Research Applications in Dolphin Morphology:
What can they tell us?

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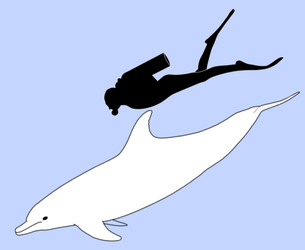


morphology mor-phol-o-gy (*noun*) : a branch of biology that deals with the form and structure of plants and animals.

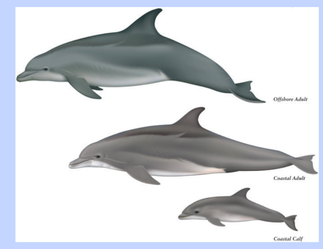
Introduction

In areas like the **New York Bight**, where population assessments are limited to observational surveys, morphological classifications of habitat use, sex, and age are poorly understood. Examining dorsal fin morphology can help to better understand phenotypical variance and polymorphism that can provide insight for how this habitat may be important for bottlenose dolphin conservation.

- **Research Applications:** Here, we compare anatomical feature classifications where sex, age, and phenotypical variance was examined.
- **Limitations:** Without biological data to confirm findings, sexual dimorphism and polymorphism is theoretical and inconclusive. However, standardized ranges help to improve methods of classification.
- **Previous research** has shown the significance of dorsal fin morphology across spatial patterns of distribution with distinctive fin shapes in the Pacific, Gulf of California, and Carribean Sea. The curvature, angle, and width of the fins were most notable. (Morteo et al. 2017).
- **Anatomical features that help to examine morphological variance** incliude skull length, body length, teeth, and fin shape.
- **Rationale**: While some species of delphinidae are easier to assess then others, there is evidence to support dorsal fin morphology as a method to assess sex and age. Fig.1 provides an example of where these classifications are clearly distinctive in the Killer Whale (*Orcinus orca*).

Questions

- What **methods** are used to examine dolphin morphology to identify
- How are **phenotypical characteristics, age, and sex** determined**?**
- How effective is **dorsal fin morphology** in identifying these classifications?



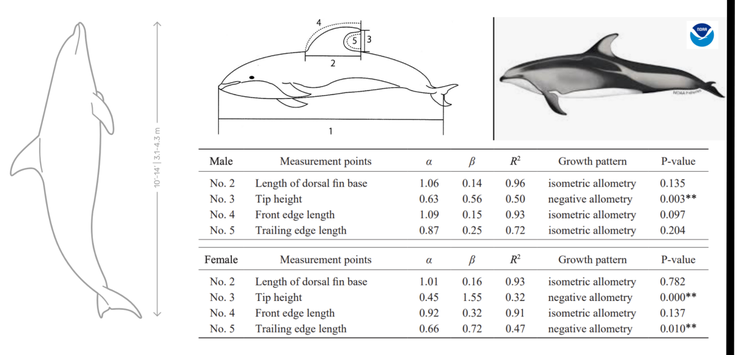
Categories of Morphological Classification

SEX

- Body Size / Length
- Overall Girth & Genital Slits
- Skull Shape
- Dorsal Fin Shape
- Echelon Position (Mother/Calf)

Morphotype	Location	Males n	Males mean	Males SD	Females n	Females mean	Females SD	*P*-level
T. cf. aduncus	EA	11	229.5	15.00	7	228.6	8.75	0.888
	CS	4	225.4	7.28	1	239.2	—	
	SAF	16	238.0	9.48	10	235.2	12.53	
	NA	18	202.1	10.50	22	208.3	13.23	0.117
T. truncatus	EA	5	282.6	7.09	7	279.1	12.81	
	CS	4	312.5	12.92	5	290.9	7.14	0.034
	SAF	4	294.3	24.93	1	279.0	—	
	SA	5	300.8	24.34	2	285.5	0.71	

Fig 2. The body lengths of the males and females are shown in accordance to location and the averages. The significant level (P-level) is also depicted (Hale et al.).



Male	Measurement points	α	β	R^2	Growth pattern	P-value
No. 2	Length of dorsal fin base	1.06	0.14	0.96	isometric allometry	0.135
No. 3	Tip height	0.63	0.56	0.50	negative allometry	0.003**
No. 4	Front edge length	1.09	0.15	0.93	isometric allometry	0.097
No. 5	Trailing edge length	0.87	0.25	0.72	isometric allometry	0.204

Female	Measurement points	α	β	R^2	Growth pattern	P-value
No. 2	Length of dorsal fin base	1.01	0.16	0.93	isometric allometry	0.782
No. 3	Tip height	0.45	1.55	0.32	negative allometry	0.000**
No. 4	Front edge length	0.92	0.32	0.91	isometric allometry	0.137
No. 5	Trailing edge length	0.66	0.72	0.47	negative allometry	0.010**

Fig 3. Katsumata et al. compared feature measurements of dorsal fin shape for Pacific white-sided dolphin (top right) as a ratio to body length. This method uses an allometric ratio for growth patterns. Results indicated that proportions of dorsal fin height and length were positively correlated to identify sexually mature males as they display a pronouncedly curved and round dorsal fin compared to females.

