The Seri report that eelgrass is a favorite food of sea turtles, and is extensively grazed primarily by the green sea turtle, *Chelonia mydas*. Preliminary analysis of stomach contents of specimens of *Chelonia* from the Infiernillo region confirms the fact that these turtles feed on eelgrass (*11*). Seri turtle hunters often seek their prey near eelgrass beds. According to the Seri, turtles feeding on eelgrass have sweet, well-flavored meat; while those found off the west coast of Tiburon Island which eat algal seaweeds are *kʔéemt* 'stinking' (*11*).

Eelgrass is primarily a food for the Seri; however, other uses for it figure in their culture. A child suffering from diarrhea is said to recover if he is fed *Xnóis*. Eelgrass is piled over a house frame for shade and roofing. A basket or sea turtle shell lined with eelgrass provides a bed on which meat is placed in order to keep it clean.

Dry eelgrass was formerly used to stuff a mule deer or desert bighorn sheep scrotum to make a ball for children to play with. In the past, dolls were often fashioned from bundles of eelgrass (*éaS*) bound into a cross with strips of cloth. Like most Seri dolls and figures, it is faceless and of haunting simplicity (see cover).

We know of no other case of the grain of an ocean plant being used as a human food resource (*12*). The cosmopolitan distribution of *Zostera* in shallow coastal waters enhances its possible significance as a food plant. The protein and starch contents of the seed compare favorably with those of major terrestrial economic grains (*13*). It has an unusually low fat content, which may have certain nutritional advantages (*13*). Prejudices against strong and unfamiliar flavors do not present a complication since the flour is bland. *Zostera* possesses positive environmental value as a crop plant because fresh water, artificial fertilizer, and pesticides would be unnecessary.

Note added in proof: Fieldwork in the Seri region in late June 1973 revealed the presence of *Ruppia maritima* in shallow seawater. However, we can conclusively state that the Seris do not utilize *Ruppia*.

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7. E. Y. Dawson, *Syst. Zool.* **9**, 93 (1960). J. Steinbeck and E. F. Ricketts [*Sea of Cortez* (Viking, New York, 1941), p. 261] report *Z. marina* in extreme southwest Sonora, Mexico.
8. In a little-known, privately printed publication, Davis [C. R. Quinn and E. Quinn, Eds., *Edward H. Davis and the Indians of the Southwest United States and Northwest Mexico* (Elena Quinn, Downey, Calif., 1965), p. 164] briefly described the use of "a green grass growing on the sea bottom," which can only be *Zostera*. E. Y. Dawson [*Desert Plant Life* **16**, 132 (1944)] claimed that the Seri ate the seeds of *Ruppia*. Dawson's specimens from the Infiernillo channel, Tiburon Island (deposited at the Los Angeles County Museum of Natural History), which were originally determined as *Ruppia maritima* L., are in fact *Zostera marina*. We have found no evidence of *Ruppia* in the present Seri region. Kroeber (*2*) mentioned "eel-grass sea-weed" in the Seri calendar and "the edible 'seeds' of eel-grass." E. Moser and M. B. Moser [*Vocabulario Seri* (Serie de Vocabulario Indigenas No. 5, Instituto Linguistico de Verano, Mexico, D.F., 1961)] translate *Xnóis* as *Zostera marina*. In retrospect, previous brief allusions to the consumption of seaweed, marine grasses, or *Ruppia* by the Seri [Davis, Dawson, Griffen (*4*), Kroeber (*2*), and McGee (*3*)] certainly refer to *Z. marina*. The Seri do not eat algal seaweeds.
9. For a description of Seri phonemes see E. W. Moser and M. B. Moser, *Linguistics* **16**, 50 (1965). Standard phonemic conventions are used here.
10. Analysis of *cardón* seeds by W. W. Turner, Jr. (Efco Laboratories, Tucson, Arizona) showed: protein, 22.59 percent; crude fat, 32.06 percent; and starch, 0.95 percent. See (*13*) for methods. The high fat content complements the low fat content of eelgrass seeds (*13*).
11. Further information on Seri knowledge of eelgrass as it relates to sea turtle hunting and biology is included in a manuscript in preparation by R. Felger, E. Moser, and P. Regal.
12. The fleshy roots and leaf bases of *Z. marina* are occasionally eaten and used as flavoring [N. C. Turner and M. A. Bell, *Econ. Bot.* **25**, 63 (1971)].
13. A preliminary analysis of the seed by W. W. Turner, Jr., showed: protein, 13.20 percent; crude fat, 1.01 percent; and starch, 50.9 percent. The seeds were separated from the husks with mortar and pestle, and fractionation through a 20-mesh Tyler sieve yielded 57.8 percent seeds and 42.2 percent husks by weight. For the methods of analysis see: (protein) W. Horowitz, Ed., *Official Methods of Analysis of the Association of Analytical Chemists* (Association of Analytical Chemists, Washington, D.C., ed. 11, 1970), sections 42.014–42.016; (fat) *ibid.*, section 7.048; (starch) W. W. Turner, Jr., *J. Ass. Offic. Anal. Chem.* **52**, 956 (1969). The sample was collected at Campo Viboras (Fig. 1). A more extensive nutritional analysis is merited, and ideally this would survey various populations.
14. We are grateful to the Seri, who taught us information recorded in this report. We thank Jean Russell and Alexander Russell for their continuing generosity. Partial assistance for initial phases of this work was provided by a grant from the Office of Naval Research [ONR-N0014-67-A-0209-003(NR 104-897)] through Dr. Donald A. Thomson, University of Arizona.

