

Lumatrex, Inc.

**REPEATABILITY OF METHODS OF PROPELLER CUT
ANALYSIS USING PHOTOGRAPHS OF CUTS AND SCARS ON
CARCASSES AND LIVING ANIMALS**

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REPEATABILITY OF METHODS OF PROPELLER CUT ANALYSIS USING PHOTOGRAPHS OF CUTS AND SCARS ON CARCASSES AND LIVING ANIMALS

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Improved methods and computational tools for analyzing the scars and cuts resulting from propeller strikes on marine mammals will allow researchers to gain insight into the types of vessels involved in fatal and nonfatal propeller strikes on various species of marine mammals. Application of the methods developed by the author require a fair degree of precision in both identifying the endpoints of cuts visible in photographs and in measuring the parameters required for the analysis. This study demonstrates that the skills required for this analysis can be developed by most members of the research community with only a minimum amount of training.

INTRODUCTION

The analysis of cuts and scars left by propellers can help provide information regarding the general size and types of vessels involved in propeller strikes on various species of marine mammals. Analytical methods developed by the author allow researchers to use photographs of propeller cuts visible on carcasses as well as living mammals to determine, among other things, the general size category of the diameter of the propeller involved in the accident. These methods require a reasonable degree of precision in both identifying the endpoints of the cuts visible in photographs and in measuring the parameters required for the analysis. This study examines and demonstrates that a small group of participants can, with minimal training, apply these methods and produce repeatable results.

METHOD

The participants in this study were a group of five high school students consisting of the author's two children and three of their friends. There were three males 14 years of age and two females 16 years of age. None of the participants had any significant training in

analytical or laboratory techniques, nor did they have any significant background in the biological sciences.

Each participant analyzed a set of three photographs taken during necropsies of Florida manatees (*Trichechus manatus latirostris*). The photographs were provided by the Florida Wildlife Research Institute's (FWRI) Marine Mammal Pathobiology Laboratory (MMPL) and were prescreened by the author for suitability for analysis. The necropsies represented by these photographs are identified as MEC0143, MEC0244, and SWFTM9905. In each case the accident was reported by the vessel operator; so, the physical properties of the propeller are known. The specific photographs used in this study are identified as MEC0143-7, MEC0224-1, and SWFTM9905-4.

The participants worked in two groups of two and one group of one. This grouping was dictated by the participant's schedules and availability. They worked under the direct supervision of the author and were allowed to ask for assistance whenever they felt it was needed. Once the initial instructions were completed, there were surprisingly few questions. Photograph MEC0143-7 was used for the initial instructions. In this photograph, one endpoint of cut #4 and one endpoint of cut #5 were used to demonstrate the technique for locating endpoints. The remaining steps of the analysis for photograph MEC0143-7 were conducted independently with close supervision from the author. The remaining two photographs were analyzed with little or no direct supervision.

The analysis consisted of six major steps. The first step was to evaluate the cuts visible in the photograph as to suitability for analysis. With each photograph, the author explained the set of criteria for identifying unsuitable cuts, and the participants marked through cuts that were not suitable for analysis. In every case, the participants eliminated the same cuts and identified the same set of cuts as suitable for analysis. In photograph MEC0143-7, cuts 3, 4, and 5 (as numbered in the necropsy report) were identified as suitable for analysis. In photograph MEC0224-1, cuts 3 and 4 were identified as suitable for analysis, and in photograph SWFTM9905-4, cuts 7 and 8 were identified as suitable for analysis.

In the next step the participants positioned the photograph over another sheet of paper with the anterior end of the animal generally at the top of the page. They then use a pushpin to locate the endpoints of the cuts and to transfer those locations to the second sheet of paper placed under the photograph. The location of the ends of the reference scale visible in each photograph was also identified and transferred using the pushpin. The photograph was set aside and no longer needed.

The third step was to identify the cuts by drawing straight lines between the endpoints of each cut and to number each cut. The length of the reference scale was also identified by drawing a line between its endpoints.

The fourth step was to draw a baseline to be used as a reference for measurements. The baseline could be any arbitrary length though, at the authors suggestion, most of the participants elected to use a length of 10 cm. The position of the baseline was also

arbitrary with three notable exceptions. The baseline must be positioned so that a viewer can recognize the direction of rotation of the propeller. A propeller rotating counterclockwise will form cuts that slope up and to the right when viewed from the approximate line of travel of the propeller, and a propeller rotating clockwise will form cuts that slope up and to the left. This is usually readily apparent in the photographs of a series of propeller cuts, and the placement of the baseline must make this relationship apparent to the viewer. Also the baseline must be placed so that the endpoints of all of the cuts are approximately centered within an imaginary rectangle having the baseline as one of its sides. Finally, the baseline must be placed so that it is not parallel to any of the lines representing the cuts or the line representing the reference scale.

Once the baseline is drawn, the fifth step is to label specific locations on the drawing so that they can be used to refer to the various measurements that will be made. The endpoint of the baseline which is on the down-slope side of the cuts is labeled A. The end of the baseline which is on the up-slope side of the cuts is labeled B. The position of these labels on the drawing may be reversed on the page from photograph to photograph depending on the rotation of the propeller. The end of each cut and the end of the reference scale closest to the baseline is labeled O. The end of each cut and the end of the reference scale farthest from the baseline is labeled U.

The final step is to use a scale calibrated in millimeters to measure the distance from each endpoint of each cut and each endpoint of the reference scale to each endpoint of the baseline and to record the measurement in a table provided by the author. This requires four measurements for each cut and four measurements for the reference scale. The actual length of the baseline must also be measured and recorded. The participants were instructed to avoid false precision by recording each measurement to the nearest whole millimeter, or in the case where the measurement fell essentially between two marks on the scale, they were to record the measurement to the nearest half millimeter.

