Data analysis manual of A-tag for fixed monitoring

Ver.1.0

September 20, 2012

CONTENTS

1. Data you will get.

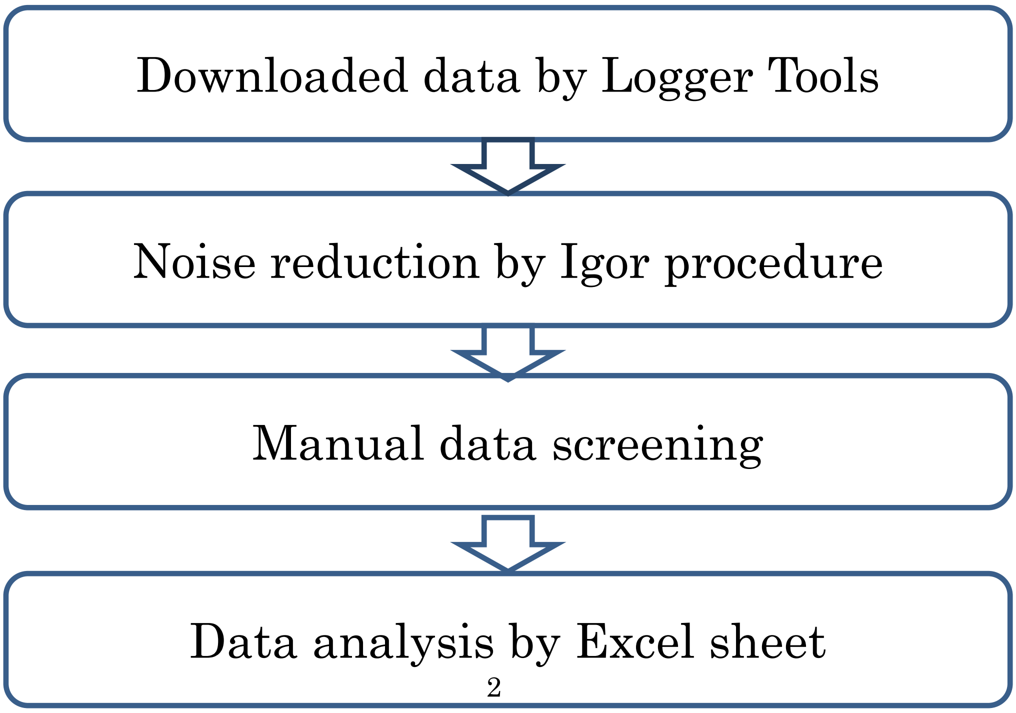
1. Diurnal or seasonal presence of dolphins and porpoises

2. Maximum sensing distance by echolocation

3. Number of phonated animals around A-tag

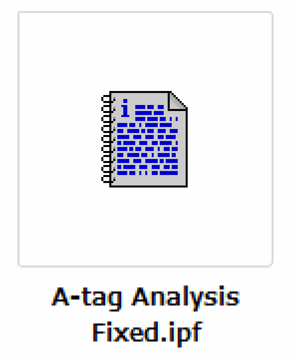
4. Further analysis such as density, abundance, g(0) estimation, behavior, movement, species ID, etc.

All these based on the time sequential statistical data of each click train provided as an Excel file. To get this Excel file, pre-processing is required by Igor procedure, which mainly reduce noise contamination.

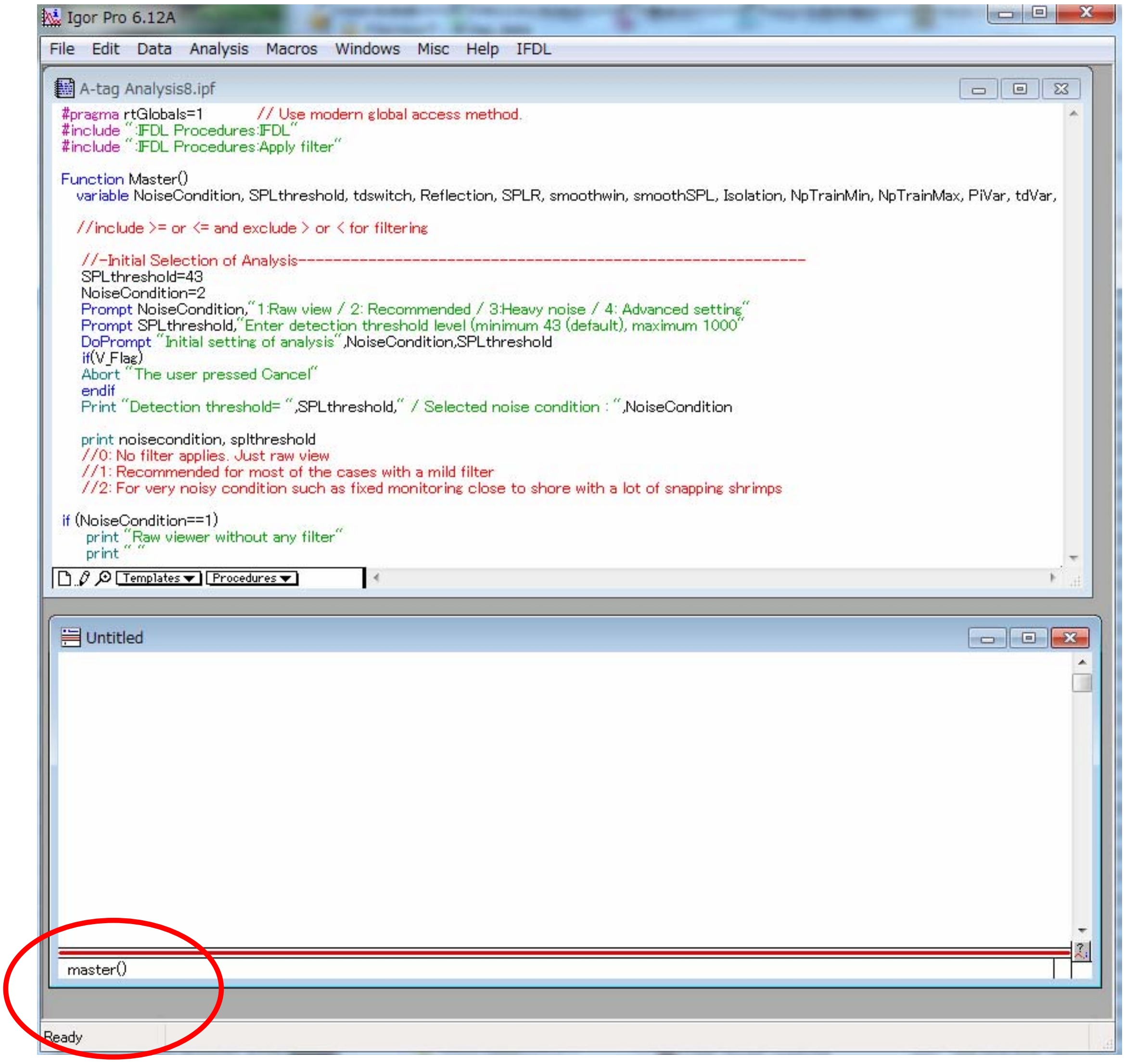


2. Noise reduction using Igor

Click **A-tag Analysis Fixed.ipf**



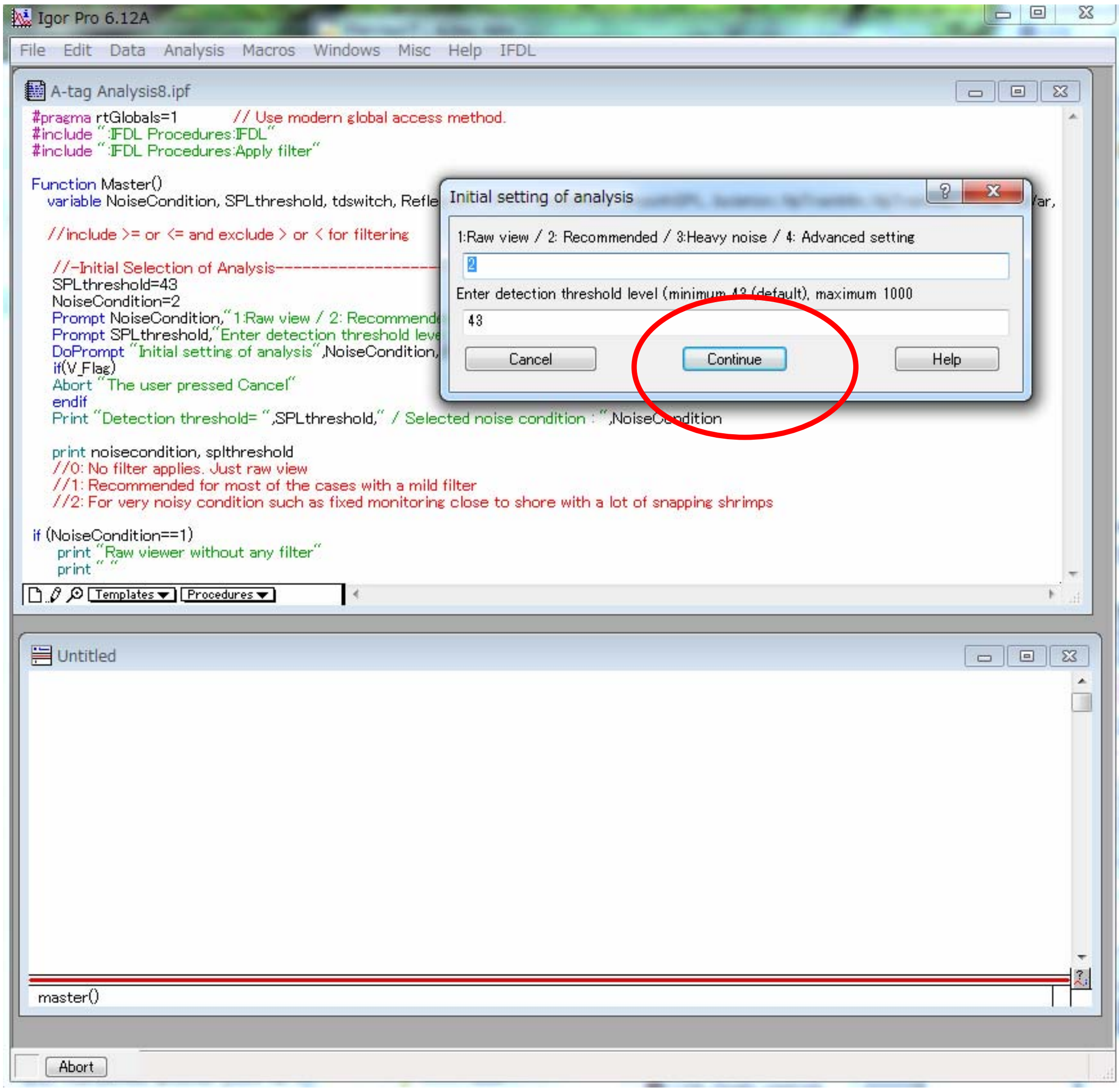
Type **master()** on the command line of Igor and press RETURN KEY



