IRIG/USG

DOCUMENT 124-72

Formerly Document 400-72

AD782688

UNDERWATER ACOUSTIC FREQUENCY STANDARDIZATION

UNDERWATER SYSTEMS GROUP

R C C

RANGE COMMANDERS COUNCIL

KWAJALEIN MISSILE RANGE
WHITE SANDS MISSILE RANGE

NAVAL WEAPONS CENTER
PACIFIC MISSILE RANGE
ATLANTIC FLEET WEAPONS RANGE
NAVAL AIR TEST CENTER

AIR FORCE EASTERN TEST RANGE
AIR FORCE FLIGHT TEST CENTER
AIR FORCE SATELLITE CONTROL FACILITY
SPACE AND MISSILE TEST CENTER
ARMAMENT DEVELOPMENT AND TEST CENTER
AIR FORCE TACTICAL FIGHTER WEAPONS CENTER

AD 782 688

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: Document ~~124~~ 400-72	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): UNDERWATER ACOUSTIC FREQUENCY STANDARDIZATION UNDERWATER SYSTEMS GROUP	5. TYPE OF REPORT & PERIOD COVERED: USG
	6. PERFORMING ORG. REPORT NUMBER: NA
7. AUTHOR(s): NA	8. CONTRACT OR GRANT NUMBER(s): NA
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Secretariat, Range Commanders Council, White Sands Missile Range, New Mexico 88002	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: NA
11. CONTROLLING OFFICE NAME AND ADDRESS: Same as Item 9	12. REPORT DATE: October 1972
	13. NUMBER OF PAGES: 38
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Same as Item 9	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

NA

18. SUPPLEMENTARY NOTES

NA

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Underwater Acoustic Frequency Standardization Underwater Systems Group

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objective of the USG Task under which this report was prepared was to determine existing acoustic frequencies, re view future requirements and to develop underwater frequency standards. The task originated from an expressed desire for "Standards for Underwater Recovery." However, as this requirement was of such a broad scope, it was decided to concentrate initial efforts on frequency standardization. This work was further narrowed to RCC-member Ranges underwater (U/W) frequency usage. The future requirements were considered to be (over)

Item 20. Abstract (cont)

extensions of present usages and were incorporated accordingly. The results of Range surveys, related work by other agencies and final conclusions/recommendations are contained in this report.

IRIG DOCUMENT ~~124~~ 400-72

OCTOBER 1972

UNDERWATER ACOUSTIC FREQUENCY STANDARDIZATION

Underwater Systems Group
Range Commanders Council

Published by

Secretariat
Range Commanders Council
White Sands Missile Range,
New Mexico 88003

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

TABLE OF CONTENTS

SUMMARY

The objective of USG Task No. 2 was to establish a guide for "standardization of underwater acoustic frequencies." This would be a very practical and worthwhile endeavor; however, the objective was so large as to be almost impossible. The idea was not original with the Ranges as several other government agencies (CNO, NESC, ASWSP, and Coast Guard) have also addressed the subject. The committee readily agreed to limit the scope to Range frequencies and associated interference in addition to research of the production of other agencies. In view of the above factors it was decided not to attempt to fully satisfy the assigned objective.

Accordingly, this report is a compilation of acoustic frequencies used by the Ranges and several related guest agencies and also the experienced acoustic interference. A summary of work by ASWSP and the Coast Guard is also presented. This report is therefore not an "Underwater Frequency Standard," but is offered as reference-type material for Ranges and Range Users and as a starting point for a more concerted "standardization" effort in future tasks.

Ad Hoc Committee:

G. Nussear, Chairman	PMR
J. Griechen	NUSC
L. Slavin	NSSC
J. Broun	AFWR
F. Ledgerwood	NELC
D. Davey	NUC

Preceding page blank

UNDERWATER ACOUSTIC FREQUENCY STANDARDIZATION

1. INTRODUCTION

The objective of the USG task under which this report was prepared was to determine existing acoustic frequencies, review future requirements and to develop underwater frequency standards. The task originated from an expressed desire for "Standards for Underwater Recovery." However, as this requirement was of such a broad scope, it was decided to concentrate initial efforts on frequency standardization. This work was further narrowed to RCC-member Ranges underwater (U/W) frequency usage. The future requirements were considered to be extensions of present usages and were incorporated accordingly. The results of Range surveys, related work by other agencies and final conclusions/recommendations are contained in this report.

1.1 Statement of Assigned Task

Title: Underwater Frequency Standardization

Scope and Objective:

The Ranges have a variety of underwater transducers (hydrophones, pingers, interrogators, sonobuoys, UQC, sonars, etc.) that operate unrestricted over an uncontrolled frequency range from just above d.c. to about 100 kHz. The scope and objective of this task is to determine existing acoustic frequencies, review future requirements and to develop underwater frequency standards.

Justification:

At the 31st meeting of the RCC, Captain Stearns (Pacific Missile Range) gave a briefing entitled, "Standards for Underwater Recovery." His conclusions were that standards should be established and implemented at government activities involved in underwater search and recovery, and he recommended that a task be assigned. Subsequently, the ETMG was assigned the task; however, after a brief investigation it was decided that action should be withheld pending formation of the USG. Due to the broad scope of the assigned task, the USG has divided recovery into the areas of recovery equipment and procedures, frequency standardization, and recovery aids. This task will cover the standardization of underwater frequencies; however, this work will be coordinated with the other areas of recovery.

There is no control whatever within the government on what energy can be acoustically emitted underwater. There is no underwater acoustic "Federal Communications Commission" to impose standards or rules on power levels, frequency allocations, bandwidth and spurious radiation. As a result of this lack of regulation, the Ranges have a serious mutual interference problem between ships, sonars, targets, countermeasures, weapons and tracking systems.

Methods of Accomplishment:

This task will include:

a. Reviewing the efforts of other agencies (MASWSP, National Science Foundation, etc.) and related industries in acoustic frequency control.

b. Surveying the acoustic frequencies presently utilized on the Ranges.

c. Preparing a standard for acoustic frequencies used on the Ranges.

Chronology of Significant Events:

Review and survey acoustic frequencies by October 1970.
Prepare and review draft of standard frequencies by March 1971.
Prepare final draft of standard frequencies by October 1971.

Estimated Completion Date:

October 1971.

1.2 Background of USG Task

1.2.1 Standards for Underwater Recovery by Captain Stearns

The Pacific Missile Range (PMR) has the responsibility of the recovery of various objects from the Ocean for the entire PMR, and off shore for the Western Test Range, Vandenberg Air Force Base. This involves the recovery of highly classified and very costly missile payloads, warheads, and associated onboard systems for tactical and strategic weapon systems; special missile components for research and development programs; target drones that are re-used and various miscellaneous items such as sea state sensors and submerged instrumentation devices.

