Whale Shark Photo-Identification Library

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FIELD STATION MANUAL

Acknowledgements

This ‘Manual’ has been produced with the support of the United Nations Environment Programme (UNEP) Regional Seas. Special thanks to Jason Holmberg for text and images and to Darcy Bradley for assistance with formatting and final edit.

ECOCEAN FIELD STATION MANUAL
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Overview

Welcome to the ECOCEAN Whale Shark Photo-identification Library User Community!

Overview of the ECOCEAN Library

The ECOCEAN Whale Shark Photo-identification Library is an Internet-based software application for cooperative whale shark research. The primary purpose of the Library is to increase our understanding of whale sharks on a global and local level and to promote related conservation efforts through high quality research and scholarship. On a purely functional level, the Library is used to collect, protect, store, and share whale shark mark-recapture data gathered from a variety of individuals and institutions worldwide.

Purpose of this Field Station Manual

The purpose of this field manual is to document the standard operating procedures for the ECOCEAN Library that are required to ensure proper and consistent data collection, processing, and analysis. The intended audience for this document includes:

- current ECOCEAN Library users managing whale shark encounter data
- prospective Library users seeking to understand how the Library operates
- external reviewers seeking an in-depth look at Library operations

For more information about this manual, please contact: info@whaleshark.org

1 Managing Encounters and Sharks

1.1 Basic assumptions

The ECOCEAN Library is a mark-recapture framework for storing and analyzing whale shark data. As such, it divides data into two distinct types.

Encounters are individual sightings of whale sharks. An encounter report is submitted to the ECOCEAN Library via the Internet and represents a "mark" (first sighting) or "recapture" (subsequent re-sighting) of an individual whale shark. Each encounter contains photos and data that represent one whale shark at one point in time. An encounter can be added to a previously identified shark in the database, representing a resighting of that animal, or it can be allocated as a new individual shark and given a name, representing a new animal previously undocumented in the ECOCEAN Library. Encounters may also remain "Unassigned," indicating that the encounter does not contain enough data to be identified as a new or previously seen shark at the current time, though it may be matched to other encounters in the future.

Sharks are uniquely identified animals and are made up of one or more encounters. To be assigned as a new shark, a new encounter must have a properly-oriented left-side spot pattern extracted from a photograph and added into the database. Encounters without a suitable left-side pattern can be added to an existing shark if some other characteristic (visual recognition of its pattern or of significant scarring, right-side pattern matching to another identified shark, etc.) can be used to link it to an existing shark in the Library. As we build up more and more encounters for each shark, we will be able to build up robust metrics for population analysis, allowing us to better understand whale shark biology and population trends on a local and a global scale.

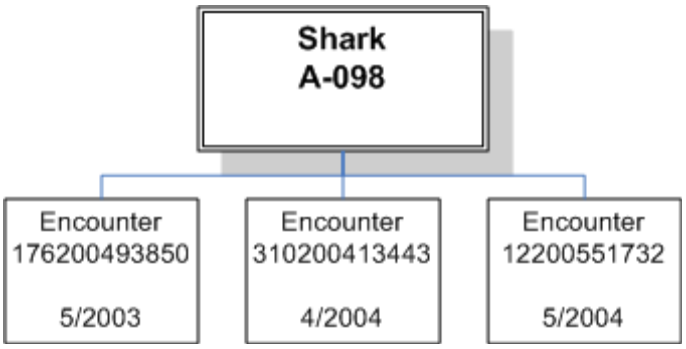


Figure 1. **One or more encounters make up an identified shark.**

1.2 Processing a new encounter: Approve or Reject

The following steps describe how to approve or reject a newly submitted encounter for inclusion in the ECOCEAN Library. Sometimes encounters are added with incomplete or inaccurate information. It is best to leave these encounters as "Unapproved" until the submitter has been contacted and the information has been corrected.

1.2.1 Reviewing a new encounter

To review a new, unapproved encounter for inclusion in the library, follow these steps:

1. Look at the new encounter in the View Unapproved Encounters view (login required) and ensure that the thumbnail image was correctly rendered. If not, use the **Reset thumbnail** command on the encounter page to choose a photo to render a new thumbnail from.
2. Check to make sure that all of the photos submitted contain material appropriate for display on the ECOCEAN web site. This is an important check to make sure that offensive material or photos showing inappropriate interaction with whale sharks are not displayed in the library. If the photos contain appropriate content and have enough information (scars, visible left- or right-side patterns in photos, or extractable spot patterns) to reasonably expect that the shark can be re-identified now or in the future, proceed to the next step. If the encounter contains offensive material, no photos, or poor quality photos, proceed to "Rejecting an Encounter" below.
3. Click on each photo one by one to view it in full detail. Note the presence of any distinguishing characteristics, such as scars, distinct spot patterning, or physical tags, using the pulldown list of keywords above each photo.
4. Check and edit the data submitted for each encounter as needed. For example, verify that the size estimate is realistic (30 feet versus 30 meters) and that the submitted comments contain appropriate language and good spelling.
5. Add the appropriate Location Code to the encounter and check any reported GPS coordinates for accuracy using the displayed Google Map.
6. If the content of the unapproved encounter is acceptable, click **Approve** to make the encounter visible to the general public once all of the above steps have been completed.
7. Check the TapirLink status of the encounter (true/false). The ECOCEAN Library TapirLink policy is available here.

1.2.2 Rejecting an encounter

There are two reasons to reject an encounter:

1. The encounter does not contain enough information to uniquely identify the shark now or in the future, but it does contain some useful data such as date and location, sex, size, etc. that can later be used for trending and aggregate analysis.
2. The encounter contains offensive or inappropriate content. These encounters should be deleted permanently.

To reject an encounter, click the **Reject** button in the left-hand blue bar of the encounter. This will give you two options:

a. Click **Save as DATA-ONLY** to preserve this encounter but not make it available to the general public. Note: Rejected DATA-ONLY encounters can be re-approved in the future if enough data is later submitted to allow for a reasonable chance of identification of this animal. As part of the DATA-ONLY rejection process, an email is sent to the encounter submitter informing him/her of the DATA-ONLY status of the encounter and of the insufficiency of data needed for accurate identification. Some submitters may have additional photographs that can be added to each encounter to allow for approval and public display.
b. Click **Permanently Delete** to remove this encounter from the Library altogether. Note: Deleted encounters can be restored by a Library administrator. If you accidentally select Permanently Delete, email webmaster at whaleshark dot org and reference the encounter number that you deleted to have the encounter restored.

1.2.3 Reaccepting a DATA-ONLY encounter

If you subsequently receive enough data for a DATA-ONLY encounter to allow for possible reidentification in the future, you can reaccept the encounter, moving it out of a DATA-ONLY status.

To reaccept a DATA-ONLY encounter, click **Reaccept** in the blue bar at the left of a DATA-ONLY encounter (a.k.a. a rejected encounter) to move it back to an Unapproved state.

2 Extracting Spot Patterns

The ECOCEAN Library is a mark-recapture framework for storing and analyzing whale shark data. Among its many features, it supports spot pattern searches to help identify new and previously sighted individual whale sharks using photographs and frame grabs from video.

2.1 Basic assumptions

1. For each encounter submitted to the Library, spot patterns can be added for the left and/or right sides if one or both sides have been appropriately photographed. Ideal photographs are taken perpendicular to the spot pattern area, as defined and demonstrated in the red box below.

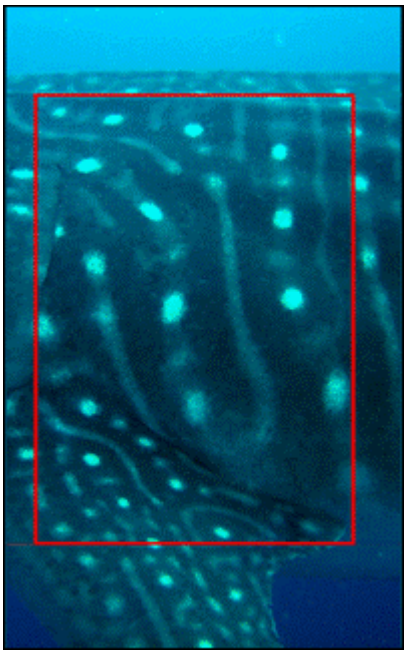


Figure 2. The area used for spot pattern extraction on the left and right sides is highlighted in red. This photo represents an ideal photograph taken perpendicular to the spot pattern area.

2. To prevent the double-counting of two separate encounters of the same shark as two separate animals (e.g. one encounter submitted with only a left side photo and a second encounter submitted with only a right side photo) only encounters with left side spot patterns that have been extracted and added to the Library can be allocated as new sharks. If they cannot be visually matched to another shark in the Library by other features (scars, etc.), encounters for which only right side spot data can be extracted, must remain "Unassigned" until they can be matched to another shark in the Library.
3. Once an encounter has been assigned to a shark, new spot data cannot be added to it. This prevents the overwriting of existing spot data which was used to identify the encounter

previously. To add spot data to an encounter that has been assigned to a shark, the encounter must first become "Unassigned" by removing it from the shark.

2.2 Pre-processing a photo for pattern recognition

Any encounter that is not assigned to a shark can have left and/or right side spot data added to it if properly oriented photos were submitted for it. Here are the steps required to extract a pattern from a photo. Let's use the following photo as a good example.

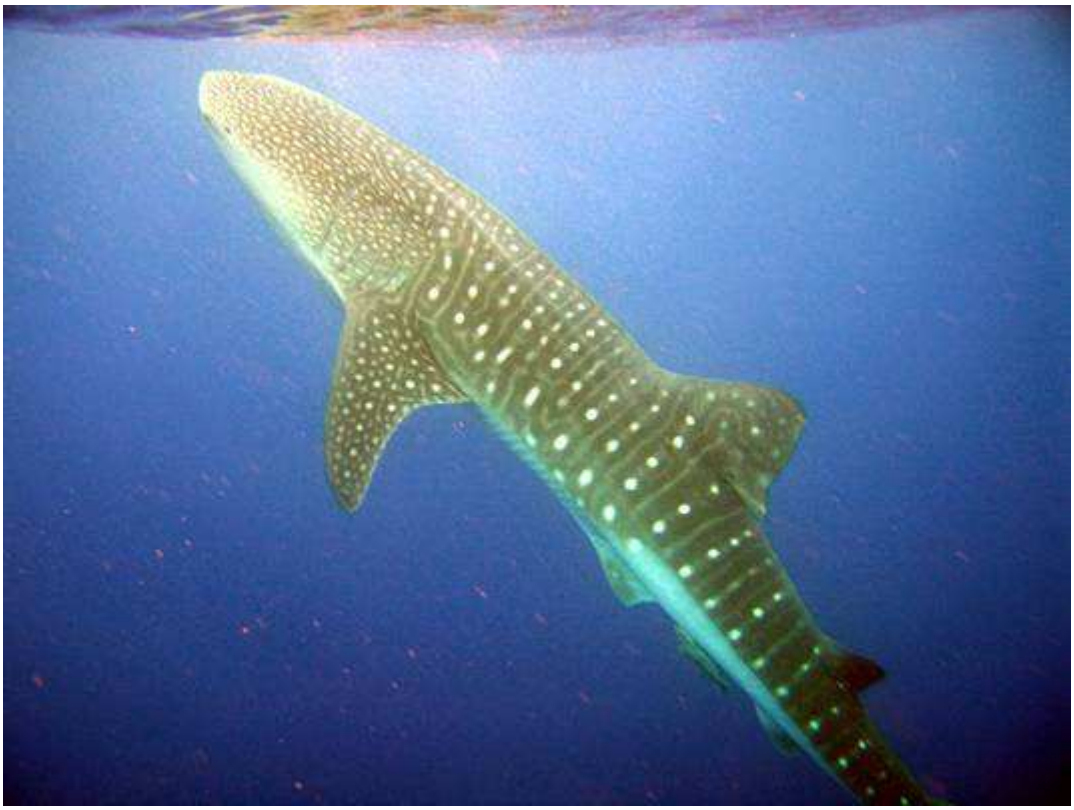


Figure 3. A new photograph submitted to the ECOCEAN Library.

To ensure that a photograph is properly aligned for spot pattern recognition analysis using either the I3S or Modified Groth algorithms supported by ECOCEAN, it must first be pre-processed in a graphics package. There are a variety of free, inexpensive, and expensive software packages that you can use for the following steps. ECOCEAN uses Adobe Fireworks for simple photo processing or Paint.NET[1], which is freely available. Other applications, such as Adobe Photoshop[2], Adobe Fireworks[3], and GIMP[4] can also be used. The directions for using your choice of graphics packages will vary. The objective is to obtain a final image of the shark that is correctly-oriented as described in the following sections.

[1] http://fileforum.betanews.com/detail/PaintNET/1096481993/1
[2] http://www.adobe.com/products/photoship/index.html
[3] http://www.adobe.com/products/fireworks/
[4] http://www.gimp.org/

2.2.1 Obtaining a source image from the ECOCEAN Library

1. Login to the Library through a web browser if you have not done so already. 2. In the Library, go to the encounter to which you want to add spot data. 3. In the encounter page, click on the photograph from which you want to extract spot data. 4. Click on the link “Click here to access the original source image.”

Figure 4. Viewing an image and accessing the source file in the ECOCEAN Library.

5. When the original image appears in your browser, right-click the image and select Save Picture As to save the picture to your Desktop.

2.2.2 Pre-processing an image in Paint.NET

If you choose to use Paint.NET to pre-process source images on Windows XP/Vista, use the following instructions. If you use another software program, replicate these basic steps using your tool.

1. Open Paint.NET on your computer.
2. Open the picture in Paint.NET by selecting **Open** from the **File** menu.

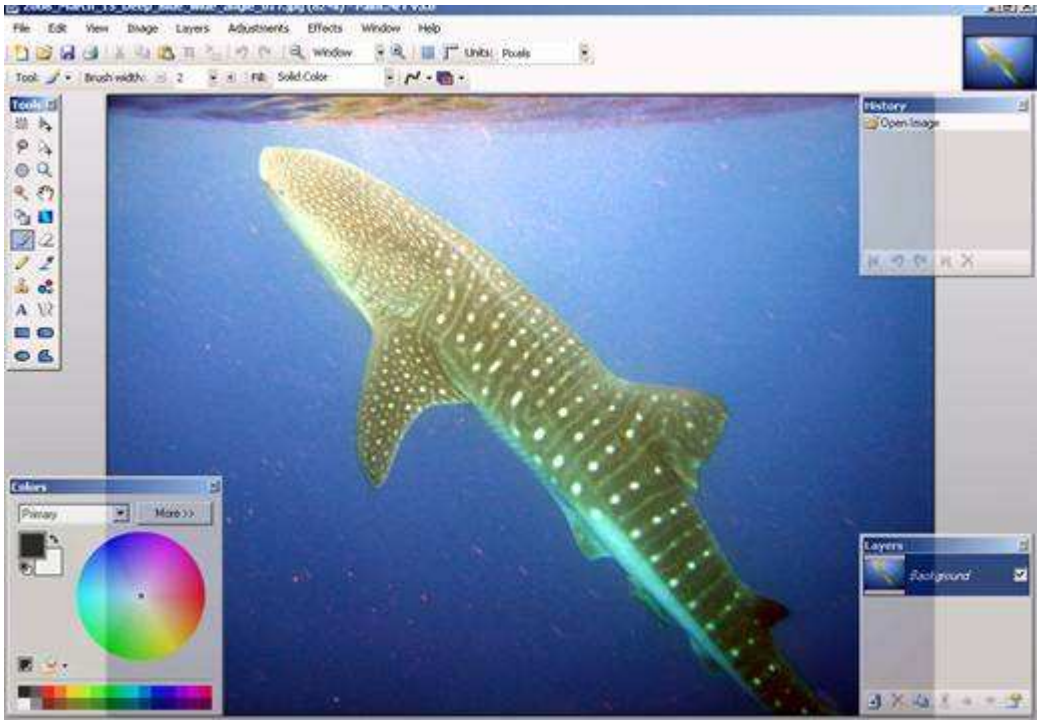


Figure 5. A whale shark image loaded in Paint.NET.

