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SOUND Database of Marine Animal Vocalizations Structure and Operations

by

William A. Watkins, Kurt Fristrup, Mary Ann Daher, and Terrance Howald

August 1992

Technical Report

Funding was provided by the Office of Naval Research through the Ocean Acoustics Program (code 11250A) under Contract No. N00014-88-K-0273 and No. N00014-91-J-1445 with supplemental support by CRINCON/DARPA and NRL (code 211).

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Approved for Distribution:

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ABSTRACT

The SOUND database system for marine animal vocalizations has been updated to include changes in the structure and operations that have evolved with use. These include more convenient operations, greater flexibility in analysis routines, and a revised database structure. The formats for data sorting and indexing, database structure, and analysis routines have developed into a convenient research tool. This report is a revision of the earlier operating manual for the SOUND databases (Watkins, Fristrup, and Daher 1991).

The interactive databases that comprise the SOUND system provide comprehensive means for quantitative analyses and statistical comparisons of marine animal vocalizations. These SOUND databases encompass (1) descriptive text databases cataloging the WHOI collection of underwater sound recordings of marine animals, (2) sets of files of digital sound sequences, (3) text databases organizing the digital sound cuts, and (4) software for analysis, display, playback, and export of selected sound files. The text databases index and sort the information about the sounds, and the digital sound cut files are accessed directly from the text record. From the text database, the sound cut data may be analyzed on screen, listened to, and compared or exported as desired.

The objective of this work has been the development of a basic set of tools for the study of marine animal sounds. The text databases for cataloging the recordings provide convenient sorting and selection of sounds of interest. Then, as specific sequences are digitized from these recordings, they become part of another database system that manages these acoustic data. Once a digital sound is part of the organized database, several tools are available for interactive spectrographic display, sound playback, statistical feature extraction, and export to other application programs.

KEY WORDS -- Sound database, Marine animals, Underwater sounds, Animal vocalizations.

SOUND Database

CONTENTS

SOUND Database

OBJECTIVES

This 1992 manual revises the description of the SOUND database system, and incorporates current formats for data sorting and indexing, for database structure, and for conducting data searches. Details of the operation of database associated programming are given for retrieval of selected digital sound files and for interactive display of text data along with waveform, FFT spectra, and RID spectral decomposition analyses. Other operations include concurrent playback of sound files and export of data for other uses.

The Marine Animal SOUND Database system (Watkins, Fristrup, and Daher 1991) provides convenient access and rapid analysis and display of acoustic data in the WHOI collection of recordings from marine species. The organization of the database structures follows that developed for convenient indexing and retrieval of data in our CETACEA database of literature references (Watkins, Daher, and Haley 1990). In addition, acoustic sequences from the various animal repertoires were digitized to provide a representative selection of sounds associated with the behaviors of the different animal species and sounds from a number of other non-biological sources. These digital sound files were organized and accessed directly from within the text databases.

The objective of this program has been the development of basic tools for the study of marine animal sounds, for accessing, analyzing, and comparing the acoustic patterns. This has included work on characterization of sound features for statistical comparison, and automatic recognition and diagnosis of marine animal vocalizations.

The SOUND databases have fulfilled these objectives of providing convenient means of relating the sounds to text data, sorting and retrieving them, allowing immediate analysis and playback of sequences of these sounds. This has opened the way for comprehensive, quantitative analyses and statistical comparisons of marine animal sounds.

ACKNOWLEDGEMENTS

The Marine Animal SOUND Database program is a joint effort by all who use these databases in their research, including William Schevill, Peter Tyack, Laela Sayigh, and Cheri Recchia. This effort is shared also by previous members of our bioacoustics program, including Nancy Haley, Karen Moore, and James Bird. The data collection at sea had expert contribution from all of those associated with the vessels and aircraft used for observations of marine animals over more than four decades. The organization and interpretation of the acoustic data encoded now by the SOUND databases are a result of the collective ideas and experiences of this entire group. The authors' contributions have emphasized basic structural organization (Watkins), innovative computer tools for augmenting the database functions (Fristrup), careful oversight of acoustic and annotation records (Daher), and analysis and software innovations (Howald). The central core of this program is the long standing collection of marine animal sound recordings -- tributes to the researchers that have made these important contributions for over 45 years.

Support for the Marine Animal SOUND Databases has been primarily from the Ocean Acoustics Program (code 11250A) of the Office of Naval Research with Contracts and Research Grants (most recent N00014-91-J-1445) and supplementary support through NRL (code 211, Stennis Center, MI) and DARPA/ORINCON (San Diego, CA). The program of bioacoustic studies that provided much of the previous work resulting in our acoustic recordings of marine life was supported for a considerable period by the Oceanic Biology Program of ONR. A wide range of other research programs and private support over this long period also have contributed to our work at sea and in the laboratory, providing understanding of the acoustic behavior of these marine species.

SOUND Database

INTRODUCTION

Database Organization --

This revision reflects changes to the SOUND database structure, organization, and associated analyses that have evolved since the original documentation (Watkins, Fristrup, and Daher 1991). These systems are in daily use, and the current arrangement is a result of its practical application for analysis and comparison of animal sounds.

The SOUND database system has a similar organization to that developed for the CETACEA databases described by Watkins, Bird, Moore, and Tyack (1988) with modified format revisions detailed by Watkins, Daher, and Haley (1990). Both SOUND and CETACEA databases use the same text systems for cataloging subjects, dates, geographic locations, and pertinent descriptive data. These notations are directly related to more than 150 species categories (Species List and List of Common Names for Marine Animals are appended). The acoustic data are referenced to text information about the species and the recording situation.

The data about the sound recordings cataloged in the SOUND databases are indexed and sorted by the database management program to provide convenient, rapid mechanisms for selecting sound recordings or digitized data of interest. The SOUND databases are presently installed on PC and AT compatible computers running Microsoft DOS, and the current organization for the system is based on INMAGIC 7.2 database software (INMAGIC INC., Cambridge, MA).

The text information for the SOUND databases are indexed in 31 fields (including date, location, recording data, sound class, species, number of animals, author, etc. -- see pages 19-22), and it allows independent sorting and retrieval of data in each field and unlimited subfields. The databases are searched by any combination of indexed or unindexed alphanumerical notations, by any combination of terms or partial phrases or stems of these notations. Searches may be complex and mixed with Boolean search statements. The data record for the desired sound file is selected by the text databases. The related digitized sound file may be immediately retrieved, analyzed, displayed, and played back, without leaving the text database. The databases continue to enlarge as the numbers of recordings increase, and as sound analyses have become more detailed. The databases (recordings, sound cuts, and literature) organize more than ten thousand records.

Marine Animal Recordings --

The library of sound recordings that provide the basis for the Marine Animal SOUND Databases were made during studies on acoustic behavior of marine species. This bioacoustic work was started in 1947 by William E. Schevill, and a continuous program of study of marine animal acoustic behaviors has been maintained at WHOI since that time. The initial set of tape recordings organized by the SOUND database included approximately 2000 magnetic tapes. These sounds on the tapes represented approximately 70 species of marine mammals, as well as fishes, crustaceans, and selected ambient noises.

The collection of marine animal sounds continues to enlarge as recordings are added from our own experiments at sea (two Arctic and four Caribbean cruises in 1989-1991), in addition to recordings by others. This library of recordings includes a variety of magnetic tapes, reel-to-reel with different widths and reel dimensions, VCR tapes, cassettes, phonograph records, computer digital media and optical disks. The combined SOUND databases now have more than 6000 entries.

The animal sounds in the recording collection and its database system incorporate a number of the historically important scientific contributions in bioacoustics, such as the first science recordings from marine mammals at sea by William Schevill (beluga, Delphinapterus leucas) and the early sound records of echolocating bats (Eptesicus and Plecotus) and oil birds (Steatornis caripensis) by Donald Griffin.

These original underwater bioacoustic studies were underway before tape recorders were readily available, so that recordings were made on a variety of different types of equipment. For example, the earliest records of the acoustic behavior of beluga were made on a "Gray Audograph" dictating machine, and signals were recorded on waxed paper disks. These sounds were then reproduced on transcription phonograph records. Copies of these recordings made on magnetic tape are retained in the collection.

SOUND Database

The sound spectra recorded by the different recording media vary with each system that was used, from bandwidths of only a few kHz to 200 kHz or more. Recordings were made with single channel systems and with arrays of four or more hydrophones, using sensor depths varying from near surface to bottom mounted units. Recording equipment has varied considerably over the years, including standard audio systems, professional standards IRIG systems, and special purpose recorders. Most systems used "Direct" recording because of the wide bandwidths or high frequencies required to reproduce the natural animal sounds.

Marine mammals have been emphasized in the studies of animal acoustic behavior, therefore, much of the recorded data has focused on the sounds of cetaceans, pinnipeds, and sirenians. Recordings in the collection include underwater sounds from more than 70 species of marine mammals. Geographic locations for these recordings are scattered worldwide, with observations in many locations often taken over much of the year. Because of the long sequence of studies and the wide range of acoustic work represented by these continuing programs, the recording collection is representative for many areas of the world.

Prior to 1970, the attribution for sounds heard underwater was not always immediately certain, but with experience, more of the repertoire of the different species became recognized. As a result, there has been a change in the nature of the recordings over time. The use of multiple hydrophone arrays has increasingly allowed identification of vocalizations and sequences of sounds from individuals. Sources for the recorded sounds have been positively identified by these means. Many of the recordings were made especially to trace the usage or development of particular sequences of vocal activity.

