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Evaluating citizen scientist efficacy at cataloging humpback whales (Megaptera novaeangliae) using the crowdsourcing web application Match My Whale

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INTERNATIONAL WHALING COMMISSION

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ABSTRACT

The large size of humpback whale (*Megaptera novaeangliae*) fluke photo-identification (ID) catalogs is both a strength and a challenge. Every year, researchers add hundreds of new flukes photographs to their catalogs, making the task of pairwise matching all individuals exponentially more difficult. A new website, "Match My Whale" (MMW), has been developed by Pacific Whale Foundation (PWF) in collaboration with Centre for Whale Research (CWR) using South Pacific humpback whale photo-IDs contributed by both organizations. MMW is aimed at harnessing the power of crowdsourcing and testing the theory that an online citizen scientist fluke matching platform will be more effective than the current method(s) of individuals manually searching for a match, or relying on complicated computer software. Crowdsourcing can offer the effort and redundancy needed for scientists to manage their current catalogs, and facilitate the integration of multiple catalogs from different organizations. PWF considers this to be a breakthrough method for comparisons across large photo-ID catalogs.

Keywords: Crowdsourcing, Citizen Science, Humpback Whale, Photo-ID, *Megaptera novaeangliae*, MatchMyWhale.org, Match My Whale.

INTRODUCTION

Citizen science and crowdsourcing

Citizen science is the collaboration between members of the public and researchers to carry out scientific projects. Some notable examples of this type of scientific collaboration being successful are Cornell Laboratory of Ornithology's Project FeederWatch (Trumbull *et al*. 2000) and PWF's Great Whale Count (Tonachella *et al*. 2012). Crowdsourcing is the process of obtaining input into a task or project by soliciting a large group of people, often from an online community. Citizen science does not have to take place in the field; volunteers can often contribute with nothing more than a computer and an internet connection. Websites such as Zooniverse (Zooniverse.org) combine citizen science with crowdsourcing to give internet users access to a large number of citizen science projects that they can participate in from their home. In 2014, Zooniverse had over one million reported volunteers and the data collected from these various projects had led to over 70 scientific papers. In 2013, PWF began development on a web application to test the effectiveness and accuracy of crowdsourcing photo-identification research using citizen scientists (Stack *et al*. 2014).

Challenges with current fluke photo-ID matching efforts

The challenge in identifying whale populations is that as their population numbers increase, so does the difficulty in photo-identification. The Southern Hemisphere humpback whale population is estimated at over 50,000 individuals and growing at approximately 10% annually (Branch 2011). The PWF photo-ID catalog for this population has over 6000 individuals, while CWR has over 2000 individuals, and new photographs are collected each year. Large catalogs mean that cross-checking is prohibitively time consuming, and, furthermore, within a catalog more and more errors can accumulate during the matching process (specifically, "false negatives" from missed matches), which reduces the confidence in the data and statistical models (Stevick *et al*. 2001). These missed matches can result in overestimates in abundance and growth because previously sighted individuals are mis-categorized as new individuals (Hammond *et al*. 1990). To determine if a newly collected photo is a match to the catalog or a new individual, one must compare the new photograph against the entire catalog, which is an extremely time consuming process. In addition, researchers often have a shortage of staff members to carry out this procedure, or must prioritize other forms of work. Volunteers can assist with the matching, however, researchers must feel confident that they have the mental stamina to compare against the entire catalog, or they are at risk of having missed matches in the catalog.

What is Match My Whale?

Match My Whale is an online platform for photo-identification of humpback whales. Using crowdsourcing, this site can perform the work carried out by research groups in a fraction of the time. Citizen scientist users volunteer their time to complete three activities: SPLASH scoring the quality of photographs (Calambokidis *et al*. 2001), classifying whale flukes into pigment types and matching of whale fluke photographs.

Members of the public can also contribute to whale research by donating their fluke photos to the site. In this way, citizen scientists can collaborate with researchers to grow a photo-ID catalog rapidly without the field expense, which often limits long-term continuous datasets.

The site was launched with the entire PWF East Australia catalog and a portion of the CWR West Australia catalog for users to work with. No one is required to donate any photos to use the site, but the vision is that in time other research organizations will feel comfortable enough to collaborate and share their catalogs to build the collection. MMW has the potential to be the first global humpback whale photo-ID catalog.

METHODS AND OBJECTIVES

User interface

Citizen scientist users must create a free account to access the site. Once logged-in, they are taken to their dashboard (Figure 1). This page is customized for each user, with different activities being available depending on their training and use of the site. There are four badges available; one for being a new user and one for passing each of the following tests: SPLASH scoring, classification by pigment type and fluke matching. The badges are greyed out until the

user achieves them, at which point they appear in full color. This provides motivation and positive feedback to users for actively participating in the site training.

Figure 1: Match My Whale citizen scientist user dashboard with all badges displayed and activities available.

Training and testing citizen scientists

All users of the site must pass a test to participate in each of the three activities offered: SPLASH scoring, classification by pigment type, and fluke matching. Each of the three activities has 10 different test sets that will be fed to the user at random. As such, users have 10 attempts to achieve a passing score per test activity, and if they do not pass before running out of attempts, they are locked out from retaking that test. Training materials are provided, in PDF format, through a link on the dashboard, with a vision of video training in the future. Users are encouraged to revisit this material as often as needed, or print it out (See appendices for full training). Only after users have successfully passed the training module are they allowed to access the actual catalog of photos. Users can choose to train in one, two, or all three activities, according to their preference and interest. The SPLASH test consists of 10 photos that must be scored correctly following methods modified from Calambokidis *et al.* (2001) (see Appendix A). The classification test consists of 10 photos that must be classified correctly using criteria developed by PWF (see Appendix B). As there is a certain amount of inherent subjectivity for both the SPLASH and classification tests, the authors have designed an algorithm which allows

for a certain amount of deviation from the correct score. For both tests, users must get 8 out 10 photos correct to pass the activity.

The matching test (Figure 2) consists of one photo which is compared pairwise against 50 other photos. The user must correctly select 'match' or 'no match' for each pairwise comparison in order to pass this test. There is no allowable deviation from the correct score in this test type. This test is simply pass/fail, where pass indicates that the user correctly identified the match(s), correctly identified all the non-matches, and did not make any incorrect matches.

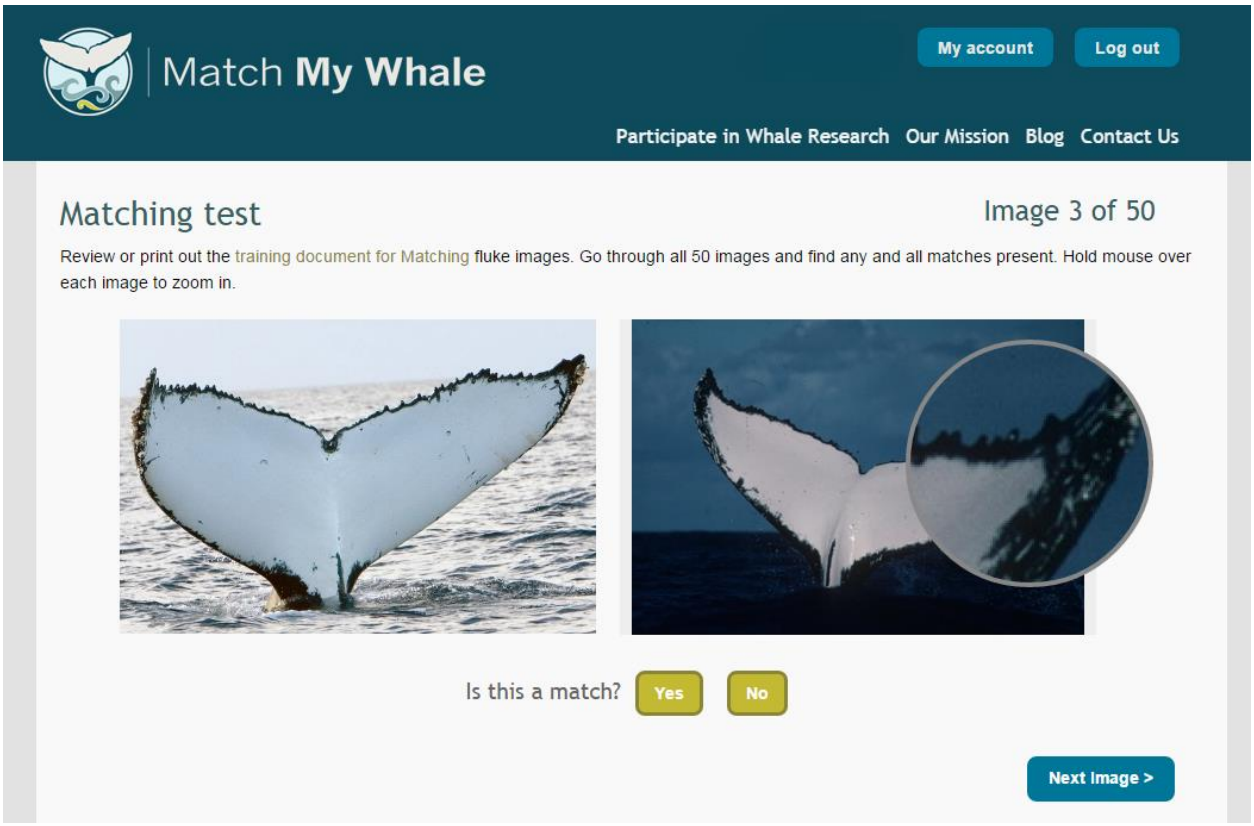

Figure 2: Match My Whale matching test page.

Research activities

Once a citizen scientist has successfully passed a test, that user will then have access to the associated research challenge for that activity. A challenge is the MMW terminology for completing one of the actual research activities: SPLASH scoring, classification and/or matching. These research challenges are designed to look the same as the tests, but with the results on each entry being recorded and compiled. Completing one challenge is considered to be SPLASH scoring one photo, assigning a classification type to one photo or deciding if two photos match or not.

Site mechanics

The goal of MMW is to move images from an unscored and unmatched state to a scored and matched state. To achieve this, images proceed through the following workflow: (1) upload, (2) SPLASH, (3) classify and (4) match. Images that are uploaded to the site are assigned a unique MMW image ID.

Images are first assigned to the SPLASH scoring challenge, where they will be fed to all users. The site is designed to have an adjustable number of independent users (*x*) assign a SPLASH score to the photo, and these scores are associated with that MMW image ID. Once an image reaches *x* number of scores the image is no longer fed to users in the SPLASH challenge. If the scores are considered "consistent" and meet the minimum SPLASH criteria, that image is moved into the classification challenge. If scores are "inconsistent", the image is flagged and an administrative user assigns a SPLASH score to the image and, if it meets minimum SPLASH score criteria, moves onto the classification challenge. Images that do not meet the minimum SPLASH score are removed from the challenge workflow.