The recovery aids discussed here are primarily piezoelectric devices that provide an acoustic signal used to detect and locate items from an ocean environment. These devices are sometimes referred to as pingers, hydrobeacons or transponders. They can operate over a wide frequency range of a few cycles per second to 500-kilocycles per second with powers from 50-milliwatts to hundreds of watts and with battery life in the order of hours to years. Some have pulse coded outputs and other parameter variations to meet individual user requirements.

Due to there being a large number of manufacturers and users of these devices, a multitude of operating characteristics prevail; thus, making the range's task of recovery difficult, as the result of not having a large variety of receiving equipments that will meet the diversified needs of all range users.

The need of these recovery aids has been demonstrated and they have been implemented to a limited extent; however, until the aids are compatible with the receiving equipments, and until enforcement of the use of these devices is a fact, large sums of money and large amounts of time will continue to be expended with a low yield in recovery operations.

Typical examples of the value of these devices to a recovery operation can be demonstrated by our own experience at PMR; (1) a recent recovery effort off Vandenberg Air Force Base, utilizing only sonar equipments because of water turbidity, was unsuccessful after many days of search and the expenditure of a great deal of time and effort; (2) a previous effort using sonar equipments proved 90% successful, but consumed three weeks; (3) and in contrast, two recent recovery operations utilizing compatible recovery aids, used only two hours of recovery effort.

Today's state-of-the-art is such that size and weight of these devices are insignificant with respect to affecting the overall flight performance of the vehicle or package that contains it. Solid state modular construction assures complete operational units that weigh in the order of a few ounces.

For packages requiring recovery that are highly classified, acoustic command systems provide high security circuits with protection against noise and spurious signals. They will perform in severe multipath propagation conditions. A wide selection of command codes can be provided. Transpond and program functions can be provided that would enable destroying classified items that might be impossible to recover due to depth, location, etc.

At present, the recovery operation is made difficult and often impossible because range users or Government activities do not provide the devices to assist the recovery operation, or they use devices whose characteristics do not comply with the receiving equipments available.

Standards, assuring compatibility between the transmitting and receiving equipments, should be established and implemented at all government activities or where any underwater search effort is implemented. Frequency assignments, frequency band-pass limits, carrier deviation limits, channel assignments, etc., should be defined to constitute a guide for the orderly application of recovery aids for both the ranges and range users within the limits of good design practice.

There is no question that use of recovery aids by activities with mandatory recovery requirements would certainly save money, time, and effort in locating, identifying, and recovering costly items from the sea.

It is recommended that this task be assigned to IRIG for investigation and implementation.

1.2.2 RCC Letter of 30 April 1968

a. At the Range Commanders Council Meeting on 23-24 April 1968, the IRIG was assigned a task by the Range Commanders which I am hereby assigning to your Working Group.

b. At the 31st meeting of the RCC, a briefing was given by Captain Stearns, subject: "Standards For Underwater Recovery." I refer you to the minutes of this meeting, Page 23, for the text of this briefing. (See para. 1.2.1 above.)

c. At the 32nd meeting, the Range Commanders tasked the IRIG to produce a standard set of specifications for underwater recovery. I am assigning this task to your Working Group. It is realized that your group may not have the necessary expertise to accomplish this task and if so, it is suggested that you form an ad hoc committee made up of the necessary range personnel to operate under the direction of the ETMWG.

d. Request you be prepared to give a preliminary report to the Steering Committee during its fall meeting. Because the Range Commanders desire a report at their October meeting, request you give special emphasis to this task. It is realized that this is not the normal procedure for task assignment, however, I am following the procedure used herein to be responsive to the Range Commanders.

1.2.3 Standards for Underwater (U/W) Recovery

At the 31st meeting of the Range Commanders Council (RCC), Captain Stearns gave a briefing entitled, "Standards for Underwater (U/W) Recovery." Subsequently the RCC tasked IRIG, which in turn, assigned ETMG the task of producing a set of specifications for underwater recovery. This task has been interpreted as applying to devices and aids for the detection and location of underwater objects, rather than general recovery equipment.

An initial step: personnel were contacted at other ranges with an U/W recovery mission to determine existing equipment and techniques. The only reply was from AFETR, which consisted of Manual 80-3 and Regulation 127-2. Also a Technical Report – "Standardization of U/W Range Instrumentation," was received from the American Ordnance Association (AOA). The AOA report recognizes the problem and offers some general suggestions, but none of the reports provide any specific information. It appears that no one is actually making wide use of recovery aids. In addition, contacts with industry indicate that although there is no off-the-shelf equipment, technology is developed to the point where almost any system is possible. Systems that have been developed for the oil industry and other special purpose applications could be readily converted and/or repackaged as recovery aids. A final configuration would depend upon the specific requirements, but by using pressure-insensitive electronics and placing them inside the transducer, a typical package (exclusive of batteries) would be a cylinder about 2½" in diameter and 3" long and weighing only a few ounces. The size of the battery pack would depend upon the desired transmitting modes, operating life, and power levels (range). However, a size of 3" x 3" x 2" and weight of about 2 pounds would be typical.

One of the primary considerations in the standardization of U/W recovery aids is the choice of acoustic frequencies. This choice is determined mainly by the extremely high attenuation of U/W signals with increasing frequency and the compatibility with other frequencies. The signal attenuation, caused mainly by absorption and spherical spreading, sets a practical upper frequency limit at about 100 kHz. A 90 dB relative to 1μ bar (approximately 200 electrical watts) signal source, for the above package size of 2½" x 3", is one that would provide a range of only about one statute mile at 100 kHz.

Another most important criteria to consider in the design and development of recovery aids is security. As Captain Stearns said in his briefing, some of the missile payloads are highly classified and will require acoustic command systems with protection against noise and spurious signals. This protection can be achieved by using coding and other anti-spoofing methods as well as interrogating the recovery aid rather than having it operating continuously. The interrogating would also greatly reduce the power requirements and provide for much longer life.

The present status of U/W acoustic frequency usage has been described as a "most confused ham band." Lyman Haley, White House Executive Staff, has been given an assignment to investigate the compatibility of U/W frequencies. Also a meeting was recently held at CNO, Washington, D. C. regarding the same subject. Attendees were from CNO, NAVELEX, NAVORD, ASW, and NUWC, Pasadena. The NUWC people have been conducting their own analyses of U/W frequencies for the Sea Lab Program. PMR has met with the NUWC people regarding the CNO meeting and other ideas on U/W recovery.

A brief investigation into the subject field indicates that recovery is but one of several underwater areas that should be considered in a standardization effort. Some of these other areas are: (1) acoustic frequency allocation and control, (2) instrumentation development - search and recovery, communications, telemetry, tracking, and command and control, (3) environmental (meteorology and oceanography), data gathering - cloud cover, wind speed and direction, other met data, sound velocity, temperature, salinity, and bathemetry, (4) ordnance, target, and sonar development, and (5) tracking range procedures - checkout and calibration, operations and exercises, and expansion and development - sonar calibration, noise measurement, WSAT's (Weapons System Accuracy Trials), FORACS (Fleet Operational Readiness Accuracy Check Site), and larger tracking ranges, and (6) general research and development.