The more recently recorded sounds deal less with species or population differences, and more with sounds that illustrate specific behaviors. Later recordings, therefore, are more focused on specific scientific objectives (vocal identity, mimicry, shared signalling, ontogeny of learned signals), and they relate to certain species (sperm whales, finbacks, bowheads, bottlenose dolphins, etc.). For example, our 1954-1968 sperm whale recordings led to specific studies of their activities, which in turn opened the way to work focused on coda signals produced by these whales, and then to analyses of distinctions between codas from individuals and those shared by the members a particular population.

INTERRELATED DATABASES

The textual data on marine animals and their sounds are organized by a series of interrelated computer databases currently using PC and AT workstations. These separate, related databases for organization of marine animal vocal behavior include: (1) CETACEA, a comprehensive database of references to the literature on marine animal sounds, (2) SOUND, a database for the descriptive information about each of the sound recordings, (3) SOUNDC, a database for the detailed information and acoustic descriptors for each of the separate digital sound cuts, (4) SOUND2 (SOUND2C, and other series), auxiliary databases for specific research emphases using these same data protocols, and (5) a set of matching digital sound cut files (filename matching the text database record). The digitized sound cuts are stored as separate files on optical disk, and they can be accessed, analyzed (time series and a variety of spectrographic portrayals), displayed, and played back from within the text (SOUNDC) databases.

Structures for all of the databases follow similar patterns, use the same systems of annotation, and relate to the same lists of species, geographic codes, etc. Separate, indexed fields within each of the database records describe the recording situation, the equipment used, the geographic locations and recording dates, species (and individuals) that were present, behavioral notes, sound types, etc. Records with any of these data or any alphanumeric combination in any field may be rapidly searched and selected. Then, the matching digital sound file can be retrieved for analysis and display or accessed for other purposes. Auxiliary databases provide separate organization for particular research projects on animal sounds (dolphin mother-calf signature whistles, beluga vocal behavior, sperm whale coda patterns, etc.).

A display-edit-export function for the sound files accesses the digital files from within the text databases. This is a pop-up, TSR utility for retrieving the stored digital sound file, and analyzing and displaying waveforms and color spectrograms (a variety of FFT and RID analyses) from within the text database. Cursors provide measurement of signal time and frequency, and select portions for expansion or export.

SOUND Database

A header with identifying information is prefixed to each digital sound file. The header duplicates a portion of the ASCII text from the related (SOUNDC) text database record. This text information is also related to the original database record of the library collection of recordings, SOUND, thereby allowing the sorting and retrieval of tape information from subsidiary databases, SOUNDC, SOUND2C, etc. The identified digital sound files are accessed from within these text databases, retrieved directly from storage, such as from optical disks.

Equipment --

Sounds from the marine animal recording collection are reproduced on a variety of reel-to-reel, VCR, and cassette equipment. As possible, frequency responses and dynamic ranges at least as good as for the original recordings are maintained, so as to provide equivalent spectra to those of the original recording systems.

Sounds are analyzed with a variety of equipment, including Kay DSP Sonagraph 5500 (Kay Elemetrics, Pinebrook, NJ), WHOI VOICE analyzer (Martin, Catipovic, Fristrup, and Tyack 1990), RSIG and CSIG routines from within the SOUND databases (Fristrup, Daher, Howald, and Watkins 1992), and other special purpose analyses adapted to specific requirements. Digital conversion for sound cuts is performed at more than twice the highest frequency of the sequences of interest. PC and AT work-stations (optimized 286, 386, and 486 computers) are used for database operations.

The digital sound cut files are stored (archival) on optical disks (Maxtor OC-800), and large capacity hard disk drives are used for temporary deposit of sound files during database manipulations.

CETACEA --

The comprehensive, background database of references to the literature, CETACEA, emphasizes information on marine animal sounds. The data in about 4500 records (to date) are indexed and sorted by 300 subjects, 150 species categories, and a variety of other indexed notations including dates, locations, sound spectral characteristics, environmental observations, etc. A unique feature of these database structures is the direct connection between species and all other indices, including subjects, locations, observation dates, notes, etc. In addition, codes have been adapted for ease in identifying and linking data in various fields. Searching the database is rapid, using a wide variety of simple and complex Boolean strategies. The CETACEA database and its operations have been described in two reports (Watkins, Bird, Moore, and Tyack 1988; and Watkins, Daher, and Haley 1990).

The CETACEA database and the related SOUND databases use an adaptation of INMAGIC software (INMAGIC Inc., Cambridge, MA) for the text data indexing, sorting, and searching routines. For each database, the programs operate with three interactive files: structure, index, and data records. They all share the direct linkage of species with other indices.

SOUND --

The databases for the marine animal collections of analog acoustic recordings organize the descriptive information about each of the sound records and sequences of sound. The SOUND databases (including auxiliary databases such as SOUND2, etc.) index and sort the data for more than 6000 recordings to date. These databases continue to grow as the collections increase in size and complexity. Separate databases are established for particular research needs (for example, one database is currently used for separate organization of the collection of VCR and cassette recordings of dolphins, and other related databases are for specific data on digitized cuts of signature sounds, etc.). Unique retrieval numbers for each record also provide the date and sequence of recording (for example, 83093 indicates the 93rd recording cataloged for the year 1983), and these retrieval codes are used in indexing and shelving of the library collections. Data about the recordings are sorted by 150 species, 30 indexed subjects that are also directly connected to species, in addition to a variety of other information, including recording locations, dates and times, identities of individuals, number of animals, sound levels, and sound types.

SOUND Database

SOUNDC --

The digital cuts of marine animal sounds are organized by specific text databases, such as SOUNDC (sound cut). These text databases for the sound cuts have similar structure and design to the other SOUND databases, and they are used in the same ways to index and sort the data appropriate to the individual sound sequence on the digital file. The sound cut databases relate specifically to the sequences of sounds taken from the different recordings in the library collection. Unique retrieval numbers for each digital sound cut file identify the original recording as well as the sequence of digital cuts made from that original (for example, 83093034 identifies the 93rd recording catalogued for 1983 listed as tape number 83093, and this cut is sound cut number 34 from that recording). Added details indexed in the sound cut databases (such as SOUNDC) include particulars about that sound sequence, including reference to library tape cue, channel numbers analyzed, duration and sampling rate for the digital file, sound comparison characters, etc. These data are sorted by 150 species, 30 indexed subjects that are directly connected to species, such as recording location, dates, number of animals, sound types, etc.

A specific digital sound cut file selected by searching the SOUNDC databases is retrieved as desired. Then, using the pop-up display utility, RSIG, without leaving the database, the sound cut may be analyzed, displayed on screen, and played back by loudspeaker. At a keystroke, the text data for the cut is back on screen or another type of analysis is underway to provide further detail about the sound cut.

Digital Sound Files --

Digital sound cuts are stored as independent files, identified by filenames that match text database record numbers. The first 512 bytes of each file include the indexing information as a header for that sound cut file. The related text SOUNDC database provides the flexible search, selection, and retrieval capabilities for accessing these files from within the database. Sound sequences are selected and digitized as separate sound cut files for a variety of purposes, including that of illustration of a particular type of sound, detailing the repertoire of individual species, analyzing sounds related to certain behaviors, comparing sequences of signals from different species, separating distinctive calls from different populations, or demonstrating variation with season and activity, etc.

ANALYSIS AND DISPLAY

The digital sound cut files identified by searching the SOUNDC database may be selected for later analysis, or as noted above, they may be immediately analyzed, displayed, and played back without leaving the SOUNDC text database. Immediate access to the digital acoustic data is provided by a pop-up utility, RSIG. RSIG retrieves the digital file identified by the current search results from SOUNDC, and the digital file is analyzed with both waveform and spectrogram displayed simultaneously on screen, with concurrent audio playback. The analyzed signals may be edited, re-analyzed, and expanded as desired. Or, the text search results may be re-examined and other signals rapidly retrieved for analysis and display. These digital sound files may also be reformatted and exported by RSIG as needed.

Alternatively, a stand alone analysis program, CSIG (with functions similar to RSIG), may be used directly, without interaction with the database, to analyze, display, and playback the digital sound files.

All of the SOUND databases, file handling routines, and signal analysis and display programs are related. They utilize common identifiers, data structures, field labels, search and sorting strategies, and display parameters. In addition to the primary databases and their analysis systems, other auxiliary databases are also maintained, such as SOUND2 and SOUND3C which organize data for different species and particular bioacoustic projects and analyses.

INMAGIC PROGRAM

The SOUND databases are currently used with an adaptation of INMAGIC database software (version 7.2, INMAGIC Inc., Cambridge, MA) for text databases. This is a flexible text database system that has proven to be relatively simple and easily searched, while retaining the needed complexity of association within indexed data. A unique feature of the data association for these databases is the direct link between species and other indexed subjects. The combination of the coding system and the database software allows every component or alphanumeric entry in the record to be available for searching by a wide variety of simple and complex Boolean strategies.

