CHARACTERIZATION OF NOISE LEVELS IN BERTHING AREAS ABOARD A U. S. NAVY AIRCRAFT CARRIER DURING FLIGHT OPERATIONS

by

LCDR Andrew J. Hunter

Industrial Hygiene Officer

United States Navy

Thesis submitted to the Faculty of the
Preventative Medicine and Biostatistics Graduate Program
Uniformed Services University of the Health Sciences
In partial fulfillment of the requirements for the degree of
Master of Science in Public Health 2018

Distribution Statement

Distribution A: Public Release.

FINAL EXAMINATION/ PRIVATE DEFENSE FOR THE DEGREE OF MASTER OF SCIENCE IN PUBLIC HEALTH IN THE DEPARTMENT OF PREVENTIVE MEDICINE AND BIOSTATISTICS

Name of Student: Andrew Hunter

Date of Examination: June 15, 2018

Time: 10:00 AM

Place: OEHS Conference Room

DECISION OF EXAMINATION COMMITTEE MEMBERS:

	PASS	FAIL
[redacted] N. Cody Schaal, PhD, CIH, CSP, LCDR, MSC, USN DEPARTMENT OF PREVENTIVE MEDICINE & BIOSTATISTICS Committee Chair	X	
[redacted] Maria Majar, MS, CIH, CSP, CAPT, MSC, USN DEPARTMENT OF PREVENTIVE MEDICINE & BIOSTATISTICS Thesis Advisor	X	
[redacted] William Whitaker, MS, LTC, MS, USA DEPARTMENT OF PREVENTIVE MEDICINE & BIOSTATISTICS Committee Member	X	

APPROVAL FOR THE MASTER OF SCIENCE IN PUBLIC HEALTH THESIS IN THE DEPARTMENT OF PREVENTIVE MEDICINE AND BIOSTATISTICS

Title of Thesis: "Characterization of Noise Levels in Berthing Areas Aboard a US Navy Aircraft Carrier During Flight Operations"

Name of Candidate: Andrew Hunter
Master of Science in Public Health
June 15, 2018

THESIS AND ABSTRACT APPROVED:

DATE:

[redacted] X 20 Jun 2018

N. Cody Schaal, PhD, CIH, CSP, LCDR, MSC, USN
DEPARTMENT OF PREVENTIVE MEDICINE & BIOSTATISTICS
Committee Chair

[redacted] X 15 Jun 2018

Maria Majar, MS, CIH, CSP, CAPT, MSC, USN
DEPARTMENT OF PREVENTIVE MEDICINE & BIOSTATISTICS
Thesis Advisor

[redacted] X 15 Jun 2018

William Whitaker, MS, LTC, MS, USA
DEPARTMENT OF PREVENTIVE MEDICINE & BIOSTATISTICS
Committee Member

ACKNOWLEDGEMENTS

I would like to thank all of the instructors and staff at USUHS and their part for helping me along my journey in earning my degree. I would like to specifically acknowledge and thank my research committee, CAPT Maria Majar, LCDR Cody N. Schaal and LCOL William Whitaker. Their wealth of knowledge, patience and persistence allowed me to complete this program. I recognize that these personnel are challenged with not just teaching the subject matter, which is often foreign to many students, but they are also challenged with motivating and molding those who have been far removed from academia, often for years. The duty to develop the minds of soldiers, sailors, airmen and public health officers turned students and challenging them to think scientifically is a great undertaking, and the enthusiasm with which they do it is truly inspiring.

DEDICATION

This study is dedicated to my father, ATC (Ret) William Paul Hunter. My father's determination to pursue higher education for himself after retiring from the Navy provided a significant source of inspiration for me to achieve lifelong learning.

COPYRIGHT STATEMENT

ABSTRACT

Background: Occupational hearing loss is one of the most common work-related illnesses in the United States (20). Navy personnel working on the flight deck of aircraft carriers are required to work 12-14 hours in noise hazardous environments ranging from 125 -150+ dBA making auditory recovery during off duty hours critical in preventing permanent hearing loss. Sleeping areas (berthing), designed for auditory rest, may be located directly below the flight deck (2). The objective of this study was to characterize and perform descriptive statistical analysis of noise exposures to determine if berthing spaces are effective areas of auditory rest.

Methods: Sound level meters with octave band analyzers were used to collect noise measurements in eight berthing areas located directly below the flight deck during both flight and non-flight operations. A total of 58 samples were taken, with each sample taken during a four-hour interval, that included octave band analysis at 16 Hz - 16 kHz center band frequencies. Average equivalent continuous levels (Leqs) were compared to auditory rest criteria. Differences in Leqs at each frequency were assessed according to berthing spaces.

Results: Eighty-seven percent of berthing spaces exceeded 70 dBA, which is the ACGIH recommended limit for 24-hour environmental noise exposure and is applicable for areas of auditory recovery. The predominant frequencies throughout the spaces were 1 & 2 kHz with Leqs ranging from 61.6 dB – 86.4 dB. Forward locations had the highest noise levels with a mean Leq of 81.2 dB while mid and aft berthing locations had mean Leqs of 78.5 dB and 61.6 dB respectively.

Conclusion: Measurements indicate that during flight operations, noise exposure in berthing spaces directly below the flight deck may lead to an increased risk of developing hearing loss by minimizing opportunity for auditory rest during off-duty hours. Control of mid-high frequency noise in berthing spaces may present the best opportunity in reducing noise exposures and allowing adequate auditory rest.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

Statement of purpose

The objective of this study was to measure noise levels and perform descriptive statistical analysis of these measurements in berthing (living spaces) located directly beneath the flight deck to determine their effectiveness as areas of auditory rest for personnel who are routinely exposed to hazardous noise. This was accomplished by measuring sound pressure levels (SPLs) at standardized octave band center frequencies within each berthing location.

Background and significance

The human ear has an ability to detect a wide range of sound intensities ranging from faint whispers to large reverberations at various frequencies. The range of audible sound intensities perceptible to the ear is six orders of magnitude from a faint whisper to the threshold of pain. When sound is unwanted it is it is classified as noise and when this noise is of such intensity that it can cause damage to the hearing it is classified as hazardous noise (11).

Hazardous noise can be created by a variety of mechanisms and when this hazardous noise is generated in the workplace it can cause occupational noise induced hearing loss. In general, there are three types of hearing loss: conductive, sensorineural, and mixed. Sensorineural hearing loss is the most common type of hearing loss, and it is caused by damage to the receptor hair cells in the cochlea. The cochlea receptor hair cells transmit mechanical motion caused by sound into action potentials, and repeated exposure to high intensity noise can overstimulate these cells and cause structural damage. (12) Once damaged these receptor hair cells are usually incapable of self-repair and hence sensorineural hearing loss is normally permanent. (17) However, if personnel are given the opportunity to go into an auditory rest area with reduced noise levels then recovery may occur with time. Temporary Threshold Shifts (TTS) are defined as recoverable while Permanent Threshold Shifts (PTS) are permanent shifts in the auditory threshold that results in permanent hearing loss (11). In addition to the direct hazard from noise, personnel who work in industrial environments and are also exposed to lead, cadmium, arsenic, toluene, and xylene while being exposed to hazardous noise are at in increased risk for hearing loss (23). The health risks from exposure to hazardous noise are not limited to only hearing loss and there is sufficient scientific evidence that noise exposure can also induce hypertension and ischemic heart disease, annoyance, sleep disturbance, and decreased school performance (22).

With increased technological advances and the development of machinery beginning with the industrial revolution, the amount of hazardous noise being produced is now at levels that has made noise induced hearing loss (NIHL) a common diagnosis (21). This exposure to hazardous noise has now become ubiquitous and can be present in the home, in the local community and most often times at work.

Occupational hearing loss is one of the most common work-related illnesses in the United States and according to the National Institute for Occupational Safety and Health (NIOSH), each year about twenty-two million U.S. workers are exposed to hazardous noise levels at work. In addition to the economic costs associated with occupational hearing loss, there are also non-monetary costs such as a decreased quality of life to workers. (20)

According to the Occupational Safety and Health Administration (OSHA) Twenty-two million workers are exposed to potentially damaging noise at work each year and in 2017, U.S. business paid more than $1.5 million in penalties for not protecting workers from noise. (21) Each year an estimated $242 million is spent on workers' compensation for hearing loss disability (21).

To adequately protect people from noise it is important to be able to quantify sound levels. Sound levels are measured in units called the Bel in honor of Alexander Graham Bell (6). The unit of the Bel is equal to ½ ln(10) Np (Neper). The unit of a Neper is defined as equal to natural log of *e* to establish a field quantity which changes by a factor of *e*, and the Neper recognizes the Scottish mathematician John Napier, the inventor of the logarithm (6). Relating the Bel to the Neper is appropriate as the unit of Bel is large and makes it difficult to describe subtle changes in sound levels. This difficulty in describing subtle changes resulted in more widespread use of a tenth of a Bel, which is the deciBel. With increased use the deciBel was eventually changed to the common writing of "decibel". The decibel (dB) is a logarithmic based unit so when a source with power P is doubled to 2P the increase is described as an addition of 3 dB.

A consideration for sound is not just the intensity of the sound but also frequency as a normal human ear is able to hear sounds with frequencies from 20 Hz to 20,000 Hz and this range is appropriately called the audible frequency range. (5) Within this audible frequency range, the perceived level of loudness by human beings is not the same for all frequencies of sound of the same power. If intensity was equal among sounds, certain frequencies would be more likely to cause hearing loss than others. Ear physiology means that noises in the 3,000 Hz to 6,000 Hz range are the most damaging (11). Sounds in the very low and very high frequency range are not perceived as loud as a sound of equal energy in the middle range, such as at 2,000 Hz. Due to this perception of loudness by human beings the “A” weighting for sound was established. There are other weighting scales for sound such as the “C” weighting, which has a flatter response compared to the “A” weighting, where low frequencies are discriminated against. An important weighting scale is the zero, which is also known as the Z weighting. This weighting was introduced in 2003 as an International Standard to replace flat or linear frequency weighting. The flat or linear weightings were established by manufacturers which resulted in different readings depending on the sound level meter used, especially with peak sound measurements.

To aid in preventing noise induced hearing loss, limits have been established by various organizations and agencies to monitor the work environment for hazardous noise. OSHA’s permissible exposure limit (PEL) is 90 dBA as an eight-hour time weighted average (TWA) and action level (AL) is 85 dBA which is the level when hearing conservation program implementation is required (21). An averaging time of 8 hours for the TWA is based upon a typical 8-hour work day. This time may be adjusted for longer or shorter work shifts such as a 4-hour, 12 hours or 24-hour work shift. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends a threshold limit value (TLV) of 80 dBA for 24-hour exposures (7). These recommendations are based on the assumption that there will be time away from the workplace to rest and sleep after noise exposure. However, when an employee’s work and living spaces are the same, such as on an oil platform or on a ship, ACGIH recommends that these living spaces, which provide auditory rest, have noise levels at or below 70 dBA (7). Spaces where personnel can recover from hazardous noise exposures are known as auditory rest areas. This research study was conducted to determine if berthing areas aboard this U.S. aircraft carrier provides sufficient auditory rest after hazardous noise exposure occurring on duty.

Military Health Relevance

Permanent hearing loss is one of the most common disabilities among sailors and in a statistical analysis of hearing loss among Navy personnel it was found that time spent on surface warships has the largest impact on hearing loss compared to time spent on surface support ships, time spent in some locations on submarines, or time spent ashore. (26)

In the United States Navy, an aircraft carrier is the centerpiece of Naval Forces and the most populated with sailors. The aircraft carrier is essential in providing air superiority and power projection by launching and recovering aircraft. Since World War II, the U.S. Navy's nuclear aircraft carriers (CVNs) have been the national force of choice. In over 80% of the times when the World was faced with international violence, the United States has responded with one or more carrier task forces. Over the past 25 years, requirements for United States Navy carrier forces to be on station to respond to a crisis have increased. (29)

CVNs are nuclear powered and have the ability to stay at sea almost indefinitely and are only limited by the need for provisions for the crew. However, the ability of CVNs to be replenished at sea (RAS) allows these provisions as well as fuel and parts for aircraft to be on loaded and the CVN to remain deployed for months or even years if necessary. Nimitz class aircraft carriers are designed for approximately 50 years of service and supports approximately 60 aircraft when the air wing is operational. The crew of an aircraft carrier consists of personnel assigned to ship's company with approximately 3,000-3,200 personnel, and an air wing with approximately 1,500 personnel when deployed (29).

For personnel assigned to an aircraft carrier and who work on the flight deck, the primary source of hazardous noise exposure is from the launching and recovery of aircraft. This noise is generated not only from the jet engines of aircraft but also from the machinery and equipment used in the launching and recovery of these aircraft. This noise permeates through the structure of the ship and affects offices, classrooms, recreational areas, religious worship spaces and berthing spaces. The areas that are most affected by noise generated from flight operations are located directly below the flight deck, specifically at the bow (front) and the area directly below where aircraft land. Another term for an aircraft landing aboard an aircraft carrier is "recovery". Figure 1 provides a cutaway view and the berthing spaces on the 03 level, labeled "Crew Quarters" is visible directly below the helicopter on the flight deck (28).

Figure 1. Cutaway view of aircraft carrier.

The fixed wing aircraft aboard are launched from a Nimitz class aircraft carrier using one of four steam-powered catapults. The steam is generated from a closed loop steam generation system which obtains its heat from one of the two nuclear reactors aboard. On a Nimitz class aircraft carrier these steam-powered catapults can thrust a 48,000-pound aircraft 300 feet, from zero to 165 miles per hour in two seconds and the flight deck crew can launch two aircraft and land one every 37 seconds in daylight, and one per minute at night. (18) All aircraft are at full power when they are launched, regardless if they are accelerated by jets or propellers.

Fixed wing aircraft land on the aircraft carrier using a hook and cable system. To land aircraft deploy a tail hook, which is a hook bolted to an 8-foot bar. It is with the tail hook that the pilot catches one of the four steel cables stretched across the deck at 20-foot intervals, bringing the plane, traveling at 150 miles per hour, to a complete stop in about 320 feet (18). The aircraft actually accelerates upon landing on the flight deck so in the event the hook doesn't catch the cable it can quickly take off again without incident. If the landing is successful and the hook catches the cable, the kinetic energy of the aircraft is dissipated using a cable and hydraulic braking system which is located directly below the flight deck. Similarly, the launching of aircraft requires a rapid dissipation of kinetic energy from the shuttle. This is accomplished utilizing a water brake system to dissipate the energy of the shuttle when it reaches the terminus of its travel. Both the recovery cable braking and shuttle launch water braking system generate high levels of noise and are both located directly underneath the flight deck and in close proximity to berthing.

Figure 2 gives an approximate location of the water braking system in reference to the forward berthing spaces.

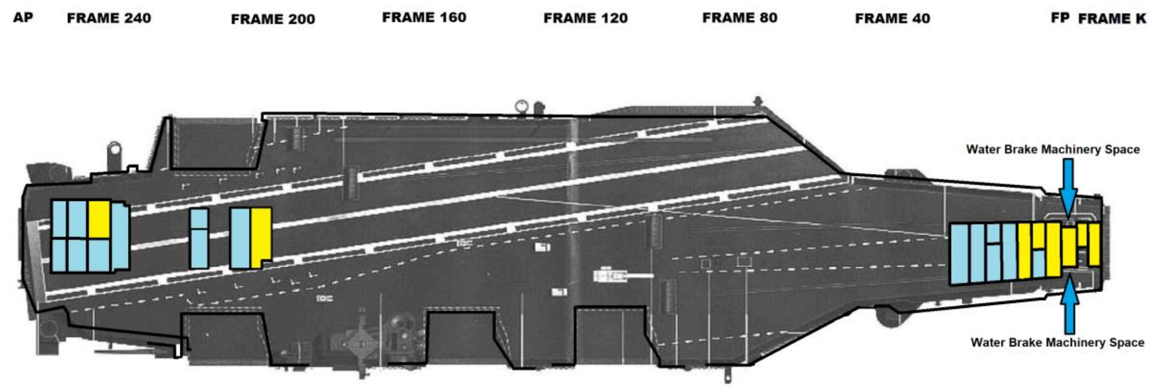


Figure 2. Water braking machinery spaces.

Even with the high levels of noise being generated from flight operations, these areas directly below the flight deck still have berthing spaces and personnel who sleep and rest in them. These berthing spaces typically house personnel who are part of the Air Department and are typically composed of ratings (job specialties) who work on the flight deck. These ratings are typically those which fuel, direct, inspect and arm the aircraft as well as those who support recovery and launching evolutions for the aircraft. These personnel are in the hearing conservation program and are required to wear double hearing protection. Other personnel who may occupy the berthing spaces directly below the flight deck may include transient personnel such as contractors and personnel from other aircraft carriers or ships who are qualifying on equipment or underway operations. For those personnel who are assigned to the aircraft carrier as ship's company and who are affected by hazardous noise during on-duty shifts from working on the flight deck, these berthing spaces serve as auditory rest areas.

This study characterized noise sound pressure levels (SPLs) at various standardized octave band center frequencies within these berthing spaces to determine if they meet the various organizational criteria to be considered valid areas of auditory rest.

According to the Department of Veterans Affairs at the close of fiscal year 2014, more than 933,000 Veterans were receiving disability compensation for hearing loss, and nearly 1.3 million received compensation for tinnitus (4). Research has also shown that many veterans score normally on hearing tests but have difficulty understanding speech due to a condition called auditory processing disorder, which is often associated with blast exposure (4).

The Department of Defense (DoD) regulates hazardous noise exposure through the promulgation of Department of Defense Instruction (DoDI) 6055.12. Instruction 6055.12 is the Hearing Conservation Program (HCP) instruction that establishes DoD policy and establishes responsibilities to protect personnel from NIHL associated with operational and occupational-related noise exposure (1). An aim of the instruction is to reduce operational noise exposure to DoD personnel whenever possible to enhance mission readiness and safety (DoD, 2010). The instruction requires all Department of Defense components conducting occupational and combat operations to establish and maintain a Hearing Conservation Program.

To meet this requirement the Department of the Navy uses two separate Safety and Occupational Health manuals endorsed by the Secretary of the Navy for Forces Afloat and Ashore, which are Office of the Chief of Naval Operations (OPNAV) Instructions 5100.19E and 5100.23G respectively. These instructions provide policy and outline responsibilities for the proper implementation of the Navy Safety and Occupational Health Program.

For Navy personnel the occupational exposure limit (OEL) is established by Department of Defense Instruction Number 6055.12 Hearing Conversation Program and is set at an 85 dBA with a three-dB exchange rate for an eight-hour Time Weighted Average (TWA). The three-dB exchange rate means that if the noise exposure is +/- three dB than the reference level of 85 dBA, then allowable noise exposure time is either halved or doubled. For example, an environment measured at 88 dBA, which is 3 dB greater than 85 dBA will limit the allowable exposure time in that environment to half that of the established eight-hour TWA, which is four hours. Exposures exceeding 85 dBA for a TWA of eight hours require enrollment in the HCP. Personnel will also require enrollment if an impulse sound pressure level reaches or exceeds 140 dB at any point in an eight-hour work shift.

BUMED NOTICE 6260 references the Industrial Hygiene Field Operations Manual (IHFOM). The IHFOM provides the Navy's standard practice of the technical aspects of Industrial Hygiene and is used for guidance regarding the designation of hazardous noise areas and equipment. BUMED NOTICE 6260 states that any work area or equipment where the sound pressure level is 85 dBA or above (continuous or intermittent) shall be considered noise hazardous. Additionally, the Department of Defense Design Criteria Standard for Noise Limits provides further guidance on compartments (spaces) within ships. This standard states that berthing spaces are considered category B compartments, which are compartments in which comfort of personnel is the primary consideration and communication considerations are secondary

(2). This designation for berthing spaces does not include sanitary space areas of the shower and toilet. Airborne noise category B also provides maximum allowable unweighted octave band SPL limits which are shown in table 1 below.

Table 1. *Department of Defense Design Criteria Standard Noise Limits*

Airborne Noise Category	**Maximum Allowable SPL Limit for Steady-State Condition, (dBA)**	**Maximum Allowable Unweighted Octave Band SPL Limit, (dB re 20 μPa)**								
		Octave Band Center Frequency, (Hz)								
		32	63	125	250	500	1,000	2,000	4,000	8,000
A-3	70	81	78	75	72	69	66	63	60	57
A-12	60	72	69	66	63	60	57	54	51	48
B	65	78	75	72	69	66	63	60	57	54
C	60	72	69	66	63	60	57	54	51	48
D	85	98	95	92	89	86	83	80	77	74
E	75	88	85	82	79	76	73	70	67	64

The Department of Defense Design Criteria Standard Noise Limits establishes a maximum allowable SPL limit for steady-state conditions when intermittently operating machinery and equipment are operational. A steady-state condition is defined as a noise environment where sound levels do not change by more than 5 dB during a given time period. An example of this is a motor operating under a steady load and not operating intermittently. This Maximum Allowable SPL limit for category B spaces is 65 dBA.

For personnel who are routinely exposed to hazardous noise, the definition of routine exposure is defined by OPNAV 5100.19E: “as those areas/equipment where the noise is of sufficient intensity and duration that it can reasonably be expected exposure will result in a loss of hearing sensitivity.” The method of conducting noise dosimetry over an eight-hour shift then comparing the result to an OEL as a basis for HCP recommendations follows OSHA and private industry for typical work shifts. This methodology is also followed by the DoDI 6055.12, DoD Hearing Conservation Program (HCP) (1). However, failure to characterize noise exposures over the full 24-hour day for personnel assigned to operational shipboard environments may result in unrecognized hazardous noise associated risks. This determination typically does not include assessment of noise exposure risk in auditory rest areas and assumes that these areas will be sufficient for auditory recovery.

The shipboard environment on an aircraft carrier provides the potential for a sailor to be exposed to significant noise levels, especially if he or she is working on or directly beneath the flight deck. If the sailor is unable to retreat to an area with sufficiently reduced noise levels to allow for auditory rest then temporary threshold shifts that may develop due to excessive noise exposures during on-duty shifts may become a permanent threshold shift. In the next section, the literature review provides additional insight for determining if these berthing areas are sufficient auditory rest areas for personnel aboard a US aircraft carrier.

Literature Review

A literature review was performed and a study was discovered that proceeded and closely paralleled this research study. The study was conducted by researchers at Massachusetts Institute of Technology (MIT). The MIT researchers presented their study in a poster and they focused their efforts on the evaluation of hazardous noise exposure of the berthing spaces directly below the flight deck aboard the USS Nimitz. The motivation for their study was to determine if the DoD hearing conservation program's implicit assumption that service members have adequate quiet recovery time is valid aboard an aircraft carrier (14). The researchers indicated that this assumption may not hold for some personnel on aircraft carriers due to work shifts that expose them to hazardous noise levels in excess of 12 hours with continued noise exposures off duty, from noise exposures in the living spaces (berthing). This research sought to validate the assumption of adequate quiet recovery time based upon the berthing location. The MIT researchers noted that characterization of 24-hour noise levels is important for understanding auditory effects of personnel serving aboard and that there were many open issues in evaluating damage risk metrics for complex noise exposures from the Navy aircraft carrier environment (14). The complex noise environment aboard an aircraft carrier included both impulsive and continuous noise, and current auditory damage metrics are for either impulsive or continuous noise, but not both (14). Elevated noise in berthing rooms may impede threshold recovery and that auditory damage metrics do not account for poor recovery conditions (14).

The MIT researchers also conclude that further research is needed to address the unknown effects of complex 24-hour noise exposures (14). The majority of noise exposure limits are based upon an 8 or 12-hour work shift, with the assumption that the time away from work, whether 16 or 12 hours, will be in environments without hazardous noise.

In *Measurements of Jet Noise Aboard US Navy Aircraft Carriers*, published in AIAA Centennial of Naval Aviation Forum "100 Years of Achievement and Progress", authors Allan Aubert and Richard McKinley state that “The requirements of launching supersonic aircraft from US Navy aircraft carriers demands that carrier deck crews routinely experience perhaps the loudest working conditions in which people regularly work.” (8). Those personnel who work on the flight deck environment may also experience temporary threshold shifts from hazardous noise exposures while on duty.

While these personnel are exposed to high levels of hazardous noise, they may also work extended duty hours. There are studies which attempt to address the effects of working extended shifts and having off work areas which may not be sufficient for auditory rest. One such study was conducted by Neitzel et al. which provided an analysis of noise exposures of personnel aboard Norwegian catcher/processor fishing vessels (19). This study parallels the MIT study in that it shares the same characteristic of personnel working and living in the same environment, with the possibility of being exposed to hazardous noise both while at and away from work. According to the authors, commercial fishing workers have extended work shifts and potential for 24-hour exposures to high noise, however exposures in this industry have not been adequately characterized (19). The researchers assessed noise exposures using noise dosimetry, sound-level mapping and self-reporting activities and hearing protection device (HPD) use. The data was used to estimate work shift, non-work, and 24-hour overall exposure levels using several metrics (19). Their research indicated that non-shift work noise contributed nothing to 24-hour exposure levels and concluded that the primary risk of hearing loss comes from work shift noise. However the researchers did acknowledge that smaller vessels or vessels with different layouts may present more risk of hearing damage from non-work periods (19).

The World Health Organization, through the publication *Occupational exposure to noise: evaluation, prevention and control* states that for a 24-hour exposure at 77 dBA. The equal energy rule will allow 82 dBA for 16 hours and 80 dBA for 24 hours (10). In the Journal *Hearing Research* the article *Long-term noise exposures: A brief review*, the author specifically cites aircraft carrier personnel as having hazardous noise exposures which may last 24-hours or longer (13). Ward et. al studied effective quiet conditions to determine the highest SPL of noise that would prevent production of a significant temporary threshold shift and that would prevent hearing recovery (30). An SPL of 76 dB for octave bands of noise centered at 250 and 500 Hz and 68 dB for the 1000, 2000, and 4000 Hz octave bands were identified as preventing permanent hearing loss assuming 8-hours of noise exposure and 16-hours of rest (30).

Additional studies support the findings of Neitzel et al., to include research conducted by Turan et al., which detailed crew noise exposure aboard ships and comparative study of applicable standards. The researchers note that in recent years there has been a significant increase in transportation activities, to include the most fuel-efficient means of transporting tons of material, which is by transoceanic shipping. This is in part due to increased globalization and commerce and that the shipping industry has responded to increased needs by providing flexible operations using new types of ships, equipped with novel technologies, materials and propulsion systems (27). These advancements, which are designed to increase fuel efficiency and propulsion may also inadvertently create increased noise pollution. The researchers note that these concerns have been addressed at the European as well as the IMO (International Maritime Organization) level with the introduction of new and revised standards and limitations on noise which are applicable to ships for the well-being of crew, commuters, as well as residents living around ship passageways and harbors (27).

With the known hazardous noise risks to personnel on ships, a study which also focused on hazardous noise exposures to military personnel while aboard a warship was a study conducted by Sunde et al. This research aimed to describe the noise levels aboard vessels in the Royal Norwegian Navy (RNoN), and to assess the noise exposure of personnel aboard RNoN vessels. (24) The study was conducted aboard 14 RNoN vessels from four different vessel classes, none of which were aircraft carriers, but instead were frigates, coastal corvettes, mine vessels, and coast guard vessels. (24) Noise levels were calculated for various locations aboard in each vessel class with the noise exposure of RNoN personnel assessed by noise dosimetry and with a task-based strategy which was used to estimate exposure. The study concluded that on all vessel classes, the engineers and electricians had amongst the highest 24-hour noise exposure both before and after adjusting for estimated use of hearing protective devices (24). The study also concluded that all vessel classes, except the coast guard vessels, had noise levels exceeding the RNoN standard's recommended maximum noise levels and that a program to reduce the noise levels should be implemented (24).

While there are hearing conservation programs that are implemented to prevent noise induced hearing loss of personnel, there are also programs in place which attempt to mitigate hazardous noise through design and engineering. Examples of this are design specifications which place noise generation restrictions on equipment, application and use of acoustical absorbing material, enclosing equipment or personnel and creating a layout to minimize the proximity of personnel to hazardous noise generating equipment. In a journal article by Kurt Yankaskas et al, they provide insight on how engineering and design can reduce exposure of personnel to hazardous noise in lieu of the often used standard of issuance of Personal Hearing Protection (PHP). For this research the Office of Naval Research (ONR) lead the effort to investigate methods and techniques to mitigate hearing loss for military personnel aboard ship. This research concluded that the use of PHP is viable and an increasingly popular method of reducing hearing exposure for many; however, it has limitations with improper use and low frequency effectiveness (31). Yankaskas et al. state that through proper vessel planning, programmatic changes and advances in noise control engineering there can be significant reductions of hazardous noise exposure to personnel by inherently reducing noise exposure through ship design and use of noise control treatments. The authors state that the improved quality of life from reduction in noise will lead to increased operational effectiveness and performance of personnel aboard. These engineering approaches also can be made to work in the lower frequency range where hearing protection is not as effective (30)

Additional review of the available literature indicates that these studies may in fact be underestimating the severity of hazardous noise exposure to personnel, whether civilian or military because, according to researchers Goley et al, current noise guidelines use an energy-based noise metric to predict the risk of hearing loss, and thus ignore the effect of temporal characteristics of the noise (15) The researchers note that the current noise guidelines underestimate the risk of a complex noise environment, where there are impulse noises embedded in a steady-state noise. An aircraft carrier during flight operations produces such an environment when aircraft are at full power and producing significant steady-state noise before being launched. The impulse noise of the shuttle impacting the water brake is buried within that steady-state noise environment that is produced by the jet engines. A basic form for noise metrics is designed by combining the equivalent sound pressure level (SPL) and a temporal correction term defined as a function of kurtosis of the noise (15). Kurtosis is a statistical measure that's used to describe the distribution of observed data around the mean, which can also be described as volatility. A mesokurtic is defined as a normal distribution while a leptokurtic curve (fat tail) is one which has a positive or tall and thin distribution and a platykurtic curve (thin tail) is considered a "negative" or flat and wide distribution. The researchers developed several noise metrics and when the developed kurtosis correction term was utilized, it significantly improved the correlation of the noise metric with the measured hearing losses in chinchillas (15). This research is important because it highlights the need to ensure that the techniques to measure hazardous noise in these complex noise environments are adequately describing the risk to personnel. These studies have provided significant insight to the challenges of conducting research on noise induced hearing loss of those who live and work on ships, especially when those ships are designed as a weapon system, and their design is focused more on effectiveness in battle and less on the comfort and safety of the crew (16).

CHAPTER 2: MATERIALS AND METHODS

Location

This study took place December 4 – 15, 2017 aboard USS Harry S. Truman (CVN 75) during an underway period that involved Fleet Replacement Squadron Carrier Qualifications (FRSCQs). FRSCQs are a time where pilots from various squadrons qualify in both arrested landings as well launching from the ship. This period of time builds proficiency for these pilots as well as those personnel who support flight operations. Often times the operational tempo (OPTEMPO) is high, with an increased rate of launches and recoveries to simulate wartime operations. The sampling locations for this study was limited to berthing spaces directly below the flight deck on the "03" level. The specific locations that were sampled are highlighted yellow and numbered in figure 3.

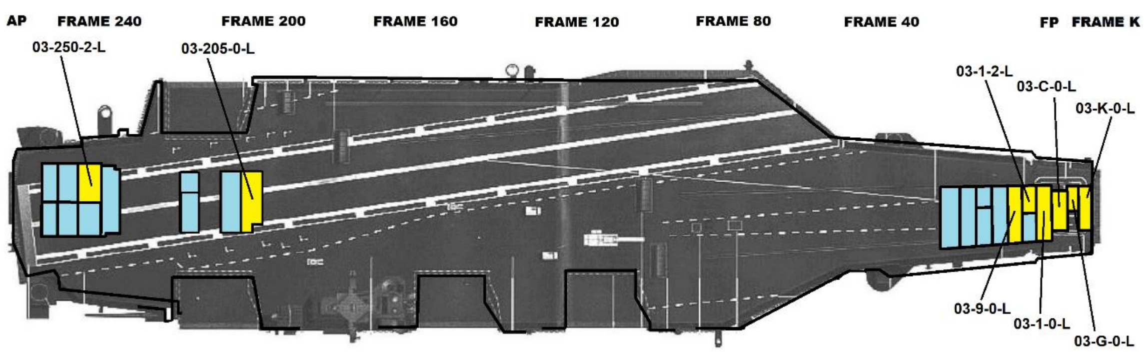


Figure 3. Berthing locations

Generally, flight operations were from 0900 until 2300 each day and took place December 4, 2017 until December 11, 2017. The researcher intended to continue noise monitoring 12-15 Dec during non-flight operation days; however, due to depletion of all batteries was unable to do so. There were variations in the rate of launches and recoveries due to poor weather conditions. The average number of launches during the day was 60 while the night launch average was 36. The average number of landings during the day was 62 while at night it was 35. There were also “touch and goes”, which are deliberate touching down of the aircraft on the flight deck without an arrested landing and then immediately taking off at full power. The average number during the day was 17 and at night this was reduced to 5. There were also minimal bolters and wave offs, which are attempted arrested landings and a landing abort ordered by flight deck personnel.

For this study, the selected berthing spaces were located directly below the flight deck and were subject to the noise produced during flight operations and adjacent machinery spaces supporting flight operations. The forward berthing spaces, which are 03-K-0-L, 03-G-0-L, 03-C-0-L, 03-1-0-L, 03-1-2-L and 03-9-0-L, had hazardous noise levels that were primarily due to aircraft launches. The noise contribution from aircraft launches included the aircraft engines, the steam catapult and water brake. Noise levels in the middle berthing space 03-205-0-L had noise exposures that were primarily due to arrested landings of aircraft. The sources of hazardous noise were from the impact of the aircraft landing and from equipment in the arresting gear machinery room which included the cable and hydraulic braking system used to stop the aircraft. Primary noise sources adjacent to the aft berthing space, 03-250-2-L included aircraft flying overhead and arrested aircraft landings.

The berthing spaces were composed of bunks which were usually three beds stacked vertically and lockers in which personnel stored their personal belongings. All berthing spaces had at least one head, which is a bathroom and water closet which included sinks, toilets and showers. Floors of the berthing spaces primarily consisted of tile while the walls (bulkhead) and ceiling (overhead) were metal with minimal sound absorption treatment. The sound level meters (SLMs) were randomly placed in various locations throughout the berthing where space was available. SLMs were placed approximately 4 feet above the deck to give an approximate at ear height for personnel sitting in chairs. The SLMs were also placed approximately 2 feet above the mattress when there were empty bunks available. When no empty bunks were available the SLMs were placed on top of lockers. In the empty bunks and on top of lockers the distance from the mattress and top of lockers was based upon the lowest setting of the tripod. Every attempt was made to keep the SLMs away from areas of heavy traffic and they were predominately located near the bulkhead (wall) as depicted in figure 4. Windscreens were used on all SLMs to minimize any aberrant noise readings from ventilation or drafts in then berthing spaces. Figure 5 provides are representation of how the sound level meter was placed in an empty bunk, but the SLM was placed more toward the ends of the mattress simulate the relative position of a person's ears while sleeping.

Figure 4. Sound level meters setup

Figure 5. A sound level meter

The majority of samples were four hours in duration and were obtained during flight operations. Samples were collected simultaneously using three SLMs and coincided with the ship’s flight plan, which provides the schedule for flight operations. However due to severe weather, schedule changes for arriving squadrons and unforeseen logistic changes, flight operations were changed often.

A total of 73 samples were taken while aboard the aircraft carrier, however 9 were excluded due to erroneous results as a result of improper settings being used during the sampling period and 6 were excluded due to short sampling times (under one hour in duration).

Equipment and Measurements

Three 3M™ SoundPro® Type 1 sound level meters with 1/1 octave band analyzers were used for this study. Two of the SLMs, serial numbers BKR070003 (SLM #1) and BKR070002 (SLM #3) were SoundPro® type DL while the remaining SLM with serial number BEL100002 (SLM #2) was a SoundPro® type SE. There were no limitations due to this, as the ability of the type DL SLM over the type SE SLM is the ability for saving intermediate measurement results. Additionally, an ANOVA was performed between the SLMs to determine if there were any significant difference between them. The results are provided in table 2 and indicated that there were no significant differences between SLMs.

Table 2. Multiple Comparisons for SLMs.