3. Use the Rectangle Select tool to select the spot pattern area used for whale sharks.

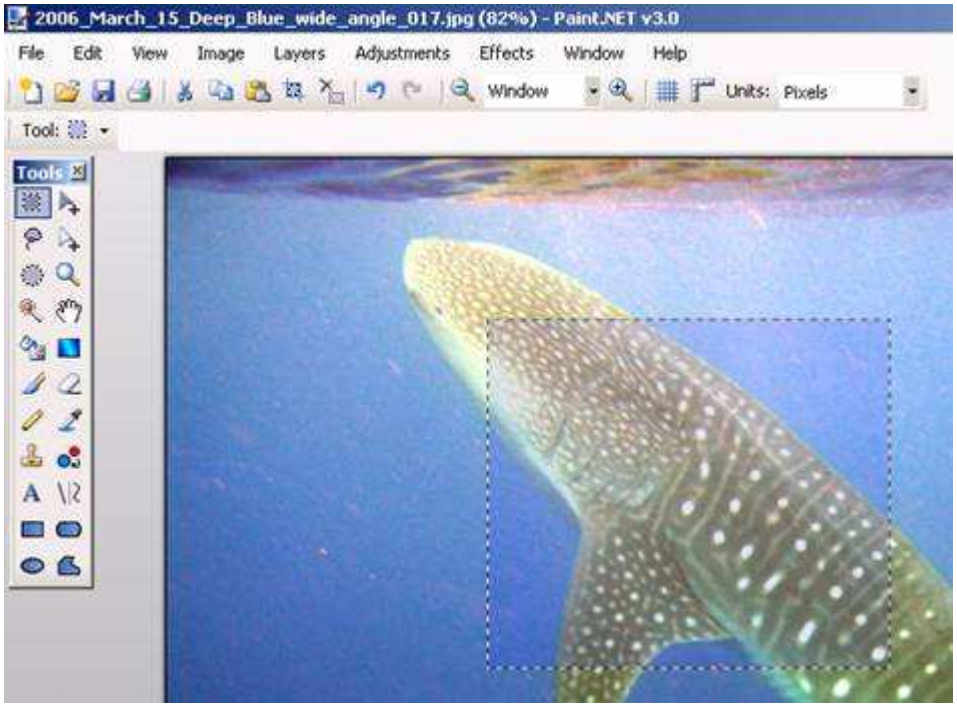


Figure 6. Selecting the spot pattern area in Paint.NET.

4. From the **Image** menu, select **Crop to Selection** to reduce the image to only the needed patterning area.

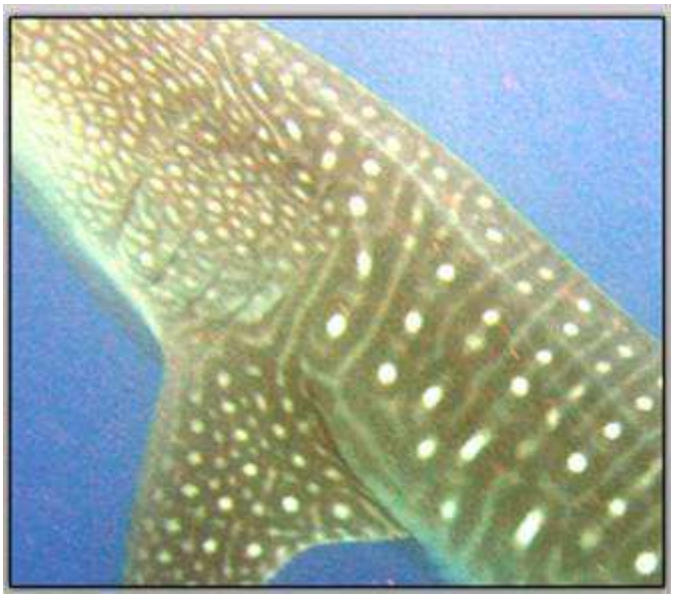


Figure 7. A cropped spot pattern area.

5. We also recommend reducing the size of very large images to ensure the spot pattern area fits neatly onto the Paint.NET canvas at 100% magnification. To adjust image size, use the Rectangle Select tool to select the entire image and then select **Resize** from the **Image** menu. Adjust image size appropriately.
6. After obtaining a reduced image of only the spot pattern area, create a new layer to hold a horizontal adjustment line using the Add New Layer button of the **Layers** pallet.

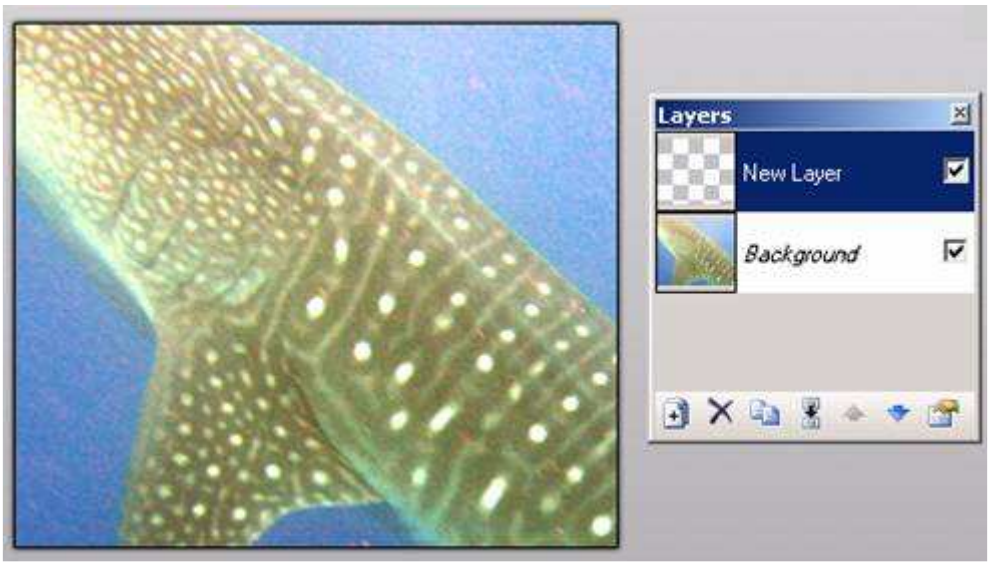


Figure 8. Adding a new layer to hold a reference line.

7. With the new layer selected in the Layers palette, add a horizontal reference line to the image using the Line\Curve tool. Hold the **Shift** key when drawing the reference line to ensure it is perfectly horizontal.

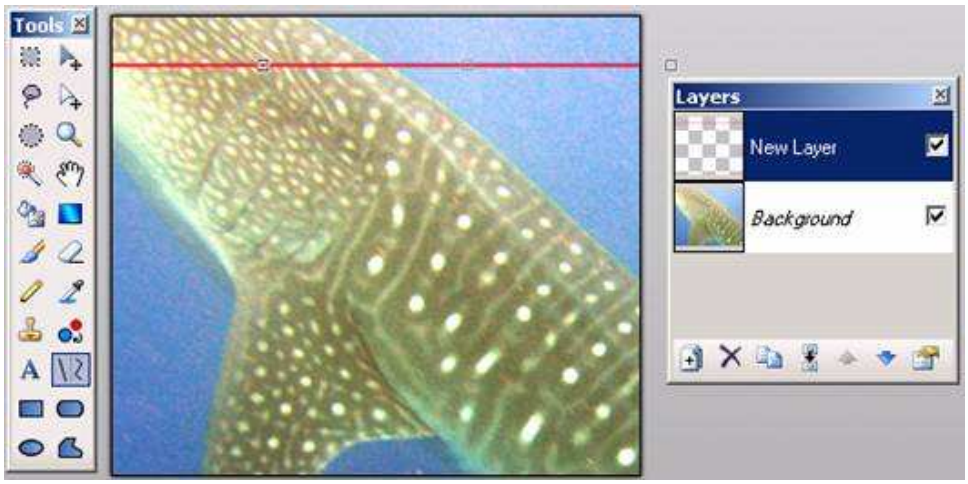


Figure 9. Adding a horizontal reference line.

8. Select the **Background** layer containing the cropped spot patterning area and then use the Rectangle Select tool to select the entire patterning area image. From the **Layers** menu, select **Rotate/Zoom**.

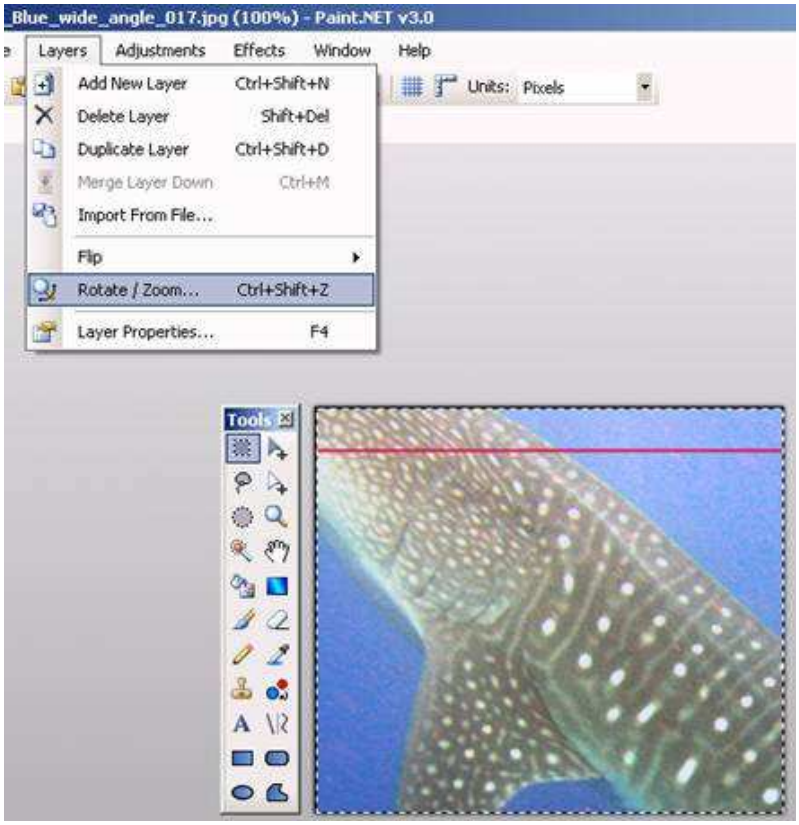


Figure 10. Accessing the Rotate tool.

9. Use the **Rotate** and **Pan** controls of the **Rotate/Zoom** dialog box to rotate and move the spot patterning area until the vertebral column is flat against the horizontal line. Click **OK** when you are done.

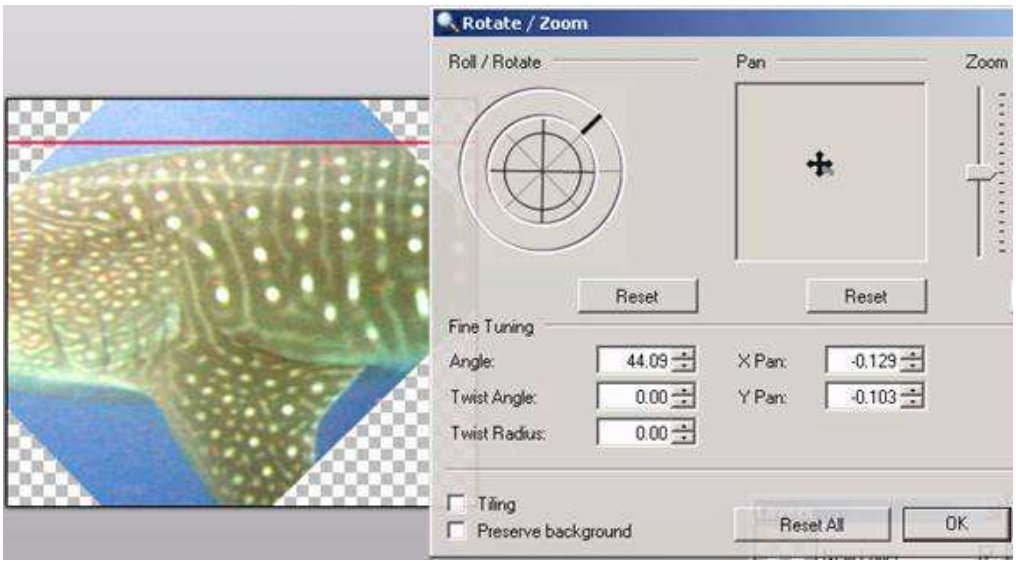


Figure 11. Obtaining a proper orientation for the spot patterning area.

***Note**: The section of the vertebral column just above the fifth gill may curve downward slightly and not fit flush to the line. This is acceptable so long as the rest of the vertebral column above the pectoral fin is parallel to the line.*

10. Select the layer with the horizontal red line in the **Layers** pallet and click the Delete Layer button to remove it.
11. Use the Rectangle Select tool and the **Image**, **Crop to Selection** menu command to reduce you image to only the needed spot patterning area.
12. Choose **File**, **Save As** to save your completed processed image under a new name.

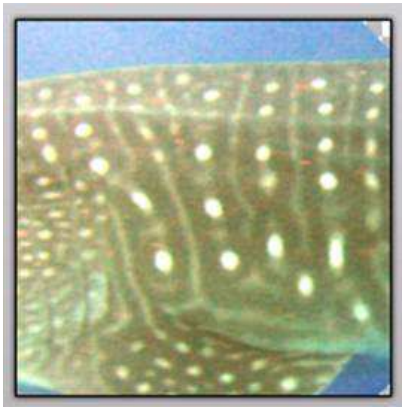


Figure 12. An image ready for spot pattern extraction.

You are now ready to extract the spots using ECOCEAN Interconnect and send them to the ECOCEAN Library.

2.3 Sending a pattern to the ECOCEAN Library with the ECOCEAN Interconnect Client

The ECOCEAN Interconnect Client is a small standalone software application that analyzes the image you prepared above and sends spot data to the ECOCEAN Library where it can be used with the I3S and modified Groth algorithms to identify potential matches.

***Note**: To use Interconnect for the first time, you will need to download it and configure your computer to run it. See Client Software for information on how to obtain and install the free Interconnect client.*

To extract a spot pattern and send it to the ECOCEAN Library:

1. Open the ECOCEAN Interconnect Client.
2. From the **File** menu, select **Open left-side shark image**.

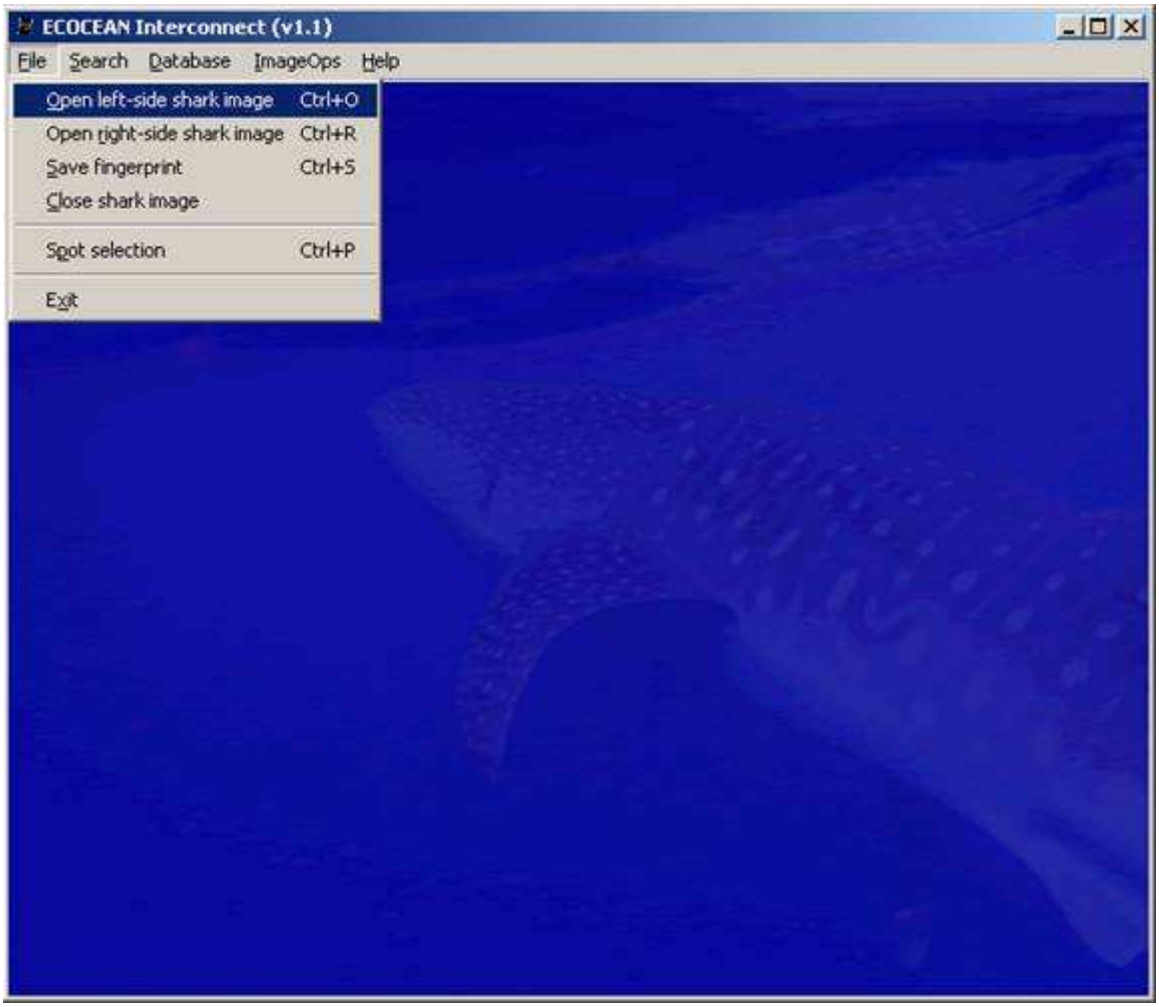


Figure 13. Opening a new image in ECOCEAN Interconnect.

