ANAL FIN MONITORING PROGRAM

User Manual: A comprehensive guide for using secondary fins to collect species- and size- specific catch data from shark fisheries in the Western Caribbean

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Overview: Secondary fins are generally low value fins that are infrequently traded, if at all. Collecting them from fishers can increase data collection, especially in circumstances when managers are unable to visit landing sites, with the added benefit of having little to no negative affect on fishers' income. The Anal Fin Monitoring Program (AFMP) uses anal fins from sharks landed to collect species- and size-specific catch data from the fishery. Shark anal fins are unique and can often be visually identified to species level. Collecting anal fins from the fishery reveals species composition (i.e., what species are being landed and how many) and the relationship between the anal fin base length and total body length can be used to calculate what length individuals are being landed just by measuring the collected anal fins. The protocols within this manual outline how to locate and remove the anal fin without compromising its ability to contribute to the monitoring program, how to identify and measure the anal fin after it has been removed, and how to convert anal fin lengths to body size lengths. Additionally, how to collect paired measurements (i.e., anal fin base length and total body length) to create linear regression equations is also explained. The Anal Fin Monitoring Program is intended to be a collaborative effort where measurements and regressions are collected and developed uniformly and can be shared amongst users. This manual should be used in combination with the *Anal Fin Guide: Using a secondary fin to identify species occurring in Western Caribbean shark fisheries* which was published in the manuscript titled "Using fisher-contributed secondary fins to fill critical shark-fisheries data gaps" (Quinlan et al. 2021).

I. Is this method for you?

Objective: Determine if this method is appropriate for the fishery being monitored

Consider the following questions to determine if this method is an appropriate tool for the fishery you are working with:

1. Does the fishery catch sharks (target or bycatch)?
    - Yes: ✓
    - No: This method is solely designed to be applied to sharks and shark fisheries

2. Do you have access to landings/ ability to collect anal fins from landed sharks or have the relationships with the appropriate people (e.g. fishers, authorities) to access anal fins from landed sharks.
    - Yes: ✓
    - No: Without the ability to access anal fins it is not possible to conduct the analyses contained in this manual

Important Note:
Some shark species do not have anal fins (i.e. Squaliformes). Though the presence of these species in a fishery doesn't inhibit the user from applying this method to other sharks in the fishery, it is important to realize that species lacking an anal fin, if present in the fishery, will not be included in this analysis. It is highly recommended to gain an understanding of how prevalent species with no anal fin are in the fishery of interest.

II. Fishery background information and data collection

Objective: Outline what to know about the fishery prior to starting, why the data collected using the Anal Fin Monitoring Program (AFMP) is important and how they can be used

Fishery Background

1. Anal Fins

It is important to gain an understanding of what species are landed, determine if their anal fins look like any other fins in the *Anal Fin Guide*, or if they look similar to any other shark's anal fins present in the fishery. It is possible species have similar looking anal fins which can result in multiple species being identified as one. In instances where anal fins cannot be visually identified it is recommended that anal fins be genetically identified.

Note: it is strongly recommended, when possible, to do an initial genetic analysis on collected anal fins to ensure look-alike fins are not being misidentified. This is especially important if the user does not have access to whole landed sharks to determine if there are species with like anal fins.

2. Fishery

Gain a basic understanding of the fishery. Consider how many fishers/ boats are accessing the resource (i.e. are catching sharks), what gear are they using, is there a seasonal pulse of fishing/ is it year round, any current regulations that affect fishers ability to land sharks (i.e., restrictions on species, size, gear etc..), do fishers have preferences (i.e. prefer certain species, certain sizes), are there established, commonly used fishing grounds etc… Any prior knowledge on the fishery that can be collected is helpful when later assessing the fishery (e.g., perhaps there are no juveniles landed, this may be due to gear restrictions or fisher preference rather than the absence of juveniles in the area and must be considered). Collecting data will be an ongoing process especially if working with fishers directly.

Data collection: What information do we need and why?

The most important data to collect are the fins themselves. If no other data mentioned below can be gathered, this method is still applicable. This method is versatile and can be as basic or complex as your fishery allows. Below are the data that should be collected under optimal conditions (e.g., you may have a good relationship with fishers, can ask these questions and take notes on their fishing methods/ fishers may submit fins with this information included.) Optimal conditions are not always the case and researchers may never even have contact with fishers, because of this, the minimum data required is also discussed.

Optimal Conditions

1. Date of capture
2. Gear used
3. Fishing area sharks were caught
4. Who captured the shark(s)
5. Any other data available (e.g., soak time, number of hooks etc..)
6. ANAL FINS

1. Dates help determine if there is any seasonal trend for a species (e.g., a species is only present in certain times of the year.) Furthermore, combined with length data we can determine if certain sized individuals are only present certain times of the year (e.g., nursery, mating/ feeding aggregations etc.)

2. The gear helps determine if certain species appear to be more vulnerable to specific gear types (e.g., are longlines with different size hooks catching different species, or different sizes of a species etc..), and determine if the species composition or size composition is different dependent on the gear used.