The INMAGIC text database system includes the following features: (1) permits records of any length, (2) relates 75 or more fields, (3) provides for unlimited numbers of defined subfields, (4) indexes and sorts fields and subfields, (5) indexes as each data record is entered, (6) allows independent sorting and retrieval of data in subfields as well as fields, (7) supports search strategies developed with Boolean operators (and, or, not) and nested arguments, (8) uses searches with qualifiers (greater than, less than, equal to, from/to), (9) provides for convenient right-hand truncation in search statements, (10) saves and combines search results, (11) allows use with user-defined formats for display or re-ordering of data, (12) prints any number of selected records in any of these formats, (13) lists any indexed terms or fields and subfields with their frequency of occurrence, (14) permits the use of extended characters in records, (15) provides for development of flexible on-line thesaurus of terms, search operators, and definitions for help in searching the records, (16) permits rapid copying of data records, and (17) allows importation of ASCII records created elsewhere. Records in the CETACEA database, for example, are indexed by more than 300 subjects, 150 species categories, and a variety of other notations including dates, locations, sound features, environmental observations, etc. With approximately 5000 records in the CETACEA database, searching and retrieval of data records or combinations of records are rapid, usually less than a second.

The databases may be searched by any combination of indexed or unindexed alphanumeric notations. Detailed searches may be made using specific indexed fields, such as genus/species (searchable by order/suborder and family as well). Searching may use any combination of terms and text words or even stems of words or partial phrases and parts of any alphanumeric entry. In addition, codes have been adapted for ease in identifying and searching species, subjects, geographic areas, etc. The alphanumeric coding of marine animal species allows indexing, sorting, and retrieval of most subject fields, geographic locations, dates, and events in direct relationship to specific species. Detailed searches may be made using genus/species, record number, identification, age, gender, observation date, geographic locations (including area names and latitude and longitude), author of recording, sound type, etc.

Detailed descriptions of search operations and potential combinations of search statements appropriate to these databases are reviewed in more detail in the previous SOUND database report (Watkins, Fristrup, and Daher 1991) and in the CETACEA database reports (Watkins, Bird, Moore, and Tyack 1988, Watkins, Daher, and Haley 1990). See the INMAGIC Manual (INMAGIC INC., Cambridge, MA 02140-1338).

Search features include simple and complex BOOLEAN relations (such as, equals, less/greater than, less than or equals, starts with, contains stem, from...to, etc.). Codes assigned to species and subject categories provide direct associations of most indexed fields. This allows generalized searches or increasingly specific searches by truncation of the codes (refer to Organization to Species List, p. 41).

The design of the database takes advantage of INMAGIC's system for right-hand truncation, so that the placement of codes at the end of fields allows searches by codes or elements of codes, as well as by the other record data. Although a bit slower, searches are also possible using any alphanumeric combination contained in any record, whether in indexed or unindexed fields.

ORGANIZATION OF DATABASE RECORDS

Database records are organized for convenience in entering the data, for relative ease of utilization of the information in records, and for reorganization of the data for display.

The organizational detail is indicated by the list of field names in the database structure and descriptions of these fields (next sections). In brief, the records are organized as follows:

-- Each record is given a unique retrieval number (RECNO). This number gives the year of recording, the recording series, and the sequence of digital analysis. In addition, it serves as a pointer for identification of the recording in the library collection.

-- Separate fields give the recording cue for specific sounds, number and sequence of channels, equipment, author, sampling rate, duration of the sound sequence, etc.

-- Separate fields also are used for entering a variety of data about the animals and the particular vocal sequence, such as activity, animal identity, age, interaction, sound class and type.

-- Genus/species names and alphanumeric codes are entered for all species recorded -- order/suborder, family, genus, and species are indicated by each code.

-- Codes for genus/species are appended to data in many other fields for direct association with location, observation date and time, sound type, etc.

-- Location for the recording is given by name, by geographic code, as well as by latitude and longitude.

-- Notes, and annotations may be included, and are related to species.

-- Data on the recording situation are also entered, such as hydrophone depths, recording conditions, received signal levels, and sound type.

Most fields in the SOUND database records are indexed and may be searched separately or in combination to provide rapid selection of these records. Notes and similar fields are not indexed, but these too may be searched (more slowly) for any words, phrases, or alphanumeric notation.

The List of Species is provided at the end of this report to assist in identification of interrelated codes and to aid in database searches. In addition, a List of Common Names for Marine Animals provides reference to some of the more frequently used vernacular names for these species.

STRUCTURE FOR SOUND DATABASES
Revised July 1992

INMAGIC Program Format
(Index: T = term, Y = both term and key-word, N = no index)
See INMAGIC Manuel for Sort and Emphasis codes.

LABEL	NAME	INDEX	SORT	EMPHASIS
RN	RECNO	T	3	1
CU	CUE	T	3	1
NC	NOCHAN	T	3	1
SR	SAMRATE	T	1	1
CS	CUTSIZE	T	1	1
PL	PLAYBAK	Y	7	1
SC	SIGCLAS	Y	5	1
ID	IDENT	Y	7	1
AG	AGE	Y	7	1
IA	INTERAC	Y	7	1
GS	GENSP	Y	5	1
GA	GEOA	Y	5	1
OD	OBSDATE	Y	4	1
NT	NOTE	N		
DA	DATE	T	4	1
IP	IDPRES	Y	7	1
AP	AGEPRES	Y	7	1
BH	BEHAV	Y	5	1
OS	OTHERSP	Y	5	1
NA	NOANIM	T	3	1
GB	GEOB	Y	5	1
GC	GEOC	Y	7	1
OT	OBSTIME	Y	7	1
SH	SHIP	Y	5	1
AU	AUTHOR	Y	5	1
LO	LOCATE	Y	5	1
HY	HYDEPTH	T	3	1
RC	RCOND	Y	5	1
RG	RGEAR	Y	5	1
SL	SIGLEVL	Y	7	1
ST	SIGTYPE	Y	5	1

Abbreviated List of Fields --

SOUND Databases
(July 1992)

RN	Retrieval number of record year/tape#/cut#)
CU	Cue or time on tape, buffer (B) size, sec in buffer
NC	Number channels recorded, digitized, chan/side ID
SR	Sample rate (convert Kay input freq. to sample rate)
CS	Cut size -- digital cut in sec (2 or 3 dec. places)
PL	Playback equip., filter setting low (L) high (H) kHz
SC	Signal class - Signature, Mimic..., qual 1-5, Overlap
ID	ID of individual vocalizing, species code
AG	Age, sex (M/F) prefix, birth year, ID, species code
IA	Interaction (MC = male-calf, etc.), ID
GS	Genus/Species animals producing sounds, species code
GA	Geographic location A = ASFIS code, species code
OD	Observation date of original recording, species code
NT	Note = Species code, observation or recording details
DA	Date of this record entry (latest modification)
IP	Identification conspecifics present, species code
AP	Age consp. present: sex-pref., birth yr., ID, sp. code
BH	Behavior of the animals, species code
OS	Other species present, species codes
NA	Number of animals vocalizing, species code
GB	Geographic location B = name of area, species code
--/2	Location of birth/capture area, species code, (ID)
GC	Geographic location C = lat. & long., species code
OT	Observation time of original recording, species code
SH	Ship/cruise, aquarium, or recording platform
AU	Author, originator of the recording
LO	Location of original recording
HY	Hydrophone depth in m
RC	Recording conditions, weather, salinity, etc.
RG	Recording gear, equipment
SL	Signal level (dB received or source), species code
ST	Signal type codes, species code
--/2	Signal type names (coda, slow clicks), species code

SOUND Database Field Description --
(July 1992)

LABEL -- NAME -- Description with example.

RN	RECNO	Retrieval number of record (Year/tape#/cut#) Year (2 digits), tape no. (3 digits), cut # (3 digits, alphanumeric base 36). Example: 850430B6
CU	CUE	Cue or time (min:sec) on tape at signal end, (B) analyzer buffer size (min:sec), decimal time sec from start of Kay buffer to cursor at beginning of sound. Example: 542 B2:8 8.130 or 1:03:12 B2:8 8.130
NC	NOCHAN	Number of channels recorded (1st digit), number of channels multiplexed (2nd digit), channel ID letter(s) -- side one A & B, side two C & D. Example: 42CD
SR	SAMRATE	Sample rate (Kay input frequency converted).
CS	CUTSIZE	Cut size -- sec (2 or 3 decimal places).
PL	PLAYBAK	Playback recorder/filter type, settings in kHz (pass-band), L = low (HP) and H = high (for LP). Example: PEMTEK/KROHN-HITE L0.1 H12
SC	SIGCLAS	Signal class, letter codes (Signature, Mimic, Variant, Deletion, Uncharacteristic, Calf, etc.), quality 1 to 5 (best), O = overlap in Time or Frequency. N = no overlap. Example: S 4 OTF
ID	IDENT	Identification of vocal animal, species code.
AG	AGE	Age with sex (M or F) prefix (decimal for part year) and ID, birth year of vocalizing animal with sex prefix and ID, species code. Example: M0.3FB19 M1985FB19 BD19D
IA	INTERAC	Interaction, male-male (MM)/ female-calf (FC), etc., with ID's. Example: FCFB10 FCFB19

Fields in SOUND Structure (continued)

GS	GENSP	Genus and species of vocalizing animal. Scientific names and species code.
GA	GEOA	Geographic location area code from ASFIS map, species code. Example: ANWAB1A (ANW area, AB1A species)
OD	OBSDATE	Observation date for original, species code. Example: 20-Dec-1960 AB1A
	OBSDATE/2	Subfield for month and year, species code. Example: DecAB1A 1960AB1A
NT	NOTE	Species code, comments, recording details. ID of animals in parentheses. Not indexed.
DA	DATE	Date of this record entry, last modification. (Use F6 key) Example: 24-May-1991
IP	IDPRES	ID of conspecifics present, species code. Separate subfields for each animal.
AP	AGEPRES	Age of conspecifics present = sex prefix (M/F) with age (decimal for part year) and ID, birth year with sex prefix and ID, species code. Separate subfields each animal. Example: M0.3FB19 M1985FB19 BD19D
BH	BEHAV	Behavior codes, species code.
OS	OTHERSP	Other species present, species codes. Separate subfields for each species.
NA	NOANIM	Number of animals vocalizing, species codes.
GB	GEOB	Geographic location area name, species code.
	GEOB/2	Location of birth/capture, species code, ID of animal (in parentheses).
GC	GEOC	Geographic location latitude and longitude, "N" or "S" and two digits for lat., "E" or "W" and three digits for long. Each with species code. Example: N70AB1A E020AB1A

Fields in SOUND Structure (continued)

OT	OBSTIME	Observation time for original, species code. Example: 1430 AB1A
SH	SHIP	Ship/cruise, aquarium, or other platform, (SMall boat, AQuarium, BEach, ICe, UNknown)
AU	AUTHOR	Author, originator of the recording.
LO	LOCATE	Location of original recording.
HY	HYDEPTH	Hydrophone depth in m.
RC	RECCOND	Conditions, weather, salinity. Not indexed.
RG	RECGEAR	Recording gear, equipment. Not indexed.
SL	SIGLEVL	Signal level Received, Source, (dB), species code. E = estimated. Example: S172AB1A E
ST	SIGTYPE	Signal type, Long= > 0.1 sec; Short= < 0.1 sec BL Broadband long, noisy, many frequencies BS Broadband short, clicks, pulses NL Narrowband long, tonal, few harmonics NS Narrowband short, bell, short tones FM Frequency modulated, sweeps, "contours" CH Chirp, short FM sweep PU Pulsed, click bursts, sidebands SE Series, train, sequence of sounds SO Song, long, repetitive, patterned -- with species code. Example: NLAB1A
	SIGTYPE/2	Signal type, general: coda, slow clicks, etc. -- with species code.

SOUND Database

GEOGRAPHIC LOCATIONS

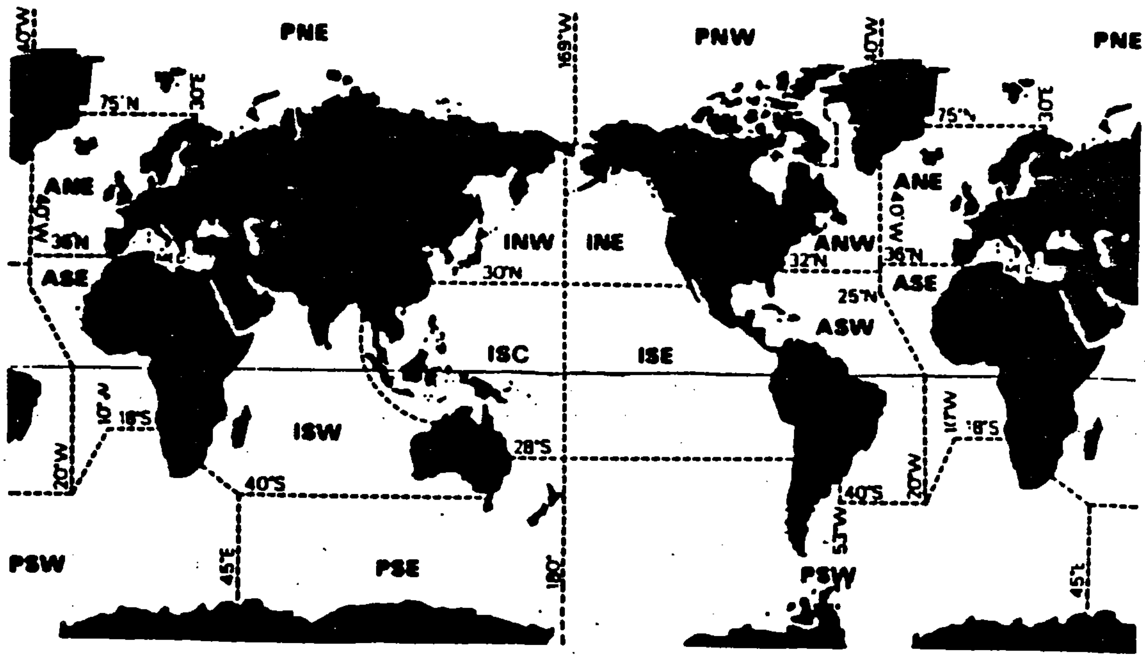
GEOA field -- The first of the geographic location fields in the structure listed above uses codes for the locations or places at which the original recordings were made. These location codes are adapted generally from the geographic codes used by the Aquatic Sciences and Fisheries Information System (Anon. 1980, ASFIS):

ANE	Northeast Atlantic
ANW	Northwest Atlantic
ASE	Southeast Atlantic
ASW	Southwest Atlantic
INE	Northeast Pacific
INW	Northwest Pacific
ISE	Southeast Pacific
ISC *	Southwest (central) Pacific
ISW	Indian Ocean
MED	Mediterranean
PNE	Eastern Arctic Ocean
PNW	Western Arctic Ocean
PSE	Eastern Antarctic Ocean
PSW	Western Antarctic Ocean
CSL *	Coastal Waters
FSR *	Freshwater
COS *	Cosmopolitan

* changes from the ASFIS codes

The species codes are combined with the ocean area codes. For example, a recording of _Megaptera novaeangliae_ in the Indian Ocean is indexed with the codes ISWAC2A (ISW for the Indian Ocean, and AC2A for _Megaptera novaeangliae_).

ASFIS Map -- Aqua. Sci. Fish. Info. Sys. (Anon. 1980, ASFIS).



SOUND Database

TEXT DATABASES

The use of text-based systems has allowed rapid association of our different existing data sets dealing with marine animals and their sounds. This includes the CETACEA database for literature references and the variety of observational information accompanying animal sightings, as well as the library of oceanic recordings of animal sounds and the SOUND cut databases. These text databases perform admirably for organizing, cataloging, and sorting such discrete pieces and sequences of information.

The text databases with INMAGIC software have provided descriptive detail for organization of the material, and we anticipate that numeric representations of acoustic features, for example, will be transitioned to other, more interactive, relational systems. For extensive comparisons of the sound data from large components of the acoustic files, work with other database and analysis systems is planned. Even so, the fundamental relationships between textual records about the sound recordings and the behavioral descriptors relative to the acoustic data will necessarily continue to be needed, regardless of the database systems that are employed. The text-based data will always be significant, and the means for intelligent organization of these data will continue to be important.

USING THE SOUND DATABASES

The following instructions for using the text program for the SOUND database provide a quick, step-by-step guide to its use, and they show the basic simplicity of database operations. The current database organization is adapted for use with INMAGIC 7.2 software (Anon. 1990).

1. Call up the directory containing the INMAGIC software and enter the database program by typing INMAGIC.

2. Choose SELECT from the Main Menu for searching the database, for printing or displaying entries.
-- or choose MAINTAIN from the Main Menu for work within a database to edit old records or to add new ones.

3. Indicate the database that is desired, such as SOUND, SOUNDC, SOUND2, SOUND3C, etc.

4. Passwords may be indicated as required.

5. And then, searches and retrieval of records may be initiated.
-- or records may be called up for modification and new records entered into the database.

Any number of indexed fields may be sorted and retrieved rapidly (much less than a second), and even unindexed fields, such descriptive notes, can be easily searched for any alphanumerical string. The time required for searching unindexed fields varies with the amount of stored data.

6. Records that are selected may be displayed, sorted, printed, or exported as desired (sequentially through the list of selections). Digital sound files for each text record may also be accessed from within the search display, then analyzed by waveform and spectrogram as well as played back (digital to analog conversion) on loudspeakers.

7. It is important to EXIT properly after maintenance work on the databases, because of potential disruption of indexing operations that could scramble the data.

These operations are similar to those described in somewhat more detail for the earlier arrangements of the SOUND databases (Watkins, Fristrup, and Daher 1991) and for the literature reference CETACEA database (Watkins, Daher, and Haley 1990; Watkins, Bird, Moore, and Tyack 1988). See also the INMAGIC Manual (Anon. 1990) for detailed descriptions of the software functions and operations.

SEARCHING -- TEXT DATABASES

The SOUND database systems using INMAGIC software provide for organization and rapid handling of the textual data associated with the library of acoustic recordings of underwater sounds from animals. Indexed database fields are rapidly searched by specifying field labels or names by simple and by a variety of complex search strategies. Records (in any sequence) may be displayed, printed, or exported in a wide variety of formats defined by the user. Unlimited subfields may be indexed and searched in the same ways to provide extremely flexible and detailed sorting and retrieval of these text records.

Unindexed fields may be similarly searched for any word, phrase, or alphanumeric string, but at a slower rate.

Search commands may be combined with search relations to provide complex Boolean command sequences (including, excluding, broadening), word and word-stem searches, comparative searches (equals, starts with, greater/less than or equals, from...to), etc. Searchable, sorted data can be listed in a wide variety of ranges and formats.

The flexibility of the database software search system is combined with a system of coding assigned to the data. Codes are appended to each species, behaviors, sound types, etc. Therefore, the codes may also be used as a rapid search strategy. In addition, the species codes are used to make sure that different subjects, dates, places, etc. are always directly linked with species. Species codes have been assigned to each species by (1) order/suborder, (2) family, (3) genus, and (4) species. For example, a finback whale (Balaenoptera physalus) has the code "AC1F" -- indicating suborder Mysticeti, family Balaenopteridae, genus Balaenoptera, species physalus. See section on Organization of Species List (p. 41).

See the INMAGIC Manual (Anon. 1990) for additional search strategies.

DIGITAL SOUND FILES

Sequences of sound (cuts) from the repertoire of vocalizations of the different species of marine animals are selected from the original underwater recordings and digitized. These digital sound cuts (often 1 to 30 sec) are stored as separate files, and they are organized, indexed, and sorted by related text databases (SOUNDC, SOUND2C, etc.). The first 512 bytes of each digital sound cut file is a binary/ASCII header, including data from the SOUNDC database record for this sound sequence. This annotation includes such detail as the tape cue for the sound sample in the original recording, sampling rate, length of cut, observation date and place, species, associated behavior, etc. -- usually all of the database fields through "Note" (see sections on Data Structure on p. 18 and on Database Fields pp. 19-22). The digital sound cut files are labeled with an extension of the tape number from the original library recording to maintain continuity of the data (including year of recording, tape number, and number of this sound cut from this tape), as noted below for the sound cut numbering convention.

Example: 8821120F

88211	The complete library recording number.
88	The year of the original recording.
211	The recording number for that year.
20F	The digital sound cut number.
8821120F	The complete digital sound cut number.

All three places of the sound cut extension number use a 36-base character set -- employing numbers 0-9 and letters A-Z, in this order (20A follows 209, 5F0 follows 5EZ).

A different character is used for the first place of the sound cut extension (last three characters) to designate different series, channels, animals, sound types, etc.

The sound cut extension number 000 is not used (88211 and 88211000 are considered to be the same by the database program).

Digitizing the Sound Cuts --

A variety of systems may be used to provide the detailed scrutiny of the analog library recordings, to select sound sequences of interest, and to convert the sounds to digital format. Two signal analyzers used most often for creation of the files for the SOUND database include VOICE (Martin, Catipovic, Fristrup, and Tyack 1990) and a KAY DSP Sonagraph 5500 (Kay Elemetrics, Pine Brook, NJ). The analog library recordings are played back on appropriate equipment, and the sound is monitored aurally by good quality loudspeakers and visually by the real-time waveform and spectrographic displays of the signal analyzers. To provide an indication of the methodology for selection and digitizing of sound cuts, procedures and operations are listed using a PC computer, tape playback, and a KAY (DSP):

1. Computer -- call up the INMAGIC program and select the sound recording of interest. (See previous section on Searching the SOUND database.)
   a. Identify the recording number for digitizing.
      (Ex: Get RN = 65005).
   b. Write (copy) this record into an ASCII file using an annotation format, such as ANN
      (Ex: write using ANN in 65005.asc).

2. Computer -- call up the KAY (K) File Management Program.
   a. From the Main Menu select "System".
   b. Choose "Data Path" and indicate Drive and Path for downloading of digitized signal files.
   c. Choose "Interface" and select "SCSI".
   d. Choose "I/O" and select "From 5500".
   (To open "Data Transfer Menu"):
      1. "File Format" = 5500.
      2. "Number of Bits" = 8, 10, 12 or 16.
      3. "Channel" = 1 or 2.
      4. "Source" = Buffer, Between Cursors, Screen, or Highlighted List.
      5. "Name of File" = Sound cut number.KAY
         Digital filename (Ex: 65005001.KAY).
         Leave cursor blinking until download.

3. Playback -- Mount and play selected recording.
   Locate sound sequence for digitization.

4. KAY DSP-- set the analyzer for real time analysis.
   a. Copy (digitize) sound onto KAY buffer and scroll through (waveform and spectrographic displays).
   b. Locate signal within parameters to be downloaded (Buffer, Between Cursors, Screen).

5. Computer -- still in the KAY File Management Program:
   a. Press [Ret] to accept the KAY file selected (named above with .KAY extension).
   b. Press [F2] to transfer digital signal from the KAY to the designated Drive and Path.
   c. Exit KAY program if no more is to be transferred or remain in KAY program for more signals.

6. Computer -- call up SideKick Plus (TSR editor utility sharing KAY program on screen).
   a. Access the ASCII text file created in #1 above.
   b. Rename this record, giving it the same number as the digital sound cut (in #2), TXT/ASC extension.
   c. Update the text information appropriate to sound cut (digital file just downloaded #5).
   d. Save the changes made to this file (press [F2]) and exit SideKick Plus program.

7. Computer -- call up the MASSEDIT program (to attach header information to digital files).
   a. Indicate the ASCII file (made in #6) containing the updated text information for the sound cut files.
   b. Designate the Drive/Directory for the digital files (Ex: MASSEDIT 65005.TXT D:).

8. Computer -- call up the INMAGIC database program (to index sound cut records in SOUNDC database).
   a. Choose MAINTAIN from the Main Menu.
   b. Select appropriate database (SOUNDC, SOUND2C, etc.)
   c. ADD the ASCII text file modified (#6) in SideKick (Ex: Add 65005.TXT) to index the new edited data records into (sound cut) SOUNDC text database.

9. Computer -- from within the INMAGIC database program:
   a. Search the SOUNDC (sound cut) text database for the sound sequence of interest (see Searching -- Text Databases, p. 29).
   b. Display the text data for the sound sequence.
   c. Using RSIG, analyze this sound on screen (a key stroke), waveform and spectrographic analyses.
   d. Return to text data for this sound (a key stroke).
   e. Listen to this sound, D-to-A conversion and playback of the sound (a key stroke).

PROGRAMS FOR THE SOUND DATABASES

A variety of programs have been designed or adapted for work with the SOUND databases and their associated digital sound cut files. The basic set of programs for these marine animal sound databases was described in detail by Fristrup, Daher, Howald, and Watkins 1992. Some of these are listed and discussed briefly below.

INMAGIC	--	Text database index and search.
SIDEKICK PLUS	--	Text ASCII data editor and transfer.
HEADEDIT	--	Edit annotation of one sound cut file.
MASSEDIT	--	Annotate one or more sound cut files.
KAYCHECK	--	Check data in file headers.
CSIG	--	Analyze and playback sound cut file without database involvement.
RSIG	--	Analyze and playback sound cut file from within text database.

INMAGIC is the current database software for organizing, indexing, sorting, and retrieving records containing information about the library collection of sound recordings, and the digital sound cuts. Program adapted from software by INMAGIC INC., Cambridge, MA (Anon. 1990).

SIDEKICK PLUS is a pop-up utility (TSR) program used to access and modify ASCII text (database output), for example, from the SOUND database to provide appropriate text data for the sound cut files to be indexed in the SOUNDC databases. Software by Borland International, Scotts Valley, CA.

HEADEDIT program allows display and editing of ASCII text header on individual digital sound files (usage: HEADEDIT FILENAME.KAY). The binary data written by the download program for the KAY DSP 5500 Sonagraph (including number of samples, sampling rate, and number of bits per sample) are displayed also but are not available for editing. HEADEDIT may be used to read the header data, change existing header text, or enter new data. New text data for the header may be entered as blocks of new data by means of a utility program such as SKPLUS, or text may be typed in place directly with HEADEDIT. Program by Kurt Fristrup.

MASSEDIT program is used to insert ASCII text into headers on one or a number of files at one operation (HEADEDIT works with one file at a time). The text data are inserted into the header space, the first 512 bytes of each digital sound file. This header space and some identifying binary code is provided by the KAY download program of the Kay Sonagraph (DSP 5500). The header data typically include the first fields of the sound cut text record (SOUNDC database) through at least the NOTE field, allowing direct connection of the information about the recording with the appropriate digital sound file. MASSEDIT matches the record retrieval numbers and ASCII data sets of a specified file (having .TXT or .ASC extension) to the appropriate files (with .KAY extension) in a specified directory (Usage: MASSEDIT FILENAME.TXT D:). See example in #7, p. 32. Program by Kurt Fristrup.

KAYCHECK is a comparison program that searches for every .KAY file (format for KAY download program) in the current directory, and checks the header text data (first 512 bytes on the digital file) for accuracy of the text information on filename, sample rate, file size, etc. Files that are found to have discrepancies or are without a proper header are identified, with date, time, and size of file indicated. The output of KAYCHECK may be written to another file (usage: KAYCHECK>FILENAME) for printing or editing. Program by Kurt Fristrup.

CSIG program provides access, analysis, and display of files of digitized sound (independent of databases). CSIG accesses the specified sound file, analyzes, and displays waveform (top of screen) and concurrent spectrographic analyses (bottom of screen). Analyses are FFT-based systems or point-by-point techniques using RID (W. Williams, Univ. Michigan). Frequency and time scales and variable cursors are provided. Portions of the displayed analysis may be selected and re-analyzed. All or any part of the data file may be exported. In addition, the digital file may be converted to an analog signal and played back repeatedly on a loudspeaker (a keystroke). See section below on Operating Commands, p. 36. Program by Kurt Fristrup and Terrance Howald.