3. In the **Open** dialog box, select the pre-processed image file and then click **Open**.

   ***Note**: Only JPG and GIF images are usable at this time in Interconnect.*

4. After the image appears in Interconnect, from the **File** menu select **Spot Selection**.
5. Select the three reference points needed for the I3S algorithm (the Modified Groth algorithm does not require these) by left-clicking on the appropriate locations in the image. The red text overlaying the image will prompt you. The order of spots is:

- Top of the 5th gill
- Posterior point of the pectoral fin on the flank. If the fin is not horizontal, select the point above it where the white countershading underneath meets the pigmented skin along the flank.
- Bottom of the 5th gill

To unselect any reference point, right-click it.

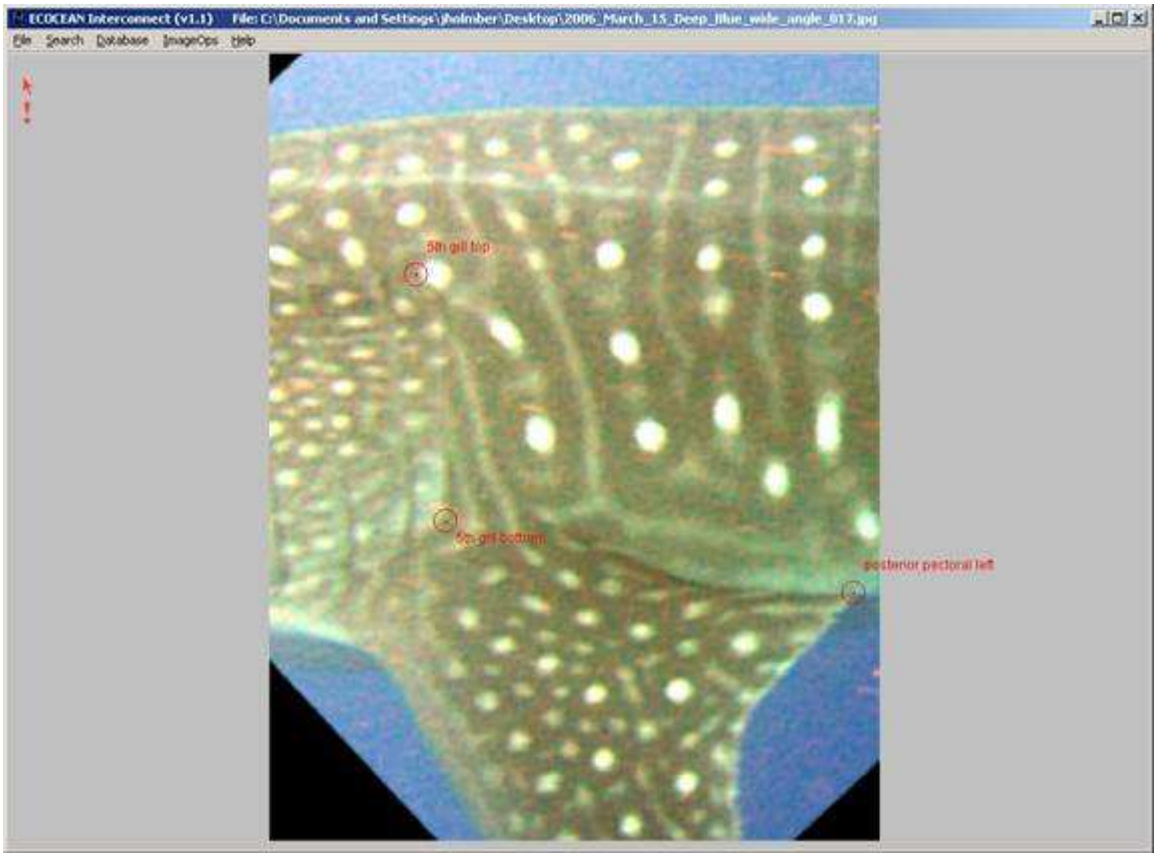


Figure 14. Selecting the three reference points needed for the I3S pattern recognition algorithm.

6. Left-click in the image to select the center points of all of the spots in region of interest. To unselect any spot, right-click it.

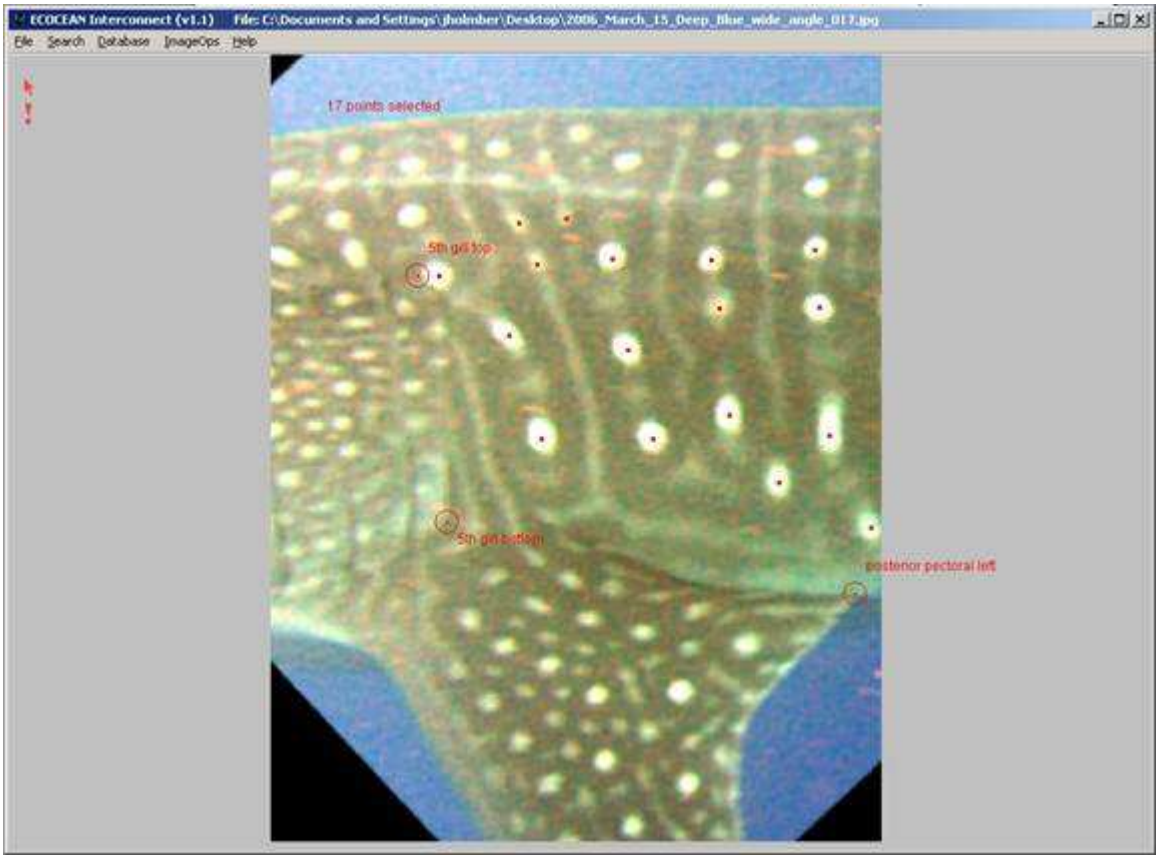


Figure 15. Selecting spots for computer-assisted photo-identification.

7. After you have selected all of your spots, from the **Database** menu, click **Submit to ECOCEAN Library** to send the spot data via the Internet to the ECOCEAN Library. You will need an open Internet connection to perform this step.

   ***Note**: Once an encounter is allocated to a shark in the Library, new spot data cannot be submitted for it unless it is removed from the shark to which it belongs. This limitation is designed to preserve spot data used to justify a match and to protect that spot data from accidental overwriting. If you are attempting to add spots to an encounter already assigned to a shark, you must first remove the encounter from the shark to add the spots.*

8. In the **Send a left\right- side pattern to the ECOCEAN Library** dialog box, enter the encounter number in the ECOCEAN Library to assign the pattern to. Click **OK** when you are ready to send the pattern.

Figure 16. Entering the encounter number to assign the extracted spot pattern to.

9. A new browser window will open to confirm that your spots have been received and prompting you to send in your processed image generated in steps 1-16 above. You may also be prompted to login first.

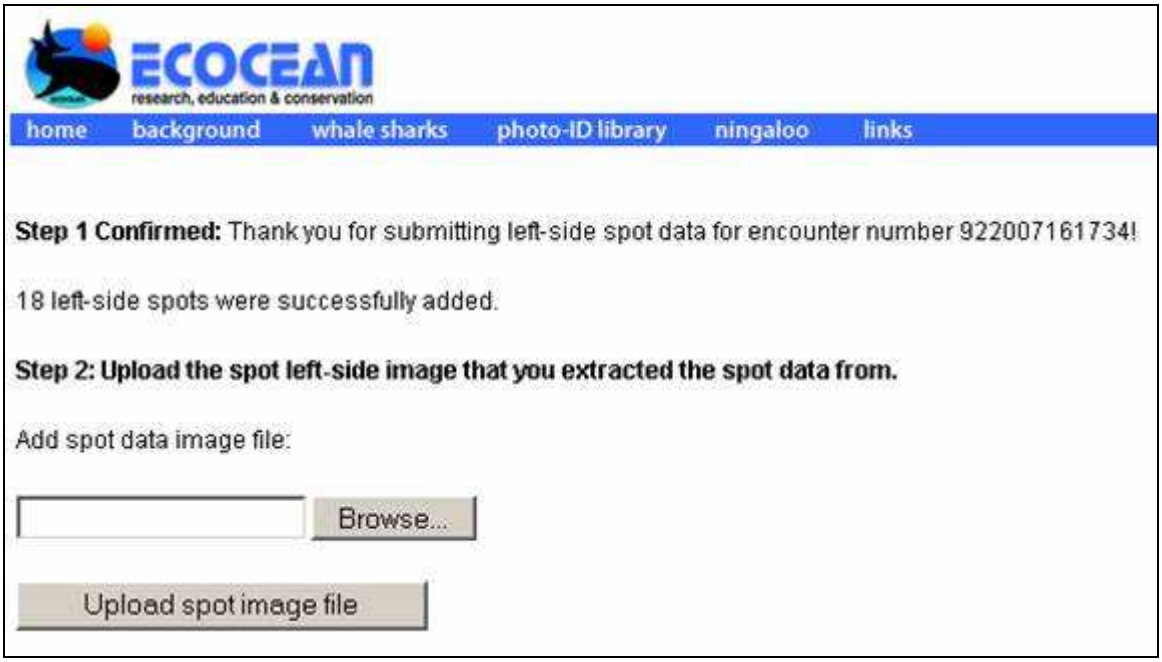


Figure 17. Uploading the processed image.

10. Browse, select, and submit the processed image in your browser.
11. Your image is now visible (when you are logged in) in the web page for the encounter.

12. Confirm that the appropriate spots have been extracted and mapped using the visual remapping capability in the Library. In the encounter's web page in the Library, select the link **Click here to see the spots mapped to the image**, which appears above the image you submitted to see the spots remapped to the image and to confirm their accuracy.

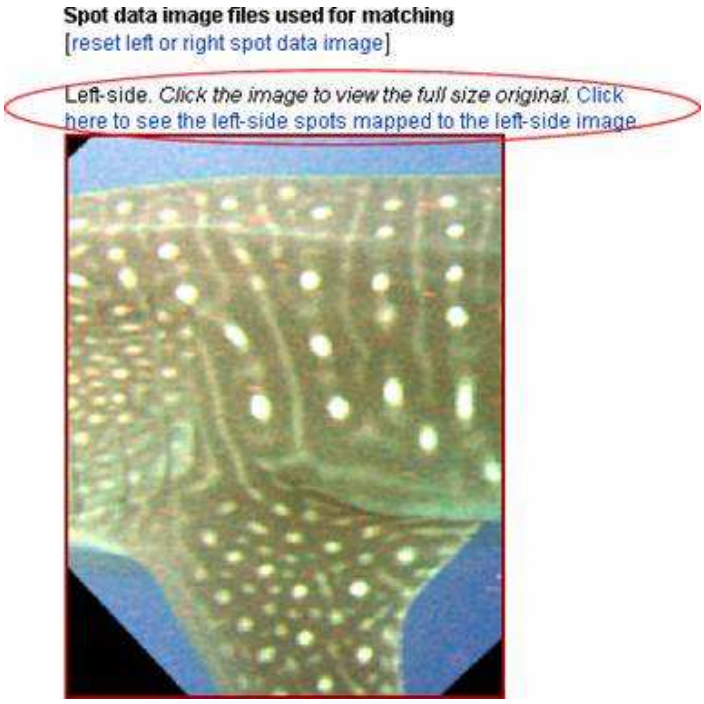


Figure 18. The spot data file itself in the ECOCEAN Library.

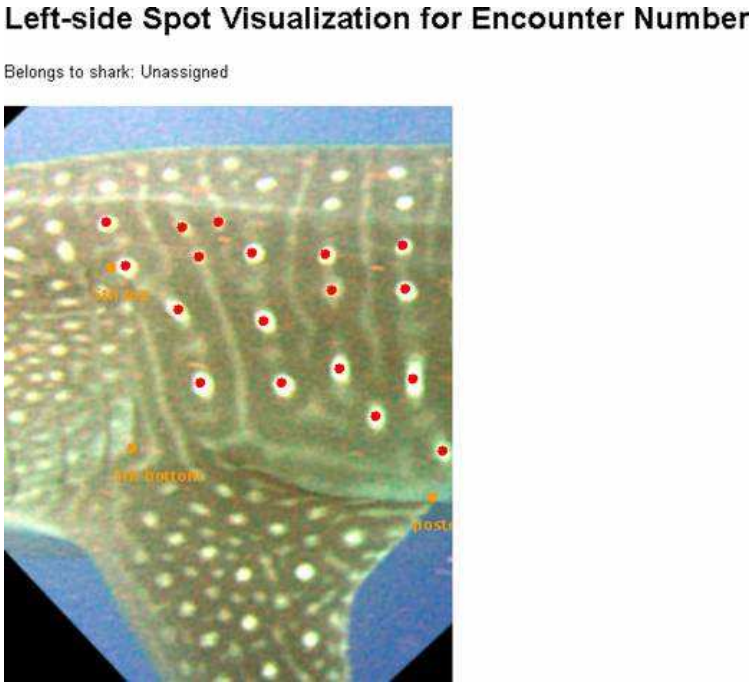


Figure 19. Ensuring that submitted spots remap to the original image correctly in the ECOCEAN Library.

3 Comparing Spot Patterns with sharkGrid

The sharkGrid allows connected computers to participate in spot pattern recognition scans run from the ECOCEAN Library. When you start a pattern matching scan for an encounter in the ECOCEAN Library, you are actually creating a scanTask made up of individual comparisons called scanWorkItems. The scanWorkItems of a scanTask are executed in efficient, parallel groups that are distributed across the grid of computers. The results are reassembled once all comparisons are complete. Each encounter can have up to two active scanTasks: one for a left side pattern and another for a right side pattern.

3.1 Starting a spot pattern comparison scan on sharkGrid

Once you have extracted a spot pattern for an encounter, you can look for matches to it across a global set of patterns stored in the ECOCEAN Library. To start looking for matches:

1. Select a **left-side** or **right-side** radio button from the **Find Pattern Match** form in the **Action/Edit** bar. 2. Click **Start Scan**.

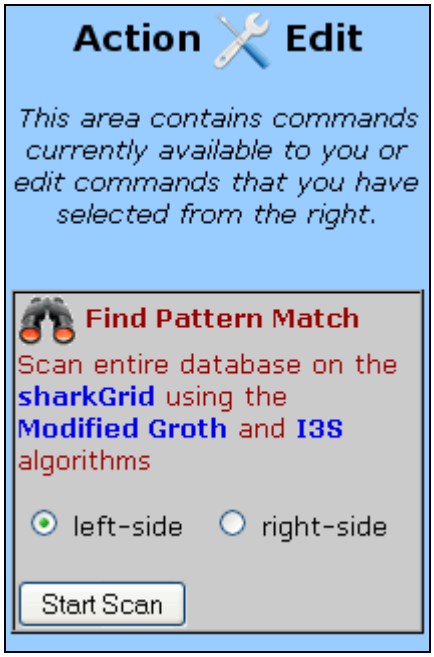


Figure 20. Staring a scan with the Find Pattern Match form

Starting a pattern matching scan creates a new scanTask in sharkGrid. The scanTask is assigned a unique identifier defined as:

- "scanL"+*encounter number* for a left-side scan
- "scanR"+*encounter number* for right-side scan

***Note**: There can be only one left-side scanTask and one right-side scanTask for an encounter, whether they are completed or uncompleted. If you decide to redo a spot pattern and scan for a match again, you must first delete the old scanTask if it still exists.*

You can manage your scanTasks in the sharkGrid Administration page by selecting **sharkGrid** from the **Administer** menu (login required).

3.2 Examining the results of a scanTask

You can check the status of and view the results of scanTasks from the sharkGrid Administration page.

