Results of the first hydroacoustic survey of the Ugandan waters of Lake Victoria

R. TUMWEBAZE & A. GETABU, *LVFRP, FIRI, P.O. Box 343, Jinja, Uganda*

Abstract: An hydroacoustic survey was conducted in western Ugandan waters of Lake Victoria in February 1999 using a Simrad EY 500 scientific echosounder. Acoustic data included GPS data at beginning and end of each record, and area backscattering coefficients (Sa) for the whole water column and layers defined on the echograms. A frame trawl was used to sample fish observed in the echo traces. Fish were distributed over the whole survey area, though the densities varied spatially. Echotraces suggested that fish schools formed during daytime but dispersed towards evening. *Caridina nilotica* (Roux) formed dense echo traces at the thermocline. Dense swarms of *Chaoborus* larvae dispersed upwards from the lake bottom as night approached.

Introduction

Acoustic surveys are conducted to obtain fisheries independent data on the abundance of fish populations and their spatial and temporal distributions. The advantage of acoustic methods is that they may be used to cover large water areas over some weeks or to provide detailed repeated coverage of small areas in a few hours (Simmonds *et al.* 1992).

Hydroacoustic surveys require well-calibrated scientific equipment, a knowledge of the organisms causing echo traces and an understanding of how the acoustic samples are related to the stocks being surveyed.

There has been limited hydroacoustic research in the past in the Ugandan waters of Lake Victoria. A study conducted around Bugaia Island revealed that the density of pelagic haplochromines was much higher than previously thought (Tumwebaze 1997). It also showed that hypoxic conditions at the bottom of the lake limited the vertical distribution of fish. Following this study, a lakewide hydroacoustic research programme was designed to ascertain the status of fish stocks with the assistance of the European Union.

Data from the hydroacoustic surveys will be complemented by catch data from multi-mesh gillnets and frame trawls to validate acoustic estimates. The estimates will include acoustic indices of abundance or quantity in numbers or weight of fish.

Methods

Calibration

The EY 500 scientific echosounder was calibrated using a 23 mm copper sphere suspended under the transducer using three acoustically transparent monofilament lines glued to the sphere to adjust its position in the acoustic beam.

With this set up, two calibrations were conducted during the survey: at the beginning and at the end of the cruise. The measured target strengths (TS) of the sphere in both cases were –40.3 ± 0.2 dB and –40.4 ± 0.01 dB respectively, which are consistent with the manufacturer's predetermined value of –40.4 dB. This indicates that the EY 500 echo-integrator can make acoustical measurements within the stated error limits.

Collection of acoustic data

Acoustic data were collected and printed continuously on a Hewlett Packard deskjet printer, with integration tables recorded every six minutes. The data subsequently entered into log sheets included record number, GPS positions at the beginning and end of the record interval, and the area scattering coefficients (Sa) for the whole water column and for each layer defined on the echogram.

Frame Trawl Samples

A frame trawl of square opening 3.5 x 3.5 m with mosquito net codend was used to catch samples of the organisms causing the echo traces. A Furuno net-sounder attached to the top of the frame was used to record the depth fished. Depth was adjusted using extra weights or floats, length of warp paid out, and speed of vessel. Detailed results from the frame trawl catches are given by Tweddle & Bassa (1999).

Calculation of abundance indices

The surveyed area was divided into squares of ¼° longitude by ¼° of latitude, each of area 225 nm^2 (Fig. 1). On this, position was plotted every 30 minutes and the cruise track was fitted. The positions of the frame trawl hauls were marked on the cruise track.

A spreadsheet of the acoustic data was made indicating the mean Sa values in each six minute period. The Sa values were partitioned into three categories, fish, *Caridina nilotica* (Roux) and *Chaoborus* sp., according to the appearance of echo traces on the echogram. The proportions by weight of the fish species caught by the frame trawl when targeting echo traces were used to apportion fish abundance indices by species.

Results

The mean area backscattering coefficients (Sa) were calculated for each square. A value of –52 dB for the mean target strength (TS) of Lake Victoria fish was assumed in converting the Sa to an acoustic index of abundance. This is derived from a formula developed for the Atlantic herring *Clupea harengus* L. which, using the modal size of the small pelagic Lake Victoria fish (about 8 cm), gives the mean TS of –52 dB. This procedure gives a nominal TS value only and it is essential in the near future to conduct experiments to obtain more accurate TS data. The nominal TS value was used to obtain an acoustic index of fish abundance. This is not the same as a biomass estimate as it is not possible to estimate the abundance without knowing the TS. The index used here will allow present results to be compared with those of future surveys.

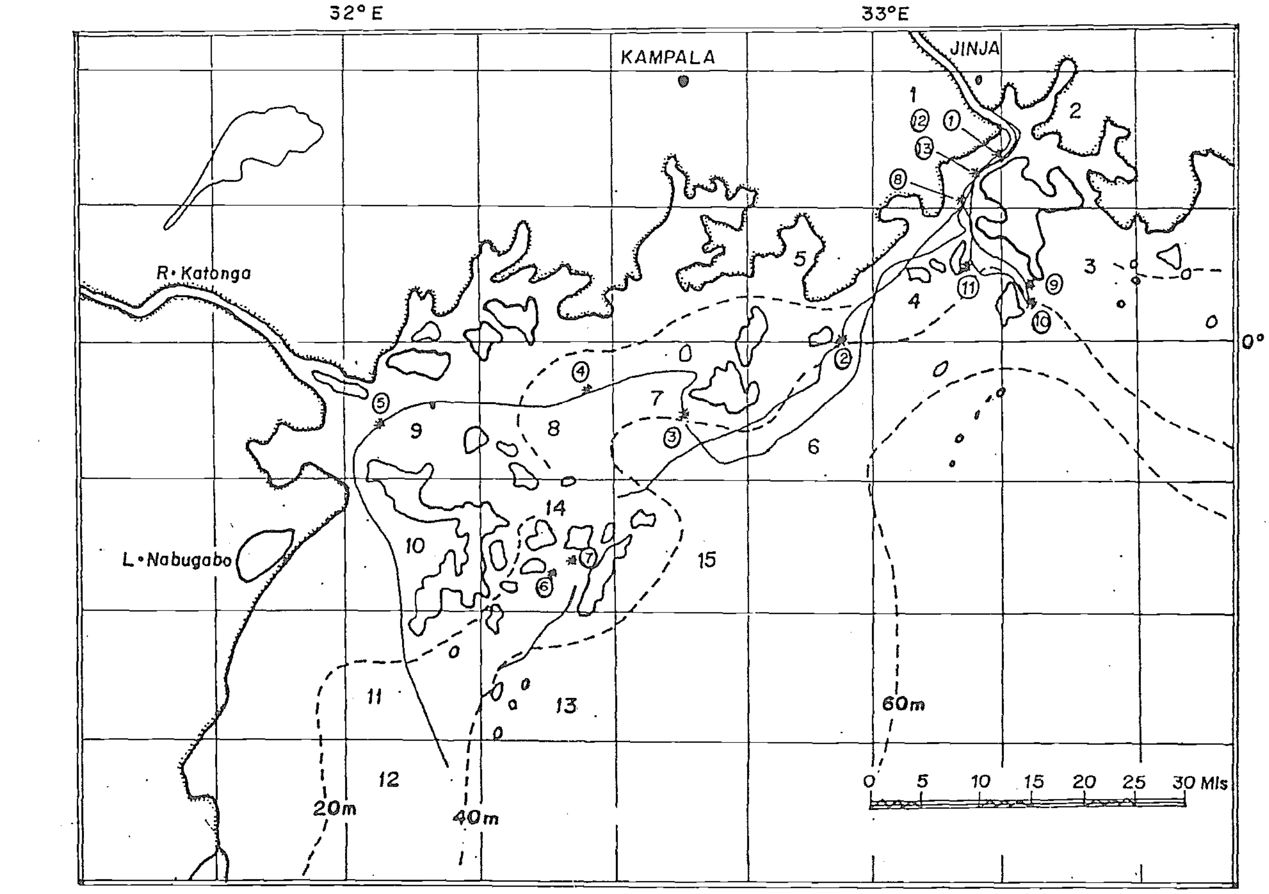

Figure 1. Map of the surveyed area of Lake Victoria. Grid squares covered by the survey tracks are numbered, while the sites sampled using the frame trawl are shown by circled numbers.

Table 1. Apportioned Sa values for fish, *Caridina* and *Chaoborus* in the surveyed area. The square numbers refer to the grid squares on the map (Fig. 1).

Squares	Sa (m^2/nm^2) Fish	Sa(m^2/nm^2) *Caridina*	Sa(m^2/nm^2) *Chaoborus*
1	750.29	23.64	160.70
2	761.90	9.82	164.23
3	1728.09	0.00	126.49
4	1270.73	28.04	139.63
5	1000.17	129.98	28.76
6	1155.76	117.70	17.48
7	1005.95	27.61	19.05
8	2358.42	76.16	0.00
9	1111.52	0.00	0.00
10	2218.74	0.00	11.07
11	1007.64	27.62	29.21
12	1040.19	0.00	0.00
13	1178.59	39.64	17.94
14	820.47	38.48	30.25
15	1122.65	61.61	12.82
Mean	**1229.25**	**41.80**	**66.72**

Table 2. Acoustic abundance indices in the surveyed area. The square numbers refer to the grid squares on the map.

Squares	Area fraction	Acoustic scattering coefft (m^2)	Acoustic abundance index (t)
1	0.20	33763	1477
2	0.50	85714	3751
3	0.25	97205	4254
4	0.80	228731	10009
5	0.50	112520	4924
6	0.90	234041	10241
7	0.70	158438	6933
8	0.85	451048	19737
9	0.75	187569	8208
10	0.65	324491	14199
11	0.90	204047	8929
12	1.00	234042	10241
13	0.85	225405	9863
14	0.50	92303	4039
15	0.85	214707	9395

Table 3. Trawl catch proportions and acoustic abundance indices for *Rastrineobola argentea* and haplochromines. The square numbers refer to the grid squares on the map.

	Trawl catch proportion		Acoustic abundance index	
Squares	*Rastrineobola argentea*	Haplochromines	*Rastrineobola argentea*	Haplochromines
1		0.44		649
2	0.56	0.44	2100	1649
3	0.19	0.81	808	3445
4	0.16	0.84	1581	8428
5	0.16	0.84	778	4146
6	0.53	0.47	5448	4793
7	0.02	0.98	111	6822
8	0.37	0.63	7263	12474
9	0.95	0.05	7789	419
10	0.95	0.05	13475	724
11	0.57	0.43	5107	3822
12	0.57	0.43	5858	4383
13	0.57	0.43	5642	4222
14	0.57	0.43	2310	1729
15	0.29	0.71	2762	6633
Total			**61862**	**64337**

Fish were distributed over the whole survey area, though the densities and species composition varied from place to place (Tables 1 – 3). Echo-traces showed that fish formed schools during daytime and became more dispersed towards evening. Approximately equivalent indices of abundance were estimated for *R. argentea* and haplochromines.

The distribution of the freshwater prawn, *C. nilotica,* and the lakefly, *Chaoborus* sp., was patchy. Dense swarms of *Chaoborus* larvae were observed to disperse from the lake bottom as the night approached, thus obscuring echo-traces formed by fish on the echogram and making their interpretation difficult. *Caridina nilotica* were observed to form dense echo-traces at the thermocline.

Discussion

A number of factors could be responsible for the distribution patterns of fish, prawns and the lakefly observed. The echo-traces produced varied spatially and temporally because fish form schools for feeding or migration and later disperse. Hydroacoustic research in the North Sea showed that pelagic fish distribution is also influenced by environmental factors (Maravelias *et al.* 1997; Bailey *et al.* 1998 and Porteiro *et al.* 1996), e.g. the herring *C. harengus* aggregates at the interface between oxic and anoxic layers in order to feed on dense zooplankton organisms (Maravelias 1995). During the present survey, *C. nilotica* was observed to form concentrations at the thermocline from which abundance indices could be estimated based on the narrow layer. The effect of the narrow dense *Caridina* layer on estimates of fish abundance indices can thus be eliminated. The presence of prawns at the thermocline was probably because they were unable to descend to the preferred daytime habitat on the bottom because of the de-oxygenated water below the thermocline. *Caridina* may obtain some degree of protection from Nile perch predation in the relatively low oxygen conditions at the thermocline. Where there was no thermocline, *Caridina* were not recorded in the traces, while in some areas, although there was apparently a thermocline and deoxygenated bottom water as no fish traces were seen near the bottom, no *Caridina* were present. This explains the differences in abundance of the prawns in Table 1.

The similar abundance estimates for haplochromines and *R. argentea* are based on the frame trawl results. At this stage in the programme, *L. niloticus* has been ignored in the equations as it is a minor component of the frame trawl catches. Further research on midwater abundance of *L. niloticus* using multidepth gillnets will allow modifications to be made to the hydroacoustic abundance estimates in future.

Chaoborus echo-traces appeared on the echograms in the evening as dense marks rising from the bottom, usually after 5.30 pm. During such periods, high indices for *Chaoborus* were estimated. To avoid errors in fish abundance estimates, sampling in future should be confined to the daytime periods before the interference by *Chaoborus* traces becomes excessive.

Acknowledgements

We thank Mr D. MacLennan for technical guidance during the survey. We thank the directors of FIRI, KMFRI and TAFIRI for permission to participate in the survey. The programme is funded by the European Union Lake Victoria Fisheries Research Project (Ref: ACP-RPR 227), coordinated by Mr M. van der Knaap. We thank Mr D. Tweddle for assistance with the frame trawl, and Mr G. Passiotis and the crew of the RV Ibis for their work on the vessel.

References

Bailey M.C., Maravelias C.D. & Simmonds E.J. (1998) Changes in the spatial distribution of autumn spawning herring (*Clupea harengus* L.) derived from annual acoustic surveys during the period 1984-1996. *ICES J. Mar. Sci.* **55**, 545-555.

MacLennan D. (1997) A report on a mission to East Africa. LVFRP STTA Consultancy Report, 21 pp.

Maravelias C. D. & Reid D.G. (1995) Relationship between herring (*Clupea harengus*, L.) distribution and sea surface salinity and temperature in the northern North Sea. *Sci. Mar.* **59**, 427-438.

Maravelias C.D. & Reid D.G. (1997) Identifying the effects of oceanographic features and zooplankton on prespawning herring abundance using generalized additive models. *Mar. Ecol Prog. Ser.* **147**, 1-9.

Porteiro C., Carrera P. & Miquel J. (1996) Analysis of Spanish acoustic surveys for sardine, 1991-1993: abundance estimates and inter-annual variability. *ICES J. Mar. Sci.* **53**, 429-433.

Simmonds E.J., Williamson N.J., Gerlotto F. & Aglen A. (1992) Acoustic survey design and analysis procedure. A comprehensive review of current practice. ICES COOPERATIVE REPORT No.187. ICES, Copenhagen, Denmark.

Tumwebaze R. (1997) Application of hydroacoustics in fish stock assessment of Lake Victoria. M.Sc. Thesis, Department of Fisheries and Marine Biology, University of Bergen, Norway, 134 pp.

Tweddle D. & Bassa S. (1999) Preliminary observation on the use of a frame trawl in hydroacoustic surveys. LVFRP Report on third FIDAWOG workshop, this volume.

Witte F., Goldschimdt T. & Wanink J.H. (1995) Dynamics of the haplochromine cichlid fauna and other ecological changes in the Mwanza Gulf of Lake Victoria. In: T.J. Pitcher & P.J.B. Hart (eds) The Impact of Species Changes in African Lakes. London: Chapman and Hall, pp. 83-110.