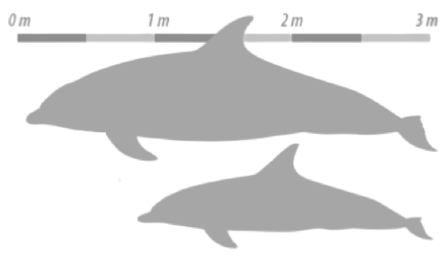


Fig 4. Relative range of size for subadult-adult bottlenose dolphins. (Collom 2023)

AGE

- Body Size / Girth / Length
- Teeth (Size / Wear)
- Muscle Fibers (Density / Dexterity)
- Skull (Fontanelles: "soft spots")

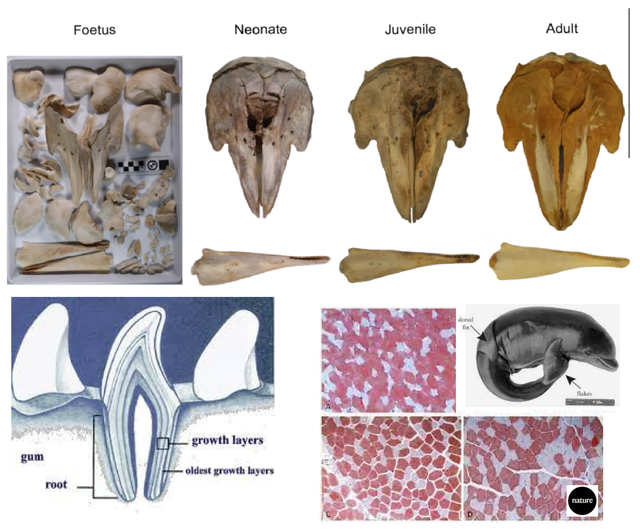


Fig 5-7. The main morphological characteristics that pertained to age were skull and body size, malleability of the skull, muscle fibres, and teeth. As shown above, teeth were most definitive in assessing accuracy with age due to the growth layers and signs of wear in older dolphins. (Ruenes et al.) Similar to human infants, neonate dolphin skulls have soft spots known as fontanelles. Habitat choice during the first year of rearing can also contribute to morphological shape. (Sierra et al.)

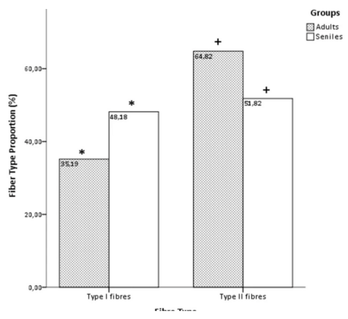


Fig 8. The proportion of fiber types in the adult and senile groups is depicted. The asterisks showcase significance through the Mann-Whitney U-test. For the dolphins in the senile group, they had a significantly higher % of type I fibres and a lower % of type II, supporting the claim that the type 2 fibres are lost with aging (Sierra et al).

HABITAT

- Dorsal Fin Shape
- Pigmentation
- Development / Growth Patterns
- Pigmentation

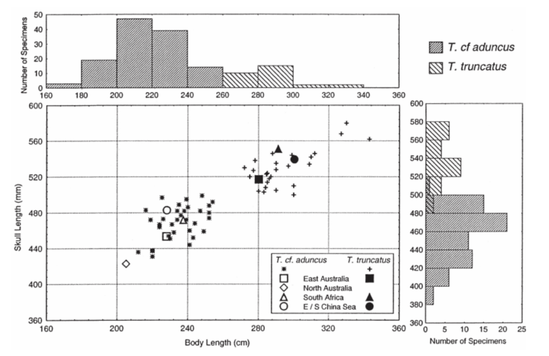


Fig 9. The correlation of the body length and skull length is shown according to the relative locations to illustrate phenotypical distinction in ecotypes. (Hale et al).

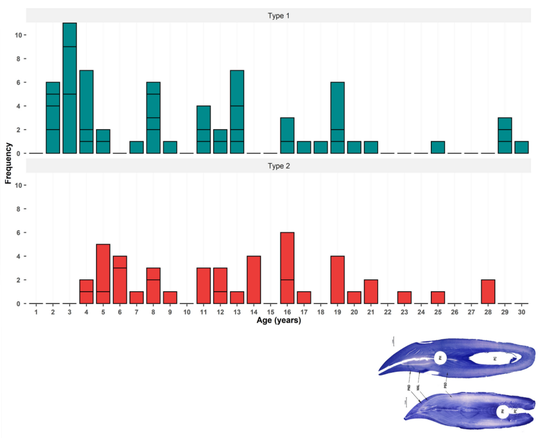
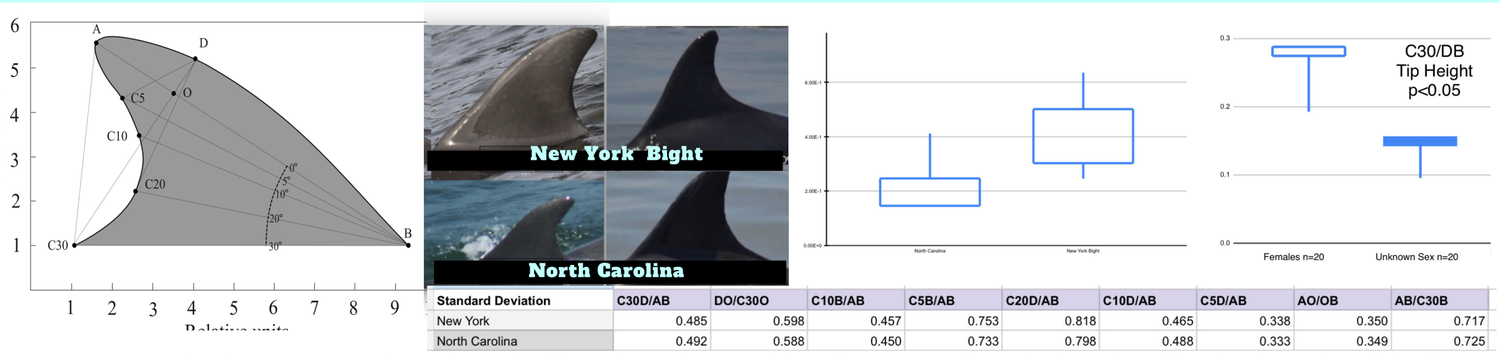


