Database documentation: acoustic

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Contents

1 Introduction

The National Institute of Water and Atmospheric Research (NIWA) currently carries out the role of Data Manager and Custodian for the fisheries research data owned by the Ministry of Fisheries.

The Ministry of Fisheries data set incorporates historic research data, data collected more recently by MAF Fisheries prior to the split in 1995 of policy to the Ministry of Fisheries and research to NIWA, and currently data collected by NIWA and other agencies for the Ministry of Fisheries.

This document is a brief introduction to the **acoustic** database, and is part of the database documentation series produced by NIWA. All documents in this series include an introduction to the database design, a description of the main data structures, and a listing of all the main tables.

This document is intended as a guide for users and administrators of the **acoustic** database.

Access to the database and data is restricted to specific Nominated Personnel as specified in the current Schedule 6 of the Data Management contract between the Ministry of Fisheries and NIWA. Any requests for data should in the first instance be directed to the Ministry of Fisheries.

Acoustic data collection

The **acoustic** database is designed for the storage of acoustic data. The data were collected using an *echosounder* either mounted on a vessel, towed by a vessel, or in a fixed location. The performance and characteristics of the echosounders used vary widely but generally involve sophisticated electronic equipment and associated software. A detailed description of how and why acoustic data are collected is given in MacLennan & Simmonds (1992). The echosounders used to collect the acoustic data have changed considerably over the years, driven mainly by advances in electronic and computer technologies. However, the basic data have remained the same.

The echosounder periodically emits a pulse of sound (it 'pings') and then listens for echoes of this pulse. The range and amplitude of the echoes are measured and stored. Associated data such as the date, time, and vessel position are also periodically stored. Depending on the particular equipment that was used to collect the data, there may also be other data such as vessel velocity and echosounder settings.

The **acoustic** database contains approximately 65 GBytes of data (as of June 2000), collected from acoustic surveys starting in the year 1984 through to 1999. Species on which acoustic data have been collected include hoki, hake, smooth and black oreos, orange roughy, and southern blue whiting. Areas from which these data have been collected include the Chatham Rise, the Campbell Plateau, the west coast of the South Island, Cook Strait and various inshore regions around New Zealand. The data are used primarily to estimate the biomass of fish species for the Ministry of Fisheries.

3 Data structures

3.1 Introduction

The acoustic data are stored in an object-oriented database. Currently, the **acoustic** database is implemented using the ObjectStore product from eXcelon Corporation. Access to the data are provided via purpose-built programs that use the ObjectStore API to store and retrieve the acoustic data.

3.2 Acoustic data

The acoustic data are divided into groups, corresponding to the data collected on a particular voyage. In each voyage the acoustic data are structured into a number of *transects*. These typically correspond to the data collected while moving the echosounder in a straight line between two pre-determined points. The acoustic data collected in each transect is further divided into groups of all the echoes received from a single ping.

The **acoustic** database is implemented using a number of objects that represent aspects of the data structure. The main objects are *Data*, *Navigation, Transect, SystemParameters* and DataRepresentation. The relationships between, and attributes in these objects are given in Figure 1.