3. The area sharks were caught can aid in understanding habitat use (e.g., are certain species only being caught in sandy bottoms, coral habitats, bays, near river outputs etc..).

4. Who captured the shark(s) helps identify if there are any trends among fishers (e.g., certain fishers only land certain species, or sizes).

5. Any other data fishers are willing to share. Some examples: bait used, soak time, time of day fished.

6. It is most important to collect the anal fins.

Minimal Conditions

1. **The anal fins**
2. **At least the year the shark was caught. Try to be as specific as possible when recording the date even if the exact date is unknown (e.g., month/year, season/year)**

Collecting the anal fins themselves and recording at least the year they were captured are the most important data to collect. This information helps determine what species are interacting with the fishery, how many of each are being landed, and in many cases what length individuals are being landed. Recording the date allows us to track changes in species and size composition of the catch over time, which can reveal important trends when it comes to management.

Note: be sure the date you record is indicative of capture not when you received the fins.

III. Locating the anal fin

Objective: Identify which fin is the anal fin

The anal fin is the last fin before the caudal/ tail, on the ventral/underside of the shark's body.

Figure 1: Anal fin location on shark's body (indicated by the white arrow)

IV. Removing of the anal fin

Objective: Encourage fishers to remove and dry the anal fin from each shark landed so these fins can be counted and measured.

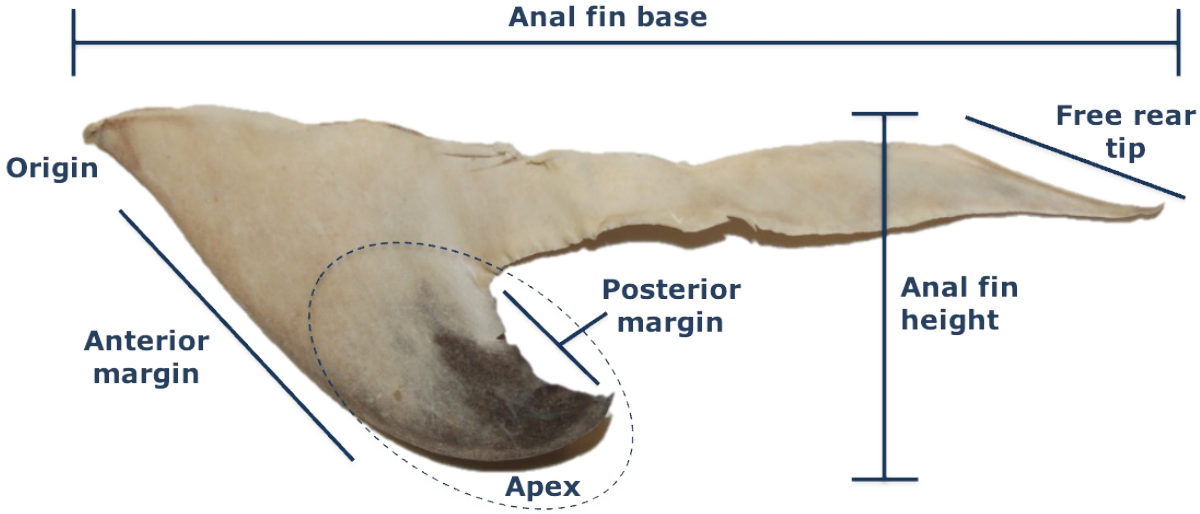
Note: It is important the entire anal fin is removed (including the free rear tip and origin) so the anal fin can be measured and contribute to length frequency data.

Removing the anal fin

Hold the apex of the fin (tip) and place the knife flush against the shark's body between the free rear tip and the body. With the knife edge facing forward towards the head, begin cutting by moving the knife towards the head along the outline of the shark's underside. Try to keep the knife as close to the body as possible when cutting and continue to move the knife forward until you have passed the origin of the fin (Figure 2).

Tip: slightly angle the knife away from the shark's body to minimize the amount of muscle removed with the fin, this reduces drying time & helps expose cartilage (see photo below)

Figure 2: Anal fin diagram and terminology



You will know if you have removed the entire fin by looking at the cartilage after excision (note: sometimes the cartilage is hidden if too much muscle was removed with the fin). There should be tissue in front of the cartilage at the origin. If it appears not all the cartilage was included, you will need to cut further forward on other sharks to include the entire fin. It is better to have cut too much than not enough; incomplete fins cannot be measured and thus cannot be included as length frequency data. Extra skin can easily be excluded from the anal fin base measurement by using the cartilage as an indicator of where the origin is.

Sometimes when fins are removed a "scoop-like" or "U" shape cut is made along the base of the anal fin. This "scoop" (no matter how dramatic) does not affect the AFB length and the fin can still be measured so long as the origin and free rear tip are intact.