The standardization of U/W Recovery Aids must consider the mission requirements, as well as what equipment and methods are available. Over a period of time as experience is gained and optimum methods are developed, special purpose equipment can be designed and built by the government and/or industry. However, initial work must be centered around existing commercial and inhouse devices. Centralized efforts, by the agencies that have an U/W recovery responsibility, e.g., Pacific Missile Range and Vandenberg AFB (Sea Test Range - Pacific), Cape Kennedy - Patrick AFB - Altantic Missile Range, and Naval Torpedo Station (Dabob Bay - Washington and Nanoose Bay - Canada), could result in the development of standardized recovery and tracking equipment that would be availabe for any user.

In view of the forthcoming RCC plans to establish an U/W Range Group, it is recommended that the "Standardization of U/W Recovery" be assigned to that group as an early project. It is felt that the people comprising that group will be significantly more qualified than the ETMG to perform this task. In the meantime PMR will continue to work with the NUWC people on frequency standardization. However, if the Steering Committee and/or the RCC feels that the task is too urgent to await the formation of the new URIG or for any other reason; PMR will assist an ETMG ad hoc committee of U/W Range, interested laboratories, and other range personnel to develop U/W recovery standards.

2. UNDERWATER ACOUSTIC FREQUENCY USAGE

2.1 Acoustic Frequency Usage Survey

1. Your Name : ______________________

   Organization : ______________________

   Mailing Adress: ______________________

   ____

   Phone : ______________________

   Autovon : ______________________

2. Are you a member of USWG? Yes ______ No ______

3. Are you a member of any other organization with an interest in the standardization of acoustic frequencies? Yes ______ No ______

4. If the answer to question 3 is "Yes", list the organization:

   Name: ______________________

5. List acoustic equipment (transmit/receiver) at your facility:

   a. Frequency Range: ______________________

      Manufacturer : ______________________

      Model : ______________________

      Status : ______________________

         Design

         Development

         Test

         Evaluation

         Operational

      Purpose : ______________________

      Other Comments : ______________________

   b. Frequency Range: ______________________

      Manufacturer : ______________________

      Model : ______________________

Status : ______________________________

Design

Development

Test

Evaluation

Operational

Purpose

Other Comments

c. Frequency Range: ______________________________

Manufacturer : ______________________________

Model : ______________________________

Status : ______________________________

Design

Development

Test

Evaluation

Operational

Purpose : ______________________________

Other Comments : ______________________________

6. List planned procurement items involving acoustic frequencies; include both long and short range items:

7. List range requirements for acoustic equipment (if different from planned procurement items):

8. General Comments - including knowledge of other "standardization" work (private and government), your thoughts on methods to achieve "standardization", etc.:

9. List anyone else you think should receive a copy of this questionnaire:

Name ________________________________

Address: ________________________________

____

2.2 Survey Results

2.2.1 Results by Agency

a. **Pacific Missile Range**

(1) Pacific Missile Range Facility Underwater Tracking System

Tracking Pingers - 8 discrete frequencies located between 8 and 50 kHz

UQC - 8.3 kHz-to-11.8 kHz

UQN - 12 kHz

Fleet Sonars, Torpedoes, and Sonobuoys - Classified, see MASWSP Report

Ambient Noise and Data System (ANADS) - Sonar transponders and 10 Hz-to-10 kHz noise measurement hydrophones

Targets - MK 30, 21B12, MK 28, TMK 6

(2) Midway MILS Acoustic Ship Positioning System

Integrate - 16 kHz

Reply - 9.5, 10.0, 10.5, 11.0, 11.5, and 12.0 kHz

(3) Pacific Missile Range Underwater Recovery

Acoustic Marker Receiver - 5 kHz-to-50 kHz in three ± 1 kHz bands: 9kHz, 37 kHz and 45 kHz (Straza No. 503)

Diver Hand Held Acoustic Receiver - 30 kHz to 45 kHz, adjustable ± 500 Hz (Burnett No. 512)

Hand Held Sonar - 25 kHz to 40 kHz, transmit and receive (Burnett No. ANPQS-1C)

Locating Pinger - 9, 27, 37, 45, and 60 kHz, SPL = 50-90 dB//μb, built by PMR

Acoustic Control System - 3.5 kHz carrier with 100-200 Hz modulation and consists of receiver and activator, built by PMR

b. **Naval Underwater Systems Center (NUSC) - AUTEC**

(1) Weapons Range

Tracking Pingers - 5 discrete frequencies located in an 8 kHz-to-50 kHz band (same as used at PMRF)

UQC - 8.3 kHz-to-11.08 kHz

Fleet Sonars, Torpedoes, and Sonobuoys - Classified, see MASWSP Report

Targets - MK 27, MK 28, and MATT

(2) Acoustic Range

UQC and Active Sonar Beacons

Tracking Pingers - 25 kHz

Noise Measurement Hydrophones - 10 Hz-to-70 kHz

(3) Sonar Range

Tunable Sonar Transducers

(4) FORACS

1.5 kHz-to-25 kHz Transponders

c. **Atlantic Fleet Weapons Range**

Acoustic Torpedoes, Fleet Sonars, and Sonobuoys - Classified, see MASWSP Report

Tracking Pinger - 75 kHz

Fathometers - 13 kHz-to-18 kHz (UQN at 12 kHz)

FORACS Transponders - 3 kHz-to-20 kHz

UQC - 8-11 kHz

Locating Pingers - 9, 27, 37, and 45 kHz

Countermeasures - multiple frequencies and combinations

Acoustic Release Devices - several frequencies

d. **Keyport NTS - DABOB BAY**

Acoustic Targets and Acoustic Torpedoes - Classified, see MASWSP Report

Locating Pingers - 45 kHz

Tracking Pingers - 75, 190, 250, and 330 kHz

Countermeasures - several combinations

Echo Ranging Search Sonars -

1. 170-to-180 kHz transmit and receive, Minneapolis - Honeywell No. 1311-A1 and mounted on the SORD I Recovery System.

2. 178 kHz and 39 kHz transmit and receive, WESTMAR No. SS300 and mounted on the SORD II Recovery System.

3. 455 to 480 kHz and 100 kHz transmit and receive, Straza No. SAD 603-1 and mounted on the CURV II Recovery System.

Transponding Torpedo Locating Beacon - 24.75 and 34.3 kHz transmit and receive, InterOceans No. 915 and supplements the 45 kHz locating pingers.

FORACS - Type Sonar Transponder - 500 Hz-to-25 kHz transmit and receive, NTS Keyport and used at Dabob Bay, Hood Canal and Nanoose.

