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March 2013, - R.INT. PDG/RBE/EMH 13- 01

EchoR package tutorial

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Introduction

EchoR[1] is a suite of R[2] codes developed by Ifremer aiming at:

- handling pre-processed fisheries acoustics data collected during sea surveys;
- computing standard ec(h)osystemic indicators based on those fisheries acoustics data. These indicators include:
    - biomass estimates per fish species and elementary sampling distance units (ESDU) ;
    - biomass-at-length estimates per fish species and ESDU ;
    - biomass-at-age estimates per fish species and ESDU;
    - biomass estimates per fish species and post-stratification regions ;
    - synthetic spatial indicators can also be computed based on per ESDU data (Woillez et al. 2007).

Methods for acoustic fish biomass assessment implemented in EchoR are described in Simmonds and MacLennan (2005) and Doray et al. (2010).

The objective of this EchoR tutorial is to produce:

- maps of biomass estimates per fish species and elementary sampling distance units (ESDU),
- maps of biomass estimates per fish species, length class, and ESDU.

Questions regarding the EchoR package can be sent to: mathieu.doray@ifremer.fr.

Requirements

Software

- Windows or linux operating system
- R statistical software version 2.15 or higher
- Rstudio
- R packages:
    - EchoR, available at: https://forge.ifremer.fr/frs/?group_id=212
    - grid
    - gridBase
    - PBSmapping
    - splancs
    - sp, and, eventually, foreign

1 https://forge.ifremer.fr/plugins/mediawiki/wiki/echor/index.php/Accueil
2 http://www.r-project.org/

Data

Option 1: using the demo dataset

A demo dataset taken from the PELGAS2012 sea cruise is available at:

https://forge.ifremer.fr/docman/?group_id=212&view=listfile&dirid=494

Download and unzip the “EchoR_tutorial1_data.zip” file in your working directory.

Option 2: testing EchoR with your own data

If you want to try out EchoR with your own data, you will need need fishing and acoustic data collected during a single survey. Data should be split into 5 files.

Please make sure that your data are formatted according to the formats described below.

FishingTotalSamples

This text, semi-colon separated .csv file comprises the catches per species and haul, as well as the haul metadata (position, time, depth...).

FishingTotalSamples file example:

SpeciesAcronym	OperationID	DepthStratum	HaulLatitude	HaulLongitud	HaulStartTime	HaulMidDepth	OperationNo	Cruise	SizeCategory	TotalWeight	TotalNumber	MeanLength	MeanWeight	NoPerKg	SpeciesCode	TSb	TSa
ENGR-ENC	T0022	CLAS	43.2592	4.3739	16/07/2012 11:30:06	11.7	22	PELMED2012	0	12.75	1450	10.18	6	165.7	ENGR-ENC-CLAS-0	20	71.2
ENGR-ENC	T0029	CLAS	43.1176	4.8528	19/07/2012 08:54:10	11.7	29	PELMED2012	0	19.96	3102	10.439	6	155.38	ENGR-ENC-CLAS-0	20	71.2
ENGR-ENC	T0031	CLAS	42.8669	3.0836	23/07/2012 08:15:24	11.7	31	PELMED2012	0	23.1	2558	11.435	9	110.71	ENGR-ENC-CLAS-0	20	71.2
ENGR-ENC	T0025	CLAS	43.2837	4.6858	17/07/2012 08:08:19	11.7	25	PELMED2012	0	170.01	28768	10.187	6	169.21	ENGR-ENC-CLAS-0	20	71.2
ENGR-ENC	T0035	CLAS	43.0627	4.5686	25/07/2012 06:23:02	18.3	35	PELMED2012	0	104.11	12022	11.389	9	115.46	ENGR-ENC-CLAS-0	20	71.2
ENGR-ENC	T0027	CLAS	43.1608	4.8089	18/07/2012 14:28:03	11.7	27	PELMED2012	0	196.8	28158	10.62	7	143.08	ENGR-ENC-CLAS-0	20	71.2