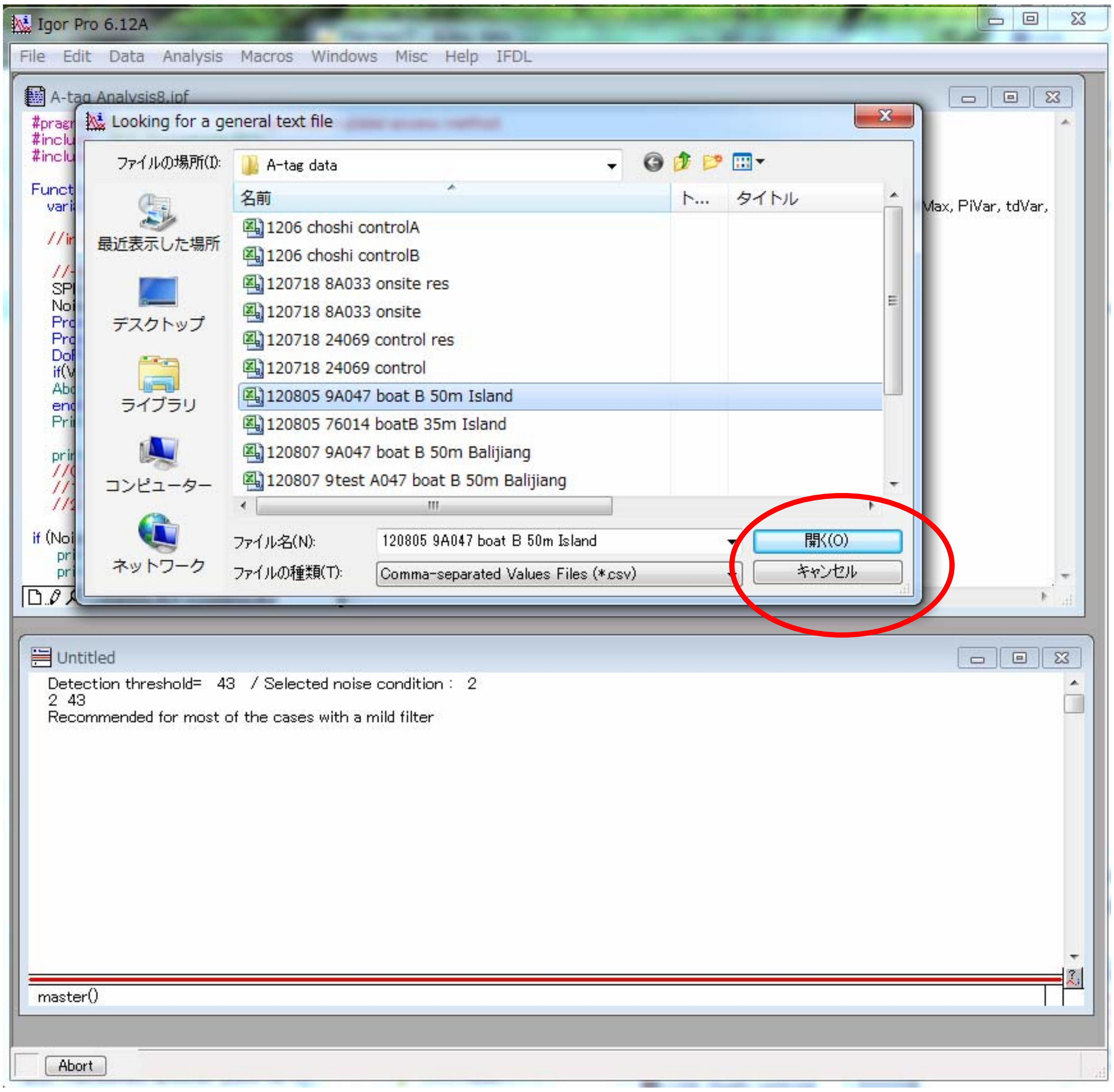
Select initial setting of analysis. Normally click **Continue** is OK.

If you wish to examine raw data appearance without any noise reductions, choose 1.
If you wish to analyse very high noise contamined data, choose 3
If you wish to modify analysis parameters, choose 4 (only for experienced persons).

Detection threshold can be changed for all type of Initial settings. Normally, use default value 43, which is the minimum value of A-tag detection threshold (nearly equal to internal electronic noise level).



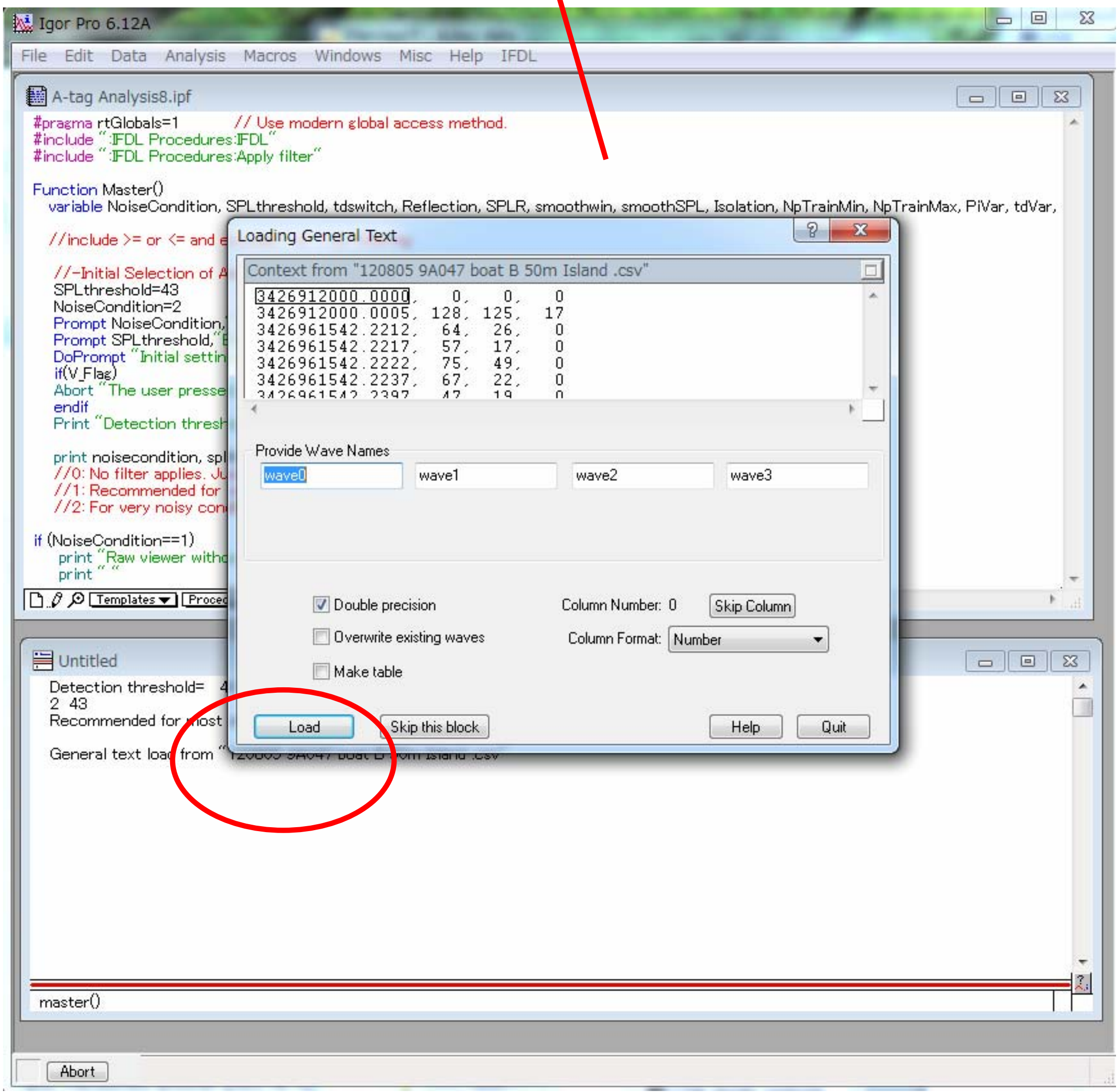
Select data file you wish to analyse and click **OPEN**
The data file is created by Logger Tools>CSV file.