Torpedo Radiated Noise Recording System - 100 Hz-to-25 kHz; NTS Keyport No. T-NAAS and No. NRS; and is sensitive, omnidirectional equipment that is very susceptible to interference.

e. **Air Force Eastern Test Range**

Mine Detection Sonar C MK 1X-1.41 and 1.33 MHz

Mine Detection Set AN/SQS-A (XN2) (XN3)-64-80 kHz varying CW

Acoustic Ship Positioning System - Bendix - ASPS No. 2

Interrogate - 16 kHz
Reply - 9.5, 10.0, 10.5, 11.0, 11.5, and 12.0 kHz

Bottom-mounted Navigation Equipment - General Instrument

Transmit - 7 and 16 kHz
Receive - 9 to 12 kHz

Sonobuoy Missile Impact Location System - Sparatan SSQ-41 Mod.

Transmit - 2.5 and 16 kHz
Receive - 2.5 and 9-12 kHz

f. Space and Missile Test and Evaluation Center

Acoustic Ship Positioning System - USNS Huntsville

Shipboard Transmit - 7.0, 15.0, 16.0 kHz
Shipboard Receive - 9.5, 10.0, 10.5, 11.0, 11.5, 12.0 kHz
Model: ASPS 1004 Mfg: Bendix Corporation

B3 Transponder Array

Located approximately 129° 30'W and 31° 55'N
Transmit - 9.5, 10.0, 10.5, 11.0, 11.5, 12.0 kHz
Receive - 7.0, 16.0 kHz
Model: AT091 Mfg: Bendix Corporation

San Clemente Transponder Array

Located 5 miles east of San Clemente Island, California.
Same frequencies as B3 array above
Model: 052L Mfg: Bendix Corporation

Two Similar Arrays At:

Hull Island - 4° 21'S and 172° 14'W
B2 - 46° 47'S and 137° 50'W

Another transponder array is planned for the vicinity of Kwajalein Island during November 1972.

Acoustic Release System - 8.5 and 9.0 kHz

g. Kwajalein Missile Range

Hydrophone Impact Timing System

Receive Phoneo - D.L. to 10 kHz
Model: DX 403 Mfg: Bendix Corporation

Calibrate Pinger - 530 MHz
Model: DX 296B Mfg: Bendix Corporation

Recovery Aids

Receiver - 40 to 50 kHz
Model: N15A-235 Mfg: Dukane

Transmitter - 45 kHz ± 500 Hz, No. SK15198

h. **Naval Civil Engineering Labcratory**

Hand-held Diver Sonar Unit - 50 to 90 kHz by Burnett No. 500 (AN/PQS-1)

Submersible Test Unit Pingers (DOTIPOS, LOBSTER) - 12 kHz and 40 kHz by NCEL

Fathometer - 12 kHz, by EDO-Western and used on the Warping Tug

i. **Naval Electronics Laboratory Center**

(1) FORACS Measuring Equipment

Sonar Test Target - normally used as an active transponder or passive signal source (noise or pulse):

Signal Source - 3 to 30 kHz
Built By: APL/UW

Transducer: 1.8 to 31 kHz
Model: ZT
Built By: APL/UW

Sonar Test Target - normally used as a white or pw/t noise source:

Signal Source - 45 Hz to 10 kHz
Model: HP8057A, series 501

Transducer - 100 Hz to 10 kHz
Model: FH-4
Built By: NUC, San Diego

Underwater Communications

Signal Source - 8 to 11 kHz
Model: AN/UQC-1, 1B, 1G
Built By: Bendix Corporation

Transducer - Model TR-233 & TR-193-D-UQC

Future planning includes the development and installation of an AN/WQC-Z system.

(2) Address and Location of FORACS Sites

MAILING ADDRESS	LOCATION
Commander (Code 6911) FORACS I Naval Electronics Laboratory Center San Diego, California 92152	San Clemente Island Northeast Coast 75 miles west of San Diego, California
Vitro Services FORACS II Range Manager Box 39 U.S. Naval Station F.P.O. New York 09593	Cuba (Guantanamo Bay) Southeast Coast 450 miles Southeast of Miami, Florida
FORACS III Laumania + Pohakunui Ave. Nanakuli, Hawaii 96792	Hawaii Island of Oahu Southwest Coast 20 miles West of Honolulu, Hawaii
FORACS IV Project Office Bldg. 66, Rm. 28 U.S. Naval Station	Cape Cod, Massachusetts Northeast tip of Cape Cod 50 miles East of Boston, Massachusetts* and Fishers Island Southeast Coast 8 miles Eastsouth East of New London, Conn.
Commanding Officer AUTEC (FORACS V) P. O. Box 15257 West Palm Beach, Florida 33406	Bahamas - Andros Island Northeast Coast 175 miles Southeast of Miami, Florida

j. **Naval Undersea Center**

Torpedo Target:

1. NTS Keyport, No. MK 17
2. Bendix, No. XSR7083512

Pinger:

1. 9 kHz by Aerojet General, No. 081700-1
2. 45 kHz by NTS Keyport
3. 37 kHz by MWN. Honeywell, No. 4911B9

Underwater Telephone - SSB (Upper):

1. 8.0875 kHz, GFE, No. AN/UQC-1A
2. 8.0875 kHz by Straza, ATM-504A

Fathometer:

1. 25 kHz ± 250 kHz by Raytheon, No. DE714/715
2. 12 kHz, GFE, No. AN/UQN-1E

Transponder:

1. 3.5 or 5 kHz, GFE, No. AN/SQQ-18
2. 3.5, 5 and 12 kHz by Straza, No. SXQN-502
3. 29.5 kHz, GFE, No. MK 1 Mod 0

k. COMSUBDEVGRUONE, San Diego

Pingers - 9, 14, 14.5, 15, 15.5, 16, 16.5, and 37 kHz.

2.2.2 - Results by Equipment Type and Frequency

EQUIPMENT TYPE AND FREQUENCY	AGENCY									
	PMR	NUSC/ AUTEC	NTS KYPRT	AFWR	AFETR	SAMTEC	KMR	NCEL	NELC	NURDC
U/W Range Tracking Pingers - 8-50 kHz	X	X								
U/W Range Tracking Pingers - 75 kHz			X	X						
U/W Range Tracking Pingers - 190, 250, 330 kHz			X							
UQN - 12 kHz	X	X		X				X		X
UQC - 8-11 kHz	X	X		X						X
Fleet Sonars, Torpedoes and Sonobuoys	X	X	X	X						
Acoustic Ship Positioning System	X				X	X				
a. Interogate - 7.0, 15.0, and 16.0 kHz b. Reply - 9.5, 10, 10.5, 11, 11.5, and 12 kHz							X			
U/W Recovery Aids	X	X	X	X						
Acoustic Noise Measurement System	X	X	X							
Tunable Sonar Transducers		X								
FORACS Transponders - 500 Hz-25 kHz		X	X	X						
Fathometers - 13-18 kHz				X						
25 kHz										X
U/W Locating Pingers - 12 & 40 kHz								X		
U/W Locating Pingers - 9, 27, 37, 45 kHz			X	X						X
Torpedo Locating Transponders - 24.75 and 34.3 kHz			X							
Countermeasures	X		X	X						
Acoustic Release Devices	X	X	X	X		X				