3.2.1 Pending scanTasks

Pending scanTasks are scanTasks that are:

- being created for submission to the grid
- being executed on the grid
- completed but whose results have not yet been written

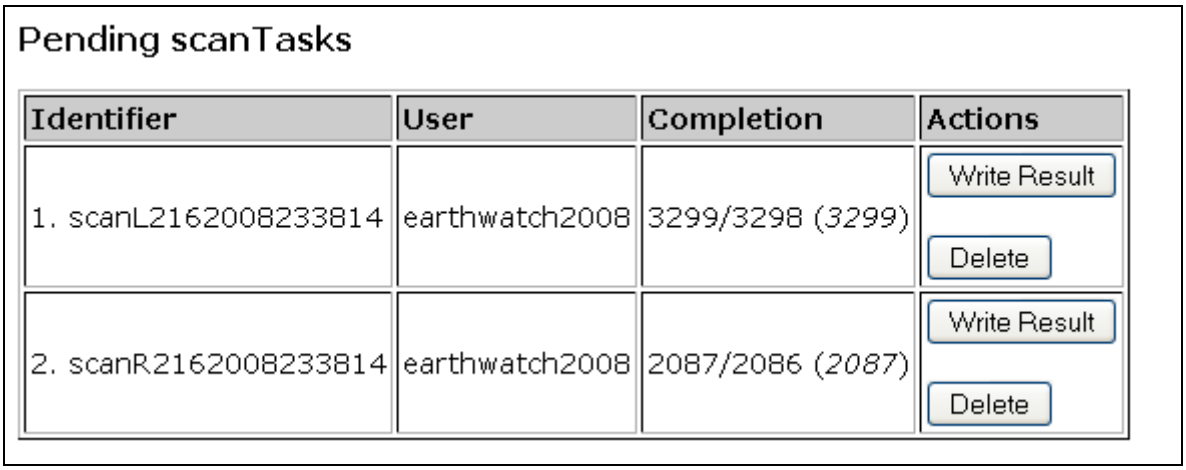


Figure 21. Two pending scanTasks in sharkGrid waiting for results to be written

You can delete a pending scanTask by clicking the **Delete** button.

You can examine the results of a pending scanTask (and move it to "Completed" status) by clicking **Write Result**. The scanTask will subsequently appear in the **Completed scanTasks** table.

3.2.2 Completed scanTasks

Completed scanTasks are scanTasks that have been successfully completed in sharkGrid and whose results have been written out for review.

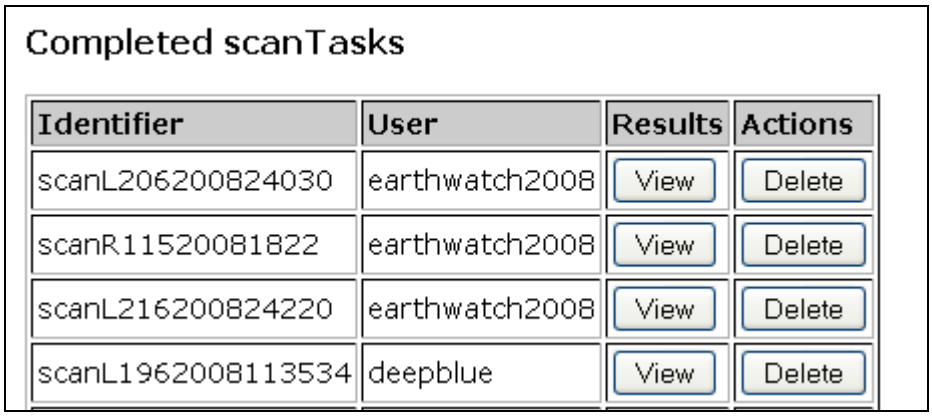


Figure 22. Several completed scanTasks in sharkGrid waiting to be removed

You can delete a completed scanTask that you initiated by clicking the **Delete** button.

You can examine the results of a completed scanTask by clicking **View**.

Note: *Please promptly delete any completed scanTasks after viewing the results. The latest results can always be reviewed from the relevant encounter page.*

3.3 Administering sharkGrid

This section describes how sharkGrid operates and how users with various levels of access can change its behavior.

3.3.1 The sharkGrid queue: Adding and deleting scanTasks

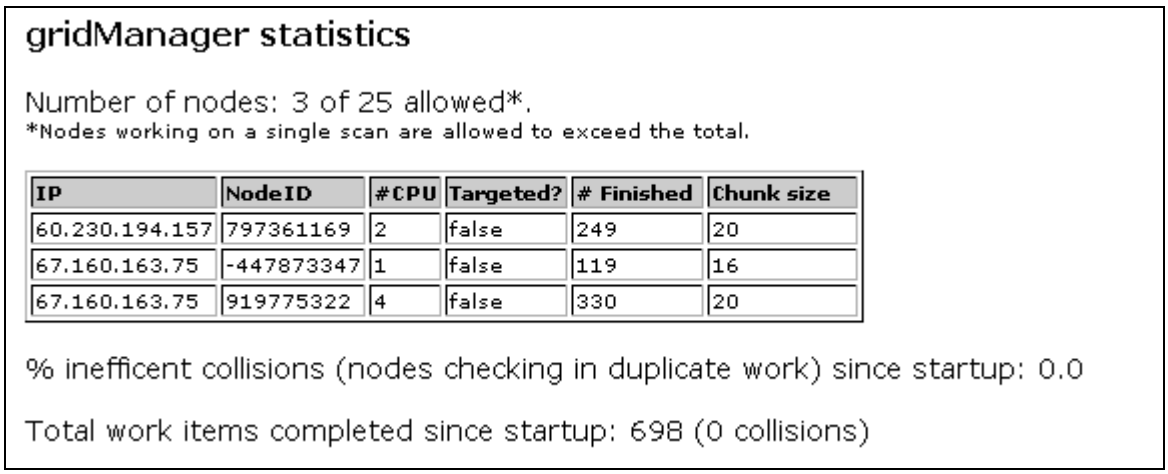
The creation and deletion of scanTasks occurs in a single queue. This means that if several users have simultaneously created new scanTasks or attempted to delete existing ones, these changes will occur one by one. A new create/delete scanTask operation will only start after the previous one in the queue has finished. Therefore, you may not see the results of a scanTask delete (i.e. the removal of the scanTask from the sharkGrid Administration page) immediately.

The number of scanTask additions/deletions in the queue for Administrator-level users is visible in this section of the sharkGrid Administration page:

Figure 23. The scanTask queue in sharkGrid

3.3.2 Viewing connected client nodes and their performance

You can view information about connected client nodes doing work in sharkGrid from this section of the sharkGrid Administration page:



gridManager statistics

Number of nodes: 3 of 25 allowed*.
*Nodes working on a single scan are allowed to exceed the total.

IP	NodeID	#CPU	Targeted?	# Finished	Chunk size
60.230.194.157	797361169	2	false	249	20
67.160.163.75	-447873347	1	false	119	16
67.160.163.75	919775322	4	false	330	20

% inefficent collisions (nodes checking in duplicate work) since startup: 0.0

Total work items completed since startup: 698 (0 collisions)

Figure 24. gridManager statistics presenting information about sharkGrid nodes and their efficiency

The following information is available for each node:

- IP - the IP address of the node
- NodeID - a unique identifier for the node. This identifier is randomly generated.
- #CPU - The number of CPUs available for processing on the node computer. sharkGrid will take advantage of multicore CPU architectures and run scanWorkItems in parallel on multicore machines.
- Targeted? - whether the client node in working on a specified scanTask or is generally available for processing all scanTasks
- # Finished - the number of scanWorkItems (individual pattern comparisons) completed by the node
- Chunk size - the number of scanWorkItems sent to the node after each request. All nodes start with one scanWorkItem initially and are given larger workloads with subsequent requests. Ultimately, chunk size is determined according to a pre-defined algorithm in the ECOCEAN Library.

Overall performance in sharkGrid is measured by:

- % inefficient collisions - this is the percentage of duplicate work performed by nodes in sharkGrid. The ideal is 0. A collision is detected when a node tries to check in a comparison already completed by another node.
- Total work items completed since startup - This is the number of total comparisons performed in sharkGrid *since the last restart of the ECOCEAN Library*.

3.3.3 Configuring sharkGrid behavior

From the sharkGrid Administration page, you can configure the following performance parameters if you have Administrator privileges:

- Set number of allowed nodes - defines the maximum number of client nodes that can participate in sharkGrid
- Set node timeout - defines how many milliseconds can pass without a heartbeat from a client node before the node is considered to be no longer connected to sharkGrid
- Set checkout timeout - defines how long (in milliseconds) after a scanWorkItem is checked out for processing that it can be checked out by another node. The assumption is that, after this timeout period, the node originally checking out the scanWorkItem has left the grid. A very small value for this may cause inefficient duplication of effort. A very large value may cause a slowdown in overall scanTask processing.
- Set number of allowed scanTasks - this is the maximum number of simultaneous scanTasks allowed in sharkGrid. Once the maximum is reached, existing scanTasks must be deleted before new ones are added. Alternatively, the maximum could be increased.
- Set maximum chunk/group size sent to nodes - this is the maximum number of comparisons (scanWorkItems) sent to a node after a request. All nodes start at one and advance in group size with each request. Setting this value too high may cause nodes to run out of memory or to take too long processing and register inefficient collisions. A very small value causes nodes to spend more time requesting data than processing it, which is also inefficient.

4 Interpreting Pattern Match Results

You can access the results of a pattern matching scan (a.k.a. scanTask) by:

- Clicking **View** for a completed scanTask in the sharkGrid Administration page
- Clicking **Groth: Left/Right-side scan results** or **I3S: Left-side scan results** from the related encounter page

The results are displayed in two tabs: **Modified Groth** and **I3S**.

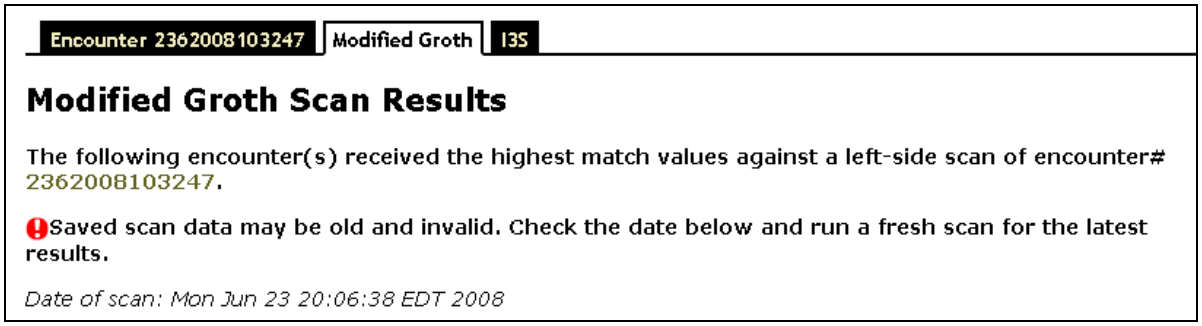


Figure 25. Scan results

4.1 Modified Groth results

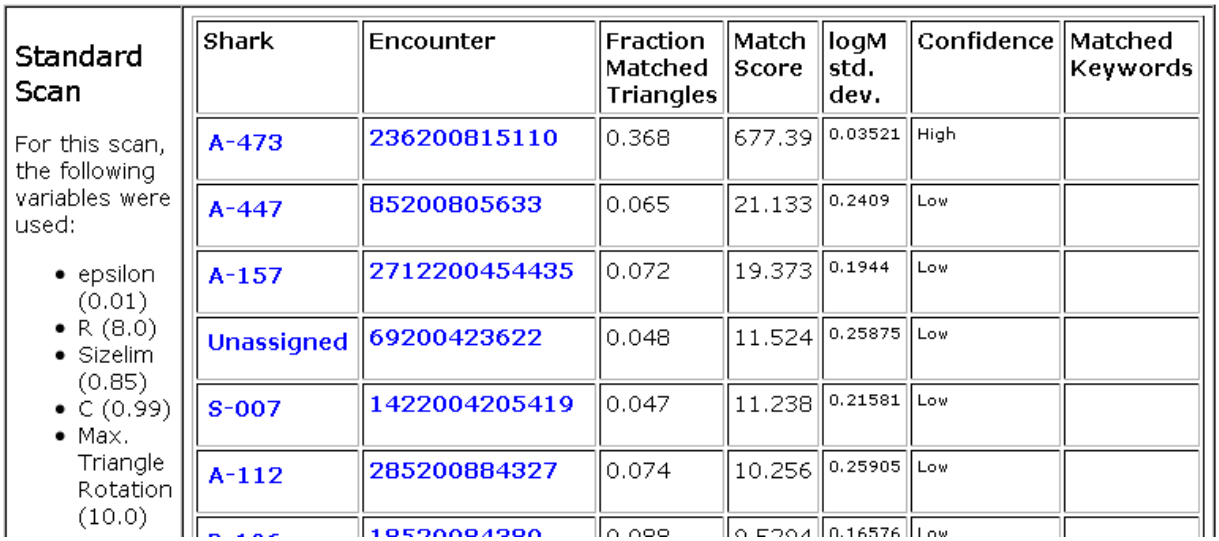
Details for the inner workings of the Modified Groth algorithm are available in the paper:

Arzoumanian, Z., Holmberg, J. & Norman, B. (2005) An astronomical pattern-matching algorithm for computer-aided identification of whale sharks Rhincodon typus. Journal of Applied Ecology, 42 (6), 999-1011.

The Modified Groth results are displayed in two areas:

4.1.1 Metric results

Metric results provide the quantitative and qualitative results of the algorithm.



Standard Scan

For this scan, the following variables were used:

- epsilon (0.01)
- R (8.0)
- Sizelim (0.85)
- C (0.99)
- Max. Triangle Rotation (10.0)

Shark	Encounter	Fraction Matched Triangles	Match Score	logM std. dev.	Confidence	Matched Keywords
A-473	236200815110	0.368	677.39	0.03521	High	
A-447	85200805633	0.065	21.133	0.2409	Low	
A-157	2712200454435	0.072	19.373	0.1944	Low	
Unassigned	69200423622	0.048	11.524	0.25875	Low	
S-007	1422004205419	0.047	11.238	0.21581	Low	
A-112	285200884327	0.074	10.256	0.25905	Low	
[illegible]	[illegible]	[illegible]	[illegible]	0.16576	Low	

Figure 26. Metric results for the Modified Groth algorithm

The metric results for each comparison are ranked from best potential match to least. The listed values are:

- Shark - The shark that the potentially matching pattern belongs to.
- Encounter - The encounter with the potentially matching patten.
- Fraction matched triangles - The fraction of matched triangles between the two spot patterns. Possible values range from 0 to 1. The higher the value, the stronger the match.
- Match score - The final match score, as described in Arzoumanian et al. The higher the value, the stronger the match.
- logM std. dev. - The standard deviation of the logarithm of magnification differences between matched triangles in the two spot patterns. The lower this value, the stronger the match.
- Confidence - The qualitative confidence of the match.
- Matched keywords - The photo keywords that both potentially matched encounters share in common.

4.1.2 Visual results

The visual results for the Modified Groth algorithm display matched spots between potentially matched patterns. To compare results, look for each colored spot on the left to match a corresponding spot in the pattern on the right. Click **Next** and **Previous** to tab through potential matches in order of match score.

Figure 27. Visual results for the Modified Groth algorithm

4.2 I3S results

Details for the inner workings of the I3S algorithm are available in the paper:

Van Tienhoven, A.M., Den Hartog, J.E., Reijns, R.A., & Peddemors, V.M. (2007) A computer-aided program for pattern-matching natural marks on the spotted raggedtooth shark Carcharias taurus (Rafinesque, 1810). Journal of Applied Ecology (2007) 44, 273–280.

The I3S results are displayed in two areas:

4.2.1 Metric results

Metric results provide the quantitative and qualitative results of the algorithm.

Shark	Encounter	Match Score
A-395	185200782025	0.0
H-018	151020069156	0.0
MZ-061	317200732439	0.5113
A-473	236200815110	0.7150
A-379	1520061157	0.9312
P-071	94200891515	1.1412
P-071	94200891515	1.1412
A-420	218200611255	1.2643
A-310	21820061103	1.3157
A-098	3102004135913	1.3305

Figure 28. Numeric results of the I3S algorithm

The metric results for each comparison are ranked from best potential match to least. The listed values are:

- Shark - The shark that the potentially matching pattern belongs to.
- Encounter - The encounter with the potentially matching patten.
- Fraction matched triangles - The fraction of matched triangles between the two spot patterns. Possible values range from 0 to 1. The higher the value, the stronger the match.
- Match score - The final match score, as described in Van Tienhoven et al. The lower the value, the stronger the match. Values of “0.0” should be ignored.

4.2.2 Visual results

The visual results for the I3S algorithm display matched spots between potentially matched patterns. To compare results, look for each colored spot on the left to match a corresponding spot in the pattern on the right. Click **Next** and **Previous** to tab through potential matches in order of match score.

Figure 29. Visual results for the I3S algorithm

5 Matching Sharks

This topic describes how to allocate matched and unmatched encounters as sharks in the ECOCEAN Library.