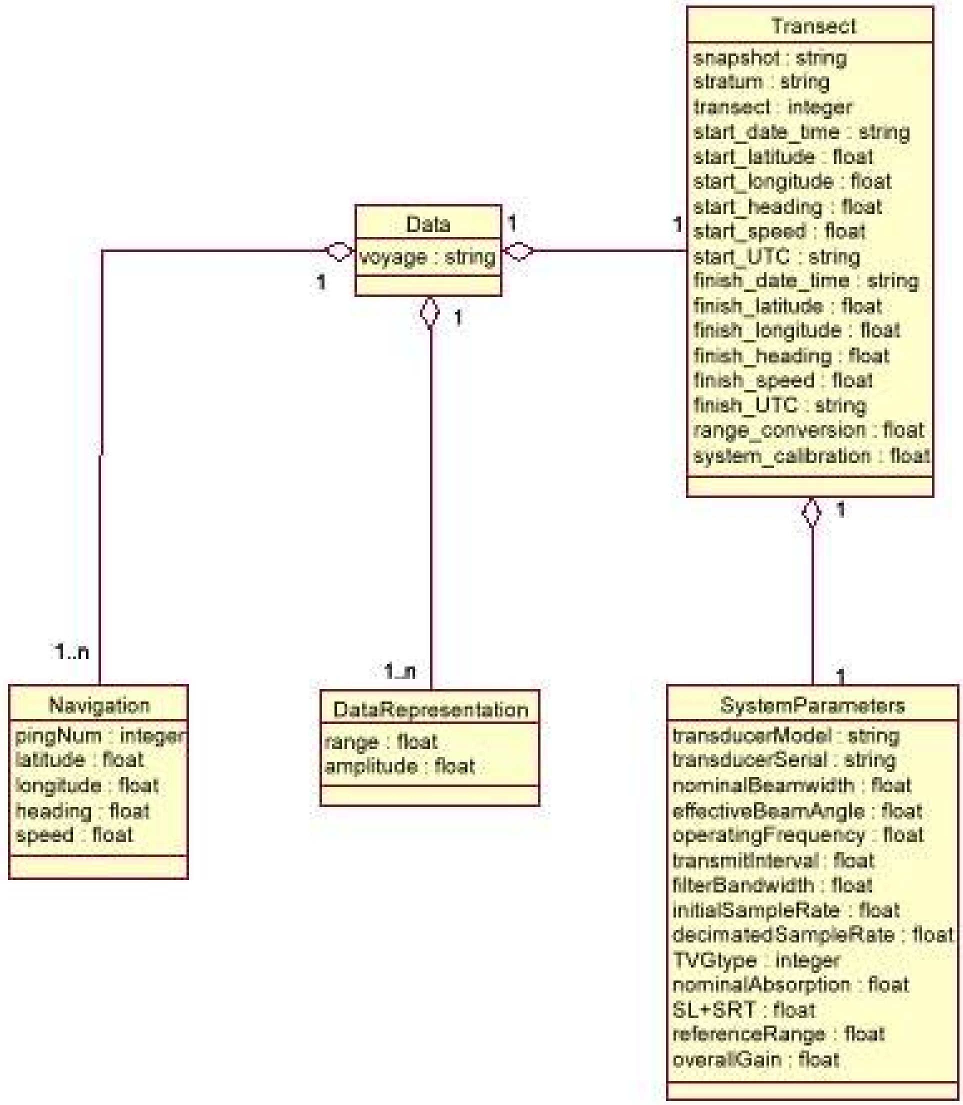

Figure 1: Unified Modelling Language (UML) diagram of the main acoustic database objects.

4 Data formats

4.1 Introduction

As at the writing of this report there is no standard format for the storage and interchange of hydroacoustic data. There are several de facto standards, one of the most common being the format output by the Simrad EK500 scientific echosounder (Simrad, 1991). A standard hydroacoustic data format has been proposed (Simard *et al.*, 1997), and may come into common use in the near future. If a suitable standard format does become commonly accepted, the **acoustic** database will be enhanced to import and export data in that format. Once a particular transect has been identified the acoustic, transect and navigation data can be exported into ASCII format files (*see* §4.2, §4.3 and §4.4, respectively).

4.2 Echo data information

The actual acoustic data are stored in the database in a number of formats, dependent primarily upon the equipment that was used to collect the data. The database provides a standard ASCII output format for these data, removing the need to know the details of the underlying data format.

The echo data attributes are given in Table 1. When exported into an ASCII file all of the data from one ping is placed on a single line. Data from successive pings are on successive lines. The range attribute can be converted to units of metres by multiplication by the range conversion factor. Likewise, the amplitude can be converted into the backscattering cross-section (s_{bs}) or the volume backscattering coefficient (S_v) via

$$x = \left(\frac{v}{c}\right)^2,$$

where x is s_{bs} or S_v, both with units of dB re 1μ Pa at 1 m, v is proportional to the echo voltage at the transducer terminals and c is the system calibration factor, and are discussed in §4.3.

An example of the echo data format is given in §A.1.

Table 1: Echo data attributes. The format '%d' indicates an integer number and '%f' and floating point number

Attribute	Data type	Format	Comments
Range	Integer	%d	Analog to digital converter sample number
Amplitude	Float	%f	Proportional to voltage at transducer terminals

4.3 Transect information

The transect attributes available for each transect are given in Table 2. When exported into an ASCII file all the information for a single transect is placed on one line of the file. Each attribute is separated from other attributes with one or more spaces. Subsequent lines contain the data from other transects. Each line also contains the name of the file that contains the echo data information. The first line of the file contains column headings. An example of this format is given in §A.2.

Table 2: Transect attributes. The format '%s' indicates a format of one or more characters, '%f' a floating point number, '%d' an integer number and 'yyyy-mm-ddThh:mm:ss' the date and time as specified by §5.4.1.a of AS/NZS 3802:1997

Attribute	Data type	Format	Comments
Snapshot	String	%s	
Stratum	String	%s	
Transect	Integer	%d	
Start date and time	String	yyyy-mm-ddThh:mm:ss	Local time
Start latitude	Float	%f	-ve indicates S
Start longitude	Float	%f	-ve indicates W
Start heading	Float	%f	Units of degrees
Start speed	Float	%f	Units of knots
Start UTC	String	hh:mm:ss	Obtained from GPS
Finish date and time	String	yyyy-mm-ddThh:mm:ss	Local time
Finish latitude	Float	%f	-ve indicates S
Finish longitude	Float	%f	-ve indicates W
Finish heading	Float	%f	Units of degrees
Finish speed	Float	%f	Units of knots
Finish UTC	String	hh:mm:ss	Obtained from GPS
Range conversion	Float	%f	
System calibration	Float	%f	

4.4 Navigation information

The navigation attributes collected for each transect are given in Table 3. Each transect of navigation data, when exported into an ASCII file, is formatted with all navigation data for a given ping on one line. The navigation data for subsequent pings are placed on separate lines. The columns of data are ordered in the same order as listed in Table 3. An example of this format is given in §A.3.