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Human Perception of Illumination with Pulsed Ultrahigh-Frequency Electromagnetic Energy

Abstract. *A psychophysical study of the perception of "sound" induced by illumination with pulse-modulated, ultrahigh-frequency electromagnetic energy indicated that perception was primarily dependent upon peak power and secondarily dependent upon pulse width. The average power did not significantly affect perception. Perceived characteristics of pitch and timbre appeared to be functions of modulation.*

Field tests with radar indicate that humans and cats perceive low-power pulse-modulated, radio-frequency (rf) energy (*1–3*). Human subjects reported that they perceived "sounds" that were in the nature of buzzes and hisses. The energy perceived was not acoustic energy; rather, it was electromagnetic (EM) energy in the ultrahigh-frequency (UHF) band of the spectrum. These findings can be related to other reports of sensory and behavioral phenomena associated with illumination with low-power rf energy. Analytical reviews of these and other reports and implications of the reviewed reports that bear on our understanding of information transfer and storage in living organisms can be found in the literature (*3–5*).

In the field tests with radar, A.H.F. determined the portion of the EM spectrum that was effective in inducing the "sounds" and the approximate thresholds. Perception occurred when the subject was illuminated with energy from approximately that portion of the EM spectrum defined as the UHF band, that is, from 0.3 to 3 Ghz (*6*). This is the portion of the spectrum at which EM energy passes into and through the head. At higher frequencies the energy is largely absorbed by the skin, and at lower frequencies it tends to be reflected by the body (*2*). An approximate threshold for perception, when the subject was in a noisy environment, occurred at a peak power density of 267 mw/cm^2 and an average power density of 0.4 mw/cm^2. The data suggested that the average power was not an important variable, but no definitive statement about its role in perception could be made. The perception had the following characteristics: (i) it did not involve an energy transduction of EM to acoustic energy, for example, by fillings in the teeth; (ii) it differed from the electrophonic effect; and (iii) it could not be accounted for by an explanation involving radiation pressure against the skin (*3, 4*).

The field studies raised questions that could not be answered at that time because of a lack of suitable laboratory sources of rf energy. Suitable rf energy sources are now available. Thus, we addressed ourselves to the following questions:

Is perceived loudness a function of peak power, average power, or both?

What is the required energy density for the perceptual threshold?

Is there a minimal or optimal pulse width?

Are there modulation characteristics that yield the perception of pitch?

We performed a series of psychophysical experiments with humans placed in an rf anechoic chamber. The rf anechoic chamber, constructed of rf energy absorber (Eccosorb FR 340) minimized rf energy reflections. The EM energy source was a pulse signal source (Applied Microwave Laboratory) emitting energy at a carrier frequency of 1.245 Ghz. The energy was conveyed by an air line (General Radio model 874) and RG-8 coaxial cable to a coax-to-waveguide adaptor (Scientific Atlanta model 11-1.1) and standard-gain horn antenna (*7*). The horn antenna emitted the energy within the rf anechoic chamber. The antenna was oriented such that the energy was vertically polarized, although pilot experiments indicated that horizontally polarized energy yielded similar data. The rf parameters used are shown in Table 1. The pulse repetition rate was selected so that it produced a buzzing "sound."

All rf energy measurements reported here were taken with a half-wave dipole antenna located where the center of the subject's head was placed during data collection. The dipole antenna was supported by a wooden pole in order to minimize field disturbance during the measurement. The dipole was connected by an RG-58 coaxial cable to an attenuator (Microlab model AF 20) outside of the chamber. The attenuator was connected to a thermistor mount (Hewlett-Packard model 477B), and the mount was connected to a power meter (Hewlett-Packard model 430C). The cable within the chamber was oriented for minimum field disturbance. This measurement equipment yields an average power measurement from which the peak power is derived by the standard duty cycle formula (*8*). The signal attenuation due to the cable and to the attenuator is accounted for in the reported measurements. There is an inherent and unspecifiable error in all rf measurements attributable to the EM field–distorting effect of the measuring instrument and the biological object.