Similar logic is applied to the classification challenge, where an image is scored by *x* different users before being evaluated for consistency and processed through the workflow. Images that have SPLASH scores which meet the minimum criteria for photo-id and are assigned a classification type are then moved into the matching challenge.

In the matching challenge, users are provided a pair of images and asked to determine if they are a "match" or "no match". After making a selection, the user is given two new images to compare. The site is designed to prioritize pairs of images that have been flagged as a potential match by any one citizen scientist. Therefore, once a single user finds a potential match, the confirmation (or rejection) by an additional *x* number of users happens quite rapidly. Once the same pair of images has been scored by *x* different users, the site checks for consistency. If *x* number of users agree on a match, the images are removed from the matching challenge and are no longer available to match. A type specimen, based on the lowest SPLASH score for each individual whale in the MMW catalog, remains in the matching challenge to allow for matching of re-sights. If scores are inconsistent, the pair of images is flagged for review by an administrative researcher.

The threshold number of consistent scores *x* needed for each image can be adjusted by the site administrator. The stepwise independent scoring and movement of images through the workflow builds upon the work of others to complete tasks that would take an independent researcher much longer.

Adding content to the site

Uploading fluke photographs to the site is optional. Any user is able to work on the two research catalogs that have been added to the site prior to launch; one from East Australia donated by PWF and one from West Australia donated by the CWR.

If users wish to upload photos to MMW, they must own the copyright or have the permission of the photographer to contribute it. This ensures there are not duplicates in the catalog.

If researchers decide to contribute their photo-ID catalog to the site, no metadata are displayed to the site users. All metadata, including date and location of the photo as well as SPLASH scores, classification types and matches made using MMW, are saved on the site and are easily accessible by the researchers who own the catalog using the back-end.

PROJECT OUTCOMES

The first phase of this project is designed to answer the question "Are citizen scientists more accurate, equal, or less accurate than researchers at matching?" With that question in mind, there were several tools built-in to the site to collect relevant data. There are four metrics being measured, outlined below, that are not seen by citizen scientists, but are accessible to admin users by logging in to a special menu (Figure 3).

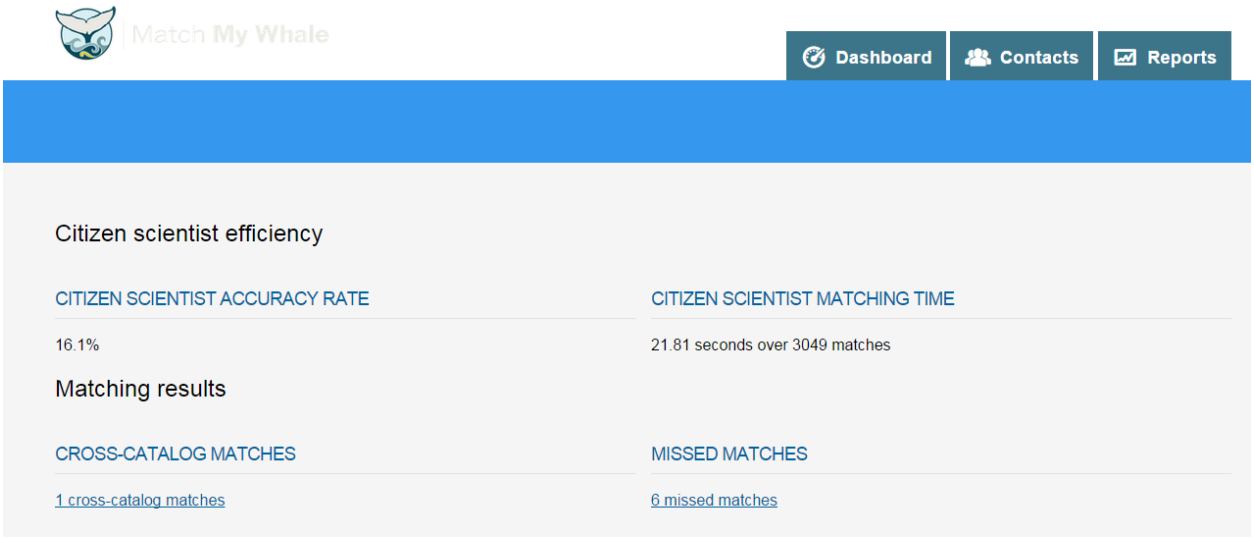

Figure 3: Match My Whale administrative user reports page, with links to view the cross-catalog and missed matches that have been identified by citizen scientists. *Note: Numbers depicted are examples only.*

Citizen scientist accuracy rate

The site feeds users pairs of known matches, *i.e.* matches that were identified by researchers prior to uploading their catalog to the site. Known matches are displayed at a certain interval to measure the "accuracy rate" for identifying these matches. This metric is a measure of how successful the users are at matching, both at a site-wide level and at a user level. This feature has the added bonus of keeping the user interested and giving them the "reward" of finding a match.

Citizen scientist matching time

The site measures "matching time", which is simply how long, in seconds, the user views a pair of images displayed side-by-side before they make a selection. This is done to compare the speed of matching between citizen scientists and researchers.

Missed matches (by researchers)

The site records the number of "missed matches". The website launched with the PWF and CWR catalogs, so this is a measure of how many matches citizen scientists find that PWF and CWR researchers missed within their respective catalogs.

Cross-catalog matches

The final metric is "cross-catalog matches", which means matches made between separate research-donated catalogs, *i.e.* East Australia and West Australia. These matches are unlikely to be found by researchers, who have limited time and/or resources to cross-match catalogs.

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Appendix A: SPLASH SCORE INFORMATION

Match My Whale: Steps to Fluke Matching

x	**Step 1. Determine if the fluke photo meets the SPLASH standards**
	Step 2. Assign a fluke "Classification Type"
	Step 3. Match the fluke

Not all whale fluke photos are suitable for matching. During this step, you'll help us determine if your fluke photo meets quality control standards modified from the SPLASH study by Cascadia Research Centre (Calambokidis *et al*. 2001).
SPLASH stands for **S**tructure of **P**opulations, **L**evels of **A**bundance and **S**tatus of **H**umpback Whales in the North Pacific. This scoring system is an objective way to measure the quality of a humpback whale fluke photo.

Does your fluke photograph meet SPLASH quality standards?
You'll be scoring each fluke photograph by answering five questions with a numerical score of 1-5. Please pay attention to the example images and, more importantly, the text in this training document to help guide your scoring. Your photo may look different from the examples provided. In this situation please rely on the text description to guide you.
Note: We've included images for each score level that represent the worst case scenario for each score. If your photo looks worse than the example image, it should be scored as the next lowest quality.

Did your photo score 1, 2 and/or 3's on all questions*?* Congratulations, it meets the SPLASH standards. If your photograph received a 4 or 5 in any one or more category, it did not pass SPLASH and will not be used for Classification or Matching.

Whale fluke photo = a photo of the underside of a whale tail used for identification. Technically each whale has two flukes, but we refer to it as a "fluke photo".

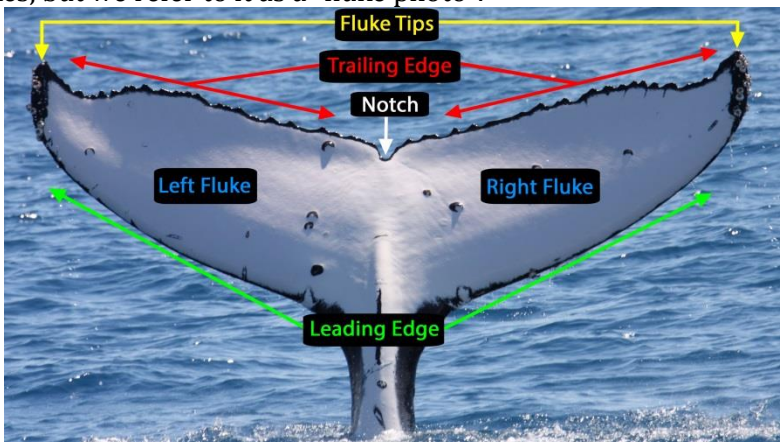


Figure 1: The labeled parts of a humpback whale tail.

1. *What proportion of the fluke is visible? Some flukes are partially under water, may be folded over, the fluke may be low to the water, water drops splashing over it, etc. The total area visible <u>for any reason</u>, including both leading and trailing edges, is:*

1- 100%
2- 75-99%
3- 50-74% (top of notch still visible)
4- Less than 50%
5- Partial (i.e. right/left side only)

Proportion Visible

1 = 100%

3 = 50 - 74% of fluke surface (top of notch still visible) AND > 80% of trailing edge visible

2 = 75 - 99%

4 = < 50% fluke surface OR < 80% of trailing edge visible

3 = 50 - 74% of fluke surface (top of notch still visible) AND > 80% of trailing edge visible

5 = Partial

2. *What is the fluke angle? This refers to the angle the whale tail as relative to the surface of the ocean:*

1- perpendicular (90 degrees) to the water
2- greater or less than perpendicular but with no loss in visibility
3- non-perpendicular with some loss in quality, but ridging easily visible
4- low angle, ridging only partially visible
5- low angle, ridging and markings not visible or very distorted

Fluke Angle

1 = Perpendicular to the water

3 = Non-perpendicular with some loss in quality, but ridging easily visible

1 = Perpendicular to the water

4 = Low angle, ridging only partially visible

2 = Greater or less than perpendicular, but no loss in visibility

5 = Low angle, ridging and markings not visible or very distorted

3. *Where is the photographer positioned (the "photographer lateral angle")? This refers to the angle of the camera relative to the whale:*

1- straight in front
2- not directly in front but minimal distortion
3- angled about 45° to side
4- angled >45° but markings still visible
5- angle so extreme that most markings are obscured

Photographer Lateral Angle

1 = Straight behind the whale

4 = Angled > 45° but markings still visible

2 = Not directly behind the whale, but minimal distortion

5 = Angle so extreme most markings obscured

3 = Angled about 45° to the side

4. *How focused/sharp is the photograph? The lack of clarity may be <u>for any reason</u>, including photographer error, computer over-enhancement, age of the photograph, etc.*

1- excellent focus with clear grain
2- good focus and grain with only minimal loss in quality
3- okay focus and grain with some loss in ability to discern marks and edges
4- fair to poor focus in grain with significant loss in clarity
5- soft focus/grainy with extreme loss in detail

Focus

1 = In focus with clear grain

4 = Fair to poor focus and grain significant loss in clarity

2 = Good focus and grain with only minimal loss in quality

5 = Soft focus/grainy

3 = Ok focus and grain, some loss in ability to discern marks and edges

5. *Is the lighting/contrast/exposure sufficient? Is the subject of the photograph bright, clear and well-lit (sun behind the photographer and shining onto the fluke) or is it backlit (sun behind the whale illuminates from behind, producing a silhouette)? Remember that dark flukes are not necessarily backlit, they are naturally dark. The photograph is:*

1- excellent, any marks present would be seen
2- good but with some loss in contrast on the flukes' surface
3- fair, some marks might not be seen, but most would likely be visible
4- fair to poor with significant backlighting or exposure problems
5- poor (*e.g.* backlit or gray), likely many marks would not be visible

Exposure/ Contrast/Lighting
(Light Flukes)


1 = Excellent, all marks would be seen


4 = Fair to poor with significant backlighting or exposure problems


2 = Good, but with some loss in contrast on the flukes surface


5 = Poor (backlit or gray), likely many marks would not be visible


3 = Okay, some marks might not be seen

Appendix B: CLASSIFICATION INFORMATION

Match My Whale: Steps to Fluke Matching

	Step 1. Determine if the fluke photo meets the SPLASH standards
x	**Step 2. Assign a fluke "Classification Type"**
	Step 3. Match the fluke

Once a photograph has met the SPLASH scoring criteria, it can then be assigned a fluke "Classification Type." The natural coloring of the whale's tissue, or pigmentation, helps us categorize whale flukes. During this step, you'll learn how to look at the pigmentation of the whale's flukes and assign a "Classification Type."