Drying/ Storing Anal Fins

Once removed, the anal fins should be set out to dry, if stored in bags wet they will mold, deteriorate and become unusable. When possible, they should be placed in areas not easily accessed by animals (e.g., dogs, cats, pets, birds, wildlife etc...) we often hear of fins getting consumed by animals when they are laid to dry in low, easily accessible areas.

V. Identifying and measuring the anal fin after it has been removed

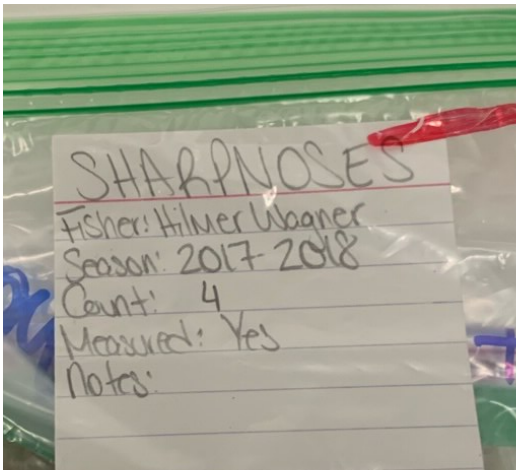
Objective: Identify the species of origin for each anal fin submitted by fishers, determine which fins are complete and how to measure complete fins.

Sample ID

Generally due to the volume of fins received not every fin gets a unique sample ID. Fins that **DO** need an ID are: scalloped hammerheads, great hammerheads, blacktips, blacknoses and any unknowns that need to be identified (more on this in the "Identification' section below). This is so once these fins are genetically identified, we know which measurements belong to which fins/ species.

Storage

If fins are submitted by individual fishers or fisher groups, it is recommended not to consolidate all fins received/ collected, but rather keep them separated by which fisher submitted them, then by species.



Label each species bag with a tag that includes:

- Date
- Fisher (if applicable)
- Species
- Count
- Measured? (Y/N)
- Notes

Identification

It is recommended to first determine species of origin then measure the anal fins. Seventeen species have been included in the accompanying *Anal Fin Guide.* **If you encounter sharks that are not included in this guide it is important to determine if their anal fin is unique enough to be visually distinguished from other species in this guide and/or caught in your fishery.** Use the guide to identify and separate all the fins by species. You may encounter fins that are not anal fins and should not be included in the count or be measured (this is done to avoid counting an individual more than once). Common fins submitted as anal fins are: second dorsal fins, lower caudal lobes and occasionally pelvic fins.

Of the 17 species included in the *Anal Fin Guide*, 3 species pair are morphologically distinct from other species' anal fins but cannot be visually distinguished from one another:

- Scalloped (*Sphyrna lewini)* and great hammerhead (*S. mokarran)*
- Blacktip (*Carcharhinus limbatus)* and blacknose (*C. acronotus*)
- Atlantic (*Rhizoprionodon terraenovae*) and Caribbean sharpnose (*R. porosus)*

These species can be grouped with their pair, and later separated after being genetically identified. *Remember to give them each a unique sample ID for this purpose. Quinlan et al. 2021 chose to not genetically identify the sharpnose species pair due to similar life history and conservation status. Sharpnoses did not receive unique sample ID's.

Measuring

Step 1: Fin Inspection

Some anal fins may be incomplete and **cannot be measured**. Anal fins are considered incomplete when either the origin or the free rear tip are incomplete or missing entirely (refer to Figure 2 for example of complete anal fin). **Note: incomplete anal fins do not contribute to length frequency data but should still be included in the count for that species.**

- *Inspecting the Origin*- To determine if an anal fin is complete, inspect the origin of the fin. The origin should have a row of cartilage along the top, with a small amount of muscle in front of it at the origin. On occasion an anal fin may have extra skin at the origin, **do not include this extra skin in the measurement.**

- *Inspecting the Free Rear Tip*- To determine if the free rear tip is intact, inspect the end of it. The free rear tip should come to a natural end, this usually ends in a slightly rounded tip. Often free rear tips become thin with a straight edge because they were damaged during the excision of the anal fin. If a free rear tip is incomplete **do not measure the fin**.

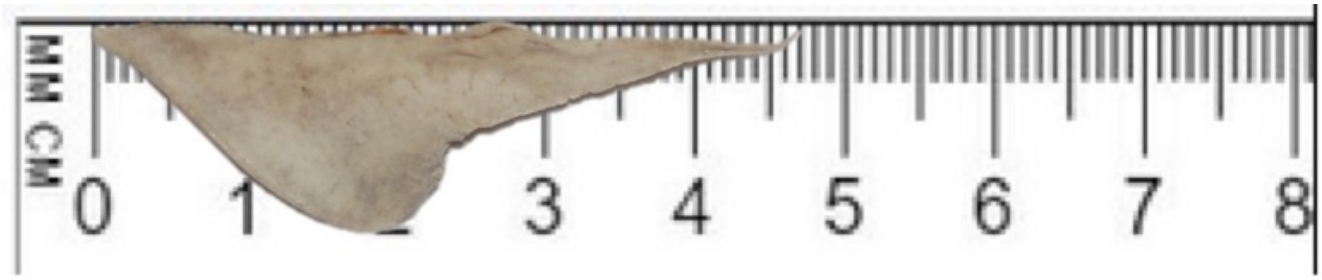
- *Other Considerations When Measuring*- Often when fishers remove anal fins there is a "scoop-like" or "U" shaped cut made along the base of the anal fin. This "scoop" does not affect the AFB length and the fin can still be measured.