Table 3: Navigation attributes. The format '%f' indicates a floating point number and '%d' an integer number

Attribute	Data type	Format	Comments
Ping number	Integer	%d	
Latitude	Float	%f	-ve indicates S
Longitude	Float	%f	-ve indicates W
Heading	Float	%f	
Speed	Float	%f	

5 System parameters

Aside from the system calibration provided as part of the transect information (§4.3) a number of other echosounder system attributes are provided to enable the correct interpretation of the acoustic data. These are typically constant during a survey and are given in Table 4. The *overall gain* is obtained by taking 20log10 of the overall echosounder gain applied to the voltage at the terminals of the transducer at the *reference range*, and includes the TVG applied at the reference range. The system parameters can be extracted from the database and are exported in a format similar to that of Table 4.

Table 4: System parameter attributes. The format '%s' indicates a format of one or more characters, '%f' a floating point number and '%d' an integer number

Attribute	Data type	Format	Comments
Transducer model	String	%s	Includes manufacturer and model
Transducer serial no.	String	%s	Manufacturers serial number
Nominal 3dB beamwidth	Float	%f	Units of degrees
Effective beam angle	Float	%f	Units of steradians
Operating frequency	Float	%f	Units of kHz
Transmit interval	Float	%f	Units of seconds
Filter bandwidth	Float	%f	Units of kHz
Initial sample rate	Float	%f	Units of kHz
Decimated sample rate	Float	%f	Units of kHz
TVG type	Integer	%d	Either 20 or 40
Nominal absorption	Float	%f	Units of dB/km
SL+SRT	Float	%f	Units of dB re 1 V at 1 m
Reference range	Float	%f	Units of metres
Overall gain	Float	%f	Calculated using 20log10 *G*ref

6 Data validation

6.1 Introduction

The philosophy behind the **acoustic** database is that it will, as far as possible, contain raw, unprocessed data. As a consequence, minimal validation is carried out on the actual acoustic data (range/amplitude pairs). The nature of echosounder systems is that the raw acoustic data are an accurate and precise record of the acoustic amplitude at a given location at a given time and any processing, filtering or corrections should be applied during the analysis and use of the data. However, the associated data are subject to a number of validation rules, and are described in the following sections.

6.2 Transect validation

The attributes given in Table 2 have the following checks performed against them:

Attribute	Rule
Snapshot	No checks performed
Stratum	No checks performed
Transect	Must be an integer
Start date and time	Date and time must be valid and be approximately 12 or 13 hours different from Start GMT
Start latitude	Latitude must fall between –90 and +90
Start longitude	Longitude must fall between –180 and +180
Start heading	Heading must fall between 0 and 360 degrees
Start speed	Speed must fall between 0 and 50 knots
Start UTC	Must be a valid time
Finish date and time	Date and time must be valid and be approximately 12 or 13 hours different from Finish GMT
Finish latitude	Latitude must fall between –90 and +90
Finish longitude	Longitude must fall between –180 and +180
Finish heading	Heading must fall between 0 and 360 degrees
Finish speed	Speed must fall between 0 and 50 knots
Finish UTC	Must be a valid time
Range conversion	No checks performed
System calibration	No checks performed

6.3 Navigation validation

The attributes given in Table 3 have the following checks performed against them:

Attribute	Rule
Ping number	Must be an integer, must increase on previous ping number
Latitude	Latitude must fall between –90 and +90
Longitude	Latitude must fall between –180 and +180
Heading	Heading must fall between 0 and 360 degrees
Speed	Speed must fall between 0 and 50 knots

6.4 System parameters

The attributes given in Table 4 have the following checks performed against them:

Attribute	Rule
Transducer model	No checks performed
Transducer serial no.	No checks performed
Nominal 3dB beamwidth	Value provided by transducer manufacturer
Effective beam angle	Value provided by transducer manufacturer
Operating frequency	Must be greater than 0
Transmit interval	Must be greater than 0
Filter bandwidth	Must be greater than 0
Initial sample rate	Must be greater than 0
Decimated sample rate	Must be greater than 0 and less than ‘Initial sample rate’
TVG type	Must be 20 or 40
Nominal absorption	Must be greater than or equal to 0
SL+SRT	Must be greater than or equal to 0
Reference range	Must be greater than or equal to 0
Overall gain	Must be greater than or equal to 0

7 References

MacLennan, D.N. & Simmonds, E.J., 1992. Fisheries Acoustics. Fish and Fisheries Series; 5. Chapman & Hall, London, 325 pp.