Pigmentation

Fluke pigmentation in humpback whales ranges from all white in some individuals to all black in others, with the majority of individuals somewhere in between. When black pigmentation is present it may be limited to the center of the flukes, or it may extend outward along the top and/or bottom. Fluke pigmentation also varies geographically, with humpback whales in the Southern hemisphere having whiter flukes than those found in the Northern hemisphere. *Note:* some flukes may bear yellow color on the flukes; this is not a pigment, but a temporary coating of diatoms (algae).

Whale fluke photo = a photo of the underside of a whale tail used for identification. Technically each whale has two flukes, but we refer to it as a "fluke photo".

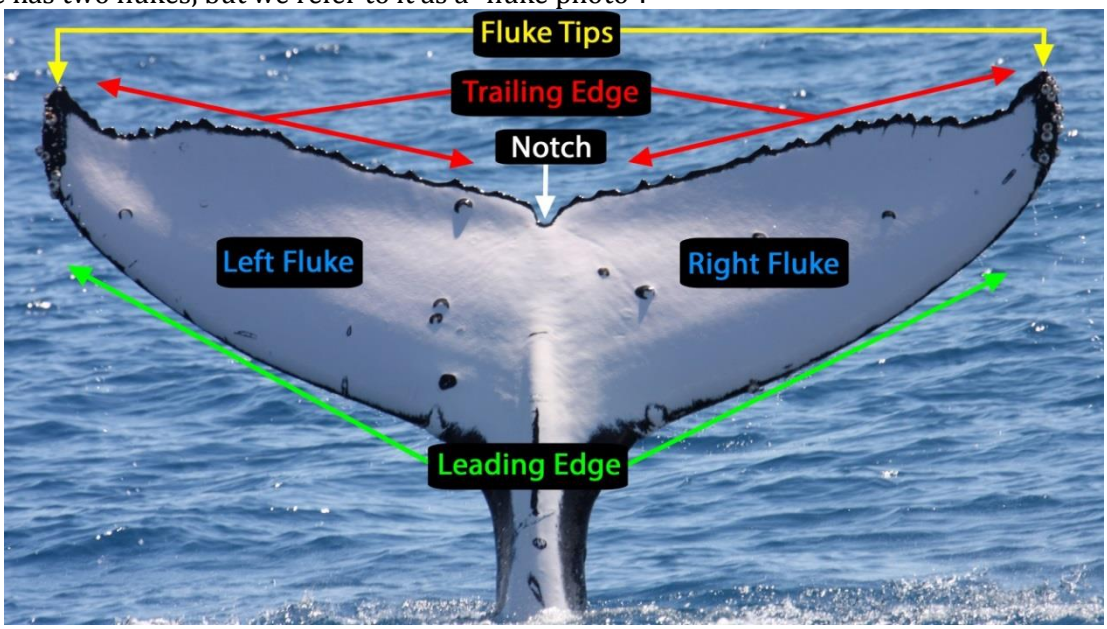


Figure 1: The labeled parts of a humpback whale tail. *Note:* the tail stock, also called caudal peduncle, is the part of the tail that connects to the body of the whale.

ASSIGNING FLUKE TYPE BASED ON PIGMENTATION

First, individuals are placed into one of the six pigmentation types.

You will need to know the locations of Sector 1 and Sector 2 in this diagram:

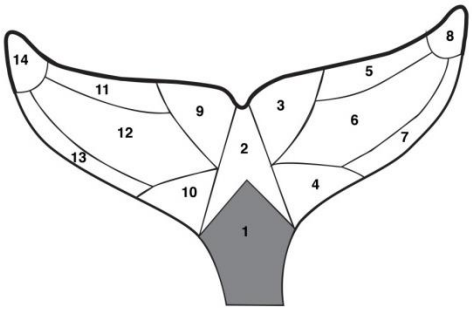
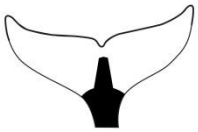
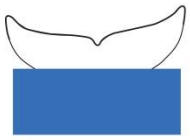


Table 1: Number Types based on pigmentation

	Type 1: Flukes that are 90-100% white, with no solid black pigmentation extending into Sector 2. (see image above to determine location of numbered sectors).
	Type 2: Flukes that are white with <u>solid</u> black pigmentation extending from the tail stock into Sector 2. Black pigment does <u>not</u> extend up to the notch.
	Type 1 or 2: Includes flukes where part of Sector 2 is not visible because it is under water, so it cannot be determined whether it is Type 1 or Type 2. *Note: not all photos with water covering this area are this type!*
	Type 3: Flukes with <u>solid</u> black pigmentation extending from the tail stock through both Sectors 1 and 2, connecting to the notch and trailing edge.
	Type 4: Includes flukes with black pigmentation extending from the tail stock to the trailing edge, and covering a width of more than 50% on each fluke.
	Type 5: Includes flukes with black pigmentation covering more than 90% of the flukes.

Examining the pigmentation on the leading and trailing edge

During the assignment of a Fluke Type, we looked at the overall pigmentation of the tail flukes. Now we will examine the pigmentation on the leading and trailing edges of the flukes and assign a letter ("A" through "G", or "O") based on the pigmentation along these edges.

Important Note: If we do not specify a color for the trailing edge, assume it is black. A black trailing edge can be thick or thin. In the rare types (5A and 5B) where there is a white trailing edge, it will be specified as being white and it will always be thick. For flukes with a white trailing edge, there will be a thin line of black along the very edge of the tail (see examples later).

Thick vs. Thin: Judging what is a thin edge and what is a thick edge takes experience and practice. If the black pigment extends onto the main area of the fluke itself, past the ridges, that is considered thick, and if not it is considered thin. However, this is not a strict definition and it will depend on the whale. Make use of the zoom tool to examine the pigment, take your time and it will get easier the more flukes you look at.

Missing Parts (MP): Includes flukes with holes, large notches, or chunks missing. Missing parts should be significant and easily identified. They should be assigned a classification (1A, 2C, etc.) as described above, and then add MP to the end. For example, 2D MP. Missing parts does NOT refer to when a portion of the fluke is under water, folded over, or cut/cropped out of the frame of the photograph (see examples later).

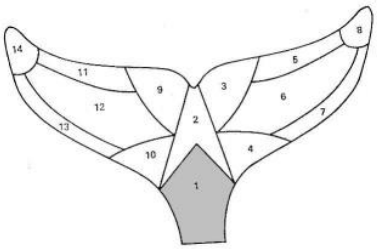
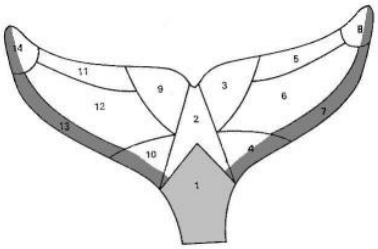
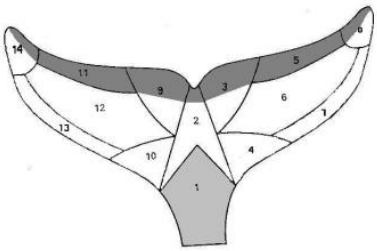
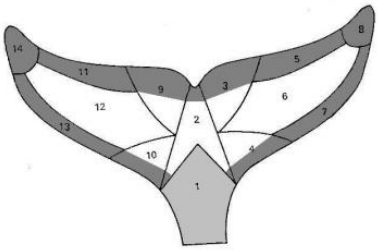
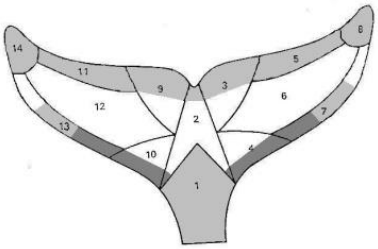
Other (O): Includes flukes that do not match any of the above described categories (see examples later). If your fluke photo does not look exactly like the example photo provided that does not make it an Other. Being assigned an Other means it does not fit into the categories using the written descriptions. They should be assigned a numerical type (4, 5, etc.) as described above, and instead of a letter category, use the letter O for Other. Example: 5O.

Combining number and letter categories to Type flukes.

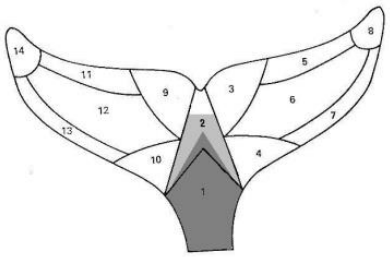
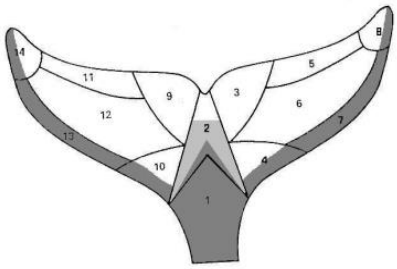
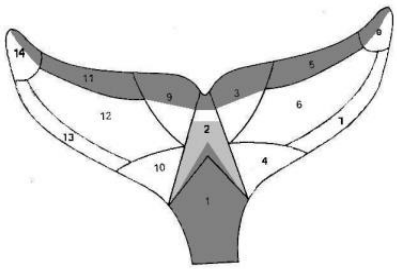
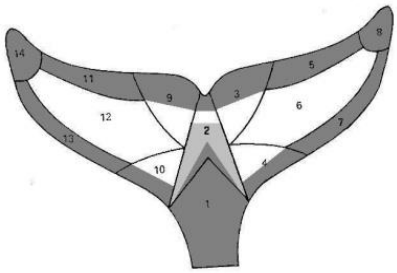
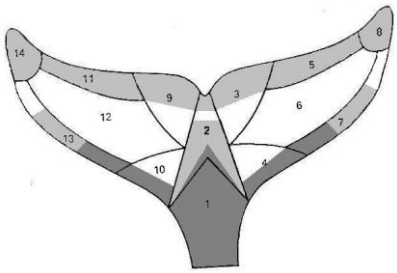
Ultimately, you will be combining the Number and the Letter Category to create a Classification Type for each whale. This Classification Type will let you narrow your search for a match for your whale, because you will look for matches from the same Classification Type, instead of searching through photos of all Types.

Please remember that the photographs and diagrams provided are examples and visual guides only, and you should rely on the written descriptions to properly classify your whale fluke photo.

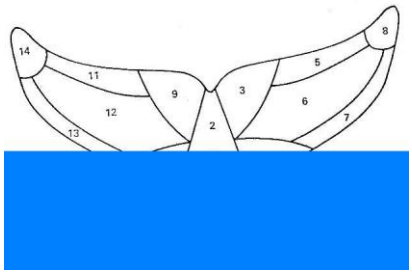
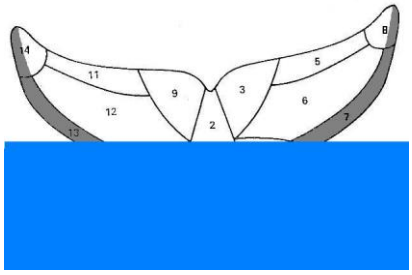
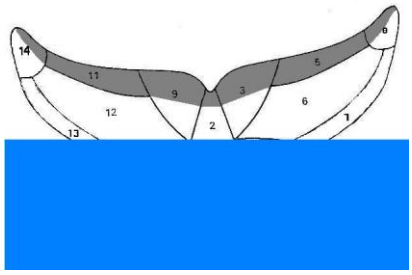
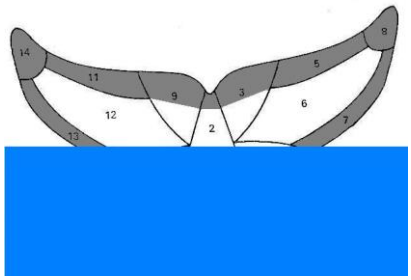
Type Number 1: Flukes that are 90-100% white, with no solid black pigmentation extending from the tail stock into Sector 2.

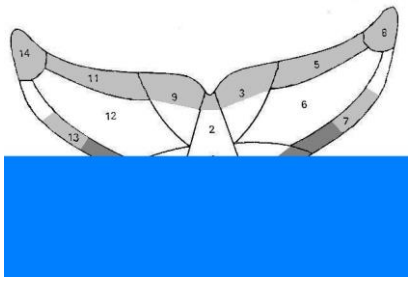
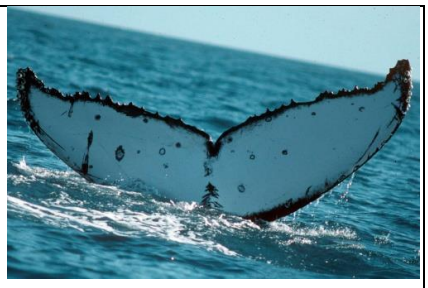
Letter Category A: White leading edge and a thin trailing edge Classification Type: 1-A		
Letter Category B: Black pigmentation on more than 75% of the leading edge and a thin trailing edge Classification Type: 1-B		
Letter Category C: White leading edge and thick trailing edge Classification Type: 1-C		
Letter Category D: Black pigmentation on 75% or more of the leading edge and a thick trailing edge Classification Type: 1-D		
Letter Category E: Black pigmentation extending along any portion of the leading edge covering 25-75%, with either a thick or thin trailing edge Classification Type: 1-E		

Type Number 2: Flukes that are white with <u>solid</u> black pigmentation extending from the tail stock into Sector 2. Black pigment does <u>not</u> extend up to the notch.

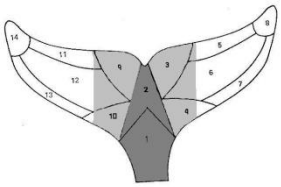
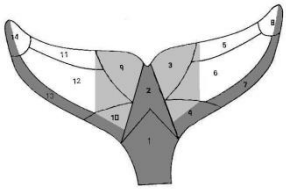
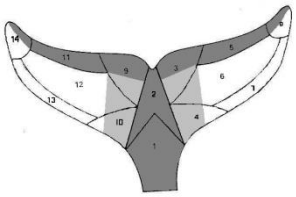
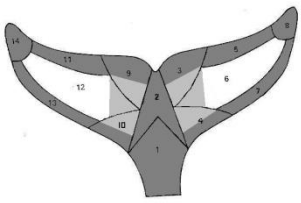
Letter Category A: White leading edge and a thin trailing edge Classification Type: 2-A		
Letter Category B: Black pigmentation on more than 75% of the leading edge and a thin trailing edge Classification Type: 2-B		
Letter Category C: White leading edge and thick trailing edge Classification Type: 2-C		
Letter Category D: Black pigmentation on 75% or more of the leading edge and a thick trailing edge Classification Type: 2-D		
Letter Category E: Black pigmentation extending along the leading edge covering 25-75%, with either a thick or thin trailing edge Classification Type: 2-E		

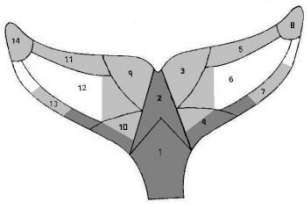
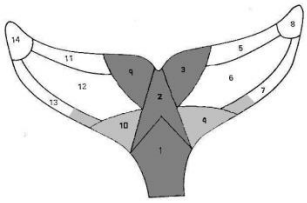
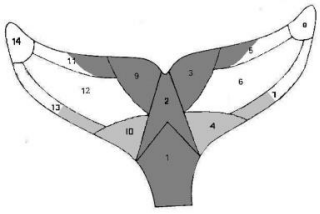
Type 1 or 2: Includes flukes where part of Sector 2 is not visible because it is under water, so it cannot be determined whether it is Type 1 or Type 2. ***Please note that not every fluke with water over the bottom is this type – ONLY if you can't tell between Type 1 and Type 2 because the water is obscuring the markings. The water needs to be fairly high to be covering the markings – about midway up the flukes.***

Letter Category A: White leading edge and a thin trailing edge Classification Type: 1 or 2-A		
Letter Category B: Black pigmentation on more than 75% of the leading edge and a thin trailing edge Classification Type: 1 or 2-B		
Letter Category C: White leading edge and thick trailing edge Classification Type: 1 or 2-C		
Letter Category D: Black pigmentation on 75% or more of the leading edge and a thick trailing edge Classification Type: 1 or 2-D		

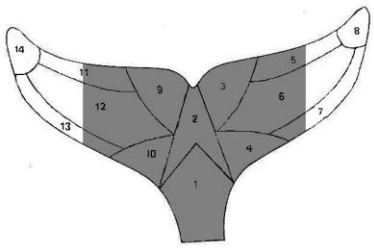
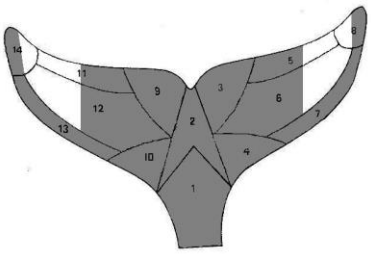
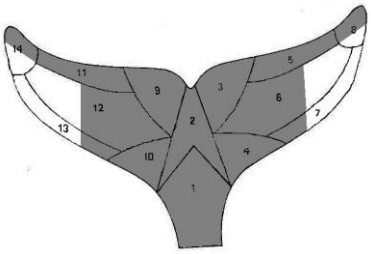
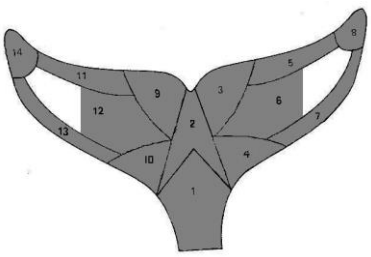
Letter Category E: Black pigmentation extending along any portion of the leading edge covering 25-75%, with either a thick or thin trailing edge Classification Type: 1 or 2-E		

Type 3: Flukes with <u>solid</u> black pigmentation extending from tail stock through Sectors 1 and 2, connecting to the notch and trailing edge.

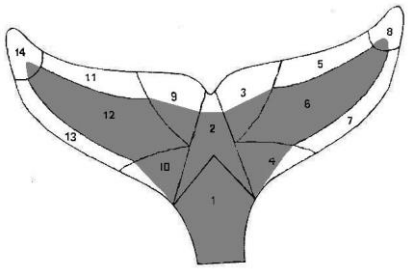
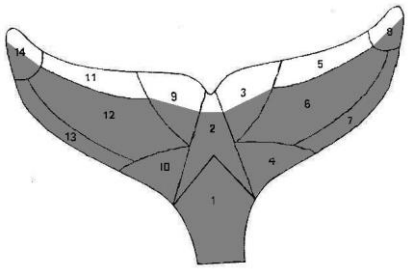
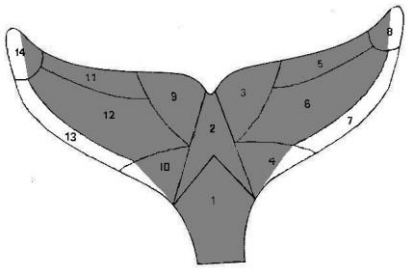
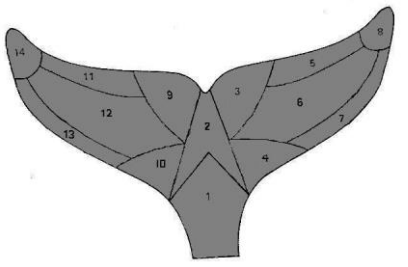
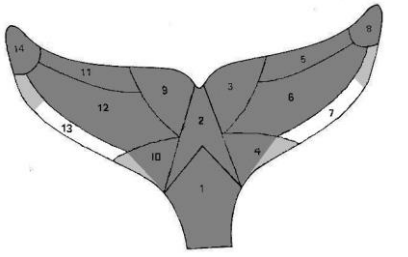
Letter Category A: White leading edge and a thin trailing edge Classification Type: 3-A			
Letter Category B: Black pigmentation on more than 75% of the leading edge and a thin trailing edge Classification Type: 3-B			
Letter Category C: White leading edge and thick trailing edge Classification Type: 3-C			
Letter Category D: Black pigmentation on 75% or more of the leading edge and a thick trailing edge Classification Type: 3-D			

Letter Category E: Black pigmentation extending along any portion of the leading edge covering 25-75%, with either a thick or thin trailing edge Classification Type: 3-E			
Letter Category F: Black pigmentation <u>fans out</u> covering ~25% of the trailing edge Classification Type: 3-F			
Letter Category G: Black pigmentation <u>fans out</u> covering 25% - 50% of the trailing edge Classification Type: 3-G			

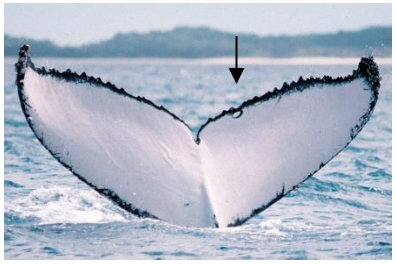
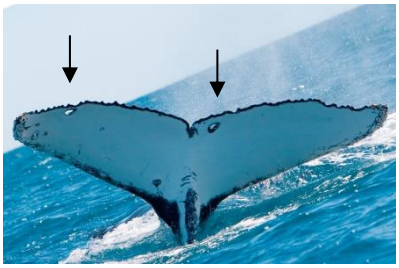
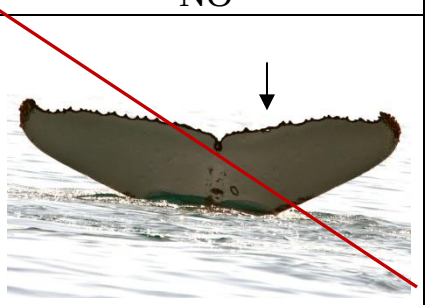
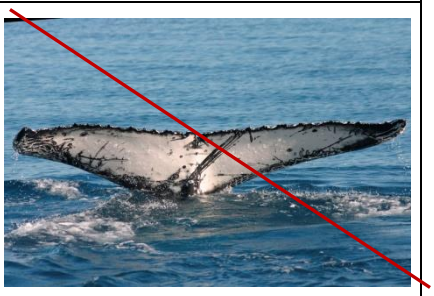
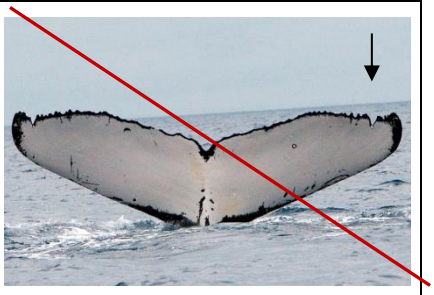
Type 4: Flukes with black pigmentation extending from the tail stock to the trailing edge, and covering a width of more than 50% on each fluke.

Letter Category A: White leading edge and a thin trailing edge Classification Type: 4-A		
Letter Category B: Black pigmentation on more than 75% of the leading edge and a thin trailing edge Classification Type: 4-B		
Letter Category C: White leading edge and thick trailing edge Classification Type: 4-C		
Letter Category D: Black pigmentation on 75% or more of the leading edge and a thick trailing edge Classification Type: 4-D		

Type 5: Includes flukes with black pigmentation covering more than 90% of the flukes.

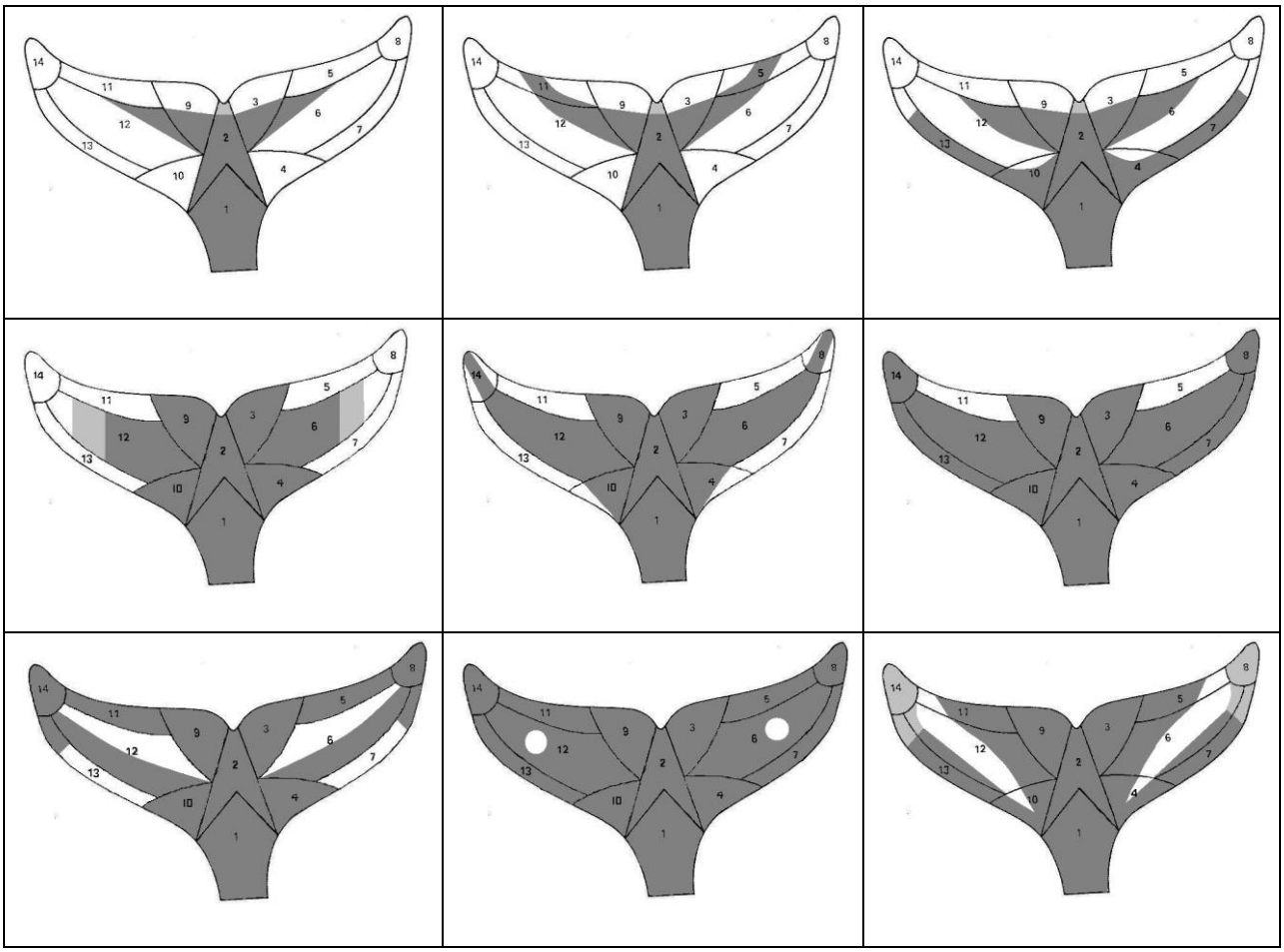
Letter Category A: White leading edge and a white trailing edge Classification Type: 5-A		N/A
Letter Category B: Black leading edge with white trailing edge Classification Type: 5-B		
Letter Category C: White leading edge and black trailing edge Classification Type: 5-C		
Letter Category D: Black pigmentation covering entire flukes Classification Type: 5-D		
Letter Category E: White pigmentation extending along any portion of the leading edge covering 25-75%. Classification Type: 5-E		N/A

Missing Parts: Includes flukes with holes, large notches, or chunks missing. Missing parts should be significant and easily identified. They should be assigned a classification (1A, 2C, etc.) as described above, and then add MP to the end. For example, 2D MP. ***Missing parts does NOT refer to when a portion of the fluke is under water, folded over, or cut/cropped out of the frame of the photograph.***

YES	YES	NO
		
		
		

Other (O): Includes flukes that do not match any of the above described categories. They should be assigned a numerical type (4, 5, etc.) as described above, and instead of a letter category, use the letter O for Other. Example: 5 O.

Your "Other" may look different from the examples below.



Appendix C: MATCHING INFORMATION

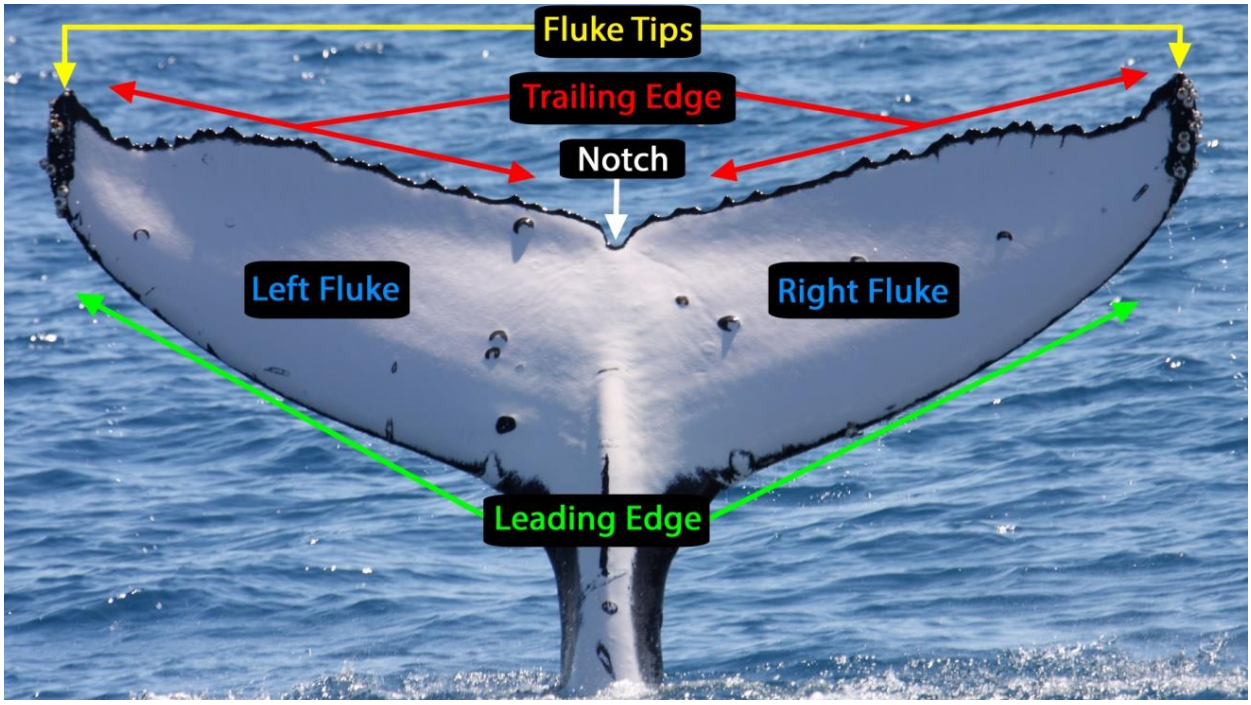
Match My Whale: Steps to Fluke Matching

	Step 1. Determine if the fluke photo meets the SPLASH standards
	Step 2. Assign a fluke "Classification Type"
X	**Step 3. Match the fluke**

Once a photo has been SPLASH scored and "Classified", it can then be matched against other photos in a catalog. Matching takes patience and great attention to detail.

MATCHING FLUKES, GENERAL INFORMATION

When matching a fluke, find two or more easily identifiable characteristics of that fluke. Do not only focus on scratches and pigment patterns, as these can fade over time and make it tricky to determine a match. It is important to pay attention to three other basic characteristics: overall fluke shape, pattern of the trailing edge, and the notch shape.



Fluke shape

The shape of the flukes can change, to some degree, depending on the angle relative to the surface of the water when the photograph was taken. Typically, it is easiest to match photos taken when the flukes are straight up and down at a 90° degree angle to the

water. However, not all of the photos turn out like this, so it may be more challenging if the photo is not at 90°. Fluke shape is something that does not change drastically, unless the whale has been injured.

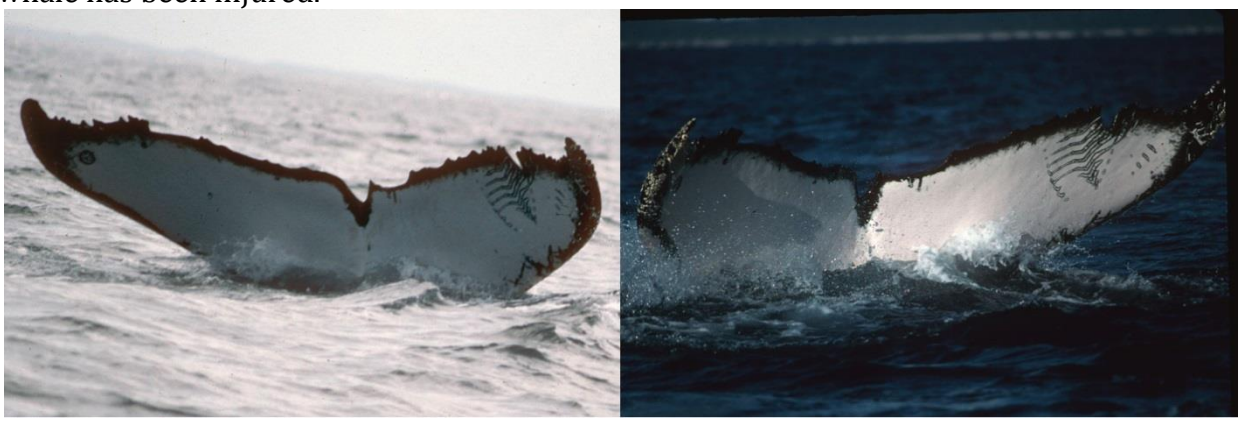


Figure 1: The same flukes photographed at a different angle.

Trailing edge

One of the most important areas of the flukes to look at is the trailing edge. The 'hills' and 'valleys' along this edge are unique to each individual and remain relatively stable throughout a whale's lifetime. There are, of course, always exceptions. A whale may lose a part of the trailing edge or even half of a fluke from an entanglement in fishing gear, an injury competing with other males in the breeding grounds, an attack from a predator, or an encounter with a vessel.

Notch shape

The notch, separating the left and right flukes, is the other main characteristic to use when trying to match flukes. Some whales have a very narrow notch and others a very wide notch. The notch shape seldom changes, so is very useful to match individuals over time.

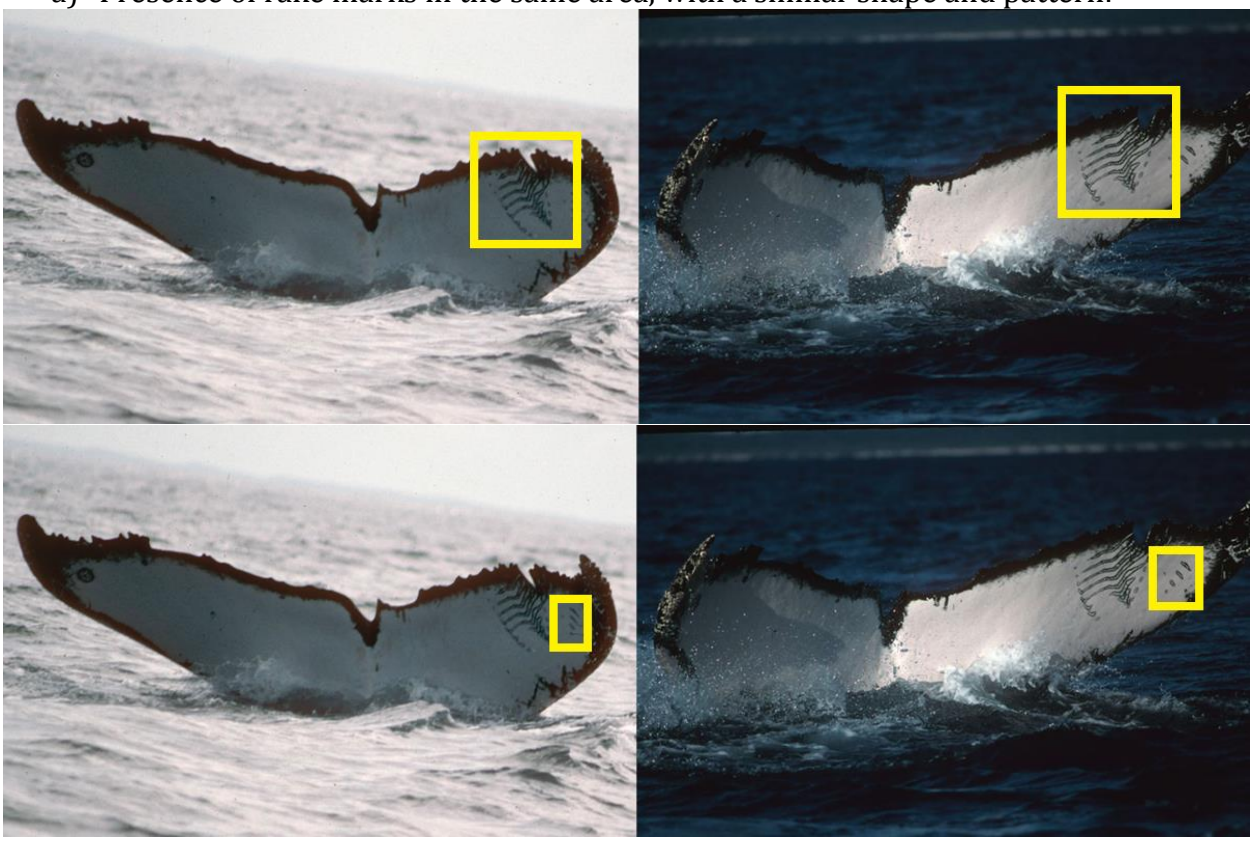
Confirming a match

When attempting to match two photos together, select a few distinctive features or characteristics on the fluke to be matched that attract your eye in the first place. These can include:

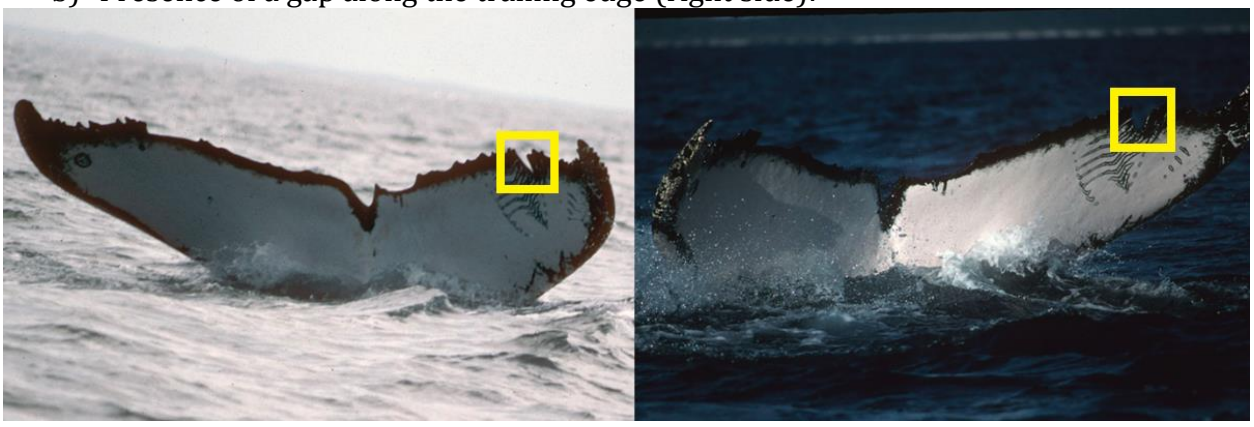
- Marks along the inside of the trailing edge, sometimes called "bleed" marks when they start at the trailing edge;
- Marks along the leading edge;
- Spots such as large black or white spots;
- Gaps and indents in the trailing edge;
- Missing parts outside the trailing edge (e.g. holes);
- Larger or more prominent peaks along the trailing edge;
- Circles, spots, crescent shapes, and lines on the left and right flukes;
- Shape of the notch; and
- Damaged areas, including rake marks from predators (such as orcas)

Using the example above, here are a selection of distinctive characteristics that can be used for matching purposes and also help to confirm that it is a match.

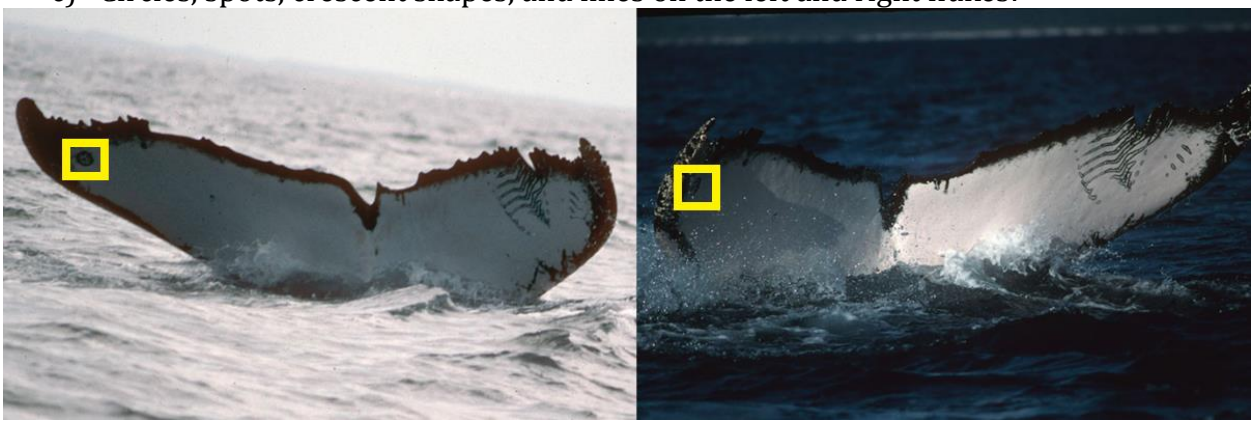
a) Presence of rake marks in the same area, with a similar shape and pattern:



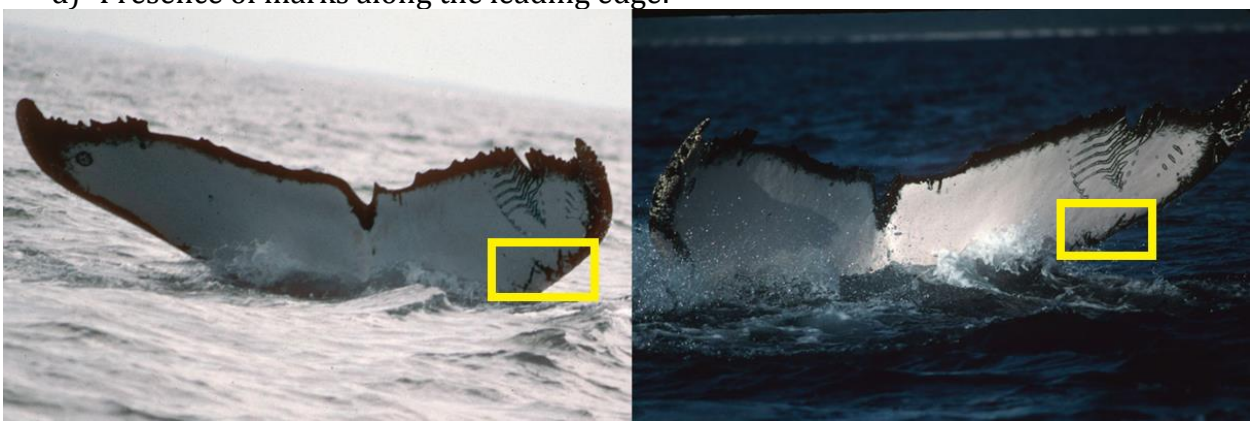
b) Presence of a gap along the trailing edge (right side):



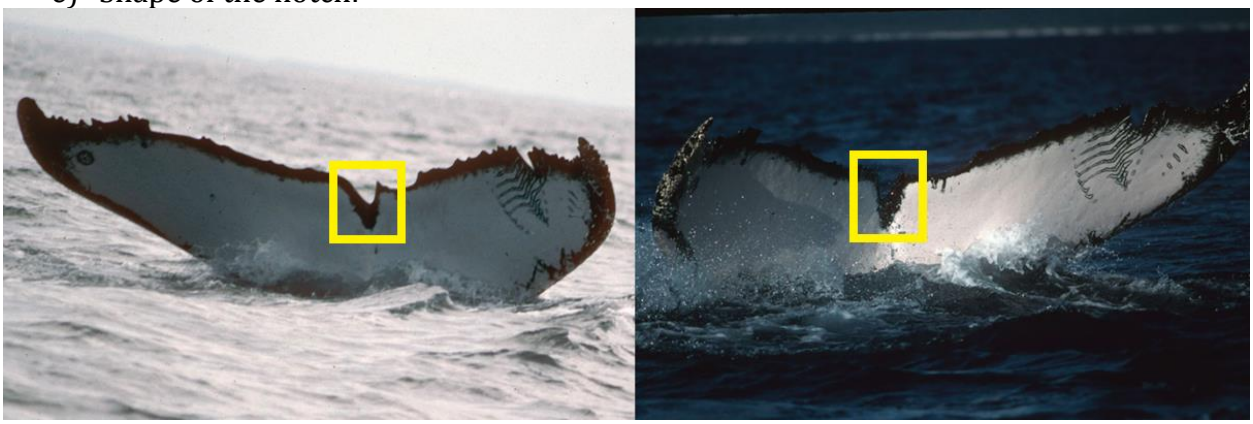
c) Circles, spots, crescent shapes, and lines on the left and right flukes:



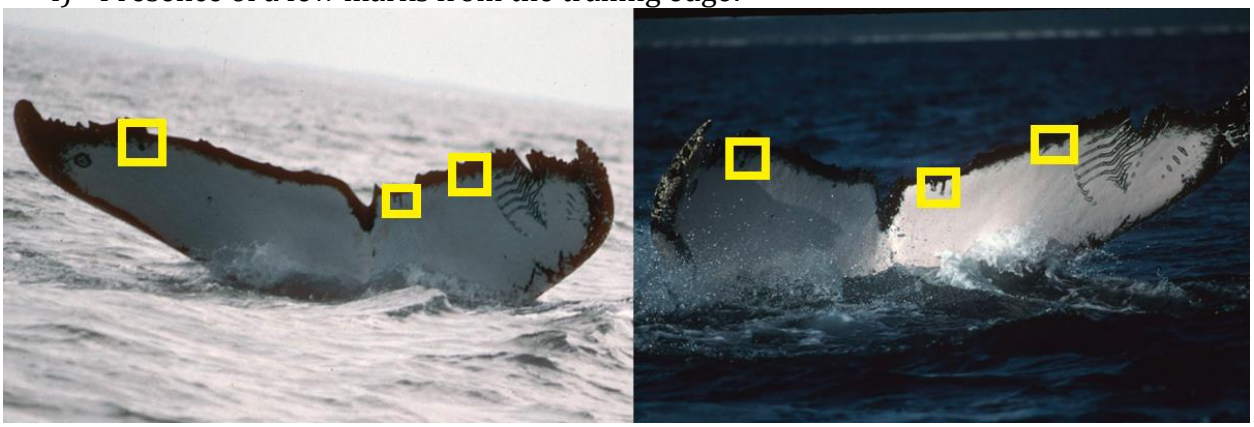
d) Presence of marks along the leading edge:



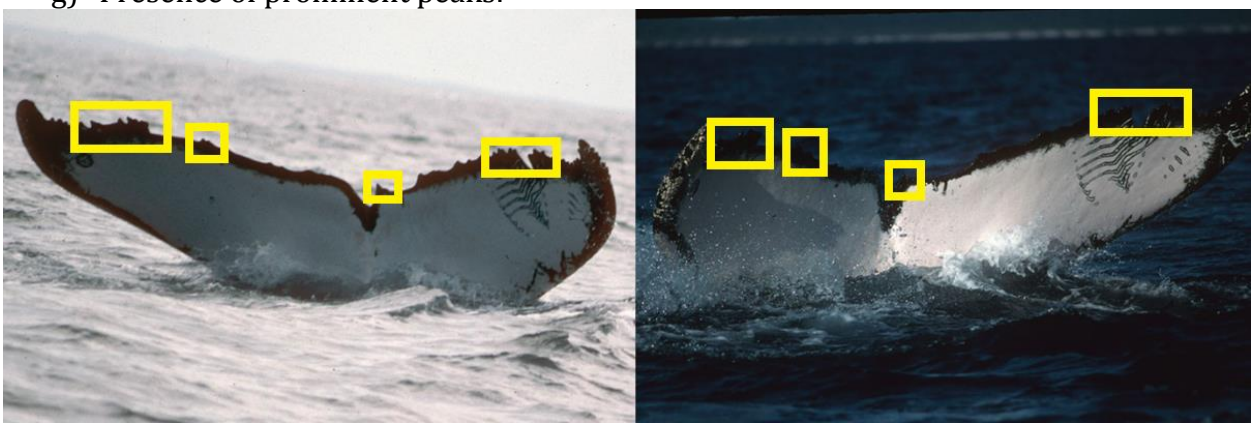
e) Shape of the notch:



f) Presence of a few marks from the trailing edge:



g) Presence of prominent peaks:



Having identified more than three distinctive characteristics in common between these two flukes, a match can be confirmed!

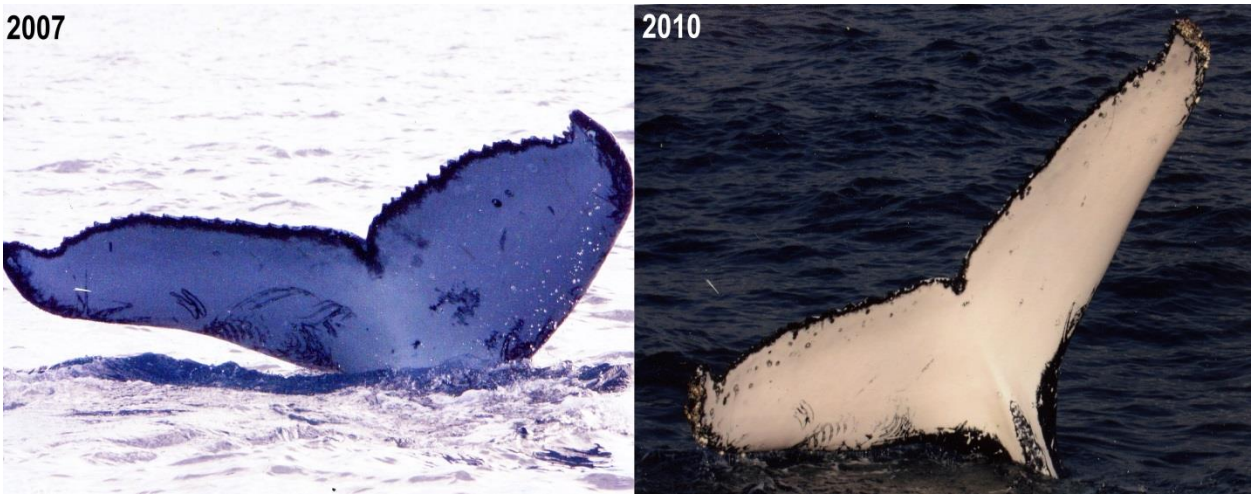
Calves and yearlings

Matching humpback whale calf and yearling flukes can be tricky! They often have a smoky or indistinct grey pattern. The pigmentation becomes more distinct as the whale gets older. Spacing of features such as nicks, points, and bumps on the trailing edge usually change as the whale grows to maturity and the flukes increase in size. Although flukes can change dramatically, fluke shape, trailing edge, and notch shape can still be used to make the positive match. Even though it can be challenging, it is very useful to match calves because it is the only well-established way to precisely determine a live whale's age from the year of birth.

Example of calf flukes:

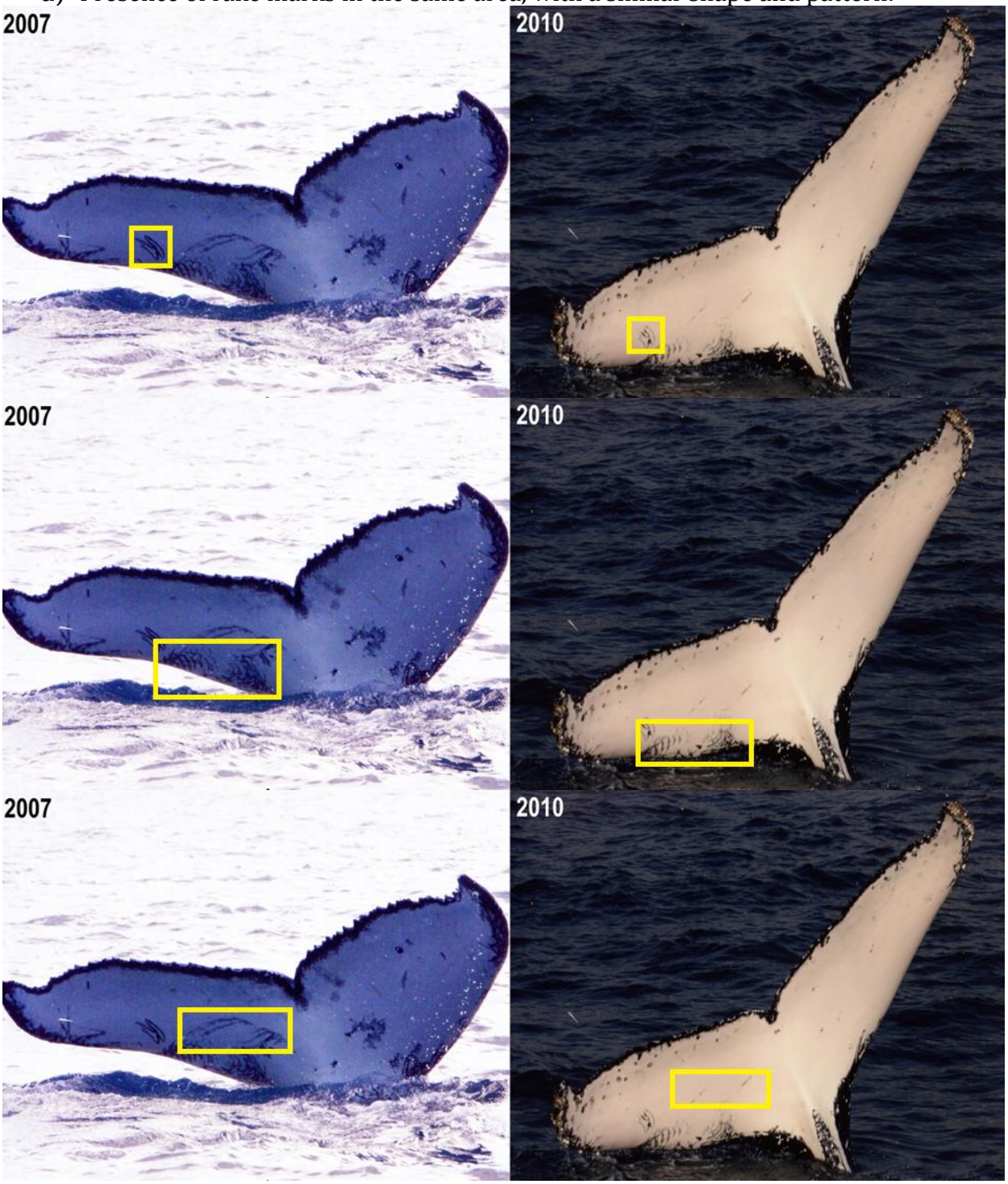
Be aware that whales will acquire new markings that change their appearance in subtle ways. Injuries such as rake marks from a killer whale's teeth, circular barnacle scars, scratches, and new nicks may make a positive match a bit more challenging. Also keep in mind that pigmentation can fade or develop over time.

An example of the same whale flukes photographed a few years apart:

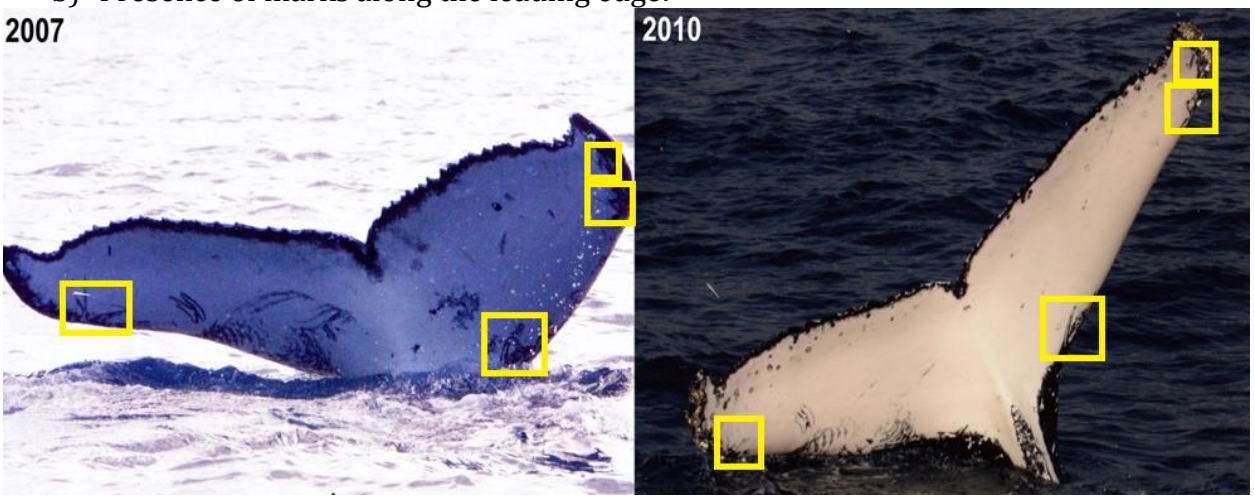


As in the previous example, we are looking at a selection of distinctive characteristics that will help us confirm whether it is a match.

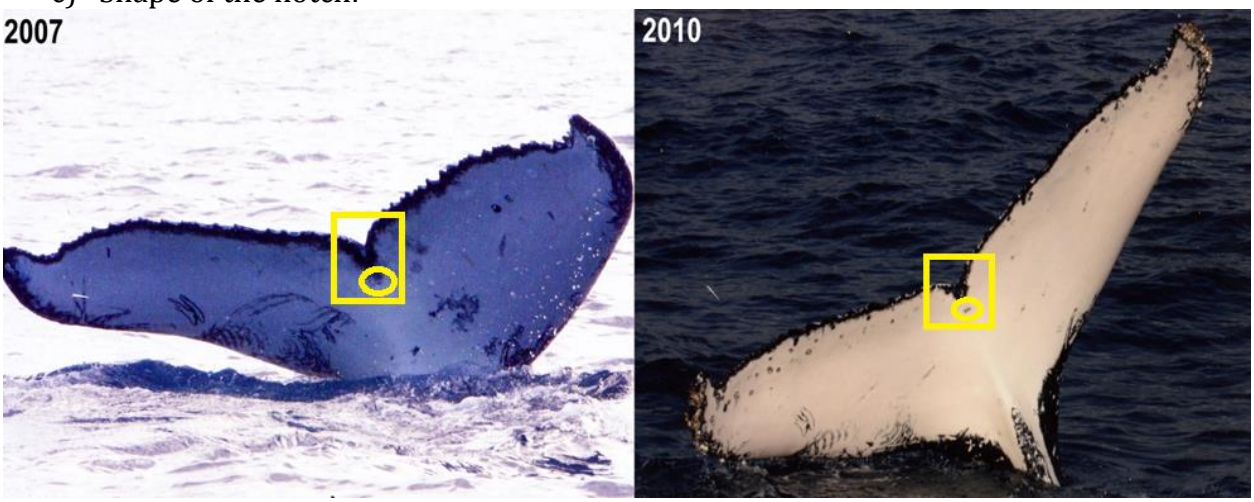
a) Presence of rake marks in the same area, with a similar shape and pattern:



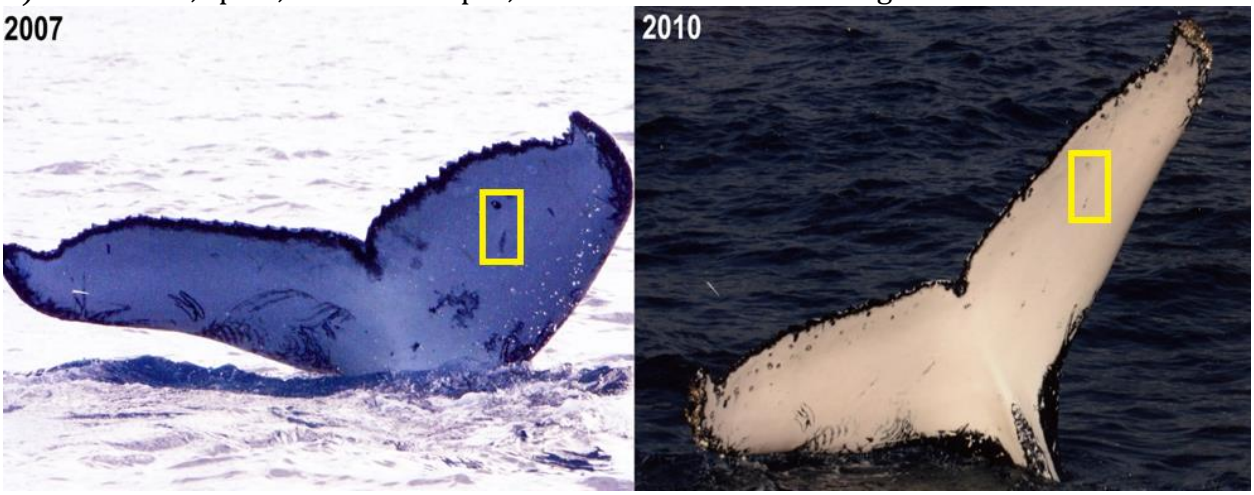
b) Presence of marks along the leading edge:



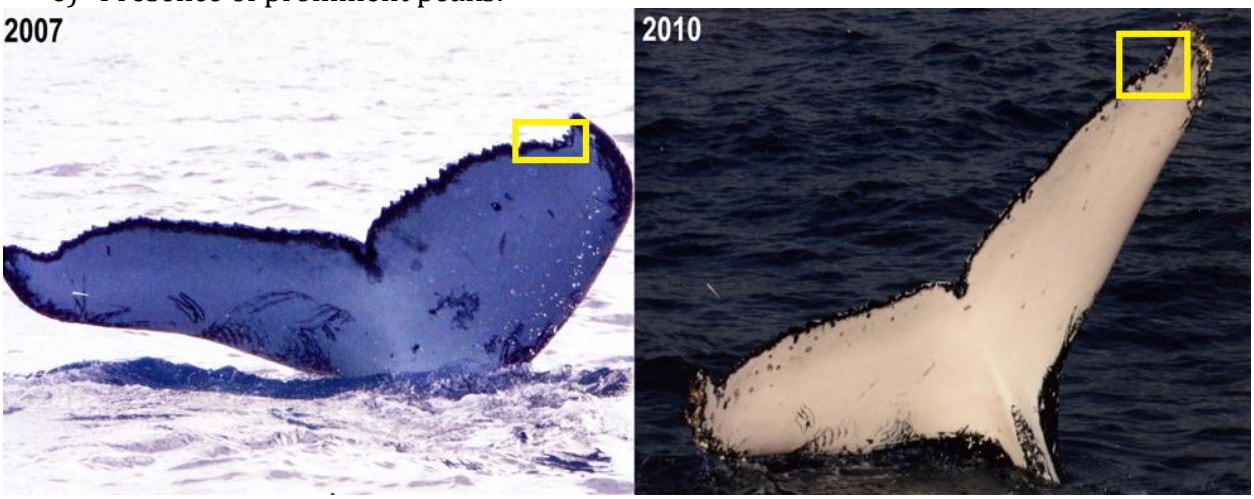
c) Shape of the notch:



d) Circles, spots, crescent shapes, and lines on the left and right flukes:



e) Presence of prominent peaks:



As you can see, these two flukes are actually from the same individual.