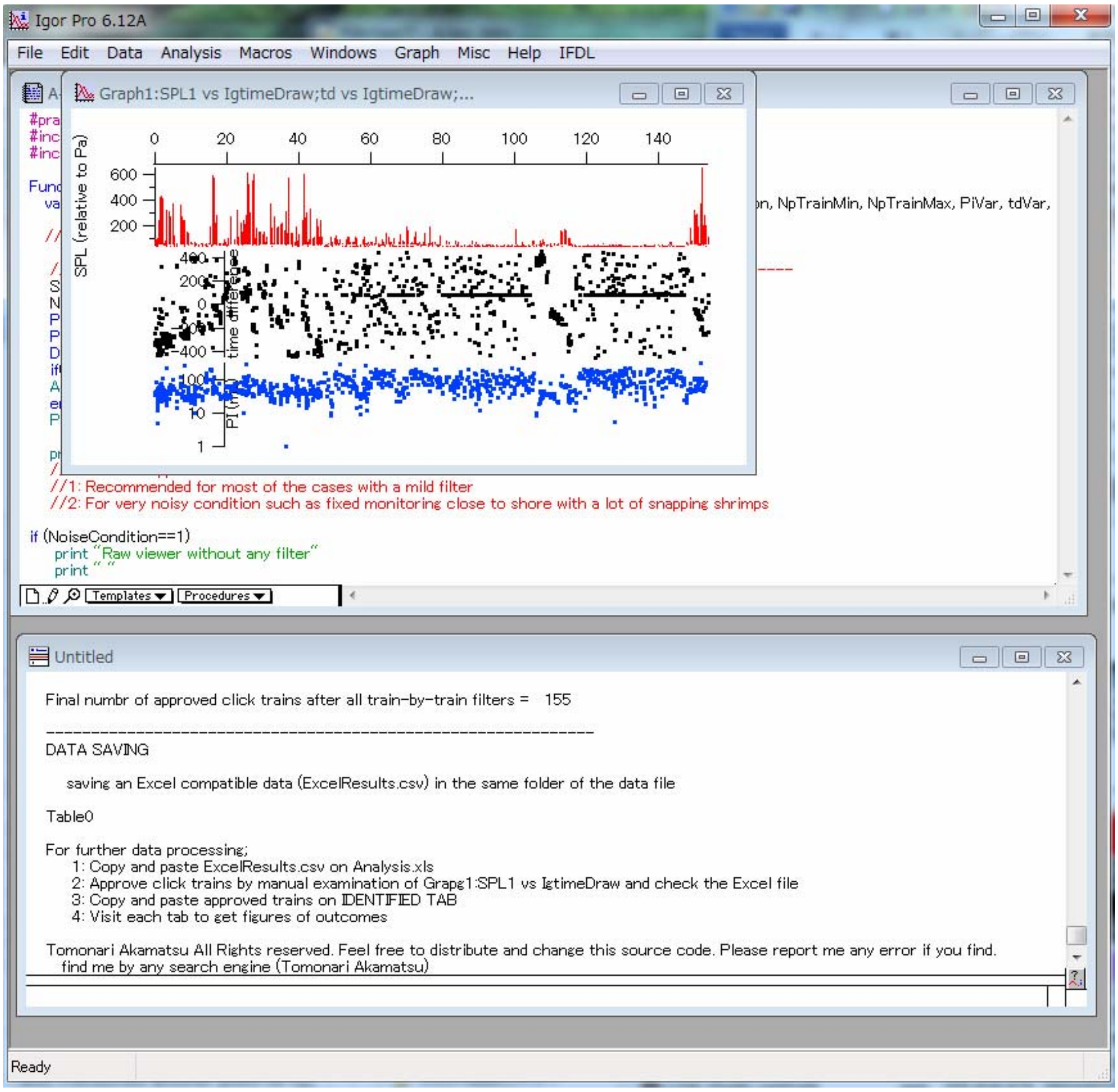
Wait for a while until dialog box below appears.

Click **Load** and wait for a while. It may take several minutes depending on the file size.

<u>DO NOT</u> change wave names

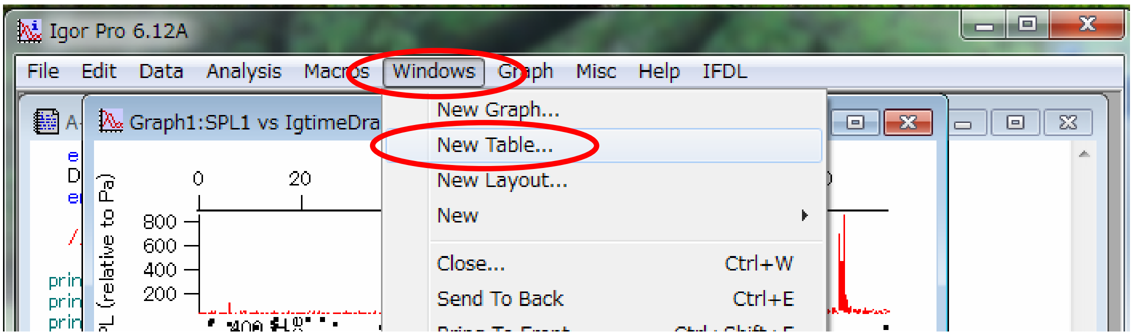


Analysis finished.