5.1 Creating a new shark

If an approved encounter has a properly-oriented, left-side spot pattern extracted and added to the database, and if the spot pattern scan and visual inspection of the encounter photos do not produce a match to an existing shark, the encounter can be allocated as a new shark. This allocation is a first “mark” of the animal. Future sightings are considered “recaptures”.

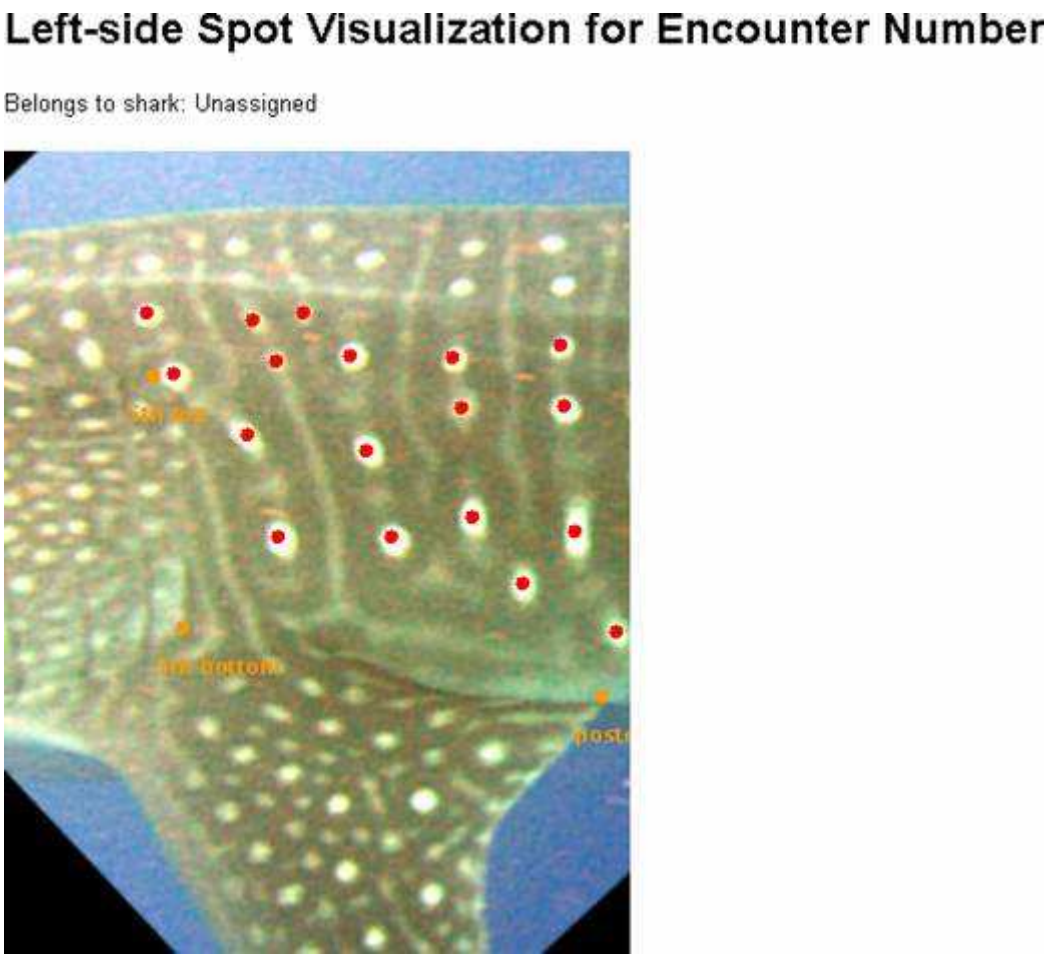


Figure 30: A perfectly-oriented left-side pattern required for new shark identification.

Does your left-side pattern look like Figure 32? Notice that the:

- top of the pattern area is perfectly horizontal
- all spots in the pattern region are selected
- the photographer was perpendicular to the patterning area

If your processed image does not look like this (or a slight variation of it), do not allocate it as a new shark. Creating new sharks with suboptimal extracted patterns lowers their potential for reidentification through pattern matching (Modified Groth and I3S) in the future.

To create a new shark from an encounter:

1. Login to the Library through a web browser if you have not done so already.
2. Go to the approved and unassigned encounter that you want to create a new shark from.
3. Click **Edit** next to the **Assigned to Shark** field at the top of the encounter.
4. In the **Create New Shark** field that appears in the blue **Action/Edit** bar on the left, type a new name for the shark. The name of the shark should conform to the series code assigned to you in the Library. For example, sharks first identified at Ningaloo Reef are assigned names according to the format 'A-XXX'. For example, 'A-011' is the eleventh shark identified in the Library at Ningaloo Reef.
5. Click **Create**. The Library will inform you of the success or failure of its efforts to allocate this encounter as a new shark. When you create a new shark, the submitter of the encounter is automatically informed via email of the updated status of their encounter as a newly identified shark in the Library.

***Note**: Once an encounter is allocated to a shark in the Library, new spot data cannot be submitted for it unless it is removed from the shark to which it belongs. This limitation is designed to preserve spot data used to justify a match and to protect that spot data from accidental overwriting.*

5.2 Adding an encounter to an existing shark

If a spot pattern scan or visual analysis shows that a new encounter is a match to a shark already identified in the Library, you can assign the encounter to the shark. This assignment represents a "recapture" of that animal. To assign an encounter to a shark:

1. Login to the ECOCEAN Library through a web browser if you have not done so already.
2. Go to the approved and unassigned encounter that you want to add to a shark.
3. Click **Edit** next to the **Assigned to Shark** field at the top of the encounter.
4. In the **Add to Shark** field that appears in the blue **Action/Edit** bar on the left, type the name of the existing shark to add the encounter to.
5. In the **Matched By** field, select:

- Pattern match ── for encounter matches made with the assistance of extracted spot patterns and database scans
- Visual inspection ── for encounter matches made from "by eye" visual comparison only

6. Click **Add**. A message confirming success or failure will appear in your browser. If successful, all submitters and photographers of the shark's new encounter and its previous encounters are informed of the re-sight of this shark via email.

***Note**: Once an encounter is assigned to a shark in the Library, new spot data cannot be submitted for it unless it is removed from the shark to which it belongs. This limitation is designed to preserve spot data used to justify a match and to protect that spot data from accidental overwriting.*

6 Searching Through the ECOCEAN Library

The ECOCEAN Library offers the following capabilities to search through submitted data.

6.1 Encounter search

The Encounter Search allows you to search through whale shark sightings reported to the ECOCEAN Library. You can filter the search according to:

- approved, rejected, or unapproved status of the encounter
- sex
- identification status and minimum number of sightings of the shark
- length
- location
- location code
- submitter or photographer name
- date range

Results are also displayed in Google Maps for those reports where GPS coordinate were provided.

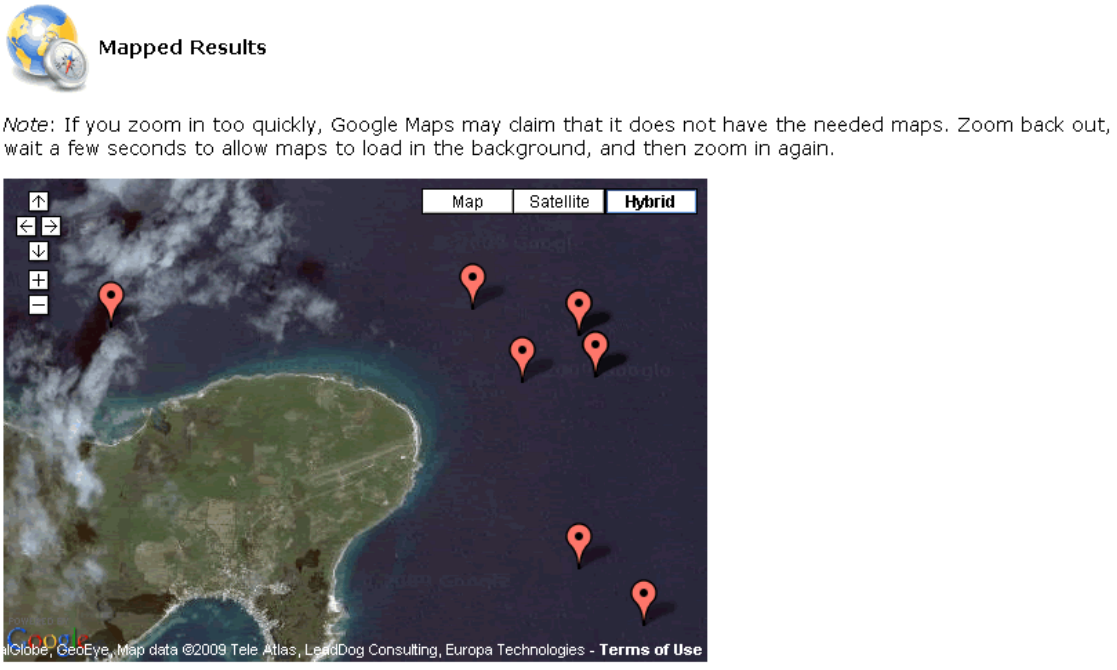


Figure 31. Google Maps result for an encounter search.

6.1.1 Data export

The Encounter Search allows filtered results to be exported in two formats:

- Excel with columns corresponding to Darwin Core values (Administrators only)
- Google Earth KML file (Google Earth version 5 or higher). Only encounters with reported GPS coordinates are added to the KML file.

1. Google Earth export options

The ECOCEAN Library provides one Google Earth export option: "Add a timestamp to the KML to animate on a timeline". if the checkbox for this option is checked, the exported KML file will contain time data that allows you to play through sightings along a timeline in Google Earth 5+. The timeline starts at the date of the earliest sighting (with GPS coordinates) in the filtered results and ends with the date of the last encounter (with GPS coordinates).

Figure 32. Google Earth with timeline displayed for encounters with timestamps

2. Google Earth export icons

Three colors of icons are displayed in Google Earth results: blue for males, pink for females, and white for whale shark encounters of unknown sex. Some icons may also have a number in them. This number represents the shark length (rounded to the nearest whole meter) for the sighting, if reported.

Figure 34. Google Earth icons for whale shark sightings interpreted as: male, female, unknown sex, and 7 meter female.

7 FAQs

1. Why do spots sometimes appear mismapped in the results of a scanTask?

Two things can happen when you see mismapped spots in a scan result.

a. The match results are stored in an XML file. However, the images they pull to map the matched spot pairs to are the latest extraction images. Therefore, when someone remapped the spots, your scan results did not change, but they're now mapped to the new extraction image that was uploaded. The best way to resolve this is:

1. Delete the old scanTask if it still exists.
2. Clear your browser cache. (The new Firefox 3 browser works well for this!)
3. Rerun the scanTask to get the new, corrected results.

b. Flash has a cache for images and patterns. This can also cause a spot mismap if you've looked at a scan result then remapped and rescanned. The second set of results might show the first mapping. In this case, clear your browser cache and then reload the page.

2. Why do some encounters show a "Bad File" thumbnail?

This situation can occur when the first submitted image/video is not of a supported image or video file type. This can be fixed by logging into the ECOCEAN Library and uploading a supported image/video type OR by asking the webmaster (webmaster at whaleshark dot org)to resolve the bad file (if you don't have required access). If you upload a supported file type, follow the instructions below to regenerate the image thumbnail.

1. Log into the ECOCEAN Library.
2. Go to the appropriate encounter page.
3. If you have edit permissions for the encounter, look in the **Action/Edit bar** for the **Reset Thumbnail box**. Choose the submitted image to generate the thumbnail from and then click **Reset Thumbnail**.
4. Go back to the page where you first encountered the “BAD FILE” thumbnail and **Refresh/Reload** the page in your browser. The updated thumbnail will appear.

3. How do you determine if a shark is "new"?

Looking at the process backwards, the end goal of whale shark mark-recapture is to obtain a large group of sharks with low misidentification for accurate population modeling. Our photo-identification standards, as presented in this wiki, are in place to help support accurate matching across the data sets of multiple users…the assumption being that some of us might be sharing sharks and therefore we need standards to ensure that we process data identically and can quickly and accurately match them between our data sets when they appear. The pattern recognition

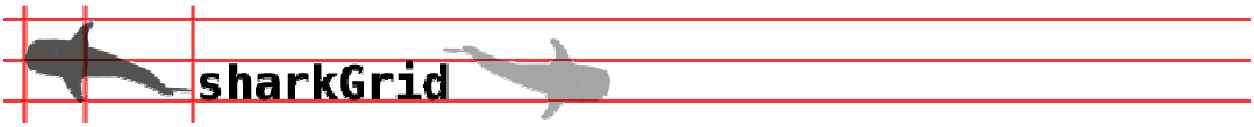
algorithms provide a reliable, fast way to do that. Ultimately we could get the same effect (very laboriously and less accurately) with “by eye” matching, but this adds the risk of double counting a shark if not properly matched to an existing photo across catalogs. The pattern recognition software we use (Modified Groth and I3S algorithms) significantly reduce this risk, and therefore we use them as a standard for all new sharks (i.e. the patterns provide a measure of statistical evidence that there is not a match elsewhere in the catalogs).

That said, there will always be some human-added variability and error, including some missing/extra mapped spots and of course variable angle between shark and photographer. We know that our probability of automated matching degrades (for both the I3S and Modified Groth algorithms) when: *angle between photographer and shark flank falls away from perpendicular *spots outside the patterning area are added *too few spots from the patterning area are added

The algorithms can internally account for some of this variability (Spot! helps too), but we have to make a judgment call for each unmatched pattern and peer review it. The questions we ask are: *Are all of the proper spots mapped? *Is the pattern properly rotated? *Is the angle between photographer and shark appropriate, roughly within fifteen degrees of perpendicular on either side and with minimal roll?

Ultimately, it's a judgment call based on those criteria, and we have peer review and discussion (even sometimes disagreements) about whether a shark is new. We're simply trying to ensure that every new shark has the maximum probability of being matched in the future.

Appendix A. How to Join sharkGrid



How to join sharkGrid : http://www.whaleshark.org/wiki/doku.php?id=how_to_join_sharkgrid

Welcome to the sharkGrid! The sharkGrid allows you to donate spare cycles of your computer to whale shark research. Specifically, the processing power of your computer can be “borrowed” for resource intensive tasks, such pattern recognition or data mining. sharkGrid uses “global volunteer computing” to distribute intensive tasks between multiple computers to allow them to complete much more quickly.

There are a few quick things you should know before participating in sharkGrid.

1. Once running, the sharkGrid client must stay open to allow your computer to aid in whale shark spot pattern processing. If for any reason you want to leave the grid, close the client. If you restart your computer, you must restart sharkGrid to participate.
2. Your Internet connection must remain open to participate in sharkGrid. sharkGrid obtains all patterns to compare from the World Wide Web.
3. Your computer must have a Java Runtime Environment (JRE) 5 or higher installed. You can download a JRE from the Sun Microsystems Java web site. The JRE is different from the Java Virtual Machine (JVM) that runs in your browser. The JRE allows Java applications to run as programs on your desktop.
4. Please disable any power saving features enabled on your computer. For example, many PCs will enter a suspended state (a.k.a. “System standby”) after a period of time with no user interaction. Other power saving schemes stop the hard drive(s), which will also interfere with the sharkGrid client.
5. sharkGrid participation is subject to the ECOCEAN Library Visitor Agreement. By visiting this web site and joining sharkGrid, you are agreeing to the terms and conditions therein.
6. sharkGrid can run in the background while you perform other tasks on your computer. However, sharkGrid is used for intensive computation, and other applications running on your computer simultaneously with sharkGrid may slow down.
7. sharkGrid requires significant computing power. We recommend you only run sharkGrid on computers with 1 gigabyte (GB) of RAM or more.

A.1 Downloading the sharkGrid client

You can download a zip file containing the sharkGrid client (http://www.whaleshark.org/interconnect/sharkGridClient_1_2.zip).

A.2 Installing and starting the sharkGrid client

To install the sharkGrid client to your desktop, follow these instructions.

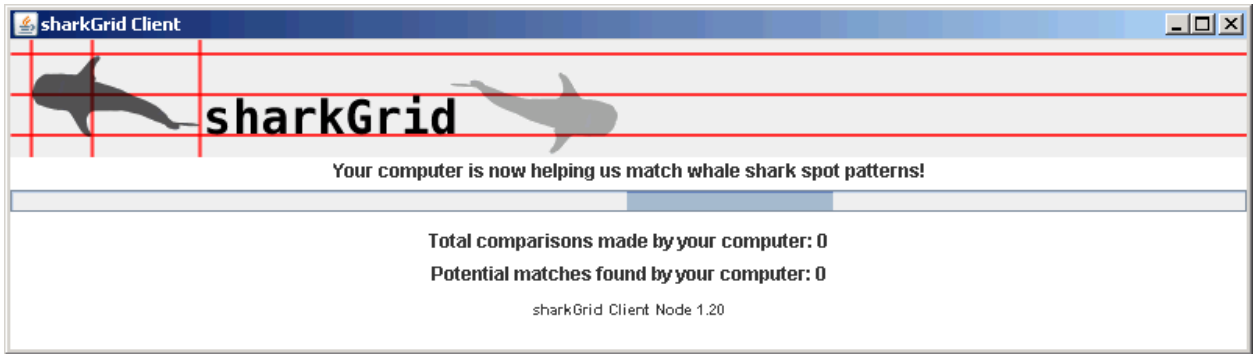


Figure A.1. The sharkGrid client running successfully.