FishingTotalSamples fields description:

Field	Description	Format
Cruise	cruise name	string
OperationID	operation id	string
OperationNo	Operation number, in increasing order	string
HaulMidLatitude	Trawl haul mean latitude in decimal degrees	double
HaulMidLongitude	Trawl haul mean longitude in decimal degrees	double
HaulStartTime	Trawl haul start time in dd/mm/yyyy hh:mm:ss format	string
HaulMidDepth	Trawl haul mean depth in meter	double
DepthStratum	Trawl haul depth stratum ('surface', 'bottom', or 'CLAS' if you do not use depth stratification)	string
SpeciesAcronym	Species rubbin code in 'GENU-SPE' format	string
SizeCategory	Size category ('small', 'big' or '0' if you do not use size category)	string
TotalWeight	Total catch in kg	double
TotalNumber	Total number of fish	integer
MeanLength	Fish mean length (in cm)	double
MeanWeight	Fish mean weight (in g)	double
NoPerKg	No. of fish per kg	double
SpeciesCode	Species code = SpeciesAcronym-DepthStratum-SizeCategory	string
TSb	Fish TS a parameter (usually a=20)	double
TSa	Fish TS b20 parameter, in dB	double

NB1:

- **TSa and TSb must be positive**
- **TSb is the slope of the TS~length equation, commonly set to 20**

FishingSubSamples

This text, semi-colon separated .csv file comprises the fish length measurements per species and haul.

FishingSubSamples file example:

SpeciesAcronym	Cruise	OperationID	SizeCategory	SubSampleWeight	SubSampleNumberOfFish	LengthClass	NumberOfFish	WeightOfFish	MeanWeight	SpeciesCode
DIVE-RS1	PELGAS2012	T0004	0	1.1	20	8	20	NA	NA	DIVE-RS1-0
DIVE-RS1	PELGAS2012	T0007	0	0.05	1	8.5	1	NA	NA	DIVE-RS1-0
ENGR-ENC	PELGAS2012	T0003	0	2.26	216	9.5	3	0.01	0333333333333	ENGR-ENC-0
ENGR-ENC	PELGAS2012	T0003	0	2.26	216	10	4	0.02	0.005	ENGR-ENC-0
ENGR-ENC	PELGAS2012	T0003	0	2.26	216	10.5	24	0.17	07083333333333	ENGR-ENC-0
ENGR-ENC	PELGAS2012	T0003	0	2.26	216	11	34	0.28	08235294117647	ENGR-ENC-0
ENGR-ENC	PELGAS2012	T0003	0	2.26	216	11.5	45	0.45	0.01	ENGR-ENC-0
ENGR-ENC	PELGAS2012	T0003	0	2.26	216	12	59	0.67	01135593220338	ENGR-ENC-0
ENGR-ENC	PELGAS2012	T0003	0	2.26	216	12.5	25	0.32	0.0128	ENGR-ENC-0

FishingSubSamples fields description:

Field	Description	Format
SpeciesAcronym	Species rubbin code in 'GENU-SPE' format	string
Cruise	cruise name	string
OperationID	operation id	string
SizeCategory	Size category ('small', 'big' or '0' if you do not use size category)	string
SubSampleWeight	Weight of the subsample from which length measurements were made in kg (optionnal)	double
SubSampleNumberOfFish	Number of fish in the subsample from which length measurements were made (optionnal)	integer
LengthClass	Length class in cm	double
NumberOfFish	Number of fish in the considered length class	integer
WeightOfFish	Total weight of all fish in the considered length class	double
MeanWeight	Fish mean weight in length class	double
SpeciesCode	Species code = SpeciesAcronym-DepthStratum-SizeCategory	string

Echotypes

This text, semi-colon separated .csv file comprises the description of the echotypes that have been used for scrunitizing.

An echotype is a particular spatial pattern observed in the survey echograms. It is associated with a species, or a group of species/size categories.