Table 1. Radio frequency parameters used at each test condition. A pulse rate of 50 pulses per second was used in each case. The constant values shown were rounded for clarity.

Test condition number	Peak power (mw/cm^2)	Average power (mw/cm^2)	Pulse width (μsec)
	Peak power varied		
1	90	0.32	70
2	105	0.32	60
3	125	0.32	50
4	210	0.32	30
5	315	0.32	20
6	630	0.32	10
6a	630	1.26	40
	Average power varied		
1	370	0.19	10
2	370	0.37	20
3	370	0.55	30
4	370	0.93	50
5	370	1.11	60
6	370	1.29	70

The psychophysical technique of magnitude estimation was used in these experiments. Four trained subjects with clinically normal hearing were tested individually within the rf anechoic chamber. The subject sat on a wooden stool with his back to the horn antenna. We fixed his head in space by having him place his chin on an acrylic rest mounted on a vertical wooden pole. He used a multikey hand switch to signal a number as a report of the loudness he perceived. The subject was told that the first rf sound he would hear in each trial would be a reference sound that was assigned the number 100 and that the second sound he heard would differ in loudness from trial to trial. It was the subject's task to assign

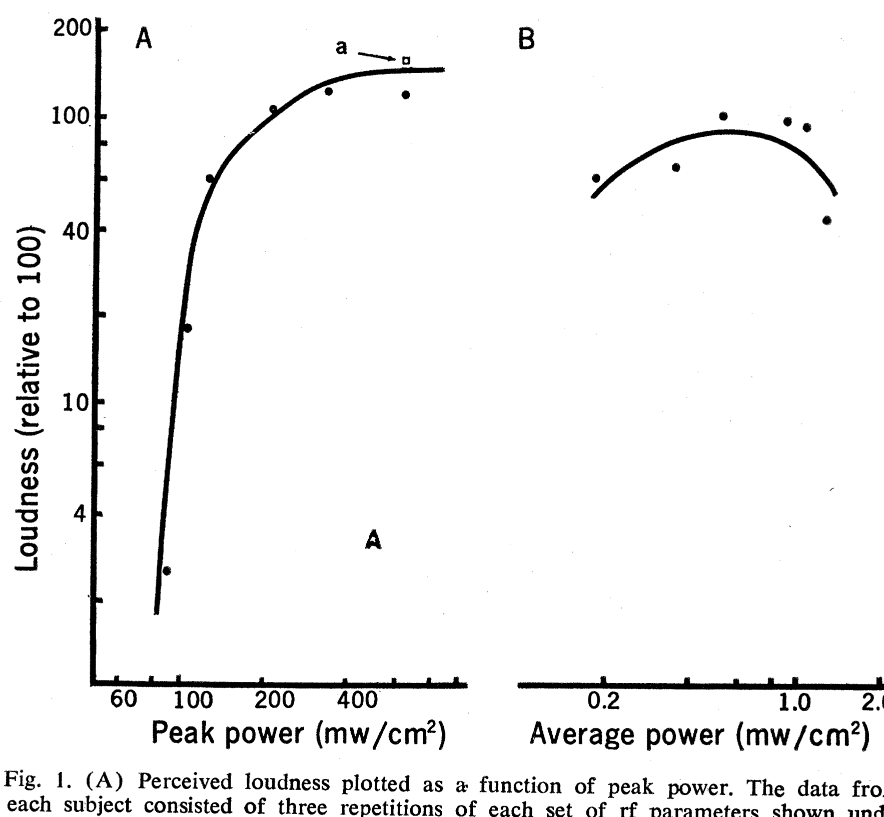

Fig. 1. (A) Perceived loudness plotted as a function of peak power. The data from each subject consisted of three repetitions of each set of rf parameters shown under each test condition number in Table 1. The average power was held constant by decreasing the pulse width while raising the peak power. (B) Perceived loudness plotted as a function of average power for the same subjects as in (A). The average power was increased by increasing the pulse width while holding peak power constant.

a number to the loudness of the second rf sound with reference to the first rf sound. The reference rf sound was selected as being approximately in the middle loudness range. A brief dim light signaled the subject that a trial would begin. After a variable period of up to 5 seconds, the reference rf sound was presented for 2 seconds. A silent period of approximately 5 seconds followed, and then the rf sound of variable loudness was presented for 2 seconds. The subject would then indicate with the hand switch the number he assigned to the loudness. On some occasions, in order to account for the possibility of false positives, no rf sound was presented at the time that the variable rf sound should have been presented. Before starting a session, the subject was given two warm-up trials. Each test condition (Table 1) is defined by a specific peak power, average power, pulse width, and pulse repetition rate. We randomized the order of presentation of these sets of rf parameter by using a table of random numbers. There were three randomized repetitions of the series.