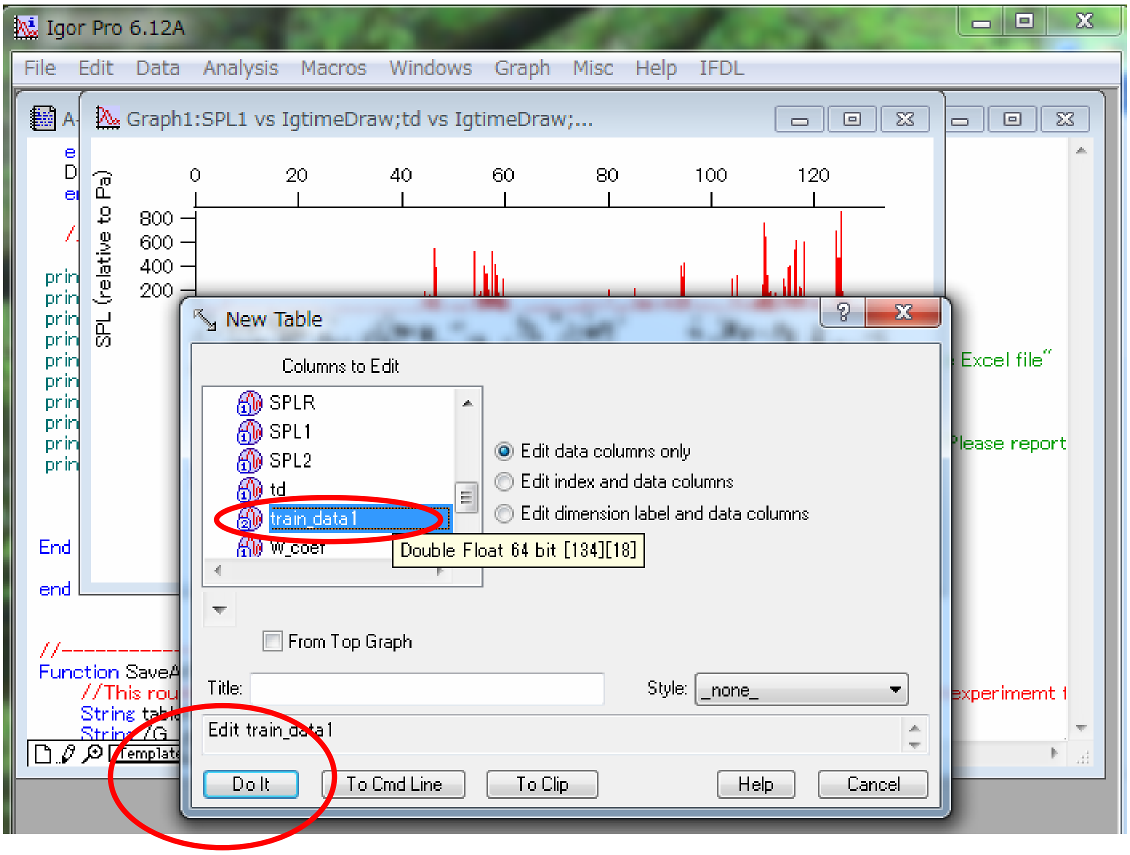


3. Manual screening of data

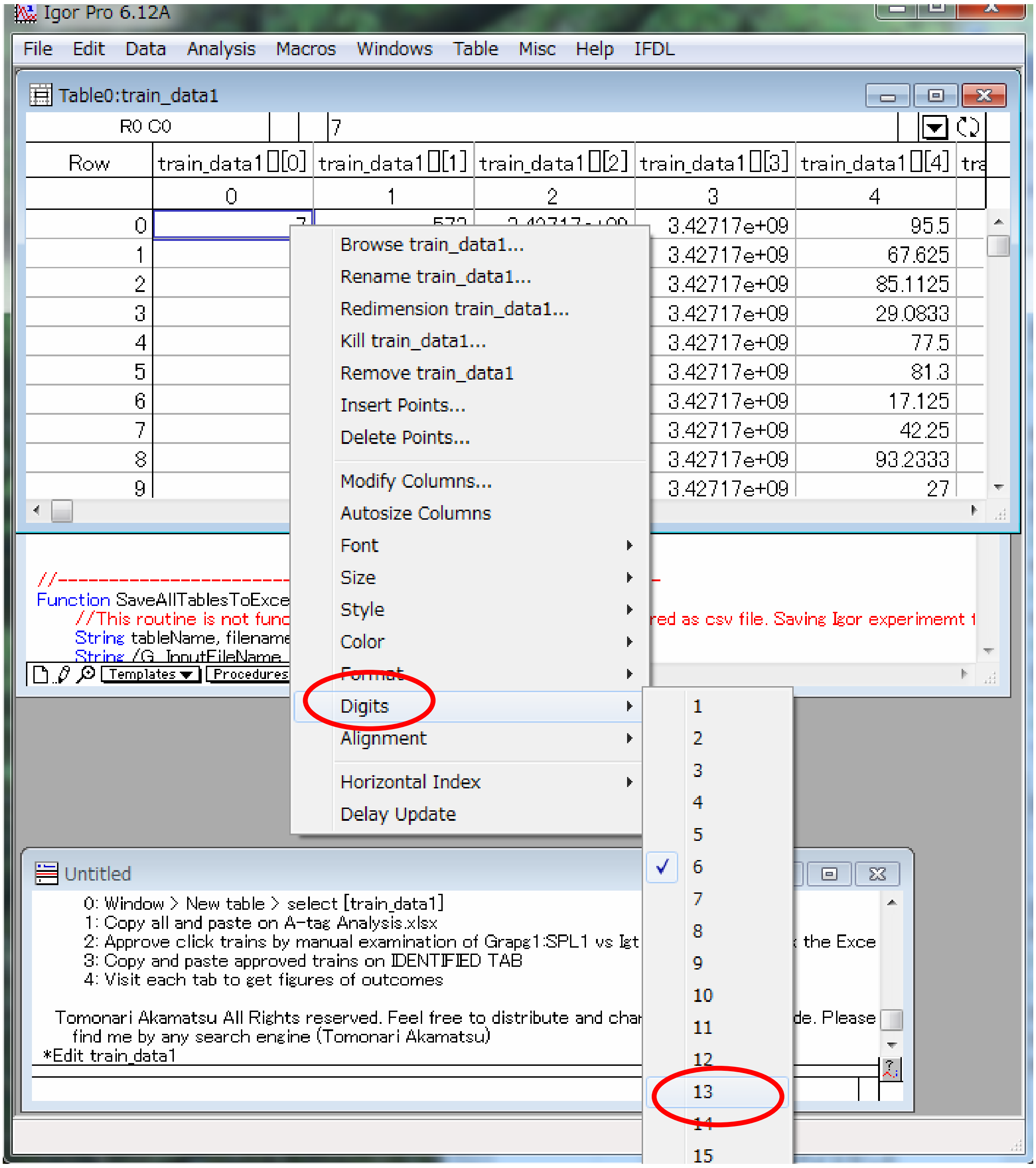
Select **Windows** > **New table**



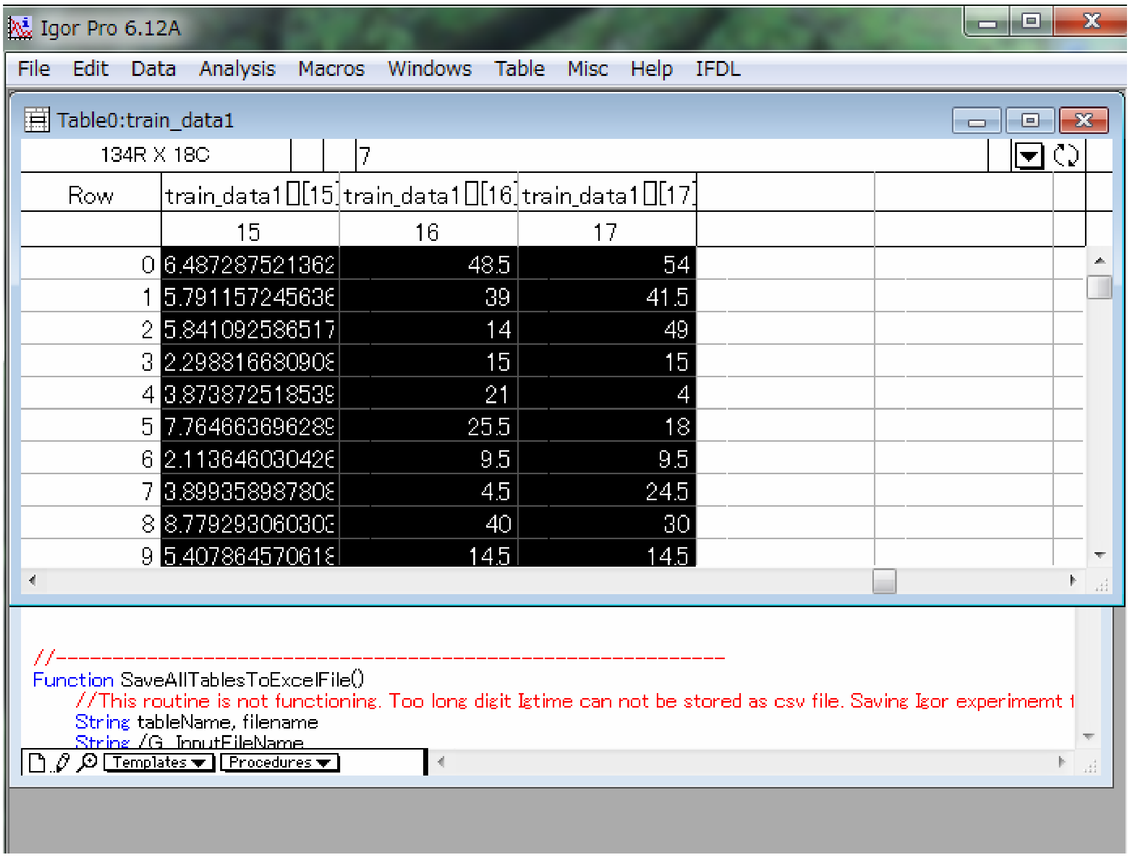
Select **train_data1** and Do it.


Igor Pro 6.12A
File Edit Data Analysis Macros Windows Graph Misc Help IFDL
Graph1:SPL1 vs IgtimeDraw;td vs IgtimeDraw;...
SPL (relative to Pa)
New Table
Columns to Edit
SPLR
SPL1
SPL2
td
train_data1
W_coef
Double Float 64 bit [134][18]
Edit data columns only
Edit index and data columns
Edit dimension label and data columns
From Top Graph
Title:
Style:
none
Edit train_data1
Do It
To Cmd Line
To Clip
Help
Cancel

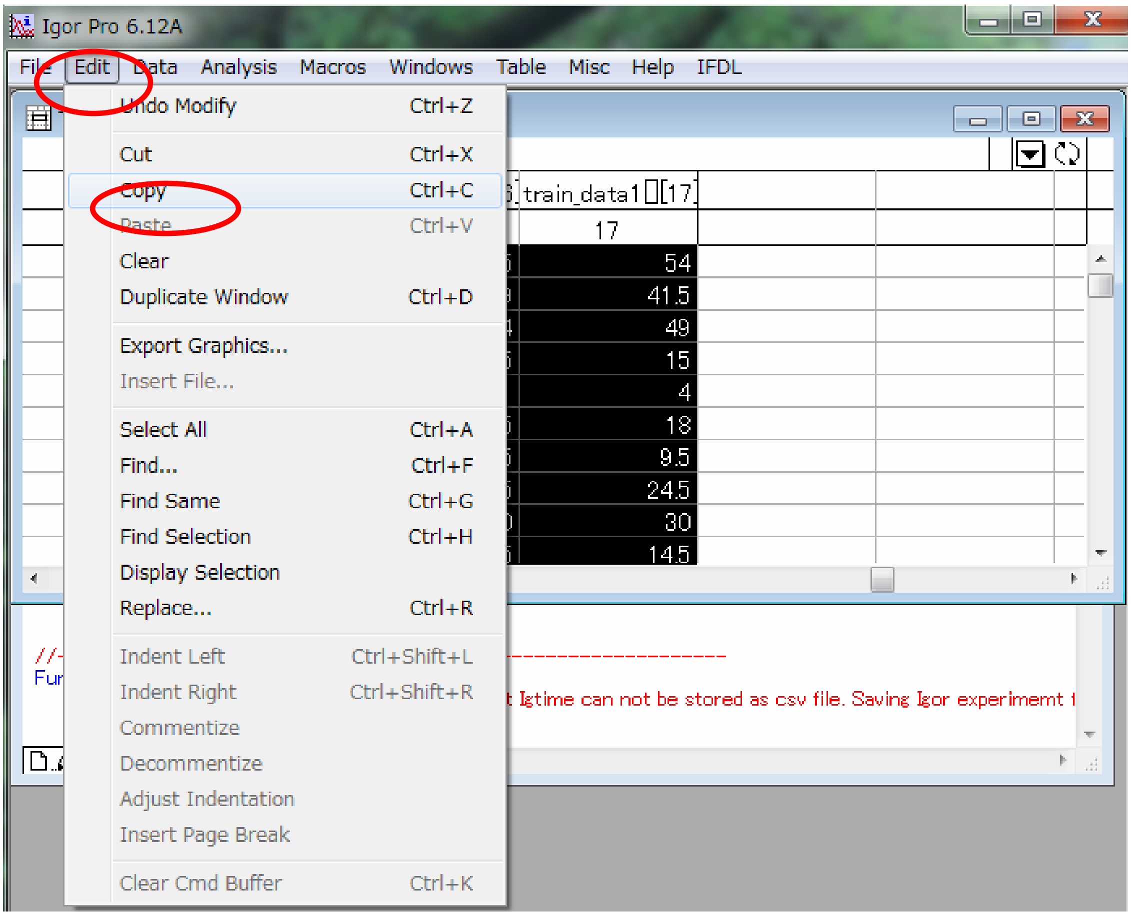
Put cursor on train_data1 table and right click on the mouse.
Check **Digits** 13



Select all of the data from 0 to 17 row



Edit > Copy

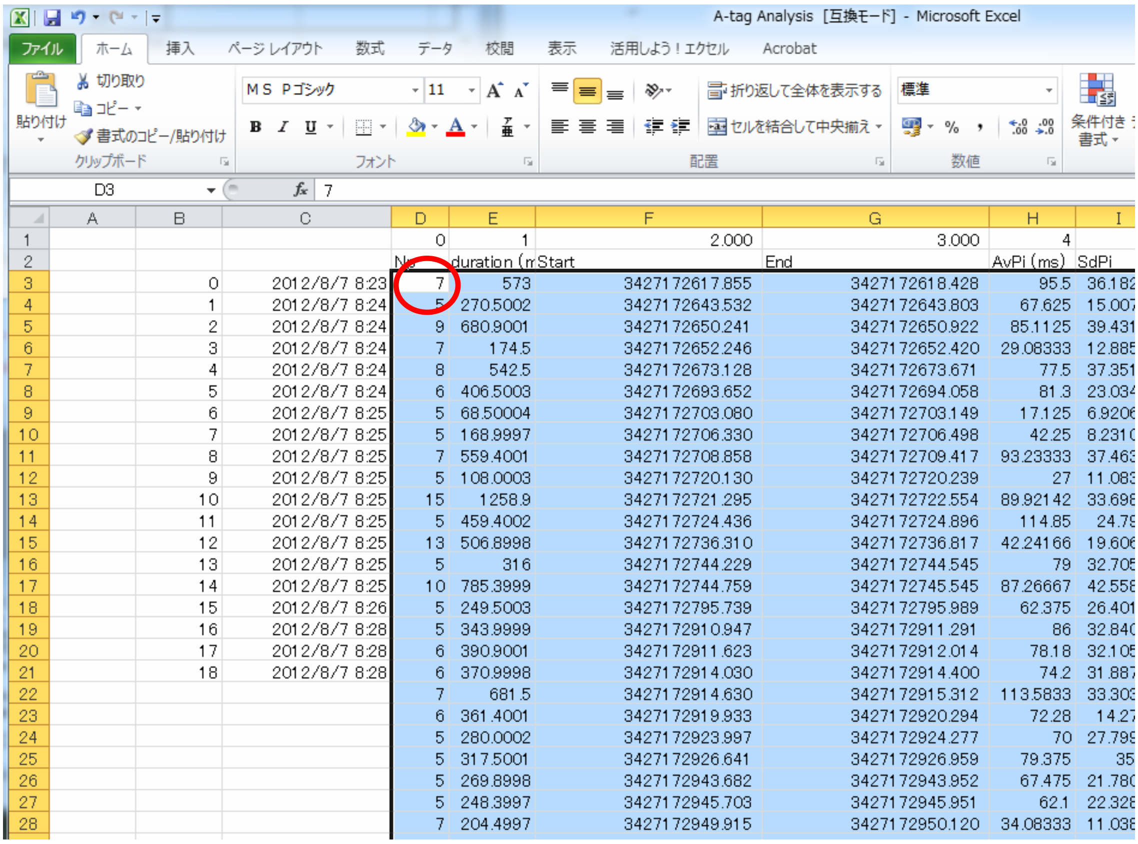

Igor Pro 6.12A
File Edit Data Analysis Macros Windows Table Misc Help IFDL
Undo Modify Ctrl+Z
Cut Ctrl+X
Copy Ctrl+C
Paste Ctrl+V
Clear
Duplicate Window Ctrl+D
Export Graphics...
Insert File...
Select All Ctrl+A
Find... Ctrl+F
Find Same Ctrl+G
Find Selection Ctrl+H
Display Selection
Replace... Ctrl+R
Indent Left Ctrl+Shift+L
Indent Right Ctrl+Shift+R
Commentize
Decommentize
Adjust Indentation
Insert Page Break
Clear Cmd Buffer Ctrl+K
train_data1[17]
17
54
41.5
49
15
4
18
9.5
24.5
30
14.5
Igtime can not be stored as csv file. Saving Igor experimemt

Train_data1 contains statistics of each click rain. 0-4 will be used for further analysis. Raws 5-17 are not used in the analysis described in this manual.

