

Audiological Findings Among Workers from Brazilian Small-Scale Fisheries

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Objective: The aim of this study was to examine the noise exposure and hearing of fishermen from small-scale fisheries from the state of Paraná in Brazil.

Design: Participants of this cross-sectional study included 141 male fishermen, ages ranging from 18 to 77 yr old and 136 controls matched by socioeconomic level, age, and gender. We conducted personal noise dosimetry and interviewed the fishermen regarding their hearing and their job. Audiological testing performed included pure-tone audiometry in the 0.5 to 8 kHz frequency range, extended high-frequency audiometry in the 9 to 16 kHz range, and transient and distortion-product otoacoustic emissions. Testing was preceded by a period of at least 14 hr without exposure to noise. Participants were subdivided in subgroups according to their noise exposure history.

Results: Sound level measurement results ranged from 38 to 58 L_{eq} dB (A) in vessels without an engine and between 90 and 108 L_{eq} dB (A) in vessels with an engine. Results from additional area sound level measurements conducted in five different seating locations in the 9HP engine boat ranged from 86 to 105 dB (A). Statistical analysis of the pure-tone audiometry results showed that fishermen with current or a history of occupational noise exposure had significantly poorer thresholds than controls or unexposed fishermen in several of the tested audiometric frequencies. Results of the otoacoustic emissions testing showed differences between exposed and unexposed groups regarding the presence of responses in bilateral amplitude and reproducibility at all frequency bands tested.

Conclusions: Because of the fishermen's increased risk of hearing disorders, a variety of solutions are recommended, which include dissemination of information on control of noise emissions generated by the boat engines, audiological care, and hearing loss prevention services tailored to workers from small-scale fisheries.

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INTRODUCTION

Brazil has one of the largest coastlines in the world, which exceeds 5000 miles. This favors commercial fishing and diving. Millions of workers are involved in this economic activity in Brazil, in a wide range of business types. Small-scale fisheries, often also referred to as artisanal fisheries, have various forms and modes of operation in the countries in which they are found, and they include labor-intensive catching of fish, postharvest treatment, and marketing of the catches (Food and Agriculture Organization of the United Nations, Regional Office for Asia and the Pacific, 2004). Small-scale fisheries operate at widely differing organizational levels ranging from self-employed single operators through informal microenterprises to formal sector businesses. In most settings, they supply seafood

to local and domestic markets, and for subsistence consumption. The small-scale fisheries subsector is characterized by its dispersed nature and by poor and marginalized populations, who are involved with it mainly as fishermen (Food and Agriculture Organization of the United Nations, Regional Office for Asia and the Pacific, 2004). This population is typically underserved in many aspects, with limited access to education and health services. Previous reports have shown different chronic health effects related to fishing activity, such as dermatological disorders, visual impairment, osteoarticular disease, and hearing loss (Axelsson, et al., 1986; Casson, et al., 1998; Inaoka, et al., 1992; Matheson, et al., 2001; Neitzel, et al., 2006; Rapisarda, et al., 2004), but these previous studies were conducted with larger, and more modern and sophisticated fishing operations than small-scale fisheries. Still, the profession is recognized as one of the most dangerous occupations today.

Fishermen can be exposed to many different sources of high-level noises and vibrations during their work shifts, which can exceed 8 hr. There are very few publications on the hearing of fishermen from large fishing operations, with data obtained through interviews or pure-tone audiometry. Despite being from countries with very different fishing methods, they are all in agreement that hearing loss is very prevalent among fishermen, and that this population is underserved regarding hearing loss prevention as well as other health promotion programs (Axelsson, et al., 1986; Casson, et al., 1998; Inaoka, et al., 1992; Matheson, et al., 2001; Neitzel, et al., 2006; Rapisarda, et al., 2004).

In the occupational arena, audiometry has been the main test used for hearing loss surveillance among workers exposed to noise. More recently, otoacoustic emissions and high-frequency audiometry have also been used as alternative tests in other occupational studies. In a population of workers, these alternative tests can contribute to hearing loss prevention by allowing the early detection of hearing disorders in subjects that show normal hearing ranges in conventional audiometry (Avan, et al., 1995; Kemp, 1978, 2002).