Echotypes file example:

Cruise	Echotype	DepthStratum	Description	SpeciesAcronym	SizeCategory	SpeciesCode
PELGAS2012	D1	CLAS	Pelagic fish close to the seabed	SARD-PIL	0	SARD-PIL-CLAS-0
PELGAS2012	D1	CLAS	Pelagic fish close to the seabed	ENGR-ENC	0	ENGR-ENC-CLAS-0
PELGAS2012	D1	CLAS	Pelagic fish close to the seabed	SCOM-SCO	0	SCOM-SCO-CLAS-0
PELGAS2012	D1	CLAS	Pelagic fish close to the seabed	SCOM-JAP	0	SCOM-JAP-CLAS-0
PELGAS2012	D1	CLAS	Pelagic fish close to the seabed	SPRA-SPR	0	SPRA-SPR-CLAS-0
PELGAS2012	D1	CLAS	Pelagic fish close to the seabed	TRAC-MED	0	TRAC-MED-CLAS-0
PELGAS2012	D1	CLAS	Pelagic fish close to the seabed	TRAC-TRU	0	TRAC-TRU-CLAS-0
PELGAS2012	D2	SURF	Pelagic fish close to the sea surface	TRAC-MED	G	TRAC-MED-CLAS-G
PELGAS2012	D2	SURF	Pelagic fish close to the sea surface	TRAC-TRU	G	TRAC-TRU-CLAS-G
PELGAS2012	D3	CLAS	Pelagic fish located at least 20 m off the seabed	SARD-PIL	G	SARD-PIL-CLAS-G
PELGAS2012	D3	CLAS	Pelagic fish located at least 20 m off the seabed	SARD-PIL	0	SARD-PIL-CLAS-0

“Echotypes.csv” fields description:

Field	Description	Format
Cruise	cruise name	string
Echotype	Echotype name, as «DX”	string
DepthStratum	Echotype depth stratum ('surface', 'bottom', or 'CLAS' if you do not use depth stratification)	string
Description	Echotype description	string
SpeciesAcronym	Species rubbin code in 'GENU-SPE' format	double
SizeCategory	Size category ('small', 'big' or 'none' if you do not use size category)	string
SpeciesCode	Species code = SpeciesAcronym-DepthStratum-SizeCategory	string

NB :

- echotypes should be names as: D1, D2, Dx

AcousticData

This text, semi-colon separated .csv file comprises the scrunitizing results, as well as the (optionnal) ESDU-echotype-hauls association.

If no ESDU-echotype-hauls association is provided, the NASC of echotype i in ESDU j will be associated with the nearest haul k, comprising at least a species associated with echotype j. Note that there must be a column for each different echotypes ('EchotypexNASC' columns) and echotype reference hauls ('EchotypexRefHaul' columns) in this file

AcousticData file example:

EsduID	EsduStartLongitude	EsduStartLatitude	EsduDepth	EsduTime	Echotype1NASC	Echotype2NASC	Echotype3NASC	EchotypenNASC	Cruise	Echotype1RefHaul	Echotype2RefHaul	Echotype3RefHaul	EchotypenRefHaul	TotalNASC
1	3.21797	42.460855	90.5	06/07/2012 12:42	0	102.568201	0	0	PELGAS2012	3	3	3	3	102.568201
2	3.20406	42.47412667	89	06/07/2012 12:49	0	233.04895	0	0	PELGAS2012	3	3	3	7	233.04895
3	3.189683333	42.48714667	74.8	06/07/2012 12:57	0	145.824444	0	3509.069667	PELGAS2012	3	3	3	3	3654.894111
4	3.175335	42.50014667	66.5	06/07/2012 13:05	0	122.148129	0	0	PELGAS2012	4	5	6	4	122.148129
5	3.160906667	42.51309333	58.7	06/07/2012 13:13	0	72.596489	0	0	PELGAS2012	4	4	4	10	72.596489
6	3.14642	42.52603	53.2	06/07/2012 13:21	0	16.079609	0	0	PELGAS2012	4	4	4	4	16.079609
7	3.132008333	42.53901167	44.3	06/07/2012 13:28	0	101.71502	0	0	PELGAS2012	31	31	31	31	101.71502
8	3.11755	42.55207333	37.5	06/07/2012 13:36	0	638.042027	0	0	PELGAS2012	12	31	10	31	638.042027
9	3.10306	42.565025	32.9	06/07/2012 13:43	0	4273.872857	0	0	PELGAS2012	31	6	31	15	4273.872857
10	3.088781667	42.57795833	28.7	06/07/2012 13:50	0	305.02119	0	0	PELGAS2012	31	31	31	31	305.02119