Multiple Comparisons

Dependent Variable: Leq

Tukey HSD

(I) SLM	(J) SLM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
SLM 1	SLM 2	.0641	2.7254	1.000	-6.501	6.629
	SLM 3	.0812	2.9913	1.000	-7.124	7.287
SLM 2	SLM 1	-.0641	2.7254	1.000	-6.629	6.501
	SLM 3	.0171	3.0201	1.000	-7.257	7.292
SLM 3	SLM 1	-.0812	2.9913	1.000	-7.287	7.124
	SLM 2	-.0171	3.0201	1.000	-7.292	7.257

After a sampling period the logged measurements were downloaded after the sampling period was completed. All SLMs were used to obtain sound level measurements at standard octave band center frequencies of 16 Hz, 31.5 Hz, 63 Hz, 125

Hz, 250 Hz, 500 Hz, 1.0 kHz, 2.0 kHz, 3.0 kHz, 4.0 kHz, 6.0 kHz, 8.0 kHz and 16 kHz during shipboard operations. In addition to electroacoustic calibration, the octave band analyzers were field calibrated before and after every sampling period. The field calibration was performed using a 3M™ QC-10 noise calibrator. The noise calibrator generates a reference tone of 1,000 Hertz at 114 dB and ensures that the SLM provides accurate noise measurement information. When a SLM failed calibration prior to taking measurements, the calibration was performed again, ensuring that the calibrator was properly positioned over the microphone element of the SLM. Calibration failures did occur but were all attributed to improper positioning of the noise calibrator over the microphone. The SLMs internal clocks were all synchronized with the ship's clock so the measurements could be analyzed at specific time period among all of the SLMs. The SLMs were each mounted on tripods to ensure isolation from direct vibrations from adjacent structures and the wind screens were used with all SLMs. All sound level meters had internal settings to measure dBA with an exchange rate of 3dB and a setting of a slow response. The measurements for centerline octave band frequency were measured in dB as no weighting was applied. The SLMs required 4 alkaline AA batteries which provided power during the sampling period. On occasion and when available, an alternating current (AC) to direct current (DC) power adapter was used to minimize battery consumption. When the SLMs were located in areas of more active noise production, the power consumption of the batteries was more significant. A total of 21 samples did not capture the entire four-hour period, however these samples were still analyzed since adverse effects on noise characterization during the time period was not expected. A total of 15 out of 21 shortened period samples, had a sampling period over 3 hours in length. A personal computer with Microsoft® Windows® 10 software utilizing 3M's™ Detection Management Software (DMS) Version 2.9.159.0 was used to download the SLM data. The data files were saved in separate folders which were organized by SLM and date. Measurements were labeled to identify not only the date the sample was taken but also the increment of sample and the specific SLM used to obtain the sample. An example of this is the filename "6DEC2017_8.1", which represents the eighth sample taken using SLM 1 on December 6, 2017.

Analysis

For analysis of the data, 3M's™ Detection Management Software (DMS)™ Version 2.9.159.0, IBM's™ Statistical Package for the Social Science (SPSS™) Version 24 and Microsoft® Corporation's Excel® 2013 were used. Descriptive and inferential statistics were calculated using SPSS™ and Microsoft® Excel®. SPSS™ was used to conduct an analysis of variance (ANOVA) with an α of 0.05 between all berthing (25) standardized octave band center frequencies from 16 Hz to 16 kHz. Leq is defined as the sound level in decibels equivalent to the total sound energy measured over a specified period of time. Leq values were calculated by the internal firmware of the sound level meters as well as by using DMS™ to measure specific selected time periods. 3M's™ DMS™ was used to analyze Leqs and determine noise contribution of aircraft launches during the monitored period.

There are two methods for averaging measurements that are logarithmic based. Thomas W. Rimmer, ScD, CIH of Fay W. Boozman College of Public Health University of Arkansas for Medical Sciences provided a presentation which demonstrates converting dB to sound energy then summing and averaging before converting it back into dB (25).

Additional sources state that if measuring logarithmic based units, such as pH levels in a lake, it is appropriate to simply utilize the arithmetic average. Some calculations were done manually, such as obtaining the average (mean) value of separate measurements. Measurements using the SoundPro™ SLM Model DL are processed by the software to provide a reading that is averaged over a period of time. However, to calculate averages of multiple measurements provided by the SLM, a simple averaging will not represent the correct level of energy measured since dB/dBA are logarithmic. An example of this would be calculating the mean value of three measurements 70 dB, 85 dB and 100 dB. A simple arithmetic mean calculation would result in 85 dB, while a mean of 95.4 dB is calculated by first removing the logarithm from the individual measurements, averaging them and then converting that average back into logarithmic form.

The determination of the mean for multiple measurements was necessary to provide a single measurement for each location measured. These individual measurements were used to describe the relationship of location to Leq and standard octave band center frequencies of 16 Hz – 16 kHz. All six forward locations which included berthing spaces 03-K-0-L, 03-G-0-L, 03-C-0-L, 03-1-0-L, 03-1-2-L and 03-9-0-L had their measurements averaged for Leq and octave bands for comparison.

CHAPTER 3: RESULTS

Results

Seven of eight total berthing spaces exceeded 65 dBA, (Figure 7), which is the maximum steady state specified by MIL-STD-1474E2 (2). MIL-STD-1474E2 states that the standard is intended to address noise levels emitted during the full range of typical operational conditions and over the life cycle of the system under consideration and that it covers tests for steady-state noise for military vehicles, aircraft, ships, general equipment, portable shelters and impulsive noise from weapons and explosive-ordnance materiel (2). The MIL-STD does not specify a time requirement to establish a steady-state condition, however if aircraft launches and recoveries have a high occurrence then they may approximate such a condition. These seven berthing spaces also exceeded the recommended level of 70 dBA for auditory recovery areas set by the ACGIH (7). Forward berthing spaces as a whole had the greatest Leq at 81.9 dBA (Figure 7).
The specific berthing locations which provided the greatest and lowest opportunity for auditory rest were berthing locations 03-250-2-L (Figure 8) and 03-K-0-L (Figure 9), respectively. Differences in sound level increased with increasing octave band frequency with the highest sound levels found in the middle-high 1 and 2 kHz range and then decreasing at frequencies at 4 kHz and above (Figure 10). Descriptive statistics of the data are provided in table 3 while table 5 provides the ANOVA results.

Table 3 below provides the descriptive statistics for the samples obtained for this study. These descriptive statistics provide the number of samples (N), the minimum, maximum, mean, standard deviation, variance, skewness and kurtosis. Of the samples collected, there were only 58 that were included in analysis. Data that met the inclusion criteria met a minimum duration of one hour and contained standardized octave band center frequencies for analysis.

Table 3 also provides the skewness of the measurements, which is a measure of symmetry, or more precisely, the lack of symmetry. This measure of symmetry is defined as 0 being a dataset that is perfectly symmetrical, with normally distributed data having 0 skewness. Kurtosis is a measure of the combined sizes of the two tails and measures the amount of probability in the tails. The kurtosis of the normal distribution is equal to 3, so if the kurtosis is greater than 3, then the dataset has heavier tails than a normal distribution, which indicates there are more outliers. Data from the 16 Hz and the 16 kHz are more skewed and also have significant kurtosis. Due to this result, noise levels at these frequencies did not meet the normal distribution assumption associated with ANOVA. These standardized octave band center frequencies represent the lowest and highest of those octave bands analyzed. The MIL-STD excludes the analysis of both 16 Hz and 16 kHz as these are on the low and high ends of the standardized octave band center frequency spectrum (2). Due to this exclusion, analysis for 16 Hz and 16 kHz was included for information purposes only. Variance was provided in table 3 and gave an indication of how these measurements were spread around the mean. Before an ANOVA could be performed the data was analyzed to determine if it was normally distributed. Quantile-quantile (Q-Q) plots were created using SPSS™ and the results of the Leq data are provided below in Figure 6, while the standardized octave band center frequencies are provided in the appendix. Since the main concern for this study were standardized octave band center frequencies which are the most significant for noise induced hearing loss (3,000 - 6,000 Hz frequency range), no additional analysis, such as non-parametric analysis methods, were performed.

Table 3. Descriptive Statistics of Samples from SPSS

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
16 Hz	58	27.2	40.2	28.895	2.3703	5.618	3.649	.314	14.499	.618
31.5 Hz	58	28.0	57.4	40.976	6.8568	47.016	.233	.314	-.611	.618
63 Hz	58	34.4	61.8	50.124	7.2473	52.523	-.736	.314	-.570	.618
125 Hz	58	40.5	73.7	57.709	8.1801	66.914	-.047	.314	-.725	.618
250 Hz	58	45.6	75.5	61.483	7.7298	59.750	-.072	.314	-1.164	.618
500 Hz	58	51.5	85.8	67.038	8.7467	76.504	-.071	.314	-.658	.618
1.00 kHz	58	50.8	87.3	69.986	9.3763	87.916	-.496	.314	-.632	.618
2.00 kHz	58	49.6	87.5	68.426	9.2641	85.823	-.417	.314	-.497	.618
4.00 kHz	58	51.6	80.9	65.443	7.5149	56.474	-.165	.314	-.677	.618
8.00 kHz	58	54.2	70.7	59.298	4.2309	17.901	.757	.314	-.245	.618
16.00 kHz	58	53.3	58.4	54.905	.9083	.825	1.107	.314	2.907	.618
Leq	58	57.5	92.1	74.710	8.7754	77.008	-.357	.314	-.624	.618
Valid N (listwise)	58									

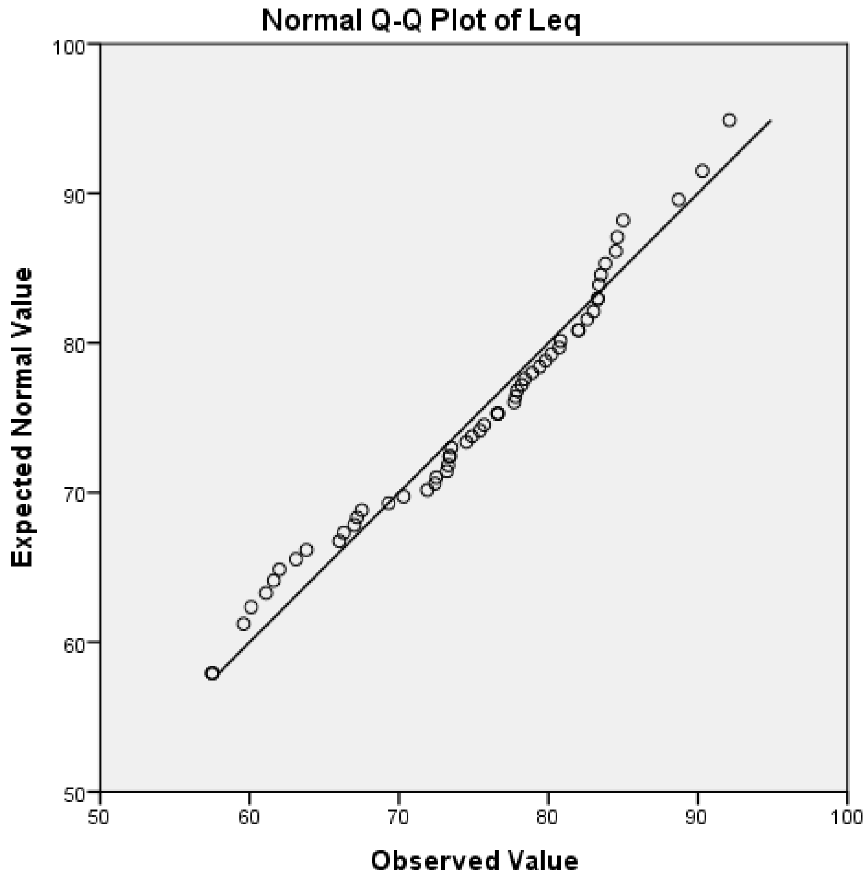


Figure 6. Normal Q-Q Plot of Leq values

Descriptive statistics were also used to compare results of measurements taken in the berthing spaces. This included Leq measurements, which were decibel measurements with an "A" weighting and standardized octave band center frequencies which had no weighting applied. Means of these multiple measurements were calculated manually by applying the method described by Thomas W. Rimmer, ScD, CIH (25). The mean Leq results for the berthing spaces are listed in Figure 7 below, with the applicable limits listed.

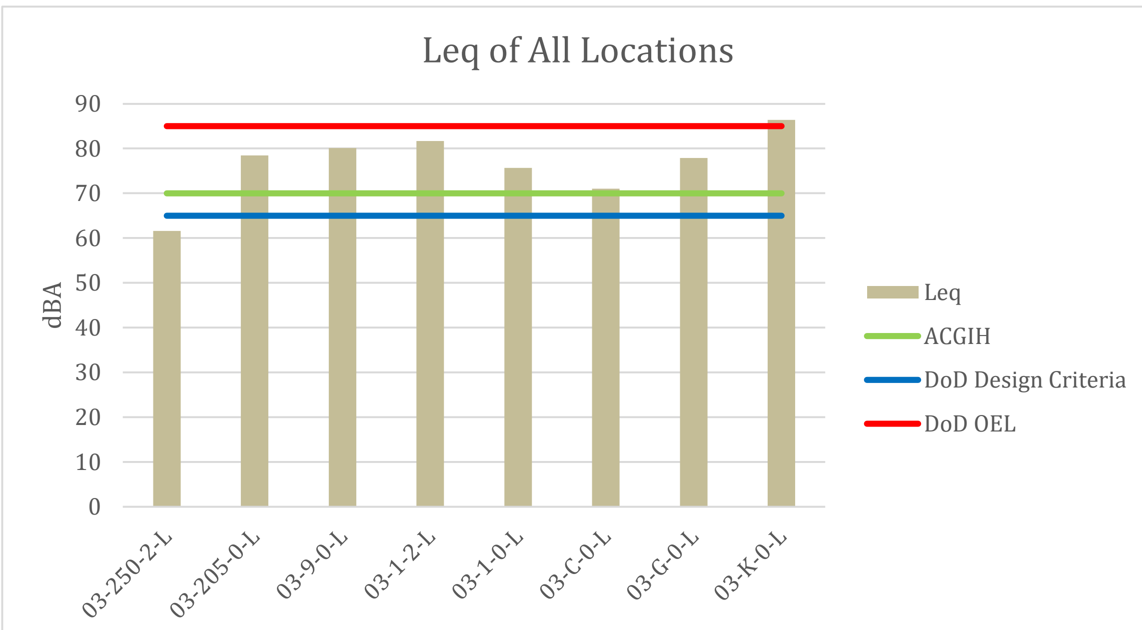


Figure 7. Mean Leq measurements taken in berthing.

The berthing locations which provided the greatest and least opportunity for auditory rest was berthing locations 03-250-2-L and 03-K-0-L, respectively. Standardized octave band center frequency distributions and Leqs of these spaces are provided in figure 8 and figure 9 below.

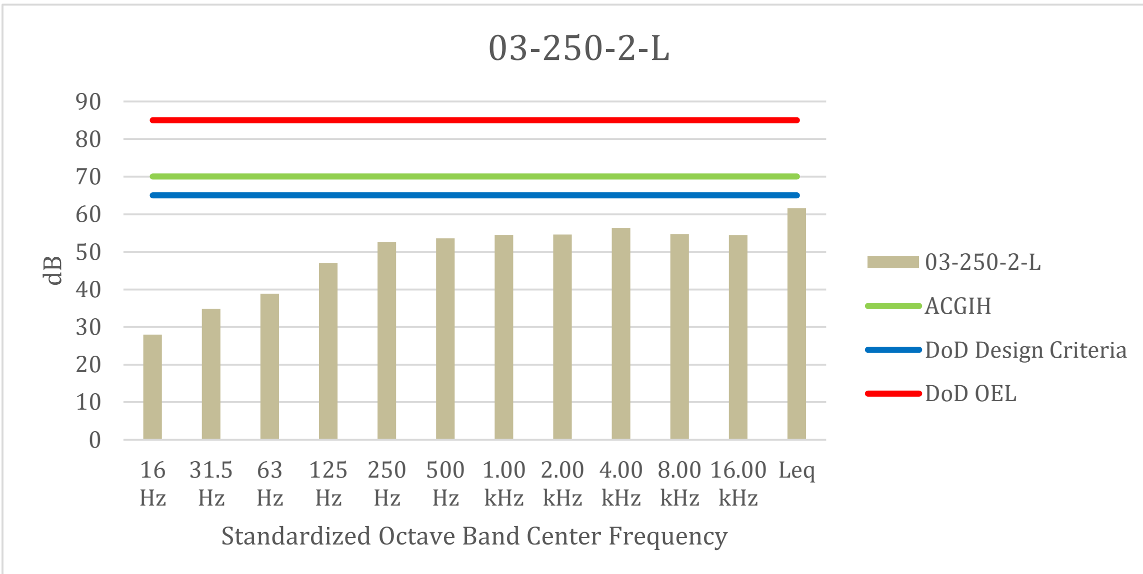


Figure 8. Leq measurements of berthing space 03-250-2-L

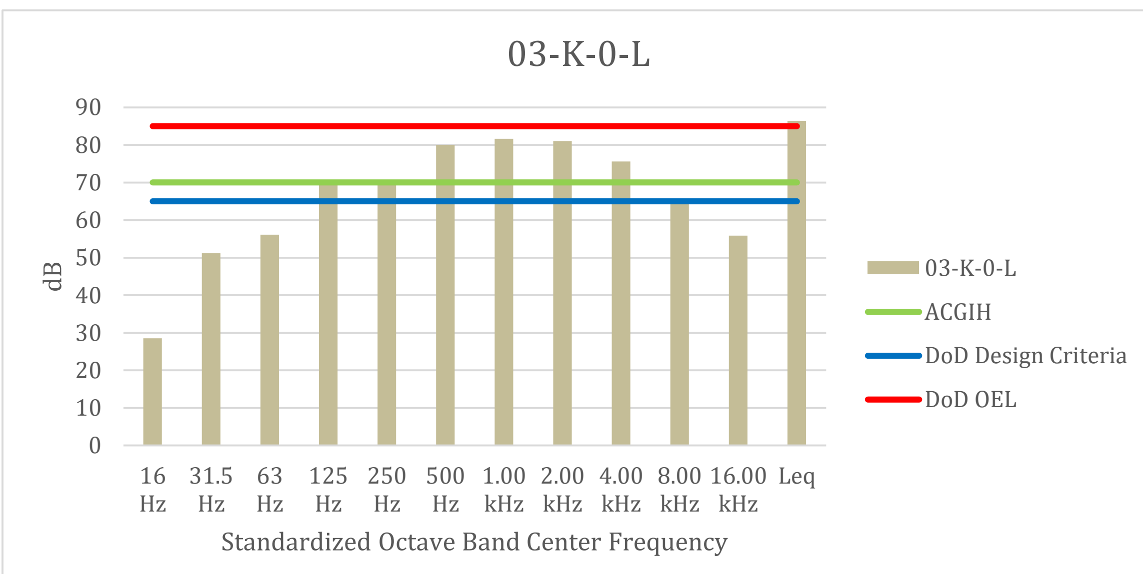


Figure 9. Leq measurements of berthing space 03-K-0-L.

Berthing locations were grouped into forward, mid and aft berthing for comparison. The six most forward berthing spaces were grouped together and compared to the mid and aft berthing locations. The grouped berthing spaces were compared by the mean Leq and standardized octave band center frequencies and the results are in Figure 10 below. The noise levels were highest in the forward and mid berthing spaces, particularly between the 1 – 2 kHz standardized octave band center frequencies.

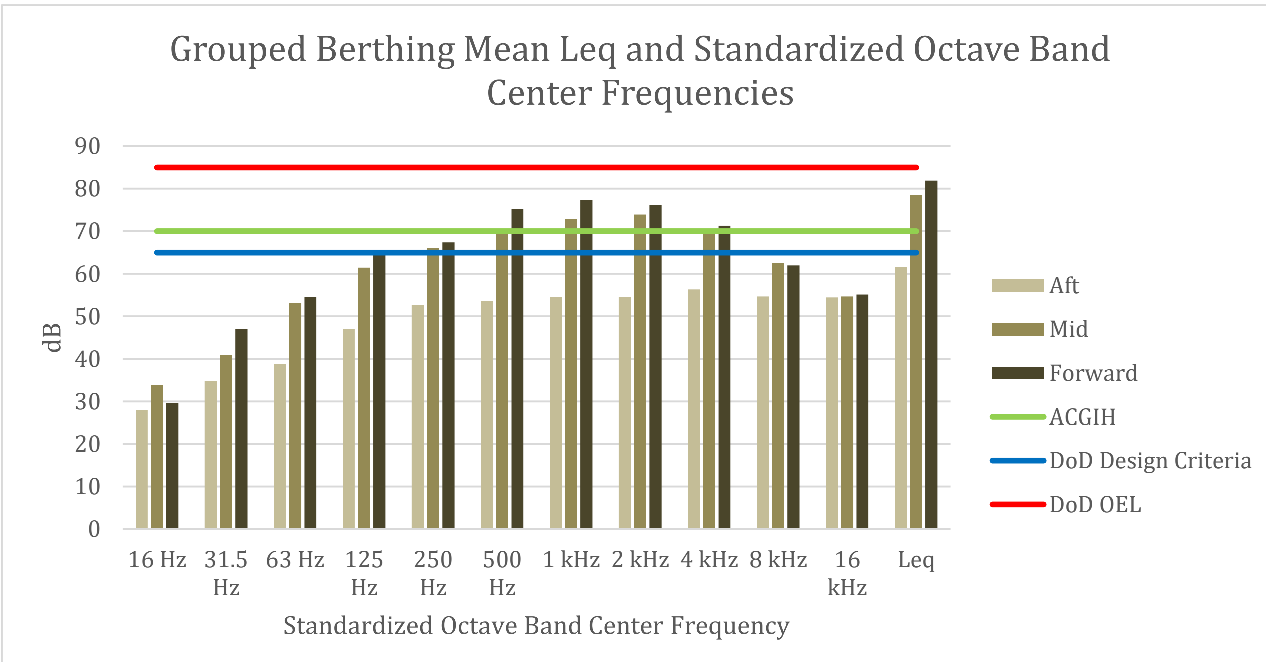


Figure 10. Grouped Berthing Mean Leq and Standardized Octave Band Frequencies

Table 4 provides the mean Leq and standardized octave band frequencies values by berthing location, with the DoD Design Criteria Standard Noise Limits provided in the last row for comparison. Measurements which exceeded noise limits are highlighted in the table. Sound levels began to exceed limits at the standardized octave band center frequency of 250 Hz. A majority of berthing spaces exceeded the noise limits of 500 Hz, 1 kHz, 2 kHz, 4 kHz and the Leq. 100% of berthing spaces exceeded the 8 kHz noise limits established by DoD design criteria standard noise limits.

Table 4. Mean Leq and standardized octave band center frequencies for berthing.

Location	16 Hz	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	16 kHz	Leq
03-250-2-L	28.0	34.8	38.8	47.0	52.6	53.6	54.5	54.6	56.3	54.6	54.5	61.6
03-205-0-L	33.9	40.9	53.2	61.4	66.1	69.5	72.9	73.9	69.9	62.5	54.7	78.5
03-9-0-L	28.9	46.6	57.1	62.7	67.1	72.2	77.1	73.1	68.0	59.8	54.7	80.1
03-1-2-L	33.8	47.4	55.4	63.3	69.0	75.8	77.6	74.9	69.9	61.4	55.2	81.7
03-1-0-L	28.0	37.2	51.4	55.4	61.8	68.2	72.1	69.2	64.8	57.8	54.6	75.6
03-C-0-L	28.2	38.4	47.7	53.5	56.4	63.1	66.7	65.1	62.4	56.1	54.6	71.0
03-G-0-L	28.3	43.4	54.4	60.6	65.8	69.2	73.6	71.7	69.6	60.8	55.0	77.9
03-K-0-L	28.6	51.2	56.1	69.6	70.5	80.0	81.6	81.0	75.6	65.6	55.8	86.4
DoD Design Criteria (Category B)	N/A	78	75	72	69	66	63	60	57	54	N/A	65

ANOVA was used to analyze the differences among group means for standardized octave band center frequencies and Leq. The data was evaluated by standardized octave band center frequencies in comparison to location which included a Tukey multiple comparisons analysis between individual berthing locations and grouped locations. Analysis indicates that there were significant differences ($p < 0.05$) between berthing spaces for Leq. There were also significant differences ($p <0.05$) between berthing spaces among standardized octave band center frequencies of 32 Hz to 8 kHz. Data for Leq and standardized octave band center frequencies is provided in table 5 below; with a Tukey multiple comparison for Leq provided in table 6. Tukey multiple comparisons analysis for standardized octave band center frequencies are located in the appendix. For Leq, a Tukey multiple comparisons analysis provided results which indicated that there are significant differences between the aft berthing, 03-205-0-L and the following berthing spaces 03-9-0-L, 03-1-2-L, 03-G-0-L and 03-K-0-L. Berthing 03-205-0-L was the only location that most closely met all organizational requirements for auditory rest which included the 85 dBA DoD OEL, ACGIH 70 dBA 24-hour auditory rest limit and the 65 dBA Department of Defense Design Criteria Standard noise limit for steady state noise for a category B space. However, all berthing spaces, including 03-250-0-L, exceeded the Department of Defense Design Criteria Standard noise limit for steady state noise for 8 kHz as referenced in table 4.

Table 5. Analysis of Variance (ANOVA) of Berthing Spaces

		Sum of Squares	df	Mean Square	F	Sig.
16 Hz	Between Groups	92.445	7	13.206	2.899	.013
	Within Groups	227.803	50	4.556		
	Total	320.248	57			
31.5 Hz	Between Groups	1017.719	7	145.388	4.373	.001
	Within Groups	1662.187	50	33.244		
	Total	2679.906	57			
63 Hz	Between Groups	1420.939	7	202.991	6.453	.000
	Within Groups	1572.887	50	31.458		
	Total	2993.826	57			
125 Hz	Between Groups	1597.695	7	228.242	5.149	.000
	Within Groups	2216.411	50	44.328		
	Total	3814.106	57			
250 Hz	Between Groups	1455.568	7	207.938	5.331	.000
	Within Groups	1950.175	50	39.004		
	Total	3405.743	57			
500 Hz	Between Groups	2128.507	7	304.072	6.811	.000
	Within Groups	2232.230	50	44.645		
	Total	4360.737	57			
1.00 kHz	Between Groups	2466.865	7	352.409	6.925	.000
	Within Groups	2544.324	50	50.886		
	Total	5011.189	57			
2.00 kHz	Between Groups	2148.015	7	306.859	5.592	.000
	Within Groups	2743.897	50	54.878		
	Total	4891.911	57			
4.00 kHz	Between Groups	1166.221	7	166.603	4.058	.001
	Within Groups	2052.821	50	41.056		
	Total	3219.042	57			
8.00 kHz	Between Groups	435.007	7	62.144	5.309	.000
	Within Groups	585.323	50	11.706		
	Total	1020.330	57			
16.00 kHz	Between Groups	9.789	7	1.398	1.878	.093
	Within Groups	37.240	50	.745		
	Total	47.028	57			
Leq	Between Groups	1997.166	7	285.309	5.963	.000
	Within Groups	2392.288	50	47.846		
	Total	4389.454	57			

Table 6. Leq Multiple Comparisons of Berthing Space

Multiple Comparisons

Dependent Variable: Leq

Tukey HSD

(I) Location_Label	(J) Location_Label	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
03-250-2-L	03-205-0-L	-15.3405*	3.8483	.005	-27.511	-3.170
	03-9-0-L	-18.3583*	4.4649	.003	-32.479	-4.237
	03-1-2-L	-20.4000*	3.9936	.000	-33.030	-7.770
	03-1-0-L	-13.3033*	4.1885	.048	-26.550	-.057
	03-C-0-L	-8.2583	3.7356	.363	-20.073	3.556
	03-G-0-L	-14.6561*	3.5105	.003	-25.759	-3.553
	03-K-0-L	-18.4561*	3.5105	.000	-29.559	-7.353
03-205-0-L	03-250-2-L	15.3405*	3.8483	.005	3.170	27.511
	03-9-0-L	-3.0179	4.3355	.997	-16.730	10.694
	03-1-2-L	-5.0595	3.8483	.889	-17.230	7.111
	03-1-0-L	2.0371	4.0502	1.000	-10.772	14.847
	03-C-0-L	7.0821	3.5799	.506	-4.240	18.404
	03-G-0-L	.6844	3.3444	1.000	-9.893	11.262
	03-K-0-L	-3.1156	3.3444	.981	-13.693	7.462
03-9-0-L	03-250-2-L	18.3583*	4.4649	.003	4.237	32.479
	03-205-0-L	3.0179	4.3355	.997	-10.694	16.730
	03-1-2-L	-2.0417	4.4649	1.000	-16.163	12.079
	03-1-0-L	5.0550	4.6401	.956	-9.620	19.730
	03-C-0-L	10.1000	4.2358	.271	-3.297	23.497
	03-G-0-L	3.7023	4.0387	.983	-9.071	16.475
	03-K-0-L	-.0977	4.0387	1.000	-12.871	12.675
03-1-2-L	03-250-2-L	20.4000*	3.9936	.000	7.770	33.030
	03-205-0-L	5.0595	3.8483	.889	-7.111	17.230
	03-9-0-L	2.0417	4.4649	1.000	-12.079	16.163
	03-1-0-L	7.0967	4.1885	.691	-6.150	20.343
	03-C-0-L	12.1417*	3.7356	.040	.327	23.956
	03-G-0-L	5.7439	3.5105	.726	-5.359	16.847
	03-K-0-L	1.9439	3.5105	.999	-9.159	13.047

Table 6. (continued) Leq Multiple Comparisons of Berthing Space

Multiple Comparisons

Dependent Variable: Leq

Tukey HSD

(I) Location_Label	(J) Location_Label	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
03-1-0-L	03-250-2-L	13.3033*	4.1885	.048	.057	26.550
	03-205-0-L	-2.0371	4.0502	1.000	-14.847	10.772
	03-9-0-L	-5.0550	4.6401	.956	-19.730	9.620
	03-1-2-L	-7.0967	4.1885	.691	-20.343	6.150
	03-C-0-L	5.0450	3.9433	.902	-7.426	17.516
	03-G-0-L	-1.3527	3.7308	1.000	-13.152	10.447
	03-K-0-L	-5.1527	3.7308	.861	-16.952	6.647
03-C-0-L	03-250-2-L	8.2583	3.7356	.363	-3.556	20.073
	03-205-0-L	-7.0821	3.5799	.506	-18.404	4.240
	03-9-0-L	-10.1000	4.2358	.271	-23.497	3.297
	03-1-2-L	-12.1417*	3.7356	.040	-23.956	-.327
	03-1-0-L	-5.0450	3.9433	.902	-17.516	7.426
	03-G-0-L	-6.3977	3.2141	.498	-16.563	3.767
	03-K-0-L	-10.1977*	3.2141	.049	-20.363	-.033
03-G-0-L	03-250-2-L	14.6561*	3.5105	.003	3.553	25.759
	03-205-0-L	-.6844	3.3444	1.000	-11.262	9.893
	03-9-0-L	-3.7023	4.0387	.983	-16.475	9.071
	03-1-2-L	-5.7439	3.5105	.726	-16.847	5.359
	03-1-0-L	1.3527	3.7308	1.000	-10.447	13.152
	03-C-0-L	6.3977	3.2141	.498	-3.767	16.563
	03-K-0-L	-3.8000	2.9494	.899	-13.128	5.528
03-K-0-L	03-250-2-L	18.4561*	3.5105	.000	7.353	29.559
	03-205-0-L	3.1156	3.3444	.981	-7.462	13.693
	03-9-0-L	.0977	4.0387	1.000	-12.675	12.871
	03-1-2-L	-1.9439	3.5105	.999	-13.047	9.159
	03-1-0-L	5.1527	3.7308	.861	-6.647	16.952
	03-C-0-L	10.1977*	3.2141	.049	.033	20.363
	03-G-0-L	3.8000	2.9494	.899	-5.528	13.128

*. The mean difference is significant at the 0.05 level.

CHAPTER 4: DISCUSSION

Noise measurements in seven of the eight berthing spaces exceeded the steady state 65 dBA criteria of MIL-STD-1474E2 and the ACGIH recommended level of 70 dBA during flight operations. ACGIH has a calculated threshold limit value (TLV) of 80 dBA for a 24-hour exposure, but when a person's work location and living location are in close proximity to one another then ACGIH recommends a limit of 70 dBA.

This exceedance during flight operations suggests personnel are not achieving adequate auditory rest during off-duty hours (Figure 7). Noise levels were highest in the forward most berthing spaces, followed by the mid berthing spaces which suggests personnel assigned to these locations are at the greatest risk of inadequate auditory recovery (Figure 10). The forward berthing location had noise produced from aircraft launching while mid berthing's source of noise exposure was predominantly due to aircraft arrested landings. On this ship, flight deck personnel were also assigned to berthing in the forward most locations. These personnel who have some of the highest on-duty noise exposures also have among the highest off duty noise exposures which further reduces opportunities for auditory rest.

Noise levels were highest between 1-2 KHz suggesting noise was predominantly composed of middle and high frequency noise originating from the flight deck compared to low frequency noise predominantly originating from machinery (Figure 7). As a result, noise treatment designed to control noise at mid-high frequencies such as improved room sound absorption materials would offer the greatest opportunity to reduce noise exposures.

Aircraft launches contribute the majority of the noise for forward berthing locations. The location of the predominant noise sources includes aircraft jet engines, the catapult shuttle traveling at high velocity to launch aircraft, the catapult water brake equipment and the mechanical equipment used to retract the shuttle after a launch.

ANOVA was performed between berthing locations and Leq and berthing locations and standardized octave band center frequencies. The ANOVA result for Leq, which is in table 5, indicates that there are significant differences between the aft berthing, 03-250-2-L, and the following berthing spaces: 03-9-0-L, 03-1-2-L, 03-G-0-L and 03-K-0-L. With the grouped spaces there are significant differences between the aft berthing compared to the forward and mid berthing as indicated with ANOVA results in Appendix F. These significant differences occurred for Leq and standardized octave band center frequencies from 31.5 Hz to 8 kHz. These differences are most likely attributed to the substantial level of noise being generated from both launches and recovery during flight operations. Berthing 03-250-2-L was the only location that most closely met all organizational requirements for auditory rest and may be due to aft berthing being isolated from sources of hazardous noise such as the arresting cables, arresting gear machinery room and aircraft landing flight paths. Aircraft fly over the aft berthing space and are at sufficient altitude above the flight deck to not contribute significant amounts of noise and the arresting cables and associated arresting machinery aren't in close proximity to the aft berthing space. The mid berthing space was in close proximity to arresting gear machinery rooms and is directly below the arresting cables which are caught during arrested landing. The forward berthing spaces had significant noise contributions from the launch catapult, aircraft jet noise and the associated machinery with launching, such as the water brake machinery spaces.

The majority of the samples provided a representation of a four-hour time period in their respective berthing spaces. A four-hour sample consists of 240 individual noise samples as a measurement is obtained every minute for four hours. These individual noise samples then constitute a single reading for not only Leq values, but also for standardized octave band center frequencies as well. In some instances, the full four hours was not measured but these samples still provided value. A single four-hour sample provided a high-quality sample in terms of representation of noise in that location versus a few noise samples taken during an extended time period, especially considering flight and at sea operations are a very dynamic environment. Ideally there would be multiple simultaneous widespread measurements using sound level meters with octave band analysis during flight operations. This would allow for the ability to determine not only the overall noise levels during a 24-hour period, but also the contribution of noise for each launch or arrested landing and the associated standardized octave band center frequencies produced during these events. The propagation of the noise could also be modeled and that would help engineers and designers create quitter berthing spaces that allow for auditory rest during off-duty hours.

According to Naval Sea Systems Command (NAVSEA) Technical Publication Shipboard Habitability Design Criteria and Practices Manual (Surface Ships) for New Ship Designs and Modernization, berthing spaces shall not be located forward of the collision bulkhead or immediately beneath machinery spaces or working spaces with considerable noise and vibration (3). However, NAVSEA T9640-AC-DSP-010/HAB Revision 1 also references MIL-STD-1474, which is the DoD's Design Criteria Standard for Noise Limits and the U.S. Navy's Hearing Conservation Program, OPNAVINST 5100.19 in an effort to protect personnel from hazardous noise. NAVSEA Technical Publication Shipboard Habitability Design Criteria and Practices Manual specifically states that consultation of these references shall be used and berthing compartment sound levels shall be determined during the design process by factoring in all known shipboard noise and vibration sources that include, but are not limited to, equipment, machinery, engines, HVAC and piping systems, motors, drive shaft, propulsors, fans, blowers, aircraft, vehicles, radio-frequency electromagnetic fields, wave slamming, water, and air turbulence (3). It also states that the combination of time weighted average noise exposure and compartment noise limits shall be factored into the design of a Navy ship in all manned spaces to support the Navy hearing conservation program in high-noise environments. Additionally, berthing spaces shall not be located in areas that put the health, safety, and survivability of personnel at risk (3). With high noise levels being measured in the forward berthing spaces on the 03 level during flight operations, the risk to the health of personnel may exist. Researchers Basner, M., et al. stated that observational and experimental studies have shown that noise exposure leads to annoyance, disturbs sleep and causes daytime sleepiness, increases the occurrence of hypertension and cardiovascular disease, and can impair cognitive performance (9). The health risk is exacerbated if these personnel work and are berthed in a high noise level environment, as this impairs their ability to recover from temporary hearing loss due to temporary threshold shifts.

CHAPTER 5: CONCLUSION

Measurements indicate that during flight operations, noise exposure in berthing spaces directly below the flight deck may lead to an increased risk of developing hearing loss by minimizing opportunity for auditory rest during off-duty hours. The sailors who work on the flight deck assist in the launching and recovery of the aircraft and some of these personnel have primary jobs which involve directing aircraft and ensuring the aircraft are properly positioned prior to launching. This requires personnel to be in very close proximity to the aircraft, including when the aircraft is at full power. These personnel who are routinely exposed to noise levels in excess of 150 dBA are also the same personnel who are required to sleep in berthing locations that may routinely exceed the 65 dBA Department of Defense Design Criteria Standard Noise Limits for steady state noise in berthing, the ACGIH 70 dBA 24-hour auditory rest limit and the 85 dBA DoD occupational exposure limit. The noise contribution from a single aircraft launch is sufficient enough to negate the effects of an hour of low ambient sound levels in berthing space 03-K-0-L. Personnel who work on the flight deck and are berthed in forward berthing spaces located directly below the flight deck may be at a greater risk for noise induced hearing loss. Control of mid-high frequency noise in berthing spaces may present the greatest opportunity in reducing noise exposures and allowing hearing loss recovery.