Step 2: Measuring an Anal Fin

(Tips: Tape the measuring tape to a hard flat surface, make it a two-person job: one for measuring, one for recording lengths. Keep measured & unmeasured piles very separate)

Use your fingers to hold the fin firmly in place with one hand at the origin, use your second hand to align the anal fin to be straight along the measuring tape, ensuring the free rear tip is in line with the origin (Figure 3) and the fin is pressed flat against the tape. Some fins can become misshapen or curl when dried. These fins can easily be laid flat in their natural position with a little pressure to get the length and should be included.

Figure 3: Depicts the position the anal fin should be in when measuring, note the origin and free rear tip are in line



VI. Converting anal fin length to total length

Objective: Convert anal fin base length measurements to inferred body length measurements for species which have established regressions.

Note: It is recommended that measurements be transferred to/recorded in a spreadsheet (e.g., Google Sheets, Microsoft Excel), this enables the user to organize lengths in size order, create figures/ visual aids (e.g., length frequency histograms), calculate statistics (e.g., mean, median etc..) and most importantly safeguard data (e.g., paper datasheets can become misplaced or ruined) which ensures users can use these data for long term monitoring.

Preparing the datasheet

Each species should have its own datasheet and each datasheet should include all data collected for each fin (Figure 4). Columns should be titled with the data categories collected from the fin (date, sample ID, fisher, gear, etc.) and each row should contain the information from each individual fin. While sorting fins, certain species (e.g., great and scalloped hammerheads, blacktip and blacknose sharks) were assigned unique ID's. Datasheets for these species should also include a column for their unique ID.

Figure 4: Example of a datasheet for collected anal fins

	A	B	C	D	E	F	G
1	Date Captured dd/mm/yy	Species	Common Name	Gear	Fisher(s)	Location Captured	AFB (cm)
2	2/6/18	C. perezi	Caribbean reef	Longline	H. Martinez	Channel Caye Area	7.2
3	2019	C. perezi	Caribbean reef	NA	NA	NA	6.7
4	June 2020	C. perezi	Caribbean reef	NA	O. Faux	NA	8.1
5							

Note: you may have additional or less data than what is shown above, or you may not have certain data for all anal fins. In this case input "NA" indicating "not available" rather than leaving the cell blank. **It is important to note: often an exact date of capture is not available but recording at least the year is important for long term monitoring (you can also include things like month, season etc. all additional information is helpful).**

Converting anal fin measurements to inferred body lengths

Step 1: Converting anal fin measurements from centimeters (cm) to millimeters (mm)

The species-specific regressions are calculated with anal fin measurements in millimeters (mm). To apply the species-specific regressions to your anal fins you must first ensure your anal fin measurements are in mm (you must also ensure your body lengths are in centimeters).

Note: If your anal fins are already measured in millimeters you can skip this step.

Instructions below outline how to convert measurements taken in cm to mm in a spreadsheet. If your measurements are taken in inches (or any other measurement) you must do the conversion for that measurement to mm (e.g., 1 inch = 25.4 mm). Similarly, if your body length measurements are not in centimeters they must be converted to centimeters before applying the regression equation.

Converting AFB measurements to mm:

- Create a new column next to the AFB(cm)
- Title the column 'AFB(mm)'
- For the first row of data: type: =[click the corresponding cell in AFB(cm)]*10 (Figure 5)
  (For inches you would type 25.4 here instead of 10)
- The cell should now have the new converted measurement
- If the calculation is correct (recommended to check with a calculator), hover your cursor over the bottom right corner of the cell containing the new measurement, the cursor should change, indicating you can double click which will apply this equation to the rest of the measurements (Microsoft Excel and Google Sheets).
  Note: check the first few rows to ensure the correct corresponding cell from AFB(cm) is being incorporated into the equation.

Figure 5: How to convert anal fin base (AFB) length from centimeters to millimeters

	A	B	C	D	E	F	G	H
1	Date Captured dd/mm/yy	Species	Common Name	Gear	Fisher(s)	Location Captured	AFB (cm)	AFB(mm)
2	2/6/18	C. perezi	Caribbean reef	Longline	H. Martinez	Channel Caye Area	7.2	=(G2*10)
3	2019	C. perezi	Caribbean reef	NA	NA	NA	6.7	
4	June 2020	C. perezi	Caribbean reef	NA	O. Faux	NA	8.1	
5								

Step 2: Converting anal fin lengths to body lengths
The species-specific regression equations are applied to the anal fin measurements in mm to convert the anal fin lengths to inferred total lengths(cm). The result is the size-composition for that species in the catch.