AcousticData file field description:

Field	Description	Format
Cruise	cruise name	string
EsduID	ESDU label (or number)	integer
EsduStartLongitude	ESDU start longitude in decimal degrees	double
EsduStartLatitude	ESDU start latitude in decimal degrees	double
EsduDepth	ESDU start seabed depth (in meter) [optionnal]	double
EsduTime	ESDU start time in 'dd/mm/yyyy hh:mm:ss' format	string
Echotype1NASC	NASC allocated to echotype 1 in the ESDU	double
Echotype2NASC	NASC allocated to echotype 2 in the ESDU	double
Echotype3NASC	NASC allocated to echotype 3 in the ESDU	double
EchotypenNASC	NASC allocated to echotype n in the ESDU	double
TotalNASC	ESDU total NASC	double
Echotype1RefHaul	Number of the trawl haul associated to echotype 1 in the ESDU	integer
Echotype2RefHaul	Number of the trawl haul associated to echotype 2 in the ESDU	integer
Echotype3RefHaul	Number of the trawl haul associated to echotype 3 in the ESDU	integer
EchotypenRefHaul	Number of the trawl haul associated to echotype n in the ESDU	integer

NB : ESDUs must be unique: no duplicated times or ids

Code

Download EchoRbiom scripts

The “EchoRbiom” R scripts used in this tutorial are available at:

https://forge.ifremer.fr/docman/?group_id=212&view=listfile&dirid=494

Download and unzip the “EchoR_scripts1_data.zip” file in your working directory to get the codes.

EchoRbiom scripts walkthrough

EchoRbiom steps

The EchoRbiom module is comprised of 3 scripts:

1. “EchoRbiom1_IMPORT.r” to import, format and check your data;
2. “EchoRbiom2_PREPROC.r” to compute and check the “X_E” scaling factors (see Doray et al. (2010) for details);
3. “EchoRbiom3_BiomESDU.r” to compute and map fish biomass per Elementary Distance Sampling Units (ESDUs), as well as global fish biomass per species, based on per ESDUs results.

Using EchoRbiom

The EchoRbiom scripts are abundantly commented and should be self-explanatory.

When using new data, you will have to change the cruise name and the paths to the data files and outputs.

The path to data files is stored in the “path.fishRview” vector. The path where to save outputs is stored in the “path.results” vector.

Graphical display

- if you use the standard Rgui, set the “ux11” argument to TRUE in every functions to display the plots in separate windows ;
- if you use RStudio, set the “ux11” argument to FALSE in every functions to display plots in the plot pane.

Have fun

References

Doray, M., Massé, J., and Petitgas, P. 2010. Pelagic fish stock assessment by acoustic methods at Ifremer. Rapp. Int. Ifremer **DOP/DCN/EMH 10- 02**: 1–17. http://archimer.ifremer.fr/doc/00003/11446/

Simmonds, E.J., and MacLennan, D.N. 2005. Fisheries Acoustics. Theory and Practice. Blackwell publishing, Oxford, UK.

Woillez, M., Poulard, J.C., Rivoirard, J., Petitgas, P., and Bez, N. 2007. Indices for capturing spatial patterns and their evolution in time, with application to European hake (Merluccius merluccius) in the Bay of Biscay. ICES J. Mar. Sci. **64**: 537-550.