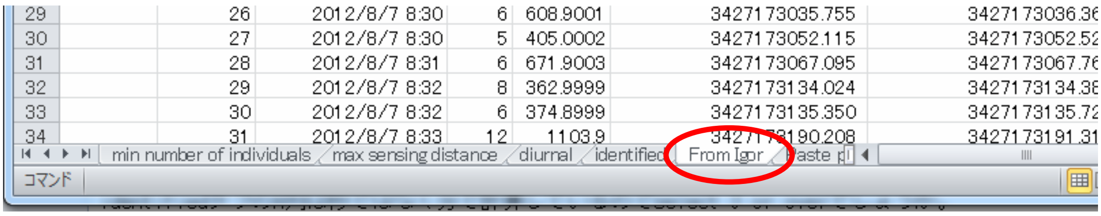
Raw. Description

0. Np : number of pulses included in a click train
1. duration (ms) : duration of a click train between the first and last pulse.
2. Start : start time of the click train
3. End : end time of the click train
4. AvPi (ms) : average inter-pulse interval of the click train
5. SdPi : standard deviation of inter-pulse interval
6. MedPi (ms) : median of inter-pulse interval
7. MaxPi(ms) : maximum of inter-pulse interval
8. AvSPLR : averaged two band ratio in the click train. Two band ratio is the ratio of received intensity at primarily hydrophone (sensitive at 130kHz) and secondary hydrophone (sensitive at 70 kHz). Approximately ratio<0.8 suggests delphinidae click trains and ratio>0.8 suggests phocoenidae click trains.
9. SdSPLR : standard deviation of two band ratio.
10. MedSPLR : median of two band ratio.
11. self more1 /other's more 0 : not used
12. # of self pulses : not used
13. # of other's pulses : not used
14. Linear regression of inter-pulse interval in the train
15. Standard deviation of regression
16. Minimum IPI within PIwin numbers of clicks in the beginning of the click train
17. Minimum IPI within PIwin numbers of clicks in the end the click train

Open **A-tag Analysis**.xls
Paste data at D3 of From Igor TAB

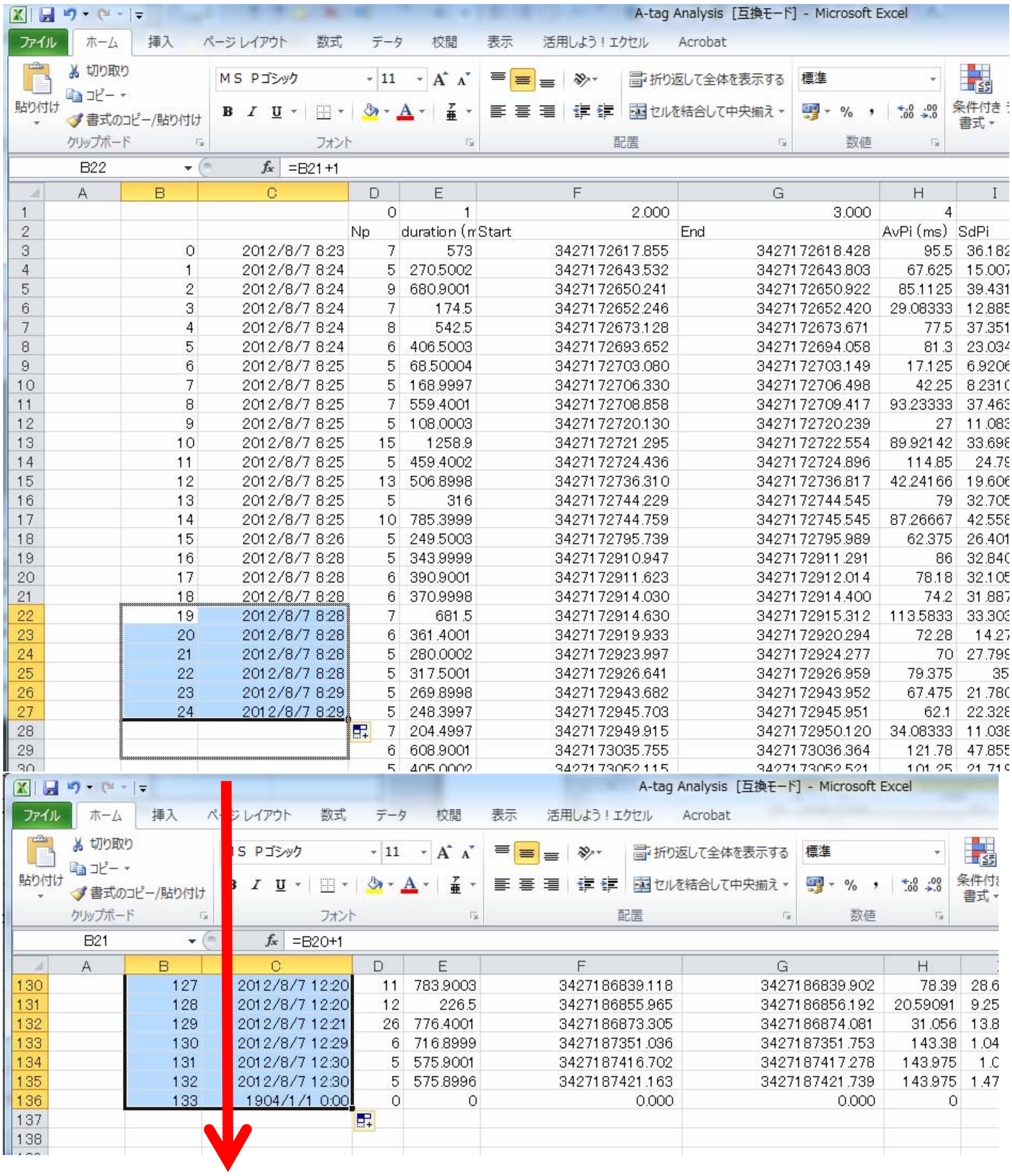


	A	B	C	D	E	F	G	H	I
1				0	1	2.000	3.000	4	
2				No	duration (m	Start	End	AvPi (ms)	SdPi
3		0	2012/8/7 8:23	7	573	342717261 7.855	34271 72618.428	95.5	36.182
4		1	2012/8/7 8:24	5	270.5002	34271 72643.532	34271 72643.803	67.625	15.007
5		2	2012/8/7 8:24	9	680.9001	34271 72650.241	34271 72650.922	85.1125	39.431
6		3	2012/8/7 8:24	7	174.5	34271 72652.246	34271 72652.420	29.08333	12.885
7		4	2012/8/7 8:24	8	542.5	34271 72673.128	34271 72673.671	77.5	37.351
8		5	2012/8/7 8:24	6	406.5003	34271 72693.652	34271 72694.058	81.3	23.034
9		6	2012/8/7 8:25	5	68.50004	34271 72703.080	34271 72703.149	17.125	6.9206
10		7	2012/8/7 8:25	5	168.9997	34271 72706.330	34271 72706.498	42.25	8.2310
11		8	2012/8/7 8:25	7	559.4001	34271 72708.858	34271 72709.417	93.23333	37.463
12		9	2012/8/7 8:25	5	108.0003	34271 72720.130	34271 72720.239	27	11.083
13		10	2012/8/7 8:25	15	1258.9	34271 72721.295	34271 72722.554	89.92142	33.698
14		11	2012/8/7 8:25	5	459.4002	34271 72724.436	34271 72724.896	114.85	24.79
15		12	2012/8/7 8:25	13	506.8998	34271 72736.310	34271 72736.817	42.24166	19.606
16		13	2012/8/7 8:25	5	316	34271 72744.229	34271 72744.545	79	32.705
17		14	2012/8/7 8:25	10	785.3999	34271 72744.759	34271 72745.545	87.26667	42.558
18		15	2012/8/7 8:26	5	249.5003	34271 72795.739	34271 72795.989	62.375	26.401
19		16	2012/8/7 8:28	5	343.9999	34271 72910.947	34271 72911.291	86	32.840
20		17	2012/8/7 8:28	6	390.9001	34271 72911.623	34271 72912.014	78.18	32.105
21		18	2012/8/7 8:28	6	370.9998	34271 72914.030	34271 72914.400	74.2	31.887
22				7	681.5	34271 72914.630	34271 72915.312	113.5833	33.303
23				6	361.4001	34271 72919.933	34271 72920.294	72.28	14.27
24				5	280.0002	34271 72923.997	34271 72924.277	70	27.799
25				5	317.5001	34271 72926.641	34271 72926.959	79.375	35
26				5	269.8998	34271 72943.682	34271 72943.952	67.475	21.780
27				5	248.3997	34271 72945.703	34271 72945.951	62.1	22.328
28				7	204.4997	34271 72949.915	34271 72950.120	34.08333	11.038

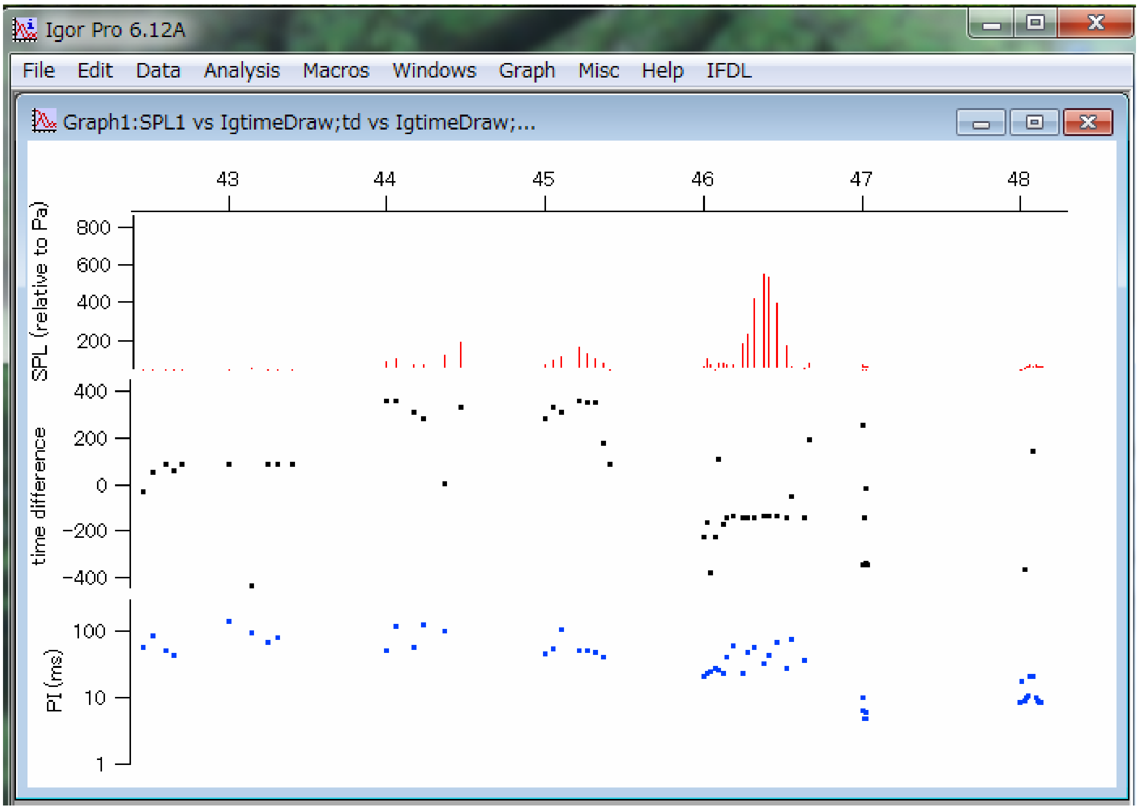


29		26	2012/8/7 8:30	6	608.9001	34271 73035.755	34271 73036.36
30		27	2012/8/7 8:30	5	405.0002	34271 73052.115	34271 73052.52
31		28	2012/8/7 8:31	6	671.9003	34271 73067.095	34271 73067.76
32		29	2012/8/7 8:32	8	362.9999	34271 73134.024	34271 73134.38
33		30	2012/8/7 8:32	6	374.8999	34271 73135.350	34271 73135.72
34		31	2012/8/7 8:33	12	1103.9	34271 73190.208	34271 73191.31

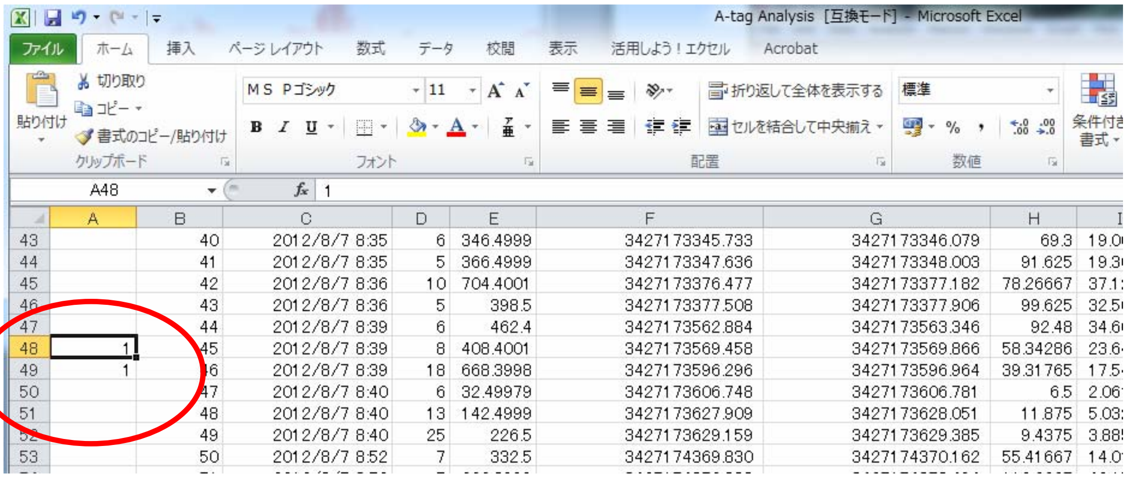
Drag last lines to the end of the data to calculate serial number of click trains.



Back to the Igor file and examine each click trains in Graph1 window. For this case, 44 and 45 are likely to be click trains.



If a train identified as real biosonar click train, mark 1 at the corresponding serial number on the 2nd row of the excel sheet. <u>This task takes time.</u>



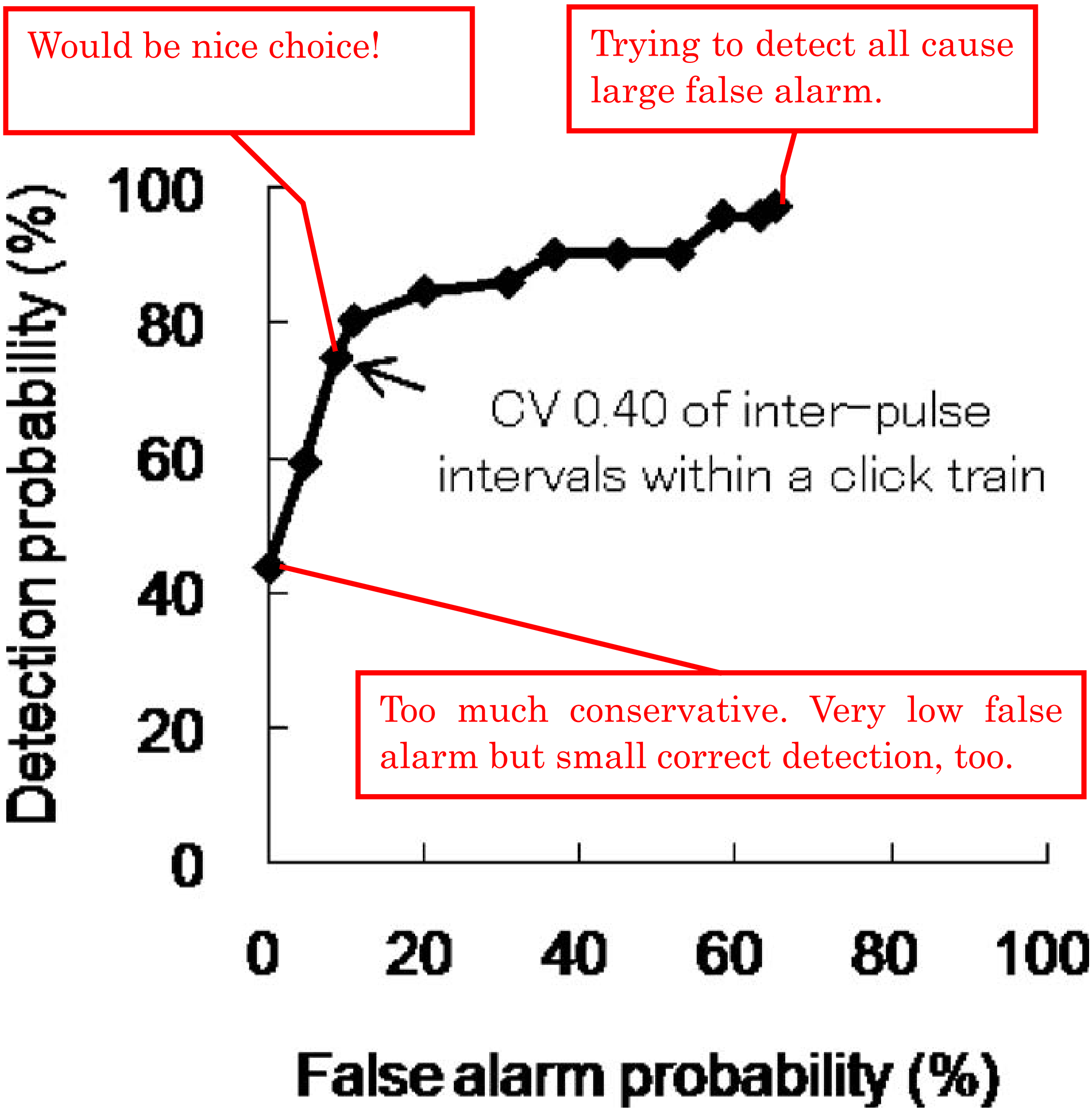
	A	B	C	D	E	F	G	H	I
43		40	2012/8/7 8:35	6	346.4999	3427173345.733	3427173346.079	69.3	19.0
44		41	2012/8/7 8:35	5	366.4999	3427173347.636	3427173348.003	91.625	19.3
45		42	2012/8/7 8:36	10	704.4001	3427173376.477	3427173377.182	78.26667	37.1
46		43	2012/8/7 8:36	5	398.5	3427173377.508	3427173377.906	99.625	32.5
47		44	2012/8/7 8:39	6	462.4	3427173562.884	3427173563.346	92.48	34.6
48	1	45	2012/8/7 8:39	8	408.4001	3427173569.458	3427173569.866	58.34286	23.6
49	1	46	2012/8/7 8:39	18	668.3998	3427173596.296	3427173596.964	39.31765	17.5
50		47	2012/8/7 8:40	6	32.49979	3427173606.748	3427173606.781	6.5	2.06
51		48	2012/8/7 8:40	13	142.4999	3427173627.909	3427173628.051	11.875	5.03
52		49	2012/8/7 8:40	25	226.5	3427173629.159	3427173629.385	9.4375	3.88
53		50	2012/8/7 8:52	7	332.5	3427174369.830	3427174370.162	55.41667	14.0

How to identify REAL click trains?

Cetacean biosonar clicks can be distinguished from random noise.