Converting AFB(mm) to Inferred Total Length(cm)

- Create a new column next to AFB(mm)
- Title the column 'Inferred TL(cm)'
- Refer to the provided *Anal Fin Guide* for the regression equation developed for the species you are working with.
- In the first row of the column titled 'Inferred TL(cm)' you will type in the species-specific regression equation
  Example: =1.2577*[click the corresponding cell in AFB(mm)]+9.8071 (Figure 6)
- The result should be the inferred total length of the animal the fin came from, in centimeters (cm)
- If the calculation is correct (recommended to check with a calculator), hover your cursor over the bottom right corner of the cell containing the new measurement, the cursor should change, indicating you can double click which will apply this equation to the rest of the measurements (Microsoft Excel and Google Sheets).
  Note: check the first few rows to ensure the correct corresponding cell from AFB(mm) is being incorporated into the equation.

Figure 6: How to convert measured AFB length to inferred total length (cm)

	A	B	C	D	E	F	G	H	I
1	Date Captured dd/mm/yy	Species	Common Name	Gear	Fisher(s)	Location Captured	AFB (cm)	AFB(mm)	Inferred TL(cm)
2	2/6/18	C. perezi	Caribbean reef	Longline	H. Martinez	Channel Caye Area	7.2	72	=(1.2577*H2+9.8071)
3	2019	C. perezi	Caribbean reef	NA	NA	NA	6.7	67	
4	June 2020	C. perezi	Caribbean reef	NA	O. Faux	NA	8.1	81	
5									

Species without regression equations: For users interested in creating a regression for a species that does not have one, Section VII outlines how to collect paired measurements consistent with how the AFMP collects them. Uniform data collection amongst users enables these data (i.e., measurements and regressions) to contribute to the ongoing work of the AFMP and be available to other users. Additionally, Section VIII outlines how to use these paired measurements to create a species-specific regression equation.

Creating length frequency histograms

Length-frequency histograms provide a visual aid for reviewing length data. The inferred lengths are organized into size intervals which allows the user to see how many individuals are of certain lengths. Users can then determine which lengths are most vulnerable to fishing, and if the length of maturity is known for the species, determining if mature individuals are being caught.

In the program you are using (e.g., Microsoft Excel, Google Sheets) click on an empty cell and choose to insert a Histogram chart/figure from the figure options available.

- Choose the data for the x-axis to be the calculated inferred total lengths, Inferred TL(cm), highlight all lengths in the column.

Google Sheets

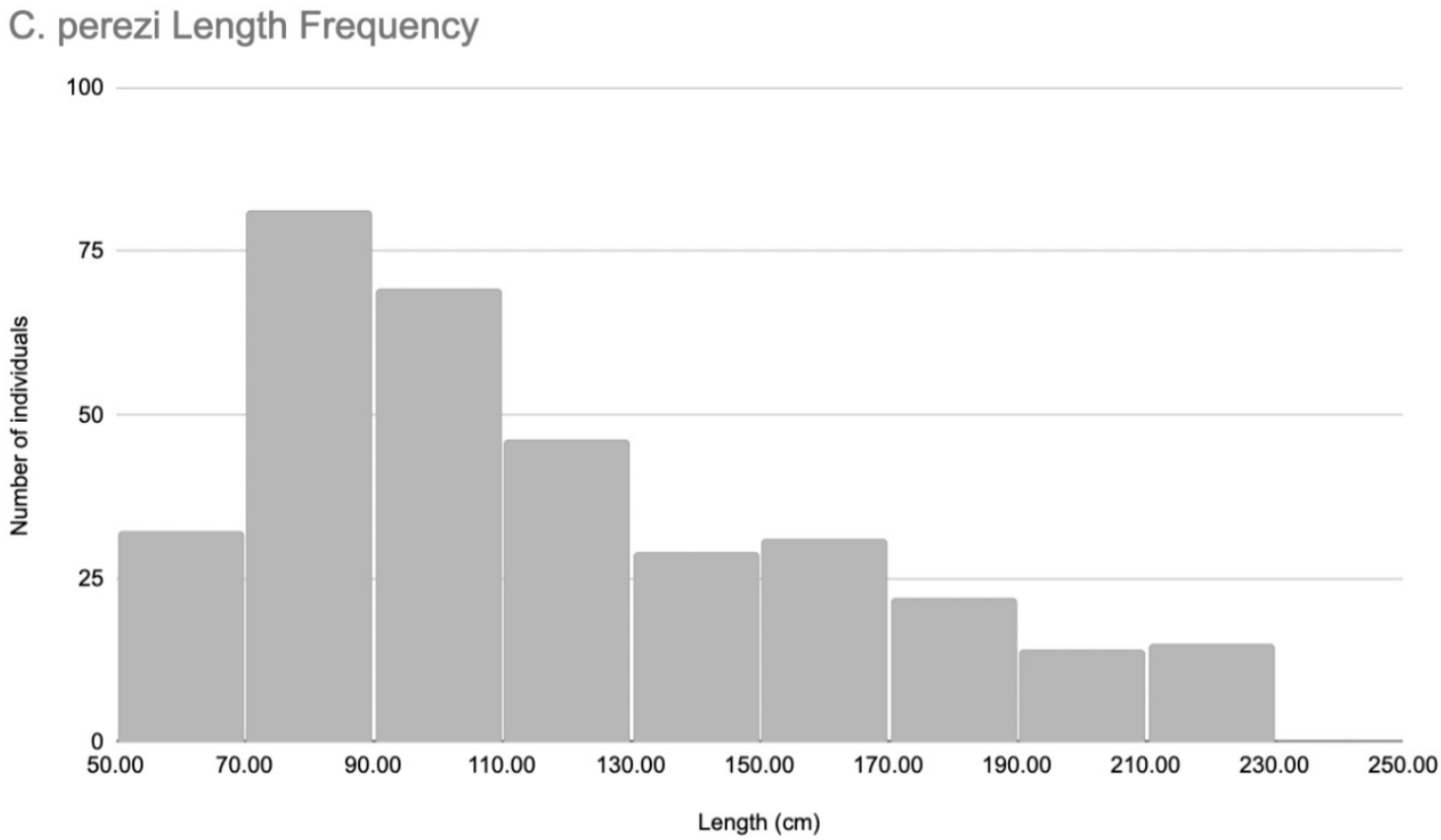
- Click the three dots on the top right of the figure and choose “Edit Chart”
- Click “Customize”
- Click “Histogram”
- Bucket size represents what intervals your total lengths will be grouped into. What you input is preference. (10 or 20 is usually a good place to start)