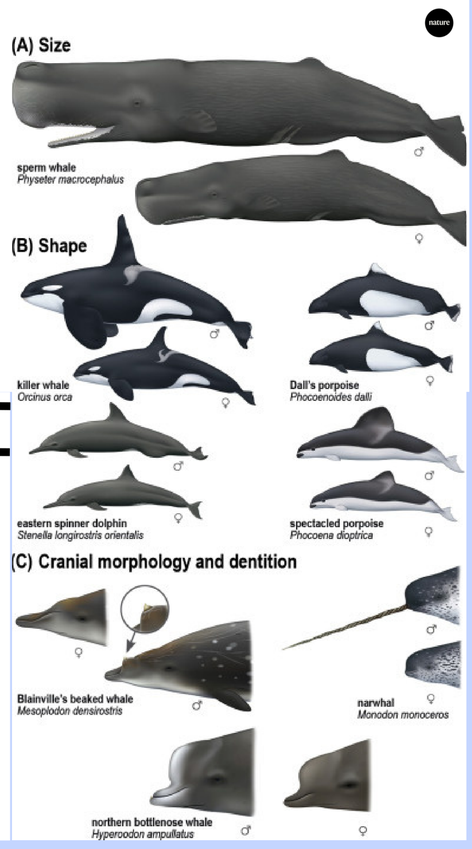
Fig 10. Type 1 and Type 2 were distinguished through a two-way MANOVA. Four types were found, but with individual statistical measurements with ANOVAs, there was some statistical variation. These clusters are mostly significant with root diameter, but age can be related to the type as well. This is depicted in the graph above, as the age increases the type of tooth is seen to correlate (Ruenes et al.).

Dorsal Fin Morphology Review



Standard Deviation	C30D/AB	DO/C30O	C10B/AB	C5B/AB	C20D/AB	C10D/AB	C5D/AB	AO/OB	AB/C30B
New York	0.485	0.598	0.457	0.753	0.818	0.465	0.338	0.350	0.717
North Carolina	0.492	0.588	0.450	0.733	0.798	0.488	0.333	0.349	0.725

Fig 10-13. Using data from a previous study sample, results of fin analysis indices revealed significant variance for tip height, angle, and base length. A subset of that data was compared unknown sex to known females and found that tip height was significantly distinctive and thus effective in evaluating possible sex. (Right) Overview of morphological classifier shperies.



Discussion

- The morphometric variation in the skull length, body length, teeth, and dorsal fin, when combined can provide one with adequate evidence for distinguishing dolphin species, age groups, and sex.
- The most common statistical tests for significance in these studies was the Mann-Whitney U-test, which was often supplemented with an ANOVA.
- When divided into two different types, it is possible to see a correlation for teeth and age (Ruenes et al.). Tooth wear was also quite prominent, as the teeth can be influenced by the food available in that region, age with how long the teeth were used for, and many other evolutionary factors (Sierra et al.).
- The skull and body length of the dolphin can showcase age through the overall length of the body and sex through sexual dimorphism (Hale et al., Katsumata et al.). When it comes to sex, the body length can be associated with factors of the fin, such as the base length.
- The muscle fibres of the dolphins were also studied, portraying a significant loss in type II fibres with the process of aging (Sierra et al).
- All in all, it can be concluded that there were significant results with most of these factors, particularly the dorsal fin curvature, muscle fibres, body lengths, and teeth, unveiling that this morphological variation has the ability to tell many aspects, the main two being sex and age.

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Author(s)	Species	Age/sex	Skull	Body	Teeth	Fin
Sierra et al.	Atlantic spotted dolphin	AGE	✓	✓	✓	
Ruenes et al.	Guiana dolphin	AGE			✓	
Hale et al.	Atlantic bottlenose	AGE and SEX		✓	✓	
Katsumata et al.	Pacific white-sided dolphins	SEX		✓		✓

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