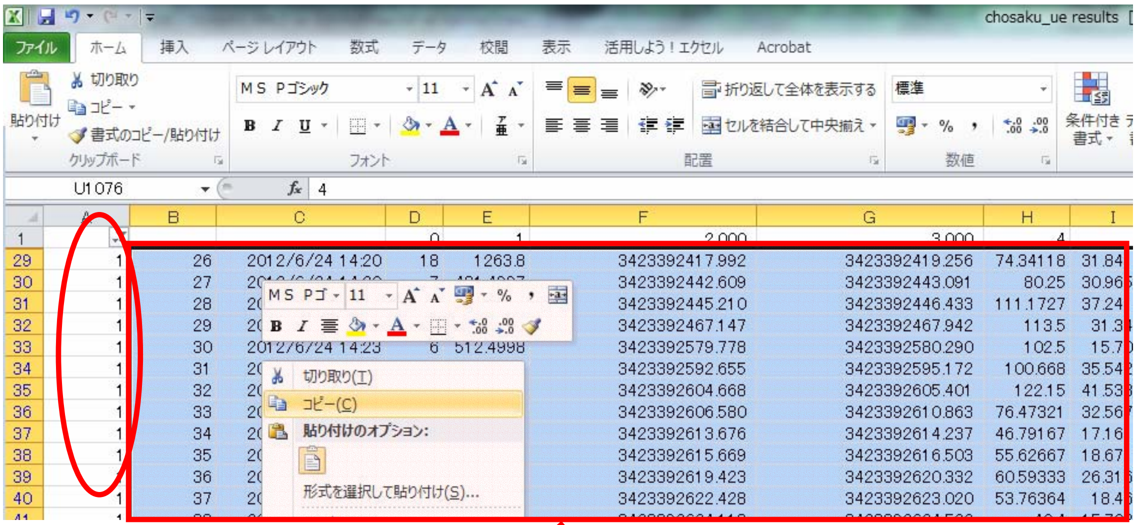
1. Regular inter-pulse interval
2. Coming from same direction
3. Smooth change of sound pressure level. A click train looks like a mountain shape.
4. Once a click train detected, several click trains tend to be recorded. Because odontocetes produce click trains frequently, namely every 10 seconds.
5. Artificial noise source such as echosounder, depth meter, ADCP etc resemble to biosonar click trains except for constant inter-pulse interval. They produce sound exactly regularly, which can be a key to remove artificial ultrasonic contaminations.
6. Ship noise is commonly detected. It shows random inter-pulse interval because the noise source is cavitation behind the screw. In addition, ship noise is continuous, but click trains are intermittent. Time difference appeared in the Igor figure shows dotted line for click trains and continuous line for ship noise.
7. Snapping shrimp noise is common in warm coastal water. It shows random inter-pulse interval and time difference is also random because numbers of shrimps produce loud but single pulse at various locations.
8. <u>Do not try to extract doubtful sounds.</u> A faint pulse trains from shrimp, ship or artificial echosounder could be quite similar to a faint click train. If you wish to detect biosonar click trains as much as possible, you will take risk to include noise as signals*.

*This is called false alarm rate. Ideally, 100% correct detection and 0% false alarm is best situation. In reality, this never happens. Second best is to maximize correct detection and minimize false alarm. For example, if you try to detect all possible click trains, false alarm rate also increased. This means data reliability is getting worse. On the other hand, if you are conservative and wish to extract extremely reliable click trains, it suppress false alarm nearly equal to zero, but need to accept small correct detection. This is OK as long as sufficient correct detection is obtained. Decide acceptable level of false alarm rate and maximize detection effort until false alarm reaches the level.

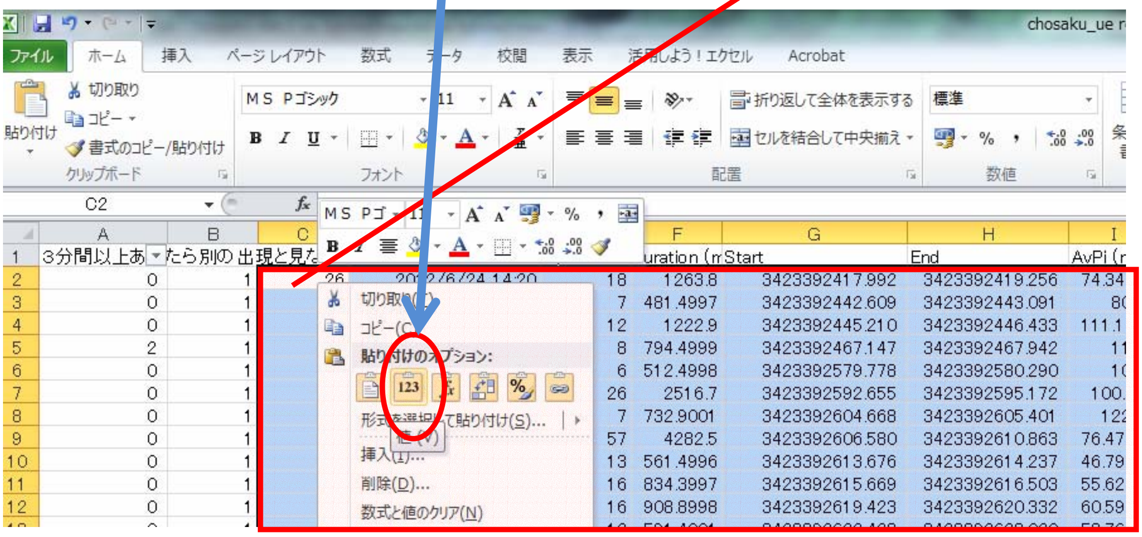


Kimura et al. (2010) Density estimation of Yangtze finless porpoises using passive acoustic sensors and automated click train detection, J. Acoust. Soc. Am. 128, 1435-1445.

After finishing examinations, set filter on A row and select only 1.



Copy selected data from B to U and paste this at C2 of identified Tab. Note to select “only values”, not just to paste.



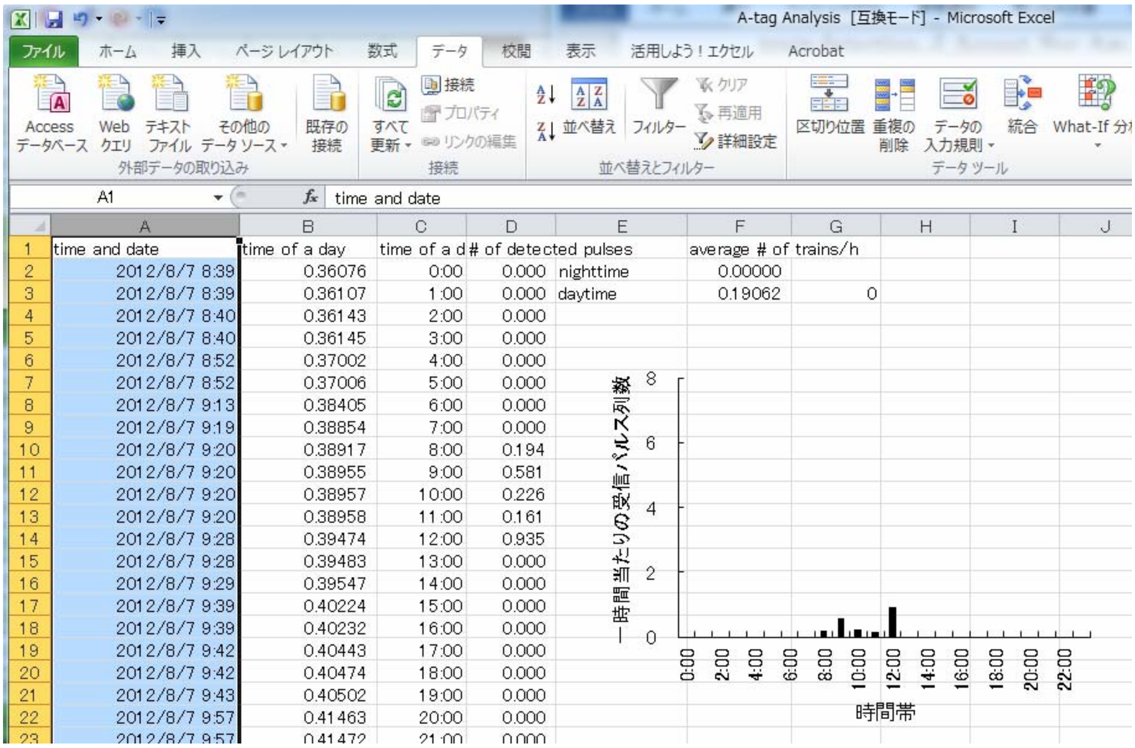
Now you’ve got qualified data of biosonar click trains.

Save this Igor file for your record.

4. Data analysis using Excel

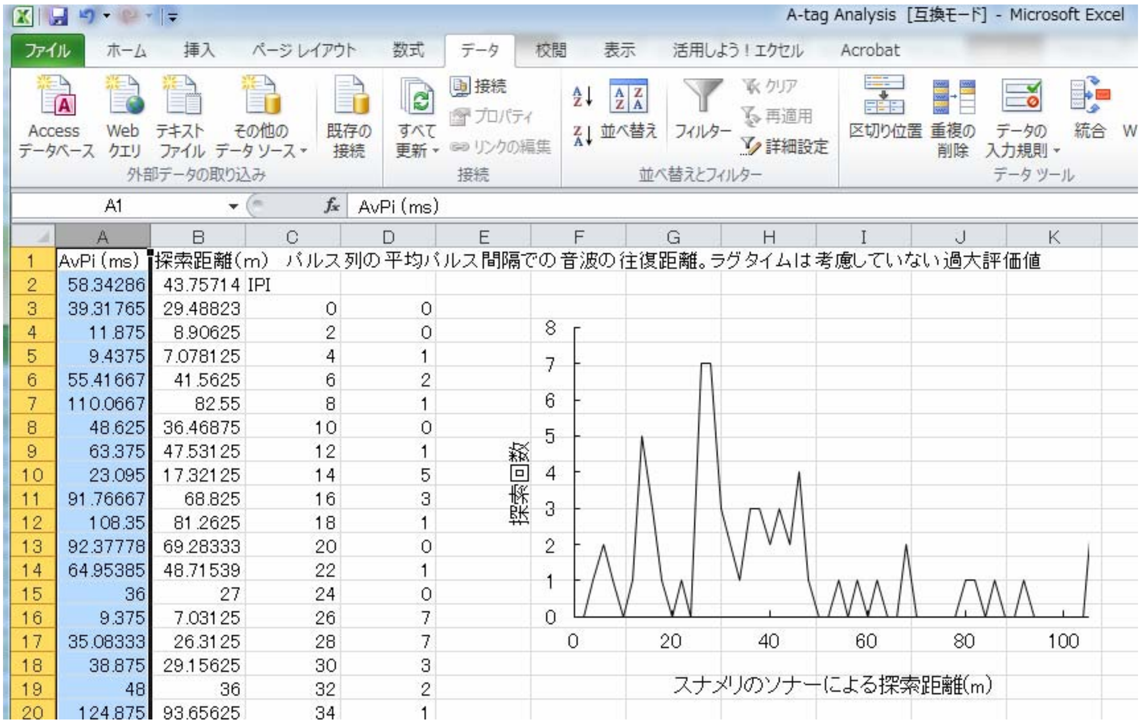
Diurnal detection pattern

Copy D row (time and date) of identified TAB of A-tag Analysis.xls to A row of diurnal TAB, number of detection in each 1 hour time bin in a day will be shown.