A.2.1 Windows

1. Unzip the sharkGrid client zip file to a custom folder on your Desktop or elsewhere on your computer. This is the folder that sharkGrid will run from.
2. Determine how much memory is available on your computer.
3. In the sharkGrid folder, right-click StartGridClient.bat and select Edit. This is the command-line statement used to start sharkGrid.

```
java -classpath .;jdo2-api-2.0.jar;jpox-1.1.9.jar -Xms512m -Xmx1g workApplet3
```

You should edit ONLY the parameter ”-Xmx1g” to match the memory on your computer. You can specify your memory as megabytes (m) or gigabytes (g). The following are sample settings:

- ”-Xmx1g” or ”-Xmx1024m” for 1 gigabyte of RAM, which is also 1024 megabytes.
- ”-Xmx2g” or ”-Xmx2048m” for 2 gigabytes of RAM, which is also 2048 megabytes.

4. Save your changes to StartGridClient.bat.
5. Double-click StartGridClient.bat. You should see the sharkGrid client start and begin looking for work to do.
6. If the sharkGrid client fails to start, you may need to manually set the JAVA_HOME environment variable on your computer. This variable tells your computer where Java is installed so that it can use it when the “java” command is issued to start the sharkGrid client. Follow these steps on Windows to set JAVA_HOME:

```
 1. Right click on the My Computer icon on your desktop and select
Properties.
 2. Click the Advanced Tab.
 3. Click the Environment Variables button.
 4. Under System Variables, click New.
 5. Enter the variable name as JAVA_HOME.
```

6. Enter the variable value as the base directory of the JRE, such as C:\Program Files\Java\jre1.5.0_09.
   The value you set depends on where the JRE was installed on your computer.
7. Click OK.
8. Double-click StartGridClient.bat. You should see the sharkGrid client start and begin looking for work to do.

A.2.2 Linux

1. Unzip the sharkGrid client zip file to a custom folder on your Desktop or elsewhere on your computer. This is the folder that sharkGrid will run from.
2. Determine how much memory is available on your computer.
3. This is the command-line statement used to start sharkGrid from the folder you unzipped it to.

```
java -classpath .:jdo2-api-2.0.jar:jpox-1.1.9.jar -Xms512m -Xmx1g workApplet3
```

You should edit ONLY the parameter ”-Xmx1g” to match the memory on your computer. You can specify your memory as megabytes (m) or gigabytes (g). The following are sample settings:

- ”-Xmx1g” or ”-Xmx1024m” for 1 gigabyte of RAM, which is also 1024 megabytes.
- ”-Xmx2g” or ”-Xmx2048m” for 2 gigabytes of RAM, which is also 2048 megabytes.

4. This command assumes that Java 5 or higher is already installed and available from the command line.
5. Create a shell script containing this command and consider creating a cron job to run this script during the times of the day that you know your machine will be idle.

Appendix B. Photo Keywords Used in the ECOCEAN Library

The following images provide examples of the keywords used to tag photos in the ECOCEAN Library.

Figure B.1. Gill damage (left or right)

Figure B.2. Horizontal pattern lines (left or right)

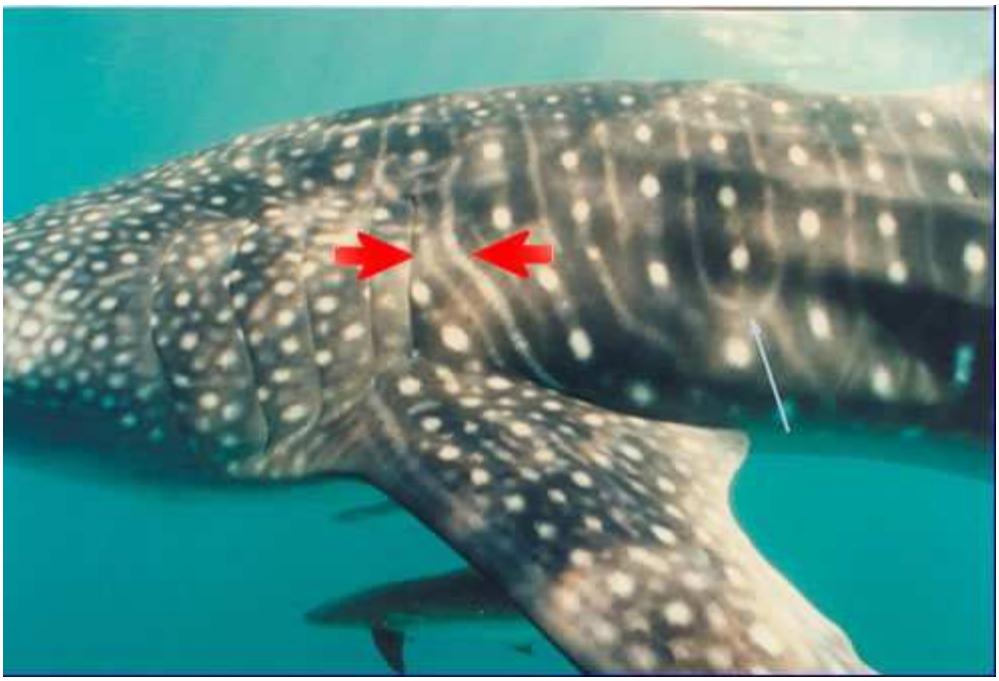


Figure B.3. Line doubled (left or right)

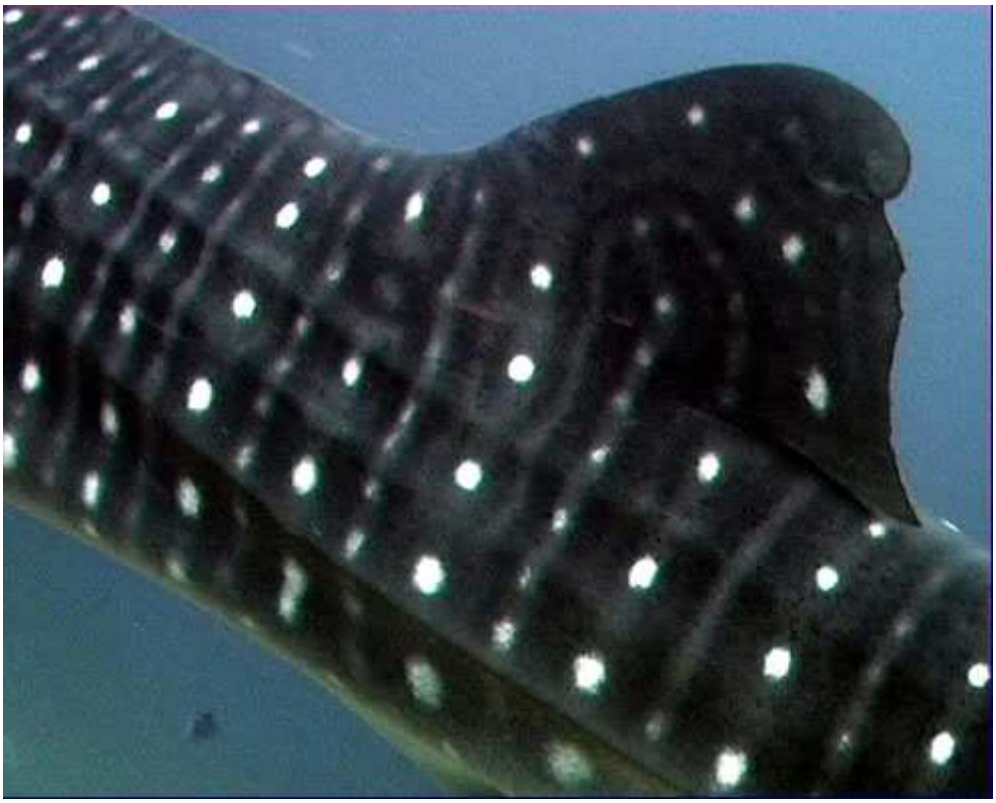


Figure B.4. Nicks, fin, 1st dorsal

Figure B.5. Nicks, fin, 2nd dorsal

Figure B.6. Nicks, fin, caudal lower

Figure B.7. Nicks, fin, caudal upper

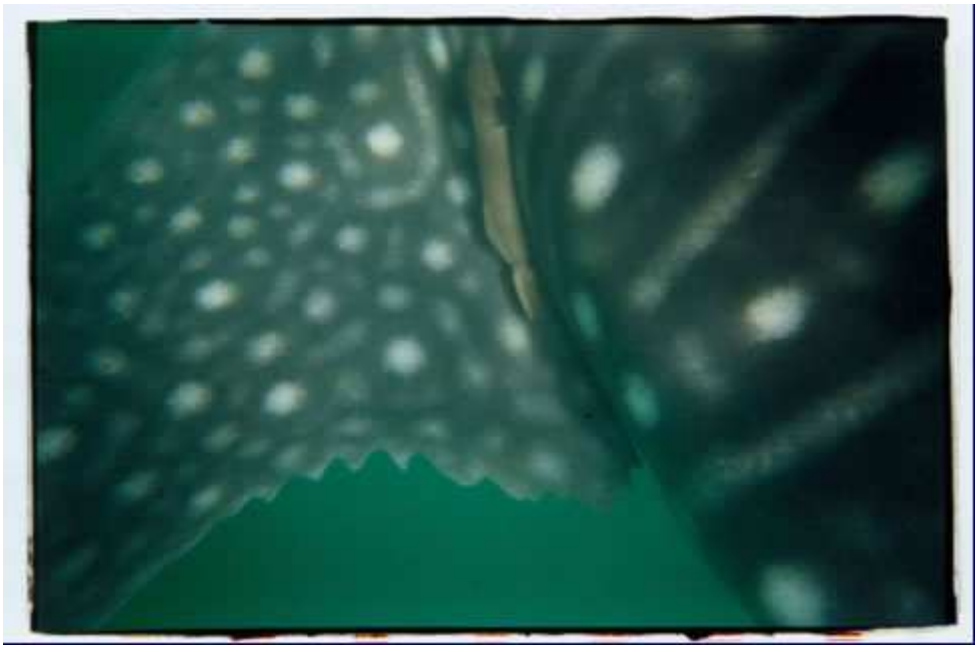


Figure B.8. Nicks, fin, pectoral left

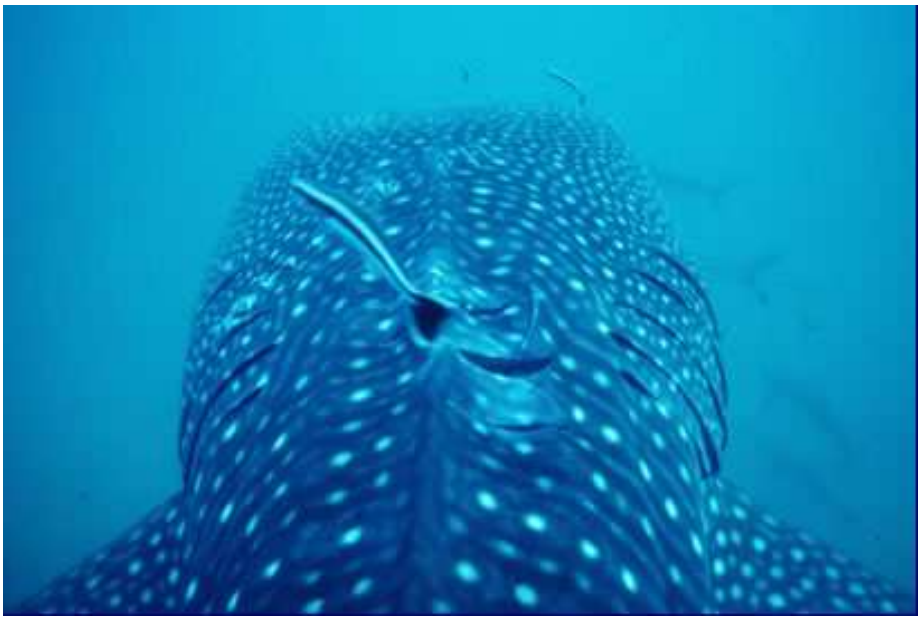


Figure B.9. Propeller cuts, body

Figure B.10. Propeller cuts, fin

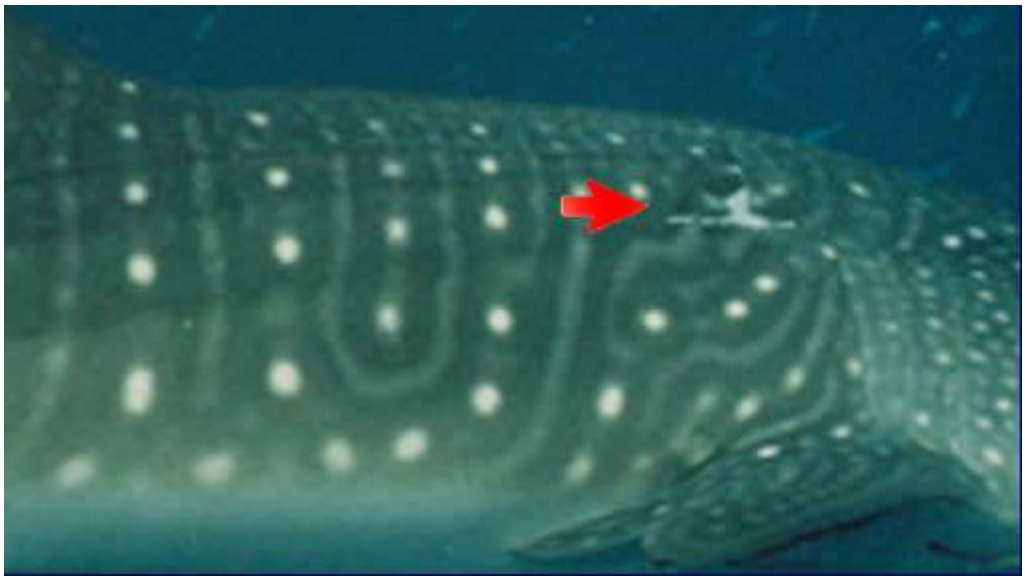


Figure B.11. Scar, body (left or right)

Figure B.12. Scar, bite

Figure B.13. Scar, head

Figure B.14. Skin growth

Figure B.15. Tag

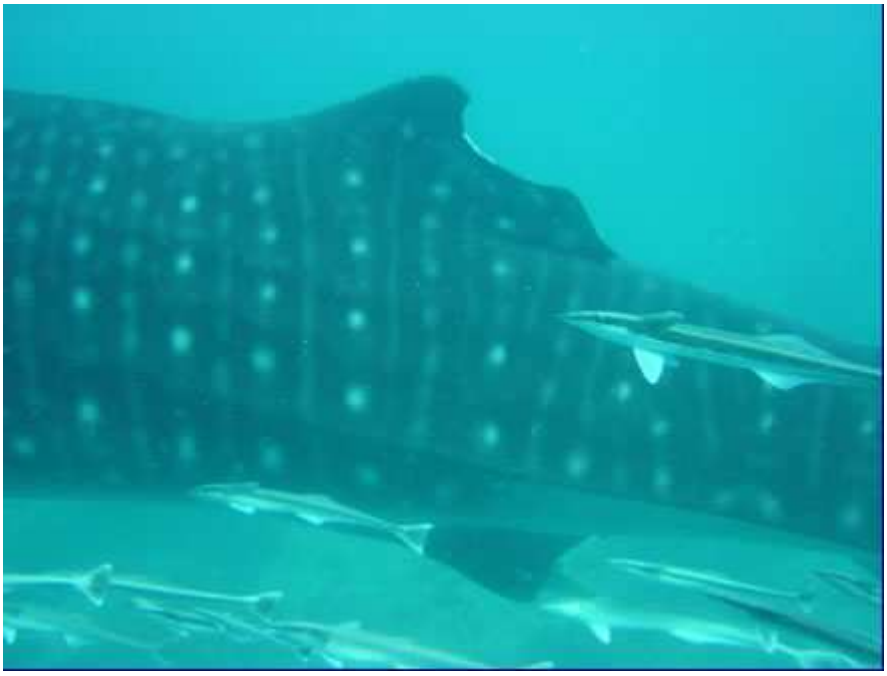


Figure B.16. Truncation, fin, 1st dorsal

Figure B.17. Truncation, fin, caudal lower

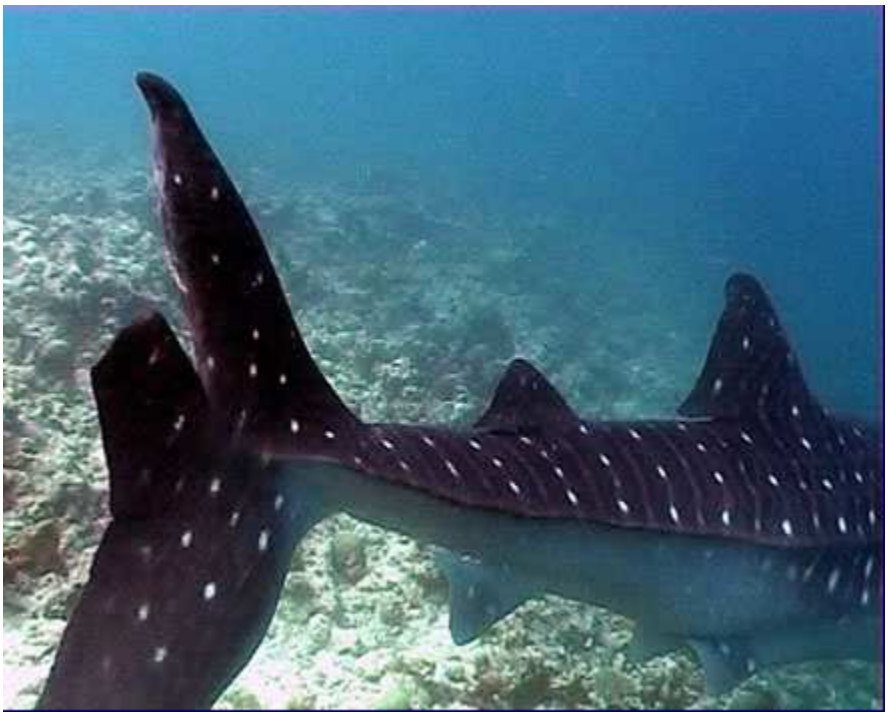


Figure B.18. Truncation, fin, caudal upper

Figure B.19. Truncation, fin, pectoral (left or right)

Figure B.20. Twinned spots, fiducial (left or right)

This tag is used for twinned spots that fall within the patterning area used for computer-assisted photo-identification.