The results are presented in Fig. 1. The point plotted for each test condition number represents the median of all subjects and all repetitions. The graph shown in Fig. 1A was derived from the results of a test series in which we studied the effect of varying the peak power while holding the average power constant, as specified in Table 1. The average power was held constant by varying the pulse width. The graph shown in Fig. 1B was derived from the results obtained in a series of tests in which the average power was allowed to vary while the peak power was held constant, as specified in Table 1. The data obtained were reliable, as is typical from trained subjects in psychophysical experiments. The curves fitted to the data are estimations and are intended only as a guide for the reader's eye. The precise shape or slope of the curves will require many more studies for definition because of the sensitivity of judgments of sensory magnitude to details of experimental procedure (*9*).

Once a minimum pulse width is used, perceived loudness is a function of peak power (Fig. 1, A and B). The location of the point for test condition 6 is inconsistent with what would be expected. The data represented by this point were obtained when a 10-μsec pulse width was used. Since a consideration of all the data shown in Fig. 1 indicates that this pulse width is outside the optimal band for loudness, we tested the possibility that the apparent inconsistency was due to the use of a nonoptimal pulse width. We therefore presented to the subjects the same peak power, but with a pulse width within the optimal band, that is, 40 μsec. The average of the data so obtained is represented by the square labeled *a* in Fig. 1A. Its location indicates that the apparent decrease in perceived loudness at test condition 6 is due more to the pulse width being less than optimal than to an actual decrease in perceived loudness at the high peak power level. The data plotted in Fig. 1B indicate that, in addition to an apparent minimum pulse width, there may be a maximum pulse width defining an optimal band of pulse widths for perceived loudness. It appears that average power does not determine loudness except when it is incidentally involved in producing a minimum pulse width for optimal effect.

In one test series, we varied the average power by changing the pulse repetition rate while holding the pulse width constant. We found that the quality of the sound is in part determined by the repetition rate. The subjects reported sounds that had pitch as well as timbre characteristics. This confused subjects who were instructed to judge loudness.

The data do not support the hypothesis of radiation pressure against the skin conveyed by bone conduction to the ear; the energy available is far below the threshold for bone conduction. Nor do the data support a mechanism involving radiation pressure against the tympanic membrane, external auditory meatus, or round window. For example, there are no significant effects of changing head orientation as would be expected if radiation pressure was an important factor. Moreover, a series in which the Gellé test (*10*) was used with plastic air tubes yielded negative results for rf sound and positive results for acoustic sound.

In summary, the perceived loudness of the rf sound as judged by the magnitude estimation technique, and within the limitation of the rf parameters investigated here, is a function of peak power rather than average power. Calculations from the data presented indicate that in this particular experiment, the peak power required for perception is somewhat less than 80 mw/cm^2. A band of optimal pulse widths seems to exist for the effect. There are also rf modulation parameters that cause subjects to report hearing "sounds" with definite pitch and timbre characteristics.

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8. Peak power is equal to the average power divided by the duty cycle.
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10. The Gellé test procedure is dependent on the fact that any force exerting sudden inward pressure on the stapes pushes the ossicles further into the oval window. This increases intralabyrinthine pressure and reduces sound perception, irrespective of whether the sound wave has reached the tympanum by air conduction or by bone conduction.
11. This work was supported by the U.S. Office of Naval Research and the U.S. Army.

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Thermoperiodic Control of Diapause in an Insect: Theory of Internal Coincidence

Abstract. *Females of the parasitic wasp* Nasonia vitripennis *raised from the egg stage in the total absence of light but subjected to daily temperature cycles (13° to 23°C), are able to distinguish a "short-day" thermoperiod (< 13 hours at 23°C per day) from a "long-day" thermoperiod (> 13 hours at 23°C per day) and produce diapausing or developing progeny accordingly.*

Many insect species develop continuously during the summer when days are long, but enter diapause in the autumn when the hours of light fall below the number necessary for a well-defined critical daylength (*1–3*). There is now substantial experimental evidence that photoperiodic induction of this nature—