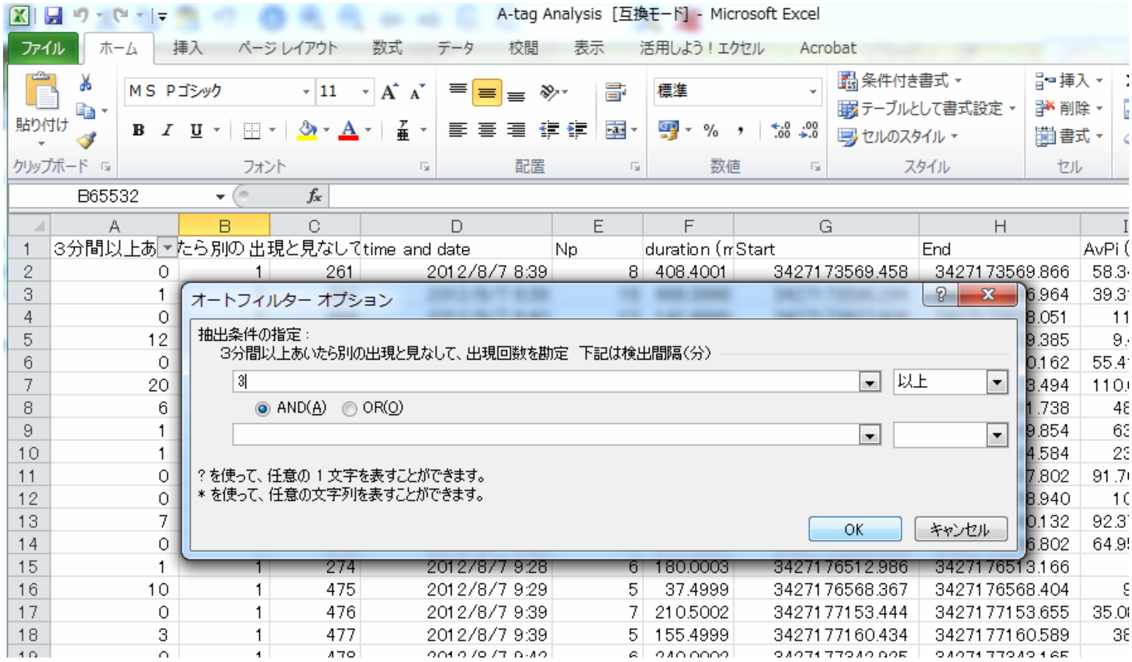
Maximum sensing distance (m)

Copy I row (AvPi (ms)) to A row of max sensing distance TAB, distribution of maximum acoustic sensing distance in meter by echolocation is indicated.



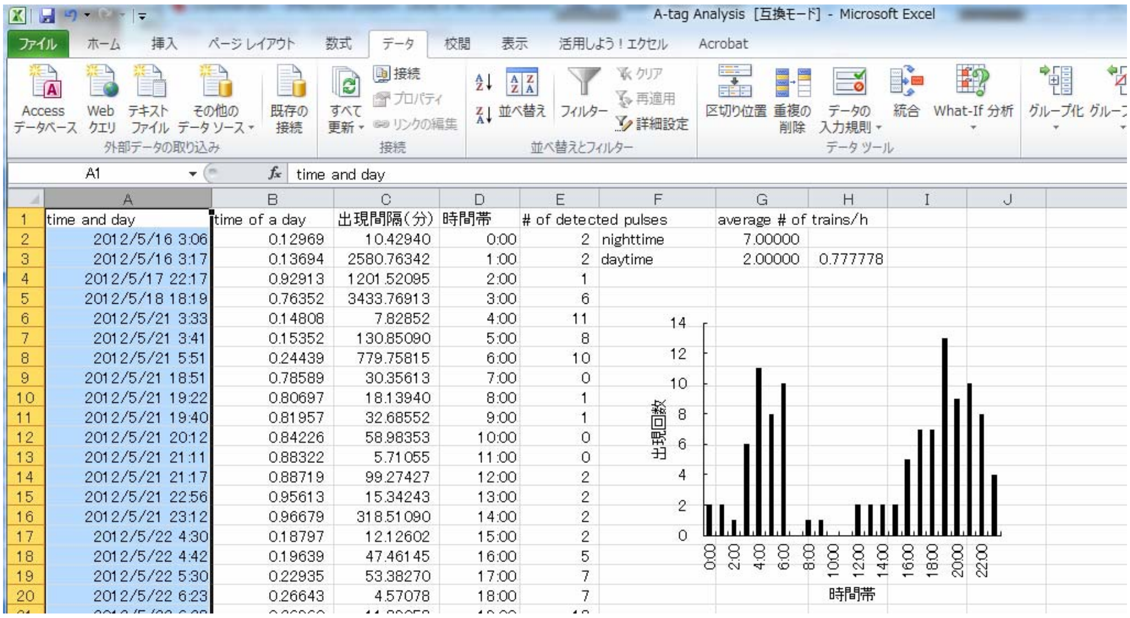
Counting individual by fixed system 1

Apply filter for A row of identified TAB and select 3 (minutes) or over. Copy Sorted data shows the minimum number of presented individuals. Definition of the number is that number of silence >=3 minutes. This means the minimum number of presented individuals. Even two or more animals presented during 180 seconds, this analysis count minimum one animal was there. If one animal passed by the monitoring site then back again after 180 seconds or longer, this calculation counts two animals presented. Note that any static observation such as visual point transect has same issue. This is the limitation of platform, not the limitation of acoustics.



Counting individual by fixed system 2

Copy D row (time and date) of identified TAB to A row of min number of individuals TAB, distribution of minimum numbers of presented animals in each time bin in a day is indicated.



5. Further analysis, up to your ideas

For example;

1. General overview

Li, S., Akamatsu, T., Dong, L., Wang, K., Wang, D., and Kimura, S. (2010) Widespread passive acoustic detection of Yangtze finless porpoise using miniature stereo acoustic data-loggers: A review, J. Acoust. Soc. Am. 128, 1476-1482.

2. Towed survey

2-1 Strip transect and detection probability

Akamatsu, T., Wang, D., Wang, K., Li, S., Dong, S., Zhao, X., Barlow, J., Stewart, B.S., Richlen, M., (2008), Estimation of the detection probability for Yangtze finless porpoises (*Neophocaena phocaenoides asiaeorientalis*) with a passive acoustic method, J. Acoust. Soc. Am. 123(6), 4403-4411.

2-2 Localization of animals

Li, S., Akamatsu, T., Wang, D., and Wang, K. (2009), Localization and tracking of phonating finless porpoises using towed stereo acoustic data-loggers, J. Acoust. Soc. Am. 126, 468-475.

2-3 Local distribution

Kimura, S., Akamatsu, T., Li, S., Dong, L., Wang, K., Wang, D., and Arai, N. (2012), Seasonal changes in the local distribution of Yangtze finless porpoises related to fish presence, Marine Mammal Science, 28(2), 308-324.

2-4 Cargoship platform

Dong, L., Wang, D., Wang, K., Li, S., Dong, S., Zhao, Z., Akamatsu, T., Kimura, S. (2011), Passive acoustic survey of Yangtze finless porpoises using a cargo ship as a moving platform, J. Acoust. Soc. Am. 130, 2285-2292.

2-5 Boat avoidance

Li, S. Akamatsu, T., Wang, D., Wang, K., Dong,S., Zhao, X., Wei, Z., Zhang, Z., Taylor, B., Barrett, L.A., Turvey, S.T., Reeves, R.R., Stewart, B.S., Richlen, M., and Brandon, J.R. (2008), Indirect Evidence of boat avoidance behavior of Yangtze finless porpoises, Bioacoustics The International Journal of Animal Sound and its Recording, 17, 174-176.

3. Fixed survey

3-1 Diurnal and seasonal presence pattern

Akamatsu,T., Nakazawa, I., Tsuchiyama, T., Kimura, N., (2008), Evidence of nighttime movement of finless porpoises through Kanmon Strait monitored using a stationary acoustic recording device, Fisheries Science 74, 970-976.

Akamatsu T., Nakamura K., Kawabe R., Furukawa S., Murata H., Kawakubo A. Komaba M., (2010), Seasonal and diurnal presence of finless porpoises at a corridor to the ocean from their habitat, Marine Biology 157, 1879-1887.

3-2 Relative density comparison

Kimura, S., Akamatsu, T., Wang, K., Wang, D., Li, S., Dong, S., and Arai, N. (2009), Comparison of stationary acoustic monitoring and visual observation of finless porpoises, J. Acoust. Soc. Am., 125, 547-553.

3-3 Absolute density estimation

Kimura, S., Akamatsu, T., Li, S., Dong, S., Dong, L., Wang, K., Wang, D., and Arai, N. (2010) Density estimation of Yangtze finless porpoises using passive acoustic sensors and automated click train detection, J. Acoust. Soc. Am. 128, 1435-1445.

3-4 Underwater movements

Sasaki-Yamamoto, Y., Akamatsu, T., Ura, T., Sugimatsu, H., Kojima, J., Bahl, R., Behera, S., Kohshima, S. (2012), Diel changes in the movement patterns of Ganges River dolphins monitored using stationed stereo acoustic data loggers, Marine Mammal Science, in press

4. Tagged survey

4-1 Biosonar behavior

Rasmussen, M.H., Akamatsu. T., Teilmann. J., Vikingsson, G., and Miller, L.A. (2012) Biosonar, diving and movements of two tagged white-beaked dolphin in Icelandic waters, Deep-Sea Research II in press

Linnenschmidt, M., Teilmann, J., Akamatsu, T., Dietz, R., Miller, L. (2012), Biosonar, dive and foraging activity of satellite tracked harbor porpoises (*Phocoena phocoena*), Marine Mammal Science, in press.

4-2 Conspecific association

Sakai, M., Wang, D., Wang, K., Li, S., Akamatsu, T. (2011), Do porpoises choose their associates? a new method for analyzing social relationships among cetaceans, PLoS ONE, 6(12), 1-8.

4-3 Feeding behavior

Akamatsu, T. Wang, D. Wang, K, Li, S., Dong, S. (2010), Scanning sonar of rolling porpoises during prey capture dives. J. Exp. Biol. 213, 146-152.

4-4 Sensing distance

Akamatsu, T., Teilmann, J., Miller, L.A., Tougaard, J., Dietz, R., Wang, D., Wang, K., Siebert, U., and Naito, Y. (2007), Comparison of echolocation behaviour between coastal and riverine porpoises, Deep-Sea Research II 54(3-4), 290-297.

Akamatsu, T. Wang, D. Wang, K. and Naito, Y. (2005), Biosonar behaviour of free-ranging porpoises, Proc. R. Soc. Lond. B 272, 797-801.

4-5 Beam pattern

Akamatsu, T. Wang, D. and Wang, K. (2005), Off-axis sonar beam pattern of free-ranging finless porpoises measured by a stereo pulse event data logger, J. Acoust. Soc. Am. 117(5), 3325-3330.