2.2.2 - Results by Equipment Type and Frequency (CONT'D)

EQUIPMENT TYPE AND FREQUENCY	AGENCY									
	PMR	NUSC/ AUTEC	NTS KYPRT	AFWR	AFETR	SAMTEC	KMR	NCEL	NELC	NURDC
Acoustic Targets	X	X	X	X						X
Echo Ranging Search Sonars										
a. 170-180 kHz, Mpls - HW			X							
b. 139 & 178 kHz, Westmar			X							
c. 100 & 455-480 kHz, Straza			X							
Mine Detection Sonar 1.33 & 1.41 MHz					X					
Mine Detection Set 64-80 kHz					X					
Bottom-Mounted NAV AID -										
a. Transmit - 7 & 16 kHz					X					
b. Receive - 9 to 12 kHz					X					
Sonobuoy MILS										
a. Transmit - 2.5 & 16 kHz					X					
b. Receive - 2.5 & 9-12 kHz					X					
Hydrophone Impact Timing System - DC to 10 kHz							X			
Hand-held Diver Sonar Unit - 50 to 90 kHz								X		
FORACS Ranges - 50 Hz to 32.5 kHz									X	
a. San Clemente Island, Calif.									X	
b. Guantanamo Bay, Cuba									X	
c. Nanakulii, Oahu, Hawaii									X	
d. Provincetown, Mass.									X	
e. AUTEC, Andros Island, Bahamas										
Passive Sonar Test Equipment - 100 Hz-5 kHz									X	

2.2.2 - **Results by Equipment Type and Frequency** (CONT'D)

EQUIPMENT TYPE AND FREQUENCY	AGENCY									
	PMR	NUSC/ AUTEC	NTS KYPRT	AFWR	AFETR	SAMTEC	KMR	NCEL	NELC	NURDC
Torpedo Target										
a. NTS Keyport #MK17										X
b. Bendix, #XSR7083512										X
Transponders										
a. 3.5 or 5 kHz, #AN/SQQ-18										X
b. 3.5, 5 & 12 kHz, #SXQN-502										X
c. 29.5 kHz, #MK 1 Mod 0										X

3. UNDERWATER ACOUSTIC FREQUENCY INTERFERENCE

3.1 Acoustic Frequency Interference Survey

Object

The purpose of this survey is to provide information to the USG Task Committee on Standardization of Underwater Acoustic Frequencies. It will furnish data on the mutual acoustic frequency interference problems encountered between users on the various U/W ranges.

Questions

Indicate the nature of each experienced interference problem by answering the following questions, if possible, for each incident:

1. What were the equipment and frequencies that were involved - both transmit and receive?

2. What were the sources levels?

3. What range/depth (if applicable)?

4. What were the consequences?

5. What were the solutions?

6. Who interfered with whom?

    a. Mil versus Mil.

    b. Mil versus Civ.

    c. Civ versus Mil.

    d. Civ versus Civ.

3.2 Survey Results

a. Pacific Missile Range Facility

Interferences (loss of track) has occurred when:

1. High-power sonars are used in the vicinity of hydrophones and

2. Certain countermeasure devices are employed.

Solutions are:

1. Request that sonar be shut off.

2. Results with countermeasures are presented in the NUSC report NPT - 4012 of 1 October 1970 (S), "Analytical Study to Optimize Tracking Capability on the AUTEC and BARSTUR Ranges in a Countermeasure Environment (U)."

b. NTS Keyport

(Numbers refer to survey question number)

(1) Transmit - Civilian and Commercial vessels radiating broadband noise.
Receive - Keyport noise measuring equipment

(2) Unknown

(3) Range - up to 25 nautical miles
Depth - 0 to 60 feet

(4) Invalid torpedo radiated noise recordings

(5) (a) Restrict civilian and commercial traffic in designated naval operating areas during torpedo tests.

(b) Wait for traffic to pass out of range.

(6) Civ versus Mil - This is a class-type problem. We routinely lose 1% to 3% of range time at Dabob Bay and Nanoose to interference.

c. Air Force Eastern Test Range

ASPS –

(1) BNE versus ASPS acoustic transponders

(2) Unknown

(3) 1½ mile range and 14,000 foot depth

(4) When BNE is used to interrogate 12 kHz transponders in the ASPS arrays, the ship cannot receive the reply as the BNE also works at 12 kHz. Also the ship's fathometer cannot be used at the same time as ASPS.

(5) Presently unresolved; but, effort is being made to retune the BNE at 12.25 kHz.

(6) Mil versus Civ - but not really as it is Range ship equipment versus APOLLO ships.

Sonobuoys -

(1) Modified sonobuoys and ship ASPS at 16 kHz

(2) Unknown

(3) 1½ nm-range and 14,000-16,000 foot depth

(4) P3 aircraft could not determine if sonobuoys were operating.

(5) Ship system was shut down for 5 minutes of quiet until aircraft acknowledged receipt of sonobuoy signals.

(6) Mil verus Civ

d. Naval Electronics Laboratory Center - FORACS

FORACS Range I -

All interference from other shipboard sonar equipments have been controlled by reduction in transponder receiver sensitivity. In the past 1½ years, no ships have been requested to go to passive.

FORACS Range II -

(1) Problems are generally with the center frequencies of the AN/SQS-23 and -26 sonars.

(2) Unknown

(3) Unknown

(4) Sonars other than the sonar under test would trigger the FORACS transponder thus disrupting the test. Occasionally the target return at the PPI would be masked by other ship's transmissions.

(5) Request that the interfering ships change frequencies. Now the Fleet Training Group (GTMO) requests the ships not to transmit within 20 miles of the FORACS range and not to use the center frequency when transmitting.

(6) Mil versus Mil

FORACS Range III -

(1) Equipment - ship sonars
Frequencies - variable in both transmit and receive

(2) Unknown

(3) Range - 5,000 to 10,000 yards
Depth - near surface

(4) Momentary delay in test operations

(5) Contact local Commander's office who in turn would contact the ship and have them turn off the sonar or move out of the area if possible.