Once the measurements were completed, each table of measurements was checked by another participant or by the author. If any significant error in the measurements was detected, the original participant was asked to redo that specific measurement. Because of the inexperience of the participants, this step was vital. There were several instances where the scale was read incorrectly and gross errors were recorded in the table. For example a measurement of 4.30 cm may be misread as 4.80 cm, or a measure of 14.3 cm may be recorded as 11.3 cm. One participant had a propensity for this type of error and unfortunately they were not available to correct the mistakes. In this case, the only solution was to not include those results in the study.

The measurements recorded in each table were then transferred to a set of Excel spreadsheets which performed the necessary calculations. The logic functions available in spreadsheets are not particularly versatile, and since the calculations involved several logic decisions, it was necessary to design specific spreadsheets for each of the photographs. Each participant's results for each photograph were reported as a propeller diameter in inches, number of blades on the propeller, percent error from the known diameter, and a variation in inches from the known diameter.

RESULTS

The goal of this study is to test the repeatability of the results obtained when the analytical methods and computational tools employed here are used to place the propeller responsible for creating a given set of cuts within a general size category. For example, identifying the difference between a 15 inch diameter propeller, a 22 inch diameter propeller, and a 30 inch diameter propeller will allow researchers to categorize these propellers according to their general size and is well within the capabilities of the methods employed here. However, distinguishing between a 14 inch diameter propeller and a 15 inch diameter propeller is far less useful to researchers, and though such a distinction is within the scope of the computational tools developed by the author the photographs and methods currently available do not allow this kind of precision. The primary limiting factors are the quality of the available photographs and the methods used for measuring distances between points. With better quality photographs taken specifically for this purpose and an automated method of measuring, it should be possible to reduce the error of the resulting calculations to about 5% of the actual propeller diameter.

This study demonstrates that the methods employed are able to place propellers within general size categories with repeatable results even when applied by relatively unskilled technicians. The one notable exception was when one participant identified the 15.5 inch diameter propeller as a 19 inch diameter propeller, which is a 23% error. This error was traced to the participant misidentifying one endpoint of one of the cuts. This participant was exceptionally fast, but it appears that precision was sacrificed for speed.

The results are tabulated below. In each case the participant's results are presented in a descending order of error. Then the results of the same analysis conducted by the author (JLW) are presented.

MEC0143-7

Known Propeller: 30 inch diameter, 4-blades

<u>Participant</u>	<u>Diameter (in.)</u>	<u>Blades</u>	<u>% Error</u>	<u>Error (in.)</u>
MP	34.2	4	14	4.2
KW	31.8	4	6	1.8
TW	30.8	4	3	0.8
DG	<u>27.6</u>	4	-8	-2.4
Average	31.1			
Std. Deviation	2.7			
JLW	28.4	4	-5	-1.6

SWFTM9905-4

Known Propeller: 22 inch diameter, 4-blades

<u>Participant</u>	<u>Diameter (in.)</u>	<u>Blades</u>	<u>% Error</u>	<u>Error (in.)</u>
MP	24.9	4	13	2.9
DG	24.2	4	10	2.2
KW	23.9	4	9	1.9
TW	<u>22.3</u>	4	2	0.3
Average	23.8			
Std. Deviation	1.1			
JLW	20.3	4	-8	-1.7

MEC0224-1

Known Propeller: 15.5 inch diameter, 3-blades

<u>Participant</u>	<u>Diameter (in.)</u>	<u>Blades</u>	<u>% Error</u>	<u>Error (in.)</u>
TW	19.0	3	23	3.5
MP	14.5	3	-7	-1.0
DG	13.7	3	-12	-1.8
KW	<u>13.1</u>	3	-15	-2.4
Average	15.1			
Std. Deviation	2.7			
JLW	13.7	3	-12	-1.8

CONCLUSIONS

This study demonstrates that these methods and computational tools can be applied to photographs of propeller cuts to identify the general size category of the propeller that created the cuts, and these results are repeatable even when the methods are applied by unskilled technicians. The successful application of these methods depends on two distinct sets of skills.

The first is proper identification of the endpoints of individual cuts. Though this is not difficult, it does require photographs that are of suitable quality and which show the ends of the cuts. It is also important that the true ends of the cuts are resolved in the photographs. This last problem can be addressed in necropsy photographs by placing markers at the endpoints of the cuts before they are photographed. Tom Pitchford of the MMPL has experimented with this idea with good success (personal communication).

The second necessary skill is the ability to measure lengths in the drawings accurately. This is a tedious process that requires a degree of precision. The participants in this study required approximately two hours to analyze three photographs and most agreed that the process required significant concentration and was fairly exhausting. This situation could be improved by using photographs larger than the 5x7 images used here. This would reduce the degree of precision required and improve the overall accuracy of the result. Unfortunately, the resolution quality of the photograph may limit the useable size of enlargement because as the image is enlarged the endpoints become less distinct.

This problem could also be improved by developing computer software which would allow researchers to work directly from digital images. This would allow the researcher to adjust the enlargement of the image to find a suitable compromise between image size and resolution of the endpoints of the cuts. This software could also be designed to automate the measuring process and to incorporate the logic and calculations necessary to convert the raw measurements into a propeller diameter. Such a system would reduce the whole process from hours to a minute or less. This would represent a significant savings of time over the methods that are currently used to document propeller cuts during the necropsy process.

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