Both transient-evoked and distortion product otoacoustic emissions (TEOAEs and DPOAEs) have been used to investigate the effects of noise exposure on cochlear function, because both provide frequency-specific information. Moreover, it has been suggested that otoacoustic emissions are more sensitive tests of cochlear function than pure-tone audiometry, because they indicate subclinical cochlear damage that is often encountered in patients with noise-induced hearing loss (Balatsouras, 2004; Prasher & Sulkowski, 1999). Several authors have argued that otoacoustic emission testing can contribute to an early identification of noise-induced auditory effects (Avan & Bonfils, 2005; Avan, et al., 1995). However, until now there is

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no consensus on which protocol and which test (TEOAEs or DPOAEs) would be the most appropriate.

Since 2000, the Brazilian occupational safety and health research agency, FUNDACENTRO, in the Ministry of Labor and Employment, is developing a national safety, health, and environmental program dedicated to commercial fishing and diving activities, the Acqua Forum. As part of this initiative, the present study was designed to measure the sound pressure level of the noise exposure fishermen experience in vessels from small-scale fisheries and to evaluate the auditory effects of their occupation using pure-tone audiometry, high-frequency audiometry, and otoacoustic emissions testing.

MATERIALS AND METHODS

Leaders of five fishing communities of small-scale fisheries (Paranaguá, Pontal do Paraná, Antonina, Guaratuba, and Matinhos) in the coast of Paraná were contacted about the study. These leaders demonstrated interest in participating in this research because of the local population's overall health complaints, which included hearing difficulties. They disseminated information inviting fishermen to participate in the study and 150 fishermen volunteered. No precise data on the total number of fishermen in those communities exist, but membership in the studied communities is ~2900 individuals.

Participants were evaluated using a questionnaire, assessment of noise exposures, and an audiological test battery. The questionnaire gathered information on work history, nonoccupational noise exposure, lifestyle factors, and medical history. Exposure assessments included data collected from interviews and site measurements of noise levels aboard different types of boats.

The present study was approved by the Committee of Ethics at the University Tuiuti do Paraná and the Brazilian National System of Information of Research Ethics, process number 94/2004. All participants signed an informed consent form before participating in the study.

Study Population

Of the 150 volunteers, 141 met the eligibility criteria and participated in the study. Six men were excluded because they showed middle ear alterations and were referred for medical treatment of their condition, whereas three had <2 yr of work experience in this activity. The participants' age ranged from 18 to 77 yr old. Because of the socioeconomic profile of the study group, the audiometric results of 136 gender and age matched controls (with no history of occupational noise exposure) from a similar socioeconomic group were obtained from the data base of the Audiology Laboratory at the University of Tuiuti in Paraná for comparison purposes. Since 1998, all new hires of the University (professional, technical and support personnel) have had their hearing tested at the University Audiology Laboratory and asked if the data obtained can be used for research purposes without personal identifiers. Medical and work histories are also obtained at the occasion of the testing and entered in the data base. The same opportunity is offered at the time of an employee's termination.

The fishermen were divided into four groups: (1) 74 fishermen [mean age 42 ± 12 (SD) yr old] who worked in small vessels with an engine, and who had no history of occupational noise exposure; (2) 30 fishermen [mean age

51 ± 11 (SD) yr old] who worked in small vessels with an engine, with a history of occupational noise exposure, either as a fisherman or in any other occupation; (3) 19 fishermen [mean age 40 ± 12 (SD) yr old] who worked in small vessels without an engine, who had no history of occupational noise exposure; (4) 18 fishermen [mean age 50 ± 13 (SD) yr old] who worked in small vessels without an engine, who had a history of occupational noise exposure. In addition, 136 nonexposed male adults without a history of ear disease or occupational noise exposure served as gender and age-matched controls.

Noise Measurements

Fishermen's noise exposures were evaluated aboard the small vessels through area sound level measurements and personal exposure measurements. Area measurements were made using a type 1 integrating sound level meter (Bruel & Kjaer, model 2230), which conformed to the American National Standards Institute S1.4 (1983; R2006) specification. A total of four personal exposure measurements were obtained. These measurements were made using a type 2 noise dosimeter (Bruel & Kjaer, model 4431) that conforms to the American National Standards Institute S1.25 (1991; R2007) specification. The equipment manufacturer recommended procedures were used.

An engineer from FUNDACENTRO conducted the measurements in the different working spots aboard the small vessels. The model 2230 integrating sound level meter was handled by the engineer and held next ($\sim 150 \pm 50$ mm) to the worker's ear, in the horizontal plane of the ear canal. The model 4431 dosimeters had the microphones clipped to the fishermen's lapel, also close to their ears. Measurements were done for both ears and the result from the side where the sound pressure level was higher was recorded. The position of the engineer and the measurement equipment in relation to the fisherman was taken into consideration to cause minimum perturbation in the acoustic field. The direction of the microphones considered the type of acoustic field and the specific response characteristics of the equipment's microphones.

The equipment was calibrated before data collection. Field calibrations were conducted before and after measurements using a type 4230 sound level calibrator from Bruel & Kjaer. The measurements were taken with the use of a windscreen.

The noise exposure metrics provided by the instruments and reported in this study are (a) A-weighted, equivalent continuous sound level (L_{eq}) to indicate the average sound level based on a 3-dB exchange rate; (b) A-weighted, average sound level (L_{av}) to indicate the average sound level based on a 5-dB exchange rate; and (c) A-weighted, maximum level (L_{max}) indicating the highest sound pressure level that occurred during the measurement period.

The fishermen's work shifts often exceeded 8 hr, sometimes reaching 24 hr. They frequently work without breaking for weekends during peak season. When data collection took place, fishermen were working from 4 or 5 A.M. until 7 or 8 P.M. The sampling period ranged from 4 to 9 hr.

Audiological Assessment

A Volkswagen bus, modified into a mobile laboratory, was equipped with a sound-treated booth that met the requirements

TABLE 1. Results for equivalent sound levels (L_{eq}) for the measurement period based on a 3-dB exchange rate, average sound levels (L_{avg}) for the measurement duration based on a 5-dB exchange rate and maximum level (L_{max}), by type of vessel

Type of boat and engine	No. fishing trips	L_{eq} dB (A)	L_{max} dB (A)	From dosimetry L_{av} dB (A)	Measurement duration (hr)
Row boat (no engine)	6	38-58	51-72	—	6
Canoe with 9 HP engine	4	90-93	100-105	77-92	6-9
Whaler 4 cylinders engine	1	—	—	80	6
Whaler 9 HP engine (no muffler)	1	108	112	—	4 (high throttle)
Whaler, 11 HP engine	1	97	106	96	6
Whaler, 13 HP engine (with and without muffler)	3	95-104	104-114	—	4-5 (high throttle)
Whaler, 18 HP engine (with and without muffler)	2	98-108	106-112	—	4

of American National Standards Institute S 3.1 (1991) for audiometric testing environments. The mobile unit was parked outside the fishermen's associations, which were located on quiet streets. In-booth sound levels were evaluated before the beginning of testing. The audiological tests were conducted by certified audiologists.

Before testing, we confirmed with each participant that he had been away from noise exposure for at least 14 hr, which was a condition for the testing. To assess the worker's hearing status, otoscopy, pure-tone audiometry, immittance audiometry, TEOAEs, and DPOAEs were performed. Otoscopy and tympanometry were performed to screen for conditions that would exclude the person from the study, that is, external otitis, perforated tympanic membrane, or tympanogram tracing type B. Only participants with a type A curve in both ears were included in the study.

Pure-tone audiometry • Pure-tone audiometry was performed for all subjects at the frequencies of 0.5, 1, 2, 3, 4, 6, 8, 9, 10, 11.2, 12.5, 14, and 16 kHz. In the 0.5 to 8 kHz range, thresholds were considered as normal if they were ≤ 25 dB HL. Bone conduction testing was performed for the affected frequencies in the range of 0.5 to 4 kHz. The interacoustics air conduction 40 audiometer was calibrated following ISO R389-1964 standard before the data collection. TDH 39 and KOSS HV/PRO earphones were used for pure-tone and high-frequency audiometry, respectively. Daily biological calibration checks were also performed immediately before testing subjects. The results of the audiometric thresholds group comparisons were analyzed using a Mann-Whitney test.

Otoacoustic emissions • The Otodynamics Ltd ILO92 Research OAE System was used for the Evoked Otoacoustic Emission tests.

TEOAE testing • Each TEOAE test was conducted with the noise-rejection level at 47.3 dB peak. The transient stimulus used was a nonlinear click, at an intensity of 80 dB SPL. The stability of the probe was always $>80\%$, and it was calibrated before data collection each day using the probe test option (in the ILO menu) and a 1-cc acoustic calibration cavity.

Reproducibility of 50% or greater, with an amplitude of response ≥ 3 dB was used as the response criterion for TEOAEs (Kemp, 2002). We evaluated the presence of response by frequency bands or in three consecutive frequency bands in both the study and control groups, as

proposed by Prieve et al. (1993). The results for the group comparisons were analyzed using the Mann-Whitney test.

DPOAE testing • The primary frequencies selected for evaluation were the geometric means of f_1 and f_2 at 1, 1.5, 2, 2.5, 3, 4, 5, and 6 kHz, using primary levels (L_1/L_2) of 65/55 dB SPL and a primary ratio (f_2/f_1) of 1.22. The number of data points collected per octave was 3. DPOAE levels had to be 6 dB above the first standard deviation or 3 dB above the second standard deviation of the noise floor, as proposed by Gorga et al. (1993). The absolute amplitudes recorded were also analyzed using the Mann-Whitney test.

RESULTS

Noise Measurements

The duration of each measurement and the results for average sound levels for the measurement period based on either a 5-dB exchange rate (L_{avg} 5) or a 3-dB exchange rate (L_{eq}) can be seen in Table 1. Noise was continuous throughout the duration of the fishing trip, regardless of the trip duration. Different results correspond to different boats, not trips.

The 9HP engine boat was the most common type of boat used in this community. Additional area sound level measurements conducted in five different seating locations in the 9HP engine boat ranged from 86 to 105 dB (A).

Interview

The fishermen's work routine is highly variable and influenced by season and weather conditions. Often they have extended work shifts and potential for 24-hr exposures to high noise. Among the 141 fishermen, only 13 (9%) of them reported having had previous hearing evaluations, although 73 (52%) believed that they had some kind of hearing impairment and 92% indicated they believed that engine noise could damage their hearing. Table 2 displays the auditory complaints and other health problems reported by the fishermen in the study.

Audiological Testing

Pure-tone audiometry • Both mean and median audiometric thresholds were calculated. These were not significantly different from one another, so we opted to report median values. Table 3 displays the results of the classification of the audiograms of all the study participants. Audiograms were

TABLE 2. Number and percentage of health conditions and auditory complaints among the fishermen, by group

Questions	Group	Group	Group	Group
	1 N (%)	2 N (%)	3 N (%)	4 N (%)
Believes engine noise can hurt hearing	71 (96)	28 (93)	15 (79)	16 (89)
Had hearing tested before	7 (9)	4 (13)	1 (5)	1 (6)
Cannot hear well, right ear	16 (22)	4 (13)	1 (5)	4 (22)
Cannot hear well, left ear	12 (16)	3 (10)	3 (15)	4 (22)
Cannot hear well, both ears	19 (25)	7 (23)	2 (10)	3 (16)
Sensitivity to loud sounds	45 (60)	19 (63)	11 (57)	11 (61)
Earache	41 (51)	15 (50)	12 (63)	11 (61)
Vertigo	23 (31)	14 (46)	4 (21)	10 (56)
Tinnitus	56 (76)	25 (83)	10 (52)	14 (78)
Hypertension	16 (22)	10 (33)	2 (11)	7 (39)
Meningitis	2 (3)	2 (7)	1 (5)	0 (0)
Malaria	2 (3)	8 (27)	0 (0)	1 (6)
Diabetes	1 (1)	0 (0)	0 (0)	0 (0)
Chicken pox	42 (57)	20 (67)	9 (48)	8 (44)
Heart disease	4 (54)	4 (13)	0 (0)	3 (17)
High cholesterol	0 (0)	2 (7)	2 (11)	5 (28)
Head trauma	1 (1)	0 (0)	0 (0)	3 (17)
Total	74 (100)	30 (100)	19 (100)	18 (100)

classified based on the results in the 0.5 to 8 kHz range. They were considered normal if all thresholds were ≤ 25 dB HL; high-frequency loss if the pattern of a "notch" was observed bilaterally and thresholds exceeded 25 dB in the 3 to 8 kHz range, or other configurations if there was no notch configuration, but thresholds exceeded 25 dB HL. A notch was defined as a recovery of 5 dB or more at the higher frequency adjacent to the poorest threshold at 3, 4, or 6 kHz.

The thresholds of the fishermen with current or previous exposures to noise were poorer than the thresholds of their respective controls. Figure 1 displays the fishermen and control group median response values for the pure-tone and high-frequency audiometry in each ear.

Otoacoustic emissions • Figure 2 displays the percentage of individuals, with presence of a TEOAE response, using the criterion proposed by Prieve et al. (1993) of presence of response in at least three consecutive frequency bands, by group. Table 4 displays the number and percentage of individuals with presence of a TEOAE response, by frequency band, by groups, and the results of the Mann-Whitney test for group comparisons between each subgroup of fishermen and their

respective controls. TEOAE responses were absent much more frequently among fishermen than in their controls, irrespective of the noise exposure history.

Table 5 provides the results of the Mann-Whitney test for group comparisons of absolute amplitudes of the DPOAE results, by ear, between the subgroup of fishermen and their respective controls. The results of the fishermen who had a history of both current and previous noise exposure revealed statistically significant differences in absolute amplitudes in most of the tested frequencies. Such differences were not observed in the group with no history of past or present noise exposure and only observed for a few test frequencies in the group with a history of past noise exposure.

DISCUSSION

One of the main economic activities on the coastline of the state of Parana is small-scale fishing (Ministério do Trabalho e Emprego, 2005), important only for regional economy with little representation in the national scenario. It is considered artisan fishing. The present study is the first to evaluate the hearing of fishermen from small-scale fisheries with a battery of audiological tests (pure-tone audiometry, high-frequency audiometry, and otoacoustic emissions), and to evaluate it in relation with their noise exposure.

Sound level measurement results ranged from 38 to 58 L_{eq} dB (A) in vessels without an engine and between 90 and 108 L_{eq} dB (A) in vessels with an engine. Similar ranges of noise levels have been reported previously (Martinis, 1977), and even higher levels have been reported for larger fishing vessels (Axelsson, et al., 1986; Casson, et al., 1998; Inaoka, et al., 1992; Matheson, et al., 2001; Neitzel, et al., 2006). The International Maritime Organization (1982) exposure limits are 85, 83, and 80 for 8-, 12-, and 24-hr shifts, respectively. A 3-dB exchange rate is used in the calculation of time-weighted averages. The International Maritime Organization guidelines reflect the potential for 24-hr exposure to noise in the fishing industry.

In the present investigation, we measured sound levels to evaluate the noise levels in small-scale fishing operations. Despite being able to perform limited measurements, our results are representative of their working conditions and revealed exposure scenarios that could explain the auditory disorders reported and observed. However, to study damage-risk relationships one would need to fully evaluate their noise exposure, which can be quite challenging but necessary for proposing guidelines for safe working conditions. The fishermen work routine is variable and unpredictable. To do a proper exposure characterization in such

TABLE 3. Audiometric classifications with the thresholds in the 0.5-8 kHz range, by each exposure history group and their respective controls (identified by the letter C). Audiometric thresholds were considered as normal if they were equal or < 25 dB HL; if a notch was present bilaterally in the 3-6 kHz range, the audiogram was classified as "high-frequency" loss; other configurations were used when neither of the 2 previous criteria was met

Group/Configuration	1	1 C	2	2 C	3	3 C	4	4 C
	n (%)							
Normal	10 (13)	61 (85)	1 (3)	21 (75)	12 (63)	15 (79)	5 (28)	10 (59)
High-frequency hearing loss	61 (82)	11 (5)	27 (90)	7 (25)	5 (26)	4 (21)	12 (67)	7 (41)
Other configurations	3 (4)	0 (0)	2 (7)	0 (0)	2 (10)	0 (0)	1 (5)	0 (0)
Total	74 (100)	72 (100)	30 (100)	28 (100)	19 (100)	19 (100)	18 (100)	17 (100)

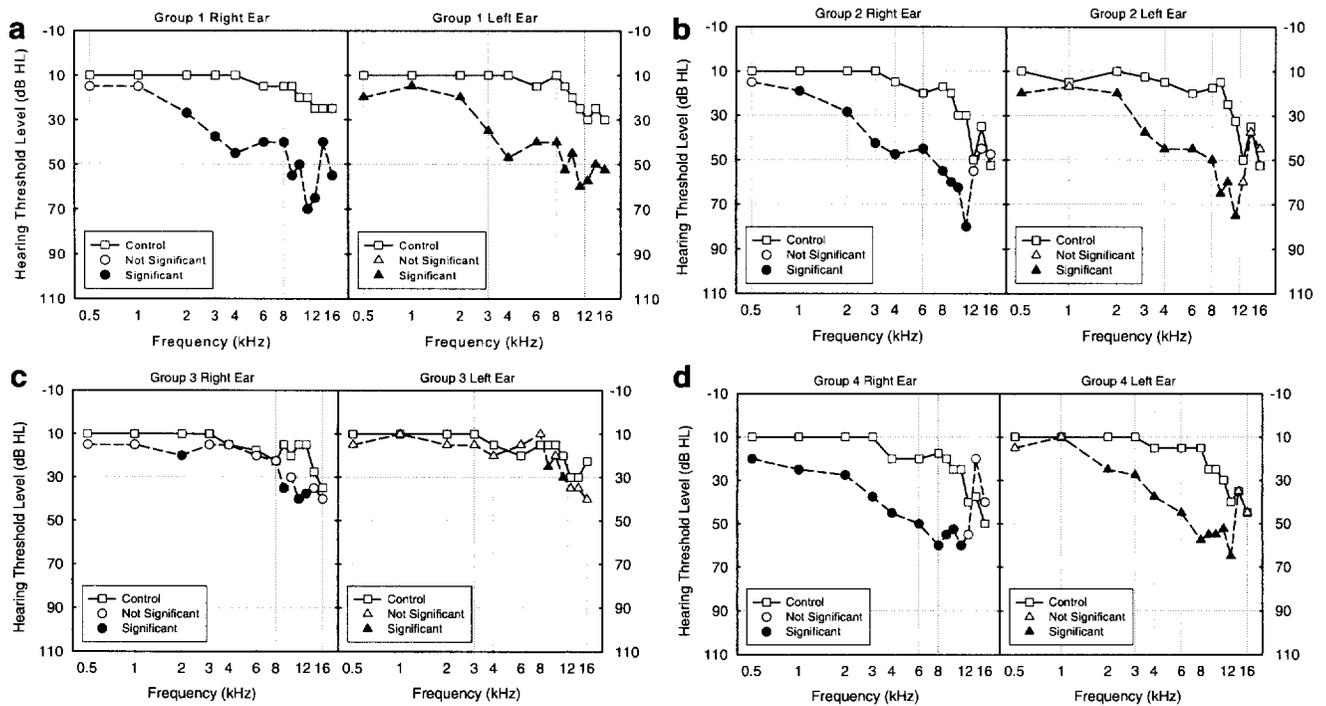


Fig. 1. a-d, Median audiometric thresholds of the study groups of fishermen and their respective controls, by ear (open circles indicate right ear thresholds of the fishermen for which differences from their controls are not statistically significant; filled circles indicate right ear thresholds of the fishermen for which differences from their controls are statistically significant; hollow triangles indicate left ear thresholds of the fishermen for which differences from their controls are not statistically significant; filled triangles indicate left ear thresholds of the fishermen for which differences from their controls are statistically significant; and squares indicate the thresholds of the controls).

circumstances would require performing dosimetry for an extensive period of time. Such time and resources were not available for this study. Still, the information gathered indicates that control measures to limit the amount of noise emissions from boat engines should be promoted and facilitated. Certainly, this would be challenging, because this population is composed of self-employed workers for whom there is no organized advocacy to get them to adhere to noise control or hearing loss prevention programs. Moreover, regulatory requirements would be difficult to enforce. The alternative seems to be the dissemination of

information on noise control approaches that would be easy to implement and affordable.

The results of the sound pressure level measurements in the small vessels with an engine showed that these fishermen were exposed to high-level sounds. Despite these results and the knowledge demonstrated in the questionnaire that they are aware of the risk of hearing loss from noise exposure, none of the fishermen studied wears hearing protectors. The fishermen's work routine varied according to several factors, as well as the work shift length, which

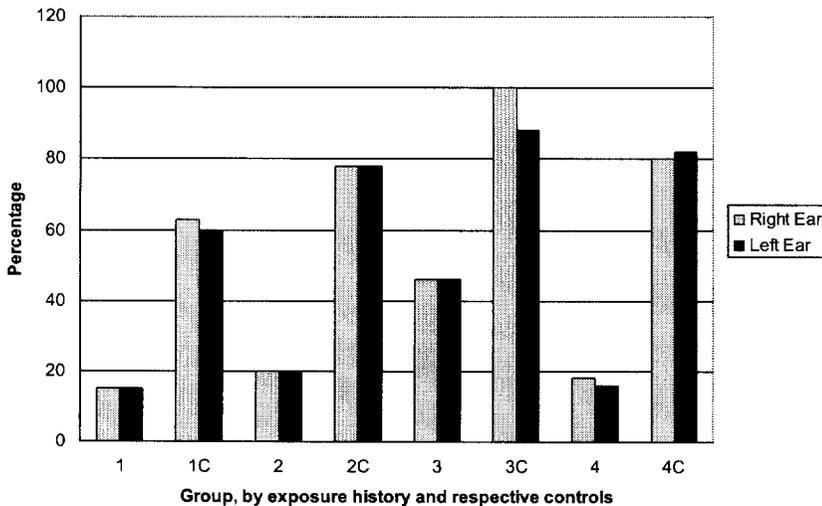


Fig. 2. Percentage of ears with presence of a TEOAE response for at least three consecutive test frequencies (Prieve, et al., 1993), by group, by ear.

TABLE 4. Number and percentage of ears with presence of a TEOAE response by test frequency, by group, by ear (RE, right ear; LE, left ear), and respective results of the Mann-Whitney test for group comparisons between the subgroup of fishermen and their respective controls, identified by the letter C

Presence of response	1	1 C	2	2 C	3	3 C	4	4 C
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
1 kHz RE	32 (43) $z = -4.8885$ $p = 0.0000$	58 (80)	8 (27) $z = -2.75725$ $p = 0.0058$	23 (82)	6 (31) $z = -2.74088$ $p = 0.0061$	16 (84)	5 (28) $z = -2.41698$ $p = 0.0156$	14 (82)
1 kHz LE	29 (39) $z = -3.85313$ $p = 0.0001$	55 (76)	12 (40) $z = -2.04129$ $p = 0.0468$	22 (78)	8 (42) $z = -2.38119$ $p = 0.0172$	14 (74)	6 (33) $z = -3.40212$ $p = 0.0006$	15 (88)
2 kHz RE	27 (36) $z = -6.19450$ $p = 0.0000$	66 (92)	13 (43) $z = -3.70783$ $p = 0.0002$	27 (96)	7 (37) $z = -2.69203$ $p = 0.0071$	19 (100)	7 (39) $z = -3.63987$ $p = 0.0002$	16 (94)
2 kHz LE	28 (38) $z = -5.40067$ $p = 0.0000$	59 (82)	11 (37) $z = -3.52769$ $p = 0.0004$	24 (86)	9 (47) $z = -2.46617$ $p = 0.0136$	17 (89)	7 (39) $z = -3.12388$ $p = 0.0017$	15 (88)
3 kHz RE	15 (20) $z = -5.67753$ $p = 0.0000$	49 (68)	8 (27) $z = -3.39000$ $p = 0.0006$	21 (75)	7 (37) $z = -2.04481$ $p = 0.0408$	19 (100)	6 (33) $z = -2.83315$ $p = 0.0046$	14 (82)
3 kHz LE	11 (15) $z = -5.50389$ $p = 0.0000$	46 (64)	6 (20) $z = -3.63000$ $p = 0.0002$	21 (75)	8 (42) $z = -0.95719$ $p = 0.3384$	15 (79)	3 (17) $z = -3.74740$ $p = 0.0001$	15 (88)
4 kHz RE	3 (4) $z = -5.07857$ $p = 0.0000$	32 (44)	4 (13) $z = -2.16040$ $p = 0.0307$	13 (46)	4 (21) $z = -1.97098$ $p = 0.048$	15 (79)	3 (17) $z = -1.71028$ $p = 0.0872$	9 (53)
4 kHz LE	8 (11) $z = -4.85717$ $p = 0.0000$	31 (43)	3 (10) $z = -3.68280$ $p = 0.0002$	15 (53)	5 (26) $z = -2.19321$ $p = 0.0282$	11 (58)	2 (11) $z = -3.04538$ $p = 0.0023$	12 (0)

Statistical significance level selected was $\alpha = 0.05$ (5%).

sometimes exceeded 24 hr. During data collection, shrimp fishing was prohibited for seasonal reasons. Fishermen reported that is the loudest activity they engage in, because the vessels' engine is always at high throttle when they fish for shrimp. As displayed in Table 1, the high-throttle condition significantly raises the noise levels to which fishermen are exposed and consequently the noise doses.

Previous studies, which vary by country, scale, and sophistication of the fishing operation and type of fishing activity and boat, all reported high-noise exposures (Axelsson, et al., 1986; Casson, et al., 1998; Inaoka, et al., 1992; Matheson, et al., 2001; Neitzel, et al., 2006). Moreover, they have indicated that

TABLE 5. Results of the Mann-Whitney test for group comparisons of absolute amplitudes of the DPOAE results, by test frequency, by ear (RE, right ear; LE, left ear), between the subgroup of fishermen and their respective controls

Test frequency	Group 1		Group 2		Group 3		Group 4	
	RE	LE	RE	LE	RE	LE	RE	LE
1001	*	*	*	*	—	—	—	—
1257	—	—	*	*	—	—	—	—
1587	—	—	—	*	—	—	—	*
2002	—	*	*	*	—	—	—	*
2515	*	*	—	*	—	—	—	—
3174	*	*	—	—	—	—	—	—
4004	*	*	—	—	—	—	*	—
5042	*	*	—	—	—	—	—	—
6348	*	—	*	*	—	—	—	—

* Statistical significance level selected was $\alpha = 0.05$ (5%).

instead of the traditional 8-hr shift for 5-day weeks, fishermen usually work continually for multiple days with no breaks outside a noisy environment. In some types of vessels, fishermen can also be exposed to high-level noise caused by the engine during their sleep. In addition, the work conditions present other hazards such as whole-body vibration, exposure to bad weather conditions, sleep deprivation, night work, strenuous work, exposure to ototoxic agents such as carbon monoxide, etc.

Regarding their hearing, the results of the present study generally agree with the very limited literature available on the hearing of fishermen, despite its focus being on fishermen from small-scale fisheries. All of the studied groups had worse hearing when compared with age and gender-matched unexposed controls, from other occupations. The group with no history of past or present noise exposure had audiometric thresholds that were mostly in agreement with their age-matched control, with a few exceptions in isolated frequencies. Sixty-three percent of the fishermen who work in vessels without an engine and no history of noise exposure had normal audiograms bilaterally; the largest percentage of all groups. A high percentage (82% and 90%) of the participants who worked in boats with an engine had hearing losses with the high-frequency notch configuration. Twenty-six percent of the fishermen in this group had sensorineural hearing loss, whereas 67% of those who also worked in boats without an engine but had a history of occupational noise exposure had the same type of hearing loss.

Overall, the group with poorest thresholds was the one that had current and previous history of noise exposure, followed by the noise exposed group with no history of previous exposure. The results found in this study could be explained by the high-level

noise and long duration work found in fishing activity. In a study with 529 Swedish fishermen conducted by Axelsson et al. (1986) a decrease of the hearing threshold at 2 to 8 kHz was observed, with the poorest thresholds being registered at 6 kHz. The same study showed that 40% of the fishermen considered themselves exposed to high-level sounds but they only used hearing protection occasionally inside the vessel's engine room.

Auditory complaints, including tinnitus, difficulty in hearing, sensitivity to loud sounds, and earache were very common among study participants of all exposure groups. It is possible that fishermen with hearing symptoms were more likely to participate in the present study than those without hearing difficulties (self-selection bias). A precise estimation of the prevalence of hearing disorders among fishermen requires a larger investigation with a different method of recruiting subjects.

The high-frequency audiometry detected differences between the groups that were not shown in the routine audiometric range. When we compared the high-frequency thresholds of the fishermen and the unexposed age-matched controls, statistically significant differences were found, even for those who have not been exposed to high-level noise. The results obtained from the fishermen groups and the control groups were different when TEOAE values were compared. The results among the fishermen showed a higher percentage of responses in three consecutive frequencies in group 3 (fishermen who work in boats with no engine) and a lower percentage of responses in group 1 (with current and past exposure to noise). TEOAE responses were absent for 42.5% of the fishermen who had normal audiograms. This confirms that TEOAEs may play an important role in the early detection of hearing dysfunction. The TEOAEs results were a bit puzzling, because even the group with no history of past or present noise exposure had a poorer performance than their age-matched controls. The evidence suggests that neither age (controls were age matched) nor noise exposure history could explain their results. Possibly other factors in their occupational or social group could be involved in this result.

The DPOAE results also showed statistically significant difference when we were comparing the fishermen groups and their controls, indicating cochlear dysfunction; but in this case differences could more easily be attributed to their noise exposure, because they varied by exposure group.

The findings of the present study confirm that working in the fishing industry can be hazardous to hearing. Noise exposure is often a risk factor for hearing loss, but risk factors to hearing other than noise might exist in this occupation, such as weather conditions, vibration, and chemical exposures. Socioeconomic factors are also likely to play a role because this population has limited access to health care.

CONCLUSION

The sound pressure levels associated with work in small-scale fisheries in vessels with an engine are higher than the permissible exposure levels recommended by the International Maritime Organization. This study revealed a significant difference in the audiological examinations conducted in this population compared with unexposed controls from different occupations. The present results indicate the importance of controlling noise exposure in small fishing vessels and developing hearing loss prevention strategies specific to these workers.

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