Limitations

A limitation of this study included lack of widespread measurements. This was due to having only three sound level meters with octave band analyzers available during the study and a finite number of AA alkaline batteries. This limited the amount of sampling throughout the 03 level especially in mid and aft berthing spaces. Another limitation were power failures that occurred during the study. These power failures were due to using partially drained batteries from a previous sampling period for an additional four-hour sampling period. The batteries provided enough power for two four-hour sampling periods provided the overall noise levels were low. There was a correlation with depletion of battery life and noise levels, with high noise levels causing increased battery depletion. The manufacturer, 3M™, also indicates that having a shorter sampling time, such as a recorded measurement every second, will also deplete the batteries at a faster rate. An alternating current to direct current power adapter was used on occasion but the scarce availability of AC power outlets and distance from the sound level meters made their use limited. A possible solution to this could have been the use of power extension cords, but it would be important to route the cord in such a manner as to not inhibit passage of personnel. If a reliable dedicated power source was available during the study a continuous sample could have been performed as the SLMs had sufficient memory capabilities with the average file size for a four-hour sampling period requiring less than 150 kB and the external memory card used was 2 GB in size.

During the study, SLM #2 (Serial number BEL100002) suffered a fall from a top rack and this was discovered at the end of its sampling period. This SLM failed post calibration and upon further inspection the researcher discovered that the sound level meter's microphone component was damaged beyond repair. Fortunately, the Industrial Hygiene Officer aboard had a compatible microphone from the same manufacturer, 3M™. Upon replacement of the microphone the SLM passed all subsequent calibrations and the ANOVA performed between the SLMs indicated there were no significant differences between them.

Another limitation of the study was the inability to guarantee that the sound level meters were free from tampering during the study. However, during checkups conducted while sampling no signs of tampering were evident. Ideally this sampling would have occurred in berthing spaces that were vacated and locked to prevent tampering as well as minimize external noise generated from personnel in the berthing. The use of video recording devices in conjunction with sampling would assist in identifying any tampering and could also provide a means to identify specific sources of noise.

A limitation of the study was the limited type of aircraft and loadout of the aircraft. The majority of aircraft launches and recoveries were of FA-18 E/F Super Hornets and there were also launches and recoveries of C-2A Greyhounds and E-2C Hawkeyes. The loadout of the Super Hornets was limited as none of the aircraft had ordnance loaded and it was not known if any of the aircraft had auxiliary fuel tanks loaded as well. The addition of ordnance or additional fuel tanks will require a more powerful launch and most likely a higher noise generation by the catapult shuttle.

During the sampling period more, focus was given to forward spaces as those had notably higher noise levels. This may have introduced bias and under sampling of mid and aft berthing spaces.

Future Research

Future research could include performing a cohort study of personnel who were berthed in those berthing locations with high hazardous noise levels to determine if those personnel have a greater risk of hearing loss in comparison to personnel berthed elsewhere. A retrospective study using the audiograms of these personnel can also help to determine if there is a correlation of predominant standard octave band center frequencies in these berthing spaces and corresponding permanent threshold shifts.

With developments in technology future research could evaluate the risk to personnel's hearing and whether these advancements in technology pose a risk or benefit for hearing conservation efforts. Advancements such as Electromagnetic Aircraft Launch System (EMALS), the Joint Strike Fighter F-35C Lightning and the development of the UX-47B Unmanned Combat Air System (UCAS) will benefit from future research that focuses on determining if these technologies pose a detriment or benefit to hearing conservation efforts.

REFERENCES

1. 2004. Department of Defense Instuction 6055.12. Department of Defense
2. 2015. Department of Defense Design Criteria Standard Noise Limits. Department of Defense
3. 2016. *Shipboard Habitability Design Criteria and Practices Manual (Surface Ships) for New Ship Designs and Modernization*. Washington DC: Naval Sea Systems Command
4. 2018. *Department of Veterans Affairs Office of Research & Development*. https://www.research.va.gov/topics/hearing.cfm
5. 2018. *Environmental Noise*. http://www.epd.gov.hk/epd/noise_education/web/ENG_EPD_HTML/m1/intro_5.html
6. 2018. *Institute for Telecommunication Sciences*. https://www.its.bldrdoc.gov/fs-1037/dir-024/_3502.htm
7. ACGIH. 2016. *Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices*. ACGIH
8. Aubert A, McKinley R. 2011. Measurements of Jet Noise Aboard US Navy Aircraft Carriers. In *AIAA Centennial of Naval Aviation Forum "100 Years of Achievement and Progress"*: American Institute of Aeronautics and Astronautics. Number of.
9. Basner M, Babisch W, Davis A, Brink M, Clark C, et al. 2014. Auditory and non-auditory effects of noise on health. *Lancet* 383:1325-32
10. Berenice Goelzer CHHaGAS. *Occupational exposure to noise: evaluation, prevention and control*. World Health Organization
11. Brazile WJ, Autenrieth, Daniel. 2017. *Occupational and Community Noise*. Kendall Hunt. 228 pp.
12. Cody AR, Russell IJ. 1985. Outer hair cells in the mammalian cochlea and noise-induced hearing loss. *Nature* 315:662
13. Davis R. 2017. Long-term noise exposures: A brief review. *Hearing Research* 349:31-3
14. Davis S, Smalt C, Calamia P. 2016. Noise Exposure in Berthing Rooms of Naval Ships. ed. ML Laboratory: MIT Lincoln Laboratory
15. Goley GS, Song WJ, Kim JH. 2011. Kurtosis corrected sound pressure level as a noise metric for risk assessment of occupational noises. *The Journal of the Acoustical Society of America* 129:1475-81
16. Medicine Io. 2006. *Noise and Military Service: Implications for Hearing Loss and Tinnitus*. Washington, DC: The National Academies Press. 338 pp.
17. Mizutari K, Fujioka M, Hosoya M, Bramhall N, Okano HJ, et al. 2013. Notch inhibition induces cochlear hair cell regeneration and recovery of hearing after acoustic trauma. *Neuron* 77:58-69
18. Navy US. 2018. *Carrier: Powerhouse of the fleet*. http://www.navy.mil/navydata/ships/carriers/powerhouse/powerhouse.asp

19. Neitzel RL, Berna BE, Seixas NS. 2006. Noise exposures aboard catcher/processor fishing vessels. *American Journal of Industrial Medicine* 49:624-33
20. NIOSH. 2018. *NIOSH*. https://www.cdc.gov/niosh/topics/noise/default.html
21. OSHA DoLOSaHA. 2018. *Occupational Noise Exposure*. https://www.osha.gov/SLTC/noisehearingconservation/
22. Passchier-Vermeer W, Passchier WF. 2000. Noise Exposure and Public Health. *Environmental Health Perspectives* 108:123-31
23. Schaal NC, Slagley JM, Richburg CM, Zreiqat MM, Paschold HW. 2018. Chemical-Induced Hearing Loss in Shipyard Workers. *Journal of Occupational and Environmental Medicine* 60:e55-e62
24. Sunde E, Irgens-Hansen K, Moen BE, Gjestland T, Koefoed VF, et al. 2015. Noise and exposure of personnel aboard vessels in the Royal Norwegian Navy. *The Annals of occupational hygiene* 59:182-99
25. Thomas W. Rimmer S, CIH. 2018. http://www.uams.edu/coph/eoh/TRimmer%20Files/Acoustical%20Fundamentals%20Slides.pdf
26. Trost RP, Shaw GB. 2007. Statistical analysis of hearing loss among navy personnel. *Mil Med* 172:426-30
27. Turan O, Helvacioglu IH, Insel M, Khalid H, Kurt RE. 2011. Crew noise exposure on board ships and comparative study of applicable standards. *Ships and Offshore Structures* 6:323-38
28. Turner P. 2018. USS Ronald Regan Cutaway View.
29. U.S.Navy. 2018. *The Aircraft Carrier*. http://www.navy.mil/navydata/ships/carriers/carriers.asp
30. Ward, W. D., Cushing, E. M., & Burns, E. M. (1976). Effective quiet and moderate TTS: Implications for noise exposure standards. *The Journal of the Acoustical Society of America*, *59*(1), 160-165.
31. Yankaskas K, Fischer R, Spence J, Komrower J. 2017. Engineering out the noise. *Hearing Research* 349:37-41

APPENDIX

APPENDIX A. Raw Data

Date	Location	Time	SLM	16 Hz	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	16 kHz	Leq
4-Dec-2017	03-205-0-L	4:00:00	1	39.2	42.5	54.1	62	66.9	71.5	75.6	76	72.1	64.6	55.3	80.7
4-Dec-2017	03-205-0-L	4:00:00	2	34.3	44.6	56.1	64.7	70.3	74.1	77.5	78.4	74.7	66.7	55.1	83
4-Dec-2017	03-205-0-L	4:00:00	1	30.2	40.5	53.7	60.9	62.7	65.1	68.8	72.3	67.1	60.4	54.1	75.7
4-Dec-2017	03-205-0-L	4:00:00	2	30.8	40.8	54.7	63.7	67.8	69.3	70.5	71.1	65.7	59.2	53.5	76.6
4-Dec-2017	03-205-0-L	4:00:00	1	28.8	33.5	44.5	52.2	56.9	62.2	65.8	68.4	65.3	58.9	55.4	72.4
4-Dec-2017	03-205-0-L	4:00:00	2	27.9	32	44.6	49.9	52.9	58.6	61.1	62.5	59.8	56.2	54.3	67.2

Date	Location	Time	SLM	16 Hz	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	16 kHz	Leq
5-Dec-2017	03-1-2-L	4:00:00	1	40.2	48.6	54.3	63.9	67.4	75.5	78.8	76.4	72.0	63.1	55.9	82.6
5-Dec-2017	03-1-2-L	4:00:00	2	31.5	51.4	57.1	64.6	70.2	76.8	79.7	77.0	72.3	63.7	55.2	83.5
5-Dec-2017	03-1-2-L	4:00:00	1	28.5	44.7	51.6	60.8	67.0	72.7	75.1	71.4	66.1	58.7	55.4	78.9
5-Dec-2017	03-1-2-L	3:18:21	2	27.5	40.0	55.6	61.4	71.2	75.0	75.3	72.5	67.4	59.5	54.7	80.2
5-Dec-2017	03-1-2-L	4:00:00	1	28.5	43.1	52.1	61.3	65.6	74.6	75.2	71.4	67.5	59.3	55.4	79.4
5-Dec-2017	03-1-2-L	4:00:00	2	28.4	47.8	58.0	65.4	70.0	78.0	78.9	76.7	70.1	61.3	54.7	83.3

Date	Location	Time	SLM	16 Hz	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	16 kHz	Leq
6-Dec-2017	03-K-0-L	4:00:00	1	30.2	52.5	56.5	70.5	69.3	75.3	80.9	78.7	74.4	65.1	56.2	84.5
6-Dec-2017	03-K-0-L	4:00:00	2	28.4	47.9	53.9	71.6	70.7	75.5	80.6	79.0	73.8	64.1	55.0	84.6
6-Dec-2017	03-K-0-L	4:00:00	3	28.2	41.0	52.2	67.2	70.8	77.5	80.6	79.7	74.2	64.8	55.1	85.0
6-Dec-2017	03-K-0-L	3:51:34	1	28.7	51.5	57.7	62.9	67.7	74.5	79.3	79.1	74.6	64.8	56.1	83.8
6-Dec-2017	03-K-0-L	3:48:50	2	28.4	53.3	55.5	68.9	74.2	75.3	77.5	77.4	75.0	63.6	55.0	83.3
6-Dec-2017	03-K-0-L	3:31:25	3	28.0	50.8	54.2	73.1	75.5	82.8	83.4	82.8	78.6	67.9	56.8	88.7
6-Dec-2017	03-K-0-L	4:00:00	1	28.9	52.2	59.4	73.7	70.7	85.4	87.3	87.5	80.9	70.7	58.4	92.1
6-Dec-2017	03-K-0-L	4:00:00	2	28.9	57.4	61.8	72.1	71.0	85.8	85.2	83.9	78.1	68.5	56.9	90.3
6-Dec-2017	03-K-0-L	3:45:10	1	28.3	31.2	34.4	43.7	53.1	54.7	56.0	53.5	53.0	55.3	54.8	61.1
6-Dec-2017	03-K-0-L	3:38:08	2	27.2	30.2	34.8	46.1	52.6	53.4	54.3	52.5	52.1	54.4	53.7	60.1

Date	Location	Time	SLM	16 Hz	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	16 kHz	Leq
7-Dec-2017	03-K-0-L	4:00:00	1	28.3	32.1	46.0	40.5	45.6	53.5	55.4	52.5	53.3	55.3	53.9	59.6
7-Dec-2017	03-9-0-L	4:00:00	1	28.7	47.3	51.4	60.8	64.9	70.1	74.6	70.7	64.6	58.0	55.3	77.7
7-Dec-2017	03-9-0-L	4:00:00	3	29.2	43.7	55.5	61.3	60.1	67.1	72.3	68.5	63.4	56.7	54.3	75.4
7-Dec-2017	03-9-0-L	3:26:03	2	30.0	49.4	59.5	62.9	68.8	74.2	79.0	75.0	70.0	61.7	54.7	82.0
7-Dec-2017	03-9-0-L	3:18:52	3	27.4	43.1	58.1	64.8	69.5	74.0	78.9	75.0	70.0	60.9	54.5	82.0

Date	Location	Time	SLM	16 Hz	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	16 kHz	Leq
8-Dec-2017	03-250-2-L	4:00:00	1	28.8	35.9	39.0	47.8	55.1	53.2	56.0	56.4	57.6	55.3	55.3	63.1
8-Dec-2017	03-250-2-L	4:00:00	2	27.9	35.3	40.0	44.3	49.2	51.5	51.6	50.5	52.2	54.3	54.2	57.5
8-Dec-2017	03-250-2-L	4:00:00	3	27.6	30.6	35.5	45.0	50.2	53.5	55.5	57.5	60.3	54.3	54.2	63.8
8-Dec-2017	03-250-2-L	4:00:00	1	28.5	36.2	39.8	49.8	55.3	54.8	55.7	54.2	54.4	55.3	55.2	62.0
8-Dec-2017	03-250-2-L	4:00:00	2	27.3	36.6	40.2	46.4	49.8	52.4	50.8	49.6	51.6	54.2	53.3	57.5
8-Dec-2017	03-250-2-L	4:00:00	3	27.4	30.5	36.3	46.3	51.7	55.1	55.0	54.2	55.5	54.3	54.2	61.6
8-Dec-2017	03-C-0-L	4:00:00	1	29.3	39.8	48.3	56.9	59.3	65.5	69.3	67.2	64.8	57.0	55.3	73.4
8-Dec-2017	03-C-0-L	4:00:00	2	27.3	36.6	40.2	46.4	49.8	52.4	50.8	49.6	51.6	54.2	53.3	57.5
8-Dec-2017	03-C-0-L	4:00:00	3	28.3	37.2	47.0	56.0	59.1	64.6	69.3	67.2	65.2	56.3	54.3	73.3
8-Dec-2017	03-C-0-L	3:55:35	1	28.6	35.2	42.5	50.3	54.0	60.3	63.2	61.2	58.5	55.8	55.3	67.5
8-Dec-2017	03-C-0-L	3:56:06	2	27.5	32.6	40.7	50.4	56.9	64.9	65.7	63.5	59.4	55.4	54.3	70.3
8-Dec-2017	03-C-0-L	3:48:16	3	27.5	33.4	41.2	50.4	51.8	59.3	62.3	59.6	57.3	54.8	54.3	66.3

Date	Location	Time	SLM	16 Hz	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	16 kHz	Leq
9-Dec-2017	03-C-0-L	4:00:00	1	29.1	40.4	51.9	56.0	56.9	65.3	68.7	67.6	64.6	57.1	55.3	73.2
9-Dec-2017	03-C-0-L	3:52:01	3	27.6	42.6	51.6	51.0	55.2	61.6	67.4	66.9	64.1	57.4	54.4	71.9
9-Dec-2017	03-G-0-L	4:00:00	1	29.5	47.1	54.8	60.1	62.4	70.3	73.9	72.3	69.8	60.8	55.6	78.2
9-Dec-2017	03-G-0-L	4:00:00	2	28.3	44.6	56.2	64.9	73.6	73.7	79	76.8	75.9	66.6	56.1	83.4
9-Dec-2017	03-G-0-L	4:00:00	3	28.1	43.4	56.3	60.2	61.6	70.1	73.6	71.7	69.4	60.2	54.5	77.8
9-Dec-2017	03-G-0-L	1:59:45	1	28.5	36.7	49.9	58.2	61.9	66.8	73.9	73	69.3	61.1	55.6	77.9
9-Dec-2017	03-G-0-L	2:00:09	2	27.9	39.7	48.3	53.3	57.4	65	69.4	68.2	63.2	57.3	54.4	73.4
9-Dec-2017	03-G-0-L	1:59:55	3	27.4	37.5	49.7	54.8	57.9	64.2	69.6	67.9	64.5	56.5	54.3	73.5
9-Dec-2017	03-G-0-L	3:08:25	1	28.5	37.3	51.1	58.1	57.7	62.4	65.2	61.1	58.7	55.9	55.3	69.3
9-Dec-2017	03-G-0-L	3:07:56	2	27.5	40.2	52.9	58.7	59.3	67.4	69.7	68.6	65.3	58.2	54.3	74.5
9-Dec-2017	03-G-0-L	3:07:05	3	27.4	40.5	51.7	52	54	59.8	61.4	58.6	55.8	54.6	54.3	66

Date	Location	Time	SLM	16 Hz	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	16 kHz	Leq
10-Dec-17	03-G-0-L	4:00:00	1	28.9	47.1	55.5	58.5	61.1	67.6	70.9	67.9	66	58	55.3	74.9
10-Dec-17	03-G-0-L	4:00:00	2	28.3	46.2	58	64.8	66.4	72.6	76.8	74.8	71.5	62.1	54.6	80.8
10-Dec-17	03-G-0-L	4:00:00	3	28.3	43.3	56.3	63.5	69.8	70.7	75.3	72.9	71.8	62.1	54.9	79.8
10-Dec-17	03-1-0-L	4:00:00	1	28.4	36.3	53.8	59.2	63.4	68.7	73.3	70.1	65	57.5	55.2	76.6
10-Dec-17	03-1-0-L	4:00:00	2	28.3	28	37.2	53.2	52.2	61.8	68	67.8	63.9	60.6	55.4	72.5
10-Dec-17	03-1-0-L	4:00:00	3	27.6	39.3	52.7	53.7	61.4	70.1	73.2	69.9	64.6	56.6	54.2	76.6
11-Dec-17	03-1-0-L	4:00:00	2	28.1	40.40	48.6	50.9	52.6	58.9	62.1	60.4	60.5	54.5	54.2	67
11-Dec-17	03-1-0-L	4:00:00	3	27.6	33.00	52.7	55.1	65.6	71.2	75	71.6	67.3	57.6	53.7	78.4

APPENDIX B. SPSS™ Descriptive Data 16 Hz – 16 kHz

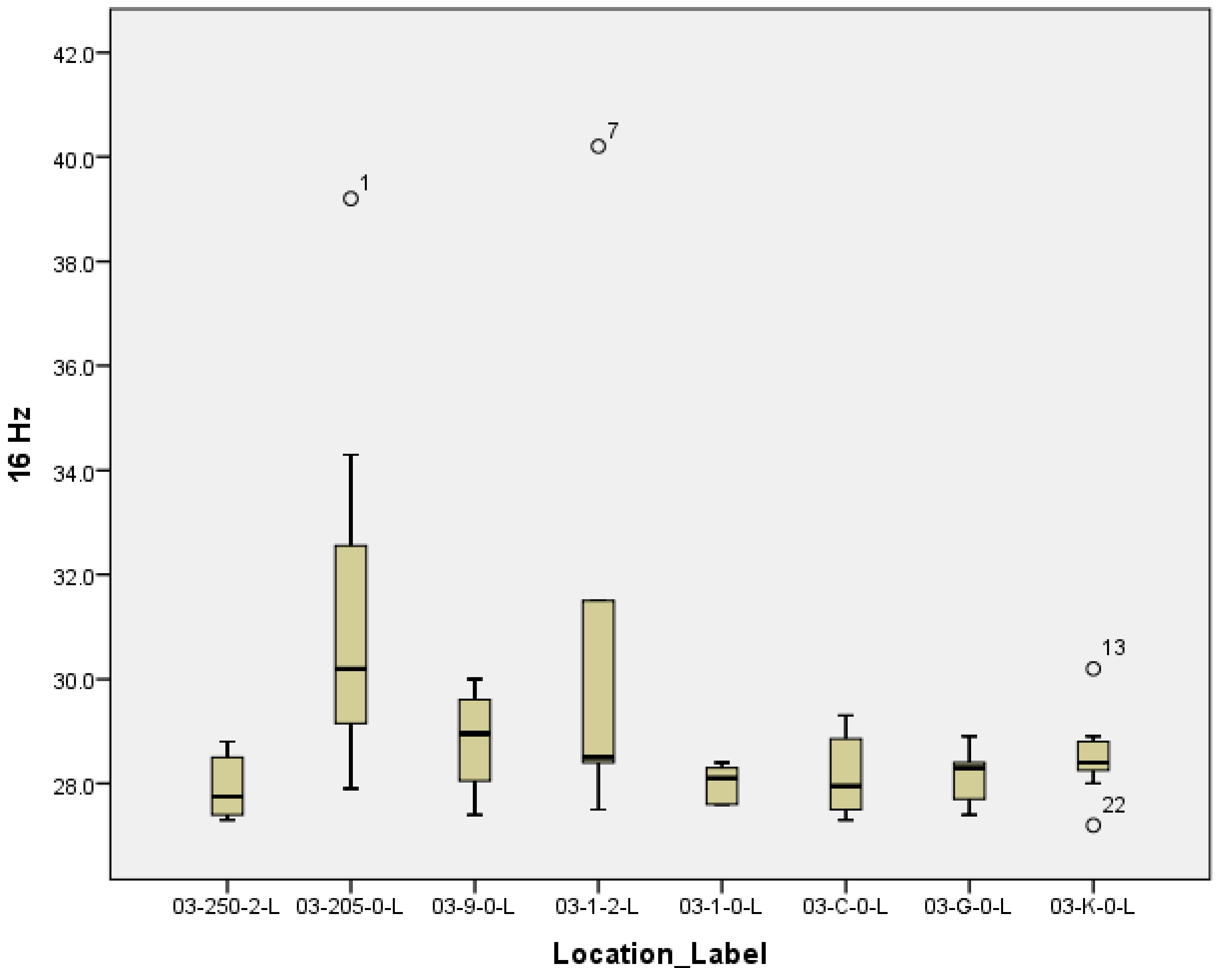
Descriptives

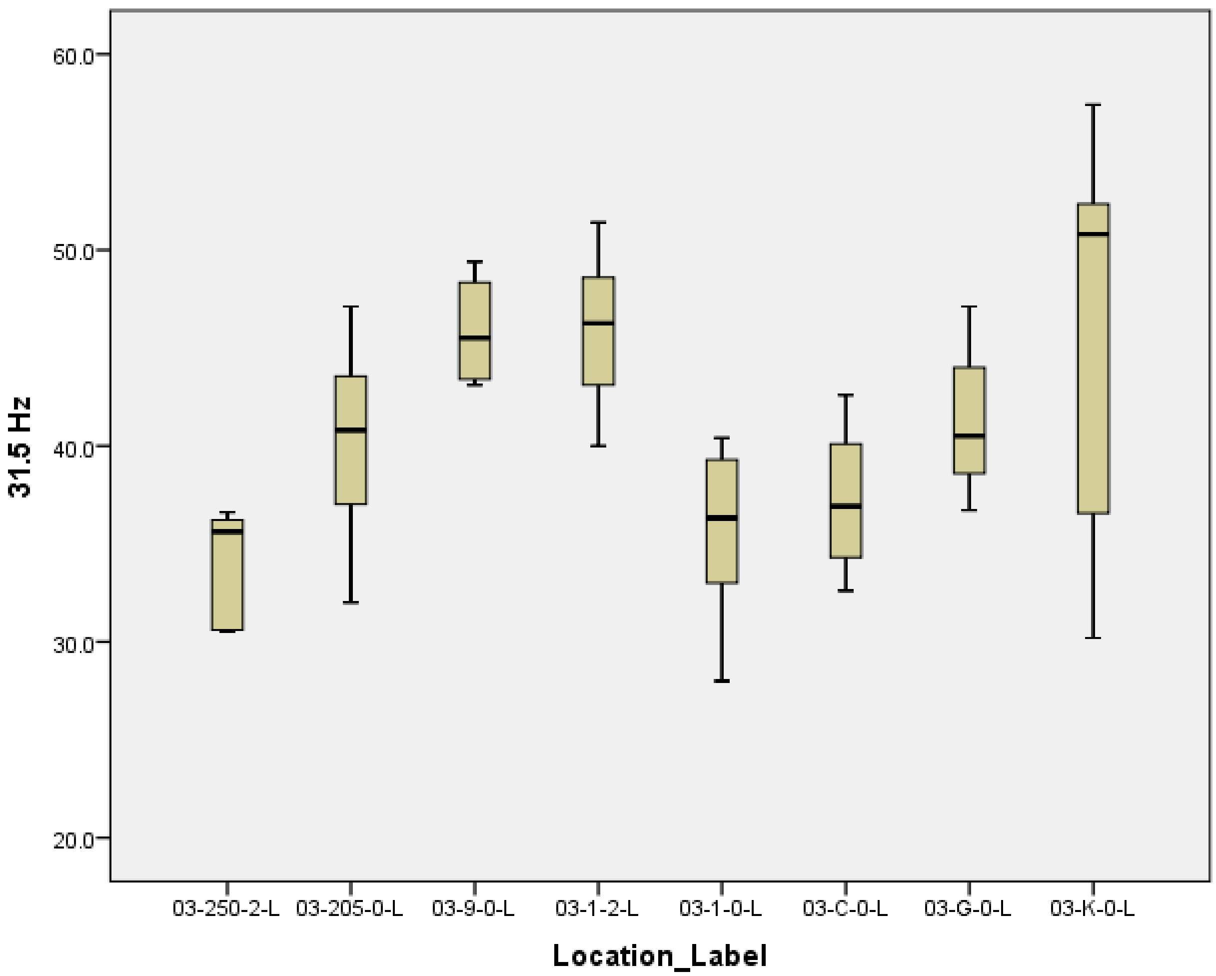
		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
16 Hz	03-250-2-L	6	27.917	.6113	.2496	27.275	28.558	27.3	28.8
	03-205-0-L	7	31.529	3.9487	1.4925	27.877	35.181	27.9	39.2
	03-9-0-L	4	28.825	1.0905	.5452	27.090	30.560	27.4	30.0
	03-1-2-L	6	30.767	4.8182	1.9670	25.710	35.823	27.5	40.2
	03-1-0-L	5	28.000	.3808	.1703	27.527	28.473	27.6	28.4
	03-C-0-L	8	28.150	.7856	.2777	27.493	28.807	27.3	29.3
	03-G-0-L	11	28.100	.4960	.1495	27.767	28.433	27.4	28.9
	03-K-0-L	11	28.500	.7335	.2212	28.007	28.993	27.2	30.2
	Total	58	28.895	2.3703	.3112	28.272	29.518	27.2	40.2
31.5 Hz	03-250-2-L	6	34.183	2.8463	1.1620	31.196	37.170	30.5	36.6
	03-205-0-L	7	40.143	5.5500	2.0977	35.010	45.276	32.0	47.1
	03-9-0-L	4	45.875	2.9937	1.4969	41.111	50.639	43.1	49.4
	03-1-2-L	6	45.933	4.1288	1.6856	41.600	50.266	40.0	51.4
	03-1-0-L	5	35.400	5.0384	2.2532	29.144	41.656	28.0	40.4
	03-C-0-L	8	37.225	3.5074	1.2401	34.293	40.157	32.6	42.6
	03-G-0-L	11	41.500	3.6403	1.0976	39.054	43.946	36.7	47.1
	03-K-0-L	11	45.464	10.0228	3.0220	38.730	52.197	30.2	57.4
	Total	58	40.976	6.8568	.9003	39.173	42.779	28.0	57.4
63 Hz	03-250-2-L	6	38.467	2.0452	.8349	36.320	40.613	35.5	40.2
	03-205-0-L	7	51.786	4.9988	1.8894	47.163	56.409	44.5	56.1
	03-9-0-L	4	56.125	3.5594	1.7797	50.461	61.789	51.4	59.5
	03-1-2-L	6	54.783	2.6057	1.0638	52.049	57.518	51.6	58.0
	03-1-0-L	5	49.000	6.8888	3.0807	40.446	57.554	37.2	53.8
	03-C-0-L	8	45.425	4.8820	1.7260	41.344	49.506	40.2	51.9
	03-G-0-L	11	53.264	3.3227	1.0018	51.031	55.496	48.3	58.0
	03-K-0-L	11	51.491	9.2899	2.8010	45.250	57.732	34.4	61.8
	Total	58	50.124	7.2473	.9516	48.219	52.030	34.4	61.8
125 Hz	03-250-2-L	6	46.600	1.9829	.8095	44.519	48.681	44.3	49.8
	03-205-0-L	7	59.071	5.7361	2.1680	53.766	64.376	49.9	64.7
	03-9-0-L	4	62.450	1.8046	.9023	59.578	65.322	60.8	64.8
	03-1-2-L	6	62.900	1.9677	.8033	60.835	64.965	60.8	65.4
	03-1-0-L	5	54.420	3.0703	1.3731	50.608	58.232	50.9	59.2
	03-C-0-L	8	52.175	3.7059	1.3102	49.077	55.273	46.4	56.9

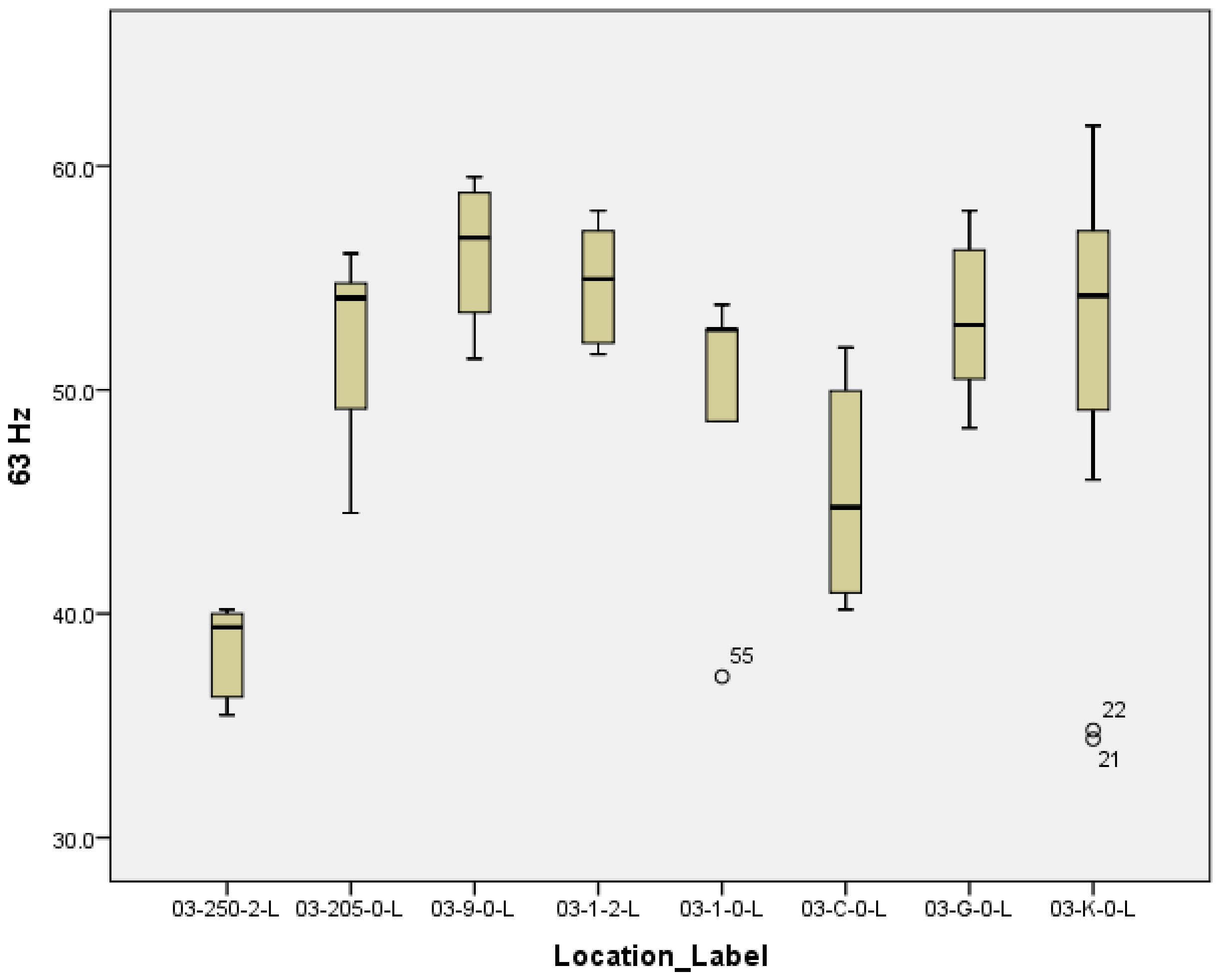
	03-G-0-L	11	58.818	4.3669	1.3167	55.884	61.752	52.0	64.9
	03-K-0-L	11	62.755	12.8284	3.8679	54.136	71.373	40.5	73.7
	Total	58	57.709	8.1801	1.0741	55.558	59.859	40.5	73.7
250 Hz	03-250-2-L	6	51.883	2.6992	1.1019	49.051	54.716	49.2	55.3
	03-205-0-L	7	62.843	6.2053	2.3454	57.104	68.582	52.9	70.3
	03-9-0-L	4	65.825	4.3200	2.1600	58.951	72.699	60.1	69.5
	03-1-2-L	6	68.567	2.2033	.8995	66.254	70.879	65.6	71.2
	03-1-0-L	5	59.040	6.2424	2.7917	51.289	66.791	52.2	65.6
	03-C-0-L	8	55.375	3.3746	1.1931	52.554	58.196	49.8	59.3
	03-G-0-L	11	61.882	5.8595	1.7667	57.945	65.818	54.0	73.6
	03-K-0-L	11	65.564	10.1169	3.0504	58.767	72.360	45.6	75.5
	Total	58	61.483	7.7298	1.0150	59.450	63.515	45.6	75.5
500 Hz	03-250-2-L	6	53.417	1.3790	.5630	51.969	54.864	51.5	55.1
	03-205-0-L	7	67.300	5.5290	2.0898	62.187	72.413	58.6	74.1
	03-9-0-L	4	71.350	3.4044	1.7022	65.933	76.767	67.1	74.2
	03-1-2-L	6	75.433	1.8338	.7486	73.509	77.358	72.7	78.0
	03-1-0-L	5	66.140	5.4565	2.4402	59.365	72.915	58.9	71.2
	03-C-0-L	8	61.738	4.4763	1.5826	57.995	65.480	52.4	65.5
	03-G-0-L	11	67.300	4.2891	1.2932	64.419	70.181	59.8	73.7
	03-K-0-L	11	72.155	12.4274	3.7470	63.806	80.503	53.4	85.8
	Total	58	67.038	8.7467	1.1485	64.738	69.338	51.5	85.8
1.00 kHz	03-250-2-L	6	54.100	2.2839	.9324	51.703	56.497	50.8	56.0
	03-205-0-L	7	70.457	5.7720	2.1816	65.119	75.795	61.1	77.5
	03-9-0-L	4	76.200	3.3116	1.6558	70.931	81.469	72.3	79.0
	03-1-2-L	6	77.167	2.1778	.8891	74.881	79.452	75.1	79.7
	03-1-0-L	5	70.320	5.2922	2.3667	63.749	76.891	62.1	75.0
	03-C-0-L	8	64.588	6.1844	2.1865	59.417	69.758	50.8	69.3
	03-G-0-L	11	71.345	5.1187	1.5433	67.907	74.784	61.4	79.0
	03-K-0-L	11	74.591	12.7278	3.8376	66.040	83.142	54.3	87.3
	Total	58	69.986	9.3763	1.2312	67.521	72.452	50.8	87.3
2.00 kHz	03-250-2-L	6	53.733	3.1392	1.2816	50.439	57.028	49.6	57.5
	03-205-0-L	7	71.571	5.1619	1.9510	66.797	76.345	62.5	78.4
	03-9-0-L	4	72.300	3.2445	1.6222	67.137	77.463	68.5	75.0
	03-1-2-L	6	74.233	2.7384	1.1179	71.360	77.107	71.4	77.0
	03-1-0-L	5	67.960	4.4377	1.9846	62.450	73.470	60.4	71.6
	03-C-0-L	8	62.850	6.1653	2.1798	57.696	68.004	49.6	67.6
	03-G-0-L	11	69.227	5.5336	1.6684	65.510	72.945	58.6	76.8
	03-K-0-L	11	73.327	13.4708	4.0616	64.277	82.377	52.5	87.5

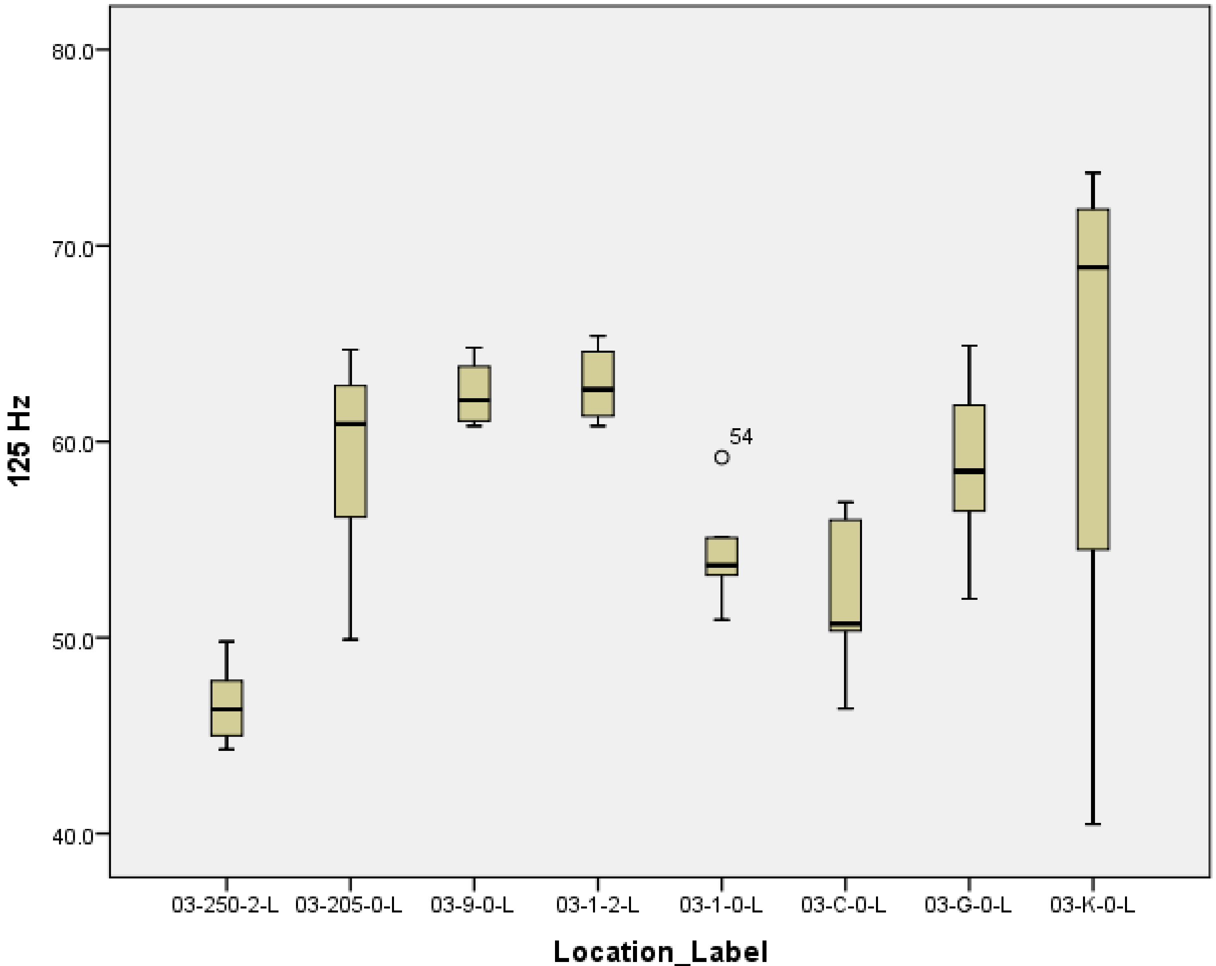
	Total	58	68.426	9.2641	1.2164	65.990	70.862	49.6	87.5
4.00 kHz	03-250-2-L	6	55.267	3.2995	1.3470	51.804	58.729	51.6	60.3
	03-205-0-L	7	67.786	4.9202	1.8597	63.235	72.336	59.8	74.7
	03-9-0-L	4	67.000	3.4986	1.7493	61.433	72.567	63.4	70.0
	03-1-2-L	6	69.233	2.6074	1.0645	66.497	71.970	66.1	72.3
	03-1-0-L	5	64.260	2.4583	1.0994	61.208	67.312	60.5	67.3
	03-C-0-L	8	60.688	4.8510	1.7151	56.632	64.743	51.6	65.2
	03-G-0-L	11	66.491	5.9128	1.7828	62.519	70.463	55.8	75.9
	03-K-0-L	11	69.818	11.1531	3.3628	62.325	77.311	52.1	80.9
	Total	58	65.443	7.5149	.9868	63.467	67.419	51.6	80.9
8.00 kHz	03-250-2-L	6	54.617	.5307	.2167	54.060	55.174	54.2	55.3
	03-205-0-L	7	60.971	3.5715	1.3499	57.668	64.275	56.2	66.7
	03-9-0-L	4	59.325	2.3641	1.1821	55.563	63.087	56.7	61.7
	03-1-2-L	6	60.933	2.1068	.8601	58.722	63.144	58.7	63.7
	03-1-0-L	5	57.360	2.1984	.9832	54.630	60.090	54.5	60.6
	03-C-0-L	8	56.000	1.1551	.4084	55.034	56.966	54.2	57.4
	03-G-0-L	11	59.327	3.4843	1.0505	56.987	61.668	54.6	66.6
	03-K-0-L	11	63.136	5.6422	1.7012	59.346	66.927	54.4	70.7
	Total	58	59.298	4.2309	.5555	58.186	60.411	54.2	70.7
16.00 kHz	03-250-2-L	6	54.400	.7457	.3044	53.617	55.183	53.3	55.3
	03-205-0-L	7	54.757	.7913	.2991	54.025	55.489	53.5	55.6
	03-9-0-L	4	54.700	.4320	.2160	54.013	55.387	54.3	55.3
	03-1-2-L	6	55.217	.4622	.1887	54.732	55.702	54.7	55.9
	03-1-0-L	5	54.540	.7266	.3250	53.638	55.442	53.7	55.4
	03-C-0-L	8	54.563	.7029	.2485	53.975	55.150	53.3	55.3
	03-G-0-L	11	54.873	.6182	.1864	54.457	55.288	54.3	56.1
	03-K-0-L	11	55.627	1.4029	.4230	54.685	56.570	53.7	58.4
	Total	58	54.905	.9083	.1193	54.666	55.144	53.3	58.4

APPENDIX C. SPSS™ Stem-and-Leaf Plots 16 Hz – 16 kHz and Leq

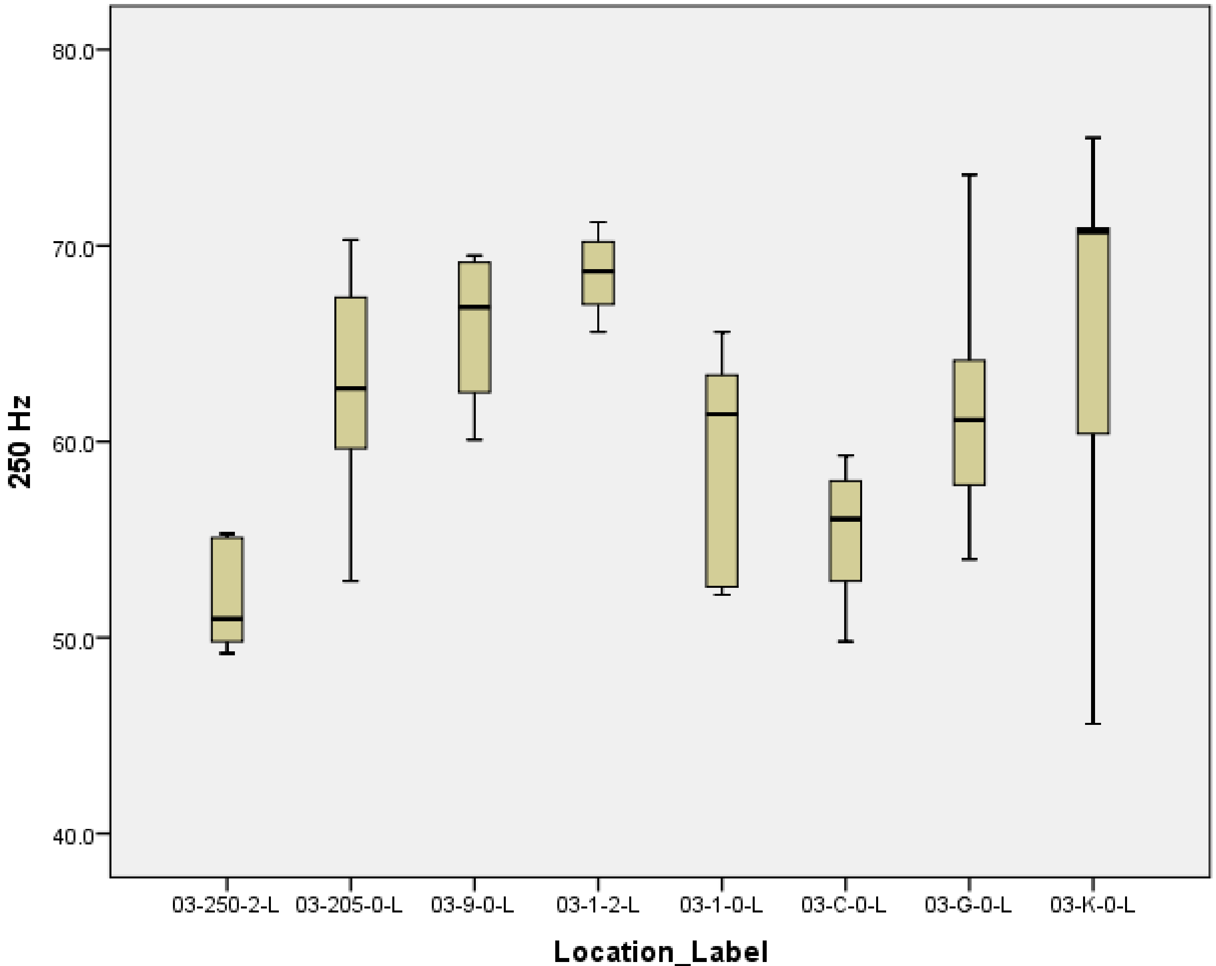


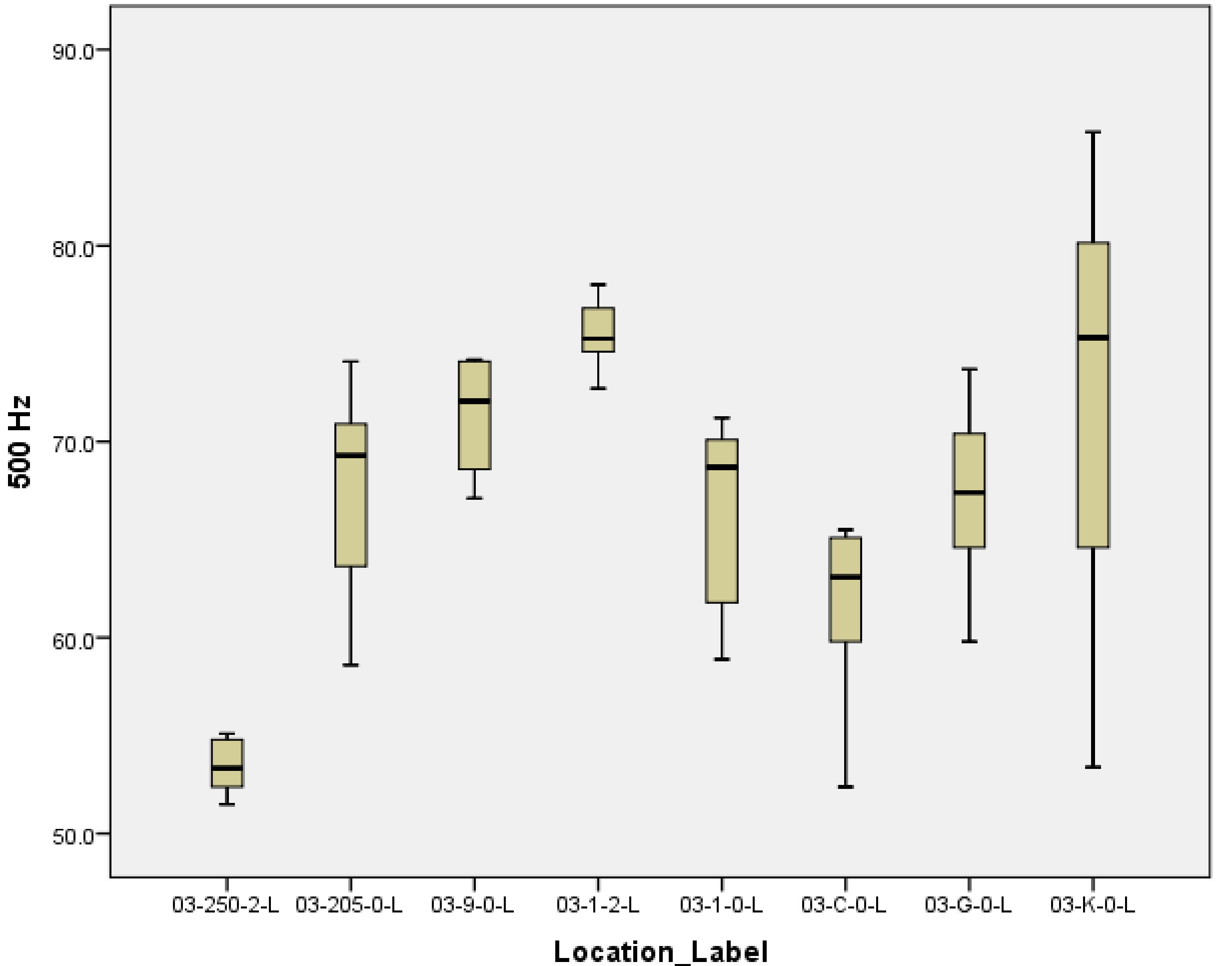

60.0
50.0
40.0
30.0
20.0
31.5 Hz
03-250-2-L
03-205-0-L
03-9-0-L
03-1-2-L
03-1-0-L
03-C-0-L
03-G-0-L
03-K-0-L
Location_Label


63 Hz
60.0
50.0
40.0
30.0
55
22
21
03-250-2-L
03-205-0-L
03-9-0-L
03-1-2-L
03-1-0-L
03-C-0-L
03-G-0-L
03-K-0-L
Location_Label

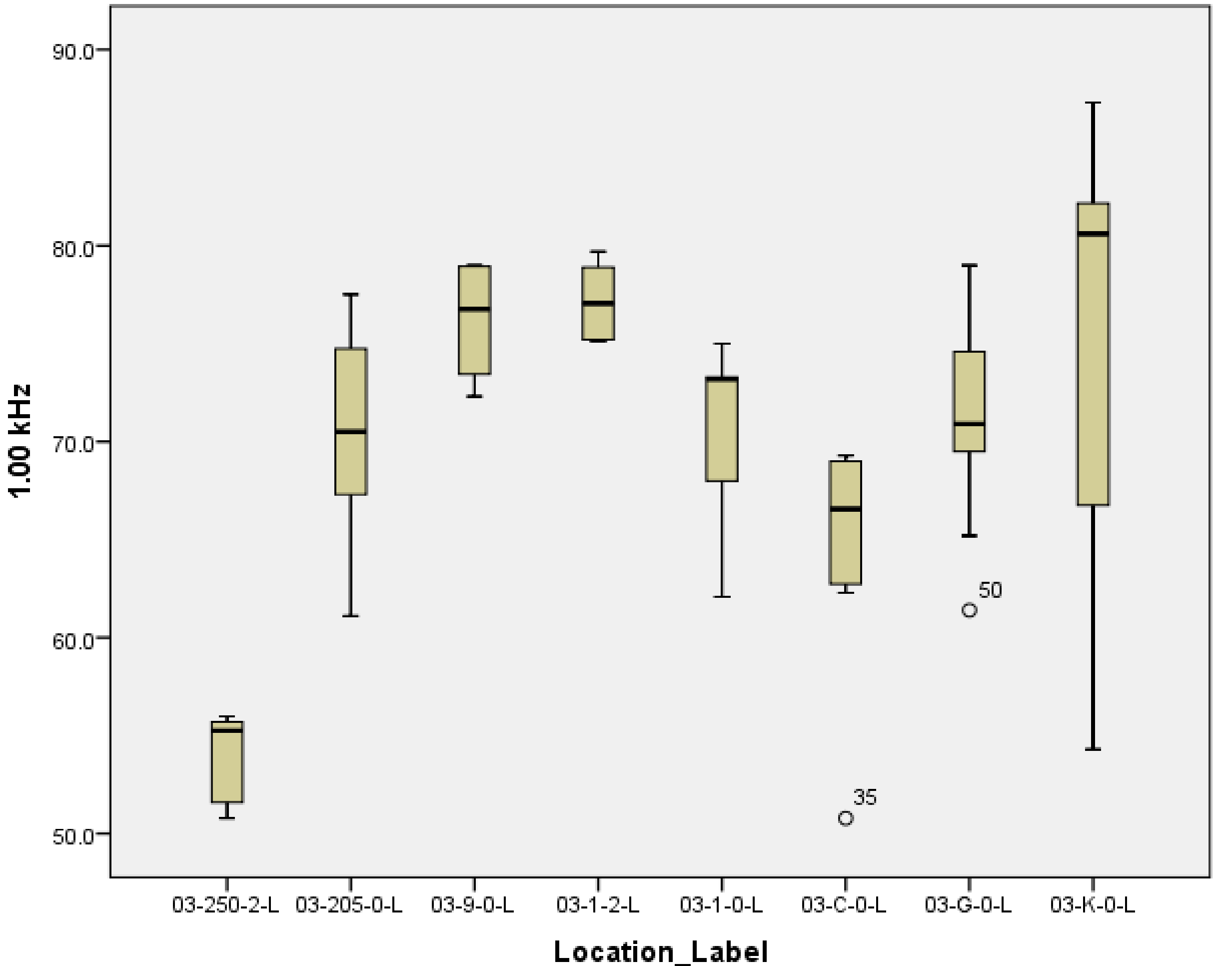


80.0
70.0
60.0
50.0
40.0
125 Hz
54
03-250-2-L
03-205-0-L
03-9-0-L
03-1-2-L
03-1-0-L
03-C-0-L
03-G-0-L
03-K-0-L
Location_Label

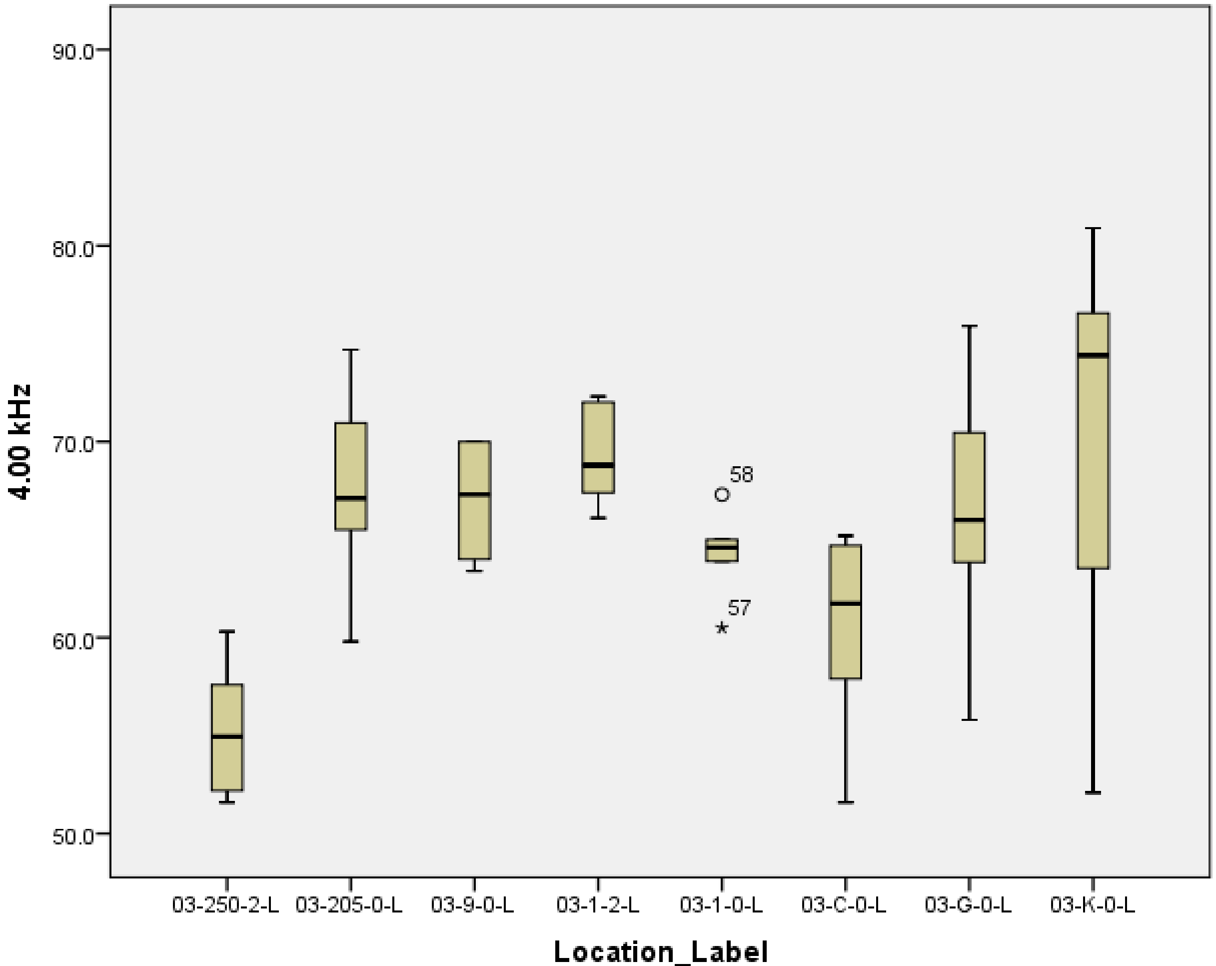

80.0
70.0
60.0
50.0
40.0
250 Hz
03-250-2-L
03-205-0-L
03-9-0-L
03-1-2-L
03-1-0-L
03-C-0-L
03-G-0-L
03-K-0-L
Location_Label



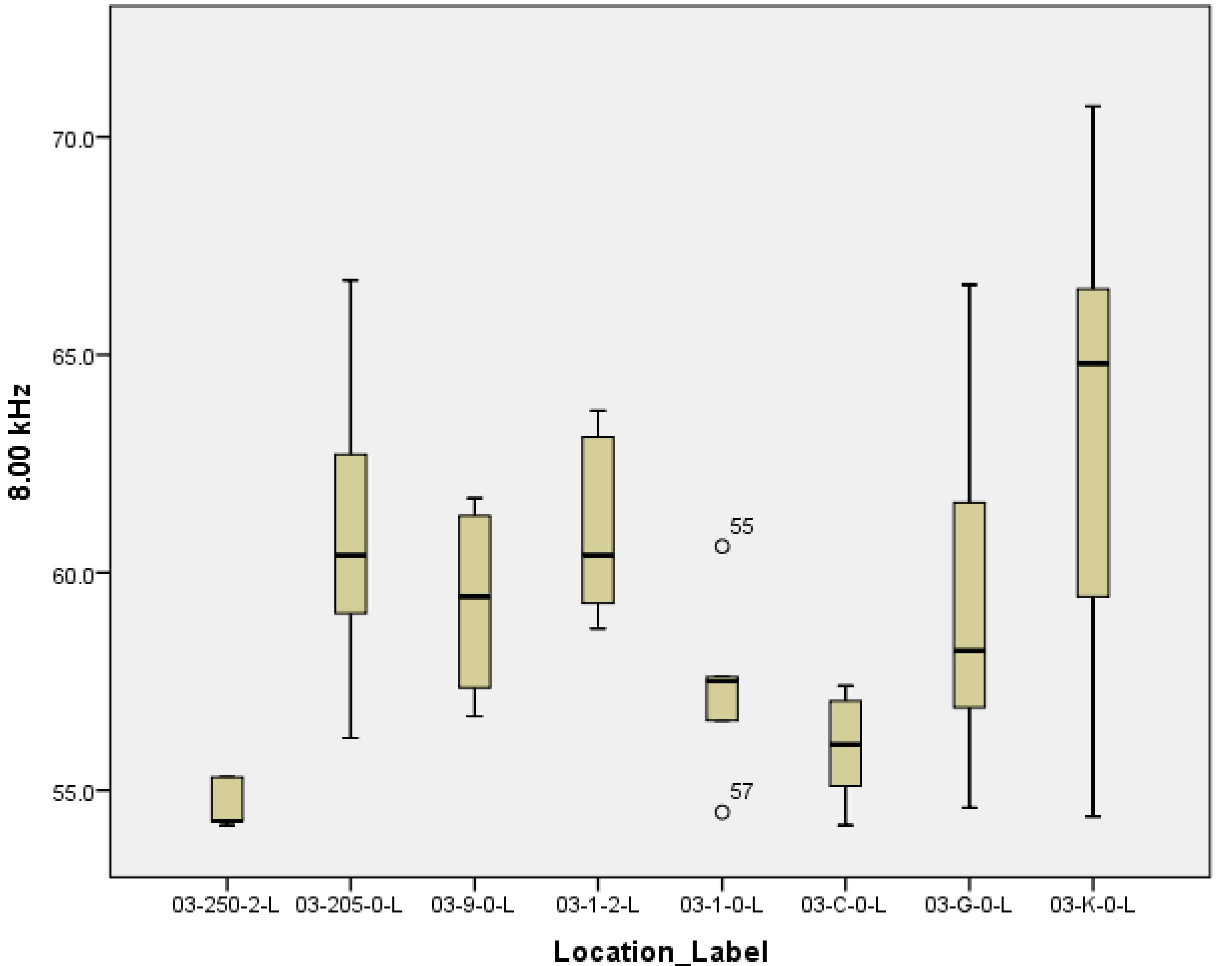
90.0
80.0
70.0
60.0
50.0
500 Hz
03-250-2-L
03-205-0-L
03-9-0-L
03-1-2-L
03-1-0-L
03-C-0-L
03-G-0-L
03-K-0-L
Location_Label



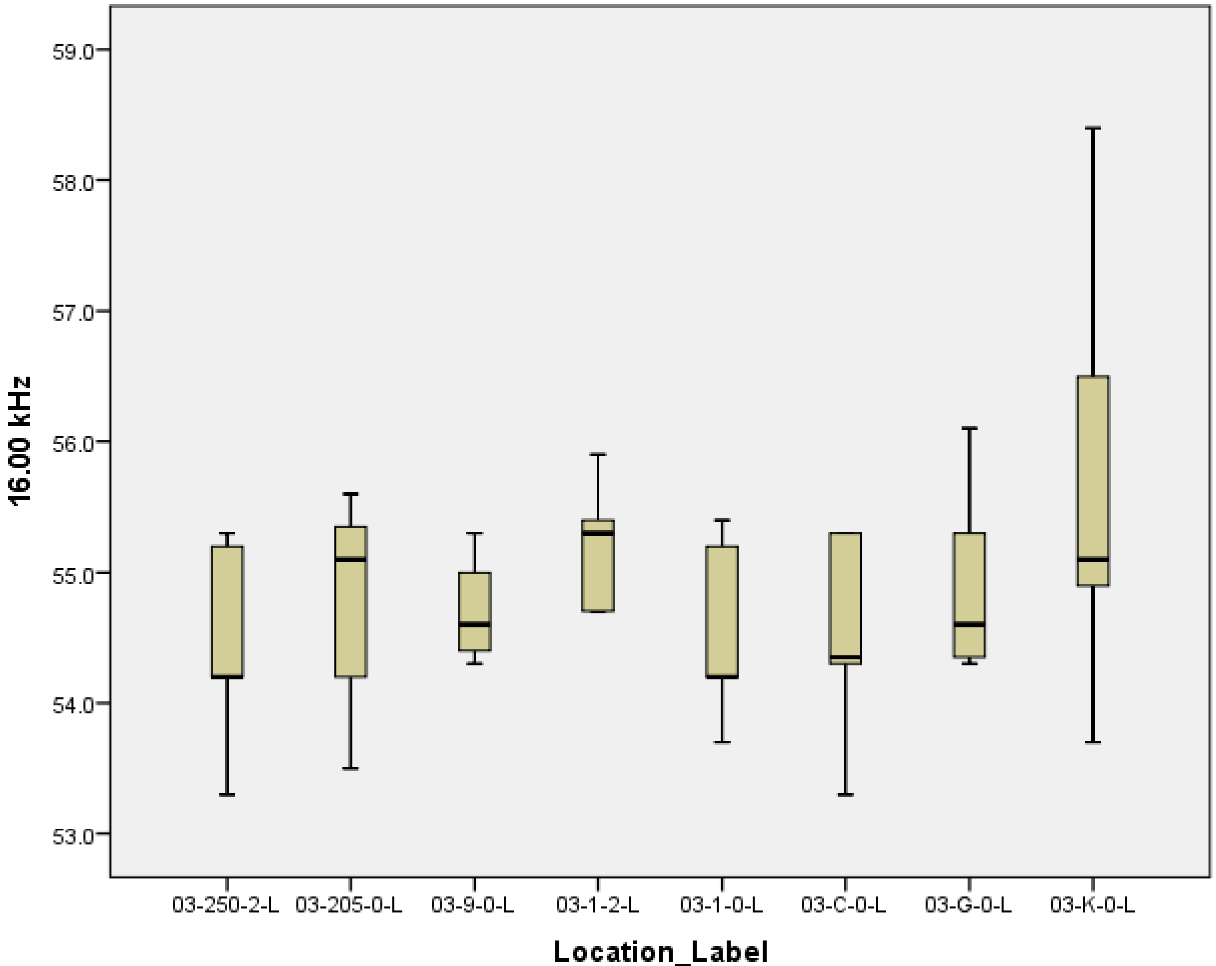
90.0
80.0
70.0
60.0
50.0
1.00 kHz
50
35
03-250-2-L
03-205-0-L
03-9-0-L
03-1-2-L
03-1-0-L
03-C-0-L
03-G-0-L
03-K-0-L
Location_Label

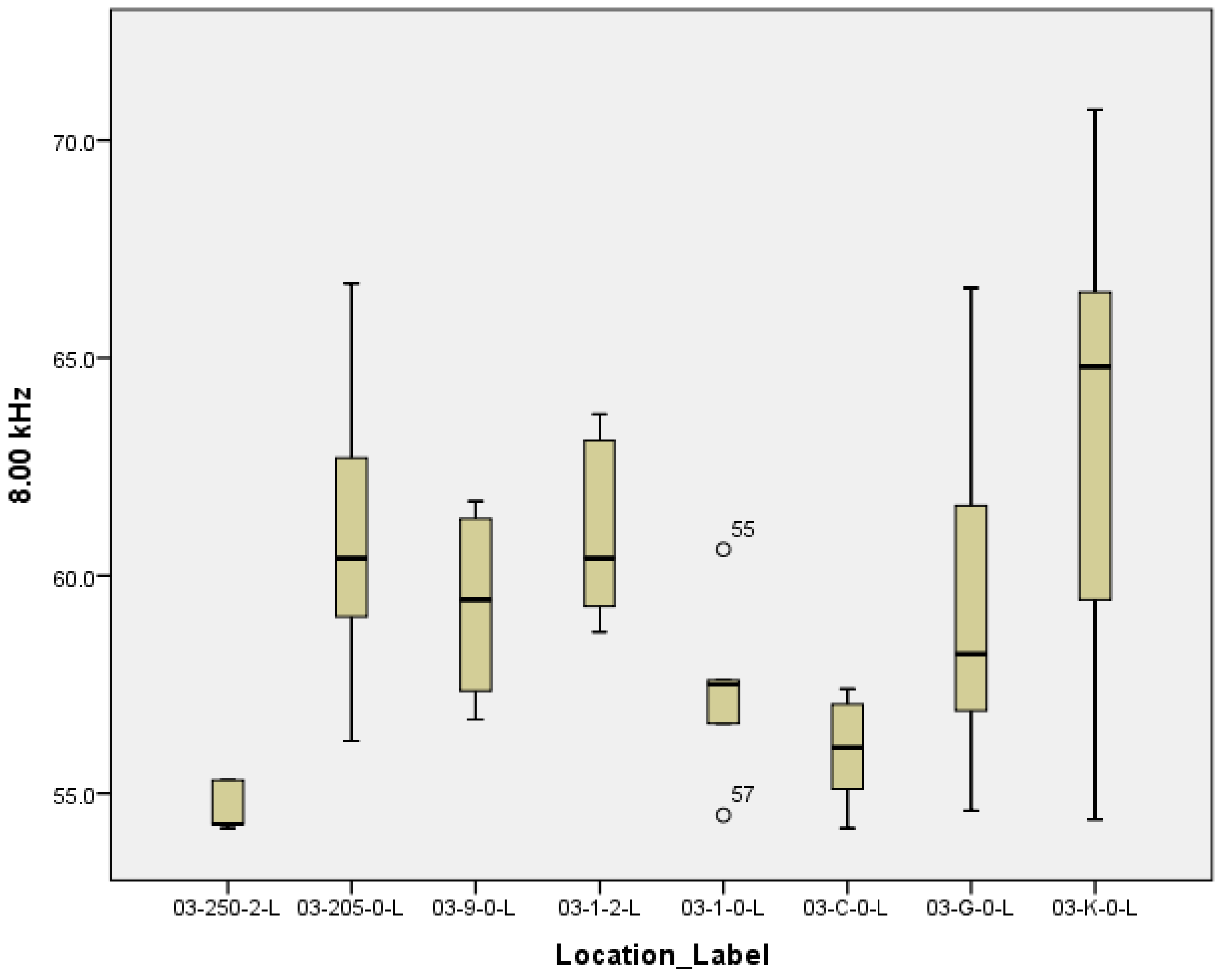


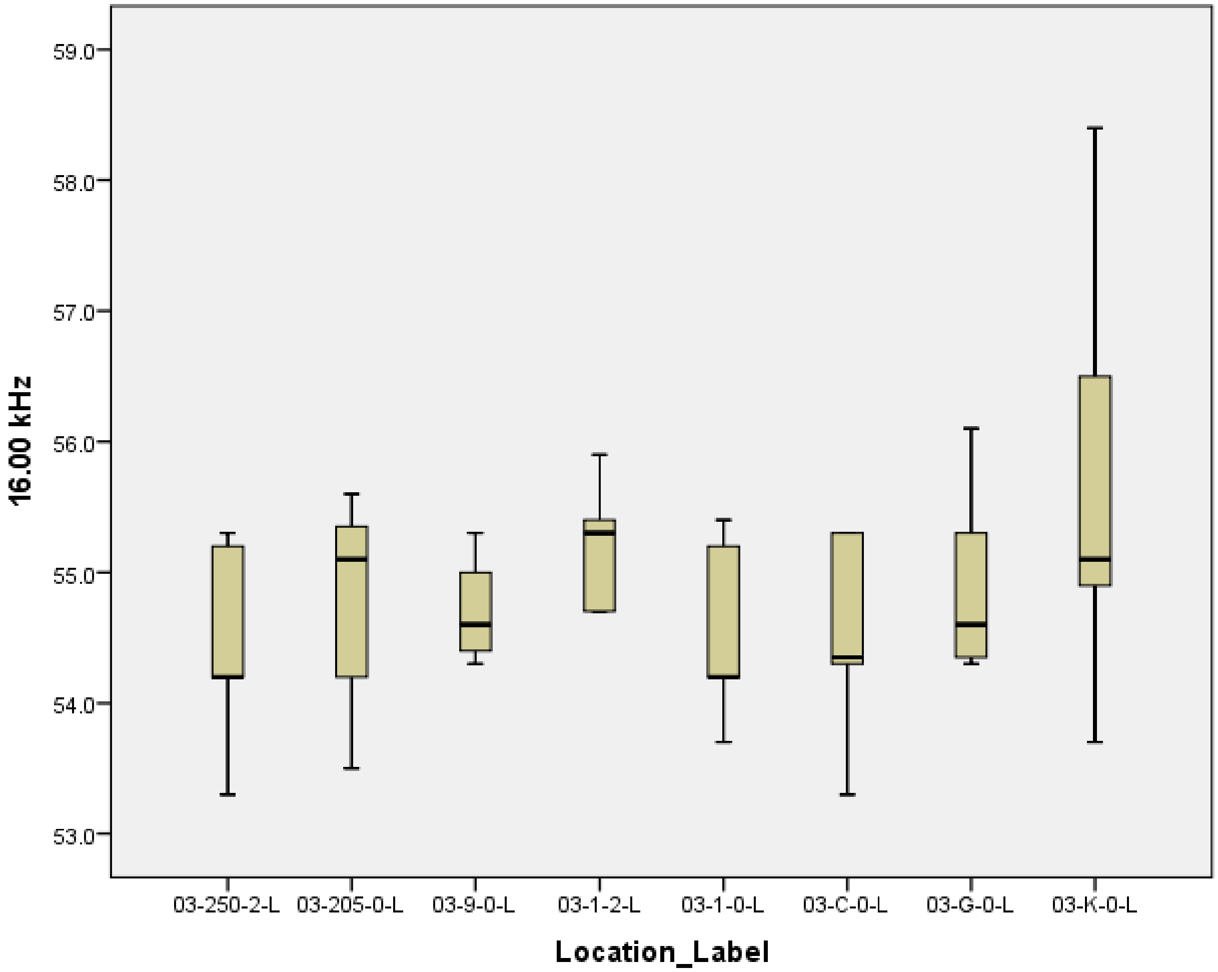
90.0
80.0
70.0
60.0
50.0
4.00 kHz
58
57
03-250-2-L
03-205-0-L
03-9-0-L
03-1-2-L
03-1-0-L
03-C-0-L
03-G-0-L
03-K-0-L
Location_Label

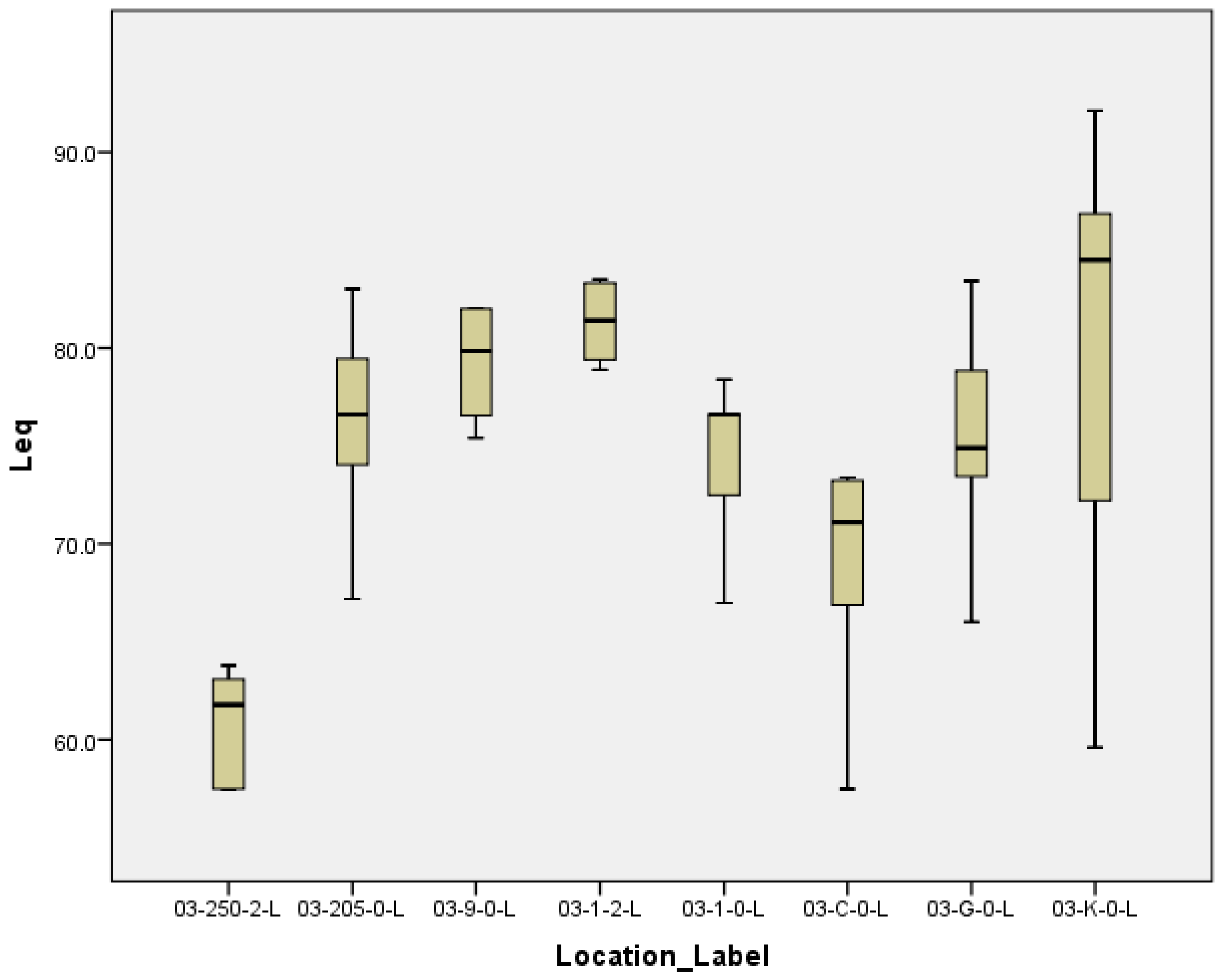


70.0
65.0
60.0
55.0
8.00 kHz
55
57
03-250-2-L
03-205-0-L
03-9-0-L
03-1-2-L
03-1-0-L
03-C-0-L
03-G-0-L
03-K-0-L
Location_Label


59.0
58.0
57.0
56.0
55.0
54.0
53.0
16.00 kHz
03-250-2-L
03-205-0-L
03-9-0-L
03-1-2-L
03-1-0-L
03-C-0-L
03-G-0-L
03-K-0-L
Location_Label


8.00 kHz
70.0
65.0
60.0
55.0
55
57
03-250-2-L
03-205-0-L
03-9-0-L
03-1-2-L
03-1-0-L
03-C-0-L
03-G-0-L
03-K-0-L
Location_Label


59.0
58.0
57.0
56.0
55.0
54.0
53.0
16.00 kHz
03-250-2-L
03-205-0-L
03-9-0-L
03-1-2-L
03-1-0-L
03-C-0-L
03-G-0-L
03-K-0-L
Location_Label



90.0
80.0
70.0
60.0
Leq
03-250-2-L
03-205-0-L
03-9-0-L
03-1-2-L
03-1-0-L
03-C-0-L
03-G-0-L
03-K-0-L
Location_Label

APPENDIX D. SPSS™ ANOVA 16 Hz – 16 kHz

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
16 Hz	Between Groups	92.445	7	13.206	2.899	.013
	Within Groups	227.803	50	4.556		
	Total	320.248	57			
31.5 Hz	Between Groups	1017.719	7	145.388	4.373	.001
	Within Groups	1662.187	50	33.244		
	Total	2679.906	57			
63 Hz	Between Groups	1420.939	7	202.991	6.453	.000
	Within Groups	1572.887	50	31.458		
	Total	2993.826	57			
125 Hz	Between Groups	1597.695	7	228.242	5.149	.000
	Within Groups	2216.411	50	44.328		
	Total	3814.106	57			
250 Hz	Between Groups	1455.568	7	207.938	5.331	.000
	Within Groups	1950.175	50	39.004		
	Total	3405.743	57			
500 Hz	Between Groups	2128.507	7	304.072	6.811	.000
	Within Groups	2232.230	50	44.645		
	Total	4360.737	57			
1.00 kHz	Between Groups	2466.865	7	352.409	6.925	.000
	Within Groups	2544.324	50	50.886		
	Total	5011.189	57			
2.00 kHz	Between Groups	2148.015	7	306.859	5.592	.000
	Within Groups	2743.897	50	54.878		
	Total	4891.911	57			
4.00 kHz	Between Groups	1166.221	7	166.603	4.058	.001
	Within Groups	2052.821	50	41.056		
	Total	3219.042	57			
8.00 kHz	Between Groups	435.007	7	62.144	5.309	.000
	Within Groups	585.323	50	11.706		
	Total	1020.330	57			
16.00 kHz	Between Groups	9.789	7	1.398	1.878	.093
	Within Groups	37.240	50	.745		
	Total	47.028	57			

APPENDIX E. SPSS™ Multiple Comparisons 16 Hz – 16 kHz

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Location_Label	(J) Location_Label	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
16 Hz	03-205-0-L	03-1-2-L	1.1000	1.2031	.983	-2.699	4.899
		03-K-0-L	3.3667*	1.0576	.047	.027	6.706
		03-9-0-L	3.0417	1.3451	.334	-1.206	7.289
		03-250-2-L	3.9500*	1.2031	.036	.151	7.749
		03-C-0-L	3.8222*	1.0983	.021	.354	7.290
		03-G-0-L	3.6500*	1.0419	.020	.360	6.940
		03-1-0-L	3.7833	1.2031	.052	-.016	7.582
	03-1-2-L	03-205-0-L	-1.1000	1.2031	.983	-4.899	2.699
		03-K-0-L	2.2667	1.0576	.402	-1.073	5.606
		03-9-0-L	1.9417	1.3451	.833	-2.306	6.189
		03-250-2-L	2.8500	1.2031	.278	-.949	6.649
		03-C-0-L	2.7222	1.0983	.227	-.746	6.190
		03-G-0-L	2.5500	1.0419	.241	-.740	5.840
		03-1-0-L	2.6833	1.2031	.351	-1.116	6.482
	03-K-0-L	03-205-0-L	-3.3667*	1.0576	.047	-6.706	-.027
		03-1-2-L	-2.2667	1.0576	.402	-5.606	1.073
		03-9-0-L	-.3250	1.2167	1.000	-4.167	3.517
		03-250-2-L	.5833	1.0576	.999	-2.756	3.923
		03-C-0-L	.4556	.9366	1.000	-2.502	3.413
		03-G-0-L	.2833	.8699	1.000	-2.463	3.030
		03-1-0-L	.4167	1.0576	1.000	-2.923	3.756
	03-9-0-L	03-205-0-L	-3.0417	1.3451	.334	-7.289	1.206
		03-1-2-L	-1.9417	1.3451	.833	-6.189	2.306
		03-K-0-L	.3250	1.2167	1.000	-3.517	4.167
		03-250-2-L	.9083	1.3451	.997	-3.339	5.156
		03-C-0-L	.7806	1.2522	.998	-3.173	4.735
		03-G-0-L	.6083	1.2031	1.000	-3.191	4.407
		03-1-0-L	.7417	1.3451	.999	-3.506	4.989
	03-250-2-L	03-205-0-L	-3.9500*	1.2031	.036	-7.749	-.151
		03-1-2-L	-2.8500	1.2031	.278	-6.649	.949

		03-K-0-L	-.5833	1.0576	.999	-3.923	2.756
		03-9-0-L	-.9083	1.3451	.997	-5.156	3.339
		03-C-0-L	-.1278	1.0983	1.000	-3.596	3.340
		03-G-0-L	-.3000	1.0419	1.000	-3.590	2.990
		03-1-0-L	-.1667	1.2031	1.000	-3.966	3.632
	03-C-0-L	03-205-0-L	-3.8222*	1.0983	.021	-7.290	-.354
		03-1-2-L	-2.7222	1.0983	.227	-6.190	.746
		03-K-0-L	-.4556	.9366	1.000	-3.413	2.502
		03-9-0-L	-.7806	1.2522	.998	-4.735	3.173
		03-250-2-L	.1278	1.0983	1.000	-3.340	3.596
		03-G-0-L	-.1722	.9189	1.000	-3.074	2.729
		03-1-0-L	-.0389	1.0983	1.000	-3.507	3.429
	03-G-0-L	03-205-0-L	-3.6500*	1.0419	.020	-6.940	-.360
		03-1-2-L	-2.5500	1.0419	.241	-5.840	.740
		03-K-0-L	-.2833	.8699	1.000	-3.030	2.463
		03-9-0-L	-.6083	1.2031	1.000	-4.407	3.191
		03-250-2-L	.3000	1.0419	1.000	-2.990	3.590
		03-C-0-L	.1722	.9189	1.000	-2.729	3.074
		03-1-0-L	.1333	1.0419	1.000	-3.157	3.423
	03-1-0-L	03-205-0-L	-3.7833	1.2031	.052	-7.582	.016
		03-1-2-L	-2.6833	1.2031	.351	-6.482	1.116
		03-K-0-L	-.4167	1.0576	1.000	-3.756	2.923
		03-9-0-L	-.7417	1.3451	.999	-4.989	3.506
		03-250-2-L	.1667	1.2031	1.000	-3.632	3.966
		03-C-0-L	.0389	1.0983	1.000	-3.429	3.507
		03-G-0-L	-.1333	1.0419	1.000	-3.423	3.157
31.5 Hz	03-205-0-L	03-1-2-L	-6.9500	3.2847	.419	-17.321	3.421
		03-K-0-L	-6.4803	2.8874	.343	-15.597	2.637
		03-9-0-L	-6.8917	3.6724	.573	-18.487	4.704
		03-250-2-L	4.8000	3.2847	.824	-5.571	15.171
		03-C-0-L	2.5389	2.9985	.989	-6.929	12.007
		03-G-0-L	-2.9833	2.8446	.964	-11.965	5.999
		03-1-0-L	3.1833	3.2847	.977	-7.188	13.555
	03-1-2-L	03-205-0-L	6.9500	3.2847	.419	-3.421	17.321
		03-K-0-L	.4697	2.8874	1.000	-8.647	9.587
		03-9-0-L	.0583	3.6724	1.000	-11.537	11.654
		03-250-2-L	11.7500*	3.2847	.016	1.379	22.121
		03-C-0-L	9.4889*	2.9985	.049	.021	18.957

		03-G-0-L	3.9667	2.8446	.856	-5.015	12.949
		03-1-0-L	10.1333	3.2847	.060	-.238	20.505
	03-K-0-L	03-205-0-L	6.4803	2.8874	.343	-2.637	15.597
		03-1-2-L	-.4697	2.8874	1.000	-9.587	8.647
		03-9-0-L	-.4114	3.3218	1.000	-10.900	10.077
		03-250-2-L	11.2803*	2.8874	.006	2.163	20.397
		03-C-0-L	9.0192*	2.5571	.019	.945	17.093
		03-G-0-L	3.4970	2.3748	.818	-4.002	10.996
		03-1-0-L	9.6636*	2.8874	.031	.547	18.781
	03-9-0-L	03-205-0-L	6.8917	3.6724	.573	-4.704	18.487
		03-1-2-L	-.0583	3.6724	1.000	-11.654	11.537
		03-K-0-L	.4114	3.3218	1.000	-10.077	10.900
		03-250-2-L	11.6917*	3.6724	.047	.096	23.287
		03-C-0-L	9.4306	3.4188	.128	-1.364	20.226
		03-G-0-L	3.9083	3.2847	.931	-6.463	14.280
		03-1-0-L	10.0750	3.6724	.133	-1.521	21.671
	03-250-2-L	03-205-0-L	-4.8000	3.2847	.824	-15.171	5.571
		03-1-2-L	-11.7500*	3.2847	.016	-22.121	-1.379
		03-K-0-L	-11.2803*	2.8874	.006	-20.397	-2.163
		03-9-0-L	-11.6917*	3.6724	.047	-23.287	-.096
		03-C-0-L	-2.2611	2.9985	.995	-11.729	7.207
		03-G-0-L	-7.7833	2.8446	.135	-16.765	1.199
		03-1-0-L	-1.6167	3.2847	1.000	-11.988	8.755
	03-C-0-L	03-205-0-L	-2.5389	2.9985	.989	-12.007	6.929
		03-1-2-L	-9.4889*	2.9985	.049	-18.957	-.021
		03-K-0-L	-9.0192*	2.5571	.019	-17.093	-.945
		03-9-0-L	-9.4306	3.4188	.128	-20.226	1.364
		03-250-2-L	2.2611	2.9985	.995	-7.207	11.729
		03-G-0-L	-5.5222	2.5087	.368	-13.444	2.399
		03-1-0-L	.6444	2.9985	1.000	-8.823	10.112
	03-G-0-L	03-205-0-L	2.9833	2.8446	.964	-5.999	11.965
		03-1-2-L	-3.9667	2.8446	.856	-12.949	5.015
		03-K-0-L	-3.4970	2.3748	.818	-10.996	4.002
		03-9-0-L	-3.9083	3.2847	.931	-14.280	6.463
		03-250-2-L	7.7833	2.8446	.135	-1.199	16.765
		03-C-0-L	5.5222	2.5087	.368	-2.399	13.444
		03-1-0-L	6.1667	2.8446	.387	-2.815	15.149
	03-1-0-L	03-205-0-L	-3.1833	3.2847	.977	-13.555	7.188

		03-1-2-L	-10.1333	3.2847	.060	-20.505	.238
		03-K-0-L	-9.6636*	2.8874	.031	-18.781	-.547
		03-9-0-L	-10.0750	3.6724	.133	-21.671	1.521
		03-250-2-L	1.6167	3.2847	1.000	-8.755	11.988
		03-C-0-L	-.6444	2.9985	1.000	-10.112	8.823
		03-G-0-L	-6.1667	2.8446	.387	-15.149	2.815
63 Hz	03-205-0-L	03-1-2-L	-3.5000	3.2498	.959	-13.761	6.761
		03-K-0-L	-.2076	2.8567	1.000	-9.228	8.813
		03-9-0-L	-4.8417	3.6334	.882	-16.314	6.631
		03-250-2-L	12.8167*	3.2498	.006	2.555	23.078
		03-C-0-L	6.7944	2.9667	.318	-2.573	16.162
		03-G-0-L	-2.1083	2.8144	.995	-10.995	6.778
		03-1-0-L	3.1000	3.2498	.979	-7.161	13.361
	03-1-2-L	03-205-0-L	3.5000	3.2498	.959	-6.761	13.761
		03-K-0-L	3.2924	2.8567	.941	-5.728	12.313
		03-9-0-L	-1.3417	3.6334	1.000	-12.814	10.131
		03-250-2-L	16.3167*	3.2498	.000	6.055	26.578
		03-C-0-L	10.2944*	2.9667	.022	.927	19.662
		03-G-0-L	1.3917	2.8144	1.000	-7.495	10.278
		03-1-0-L	6.6000	3.2498	.472	-3.661	16.861
	03-K-0-L	03-205-0-L	.2076	2.8567	1.000	-8.813	9.228
		03-1-2-L	-3.2924	2.8567	.941	-12.313	5.728
		03-9-0-L	-4.6341	3.2865	.849	-15.011	5.743
		03-250-2-L	13.0242*	2.8567	.001	4.004	22.044
		03-C-0-L	7.0020	2.5300	.126	-.986	14.990
		03-G-0-L	-1.9008	2.3496	.992	-9.320	5.518
		03-1-0-L	3.3076	2.8567	.940	-5.713	12.328
	03-9-0-L	03-205-0-L	4.8417	3.6334	.882	-6.631	16.314
		03-1-2-L	1.3417	3.6334	1.000	-10.131	12.814
		03-K-0-L	4.6341	3.2865	.849	-5.743	15.011
		03-250-2-L	17.6583*	3.6334	.000	6.186	29.131
		03-C-0-L	11.6361*	3.3825	.024	.956	22.316
		03-G-0-L	2.7333	3.2498	.990	-7.528	12.995
		03-1-0-L	7.9417	3.6334	.377	-3.531	19.414
	03-250-2-L	03-205-0-L	-12.8167*	3.2498	.006	-23.078	-2.555
		03-1-2-L	-16.3167*	3.2498	.000	-26.578	-6.055
		03-K-0-L	-13.0242*	2.8567	.001	-22.044	-4.004
		03-9-0-L	-17.6583*	3.6334	.000	-29.131	-6.186

		03-C-0-L	-6.0222	2.9667	.473	-15.389	3.345
		03-G-0-L	-14.9250*	2.8144	.000	-23.812	-6.038
		03-1-0-L	-9.7167	3.2498	.076	-19.978	.545
	03-C-0-L	03-205-0-L	-6.7944	2.9667	.318	-16.162	2.573
		03-1-2-L	-10.2944*	2.9667	.022	-19.662	-.927
		03-K-0-L	-7.0020	2.5300	.126	-14.990	.986
		03-9-0-L	-11.6361*	3.3825	.024	-22.316	-.956
		03-250-2-L	6.0222	2.9667	.473	-3.345	15.389
		03-G-0-L	-8.9028*	2.4821	.016	-16.740	-1.066
		03-1-0-L	-3.6944	2.9667	.914	-13.062	5.673
	03-G-0-L	03-205-0-L	2.1083	2.8144	.995	-6.778	10.995
		03-1-2-L	-1.3917	2.8144	1.000	-10.278	7.495
		03-K-0-L	1.9008	2.3496	.992	-5.518	9.320
		03-9-0-L	-2.7333	3.2498	.990	-12.995	7.528
		03-250-2-L	14.9250*	2.8144	.000	6.038	23.812
		03-C-0-L	8.9028*	2.4821	.016	1.066	16.740
		03-1-0-L	5.2083	2.8144	.590	-3.678	14.095
	03-1-0-L	03-205-0-L	-3.1000	3.2498	.979	-13.361	7.161
		03-1-2-L	-6.6000	3.2498	.472	-16.861	3.661
		03-K-0-L	-3.3076	2.8567	.940	-12.328	5.713
		03-9-0-L	-7.9417	3.6334	.377	-19.414	3.531
		03-250-2-L	9.7167	3.2498	.076	-.545	19.978
		03-C-0-L	3.6944	2.9667	.914	-5.673	13.062
		03-G-0-L	-5.2083	2.8144	.590	-14.095	3.678
125 Hz	03-205-0-L	03-1-2-L	-4.0000	3.8490	.966	-16.153	8.153
		03-K-0-L	-3.8545	3.3835	.945	-14.538	6.829
		03-9-0-L	-3.5500	4.3034	.991	-17.138	10.038
		03-250-2-L	12.3000*	3.8490	.045	.147	24.453
		03-C-0-L	7.3667	3.5137	.431	-3.728	18.461
		03-G-0-L	-.0250	3.3334	1.000	-10.550	10.500
		03-1-0-L	5.9500	3.8490	.779	-6.203	18.103
	03-1-2-L	03-205-0-L	4.0000	3.8490	.966	-8.153	16.153
		03-K-0-L	.1455	3.3835	1.000	-10.538	10.829
		03-9-0-L	.4500	4.3034	1.000	-13.138	14.038
		03-250-2-L	16.3000*	3.8490	.002	4.147	28.453
		03-C-0-L	11.3667*	3.5137	.041	.272	22.461
		03-G-0-L	3.9750	3.3334	.931	-6.550	14.500
		03-1-0-L	9.9500	3.8490	.185	-2.203	22.103

	03-K-0-L	03-205-0-L	3.8545	3.3835	.945	-6.829	14.538
		03-1-2-L	-.1455	3.3835	1.000	-10.829	10.538
		03-9-0-L	.3045	3.8925	1.000	-11.986	12.595
		03-250-2-L	16.1545*	3.3835	.000	5.471	26.838
		03-C-0-L	11.2212*	2.9965	.010	1.760	20.683
		03-G-0-L	3.8295	2.7828	.864	-4.957	12.616
		03-1-0-L	9.8045	3.3835	.094	-.879	20.488
	03-9-0-L	03-205-0-L	3.5500	4.3034	.991	-10.038	17.138
		03-1-2-L	-.4500	4.3034	1.000	-14.038	13.138
		03-K-0-L	-.3045	3.8925	1.000	-12.595	11.986
		03-250-2-L	15.8500*	4.3034	.012	2.262	29.438
		03-C-0-L	10.9167	4.0062	.138	-1.733	23.566
		03-G-0-L	3.5250	3.8490	.983	-8.628	15.678
		03-1-0-L	9.5000	4.3034	.364	-4.088	23.088
	03-250-2-L	03-205-0-L	-12.3000*	3.8490	.045	-24.453	-.147
		03-1-2-L	-16.3000*	3.8490	.002	-28.453	-4.147
		03-K-0-L	-16.1545*	3.3835	.000	-26.838	-5.471
		03-9-0-L	-15.8500*	4.3034	.012	-29.438	-2.262
		03-C-0-L	-4.9333	3.5137	.851	-16.028	6.161
		03-G-0-L	-12.3250*	3.3334	.011	-22.850	-1.800
		03-1-0-L	-6.3500	3.8490	.718	-18.503	5.803
	03-C-0-L	03-205-0-L	-7.3667	3.5137	.431	-18.461	3.728
		03-1-2-L	-11.3667*	3.5137	.041	-22.461	-.272
		03-K-0-L	-11.2212*	2.9965	.010	-20.683	-1.760
		03-9-0-L	-10.9167	4.0062	.138	-23.566	1.733
		03-250-2-L	4.9333	3.5137	.851	-6.161	16.028
		03-G-0-L	-7.3917	2.9398	.212	-16.674	1.891
		03-1-0-L	-1.4167	3.5137	1.000	-12.511	9.678
	03-G-0-L	03-205-0-L	.0250	3.3334	1.000	-10.500	10.550
		03-1-2-L	-3.9750	3.3334	.931	-14.500	6.550
		03-K-0-L	-3.8295	2.7828	.864	-12.616	4.957
		03-9-0-L	-3.5250	3.8490	.983	-15.678	8.628
		03-250-2-L	12.3250*	3.3334	.011	1.800	22.850
		03-C-0-L	7.3917	2.9398	.212	-1.891	16.674
		03-1-0-L	5.9750	3.3334	.628	-4.550	16.500
	03-1-0-L	03-205-0-L	-5.9500	3.8490	.779	-18.103	6.203
		03-1-2-L	-9.9500	3.8490	.185	-22.103	2.203
		03-K-0-L	-9.8045	3.3835	.094	-20.488	.879

		03-9-0-L	-9.5000	4.3034	.364	-23.088	4.088
		03-250-2-L	6.3500	3.8490	.718	-5.803	18.503
		03-C-0-L	1.4167	3.5137	1.000	-9.678	12.511
		03-G-0-L	-5.9750	3.3334	.628	-16.500	4.550
250 Hz	03-205-0-L	03-1-2-L	-5.6500	3.5514	.753	-16.863	5.563
		03-K-0-L	-2.6470	3.1218	.989	-12.504	7.210
		03-9-0-L	-2.9083	3.9706	.996	-15.445	9.629
		03-250-2-L	11.0333	3.5514	.057	-.180	22.247
		03-C-0-L	7.7167	3.2420	.273	-2.520	17.953
		03-G-0-L	.9917	3.0756	1.000	-8.719	10.703
		03-1-0-L	3.1667	3.5514	.986	-8.047	14.380
	03-1-2-L	03-205-0-L	5.6500	3.5514	.753	-5.563	16.863
		03-K-0-L	3.0030	3.1218	.978	-6.854	12.860
		03-9-0-L	2.7417	3.9706	.997	-9.795	15.279
		03-250-2-L	16.6833*	3.5514	.000	5.470	27.897
		03-C-0-L	13.3667*	3.2420	.003	3.130	23.603
		03-G-0-L	6.6417	3.0756	.392	-3.069	16.353
		03-1-0-L	8.8167	3.5514	.226	-2.397	20.030
	03-K-0-L	03-205-0-L	2.6470	3.1218	.989	-7.210	12.504
		03-1-2-L	-3.0030	3.1218	.978	-12.860	6.854
		03-9-0-L	-.2614	3.5915	1.000	-11.602	11.079
		03-250-2-L	13.6803*	3.1218	.001	3.823	23.538
		03-C-0-L	10.3636*	2.7647	.010	1.634	19.093
		03-G-0-L	3.6386	2.5676	.845	-4.469	11.746
		03-1-0-L	5.8136	3.1218	.582	-4.044	15.671
	03-9-0-L	03-205-0-L	2.9083	3.9706	.996	-9.629	15.445
		03-1-2-L	-2.7417	3.9706	.997	-15.279	9.795
		03-K-0-L	.2614	3.5915	1.000	-11.079	11.602
		03-250-2-L	13.9417*	3.9706	.019	1.405	26.479
		03-C-0-L	10.6250	3.6964	.099	-1.046	22.296
		03-G-0-L	3.9000	3.5514	.954	-7.313	15.113
		03-1-0-L	6.0750	3.9706	.788	-6.462	18.612
	03-250-2-L	03-205-0-L	-11.0333	3.5514	.057	-22.247	.180
		03-1-2-L	-16.6833*	3.5514	.000	-27.897	-5.470
		03-K-0-L	-13.6803*	3.1218	.001	-23.538	-3.823
		03-9-0-L	-13.9417*	3.9706	.019	-26.479	-1.405
		03-C-0-L	-3.3167	3.2420	.969	-13.553	6.920
		03-G-0-L	-10.0417*	3.0756	.038	-19.753	-.331

		03-1-0-L	-7.8667	3.5514	.360	-19.080	3.347
	03-C-0-L	03-205-0-L	-7.7167	3.2420	.273	-17.953	2.520
		03-1-2-L	-13.3667*	3.2420	.003	-23.603	-3.130
		03-K-0-L	-10.3636*	2.7647	.010	-19.093	-1.634
		03-9-0-L	-10.6250	3.6964	.099	-22.296	1.046
		03-250-2-L	3.3167	3.2420	.969	-6.920	13.553
		03-G-0-L	-6.7250	2.7124	.227	-15.289	1.839
		03-1-0-L	-4.5500	3.2420	.852	-14.786	5.686
	03-G-0-L	03-205-0-L	-.9917	3.0756	1.000	-10.703	8.719
		03-1-2-L	-6.6417	3.0756	.392	-16.353	3.069
		03-K-0-L	-3.6386	2.5676	.845	-11.746	4.469
		03-9-0-L	-3.9000	3.5514	.954	-15.113	7.313
		03-250-2-L	10.0417*	3.0756	.038	.331	19.753
		03-C-0-L	6.7250	2.7124	.227	-1.839	15.289
		03-1-0-L	2.1750	3.0756	.996	-7.536	11.886
	03-1-0-L	03-205-0-L	-3.1667	3.5514	.986	-14.380	8.047
		03-1-2-L	-8.8167	3.5514	.226	-20.030	2.397
		03-K-0-L	-5.8136	3.1218	.582	-15.671	4.044
		03-9-0-L	-6.0750	3.9706	.788	-18.612	6.462
		03-250-2-L	7.8667	3.5514	.360	-3.347	19.080
		03-C-0-L	4.5500	3.2420	.852	-5.686	14.786
		03-G-0-L	-2.1750	3.0756	.996	-11.886	7.536
500 Hz	03-205-0-L	03-1-2-L	-8.6333	3.7903	.325	-20.601	3.335
		03-K-0-L	-5.3545	3.3319	.744	-15.875	5.166
		03-9-0-L	-4.5500	4.2377	.959	-17.931	8.831
		03-250-2-L	13.3833*	3.7903	.018	1.415	25.351
		03-C-0-L	4.7778	3.4601	.862	-6.147	15.703
		03-G-0-L	-.7500	3.2825	1.000	-11.115	9.615
		03-1-0-L	1.0833	3.7903	1.000	-10.885	13.051
	03-1-2-L	03-205-0-L	8.6333	3.7903	.325	-3.335	20.601
		03-K-0-L	3.2788	3.3319	.975	-7.242	13.799
		03-9-0-L	4.0833	4.2377	.978	-9.297	17.464
		03-250-2-L	22.0167*	3.7903	.000	10.049	33.985
		03-C-0-L	13.4111*	3.4601	.007	2.486	24.336
		03-G-0-L	7.8833	3.2825	.262	-2.481	18.248
		03-1-0-L	9.7167	3.7903	.193	-2.251	21.685
	03-K-0-L	03-205-0-L	5.3545	3.3319	.744	-5.166	15.875
		03-1-2-L	-3.2788	3.3319	.975	-13.799	7.242

		03-9-0-L	.8045	3.8332	1.000	-11.299	12.908
		03-250-2-L	18.7379*	3.3319	.000	8.217	29.258
		03-C-0-L	10.1323*	2.9508	.024	.815	19.449
		03-G-0-L	4.6045	2.7404	.700	-4.048	13.257
		03-1-0-L	6.4379	3.3319	.536	-4.083	16.958
	03-9-0-L	03-205-0-L	4.5500	4.2377	.959	-8.831	17.931
		03-1-2-L	-4.0833	4.2377	.978	-17.464	9.297
		03-K-0-L	-.8045	3.8332	1.000	-12.908	11.299
		03-250-2-L	17.9333*	4.2377	.002	4.553	31.314
		03-C-0-L	9.3278	3.9451	.280	-3.129	21.784
		03-G-0-L	3.8000	3.7903	.972	-8.168	15.768
		03-1-0-L	5.6333	4.2377	.883	-7.747	19.014
	03-250-2-L	03-205-0-L	-13.3833*	3.7903	.018	-25.351	-1.415
		03-1-2-L	-22.0167*	3.7903	.000	-33.985	-10.049
		03-K-0-L	-18.7379*	3.3319	.000	-29.258	-8.217
		03-9-0-L	-17.9333*	4.2377	.002	-31.314	-4.553
		03-C-0-L	-8.6056	3.4601	.224	-19.531	2.320
		03-G-0-L	-14.1333*	3.2825	.002	-24.498	-3.769
		03-1-0-L	-12.3000*	3.7903	.040	-24.268	-.332
	03-C-0-L	03-205-0-L	-4.7778	3.4601	.862	-15.703	6.147
		03-1-2-L	-13.4111*	3.4601	.007	-24.336	-2.486
		03-K-0-L	-10.1323*	2.9508	.024	-19.449	-.815
		03-9-0-L	-9.3278	3.9451	.280	-21.784	3.129
		03-250-2-L	8.6056	3.4601	.224	-2.320	19.531
		03-G-0-L	-5.5278	2.8949	.551	-14.668	3.613
		03-1-0-L	-3.6944	3.4601	.961	-14.620	7.231
	03-G-0-L	03-205-0-L	.7500	3.2825	1.000	-9.615	11.115
		03-1-2-L	-7.8833	3.2825	.262	-18.248	2.481
		03-K-0-L	-4.6045	2.7404	.700	-13.257	4.048
		03-9-0-L	-3.8000	3.7903	.972	-15.768	8.168
		03-250-2-L	14.1333*	3.2825	.002	3.769	24.498
		03-C-0-L	5.5278	2.8949	.551	-3.613	14.668
		03-1-0-L	1.8333	3.2825	.999	-8.531	12.198
	03-1-0-L	03-205-0-L	-1.0833	3.7903	1.000	-13.051	10.885
		03-1-2-L	-9.7167	3.7903	.193	-21.685	2.251
		03-K-0-L	-6.4379	3.3319	.536	-16.958	4.083
		03-9-0-L	-5.6333	4.2377	.883	-19.014	7.747
		03-250-2-L	12.3000*	3.7903	.040	.332	24.268

		03-C-0-L	3.6944	3.4601	.961	-7.231	14.620
		03-G-0-L	-1.8333	3.2825	.999	-12.198	8.531
1.00 kHz	03-205-0-L	03-1-2-L	-7.2833	4.0953	.637	-20.214	5.648
		03-K-0-L	-4.7076	3.6000	.892	-16.075	6.659
		03-9-0-L	-6.3167	4.5787	.862	-20.774	8.141
		03-250-2-L	15.7833*	4.0953	.007	2.852	28.714
		03-C-0-L	4.9722	3.7385	.883	-6.832	16.777
		03-G-0-L	-1.6750	3.5467	1.000	-12.874	9.524
		03-1-0-L	1.1167	4.0953	1.000	-11.814	14.048
	03-1-2-L	03-205-0-L	7.2833	4.0953	.637	-5.648	20.214
		03-K-0-L	2.5758	3.6000	.996	-8.791	13.943
		03-9-0-L	.9667	4.5787	1.000	-13.491	15.424
		03-250-2-L	23.0667*	4.0953	.000	10.136	35.998
		03-C-0-L	12.2556*	3.7385	.037	.451	24.060
		03-G-0-L	5.6083	3.5467	.759	-5.590	16.807
		03-1-0-L	8.4000	4.0953	.459	-4.531	21.331
	03-K-0-L	03-205-0-L	4.7076	3.6000	.892	-6.659	16.075
		03-1-2-L	-2.5758	3.6000	.996	-13.943	8.791
		03-9-0-L	-1.6091	4.1416	1.000	-14.686	11.468
		03-250-2-L	20.4909*	3.6000	.000	9.124	31.858
		03-C-0-L	9.6798	3.1882	.068	-.387	19.747
		03-G-0-L	3.0326	2.9609	.969	-6.317	12.382
		03-1-0-L	5.8242	3.6000	.738	-5.543	17.191
	03-9-0-L	03-205-0-L	6.3167	4.5787	.862	-8.141	20.774
		03-1-2-L	-.9667	4.5787	1.000	-15.424	13.491
		03-K-0-L	1.6091	4.1416	1.000	-11.468	14.686
		03-250-2-L	22.1000*	4.5787	.000	7.643	36.557
		03-C-0-L	11.2889	4.2626	.162	-2.170	24.748
		03-G-0-L	4.6417	4.0953	.946	-8.289	17.573
		03-1-0-L	7.4333	4.5787	.734	-7.024	21.891
	03-250-2-L	03-205-0-L	-15.7833*	4.0953	.007	-28.714	-2.852
		03-1-2-L	-23.0667*	4.0953	.000	-35.998	-10.136
		03-K-0-L	-20.4909*	3.6000	.000	-31.858	-9.124
		03-9-0-L	-22.1000*	4.5787	.000	-36.557	-7.643
		03-C-0-L	-10.8111	3.7385	.095	-22.615	.993
		03-G-0-L	-17.4583*	3.5467	.000	-28.657	-6.260
		03-1-0-L	-14.6667*	4.0953	.016	-27.598	-1.736
	03-C-0-L	03-205-0-L	-4.9722	3.7385	.883	-16.777	6.832

		03-1-2-L	-12.2556*	3.7385	.037	-24.060	-.451
		03-K-0-L	-9.6798	3.1882	.068	-19.747	.387
		03-9-0-L	-11.2889	4.2626	.162	-24.748	2.170
		03-250-2-L	10.8111	3.7385	.095	-.993	22.615
		03-G-0-L	-6.6472	3.1279	.413	-16.523	3.229
		03-1-0-L	-3.8556	3.7385	.967	-15.660	7.949
	03-G-0-L	03-205-0-L	1.6750	3.5467	1.000	-9.524	12.874
		03-1-2-L	-5.6083	3.5467	.759	-16.807	5.590
		03-K-0-L	-3.0326	2.9609	.969	-12.382	6.317
		03-9-0-L	-4.6417	4.0953	.946	-17.573	8.289
		03-250-2-L	17.4583*	3.5467	.000	6.260	28.657
		03-C-0-L	6.6472	3.1279	.413	-3.229	16.523
		03-1-0-L	2.7917	3.5467	.993	-8.407	13.990
	03-1-0-L	03-205-0-L	-1.1167	4.0953	1.000	-14.048	11.814
		03-1-2-L	-8.4000	4.0953	.459	-21.331	4.531
		03-K-0-L	-5.8242	3.6000	.738	-17.191	5.543
		03-9-0-L	-7.4333	4.5787	.734	-21.891	7.024
		03-250-2-L	14.6667*	4.0953	.016	1.736	27.598
		03-C-0-L	3.8556	3.7385	.967	-7.949	15.660
		03-G-0-L	-2.7917	3.5467	.993	-13.990	8.407
2.00 kHz	03-205-0-L	03-1-2-L	-2.7833	4.3493	.998	-16.516	10.950
		03-K-0-L	-1.8773	3.8232	1.000	-13.949	10.195
		03-9-0-L	-.8500	4.8626	1.000	-16.204	14.504
		03-250-2-L	17.7167*	4.3493	.004	3.984	31.450
		03-C-0-L	7.7833	3.9703	.518	-4.753	20.320
		03-G-0-L	1.9667	3.7666	.999	-9.926	13.860
		03-1-0-L	5.7333	4.3493	.888	-8.000	19.466
	03-1-2-L	03-205-0-L	2.7833	4.3493	.998	-10.950	16.516
		03-K-0-L	.9061	3.8232	1.000	-11.166	12.978
		03-9-0-L	1.9333	4.8626	1.000	-13.420	17.287
		03-250-2-L	20.5000*	4.3493	.000	6.767	34.233
		03-C-0-L	10.5667	3.9703	.158	-1.970	23.103
		03-G-0-L	4.7500	3.7666	.909	-7.143	16.643
		03-1-0-L	8.5167	4.3493	.519	-5.216	22.250
	03-K-0-L	03-205-0-L	1.8773	3.8232	1.000	-10.195	13.949
		03-1-2-L	-.9061	3.8232	1.000	-12.978	11.166
		03-9-0-L	1.0273	4.3984	1.000	-12.861	14.915
		03-250-2-L	19.5939*	3.8232	.000	7.522	31.666

		03-C-0-L	9.6606	3.3859	.104	-1.030	20.352
		03-G-0-L	3.8439	3.1445	.921	-6.085	13.773
		03-1-0-L	7.6106	3.8232	.498	-4.461	19.682
	03-9-0-L	03-205-0-L	.8500	4.8626	1.000	-14.504	16.204
		03-1-2-L	-1.9333	4.8626	1.000	-17.287	13.420
		03-K-0-L	-1.0273	4.3984	1.000	-14.915	12.861
		03-250-2-L	18.5667*	4.8626	.008	3.213	33.920
		03-C-0-L	8.6333	4.5269	.552	-5.660	22.927
		03-G-0-L	2.8167	4.3493	.998	-10.916	16.550
		03-1-0-L	6.5833	4.8626	.873	-8.770	21.937
	03-250-2-L	03-205-0-L	-17.7167*	4.3493	.004	-31.450	-3.984
		03-1-2-L	-20.5000*	4.3493	.000	-34.233	-6.767
		03-K-0-L	-19.5939*	3.8232	.000	-31.666	-7.522
		03-9-0-L	-18.5667*	4.8626	.008	-33.920	-3.213
		03-C-0-L	-9.9333	3.9703	.218	-22.470	2.603
		03-G-0-L	-15.7500*	3.7666	.003	-27.643	-3.857
		03-1-0-L	-11.9833	4.3493	.129	-25.716	1.750
	03-C-0-L	03-205-0-L	-7.7833	3.9703	.518	-20.320	4.753
		03-1-2-L	-10.5667	3.9703	.158	-23.103	1.970
		03-K-0-L	-9.6606	3.3859	.104	-20.352	1.030
		03-9-0-L	-8.6333	4.5269	.552	-22.927	5.660
		03-250-2-L	9.9333	3.9703	.218	-2.603	22.470
		03-G-0-L	-5.8167	3.3218	.655	-16.305	4.672
		03-1-0-L	-2.0500	3.9703	1.000	-14.586	10.486
	03-G-0-L	03-205-0-L	-1.9667	3.7666	.999	-13.860	9.926
		03-1-2-L	-4.7500	3.7666	.909	-16.643	7.143
		03-K-0-L	-3.8439	3.1445	.921	-13.773	6.085
		03-9-0-L	-2.8167	4.3493	.998	-16.550	10.916
		03-250-2-L	15.7500*	3.7666	.003	3.857	27.643
		03-C-0-L	5.8167	3.3218	.655	-4.672	16.305
		03-1-0-L	3.7667	3.7666	.972	-8.126	15.660
	03-1-0-L	03-205-0-L	-5.7333	4.3493	.888	-19.466	8.000
		03-1-2-L	-8.5167	4.3493	.519	-22.250	5.216
		03-K-0-L	-7.6106	3.8232	.498	-19.682	4.461
		03-9-0-L	-6.5833	4.8626	.873	-21.937	8.770
		03-250-2-L	11.9833	4.3493	.129	-1.750	25.716
		03-C-0-L	2.0500	3.9703	1.000	-10.486	14.586
		03-G-0-L	-3.7667	3.7666	.972	-15.660	8.126

4.00 kHz	03-205-0-L	03-1-2-L	-1.7833	3.7502	1.000	-13.625	10.058
		03-K-0-L	-2.3682	3.2966	.996	-12.777	8.041
		03-9-0-L	.4500	4.1928	1.000	-12.789	13.689
		03-250-2-L	12.1833*	3.7502	.040	.342	24.025
		03-C-0-L	6.2278	3.4234	.610	-4.582	17.037
		03-G-0-L	.6833	3.2478	1.000	-9.571	10.938
		03-1-0-L	5.1500	3.7502	.865	-6.691	16.991
	03-1-2-L	03-205-0-L	1.7833	3.7502	1.000	-10.058	13.625
		03-K-0-L	-.5848	3.2966	1.000	-10.994	9.824
		03-9-0-L	2.2333	4.1928	.999	-11.006	15.472
		03-250-2-L	13.9667*	3.7502	.011	2.125	25.808
		03-C-0-L	8.0111	3.4234	.292	-2.798	18.821
		03-G-0-L	2.4667	3.2478	.994	-7.788	12.721
		03-1-0-L	6.9333	3.7502	.591	-4.908	18.775
	03-K-0-L	03-205-0-L	2.3682	3.2966	.996	-8.041	12.777
		03-1-2-L	.5848	3.2966	1.000	-9.824	10.994
		03-9-0-L	2.8182	3.7926	.995	-9.157	14.793
		03-250-2-L	14.5515*	3.2966	.001	4.143	24.961
		03-C-0-L	8.5960	2.9195	.084	-.622	17.814
		03-G-0-L	3.0515	2.7114	.948	-5.510	11.613
		03-1-0-L	7.5182	3.2966	.324	-2.891	17.927
	03-9-0-L	03-205-0-L	-.4500	4.1928	1.000	-13.689	12.789
		03-1-2-L	-2.2333	4.1928	.999	-15.472	11.006
		03-K-0-L	-2.8182	3.7926	.995	-14.793	9.157
		03-250-2-L	11.7333	4.1928	.118	-1.506	24.972
		03-C-0-L	5.7778	3.9033	.814	-6.547	18.102
		03-G-0-L	.2333	3.7502	1.000	-11.608	12.075
		03-1-0-L	4.7000	4.1928	.949	-8.539	17.939
	03-250-2-L	03-205-0-L	-12.1833*	3.7502	.040	-24.025	-.342
		03-1-2-L	-13.9667*	3.7502	.011	-25.808	-2.125
		03-K-0-L	-14.5515*	3.2966	.001	-24.961	-4.143
		03-9-0-L	-11.7333	4.1928	.118	-24.972	1.506
		03-C-0-L	-5.9556	3.4234	.662	-16.765	4.854
		03-G-0-L	-11.5000*	3.2478	.018	-21.755	-1.245
		03-1-0-L	-7.0333	3.7502	.573	-18.875	4.808
	03-C-0-L	03-205-0-L	-6.2278	3.4234	.610	-17.037	4.582
		03-1-2-L	-8.0111	3.4234	.292	-18.821	2.798
		03-K-0-L	-8.5960	2.9195	.084	-17.814	.622

		03-9-0-L	-5.7778	3.9033	.814	-18.102	6.547
		03-250-2-L	5.9556	3.4234	.662	-4.854	16.765
		03-G-0-L	-5.5444	2.8642	.534	-14.588	3.499
		03-1-0-L	-1.0778	3.4234	1.000	-11.887	9.732
	03-G-0-L	03-205-0-L	-.6833	3.2478	1.000	-10.938	9.571
		03-1-2-L	-2.4667	3.2478	.994	-12.721	7.788
		03-K-0-L	-3.0515	2.7114	.948	-11.613	5.510
		03-9-0-L	-.2333	3.7502	1.000	-12.075	11.608
		03-250-2-L	11.5000*	3.2478	.018	1.245	21.755
		03-C-0-L	5.5444	2.8642	.534	-3.499	14.588
		03-1-0-L	4.4667	3.2478	.864	-5.788	14.721
	03-1-0-L	03-205-0-L	-5.1500	3.7502	.865	-16.991	6.691
		03-1-2-L	-6.9333	3.7502	.591	-18.775	4.908
		03-K-0-L	-7.5182	3.2966	.324	-17.927	2.891
		03-9-0-L	-4.7000	4.1928	.949	-17.939	8.539
		03-250-2-L	7.0333	3.7502	.573	-4.808	18.875
		03-C-0-L	1.0778	3.4234	1.000	-9.732	11.887
		03-G-0-L	-4.4667	3.2478	.864	-14.721	5.788
8.00 kHz	03-205-0-L	03-1-2-L	.0667	1.9482	1.000	-6.085	6.218
		03-K-0-L	-2.1364	1.7126	.913	-7.544	3.271
		03-9-0-L	1.6750	2.1781	.994	-5.203	8.553
		03-250-2-L	6.3833*	1.9482	.037	.232	12.535
		03-C-0-L	5.1333	1.7785	.096	-.482	10.749
		03-G-0-L	1.5500	1.6872	.983	-3.777	6.877
		03-1-0-L	3.9833	1.9482	.463	-2.168	10.135
	03-1-2-L	03-205-0-L	-.0667	1.9482	1.000	-6.218	6.085
		03-K-0-L	-2.2030	1.7126	.900	-7.610	3.204
		03-9-0-L	1.6083	2.1781	.995	-5.269	8.486
		03-250-2-L	6.3167*	1.9482	.040	.165	12.468
		03-C-0-L	5.0667	1.7785	.105	-.549	10.682
		03-G-0-L	1.4833	1.6872	.987	-3.844	6.811
		03-1-0-L	3.9167	1.9482	.485	-2.235	10.068
	03-K-0-L	03-205-0-L	2.1364	1.7126	.913	-3.271	7.544
		03-1-2-L	2.2030	1.7126	.900	-3.204	7.610
		03-9-0-L	3.8114	1.9702	.534	-2.410	10.032
		03-250-2-L	8.5197*	1.7126	.000	3.112	13.927
		03-C-0-L	7.2697*	1.5167	.000	2.481	12.059
		03-G-0-L	3.6864	1.4085	.173	-.761	8.134

		03-1-0-L	6.1197*	1.7126	.016	.712	11.527
	03-9-0-L	03-205-0-L	-1.6750	2.1781	.994	-8.553	5.203
		03-1-2-L	-1.6083	2.1781	.995	-8.486	5.269
		03-K-0-L	-3.8114	1.9702	.534	-10.032	2.410
		03-250-2-L	4.7083	2.1781	.391	-2.169	11.586
		03-C-0-L	3.4583	2.0277	.684	-2.944	9.861
		03-G-0-L	-.1250	1.9482	1.000	-6.276	6.026
		03-1-0-L	2.3083	2.1781	.962	-4.569	9.186
	03-250-2-L	03-205-0-L	-6.3833*	1.9482	.037	-12.535	-.232
		03-1-2-L	-6.3167*	1.9482	.040	-12.468	-.165
		03-K-0-L	-8.5197*	1.7126	.000	-13.927	-3.112
		03-9-0-L	-4.7083	2.1781	.391	-11.586	2.169
		03-C-0-L	-1.2500	1.7785	.997	-6.865	4.365
		03-G-0-L	-4.8333	1.6872	.101	-10.161	.494
		03-1-0-L	-2.4000	1.9482	.918	-8.551	3.751
	03-C-0-L	03-205-0-L	-5.1333	1.7785	.096	-10.749	.482
		03-1-2-L	-5.0667	1.7785	.105	-10.682	.549
		03-K-0-L	-7.2697*	1.5167	.000	-12.059	-2.481
		03-9-0-L	-3.4583	2.0277	.684	-9.861	2.944
		03-250-2-L	1.2500	1.7785	.997	-4.365	6.865
		03-G-0-L	-3.5833	1.4880	.259	-8.282	1.115
		03-1-0-L	-1.1500	1.7785	.998	-6.765	4.465
	03-G-0-L	03-205-0-L	-1.5500	1.6872	.983	-6.877	3.777
		03-1-2-L	-1.4833	1.6872	.987	-6.811	3.844
		03-K-0-L	-3.6864	1.4085	.173	-8.134	.761
		03-9-0-L	.1250	1.9482	1.000	-6.026	6.276
		03-250-2-L	4.8333	1.6872	.101	-.494	10.161
		03-C-0-L	3.5833	1.4880	.259	-1.115	8.282
		03-1-0-L	2.4333	1.6872	.833	-2.894	7.761
	03-1-0-L	03-205-0-L	-3.9833	1.9482	.463	-10.135	2.168
		03-1-2-L	-3.9167	1.9482	.485	-10.068	2.235
		03-K-0-L	-6.1197*	1.7126	.016	-11.527	-.712
		03-9-0-L	-2.3083	2.1781	.962	-9.186	4.569
		03-250-2-L	2.4000	1.9482	.918	-3.751	8.551
		03-C-0-L	1.1500	1.7785	.998	-4.465	6.765
		03-G-0-L	-2.4333	1.6872	.833	-7.761	2.894
16.00 kHz	03-205-0-L	03-1-2-L	-.6000	.4895	.920	-2.146	.946
		03-K-0-L	-1.0106	.4303	.288	-2.369	.348

		03-9-0-L	-.0833	.5473	1.000	-1.811	1.645
		03-250-2-L	.2167	.4895	1.000	-1.329	1.762
		03-C-0-L	.0944	.4468	1.000	-1.316	1.505
		03-G-0-L	-.3167	.4239	.995	-1.655	1.022
		03-1-0-L	-.0333	.4895	1.000	-1.579	1.512
	03-1-2-L	03-205-0-L	.6000	.4895	.920	-.946	2.146
		03-K-0-L	-.4106	.4303	.979	-1.769	.948
		03-9-0-L	.5167	.5473	.980	-1.211	2.245
		03-250-2-L	.8167	.4895	.707	-.729	2.362
		03-C-0-L	.6944	.4468	.774	-.716	2.105
		03-G-0-L	.2833	.4239	.997	-1.055	1.622
		03-1-0-L	.5667	.4895	.940	-.979	2.112
	03-K-0-L	03-205-0-L	1.0106	.4303	.288	-.348	2.369
		03-1-2-L	.4106	.4303	.979	-.948	1.769
		03-9-0-L	.9273	.4950	.575	-.636	2.490
		03-250-2-L	1.2273	.4303	.104	-.131	2.586
		03-C-0-L	1.1051	.3811	.093	-.098	2.308
		03-G-0-L	.6939	.3539	.517	-.423	1.811
		03-1-0-L	.9773	.4303	.329	-.381	2.336
	03-9-0-L	03-205-0-L	.0833	.5473	1.000	-1.645	1.811
		03-1-2-L	-.5167	.5473	.980	-2.245	1.211
		03-K-0-L	-.9273	.4950	.575	-2.490	.636
		03-250-2-L	.3000	.5473	.999	-1.428	2.028
		03-C-0-L	.1778	.5095	1.000	-1.431	1.786
		03-G-0-L	-.2333	.4895	1.000	-1.779	1.312
		03-1-0-L	.0500	.5473	1.000	-1.678	1.778
	03-250-2-L	03-205-0-L	-.2167	.4895	1.000	-1.762	1.329
		03-1-2-L	-.8167	.4895	.707	-2.362	.729
		03-K-0-L	-1.2273	.4303	.104	-2.586	.131
		03-9-0-L	-.3000	.5473	.999	-2.028	1.428
		03-C-0-L	-.1222	.4468	1.000	-1.533	1.289
		03-G-0-L	-.5333	.4239	.910	-1.872	.805
		03-1-0-L	-.2500	.4895	1.000	-1.796	1.296
	03-C-0-L	03-205-0-L	-.0944	.4468	1.000	-1.505	1.316
		03-1-2-L	-.6944	.4468	.774	-2.105	.716
		03-K-0-L	-1.1051	.3811	.093	-2.308	.098
		03-9-0-L	-.1778	.5095	1.000	-1.786	1.431
		03-250-2-L	.1222	.4468	1.000	-1.289	1.533

		03-G-0-L	-.4111	.3738	.954	-1.592	.769
		03-1-0-L	-.1278	.4468	1.000	-1.539	1.283
	03-G-0-L	03-205-0-L	.3167	.4239	.995	-1.022	1.655
		03-1-2-L	-.2833	.4239	.997	-1.622	1.055
		03-K-0-L	-.6939	.3539	.517	-1.811	.423
		03-9-0-L	.2333	.4895	1.000	-1.312	1.779
		03-250-2-L	.5333	.4239	.910	-.805	1.872
		03-C-0-L	.4111	.3738	.954	-.769	1.592
		03-1-0-L	.2833	.4239	.997	-1.055	1.622
	03-1-0-L	03-205-0-L	.0333	.4895	1.000	-1.512	1.579
		03-1-2-L	-.5667	.4895	.940	-2.112	.979
		03-K-0-L	-.9773	.4303	.329	-2.336	.381
		03-9-0-L	-.0500	.5473	1.000	-1.778	1.678
		03-250-2-L	.2500	.4895	1.000	-1.296	1.796
		03-C-0-L	.1278	.4468	1.000	-1.283	1.539
		03-G-0-L	-.2833	.4239	.997	-1.622	1.055
Leq	03-205-0-L	03-1-2-L	-5.3833	3.9588	.871	-17.883	7.117
		03-K-0-L	-3.4394	3.4800	.974	-14.428	7.549
		03-9-0-L	-3.3417	4.4261	.995	-17.317	10.634
		03-250-2-L	15.0167*	3.9588	.009	2.517	27.517
		03-C-0-L	6.2667	3.6139	.666	-5.144	17.678
		03-G-0-L	.1417	3.4285	1.000	-10.684	10.967
		03-1-0-L	2.7667	3.9588	.997	-9.733	15.267
	03-1-2-L	03-205-0-L	5.3833	3.9588	.871	-7.117	17.883
		03-K-0-L	1.9439	3.4800	.999	-9.044	12.932
		03-9-0-L	2.0417	4.4261	1.000	-11.934	16.017
		03-250-2-L	20.4000*	3.9588	.000	7.900	32.900
		03-C-0-L	11.6500*	3.6139	.042	.239	23.061
		03-G-0-L	5.5250	3.4285	.741	-5.300	16.350
		03-1-0-L	8.1500	3.9588	.454	-4.350	20.650
	03-K-0-L	03-205-0-L	3.4394	3.4800	.974	-7.549	14.428
		03-1-2-L	-1.9439	3.4800	.999	-12.932	9.044
		03-9-0-L	.0977	4.0036	1.000	-12.544	12.739
		03-250-2-L	18.4561*	3.4800	.000	7.468	29.444
		03-C-0-L	9.7061	3.0820	.051	-.025	19.437
		03-G-0-L	3.5811	2.8622	.912	-5.456	12.619
		03-1-0-L	6.2061	3.4800	.634	-4.782	17.194
	03-9-0-L	03-205-0-L	3.3417	4.4261	.995	-10.634	17.317

		03-1-2-L	-2.0417	4.4261	1.000	-16.017	11.934
		03-K-0-L	-.0977	4.0036	1.000	-12.739	12.544
		03-250-2-L	18.3583*	4.4261	.003	4.383	32.334
		03-C-0-L	9.6083	4.1205	.297	-3.402	22.619
		03-G-0-L	3.4833	3.9588	.987	-9.017	15.983
		03-1-0-L	6.1083	4.4261	.862	-7.867	20.084
	03-250-2-L	03-205-0-L	-15.0167*	3.9588	.009	-27.517	-2.517
		03-1-2-L	-20.4000*	3.9588	.000	-32.900	-7.900
		03-K-0-L	-18.4561*	3.4800	.000	-29.444	-7.468
		03-9-0-L	-18.3583*	4.4261	.003	-32.334	-4.383
		03-C-0-L	-8.7500	3.6139	.253	-20.161	2.661
		03-G-0-L	-14.8750*	3.4285	.002	-25.700	-4.050
		03-1-0-L	-12.2500	3.9588	.059	-24.750	.250
	03-C-0-L	03-205-0-L	-6.2667	3.6139	.666	-17.678	5.144
		03-1-2-L	-11.6500*	3.6139	.042	-23.061	-.239
		03-K-0-L	-9.7061	3.0820	.051	-19.437	.025
		03-9-0-L	-9.6083	4.1205	.297	-22.619	3.402
		03-250-2-L	8.7500	3.6139	.253	-2.661	20.161
		03-G-0-L	-6.1250	3.0236	.475	-15.672	3.422
		03-1-0-L	-3.5000	3.6139	.977	-14.911	7.911
	03-G-0-L	03-205-0-L	-.1417	3.4285	1.000	-10.967	10.684
		03-1-2-L	-5.5250	3.4285	.741	-16.350	5.300
		03-K-0-L	-3.5811	2.8622	.912	-12.619	5.456
		03-9-0-L	-3.4833	3.9588	.987	-15.983	9.017
		03-250-2-L	14.8750*	3.4285	.002	4.050	25.700
		03-C-0-L	6.1250	3.0236	.475	-3.422	15.672
		03-1-0-L	2.6250	3.4285	.994	-8.200	13.450
	03-1-0-L	03-205-0-L	-2.7667	3.9588	.997	-15.267	9.733
		03-1-2-L	-8.1500	3.9588	.454	-20.650	4.350
		03-K-0-L	-6.2061	3.4800	.634	-17.194	4.782
		03-9-0-L	-6.1083	4.4261	.862	-20.084	7.867
		03-250-2-L	12.2500	3.9588	.059	-.250	24.750
		03-C-0-L	3.5000	3.6139	.977	-7.911	14.911
		03-G-0-L	-2.6250	3.4285	.994	-13.450	8.200

*. The mean difference is significant at the 0.05 level.

APPENDIX F. SPSS™ Grouped Locations Descriptive 16 Hz – 16 kHz

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
16 Hz	Aft	6	27.917	.6113	.2496	27.275	28.558	27.3	28.8
	Mid	6	31.867	4.2132	1.7200	27.445	36.288	27.9	39.2
	Forward	46	28.635	1.9309	.2847	28.061	29.208	27.2	40.2
	Total	58	28.895	2.3703	.3112	28.272	29.518	27.2	40.2
31.5 Hz	Aft	6	34.183	2.8463	1.1620	31.196	37.170	30.5	36.6
	Mid	6	38.983	5.0665	2.0684	33.666	44.300	32.0	44.6
	Forward	46	42.122	6.9121	1.0191	40.069	44.174	28.0	57.4
	Total	58	40.976	6.8568	.9003	39.173	42.779	28.0	57.4
63 Hz	Aft	6	38.467	2.0452	.8349	36.320	40.613	35.5	40.2
	Mid	6	51.283	5.2788	2.1551	45.744	56.823	44.5	56.1
	Forward	46	51.493	6.5386	.9641	49.552	53.435	34.4	61.8
	Total	58	50.124	7.2473	.9516	48.219	52.030	34.4	61.8
125 Hz	Aft	6	46.600	1.9829	.8095	44.519	48.681	44.3	49.8
	Mid	6	58.900	6.2639	2.5572	52.326	65.474	49.9	64.7
	Forward	46	59.002	7.8491	1.1573	56.671	61.333	40.5	73.7
	Total	58	57.709	8.1801	1.0741	55.558	59.859	40.5	73.7
250 Hz	Aft	6	51.883	2.6992	1.1019	49.051	54.716	49.2	55.3
	Mid	6	62.917	6.7942	2.7737	55.787	70.047	52.9	70.3
	Forward	46	62.548	7.4849	1.1036	60.325	64.771	45.6	75.5
	Total	58	61.483	7.7298	1.0150	59.450	63.515	45.6	75.5
500 Hz	Aft	6	53.417	1.3790	.5630	51.969	54.864	51.5	55.1
	Mid	6	66.800	5.8808	2.4008	60.628	72.972	58.6	74.1
	Forward	46	68.846	8.0477	1.1866	66.456	71.236	52.4	85.8
	Total	58	67.038	8.7467	1.1485	64.738	69.338	51.5	85.8
1.00 kHz	Aft	6	54.100	2.2839	.9324	51.703	56.497	50.8	56.0
	Mid	6	69.883	6.1003	2.4904	63.481	76.285	61.1	77.5
	Forward	46	72.072	8.2794	1.2207	69.613	74.530	50.8	87.3
	Total	58	69.986	9.3763	1.2312	67.521	72.452	50.8	87.3
2.00 kHz	Aft	6	53.733	3.1392	1.2816	50.439	57.028	49.6	57.5
	Mid	6	71.450	5.6437	2.3040	65.527	77.373	62.5	78.4
	Forward	46	69.948	8.4679	1.2485	67.433	72.462	49.6	87.5
	Total	58	68.426	9.2641	1.2164	65.990	70.862	49.6	87.5

4.00 kHz	Aft	6	55.267	3.2995	1.3470	51.804	58.729	51.6	60.3
	Mid	6	67.450	5.3012	2.1642	61.887	73.013	59.8	74.7
	Forward	46	66.509	7.1900	1.0601	64.374	68.644	51.6	80.9
	Total	58	65.443	7.5149	.9868	63.467	67.419	51.6	80.9
8.00 kHz	Aft	6	54.617	.5307	.2167	54.060	55.174	54.2	55.3
	Mid	6	61.000	3.9115	1.5969	56.895	65.105	56.2	66.7
	Forward	46	59.687	4.1809	.6164	58.445	60.929	54.2	70.7
	Total	58	59.298	4.2309	.5555	58.186	60.411	54.2	70.7
16.00 kHz	Aft	6	54.400	.7457	.3044	53.617	55.183	53.3	55.3
	Mid	6	54.617	.7653	.3124	53.814	55.420	53.5	55.4
	Forward	46	55.009	.9285	.1369	54.733	55.284	53.3	58.4
	Total	58	54.905	.9083	.1193	54.666	55.144	53.3	58.4

APPENDIX G. SPSS™ Grouped ANOVA 16 Hz – 16 kHz

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
16 Hz	Between Groups	61.842	2	30.921	6.581	.003
	Within Groups	258.406	55	4.698		
	Total	320.248	57			
31.5 Hz	Between Groups	361.051	2	180.526	4.282	.019
	Within Groups	2318.855	55	42.161		
	Total	2679.906	57			
63 Hz	Between Groups	909.696	2	454.848	12.003	.000
	Within Groups	2084.130	55	37.893		
	Total	2993.826	57			
125 Hz	Between Groups	825.896	2	412.948	7.601	.001
	Within Groups	2988.210	55	54.331		
	Total	3814.106	57			
250 Hz	Between Groups	617.411	2	308.706	6.089	.004
	Within Groups	2788.331	55	50.697		
	Total	3405.743	57			
500 Hz	Between Groups	1263.894	2	631.947	11.223	.000
	Within Groups	3096.842	55	56.306		
	Total	4360.737	57			
1.00 kHz	Between Groups	1714.367	2	857.184	14.300	.000
	Within Groups	3296.822	55	59.942		
	Total	5011.189	57			
2.00 kHz	Between Groups	1456.648	2	728.324	11.661	.000
	Within Groups	3435.263	55	62.459		
	Total	4891.911	57			
4.00 kHz	Between Groups	697.757	2	348.879	7.611	.001
	Within Groups	2521.285	55	45.842		
	Total	3219.042	57			
8.00 kHz	Between Groups	155.829	2	77.915	4.957	.010
	Within Groups	864.501	55	15.718		
	Total	1020.330	57			
16.00 kHz	Between Groups	2.524	2	1.262	1.559	.219
	Within Groups	44.505	55	.809		
	Total	47.028	57			

APPENDIX H. SPSS™ Multiple Comparisons Grouped 16 Hz – 16 kHz

Multiple Comparisons

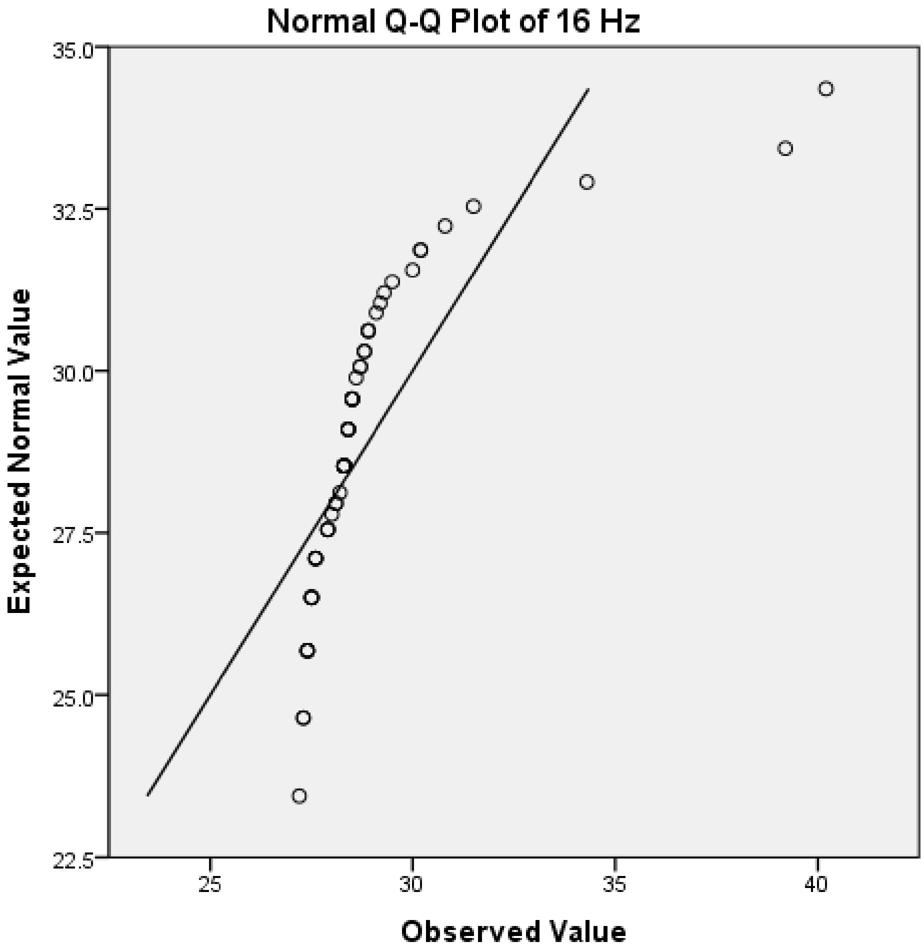
Tukey HSD

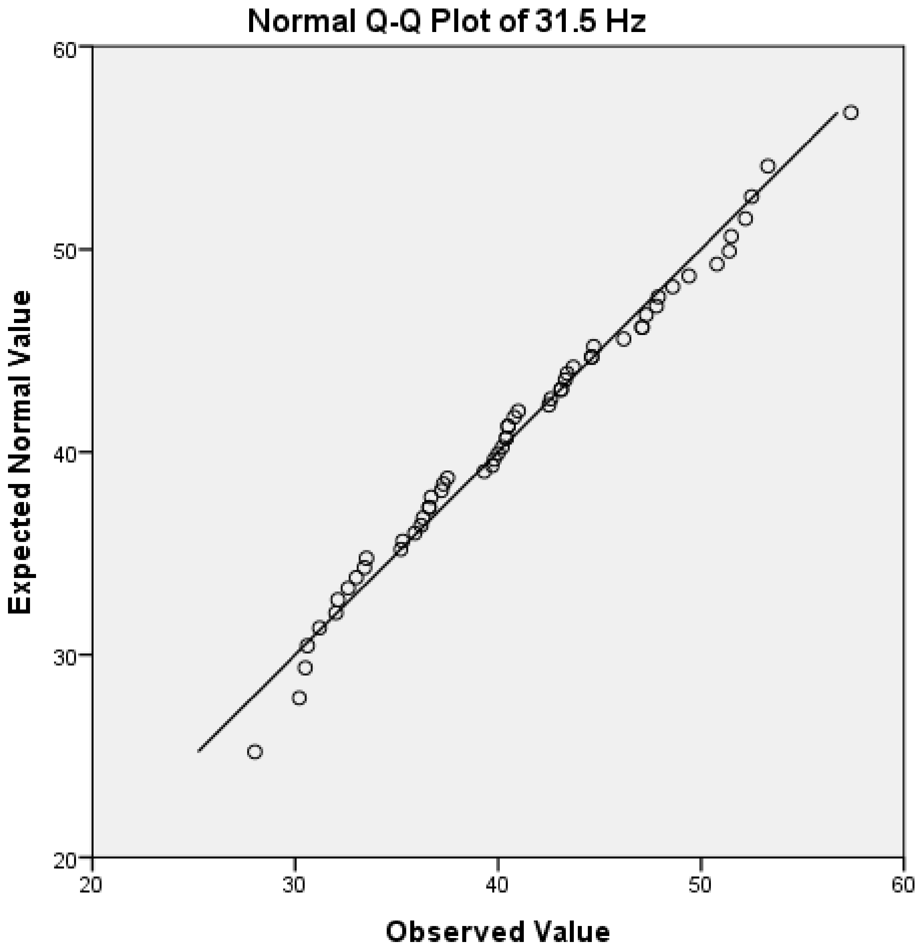
Dependent Variable	(I) Grouped_Loc	(J) Grouped_Loc	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
16 Hz	Aft	Mid	-3.9500*	1.2514	.007	-6.964	-.936
		Forward	-.7181	.9408	.727	-2.984	1.548
	Mid	Aft	3.9500*	1.2514	.007	.936	6.964
		Forward	3.2319*	.9408	.003	.966	5.498
	Forward	Aft	.7181	.9408	.727	-1.548	2.984
		Mid	-3.2319*	.9408	.003	-5.498	-.966
31.5 Hz	Aft	Mid	-4.8000	3.7488	.412	-13.830	4.230
		Forward	-7.9384*	2.8184	.018	-14.727	-1.150
	Mid	Aft	4.8000	3.7488	.412	-4.230	13.830
		Forward	-3.1384	2.8184	.510	-9.927	3.650
	Forward	Aft	7.9384*	2.8184	.018	1.150	14.727
		Mid	3.1384	2.8184	.510	-3.650	9.927
63 Hz	Aft	Mid	-12.8167*	3.5540	.002	-21.377	-4.256
		Forward	-13.0268*	2.6719	.000	-19.463	-6.591
	Mid	Aft	12.8167*	3.5540	.002	4.256	21.377
		Forward	-.2101	2.6719	.997	-6.646	6.226
	Forward	Aft	13.0268*	2.6719	.000	6.591	19.463
		Mid	.2101	2.6719	.997	-6.226	6.646
125 Hz	Aft	Mid	-12.3000*	4.2556	.015	-22.551	-2.049
		Forward	-12.4022*	3.1994	.001	-20.109	-4.696
	Mid	Aft	12.3000*	4.2556	.015	2.049	22.551
		Forward	-.1022	3.1994	.999	-7.809	7.604
	Forward	Aft	12.4022*	3.1994	.001	4.696	20.109
		Mid	.1022	3.1994	.999	-7.604	7.809
250 Hz	Aft	Mid	-11.0333*	4.1108	.026	-20.935	-1.131
		Forward	-10.6645*	3.0906	.003	-18.109	-3.220
	Mid	Aft	11.0333*	4.1108	.026	1.131	20.935
		Forward	.3688	3.0906	.992	-7.076	7.813
	Forward	Aft	10.6645*	3.0906	.003	3.220	18.109
		Mid	-.3688	3.0906	.992	-7.813	7.076
500 Hz	Aft	Mid	-13.3833*	4.3323	.009	-23.819	-2.948

		Forward	-15.4290*	3.2571	.000	-23.274	-7.584
	Mid	Aft	13.3833*	4.3323	.009	2.948	23.819
		Forward	-2.0457	3.2571	.805	-9.891	5.800
	Forward	Aft	15.4290*	3.2571	.000	7.584	23.274
		Mid	2.0457	3.2571	.805	-5.800	9.891
1.00 kHz	Aft	Mid	-15.7833*	4.4700	.002	-26.550	-5.016
		Forward	-17.9717*	3.3606	.000	-26.067	-9.877
	Mid	Aft	15.7833*	4.4700	.002	5.016	26.550
		Forward	-2.1884	3.3606	.792	-10.283	5.906
	Forward	Aft	17.9717*	3.3606	.000	9.877	26.067
		Mid	2.1884	3.3606	.792	-5.906	10.283
2.00 kHz	Aft	Mid	-17.7167*	4.5629	.001	-28.707	-6.726
		Forward	-16.2145*	3.4304	.000	-24.477	-7.951
	Mid	Aft	17.7167*	4.5629	.001	6.726	28.707
		Forward	1.5022	3.4304	.900	-6.761	9.765
	Forward	Aft	16.2145*	3.4304	.000	7.951	24.477
		Mid	-1.5022	3.4304	.900	-9.765	6.761
4.00 kHz	Aft	Mid	-12.1833*	3.9090	.008	-21.599	-2.767
		Forward	-11.2420*	2.9388	.001	-18.321	-4.163
	Mid	Aft	12.1833*	3.9090	.008	2.767	21.599
		Forward	.9413	2.9388	.945	-6.138	8.020
	Forward	Aft	11.2420*	2.9388	.001	4.163	18.321
		Mid	-.9413	2.9388	.945	-8.020	6.138
8.00 kHz	Aft	Mid	-6.3833*	2.2890	.020	-11.897	-.870
		Forward	-5.0703*	1.7209	.013	-9.215	-.925
	Mid	Aft	6.3833*	2.2890	.020	.870	11.897
		Forward	1.3130	1.7209	.727	-2.832	5.458
	Forward	Aft	5.0703*	1.7209	.013	.925	9.215
		Mid	-1.3130	1.7209	.727	-5.458	2.832
16.00 kHz	Aft	Mid	-.2167	.5194	.909	-1.468	1.034
		Forward	-.6087	.3905	.272	-1.549	.332
	Mid	Aft	.2167	.5194	.909	-1.034	1.468
		Forward	-.3920	.3905	.577	-1.333	.548
	Forward	Aft	.6087	.3905	.272	-.332	1.549
		Mid	.3920	.3905	.577	-.548	1.333

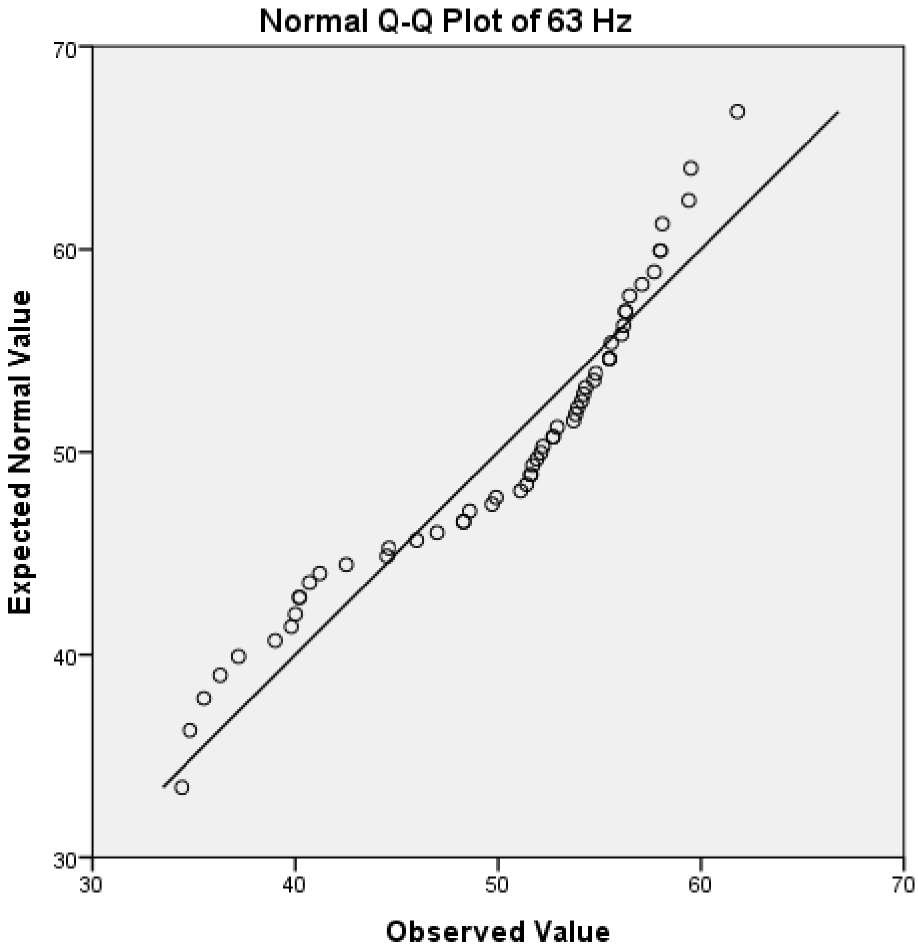
*. The mean difference is significant at the 0.05 level.

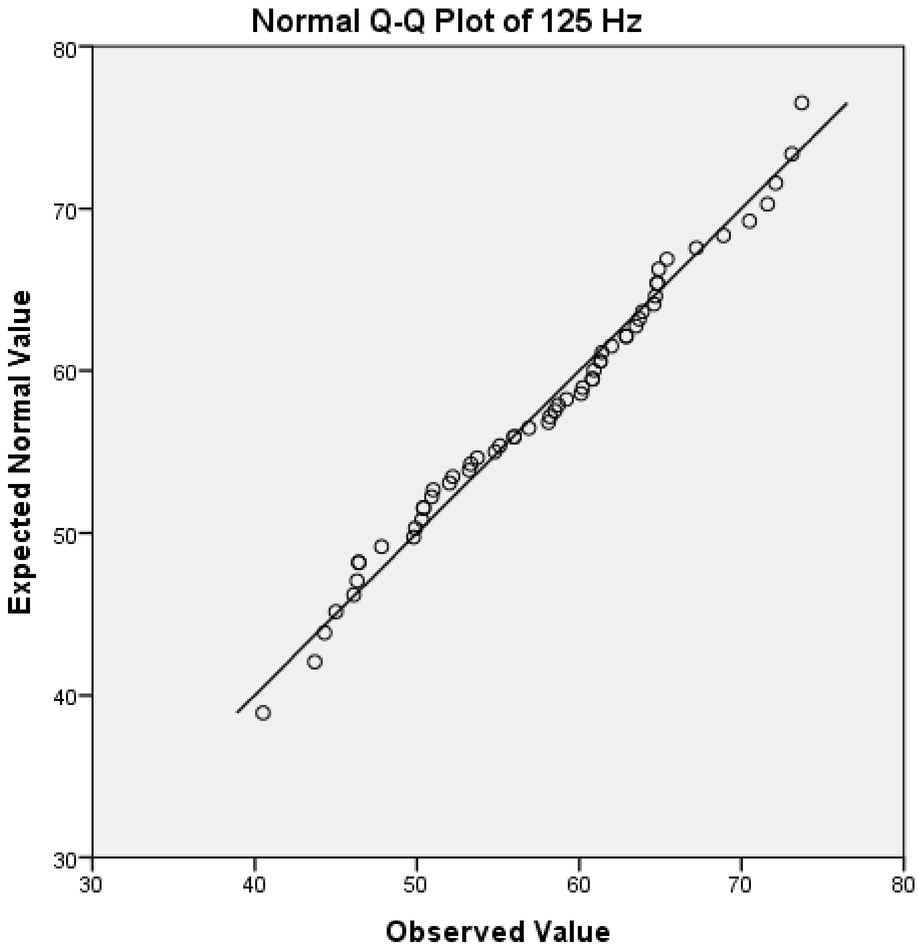
APPENDIX I. Q-Q Plots 16 Hz – 16 kHz

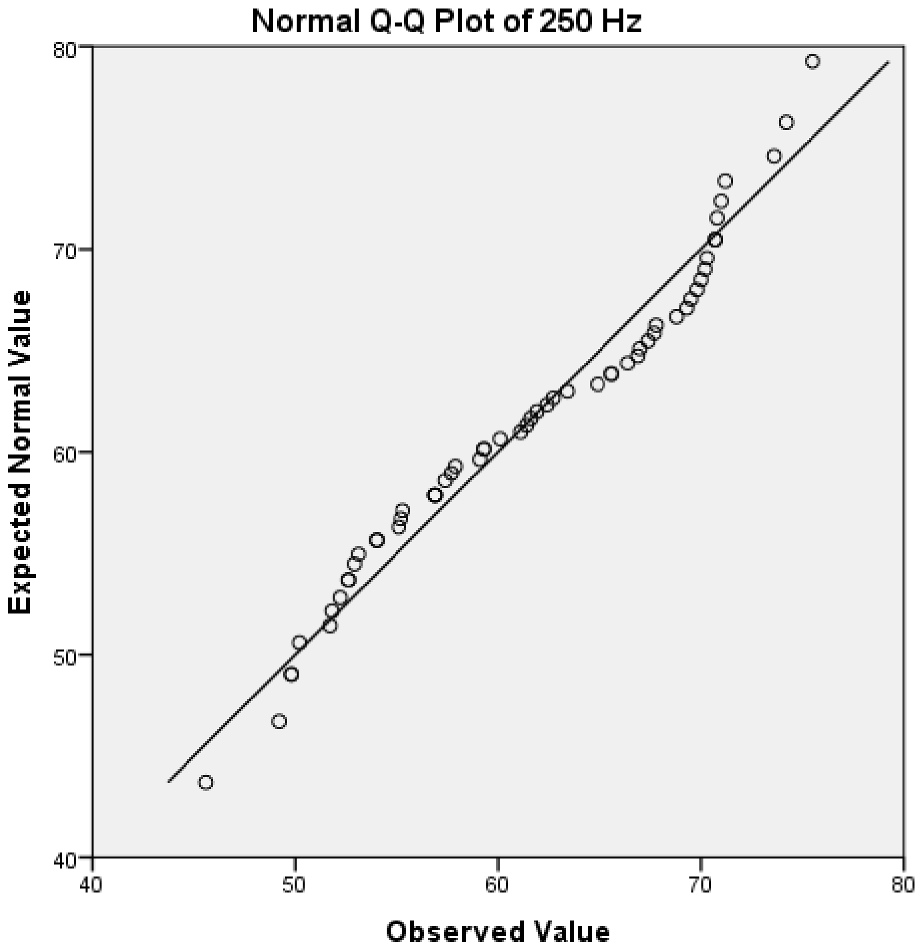


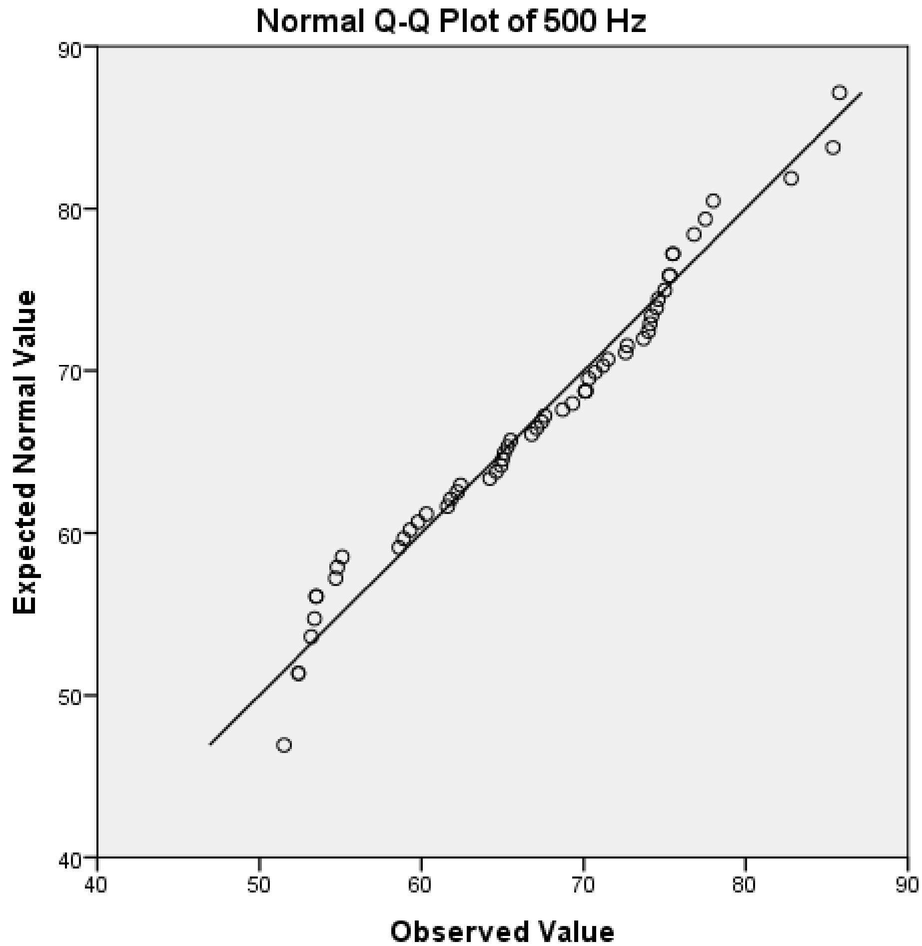


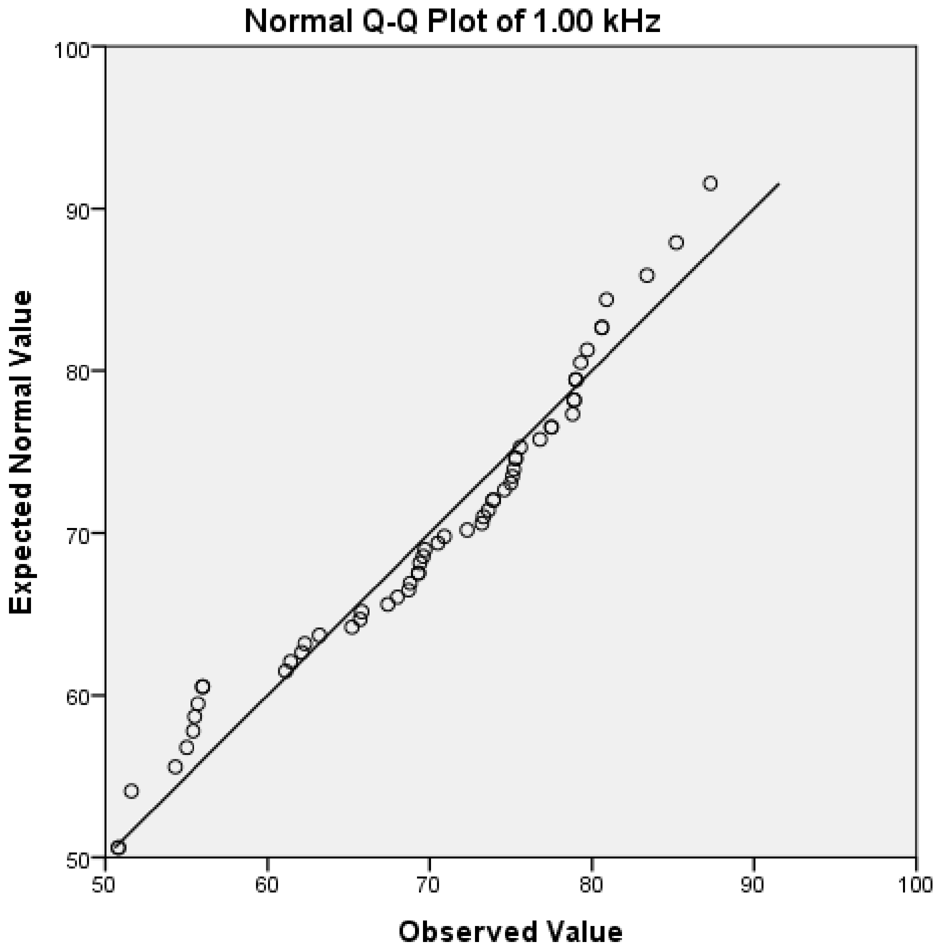
Normal Q-Q Plot of 31.5 Hz
Expected Normal Value
Observed Value
60
50
40
30
20
20
30
40
50
60

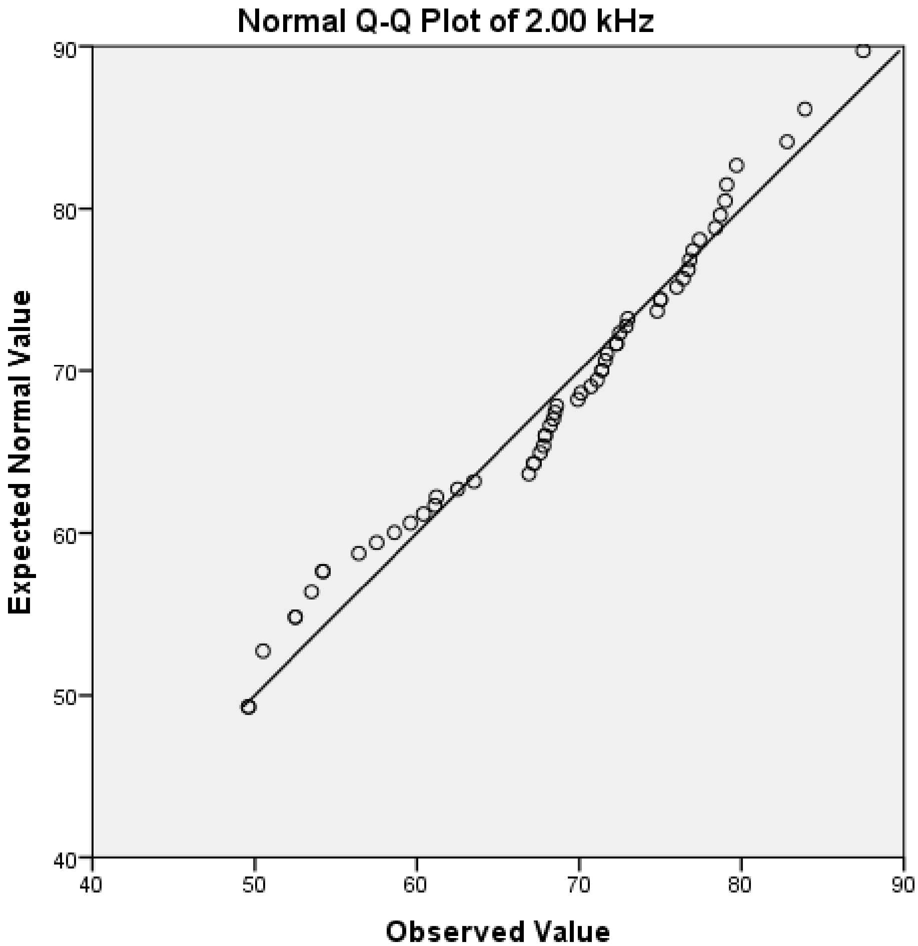

Normal Q-Q Plot of 63 Hz
Expected Normal Value
Observed Value
30
40
50
60
70
30
40
50
60
70

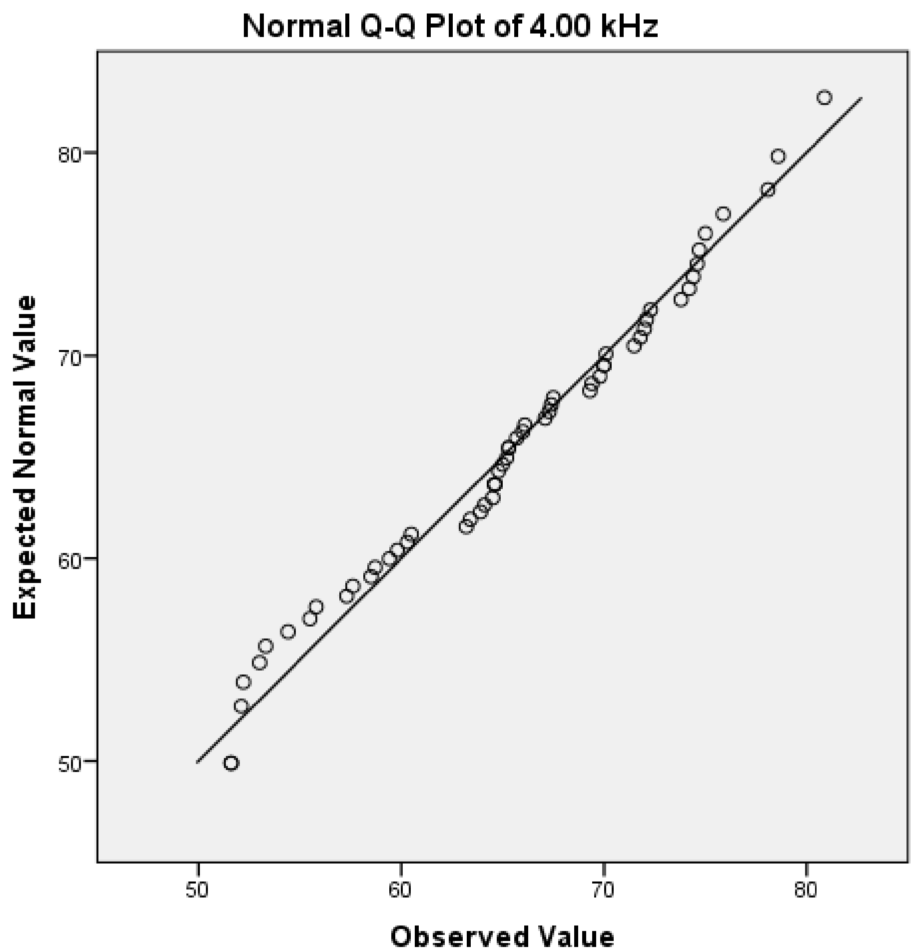

Normal Q-Q Plot of 125 Hz
Expected Normal Value
Observed Value
30
40
50
60
70
80

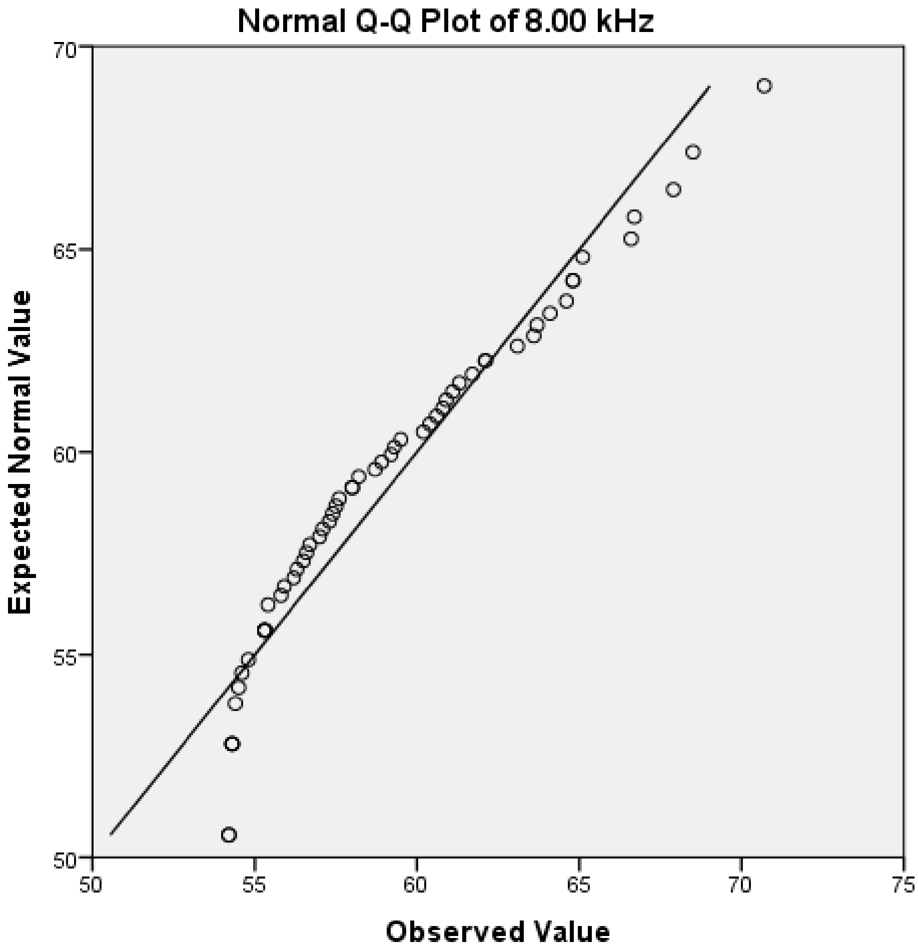

Normal Q-Q Plot of 250 Hz
Expected Normal Value
Observed Value
80
70
60
50
40
40
50
60
70
80

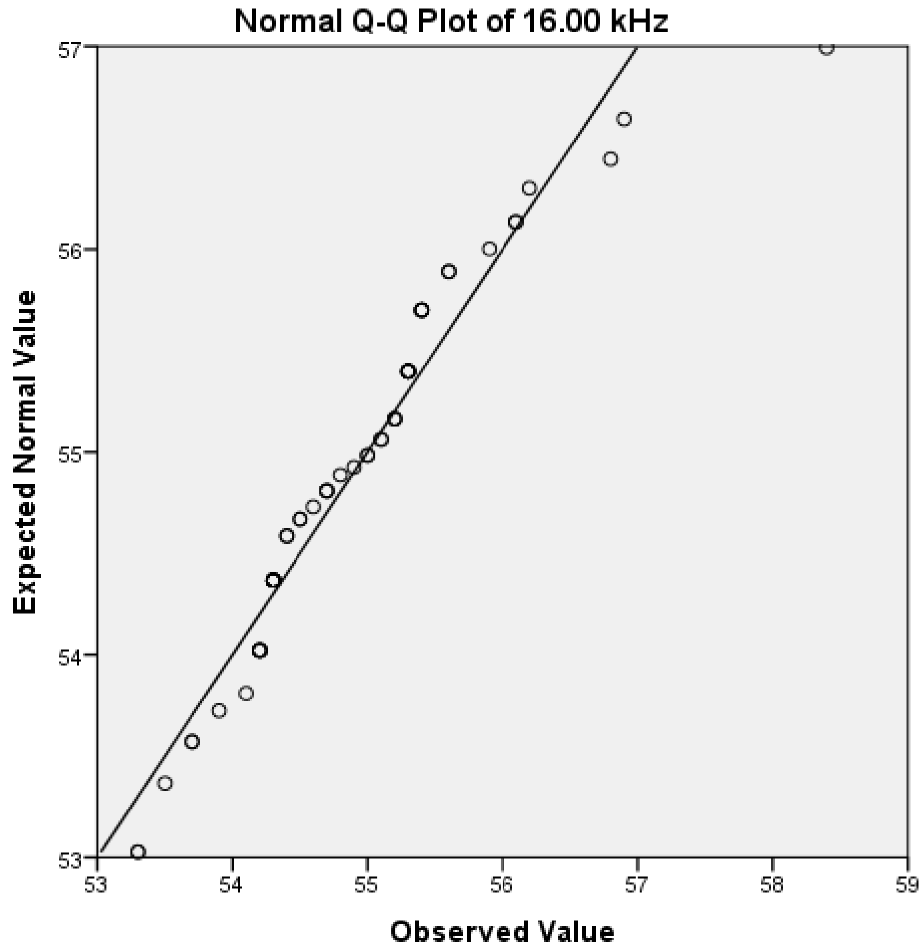

Normal Q-Q Plot of 500 Hz
Expected Normal Value
Observed Value
40
50
60
70
80
90
40
50
60
70
80
90


Normal Q-Q Plot of 1.00 kHz
Expected Normal Value
Observed Value
100
90
80
70
60
50
50
60
70
80
90
100

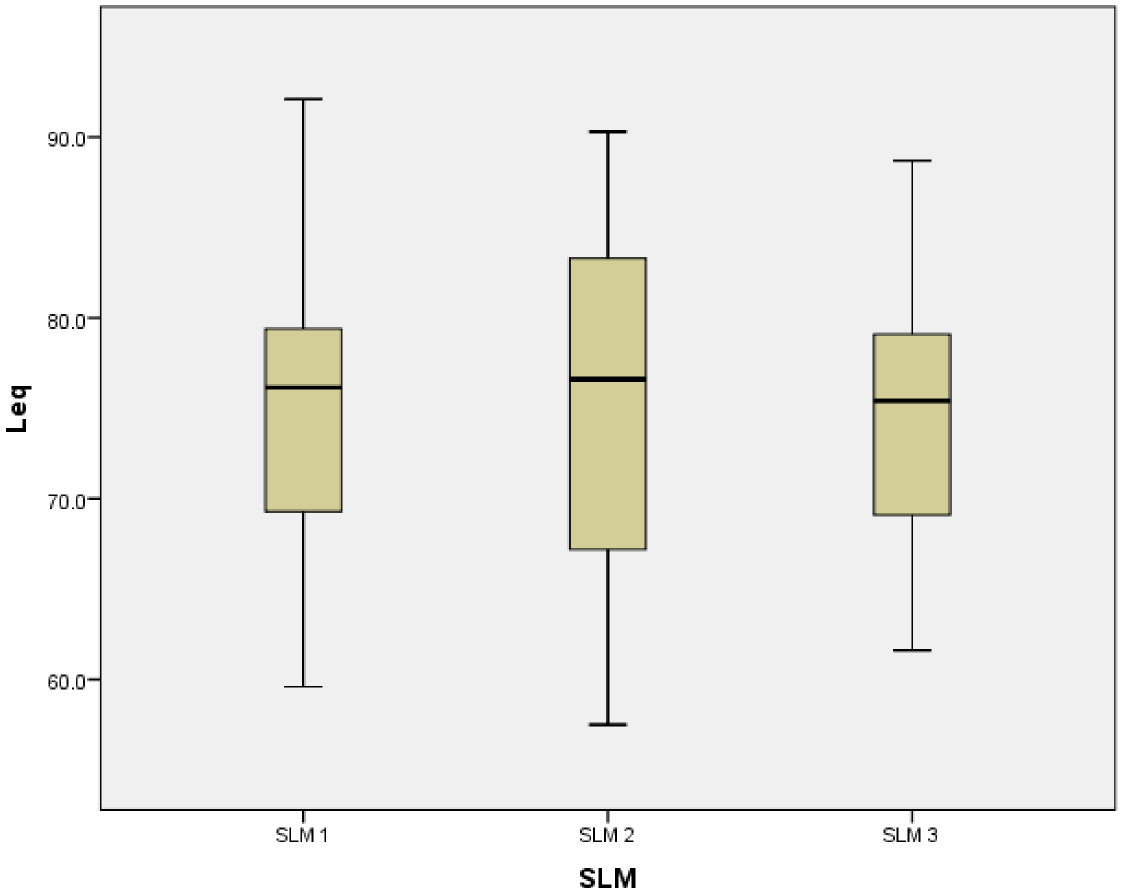

Normal Q-Q Plot of 2.00 kHz
Expected Normal Value
Observed Value
90
80
70
60
50
40
40
50
60
70
80
90

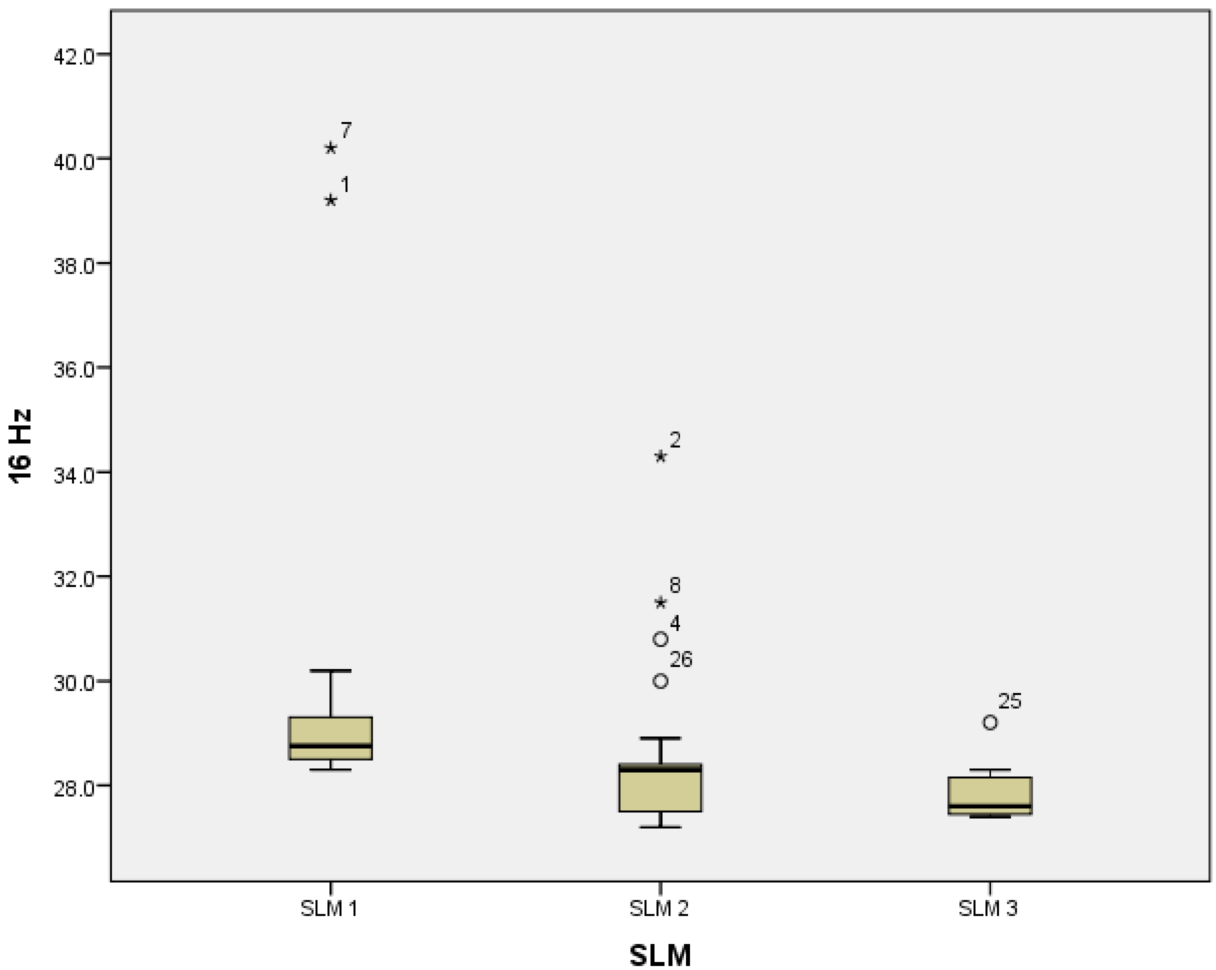

Normal Q-Q Plot of 4.00 kHz
Expected Normal Value
Observed Value
80
70
60
50
50
60
70
80

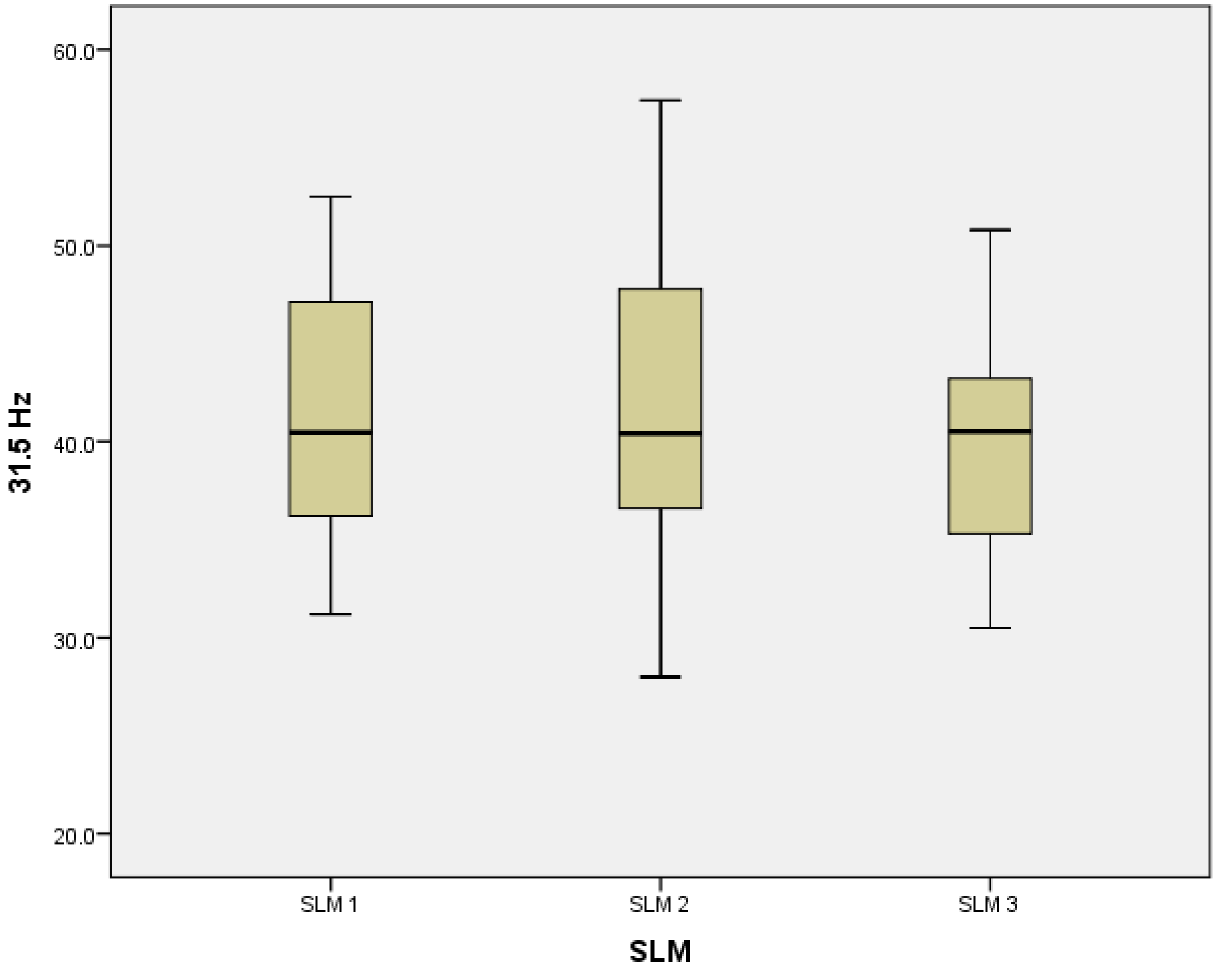

Normal Q-Q Plot of 8.00 kHz
Expected Normal Value
Observed Value
70
65
60
55
50
50
55
60
65
70
75


Normal Q-Q Plot of 16.00 kHz
Expected Normal Value
Observed Value
57
56
55
54
53
53
54
55
56
57
58
59

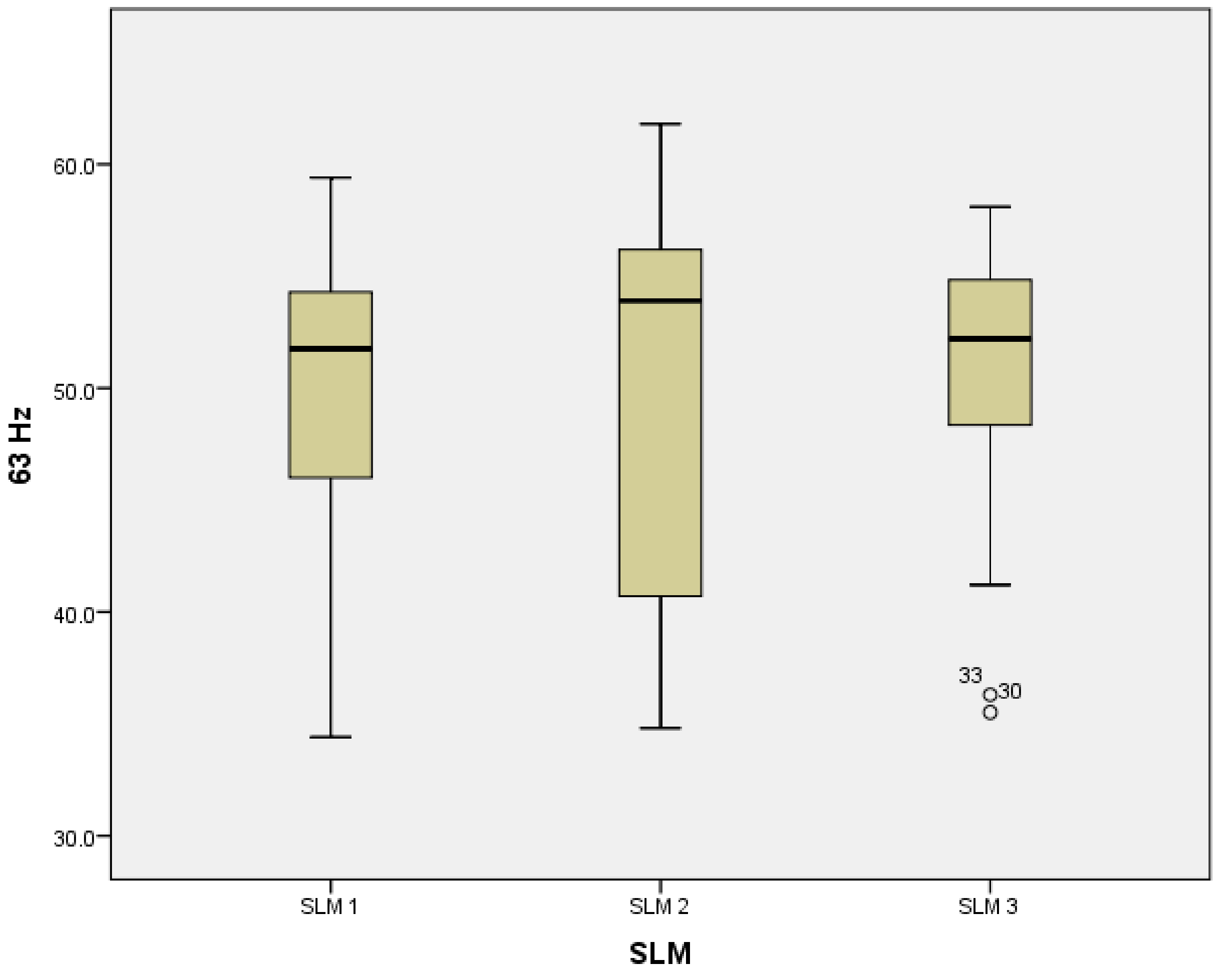
APPENDIX J. Stem-and-Leaf Plots by SLM



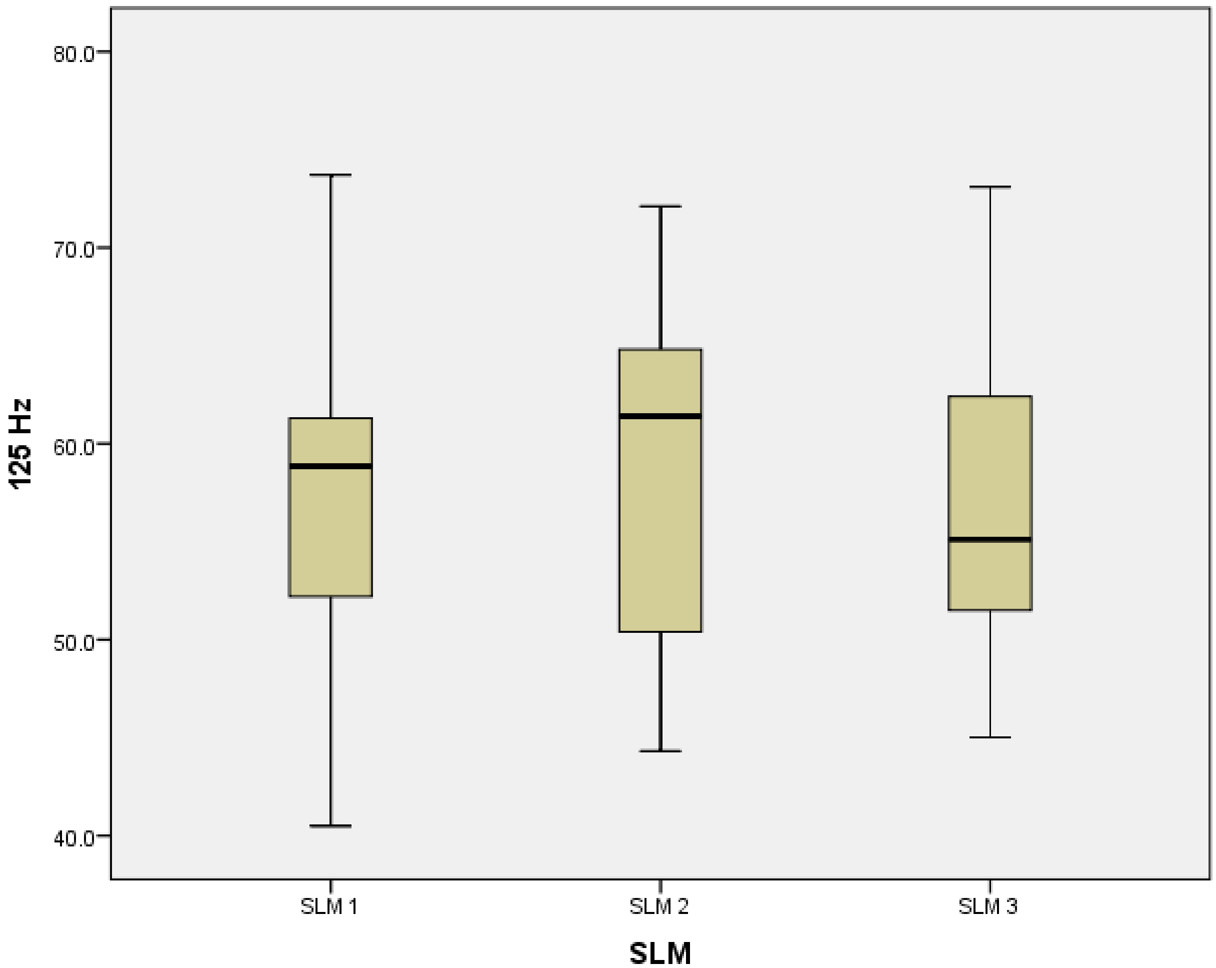

42.0
40.0
38.0
36.0
34.0
32.0
30.0
28.0
16 Hz
7
1
2
8
4
26
25
SLM 1
SLM 2
SLM 3
SLM

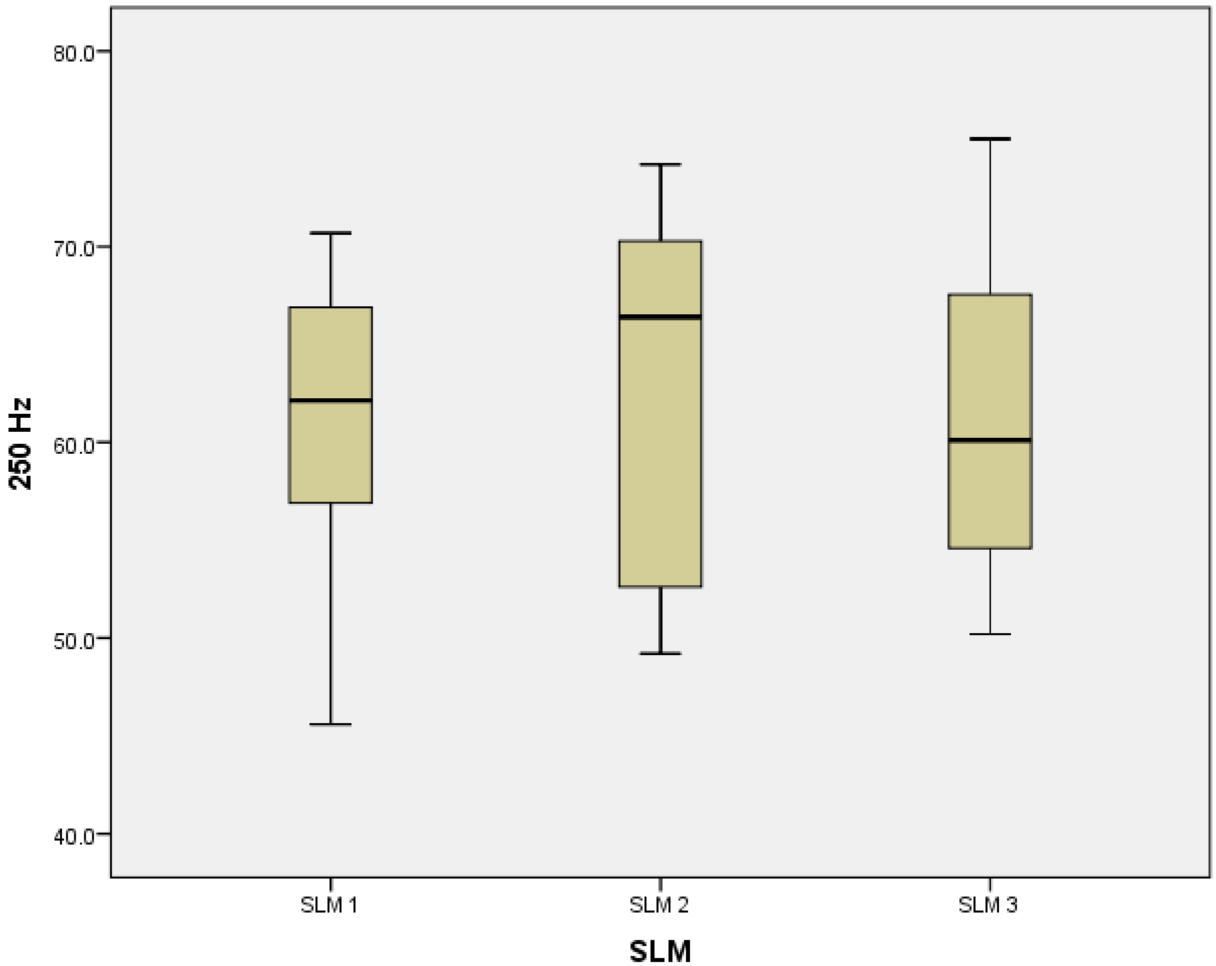


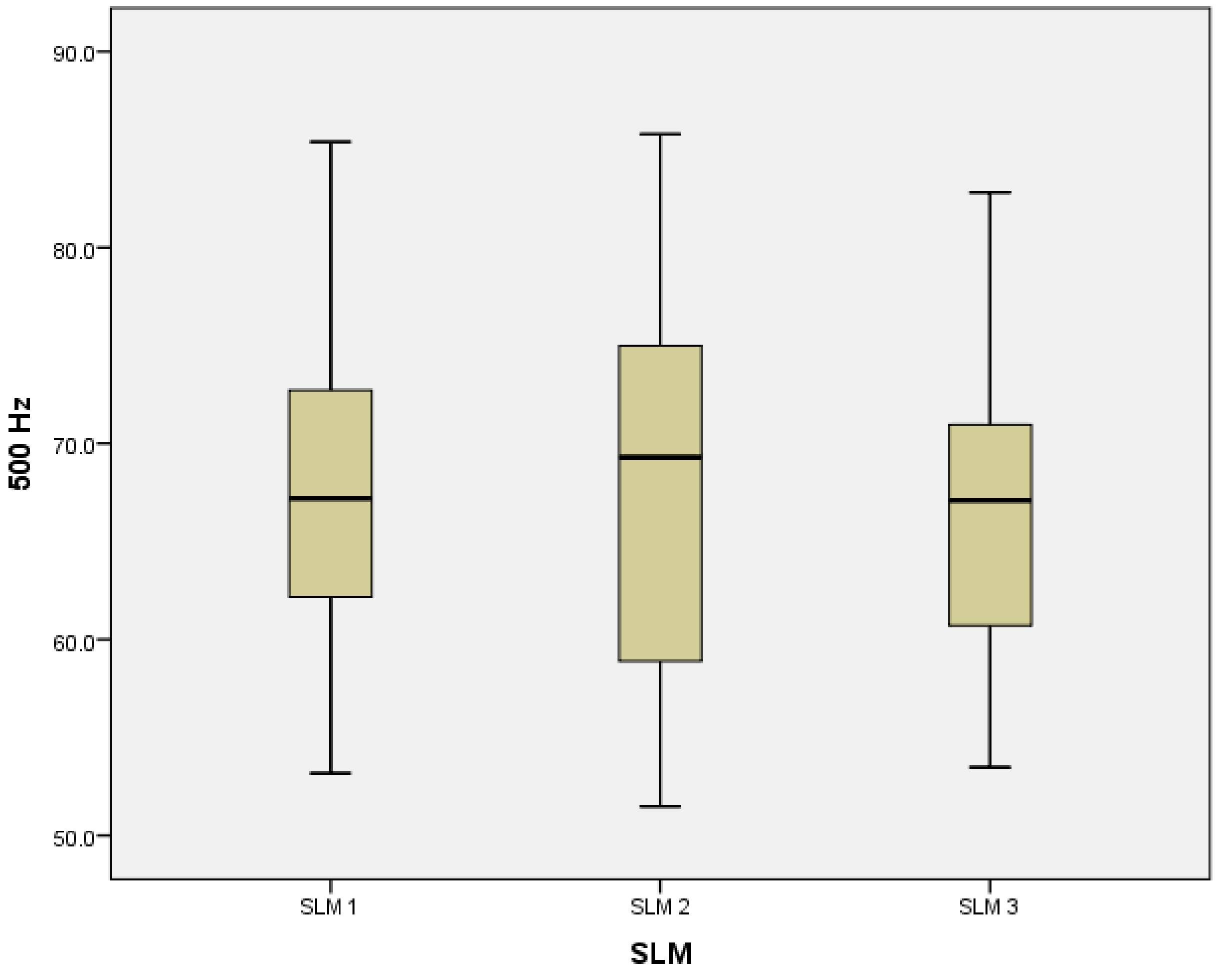
60.0
50.0
40.0
30.0
20.0
31.5 Hz
SLM 1
SLM 2
SLM 3
SLM



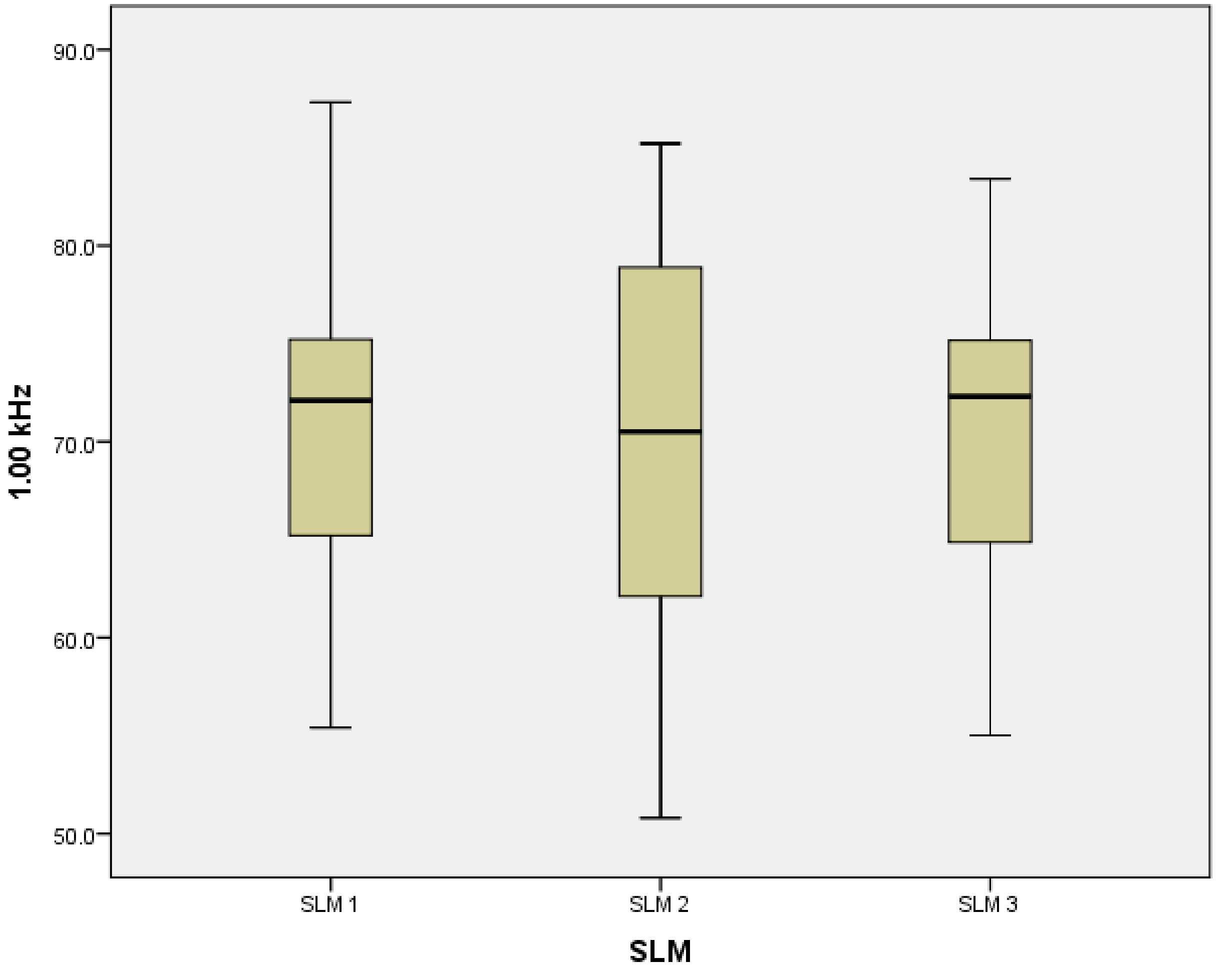
60.0
50.0
40.0
30.0
63 Hz
33
30
SLM 1
SLM 2
SLM 3
SLM

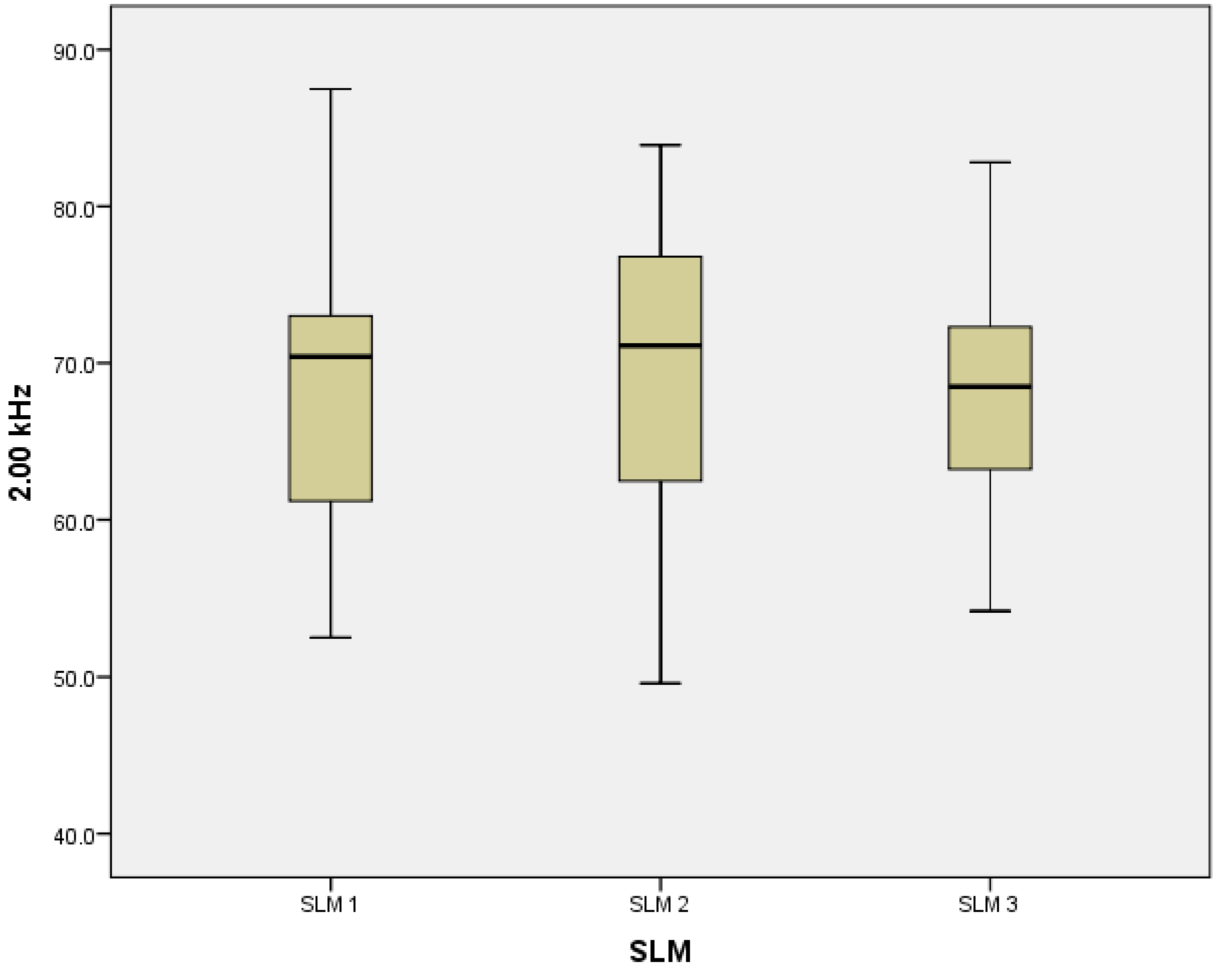

80.0
70.0
60.0
50.0
40.0
125 Hz
SLM 1
SLM 2
SLM 3
SLM


80.0
70.0
60.0
50.0
40.0
250 Hz
SLM 1
SLM 2
SLM 3
SLM

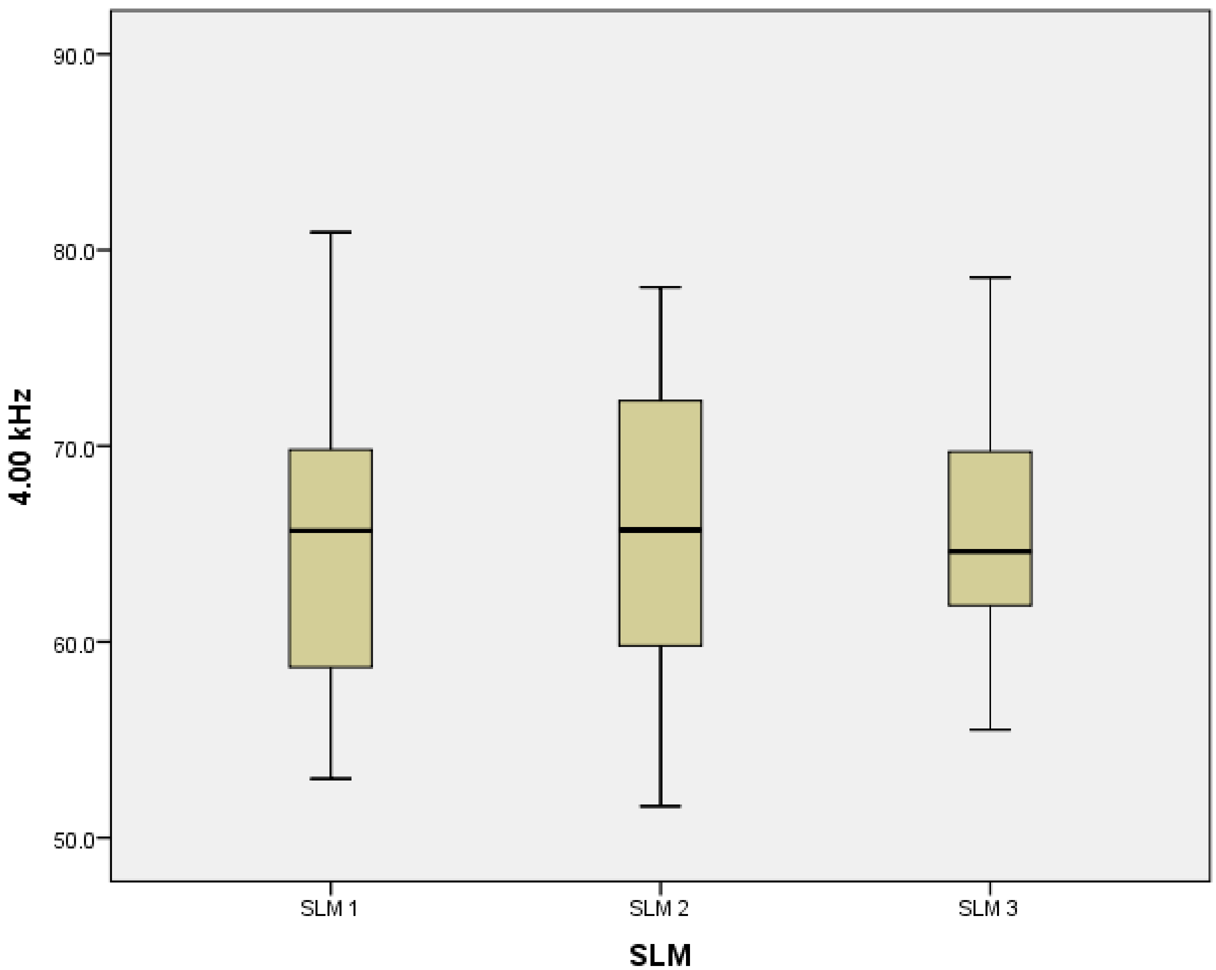


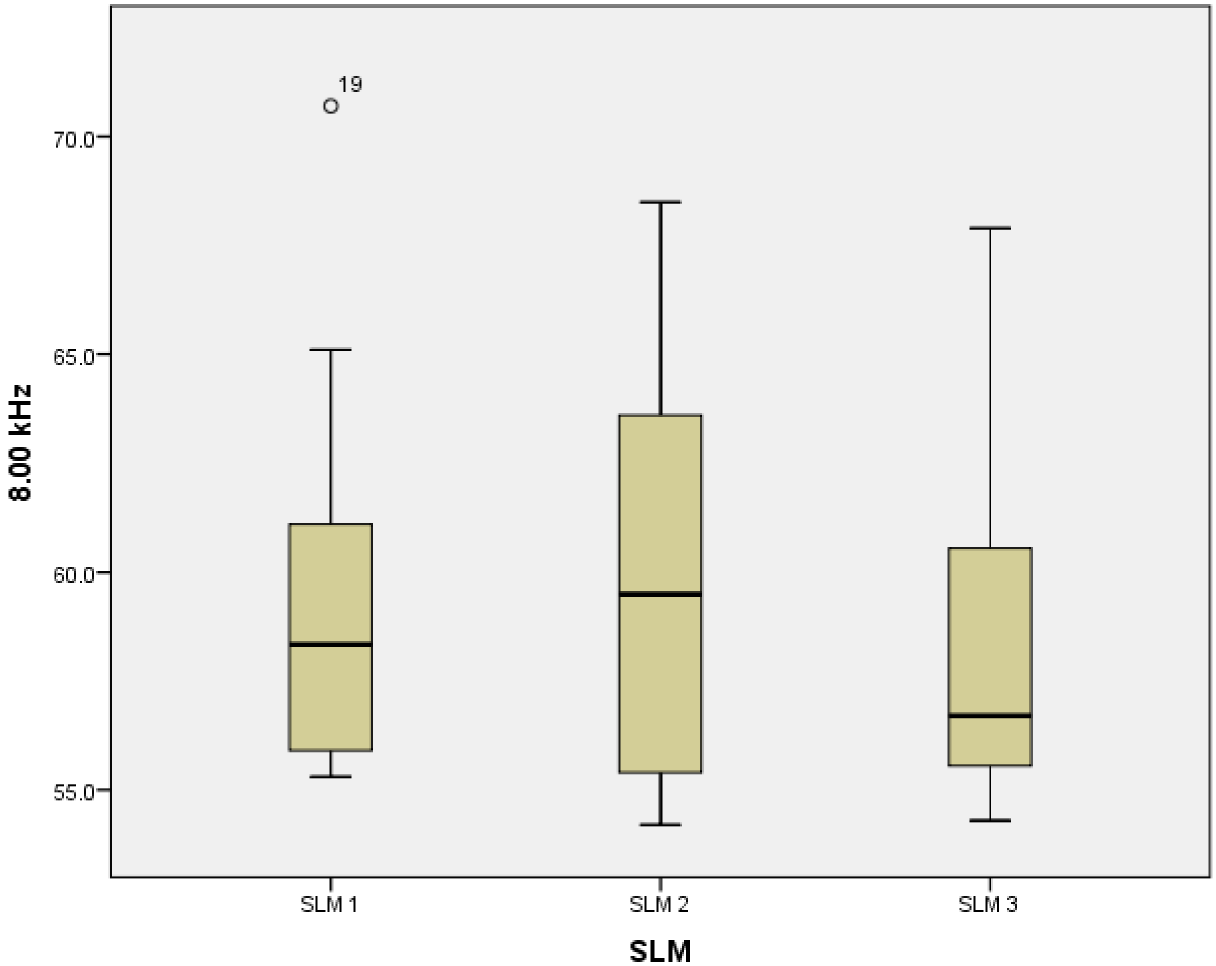
90.0
80.0
70.0
60.0
50.0
500 Hz
SLM 1
SLM 2
SLM 3
SLM

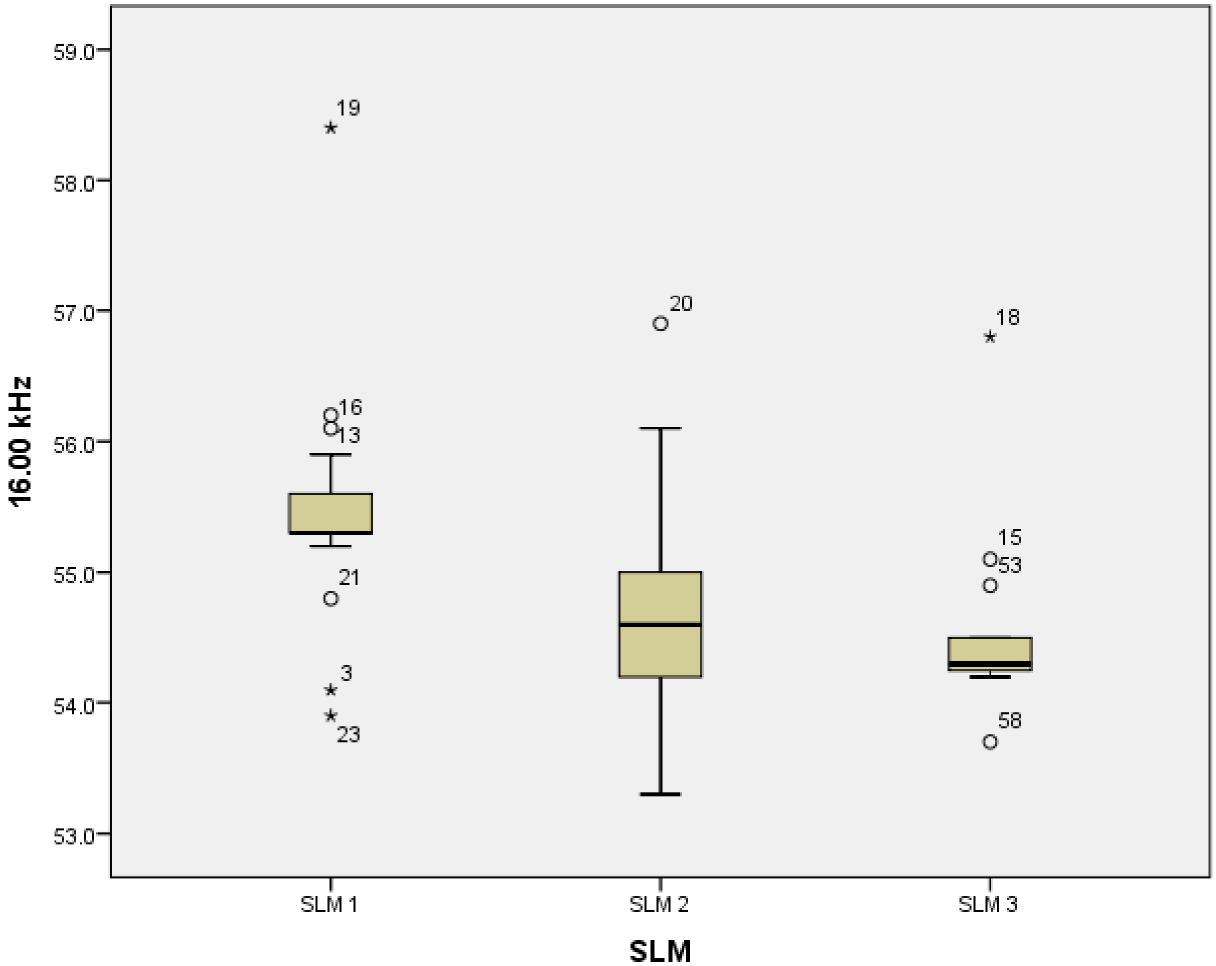

90.0
80.0
70.0
60.0
50.0
1.00 kHz
SLM 1
SLM 2
SLM 3
SLM



90.0
80.0
70.0
60.0
50.0
40.0
2.00 kHz
SLM 1
SLM 2
SLM 3
SLM


90.0
80.0
70.0
60.0
50.0
4.00 kHz
SLM 1
SLM 2
SLM 3
SLM


19
70.0
65.0
60.0
55.0
8.00 kHz
SLM 1
SLM 2
SLM 3
SLM



59.0
58.0
57.0
56.0
55.0
54.0
53.0
16.00 kHz
19
16
13
21
3
23
20
18
15
53
58
SLM 1
SLM 2
SLM 3
SLM

APPENDIX K. SPSS™ ANOVA SLM

ANOVA

Leq

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.072	2	.036	.000	1.000
Within Groups	4389.382	55	79.807		
Total	4389.454	57			

APPENDIX L. SPSS™ Multiple Comparisons SLM

Multiple Comparisons

Dependent Variable: Leq

Tukey HSD

		Mean Difference			95% Confidence Interval	
(I) SLM	(J) SLM	(I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
SLM 1	SLM 2	.0641	2.7254	1.000	-6.501	6.629
	SLM 3	.0812	2.9913	1.000	-7.124	7.287
SLM 2	SLM 1	-.0641	2.7254	1.000	-6.629	6.501
	SLM 3	.0171	3.0201	1.000	-7.257	7.292
SLM 3	SLM 1	-.0812	2.9913	1.000	-7.287	7.124
	SLM 2	-.0171	3.0201	1.000	-7.292	7.257