RSIG is a TSR (terminal stay resident) program used for access, analysis, display, and playback of the digital sound file from within the SOUNDC database. Just as for CSIG, above, spectrographic analyses are FFT-based systems or point-by-point techniques using RID (W. Williams, Univ. Michigan). Each sound cut may be immediately analyzed while the text data record for that cut is displayed on screen by the database. RSIG is loaded as a TSR utility before database selections are made, then file access and analyses are initiated (a key stroke) from within the database. At anytime, the screen display may be returned immediately to the text data record, re-analyzed, or any segment of the display expanded for further analysis. Any sequence or number of files selected by the database may be accessed, analyzed, and displayed in turn. All or any part of the data file may be exported. In addition, the digital file may be converted to an analog signal and played back repeatedly by loudspeaker. See section below on Operating Commands, p. 38. Program by Kurt Fristrup and Terrance Howald.

Operating Commands for CSIG and RSIG --

CSIG operates independently from the SOUND database
Usage: CSIG filename; [ESC] exits program.

RSIG is used during database operations and is first loaded as a TSR utility into the sound file directory.

From the text database display:

[Alt] [Esc]	Invokes RSIG which accesses the selected digital sound file, draws signal waveform and spectrogram, and sound playback.
[Esc]	Ends this analysis and re-displays text.

Key Functions for CSIG and RSIG

[Alt] [D]	Re-draws analysis screen with defaults.
[Up/Down Arrows]	Move (horizontal) frequency cursor up/down.
[Left/Right Arrows]	Move (vertical) time cursor left/right.
[Ctrl] [Left/Right Arrows]	5 X speedup time cursor movement.
[Home]	Toggle left/right (vertical) time cursor.
[PgDn]	Zoom in to re-display data between cursors.
[PgUp]	Return to previous display bounds.
[F7]	Move backward partial (1/3) screen.
[F8]	Move forward partial (1/3) screen.
[F9]	Move backward full screen.
[F10]	Move forward full screen.
[Ctrl] [PrtSc]	Write data between cursors to a file.
[Alt] [X]	Save cursor information to SIGCURSE.DAT.
[Alt] [P]	Playback data on screen, between cursors.
[ALT] [F1]	Increase playback rate by two.
[Alt] [F2]	Decrease playback rate by half.
[Alt] [F]	Toggle full-screen waveform display.
[Alt] [N]	Toggle noise compensation.
[Ins]	Increase dynamic range by 3 dB.
[Del]	Decrease dynamic range by 3 dB.
[Ctrl] [Home]	Increase signal level (attenuator) 3 dB.
[Ctrl] [End]	Decrease signal level (attenuator) 3 dB.
[Alt] [F5]	Increase FFT size two times for spectrogram.
[Alt] [F6]	Decrease FFT size by half for spectrogram.
[Alt] [F8]	RID 1st order spectral decomposition, raise to 9th, 17th order (additional keystrokes).
[Alt] [F9]	RID lower order spectral decomposition.

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SPECIES LIST -- SOUND Databases

SPECIES LIST -- SOUND Databases

Organization of the Species List --

The Species List for the SOUND Databases have undergone only minor modification since the previous description of the system (Watkins, Fristrup, and Daher 1991). This is the same species list as that developed for the CETACEA literature database (Watkins, Bird, Moore, and Tyack 1988; Watkins, Daher, and Haley 1990). Species are listed alphabetically within families. Alphanumeric codes have been assigned by (1) order/suborder, (2) family, (3) genus, and (4) species, in ascending alphanumeric order.

The first place of the species code is a letter representing the order or suborder. The letter "A" denotes the suborder Mysticeti and includes 11 species. The letter "B" denotes the suborder Odontoceti and includes 68 species. The letter "C" denotes the order Carnivora, including 37 species of pinnipeds, sea otters, and polar bear. The letter "D" denotes Sirenia and includes 5 species. Other orders and suborders are included in general categories and are coded by letter (E-Z).

The second place of the species code is a letter representing the family. For example, in the Species List the Balaenopteridae are indicated as code "AC" -- order/suborder Mysticeti "A" and family Balaenopteridae "C". The code for the Ziphiidae is "BC" -- order/suborder Odontoceti "B", family Ziphiidae "C".

The third place of the species code is a number containing one or two digits representing the genus. For example, the code for the genus Mesoplodon is "BC5" -- order/suborder Odontoceti "B", family Ziphiidae "C", genus Mesoplodon "5". The code for the genus Kogia is "BA1"-- order/suborder Odontoceti "B", family Physeteridae "A", genus Kogia "1". The code for the genus Stenella is "BD15" -- order/suborder Odontoceti "B", family Delphinidae "D", and genus Stenella "15").

The last place of the species code is a letter representing species. For example, the code for Kogia breviceps is "BA1A" (suborder Odontoceti "B", family Physeteridae "A", genus Kogia "1", species breviceps "A"). The code for the related species, Kogia simus is "BA1B". The code for Cephalorhynchus hectori is "BD1D" (suborder Odontoceti "B", family Delphinidae "D", genus Cephalorhynchus "1", species hectori "D"). Both the scientific names and the genus/species codes are given in the GENSP field -- for example, a finback whale will have "Balaenoptera physalus AC1F" in the genus/species field.

SPECIES LIST -- SOUND Databases

Mysticeti ------------- A	
Balaenidae -------- AA	
Balaena mysticetus Linnaeus 1758	AA1A
Eubalaena glacialis (Borowski) 1781	AA3A
Eubalaena australis (Desmoulins) 1822	AA3B
Eschrichtiidae ---- AB	
Eschrichtius robustus (Lilljeborg) 1861	AB1A
Balaenopteridae --- AC	
Balaenoptera acutorostrata Lacépède 1804	AC1A
Balaenoptera bonaerensis Burmeister 1867	AC1D
Balaenoptera borealis Lesson 1828	AC1B
Balaenoptera edeni Anderson 1878	AC1C
Balaenoptera musculus (Linnaeus) 1758	AC1E
Balaenoptera physalus (Linnaeus) 1758	AC1F
Megaptera novaeangliae (Borowski) 1781	AC2A
Neobalaenidae ----- AD	
Caperea marginata (Gray) 1846	AD1A
Odontoceti ------------ B	
Physeteridae ------ BA	
Kogia breviceps (Blainville) 1838	BA1A
Kogia simus (Owen) 1866	BA1B
Physeter catodon Linnaeus 1758	BA2A
Monodontidae ------ BB	
Delphinapterus leucas (Pallas) 1776	BB1A
Monodon monoceros Linnaeus 1758	BB2A
Ziphiidae --------- BC	
Berardius arnuxii Duvernoy 1851	BC1A
Berardius bairdii (Stejneger) 1883	BC1B
Hyperoodon ampullatus (Forster) 1770	BC2A
Hyperoodon planifrons Flower 1882	BC2B
Indopacetus pacificus (Longman) 1926	BC3D
Mesoplodon bidens (Sowerby) 1804	BC5A
Mesoplodon bowdoini Andrews 1908	BC5B
Mesoplodon carlhubbsi Moore 1963	BC5C
Mesoplodon densirostris (Blainville) 1817	BC5D
Mesoplodon europaeus Gervais 1855	BC5E
Mesoplodon ginkgodens Nishiwaki and Kamiya 1958	BC5H
Mesoplodon grayi von Haast 1876	BC5J
Mesoplodon hectori (Gray) 1871	BC5K
Mesoplodon layardii (Gray) 1865	BC5L
Mesoplodon mirus True 1913	BC5M
Mesoplodon peruvianus Reyes, Mead, Waerebeek 1991	BC5P
Mesoplodon stejnegeri True 1885	BC5S
Tasmacetus shepherdi Oliver 1937	BC7A
Ziphius cavirostris G. Cuvier 1823	BC9A