(6) Mil versus Mil

4. APPLICABLE EFFORT BY OTHER AGENCIES

4.1 Anti-Submarine Warfare Systems Project

4.1.1 ASW Systems Project Office - "Underwater Acoustics Mutual Interference Data Bank:" 14147-8521-C19 - Reference 6.1

a. This CONFIDENTIAL report provides a concise reference of the characteristics of Navy underwater acoustic equipments as related to the problems of mutual interference. The data bank is intended to serve as a reference for the designer of new equipment and for the analyst concerned with the mutual interference problem. As such, it contains enough information to indicate where problems of mutual interference may exist. The data bank is organized in four parts. In parts I and II, for each platform type the equipments are listed alphanumerically by AN Equipment Designation. Transmitting systems are listed first in Part I and are followed by receiving systems in Part II. In Parts III and IV the listing is in order of increasing frequency for all systems, independently of platform type. Transmitting systems are contained in Part III and receiving systems are contained in Part IV.

b. In Parts I and II the equipments are identified by their AN Equipment Designation (with the "AN/" deleted for brevity) and are grouped according to the equipment categories. Under each platform the equipments are listed in alphanumeric order. The equipment categories are:

1. Surface Ship Sonars
2. Submarine Sonars
3. Helicopter Sonars
4. Sonobuoys
5. Torpedoes
6. Communication

c. The information given for the transmitting systems in Part I consists of frequency, transmitted signals type, maximum source level, maximum pulse width, and horizontal beamwidth. For CW transmissions only the nominal center frequency is given, as indicated by use of the mnemonic, CF. However, for transmissions of pulses containing FM sweeps the lower and upper frequencies transmitted during the sweep are given under low and high headings. If the transmitting center frequency can be changed in discrete steps (usually by operator selection) a separate card is used for each such step. Although many systems have a capability for varying the source level, only the maximum level is given since this is the worst case from a mutual interference standpoint. Also, many of the newer systems have the capability of broad variations in transmitted pulse width. Although pulse width does have an effect on the frequency spectral density, only the maximum pulse width is given in order to minimize the number of entries for each system. The horizontal beamwidth is given as the specification value at the -3 dB points. If a system has both an omnidirectional and a narrow beam capability, dual entries are made because of the significance to mutual interference.

d. The information given for the receiving systems in Part II consists of frequency, signal processing type, noise limited recognition differential, and horizontal beamwidth. The frequency information is presented in either of two formats. Since active receivers operate in a relatively narrow band about some specified frequency, the frequency information for active receivers is generally given as the center frequency and bandwidth. The mnemonic, BW, is specifically included to avoid confusion with the format for passive receivers. Since passive receivers generally operate in a relatively broad band, a center frequency has little meaning. Therefore, for passive receivers, the frequency information is presented as the low end of the band followed by the high end. Under processing type, coherent processing is used with active receivers and indicates comparison of the received pulse with a stored replica of the transmitted pulse. Incoherent processing indicates that no stored replica is used. For passive systems, narrowband processing is implied by use of the terms LOFAR, CODAR, and DIFAR.

e. Noise limited recognition differential is the minimum value of signal-to-noise ratio, at the output of the beamformer, required for 50 percent probability of detection.

f. The complete MASWSP report has previously been distributed to all USG members; hence, in order to keep this report unclassified and to avoid duplication, the data bank is not contained herein. Additional copies may be obtained from ASW Systems Project Office, Naval Material Command, Washington, D.C. 20360, or from George Nussear, Pacific Missile Range, Code 3144, Point Mugu, California 93042.

g. Continued effort by the Manager, ASWSP in this area is indicated by the letter on the following page.

DEPARTMENT OF THE NAVY
ANTI-SUBMARINE WARFARE SYSTEMS PROJECT OFFICE
WASHINGTON, D.C. 20360

ASW-150:SL
4 December 1970

From: Manager, Anti-Submarine Warfare Systems Project
To: Distribution List

Subj: Underwater Acoustic Interference

Ref: (a) MASWSPINST 5200.18B of 31 Jul 1970 Subj: Underwater Acoustic Interference Coordination Committee

1. Reference (a) established an Underwater Acoustic Interference Coordination Committee (UAICC) to examine and report on potential underwater acoustic interference between sonars, torpedoes, sonobuoys, communication sets, countermeasures, underwater range equipments and other equipments that transmit and/or receive acoustical energy. Membership in the UAICC includes representatives of Naval Material Command, Naval Systems Commands, Naval Laboratories and ASWSPO.

2. The UAICC plans to assess the problem of acoustic interference among ASW equipment. Addressees are requested to submit the following information by 23 December 1970 to MASWSP (ASW-150) on equipments under their cognizance to assist in the assessment. Negative replies are required.

a. Identification of potential acoustic interference between equipments of the same type (e.g., SQS-26 vs. SQS-26).

b. Identification of potential acoustic interference between equipment of different types (e.g., BQS-13 vs. MK 48 torpedo).

c. Planned or underway programs to gather data and/or to correct potential acoustic interference problems.

d. Current operational constraints to avoid acoustic interference.

e. List of 1969 and 1970 reports on acoustic interference.

/s/T. B. Armstrong
T. B. ARMSTRONG

Distribution:
NAVMAT (MAT-015E, 0326B)
NAVSHIPS (SHIPS-00V2.2, PMS-386, -387, - 394)
NAVORD (ORD-0544, 0541, PMO-402)
NAVAIR (AIR-370A, -533012D, PMA-249)
NAVELEX (EPO-3)
NAVAIRDEVCEN (Code AES)
NUC (Code 35)
NUSC (NLON) (Code 2134.2)

4.2 U. S. Coast Guard

The U. S. Coast Guard supported a National Academy of Science study under Contract DOT-CG-91910-A to determine the "desirability and practicality of standardizing, allocating and controlling acoustical frequencies for underwater telecommunications." More specifically, the Coast Guard asked for help "in identifying the critical parameters of such a study; in assessing the present state of relevant technology; in projecting future trends and in determining the possible advantages and disadvantages of government standardization or regulation." An Academy ad hoc committee met several times during 1968-1969 and arranged a two-day conference for 26-27 February 1969 with representatives of government and industry. The study results and eight technical conference papers are presented in the report "Present and Future Civil Uses of Underwater Sound," (reference 6.2) that was prepared by the Committee on Underwater Telecommunication, National Research Council, National Academy of Sciences. The 131 page report is available for $3.50 from the Printing and Publishing Office, National Academy of Sciences, 2101 Constitution Avenue, Washington, D. C. 20418.

For those that do not have access to the full report, some of the highlights are presented below.

a. Conclusions

1. The hazards and requirements of underwater operations take a variety of forms and pose problems of signaling and marking, most of which can be solved only by the use of underwater acoustic techniques.

2. The committee finds that: (a) presently there are about 40 research submarines, and that this number may double in 10-15 years; (b) a much smaller number of research submarines is used for recreational purposes, but a possibly large although unpredictable increase in their use can be expected; (c) there will be a great increase in scuba diving; (d) there will be a large increase in underwater oil field development, which may or may not involve use of acoustical devices; (e) there are underwater structures and the number is likely to increase greatly; and (f) the introduction of submarine cargo or oil carriers is a possibility. All these must be considered in light of possible underwater collision.

3. Fishing trawls constitute an important hazard to submersibles. While it is technically feasible to mark them, it is probably not practical. Fishing vessels of many nationalities cover much of the ocean, and use of standard signaling equipment could probably not be made mandatory or enforced.

4. Fixed structures within territorial waters, considered by the responsible federal agency to offer a hazard because of their size and location, can best be marked by a pulsed single-freqency acoustic source. Adequate range could be obtained with a long-life, self-contained power supply and a source operating at a frequency of the order of 35-40 kHz. Pingers and receivers operating in this frequency range are commercially available.