Simard, Y., McQuinn, I., Montminy, M., Lang, C., Miller, D., Stevens, C., Wiggins, D. & Marchalot, C., 1997. Description of the HAC standard format for raw and edited hydroacoustic data, version 1.0. Canadian Technical Report of Fisheries and Aquatic Sciences, 2174, vii+65 pp.

Simrad, 1991. Simrad EK500 Scientific Echo Sounder, Instruction Manual P2172E.

A Exported file examples

A.1 Echo data file

A small sample of an echo data file is:

```
0 267 3 268 4 269 5
1 271 2 272 2 273 2
```

where 0 is the ping number, the first recorded data were at sample number 267, and had an amplitude of 3. The second recorded value was 4 at a sample number of 268, etc. The second line contains the data for transmit 1, etc.

A.2 Transect file

An example transect file is:

```
stratum transect snapshot filename start_time stop_time start_gmt stop_gmt start_position stop_position start_sog stop_sog start_heading stop_heading range_conv sys_cal
search 4 2 i0000010 1999-09-01T11:50:28 1999-09-01T13:34:36 23:50:02 01:34:36 -42.459 170.549 -42.413 170.151 9.6 9.9 286.1 313.7 0.1875 82400
search_deep 1 1 i0000014 1999-09-01T23:00:59 1999-09-01T23:48:27 11:00:59 11:48:27 -42.435 170.328 -42.411 170.146 10.0 10.2 277.7 281.7 0.1875 82400
search_deep 2 1 i0000015 1999-09-02T00:02:23 1999-09-02T00:52:43 12:02:23 12:52:43 -42.378 170.148 -42.401 170.347 10.2 10.7 97.1 95.4 0.1875 82400
search_deep 3 1 i0000016 1999-09-02T01:09:32 1999-09-02T02:01:56 13:09:32 14:01:56 -42.364 170.336 -42.341 170.146 9.5 8.1 271.2 314.9 0.1875 82400
search_deep 4 1 i0000017 1999-09-02T02:17:52 1999-09-02T03:03:48 14:17:52 15:03:48 -42.309 170.169 -42.335 170.345 10.4 10.3 101.8 97.7 0.1875 82400
search_deep 5 1 i0000018 1999-09-02T03:20:40 1999-09-02T04:05:57 15:20:40 16:05:57 -42.298 170.345 -42.285 170.177 9.6 11.1 285.6 176.5 0.1875 82400
trawl 1 1 i0000011 1999-09-01T14:41:08 1999-09-01T15:38:37 02:41:08 03:38:37 -42.442 170.369 -42.445 170.280 6.8 3.0 261.7 265.6 0.1875 82400
trawl 2 1 i0000012 1999-09-01T17:08:26 1999-09-01T18:23:03 05:08:26 06:23:02 -42.339 170.136 -42.251 170.147 6.9 2.4 5.6 4.7 0.1875 82400
trawl 3 1 i0000013 1999-09-01T20:29:41 1999-09-01T22:05:30 08:29:41 10:05:30 -42.438 170.393 -42.443 170.272 6.9 2.2 260.0 271.7 0.1875 82400
trawl 4 1 i0000019 1999-09-02T04:56:05 1999-09-02T06:28:14 16:56:05 18:28:14 -42.368 170.290 -42.454 170.271 3.6 2.5 190.2 192.6 0.1875 82400
```

A.3 Navigation file

An example navigation file is:

0 -42.6540 169.9722 079.4 02.9
1 -42.6540 169.9722 079.9 03.0
2 -42.6540 169.9723 079.5 03.0
3 -42.6540 169.9723 079.0 03.0
4 -42.6540 169.9723 077.9 03.0
5 -42.6540 169.9723 077.8 02.9
6 -42.6540 169.9724 078.4 02.9
7 -42.6540 169.9724 079.0 02.9
8 -42.6540 169.9724 079.5 02.9
9 -42.6540 169.9724 079.6 02.9
10 -42.6540 169.9725 079.5 02.9
11 -42.6540 169.9725 079.0 03.0
12 -42.6540 169.9725 078.9 03.0
13 -42.6540 169.9725 079.1 03.1
14 -42.6540 169.9726 079.7 03.1
15 -42.6540 169.9726 079.9 03.1
16 -42.6540 169.9726 079.5 03.0
17 -42.6540 169.9726 078.8 03.0
18 -42.6540 169.9726 078.3 03.0
19 -42.6540 169.9727 078.2 03.0
20 -42.6540 169.9727 078.2 03.0
21 -42.6539 169.9727 078.4 03.0
22 -42.6539 169.9728 078.4 03.0