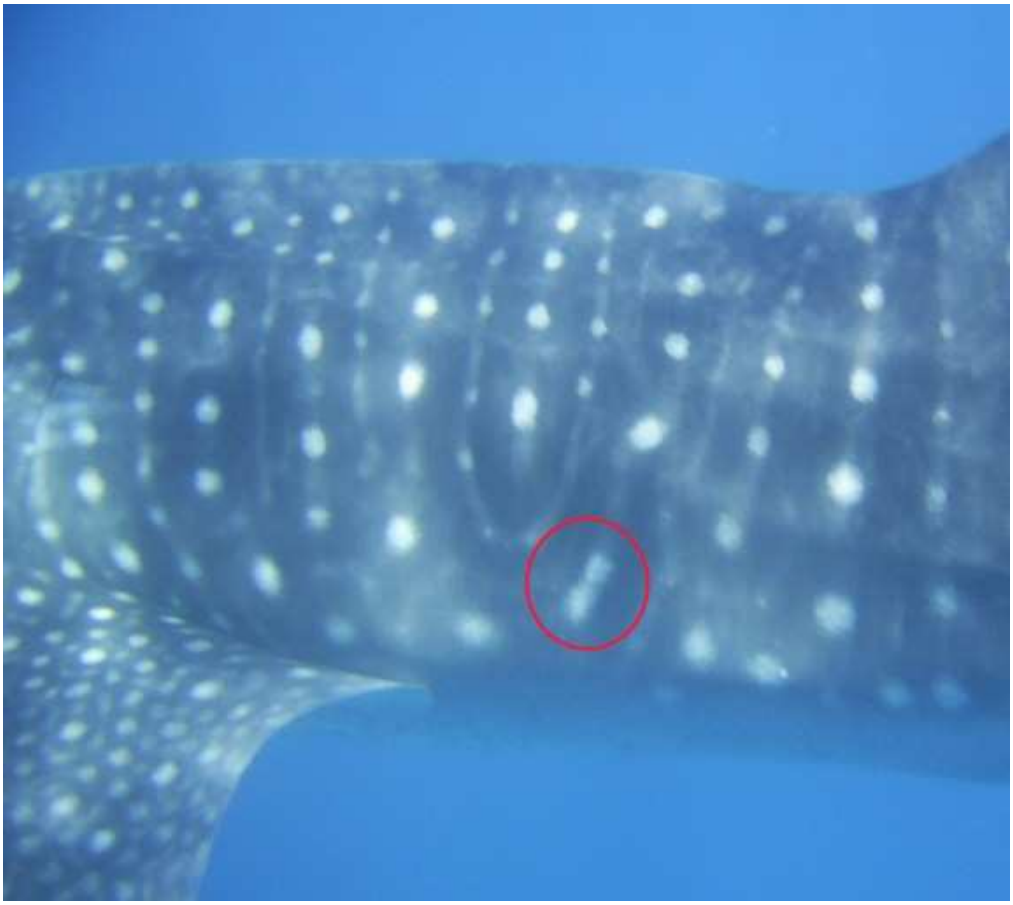


Figure B.21. Twinned spots, external (left or right)

This tag is used for twinned spots that fall outside the patterning area used for computer-assisted photo-identification.

Appendix C. Spot!

The spot pattern recognition algorithms used in whale shark mark-recapture (Modified Groth and I3S) assume a flat, two-dimensional surface when analyzing the relationships between spots. While each algorithm has some tolerance for skew in an image, both quickly degrade in their ability to match identical patterns as the angles between those patterns increases.

Spot! allows you to map a skewed 2D image to a 3D whale shark model and obtain a properly-oriented left- or right-side pattern for use with the Modified Groth and I3S algorithms.

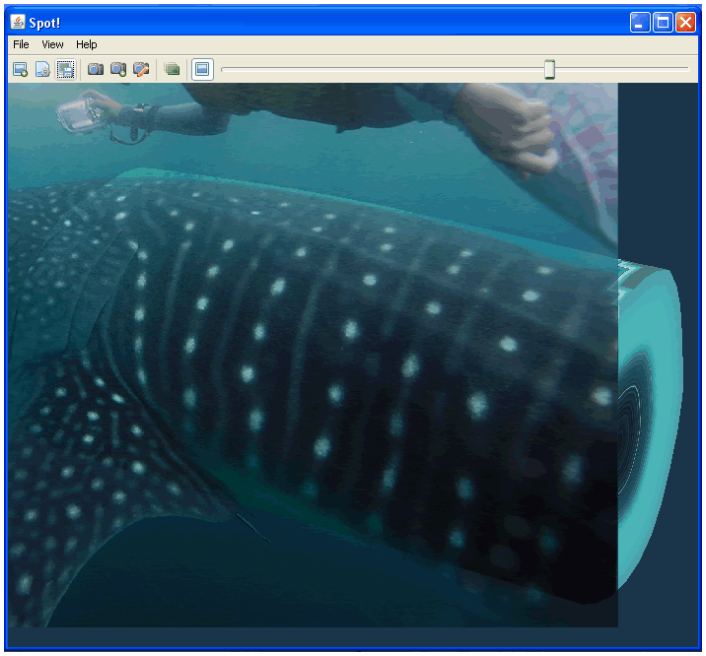


Figure C.1. Spot!

This perspective correction has been used in the ECOCEAN Library to match images taken from very extreme angles to previously tagged whale sharks. For example, Spot! was used to make this match for shark M-025 in the ECOCEAN Library.

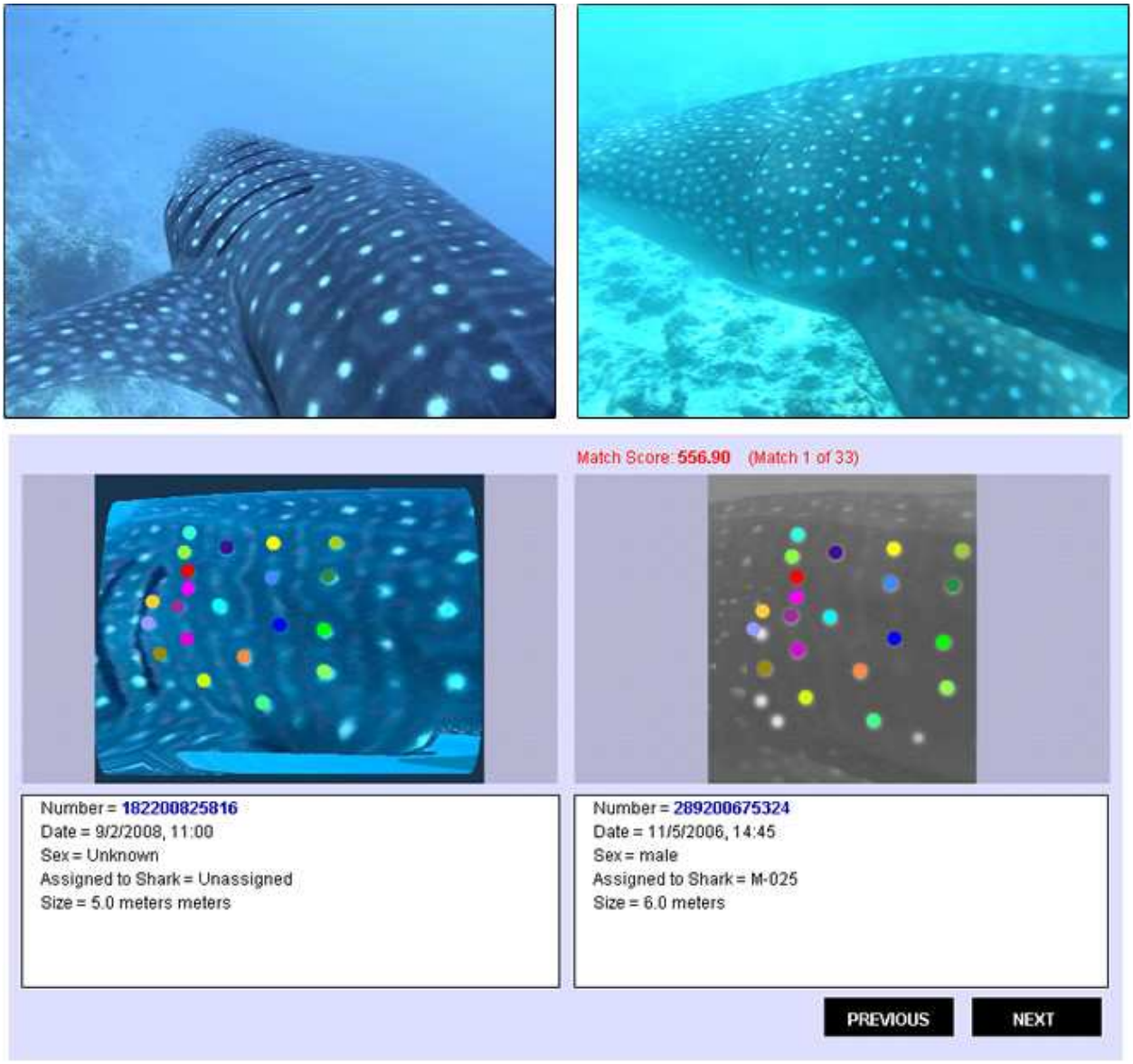


Figure C.2: Pattern match from Spot!

C.1 Spot! requirements

Spot! requires Java 5 or Java 6 on your computer. The Java Runtime Environment (JRE) can be downloaded from Sun Microsystems at: http://www.java.com

C.2 Loading Spot!

Spot! can be loaded from within the Client Software page of the ECOCEAN Library or directly from this link: http://www.whaleshark.org/spot/spot.jnlp

C.3 Basic Spot! instructions

There are just a few basic steps to using Spot!.

1. Load the skewed image into Spot! using the **Open** button.
2. Scale the image to the 3D model by holding down the middle mouse button and moving the mouse forward and backward.
3. Move the loaded image left and right by holding down the right mouse button.
4. Manipulate the 3D model by holding down the left mouse button on its edges and moving the mouse up, down, left, and right.
5. Repeat steps 2-4 to align the guidelines on the 3D to these features on the 2D image: 5th gill, lowest lateral line, and vertebral column.
6. Once aligned, click the **Map** button to map the 2D image to the 3D model.
7. Click the Export button to save the properly aligned image for spot mapping with ECOCEAN Interconnect

C.4 Spot! FAQ

1. How accurate is Spot?

We're still testing it. So far, we've made a lot of very strong matches in our test cases using real-world data. Spot! has exceeded our expectations in its ability to match patterns from skewed images to properly-oriented patterns. As with any software tool, the result is as good as the user, and Spot! requires patient, careful alignment between 3D model and 2D image. At this time, we're using Spot! to go back through encounter reports and identify sharks from images that were previously unsuitable for existing pattern recognition algorithms. Statistical tests of Spot!'s accuracy will be performed in the near future. But again...it's always going to be only as good as its user.

2. Can I use Spot! to identify new whale sharks from skewed images?

That's a longer discussion about misidentification in mark-recapture population modeling. At this point, Spot! is NOT being used to identify new whale sharks in the ECOCEAN Library. However, we may choose to do so in the future. We currently use it only to identify previously marked whale sharks. In general, we HIGHLY recommend the tandem use of both the Modified Groth and I3S pattern recognition algorithms in addition to rigorous peer review to reduce misidentification.

3. Can Spot! be used for other species?

Yes! Spot! can load other 3D models (.obj file format) and map images to them. This allows researchers for other spotted species to use image catalogs and pattern recognition algorithms where the observer cannot orient the camera correctly to the animal, such as when camera traps

are used. If you are interested in using Spot! and the dual pattern recognition algorithms of the ECOCEAN Library, please contact *webmaster at whaleshark.org*.

4. Is Spot! open source?

It will be as soon as our initial tests are complete. For now, it is freeware under license. Use it as you like.

5. Is a single whale shark model representative of the long-term morphology of an individual?

Probably not for very small (rare) and very large whale sharks, such as those found in the Galapagos Islands. The truncated 3D whale shark model used in Spot! is based on the proportions of average sized whale sharks, generally about 7 meters in total length (TL). We assume changes are proportional in all three dimensions for smaller and larger sharks (generally 5 m to 10 m in TL) within the range of most ecotourism activity. As our understanding of whale shark biology increases, we may use multiple models for different stages of growth.

6. Why is this model truncated at the front and back? Where are the fins?

The model focuses only on the fiducial region used for spot pattern recognition of whale sharks: left- and right-side patterning behind the gills. This area does not distort as much as many other regions of the shark during normal motion. By using a truncated model, we focus the eye on only the region of interest and consider only the region of interest.

Appendix D. TapirLink and the ECOCEAN Library

Certain data from the ECOCEAN Library are shared with other biology and ecology portals, such as the Global Biodiversity Information Facility and Fishbase. This sharing occurs at regular intervals via an installed TapirLink provider. Information shared fits the basic DarwinCore and Geospatial Extension specifications. The specifications map cleanly to the base “encounter” data structure displayed in the ECOCEAN Library.

ECOCEAN, after consulting with some of its users, has adopted these restrictions on shared data:

- Publicly submitted data is shared by default
- Users with login access can manage which encounters are shared
- Photos are not shared due to copyright restrictions
- Spot pattern data is not shared to protect ongoing research initiatives
- Individual shark identifications are not shared to protect ongoing research initiatives
- Data is shared with the following restriction listed in the metadata: “Original photos and extracted spot patterns withheld. Please contact info@whaleshark.org regarding usage permissions.” Requests for usage of data submitted by users with ECOCEAN Library login access will be routed to the library user for the ultimate decision.
- ECOCEAN as a general policy, but without strict enforcement, will not share via TapirLink publicly submitted data for the current calendar year as a precaution to protect this vulnerable species. Individual users of the ECOCEAN Library retain the right to decide which encounters to share.

Appendix E. ECOCEAN Library Location Codes

The following are the location codes used for standardized location identification in the ECOCEAN Library.

1a - Ningaloo, non-specific

1a1 - North Ningaloo, off Exmouth

1a2 - South Ningaloo, off Coral Bay

1b - Christmas Island

1c - Indonesia

1d - Malaysia

1e - Thailand

1f - Myanmar

2- Caribbean, non-specific

2a - Utila, Honduras

2b - Belize

2c - Mexico, East Coast

2d - Texas, Flower Gardens

2e - U.S. Gulf Coast

4a - Mozambique

4b - Tanzania

4c - Kenya

4d - South Africa permissions

4e- Djibouti

4f- Madagascar

5a - Maldives

5b - Seychelles

6a - Donsol, Philippines

6b - Taiwan

7 - eastern Pacific

7a - Galapagos Islands

7b - Cocos Island

7c - Panama, Pacific coast

8a - Great Barrier Reef

Appendix F. ECOCEAN Whale Shark Photo-Identification Library Access Policy

This policy defines who may be given access to the ECOCEAN Library and how access may be requested.

Background

The ECOCEAN Whale Shark Photo-identification Library ("ECOCEAN Library") is privately funded by ECOCEAN, a non-profit organization in Australia. The ECOCEAN Library provides standardized research software and analytical techniques for the study of whale sharks (*Rhincodon typus*). Access to the ECOCEAN Library is provided free of charge to individuals or organizations selected according to the criteria of this policy. The number of new accounts that can be provided for the ECOCEAN Library each year is limited by:

- ECOCEAN's available resources to support existing users
- ECOCEAN's available resources for existing whale shark research efforts

Requesting access

Requests for access to the ECOCEAN Library should be sent via email to: webmaster at whaleshark dot org

In the request, please state:

- Your research objectives
- The organization you represent (if appropriate)
- The timeframe of your research
- How ECOCEAN Library tools and data could benefit your research
- How much data you have already collected for your research
- Your qualifications

Request review

Requests for access to the ECOCEAN Library are reviewed and voted upon by the Management Committee of ECOCEAN within 60 days. The Management Committee may also request outside assistance in reviewing your application.