SPECIES LIST -- SOUND Databases

Delphinidae --------- BD	
<u>Cephalorhynchus</u> <u>commersonii</u> Lacépède 1804	BD1A
<u>Cephalorhynchus</u> <u>eutropia</u> (Gray) 1846(9?)	BD1B
<u>Cephalorhynchus</u> <u>heavisidii</u> (Gray) 1828	BD1C
<u>Cephalorhynchus</u> <u>hectori</u> van Beneden 1881	BD1D
<u>Delphinus</u> <u>bairdii</u> Dall 1873	BD3A
<u>Delphinus</u> <u>delphis</u> Linnaeus 1758	BD3B
<u>Delphinus</u> <u>tropicalis</u> van Bree 1971	BD3C
<u>Grampus</u> <u>griseus</u> (Cuvier) 1812	BD4A
<u>Lagenodelphis</u> <u>hosei</u> Fraser 1957	BD5A
<u>Lagenorhynchus</u> <u>acutus</u> (Gray) 1828	BD6A
<u>Lagenorhynchus</u> <u>albirostris</u> Gray 1846	BD6B
<u>Lagenorhynchus</u> <u>australis</u> (Peale) 1848	BD6C
<u>Lagenorhynchus</u> <u>cruciger</u> (Quoy and Gaimard) 1824	BD6E
<u>Lagenorhynchus</u> <u>obliquidens</u> Gill 1865	BD6G
<u>Lagenorhynchus</u> <u>obscurus</u> (Gray) 1828	BD6H
<u>Lissodelphis</u> <u>borealis</u> (Peale) 1848	BD8A
<u>Lissodelphis</u> <u>peronii</u> (Lacépède) 1804	BD8B
<u>Peponocephala</u> <u>electra</u> (Gray) 1846	BD10A
<u>Sotalia</u> <u>borneensis</u> Lydekker 1901	BD12A
<u>Sotalia</u> <u>brasiliensis</u> Van Beneden 1875	BD12C
<u>Sotalia</u> <u>fluviatilis</u> (Gervais) 1855	BD12B
<u>Sotalia</u> <u>guianensis</u> Van Beneden 1864	BD12D
<u>Sousa</u> <u>chinensis</u> (Osbeck) 1765	BD13A
<u>Sousa</u> <u>plumbea</u> (Cuvier) 1829	BD13B
<u>Sousa</u> <u>tëuszii</u> (Kukënthal) 1892	BD13C
<u>Stenella</u> <u>attenuata</u> (Gray) 1846	BD15A
<u>Stenella</u> <u>clymene</u> Gray 1850	BD15B
<u>Stenella</u> <u>coeruleoalba</u> (Meyen) 1833	BD15C
<u>Stenella</u> <u>frontalis</u> (G. Cuvier) 1829	BD15F
<u>Stenella</u> <u>longirostris</u> (Gray) 1828	BD15L
<u>Steno</u> <u>bredanensis</u> (Cuvier) 1828	BD17A
<u>Tursiops</u> <u>aduncus</u> (Ehrenberg) 1832	BD19A
<u>Tursiops</u> <u>catalania</u> (Gray) 1868	BD19B
<u>Tursiops</u> <u>gillii</u> Dall 1873	BD19C
<u>Tursiops</u> <u>truncatus</u> (Montagu) 1821	BD19D
Globicephalidae - BE	
<u>Feresa</u> <u>attenuata</u> Gray 1874	BE1A
<u>Globicephala</u> <u>edwardii</u> Smith 1934	BE3A
<u>Globicephala</u> <u>macrorhynchus</u> (Gray) 1846	BE3B
<u>Globicephala</u> <u>melaena</u> (Traill) 1809	BE3C
<u>Globicephala</u> <u>scammoni</u> Cope 1869	BE3D
<u>Orcaella</u> <u>brevirostris</u> (Owen 1866)	BE5A
<u>Orcaella</u> <u>fluminalis</u> Anderson 1871	BE5B
<u>Orcinus</u> <u>orca</u> (Linnaeus) 1758	BE7A
<u>Pseudorca</u> <u>crassidens</u> (Owen) 1846	BE9A
Phocoenidae ------- BF	
<u>Australophocaena</u> <u>dioptrica</u> Lahille 1912	BF1A
<u>Phocoena</u> <u>phocoena</u> (Linnaeus) 1758	BF2A
<u>Phocoena</u> <u>spinipinnis</u> Burmeister 1865	BF2B

Phocoenidae -- (continued)

Phocoena sinus Norris and McFarland 1958	BF2C
Phocoenoides dalli (True) 1885	BF4A
Neophocaena phocaenoides (G.Cuvier) 1829	BF6A
Susuidae ---------- BG	
Susu gangetica Lebeck 1801	BG1A
Susu indii Blyth 1859	BG1B
Inia geoffrensis Blainville 1817	BG2A
Lipotes vexillifer Miller 1918	BG3A
Pontoporia blainvillei (Gervais) 1844	BG4A
Carnivora ------------- C	
Otariidae --------- CA	
Arctocephalus australis (Zimmerman) 1783	CA1A
Arctocephalus forsteri Lesson 1828	CA1F
Arctocephalus galapagoensis Heller 1904	CA1G
Arctocephalus gazella Peters 1875	CA1H
Arctocephalus philippii Peters 1866	CA1P
Arctocephalus pusillus (Schreber) 1776	CA1R
Arctocephalus townsendi Merriam 1897	CA1T
Arctocephalus tropicalis (Gray) 1872	CA1W
Callorhinus ursinus (Linnaeus) 1758	CA2A
Eumetopias jubatus (Schreber) 1776	CA3B
Neophoca cinerea (Peron) 1816	CA4A
Otaria flavescens (Shaw) 1800	CA6A
Phocarctos hookeri (Gray) 1844	CA8A
Zalophus californianus (Lesson) 1828	CA9A
Odobenidae -------- CB	
Odobenus rosmarus (Linnaeus) 1758	CB1A
Phocidae ---------- CC	
Cystophora cristata (Erxleben) 1777	CC1A
Erignathus barbatus (Erxleben) 1777	CC2A
Halichoerus grypus (Fabricius) 1791	CC3A
Hydrurga leptonyx (Blainville) 1820	CC4A
Leptonychotes weddellii (Lesson) 1826	CC5A
Lobodon carcinophagus (Hombron & Jacquinot) 1842	CC6A
Monachus monachus (Hermann) 1779	CC8A
Monachus schauinslandi Matschie 1905	CC8B
Monachus tropicalis Gray 1850	CC8C
Mirounga angustirostris Gill 1866	CC10A
Mirounga leonina (Linnaeus) 1758	CC10B
Phoca caspica Gmelin 1788	CC12C
Phoca fasciata Zimmermann 1783	CC12F
Phoca groenlandica Erxleben 1777	CC12G
Phoca hispida Schreber 1775	CC12H
Phoca largha Pallas 1811	CC12L
Phoca sibirica Gmelin 1788	CC12S
Phoca vitulina Linnaeus 1758	CC12V
Ommatophoca rossi Gray 1844	CC14A
Mustelidae -------- CD	
Enhydra lutris (Linnaeus) 1758	CD1A
Lutra felina Molina 1782	CD2B

SPECIES LIST -- SOUND Databases

Ursidae ------------ CE
Ursus maritimus Phipps 1774 CE1A

Sirenia ---------------- D
Dugongidae --------- DA
Dugong dugon Muller 1776 DA1A
Hydrodamalis gigas Zimmermann 1780 DA2B

Trichechidae ------- DB
Trichechus inunguis (Natterer) 1883 DB1A
Trichechus manatus Linnaeus 1758 DB1B
Trichechus senegalensis Link 1795 DB1C

OTHER MAMMALS
Primates --------------------- E
Chiroptera ------------------- F
Ungulates, *sensu lato* -------- G
Elephantidae --------------------------- GA
Elephas maximus Linnaeus 1758 GA1A
Loxodonta africana (Blumenbach) 1797 GA2A

Other mammals ---------------- H

VERTEBRATES
Aves ------------------------- I
Reptilia --------------------- J
Amphibia --------------------- K
Fish, *sensu lato* ------------- L
Other vertebrates ------------ S

INVERTEBRATES
Molluscs
Cephalopoda ------------- M
Other molluscs ---------- N
Arthropods
Crustacea --------------- O
Insecta ----------------- P
Other arthropods -------- Q
Other invertebrates ---------- R

GENERAL
Fossils ------------------------------ T
Uncertain (sea serpents and
other indeterminate animals) ----- U
General pinniped --------------------- V
General cetacean --------------------- W
Ambient noise (ship, geologic, ice) --- X
General mammal ----------------------- Y
Animals in general ------------------- Z

COMMON NAMES FOR MARINE ANIMALS

List of Common Names for Marine Animals --

The "common" names given to different species of marine animals vary considerably, with only a few of these names consistently used by English speakers. Other language areas, of course, have their own (variable) set of common names. For accuracy, therefore, the databases always use the scientific nomenclature. However, for cross-reference, we have included the following list of some of the most commonly used names for these animals. The common names are listed in the same order, directly with the scientific names and the species codes used by the databases. Many species are not well known by any but their scientific names -- it is always acceptable, and often much easier, to refer to these marine animals by their scientific names. The scientific nomenclature is recognized worldwide, regardless of language.

COMMON NAMES FOR MARINE ANIMALS

Baleen whales (Mysticeti) -- A	
Family Balaenidae ----------- AA	
Bowhead whale -- Balaena mysticetus	AA1A
Northern right whale -- Eubalaena glacialis	AA3A
Southern right whale -- Eubalaena australis	AA3B
Family Eschrichtiidae ------- AB	
Gray whale -- Eschrichtius robustus	AB1A
Family Balaenopteridae ------ AC	
Minke whale -- Balaenoptera acutorostrata	AC1A
Southern minke whale -- Balaenoptera bonaerensis	AC1D
Sei whale -- Balaenoptera borealis	AC1B
Bryde's whale -- Balaenoptera edeni	AC1C
Blue whale -- Balaenoptera musculus	AC1E
Fin, Finback whale -- Balaenoptera physalus	AC1F
Humpback whale -- Megaptera novaeangliae	AC2A
Family Neobalaenidae -------- AD	
Pygmy right whale -- Caperea marginata	AD1A
Toothed whales (Odontoceti) -- B	
Family Physeteridae --------- BA	
Pygmy sperm whale -- Kogia breviceps	BA1A
Dwarf sperm whale -- Kogia simus	BA1B
Sperm whale -- Physeter catodon	BA2A
Family Monodontidae --------- BB	
Beluga, white whale -- Delphinapterus leucas	BB1A
Narwhal -- Monodon monoceros	BB2A
Family Ziphiidae ------------ BC	
Arnoux bottlenose whale -- Berardius arnuxii	BC1A
Baird's bottlenose -- Berardius bairdii	BC1B
Northern bottlenose -- Hyperoodon ampullatus	BC2A
Southern bottlenose -- Hyperoodon planifrons	BC2B
-- Indopacetus pacificus	BC3D
Sowerby's beaked whale -- Mesoplodon bidens	BC5A
-- Mesoplodon bowdoini	BC5B
Hubb's beaked whale -- Mesoplodon carlhubbsi	BC5C
Blainville's beaked -- Mesoplodon densirostris	BC5D
-- Mesoplodon europaeus	BC5E
-- Mesoplodon ginkgodens	BC5H
-- Mesoplodon grayi	BC5J
Hector's beaked whale -- Mesoplodon hectori	BC5K
-- Mesoplodon layardii	BC5L
True's beaked whale -- Mesoplodon mirus	BC5M
-- Mesoplodon peruvianus	BC5P
-- Mesoplodon stejnegeri	BC5S
Tasman beaked whale -- Tasmacetus shepherdi	BC7A
Cuvier's, goose-beaked -- Ziphius cavirostris	BC9A

COMMON NAMES FOR MARINE ANIMALS

Family Delphinidae (dolphins) ------------- BD

Commerson's dolphin _Cephalorhynchus commersonii_ BD1A
-- _Cephalorhynchus eutropia_ BD1B
-- _Cephalorhynchus heavisidii_ BD1C
Hector's dolphin -- _Cephalorhynchus hectori_ BD1D
Pacific common dolphin -- _Delphinus bairdii_ BD3A
Saddleback, common dolphin -- _Delphinus delphis_ BD3B
-- _Delphinus tropicalis_ BD3C
Grampus, Risseau's dolphin -- _Grampus griseus_ BD4A
Fraser's dolphin -- _Lagenodelphis hosei_ BD5A
White-sided dolphin -- _Lagenorhynchus acutus_ BD6A
White-beaked dolphin _Lagenorhynchus albirostris_ BD6B
Peale's dolphin -- _Lagenorhynchus australis_ BD6C
-- _Lagenorhynchus cruciger_ BD6E
Pacific white-sided _Lagenorhynchus obliquidens_ BD6G
Dusky dolphin -- _Lagenorhynchus obscurus_ BD6H
North. rt. whale dolphin - _Lissodelphis borealis_ BD8A
South. rt. whale dolphin -- _Lissodelphis peronii_ BD8B
-- _Peponocephala electra_ BD10A
Borneo dolphin -- _Sotalia borneensis_ BD12A
Amazon dolphin -- _Sotalia brasiliensis_ BD12C
-- _Sotalia fluviatilis_ BD12B
Guiana dolphin -- _Sotalia guianensis_ BD12D
Chinese river dolphin -- _Sousa chinensis_ BD13A
-- _Sousa plumbea_ BD13B
-- _Sousa tëuszii_ BD13C
Spotted dolphin -- _Stenella attenuata_ BD15A
-- _Stenella clymene_ BD15B
Striped dolphin -- _Stenella coeruleoalba_ BD15C
-- _Stenella frontalis_ BD15F
Spinner dolphin -- _Stenella longirostris_ BD15L
Rough-toothed dolphin -- _Steno bredanensis_ BD17A
Southern bottlenose dolphin -- _Tursiops aduncus_ BD19A
-- _Tursiops catalania_ BD19B
Pacific bottlenose dolphin -- _Tursiops gillii_ BD19C
Bottlenose dolphin, Atlantic-- _Tursiops truncatus_ BD19D

Family Globicephalidae (small toothed whales) -- BE

-- _Feresa attenuata_ BE1A
Southern pilot whale -- _Globicephala edwardii_ BE3A
Short-finned pilot -- _Globicephala macrorhynchus_ BE3B
Long-finned pilot -- _Globicephala melaena_ BE3C
Pacific pilot whale -- _Globicephala scammoni_ BE3D
Irrawaddy dolphin -- _Orcaella brevirostris_ BE5A
-- _Orcaella fluminalis_ BE5B
Killer whale -- _Orcinus orca_ BE7A
False killer -- _Pseudorca crassidens_ BE9A

Family Phocoenidae (porpoises) -- BF

-- _Australophocaena dioptrica_ BF1A
Harbor porpoise -- _Phocoena phocoena_ BF2A
Burmeister's porpoise -- _Phocoena spinipinnis_ BF2B
-- _Phocoena sinus_ BF2C

COMMON NAMES FOR MARINE ANIMALS

Family Phocoenidae (porpoises -- continued)	
Dall's porpoise -- Phocoenoides dalli	BF4A
Finless porpoise -- Neophocaena phocaenoides	BF6A
Family Susuidae (dolphins -- River & South) -- BG	
Ganges river dolphin -- Susu gangetica	BG1A
Indus river dolphin -- Susu indii	BG1B
Boutu (Amazon river) -- Inia geoffrensis	BG2A
Yangtze river dolphin -- Lipotes vexillifer	BG3A
Franciscana -- Pontoporia blainvillei	BG4A
Seals, Sea otters, etc. (Carnivora) -- C	
Family Otariidae (fur seals, sea lions) ------ CA	
Southern fur seal -- Arctocephalus australis	CA1A
N. Z. fur seal -- Arctocephalus forsteri	CA1F
Galapagos fur -- Arctocephalus galapagoensis	CA1G
Kerguelen fur -- Arctocephalus gazella	CA1H
Juan Fernandez fur -- Arctocephalus philippii	CA1P
South African fur -- Arctocephalus pusillus	CA1R
-- Arctocephalus townsendi	CA1T
-- Arctocephalus tropicalis	CA1W
Northern fur seal -- Callorhinus ursinus	CA2A
Steller sea lion -- Eumetopias jubatus	CA3B
Australian sea lion -- Neophoca cinerea	CA4A
Southern sea lion -- Otaria flavescens	CA6A
N. Z. sea lion -- Phocarctos hookeri	CA8A
California sea lion -- Zalophus californianus	CA9A
Family Odobenidae (walrus) ------------------ CB	
Walrus -- Odobenus rosmarus	CB1A
Family Phocidae (seals) --------------------- CC	
Hood seal -- Cystophora cristata	CC1A
Bearded seal -- Erignathus barbatus	CC2A
Gray seal -- Halichoerus grypus	CC3A
Leopard seal -- Hydrurga leptonyx	CC4A
Weddell seal -- Leptonychotes weddellii	CC5A
Crabeater seal -- Lobodon carcinophagus	CC6A
Med. monk seal -- Monachus monachus	CC8A
Hawaiian monk seal -- Monachus schauinslandi	CC8B
Caribbean monk seal -- Monachus tropicalis	CC8C
North elephant seal -- Mirounga angustirostris	CC10A
South elephant seal -- Mirounga leonina	CC10B
Caspian seal -- Phoca caspica	CC12C
Ribbon seal -- Phoca fasciata	CC12F
Harp seal -- Phoca groenlandica	CC12G
Ringed seal -- Phoca hispida	CC12H
Spotted seal -- Phoca largha	CC12L
Baikal seal -- Phoca sibirica	CC12S
Harbor seal -- Phoca vitulina	CC12V
Ross seal -- Ommatophoca rossi	CC14A
Family Mustelidae (sea otter) --------------- CD	
Sea otter -- Enhydra lutris	CD1A
-- Lutra felina	CD2B

COMMON NAMES FOR MARINE ANIMALS

Family Ursidae (polar bear) ------------------- CE
Polar bear -- _Ursus maritimus_ CE1A

Manatees (Sirenia) ---------------- D

Family Dugongidae (dugong) ------------------- DA
Dugong -- _Dugong dugon_ DA1A
-- _Hydrodamalis gigas_ DA2B

Family Trichechidae (manatee) ---------------- DB
Amazonian manatee -- _Trichechus inunguis_ DB1A
West Indies manatee -- _Trichechus manatus_ DB1B
West African manatee -- _Trichechus senegalensis_ DB1C

OTHER MAMMALS
Primates --------------------- E
Chiroptera ------------------- F
Ungulates, _sensu lato_ -------- G
Family Elephantidae (Elephants) --------- GA
Indian elephant -- _Elephas maximus_ GA1A
African elephant -- _Loxodonta africana_ GA2A

Other mammals ---------------- H

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Aves ------------------------- I
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Amphibia --------------------- K
Fish, _sensu lato_ ------------- L
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Animals in general -------------------- Z

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16. Abstract (Limit: 200 words)

The SOUND database system for marine animal vocalizations has been updated to include changes in the structure and operations that have evolved with use. These include more convenient operations, greater flexibility in analysis routines, and a revised database structure. The formats for data sorting and indexing, database structure, and analysis routines have developed into a convenient research tool. This report is a revision of the earlier operating manual for the SOUND databases (Watkins, Fristrup, and Daher 1991.)

The interactive databases that comprise the SOUND system provide comprehensive means for quantitative analyses and statistical comparisons of marine animal vocalizations. These SOUND databases encompass (1) descriptive text databases cataloging the WHOI collection of underwater sound recordings of marine animals, (2) sets of files of digital sound sequences, (3) text databases organizing the digital sound cuts, and (4) software for analysis, display, playback, and export of selected sound files. The text databases index and sort the information about the sounds, and the digital sound cut files are accessed directly from the text record. From the text database, the sound cut data may be analyzed on screen, listened to, and compared or exported as desired.

The objective of this work has been the development of a basic set of tools for the study of marine animal sound. The text databases for cataloging the recordings provide convenient sorting and selection of sounds of interest. Then, as specific sequences are digitized from these recordings, they become part of another database system that manages these acoustic data. Once a digital sound is part of the organized database, several tools are available for interactive specrographic display, sound playback, statistical feature extraction, and export to other application programs.

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