Microsoft Excel

- Right click the bars in the figure and choose “Format Data Series”
- Under the options for “Bins”, change ‘Bin Width’ to your preference. (10 or 20 is usually a good place to start)

The output (Google Sheets example; Figure 7)
x-axis has the intervals the inferred lengths are grouped into
y-axis represents the frequency of individuals which are of that length

Figure 7: Example of length frequency histogram in Google Sheets



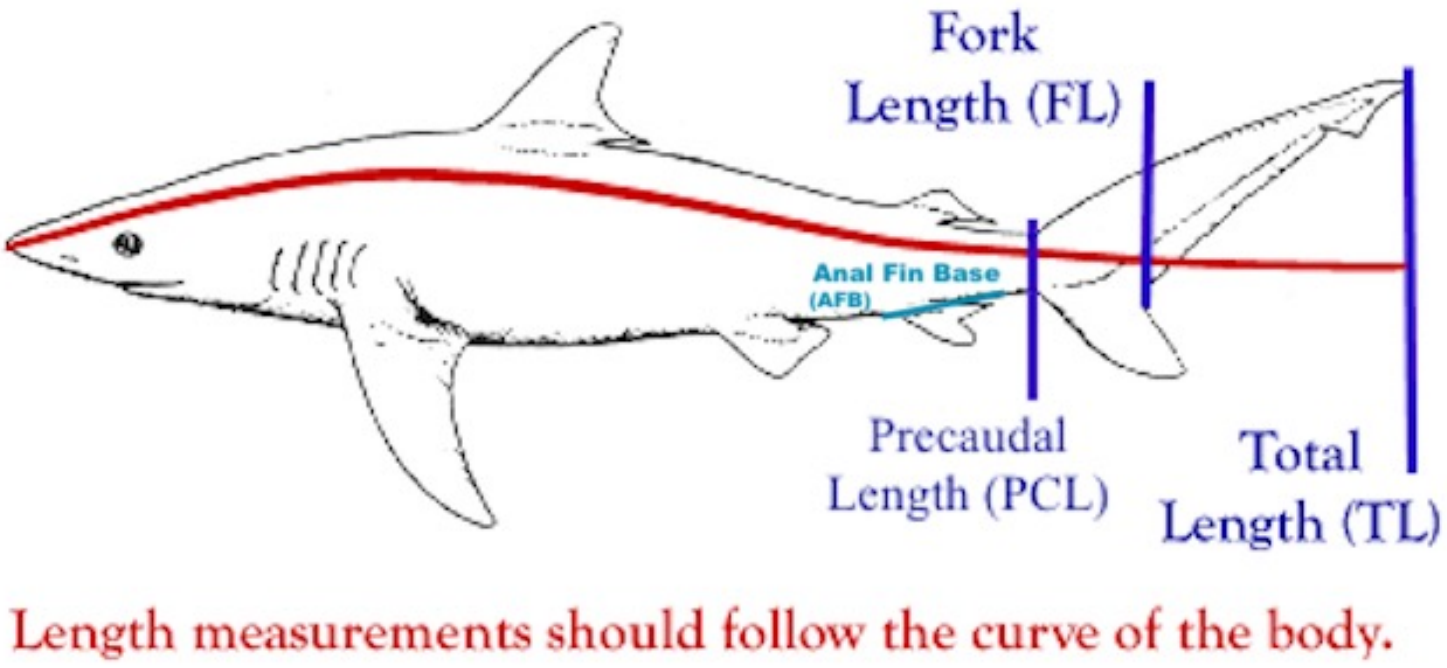
VII. Collecting paired measurements

Objective: Collect body length measurements and the anal fin base (AFB) measurement.