The Management Committee weighs these and other criteria when reviewing a request for access:

- Your ability and willingness to contribute new whale shark data
- Your ability and willingness to follow the analytical techniques used in the ECOCEAN Library
- Your ability and willingness to develop new techniques for whale shark research
- Your ability and willingness to develop new science for other fields using whale shark data
- Your ability and willingness to use whale shark data collaboratively
- ECOCEAN's available resources to properly support you

The final decision for a request is made by a majority decision of the ECOCEAN Management Committee. Responses are provided via email. The Management Committee wishes to acknowledge in advance that not all valid requests for access can be approved due to limitations on available resources.

By invitation

The Management Committee of ECOCEAN may choose to invite appropriate individuals to participate in the ECOCEAN Library without a formal request for access. Invitations for access require a majority decision by the Management Committee and are reviewed in accordance with the criteria defined above.

Appendix G. ECOCEAN Library Visitor Agreement

Welcome to the ECOCEAN Library! Please read this Visitor Agreement. By using this web site, you accept its terms. This Visitor Agreement applies to any web page using the following domains, which are collectively known as the "ECOCEAN Whale Shark Photo-identification Library" or in shortened form "ECOCEAN Library":

- whaleshark.org
- sharkgrid.org

The Internet is an evolving medium, and we may change the terms of this Visitor Agreement from time to time. By continuing to use any of the ECOCEAN Library sites after we post any such changes, you accept the Visitor Agreement, as modified. We may change, restrict access to, suspend or discontinue the ECOCEAN Library, or any portion of the ECOCEAN Library, at any time.

If you disagree with any material you find in the ECOCEAN Library, we suggest that you respond by noting your disagreement in an email to webmaster at whaleshark dot org. We invite you to bring to our attention any material you believe to be factually inaccurate. Please forward a copy of the material to our webmaster along with an explanation of your disagreement.

If you are an owner of intellectual property who believes your intellectual property has been improperly posted or distributed via the ECOCEAN Library, please notify us immediately by sending email to our webmaster.

A link to another Web site does not constitute an endorsement of that site (nor of any product, service or other material offered on that site) by the ECOCEAN Library or its participants.

NO SOLICITING

You agree not to use the ECOCEAN Library to advertise or to solicit anyone to buy or sell products or services, or to make donations of any kind, without our express written approval.

USE OF MATERIALS

Any photographs that you submit to the ECOCEAN Library remain YOUR intellectual property, and the ECOCEAN Library and its participants agree not to use them for media purposes without your express permission. However, by submitting photographs and whale shark sighting data you give ECOCEAN and its participants permission to use this data for research and conservation purposes. Data, such as shark identifications, may be derived from your submissions. This data becomes the intellectual property of the ECOCEAN Library and may not be published or re-used without the express permission of the ECOCEAN Library.

The Internet allows people throughout the world to share valuable information, ideas and creative works. To ensure continued open access to such materials, we all need to protect the rights of those who share their creations with us. Although we make the ECOCEAN Library freely accessible, we don't intend to give up our rights, or anyone else's rights, to the materials appearing in the ECOCEAN Library. The materials available through the ECOCEAN Library are the property of the ECOCEAN Library or, in the case of photographs and images, the property of individual contributors. All photographs and data are protected by copyright, trademark and other intellectual property laws. You may not reproduce any of the materials without the prior written consent of the owner. You may not distribute copies of materials found on the ECOCEAN Library in any form (including by email or other electronic means), without prior written permission from the ECOCEAN Library.

Requests for permission to use, reproduce, or distribute materials found in the ECOCEAN Library should first be sent to webmaster at whaleshark dot org. Requests will be evaluated and responded to (yes or no) as quickly as possible. Our main concern is to protect intellectual property and to ensure that credit is given where credit is due. Our mission is to facilitate global cooperation within the whale shark research community, and we are working to make as much data as possible available while protecting the rights of individual contributors.

LINKING

We welcome links to the ECOCEAN Library. You are usually free to establish a hypertext link to any of the ECOCEAN Library pages so long as the link does not state or imply any sponsorship of your site by the ECOCEAN Library. Pages linking to the Library should include, to the best of your ability, factually correct information about the ECOCEAN Library and about whale sharks. In other words, please respect the scientific mission of the ECOCEAN Library and help us ensure that only accurate information about whale sharks is disseminated.

FRAMING

No Framing. Without the prior written permission of the ECOCEAN Library, you may not frame any of the content in the ECOCEAN Library, or incorporate into another Web site or other service any intellectual property of the ECOCEAN Library or its data contributors. Requests for permission to frame our content may be sent to: webmaster at whaleshark dot org.

DISCLAIMER OF WARRANTIES AND LIABILITY

We work hard to make the ECOCEAN Library interesting and informative, but we cannot guarantee that our users will always find everything to their liking. Please read this Disclaimer carefully before using the ECOCEAN Library.

YOU AGREE THAT YOUR USE OF THE ECOCEAN LIBRARY IS AT YOUR SOLE RISK. BECAUSE OF THE NUMBER OF POSSIBLE SOURCES OF INFORMATION AVAILABLE THROUGHOUT, AND THE INHERENT HAZARDS AND UNCERTAINTIES OF ELECTRONIC DISTRIBUTION, THERE MAY BE DELAYS, OMISSIONS, INACCURACIES OR OTHER PROBLEMS WITH SUCH INFORMATION. IF YOU RELY

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USER ACCOUNTS

The ECOCEAN Library staff does its best to ensure that information we post to the ECOCEAN Library is timely, accurate, and scientifically valuable. To obtain access to certain services of the ECOCEAN Library, you may be given an opportunity to register with the ECOCEAN Library. As part of any such registration process, you will be provided an user name and a password. You agree that the information you supply during that registration process will be accurate and complete and that you will not register under the name of, or attempt to enter the ECOCEAN Library under the name of, another person. You will be responsible for preserving the confidentiality of your password, sharing it with no one else without express permission, and will notify the staff of the ECOCEAN Library of any known or suspected unauthorized use of your account. You agree to indemnify, defend and hold harmless ECOCEAN, its affiliates and participants, and their officers, directors, employees, agents, licensors and suppliers, from and against any and all losses, expenses, damages and costs (including reasonable attorneys' fees) resulting from any violation of this Visitor Agreement or any activity related to your account (including negligent or wrongful conduct) by you or any other person accessing the ECOCEAN Library using your account.

MISCELLANEOUS

In the event that any portion of this Visitor Agreement is found to be invalid or unenforceable for any reason, such invalidity or unenforceability shall not affect the enforceability or validity of any other portion of this Visitor Agreement, which shall remain in full force and effect and be construed as if the invalid or unenforceable portion were not part of the Visitor Agreement.

By using the ECOCEAN Library, you agree to abide by the terms of this Visitor Agreement.

We hope you enjoy using the ECOCEAN Library, and we welcome suggestions for improvements.

Appendix H. User Agreement 'ECOCEAN Library'

The following policy applies only to individuals with login access to the ECOCEAN Library.

ECOCEAN Whale Shark Photo-identification Library Usage Agreement

Subscribers: Please read the following Usage Agreement logging in to the ECOCEAN Whale Shark Photo-identification Library. By logging into the ECOCEAN Whale Shark Photo-Identification Library, you agree to all of the terms and conditions of this ECOCEAN Whale Shark Photo-identification Library Usage Agreement ("Usage Agreement"), including the terms, conditions and notices contained in the "Usage" section of this Usage Agreement. If you do not agree with ANY of the terms or conditions contained herein, please do not use the ECOCEAN Whale Shark Photo-identification Library. Please contact webmaster at whaleshark dot org for any questions related to this agreement.

ECOCEAN reserves the right to change, modify, add or remove portions of this Usage Agreement or the terms or conditions contained herein. However, subscribers need to be notified 30 days prior to the changes taking place. If the Subscriber deems that they will no longer be able to meet their obligations under the User Agreement or that they will no longer be able to use or access the Service in a useful manner they must inform ECOCEAN directly and no longer use the ECOCEAN Whale Shark Photo-identification Library in any manner.

1. Definitions.

The ECOCEAN Whale Shark Photo-identification Library (the "Library") is a suite of online informational services (the "Services") provided by ECOCEAN, consisting of software applications and content provided by members of ECOCEAN, members of the general public, and governmental management agencies. "You" or "yours" refers to each person or entity, as applicable, that subscribes to the ECOCEAN Whale Shark Photo-identification Library (the "Subscriber").

1.a Authorized Users

Authorized users are those persons, and only those persons, who have been issued a user identifier and password by ECOCEAN.

2. General.

The User Account Request Form, this Usage Agreement and any other policies relating to the use of the ECOCEAN Whale Shark Photo-identification Library (collectively, this "Agreement") set forth the terms and conditions that apply to your use of the ECOCEAN Whale Shark Photo-

identification Library. By signing and submitting the User Account Request Form to ECOCEAN, you are deemed to have agreed to comply with all of the terms and conditions of this Agreement. The right to use the Services is limited to Subscribers and Authorized Users and is not transferable to any other person or entity. You are responsible for protecting the confidentiality of your access to the Services and for complying with any guidelines relating to security measures designed to prevent unauthorized access as outlined in the Usage Agreement. You are responsible to make reasonable efforts to inform Authorized Users aware of the terms of use as outlined by this agreement. You are not liable for actions of other users but agree to work with ECOCEAN to rectify any problems caused by Authorized users who infringe upon the terms of the Agreement. If the Subscriber fails comply with any material term or condition of the Usage Agreement ECOCEAN, may terminate this Agreement upon written notice if the Subscriber does not cure such noncompliance within sixty (3) days of receiving written notice of the breach.

All Subscribers are authorized to provide remote access to Services only to Authorized Users as long as reasonable security procedures are undertaken that will prevent remote access by institutions or individuals that are not Authorized Users under this Usage Agreement.

3. Usage.

Your use of the Services constitutes your agreement to all of the terms, conditions and notices below in addition to the general terms and conditions contained in this Agreement. If you do not agree with these provisions, please do not use the Services and request an immediate termination of your account.

In General

As a condition of using the Services you agree to abide by all applicable local, Provincial, national and international laws and regulations relevant to the use of the Services including, without limitation, any applicable privacy legislation and policies. In addition, you warrant that you will not use the Services for any purpose that is unlawful or prohibited by this Agreement (including, without limitation, any use that infringes another's copyright rights). You may not use the Services in any manner that could damage, disable, overburden or impair the Web site or any user of the Web site, or interfere with any other party's use of the Services. You will not use the Services or content of the Library to accumulate data for or promote a Whale Shark Photo-identification Library that may in any way be deemed by ECOCEAN to be competitive with its own efforts.

Good Faith Data Collection, Reporting, Sharing, and Collaboration

As a Subscriber, you have the right to submit photographs, data, and content to the Library. The Library is a community resource, and its content is used by a number of different individuals and agencies for a variety of research and conservation purposes. In all cases, you will submit content and encounter reports as completely and as accurately as possible, obtaining permission to use any copyrighted materials before submitting them to the Library. In addition, you will not

submit any content that uses language or imagery (verbal or visual) that is deemed as offensive by anyone for any reason. ECOCEAN reserves the right to edit your content to enforce this.

While you retain the copyright to your photographic data, you are agreeing to share this information with other Subscribers and to a limited extent with the general public. No requests for content "hiding" from other Subscribers will be honored by ECOCEAN, though our security system does prevent content "tampering" and protects your critical data. Additionally, you agree not to compete with users of the ECOCEAN Library from other regions or to allow others to compete through your access. The ECOCEAN Library is for collaboration, and users must respect the individual research interests of others outside their region of interest.

Publications Using Data from the Library

In any case where the content or Services of the Library are used in any way to contribute to any publication (online or print), Subscribers must make a good faith effort to include a visible acknowledgment of the ECOCEAN Library in their publications. Furthermore, any Subscriber taking copyrighted content directly from the Library and using it in any publication or medium must first obtain the written consent of the appropriate copyright holder(s) (such as encounter photographers) and comply with all national and international copyright laws.

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Hyperlinks to other Internet resources are provided for your convenience. ECOCEAN has selected these resources as having some value and pertinence, but such resources' development and maintenance are not under the direction of ECOCEAN. Thus, the content, accuracy, opinions expressed and other links provided by these resources are neither verified by ECOCEAN editors nor endorsed by ECOCEAN. Because ECOCEAN has no control over such Web sites and resources, you acknowledge and agree that ECOCEAN is not responsible for the availability of such external Web sites or resources. In addition, you acknowledge and agree that ECOCEAN does not endorse and is not responsible or liable for any content, advertising, products or other materials on or available from such Web sites or resources. Furthermore, you acknowledge and agree that ECOCEAN will not be liable, directly or indirectly, for any damage or loss caused by the use of any such content, products or materials.

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5. Account and Security.

You are responsible for maintaining the confidentiality of your method of accessing the Services.

6. Disclaimer of Warranty; Limitation of Liability.

YOU EXPRESSLY AGREE THAT USE OF THE SERVICES IS AT YOUR SOLE RISK. NEITHER ECOCEAN, ITS AFFILIATES NOR ANY OF THEIR RESPECTIVE EMPLOYEES, AGENTS, THIRD PARTY CONTENT PROVIDERS OR LICENSORS WARRANT THAT THE SERVICES WILL BE AVAILABLE AT ANY PARTICULAR TIME, UNINTERRUPTED, OR ERROR FREE; NOR DO THEY MAKE ANY WARRANTY AS TO THE RESULTS THAT MAY BE OBTAINED FROM USE OF THE SERVICES, OR AS TO THE ACCURACY, RELIABILITY OR CONTENT OF ANY INFORMATION OR SERVICE PROVIDED THROUGH THE SERVCIES. THE SERVICESARE PROVIDED ON AN "AS IS" BASIS WITHOUT WARRANTIES OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO WARRANTIES OF TITLE OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, OTHER THAN THOSE WARRANTIES WHICH ARE IMPLIED BY AND INCAPABLE OF EXCLUSION, RESTRICTION OR MODIFICATION UNDER APPLICABLE LAW.

IN NO EVENT SHALL ECOCEAN BE LIABLE TO YOU OR ANY OTHER PERSON FOR LOSS OF BUSINESS OR PROFITS, OR FOR ANY INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OF, OR INABILITY TO USE, THE SERVICES, EVEN IF ECOCEAN WAS PREVIOUSLY ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, OR FOR ANY OTHER CLAIM BY A SUBSCRIBER, AUTHORIZED USER, OR ANY OTHER PERSON. THIS WARRANTY GIVES YOU SPECIFIC LEGAL RIGHTS, AND YOU MAY ALSO HAVE OTHER RIGHTS WHICH VARY BY LOCATION.

In the event any claim relating to the performance or nonperformance by ECOCEAN pursuant to this Agreement, or in any other way concerning the Services, is made by a Subscriber or Authorized User, the actual damages to which such Subscriber or Authorized User may be entitled shall be limited to the lesser of the fees paid by the Subscriber or Authorized User for the Services or One US Dollar (US $1).

7. Indemnification.

To the maximum extent permitted by law, you agree to defend, indemnify and hold harmless ECOCEAN, its affiliates and their respective directors, officers, employees and agents from and against any and all claims and expenses, including attorneys' fees, arising out of the use or unauthorized copying of the Services or any of their content, the violation of this Agreement or any applicable laws or regulations, or arising out of your violation of any rights of a user.

8. Term and Termination of Agreement.

Either party shall have the right to terminate this Agreement at any time by providing notice of termination to the other party in accordance with the Subscription Form. In the event of termination of this Agreement by either party, you shall have no claims against ECOCEAN, its affiliates, or any individual contributors to the Library. Termination of this Agreement automatically terminates your license to use the Services, any content or any other materials contained therein.

9. Miscellaneous.

This Agreement is entire and complete, and no representations, warranties, agreements or covenants, express or implied, of any kind or character whatsoever have been made by either party hereto to the other, except as expressly set forth in this Agreement. Except as provided herein, this Agreement may not be modified or changed unless the same shall be in writing and signed by an authorized officer of the party to be bound thereby.

You may not assign any of your rights or delegate any of your obligations under this Agreement without ECOCEAN's prior written consent. If any provision of this Agreement is held to be overly broad in scope or duration by a court of competent jurisdiction such provision shall be deemed modified to the broadest extent permitted under applicable law. If any provision of this Agreement shall be held to be illegal, invalid or unenforceable by a court of competent jurisdiction, the validity, legality and enforceability of the remaining provisions shall not, in any

way, be affected or impaired thereby. No waiver by either party of any breach or default hereunder shall be deemed to be a waiver of any preceding or subsequent breach or default. The section headings used herein are for convenience only and shall not be given any legal import.

The provisions of Sections 4, 6, 7 and 8 shall survive termination of this Agreement.