5. If underwater navigation aids or channel markers are needed, as they might be for submarine tankers, acoustic sources of a few watts peak power, again in the 35-40 kHz region

and with appropriate pulse coding, would serve for short ranges of half a mile or less. For longer ranges, e.g., 5-10 miles, power of the order 1 kW and a frequency of the order of 5-10 kHz would be needed.

6. Submersibles, either manned or unmanned, can be marked best in a standard way by an omnidirectional pulsed single-frequency source, the repetition rate of which is controlled automatically by depth. Manned submersibles could, with simple gear, estimate bearing and interpret depth from these signals, and, with suitable rules of the road, collision could be avoided. The same frequency and power supply as those specified in Conclusion 4 would be adequate. For large high-speed vehicles, such as submarine tankers, much higher acoustic power and special pulse coding would be needed.

7. Distress signals could be installed on manned submersible and could be manually triggered and automatically triggered at a present depth. Since being heard and recognized is the all-important factor, it is concluded that, in spite of possible interference, the operating frequency should be within the range of the most common underwater telephone, 8 to 11 kHz. To provide maximum recognition, the demodulated signal must be the alternate 1300-2200 Hz used as the marine radiotelephone alarm signal. To ensure adequate endurance in case of power failure on the regular underwater telephone transmitter, which will probably be standard equipment on the submersible, a separate battery-operated unit to emit the signal should be used.

8. To facilitate search and recovery, manned submersibles should carry a smaller higher-frequency pinger with long battery life. The frequency should probably be in the 35-40 kHz interval with appropriate distinctive pulsing. Small units suitable for such use have been built.

9. As a recovery aid for unmanned submersibles or other lost objects such as airplane flight recorders, devices similar to those mentioned in Conclusion 8 could be used.

10. The great advantage in using approximately the same frequency in the 35-40 kHz range for many of the purposes discussed above is that the same listening gear would serve a large variety of needs. In addition, if interference by other uses becomes a problem, only a narrow band needs to be set aside exclusively for these safety uses.

11. With the possible exception of about a 2 kHz band (including guard bands) somewhere between 35 and 40 kHz, it does not appear that any other frequencies need to be regulated. However, it may be necessary to take some action to avoid interference with the special distress signal suggested in Conclusion 7 for the underwater telephone band.

12. Voluntary standardization of frequencies is desirable for such equipment as scuba divers' telephones.

13. If the use of underwater telemetering and control by the oil industry and others increases to the point of causing interference, voluntary standardization of frequencies and codes will be desirable.

b. **Recommendations**

1. Within the foreseeable future, there should be no general control, allocation, or standardization of underwater acoustic frequencies except as specified in the remaining recommendations.

2. There should be designation soon by the appropriate federal agency of about a 2-kHz band between 35 to 40 kHz. Within this band, guard bands, operating frequencies, and codes should be standardized for (a) marking submersibles, (b) marking submerged structures, (c) navigational aids, (d) search and rescue, and (e) recovery of lost objects. If the U.S. Coast Guard is deemed to be the appropriate agency, enabling legislation will probably be desirable to clearly establish its authority for acting.

3. The appropriate federal agency should designate a distress signal for use in the common underwater telephone bands. If the U. S. Coast Guard is deemed to the appropriate agency, enabling legislation will probably be desirable to clearly establish its authority for acting.

4. Voluntary industry standardization of frequencies and codes for underwater telemetry and control should be encouraged. The American National Standards Institute (ANSI), the American Petroleum Institute (API), the Society of Exploration Geophysicists (SEG), and the American Society of Mechanical Engineers (ASME) are examples of organizations through which such voluntary standardization might be achieved and indeed some of those named already show an interest in the matter.

5. Voluntary industry standardization of frequencies and type of modulation for underwater telephones should be encouraged immediately. Examples of organizations through which such standardization might be achieved include some of those named in 4, plus the Institute of Electrical and Electronic Engineers (IEEE), the Marine Technology Society (MTS), and perhaps various divers clubs.

c. **The major topics covered are:**

1. Submersibles
2. Signaling Methods
3. The Acoustic Situation
4. Underwater Acoustic Markers
5. Application of Markers to Submersibles
6. Routine and Emergency Communications
7. DistressSearch and Recovery
8. SOFAR

9. Seismic Exploration

10. Marine Acoustic Telemetry and Control

11. Survey Markers and Sonars

12. Fishing

13. Interfering Uses of Underwater Acoustics

14. Laws, Allocation, Regulation, and Standardization

d. Laws, Allocation, Regulation, and Standardization

In preparing this report, methods of controlling the use of underwater sound, the value of controls, and the effect of controls on use were considered. Controls can be of many kinds; those imposed by nature, by the state of technology, by economics, by mutual agreement, and finally, by the government. The first three have already been covered, and the last two will be discussed here as they could be applied.

In the United States, controls could be by the direct legal enforcement of laws spelling out all the details, such as what frequencies could be used for what purposes, how much power could be radiated both directionally and omnidirectionally, the maximum harmonics permitted, minimum pulse lengths, what equipments submersibles would be required to carry, and in what areas they could be used. The development of underwater technology and the rapid expansion of underwater activities make it undesirable to impose the rigidity, the slowness, and the difficulty of accommodating to changing conditions that are inherent in the law-making process. This very slowness brings with it at least one advantage in giving everyone who might be affected sufficient time to make his influence felt or to adjust plans to the probable change.

A more conventional method of control designed to avoid the long legislative process with the difficulty of correcting mistakes is to enact legislation assigning responsibility and authority to an executive agency to develop and administer controls. The scope of the authority would be specified, and in addition, some detailed items which must be enforced would sometimes be included as would be requirements on public hearings. An example in which many details are spelled out is the "Federal Boating Act of 1958," but which additionally gives the Secretary of the Department in which the Coast Guard is operating authority to draw up regulations within specified limits. The latter are then issued as "Regulations drafted by the United States Coast Guard to implement the Federal Boating Act of 1958." For the case of underwater telecommunications, an act of Congress could be as broad as giving an executive department authority to allocate frequencies and regulate the use of underwater acoustics, or it might be as narrow as authorizing the department to set aside a single frequency band for the exclusive use of submersible distress signals. The former would probably be too broad and the latter too narrow.

Discussions within the committee and with experts on the Law of the Sea indicated that the Coast Guard may already have authority to allocate specific frequencies for navigation and safety. However, since the broad grants of authority relating to safety antedate use of underwater acoustics in this connection, the existence of this authority might have to be tested in court. Having the authority specifically granted would remove any doubts.

General allocation of frequencies would mean that the acoustic spectrum from, say, 5 Hz to 500 kHz would be divided into bands. One or more bands would be assigned to specific uses such as depth finding, fish finding, bottom surveys, Doppler navigation, telemetry and control, navigational aids, distress signals. The chief reason for regulating the use of frequencies, except those used for distress and navigation aids, would be to prevent interference. The interference situation is quite unlike that found in the radio-frequency spectrum wherein the most convenient frequency band and the distances at which serious interference occurs often extend to many hundreds of miles. In underwater acoustics these interference distances are of the order of 1 percent as much, that is, the area of interference is only a ten-thousandth as large. An exception to this is in the band below 1000 Hz, where transmission ranges are great. As far into the future as can be foretold, the only use of this band will be by the military, for research, oil exploration, and survey unless the use of SOFAR is introduced. The last three uses employ impulsive sounds of short duration that are widely spaced, and experience indicates little interference. The greatest source of interference is the low-frequency noise from the ships and ship propellers, and this is overcome by using a larger explosive charge or other sound source.

In the case of navigational distress and search signals the situation is different. The probability of interference is still low, but the penalty for interference is so great that even this low probability should be eliminated. Therefore, the frequencies or signals used for these purposes should not be used for any other. Even more important is that only these specified frequencies be used for the safety purposes in order that all properly designed equipments will pick them up and operators will routinely guard them.

If safety frequency bands are set up, regulations will need to be issued to control their use and to control interference that might result from improper use of other bands. These regulations would also need to specify the various codes to be used within the safety band and the applications. It is assumed that if the authority to set up safety bands is granted by law that this would include authority for such regulations.

For the general good of users of underwater telecommunications, some further controls are desirable, and a few examples will be discussed. Communications between scuba divers and between divers and their boats have been mentioned. Just as it is desirable that as many people as possible speak and understand the same languages it is also desirable that all scuba divers be able to talk to each other. This means that the underwater telephones they use should operate on the same frequency and that the modulation be compatible. This can best be done through voluntary standardization, and both national and international organizations exist through which such standards can be set up. Compliance is not enforced except through the market place where, unless a vendor can show that the standard is obviously wrong or out of date, there will be few sales of nonstandard products. The government, as an important customer, often has a strong hand in enforcement by referencing the standard in purchase specifications. Wherever applicable, government representatives usually serve on the standardizing committees.

Another case for which standardization is already being considered is telemetry and control of offshore oil operations. Because of the concentration of activity within small areas, interferences and false operations could result. To avoid these, standards are proposed to control frequencies and codes. Here there are only a few large users in a given area and all gain by standardization. Hence, enforcement is not a problem requiring an outside agency with police powers. Malicious operation of values can probably be handled under the same laws that prohibit other malicious acts.

Thus far the discussion has been limited to controls in the waters over which the United States has jurisdiction, but the time may come when controls should be extended into international waters. This should first prove true in the case of the distress and search signals. International agreements can be reached through sections of the United Nations, through special international commissions, or through the International Standards Institute. In no case could such agreements be absolutely enforced, but to the extent that compliance is of mutual benefit, there would probably be cooperation. An example is the agreement on use of the radio spectrum.

International agreement can be approached in two major ways. The first consists of properly sponsored meetings of representatives of each country attempting to reach agreement purely from the standpoint of an unsolved problem. A more effective approach is for a leading nation in the field, as is the United States in underwater technology, to work out a satisfactory solution and demonstrate its effectiveness. It will then be much easier to persuade other nations to go along. In this case it is believed that the United States is so far in the lead that there is presently no urgency for international controls.

Applying these observations to the underwater telecommunications problem, it is concluded that those matters relating to safety should be controlled by regulation, whereas those matters relating only to economy or convenience should be controlled by industrial standards. The regulations and standards should first be worked out where the United States has jurisdiction, and then, where desirable, international agreement should be attempted. Because of the desire of foreign manufacturers to reach the U.S. market, equipment standards would quickly become worldwide.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

a. As stated in Section 1.1, the objective of this task was to develop standard acoustic frequencies for use on all member Ranges. This included pingers for underwater range tracking and beacons/transponders for both acoustic ship positioning systems (ASPS) and aids for recovery and salvage. This work would be accomplished by (1) the identification of acoustic frequencies presently in use, (2) the determination of acoustic interference problems, (3) the review of other agencies efforts, (4) the review of anticipated future requirements, and (5) the development of recommended standard acoustic frequencies.

b. The frequency usage survey results contained in Section 2.2 identify the major frequencies that are presently used at member Ranges and several other government agencies. It is encouraging to note from the results that a high degree of commonality already exists. The AUTEC and the PMRF "long-base line" ranges have basically the same frequencies. Also, the AFWR and NTS, Keyport "short-base line" ranges are quite similar. The MILS/ASPS systems at PMR, AFETR and SAMTEC are identical. This degree of similarity was generally known and the overall results were not too surprising.

c. The acoustic frequency interference survey results were not nearly as comprehensive as the frequency usage; however, they indicate that interference may not be as bad as expected. Operational techniques are most commonly employed to solve interference problems. Use of the MASWSP Data Bank during system and equipment design phases can further minimize the interference problem.

d. While it was not possible to review the efforts of very many agencies besides USG members and guests, the MASWSP Data Bank and the Coast Guard reports probably contain the most significant information available. It appears that the Coast Guard work resulted in part from the efforts of Messrs. Lyman Haley and Robert Raish on the White House Executive Staff, Office of Telecommunications Policy. Also, the Naval Electronic Systems Command has held conferences on acoustic frequency compatibility. The Chief of Naval Operations established an U/W Acoustic Interference Coordinating Committee dealing primarily with the serious problem of acoustic compatibility between sonars. However, no information is available on the efforts of NESC or CNO.

e. The surveys did not yield a great amount of information on anticipated future requirements; consequently, there is no such material presented herein. The Ranges could be resurveyed now or wait until the data contained in this report has been reviewed, some standards set, and joint procurements have been effected.

5.2 Recommendations

The following recommendations for underwater frequency standardization are based on the results of the two surveys, the MASWSP Data Bank, and the Coast Guard report.

a. Continue NUSC-PMR liaison on common tracking frequencies.

b. Continue AFWR-NTS Keyport liaison on common tracking frequencies.

c. Continue PMR-AFETR-SAMTEC liaison on common MILS/ASPS frequencies.

d. Establish the frequencies used in 1, 2, and 3 above as official Range frequencies.

e. Maintain a permanent ad hoc committee to monitor range frequency usage requirements both present and future.

f. Establish a separate ad hoc group for range sonars and recovery equipment and frequencies.

g. Establish a separate ad hoc group to review and standardize U/W equipment characteristics other than frequency; this would include such items as: power levels, repetition rates and pulse lengths.

h. Contact MASWSP and Coast Guard to combine efforts with the USG.

i. Assign a new task to develop total U/W standards similar to the IRIG Telemetry Standards.

6. REFERENCES

6.1 "Underwater Acoustics Mutual Interference Data Bank," 14147-8521-C19, ASW Systems Project Office, Naval Material Command, Washington, D. C. 20360, 9 March 1970.

6.2 "Present and Future Civil Uses of Underwater Sound," Committee on Underwater Telecommunication, National Research Council, National Academy of Sciences, Washington, D. C., Standard Book Number 309-01771-8, 1970.