For each shark collect:

- Date
- Unique ID
- Species
- Common Name
- Sex
- Precaudal length
- Fork length
- Total length-keep tape straight through fork, do not run measuring tape along upper lobe of the caudal
- Anal fin base length- from the fin origin through the free rear tip (see figure 2)
- Record who is taking the measurements

Figure 8: Depiction of measurements taken when collecting paired measurements



VIII. Developing a species-specific regression equation

Objective: Create species-specific regression equations to calculate inferred body lengths from collected, measured anal fins.

Preparing the datasheet

Every species should have its own datasheet and each datasheet should include all data collected for each individual shark's paired measurements. Columns should be titled with the data categories collected from individual sharks (See Section VII) and each row should contain the information collected from a single shark (Figure 9).

Figure 9: Example of a datasheet for paired length measurements

	A	B	C	D	E	F	G	H	I	J	K
1	Date (dd/mm/yy	Unique ID	Species	Common Name	Sex	Precaudal Length (cm)	Fork Length (cm)	Total Length (cm)	AFB (cm)	Measurer	Notes
2	6/8/19	FIU-007	C. falciformis	Silky	F	59	66.2	80.0	6	Jess	
3	21/7/20	FIU-022	C. falciformis	Silky	M	67	74	91.0	6.5	Devanshi	
4	21/7/20	FIU-023	C. falciformis	Silky	F	68	74.5	93.5	6.0	Devanshi	
5	16/8/20	FIU-048	C. falciformis	Silky	M	69	76	94.0	6.4	Hector	
6	16/8/20	FIU-049	C. falciformis	Silky	M	71	80.5	98.0	7.0	Hector	
7	15/2/21	FIU-067	C. falciformis	Silky	M	74	83	103.0	8.0	Jess	
8	15/2/21	FIU-068	C. falciformis	Silky	F	77	83.7	106.0	7.1	Jess	
9	15/2/21	FIU-069	C. falciformis	Silky	M	77.5	85.3	107.0	7.5	Jess	
10											

Converting anal fin measurements from centimeters (cm) to millimeters (mm)

The species-specific regressions are calculated with anal fin measurements in millimeters (mm). To create a regression equation you must first ensure your anal fin measurements are in mm (you must also ensure your body lengths are in centimeters).

Note: Generally measurements are taken in centimeters in the field but if your anal fins are already measured in millimeters you can skip this step.

Instructions below outline how to convert measurements taken in cm to mm in a spreadsheet. If your measurements are taken in inches (or any other measurement) you must do the conversion for that measurement to mm (e.g., 1 inch = 25.4 mm). Similarly, if your body length measurements are not in centimeters they must be converted to centimeters before applying the regression equation.

Converting AFB measurements to mm:

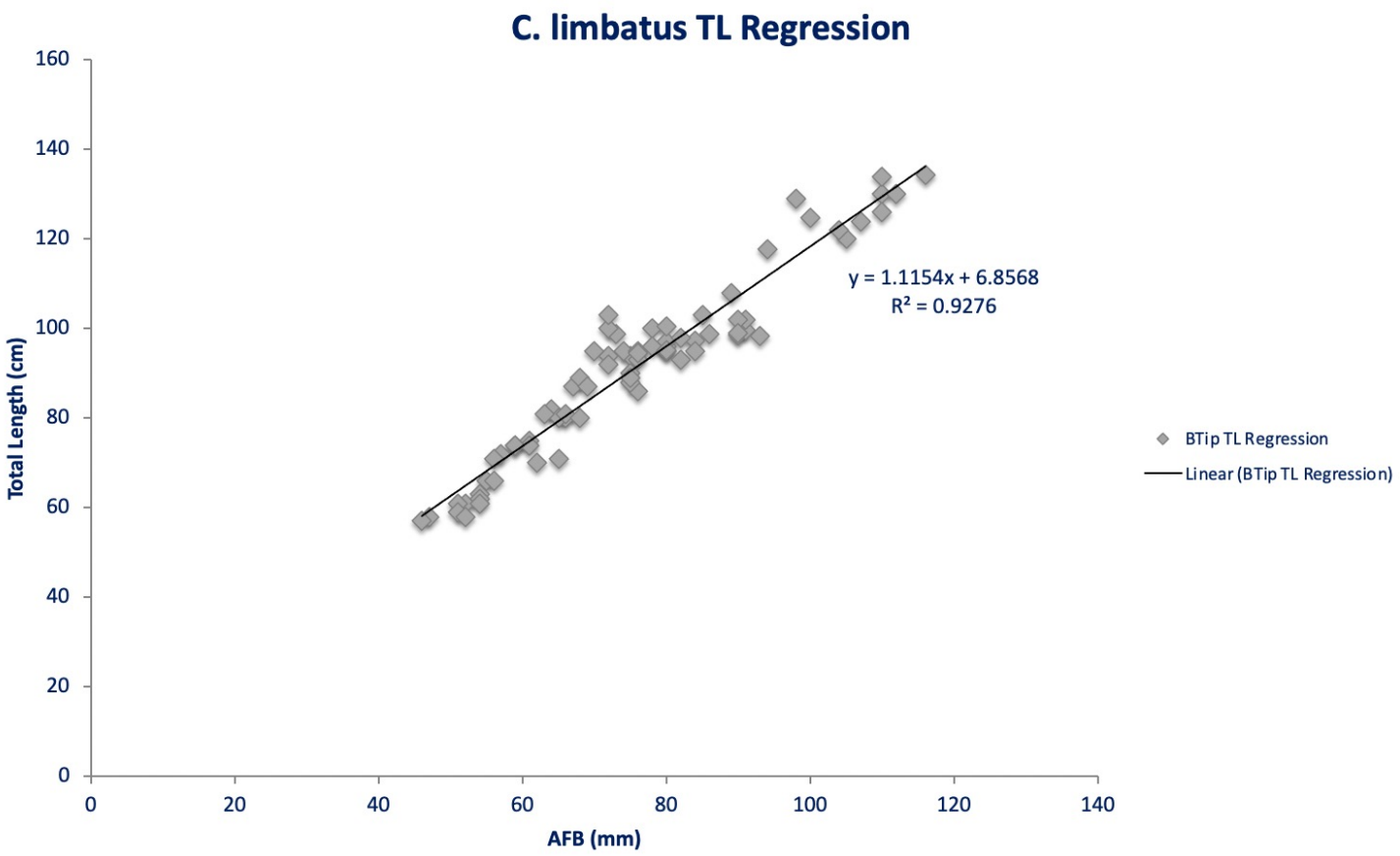
- Create a new column next to the AFB(cm)
- Title the column 'AFB(mm)'
- For the first row of data: type: =[click the corresponding cell in AFB(cm)]*10 (Figure 5)
  (For inches you would type 25.4 here instead of 10)
- The cell should now have the new converted measurement
- If the calculation is correct (recommended to check with a calculator), hover your cursor over the bottom right corner of the cell containing the new measurement, the cursor should change, indicating you can double click which will apply this equation to the rest of the measurements (Microsoft Excel and Google Sheets).
  Note: check the first few rows to ensure the correct corresponding cell from AFB(cm) is being incorporated into the equation.

Creating a scatter plot

In the program you are using (e.g., Microsoft Excel, Google Sheets) click on an empty cell and choose to insert a scatter plot/chart from the figure options available.

- Choose the data for the x-axis to be the (AFB(mm) column, highlight all measurements in this column
- Choose the data for the y-axis to be the TL(cm) column, highlight all measurements in this column
- Choose the options to have the r-squared (r^2) value and the regression equation to be displayed on the chart (how to do this varies for each program/version)
- It is recommended to add axes titles and a chart title (Figure 10)

Figure 10: Example of a species-specific linear regression (scatterplot) with r-squared and regression equation displayed



R-squared (r^2) value

The r-squared value indicates how reliable your regression equation is. The closer to 1 the r-squared value is, the more reliable the equation is.

CRITICALLY IMPORTANT POINTS:

- It is highly suggested not to use an equation with an r-squared value below 0.75
- Often in the beginning, with only a few collected paired measurements, r-squared values tend to be artificially high due to the few number of data points included. It is recommended that a regression have at least 30 paired measurements.
- More importantly it is paramount to have paired measurements from individuals of all sizes for a species. A regression cannot be built with measurements taken only from one size class- this is why it is important all users collect measurements uniformly to ensure data can be combined to create universal species-specific regressions.

Regression equation

The regression equation is the equation that will be applied to collected, measured anal fins to infer the total length of the animal the fin came from. **This equation should only be used when there is a reliable r-squared value (i.e. at least 0.75).**

Special Thanks

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The Roe Foundation

Contributors:

Demian Chapman, Ph.D
Director of Sharks and Rays Conservation Program, Mote Marine Laboratory
Perry W. Gilbert Chair in Shark Conservation
IUCN Shark Specialist Working Group
Lead Scientist of Global FinPrint
Is the originator of the idea to use shark anal fins to reconstruct the fishery.

Belize Fisheries Department (BFD)
The development of this program was done in collaboration with BFD.
They provided access to anal fins collected from the fishery
and worked alongside researchers to collect paired measurements.

Belizean Shark Fishing Team
The working relationship with local Belizean shark fishers made it possible to sample sharks and collect necessary paired measurements for regression equations.

Diego Cardeñosa, Ph.D
Translated all training materials into Spanish

And a thanks to all researchers from different institutions who collected paired measurements which contributed to the species-specific regression equations: