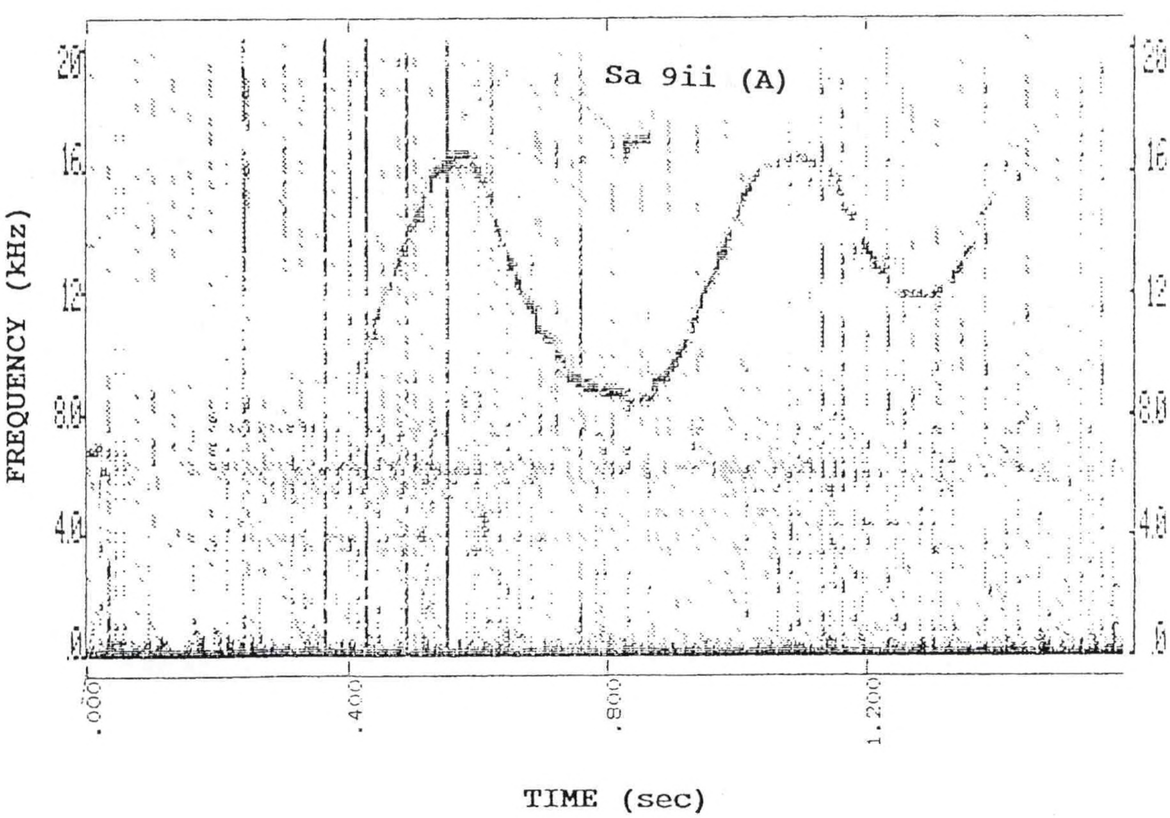

Sa 9i (A)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
TIME (sec)

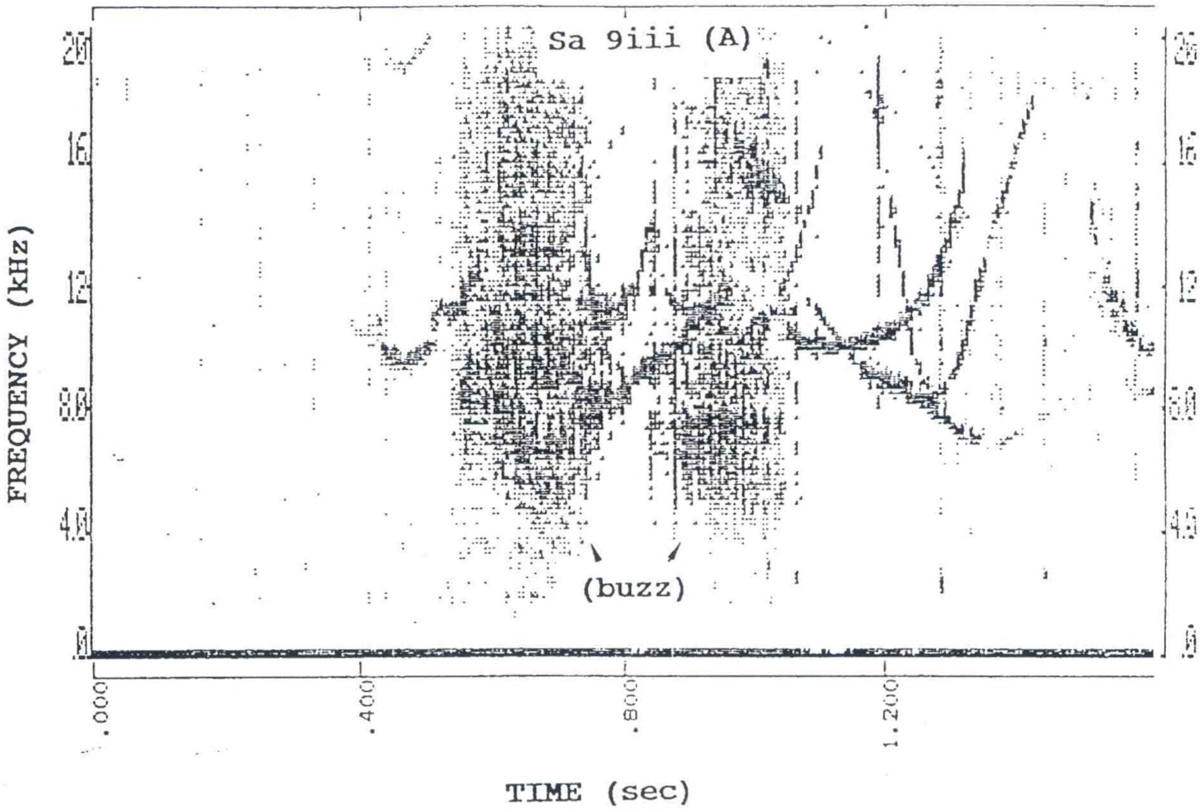

Sa 9i (A)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
.000
.400
.800
1.200
TIME (sec)

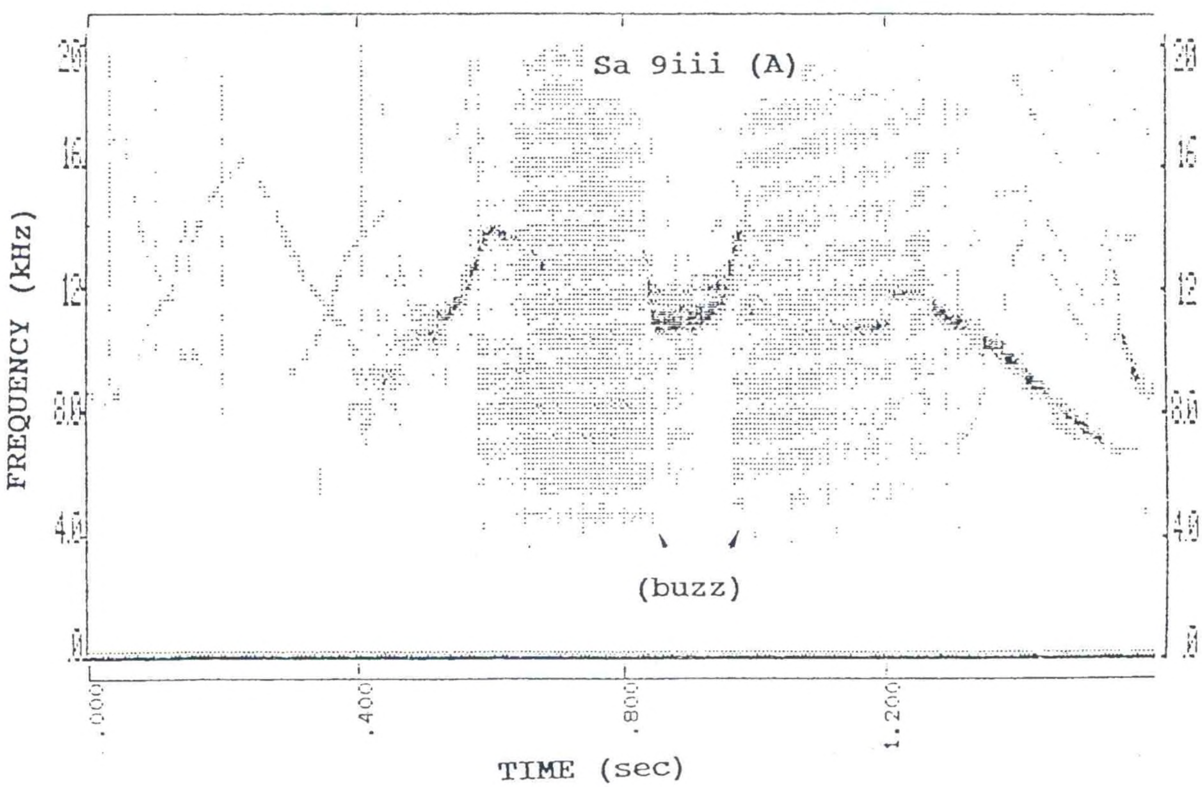

Sa 9i (A)
FREQUENCY (kHz)
TIME (sec)


Sa 9i (A)
FREQUENCY (kHz)
TIME (sec)


Sa 9i (A) (w/ Sa 1iii-A?)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)


Sa 9ii (A)
FREQUENCY (kHz)
20
16
12
8.0
4.0
0
.000
.400
.800
1.200
TIME (sec)


Sa 9iii (A)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
(buzz)
.000
.400
.800
1.200
TIME (sec)


Sa 9iii (A)
FREQUENCY (kHz)
20
16
12
8.0
4.0
.0
(buzz)
.000
.400
.800
1.200
TIME (sec)