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Behavorial Lateralization of Pectoral Fin Rubbing Researched In 27 Identified Bottlenose Dolphins

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BEHAVORIAL LATERALIZATION OF PECTORAL FIN RUBBING RESEARCHED IN 27 IDENTIFIED BOTTLENOSE DOLPHINS

by

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Abstract

This thesis takes a look at the behavioral lateralization of handedness present or not present within the bottlenose dolphin (*Tursiops truncatus*) population housed at the Roatan Institute for Marine Sciences. Dolphins and humans share similar brain structures in that the brain is split into hemispheres that allow an individual to present behaviorally dominate features on different sides of their body. This type of split brain structure allows for a phenomenon known as handedness, where one hand presents dominant motor control. For dolphins, their "hand" is their pectoral fin. This thesis looked at a managed care population to investigate the possibility of a dominant pectoral fin when engaging in contact behaviors or carrying objects. The statistics seemed to show a more even distribution of ambidextrousness than dominance, which still offers insight into their unconscious behaviors.

Key terms: behavioral lateralization; brain lateralization; handedness; pectoral fin contact; Roatan Institute for Marine Sciences; Atlantic bottlenose dolphins; Tursiops truncatus

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Behavioral Lateralization of Pectoral Fin Rubbing Researched in 27 Identified Dolphins (*Tursiops truncatus*)

Dolphins utilize their pectoral fins for a variety of behaviors. Some basic functions of their pectoral fins are for steering through the water or slowing their speed when traveling too fast. When interacting, it is not uncommon to see one rubbing against another dolphin with just their pectoral fin in a form of a social behavior. It is also not uncommon to see a dolphin carrying objects such as sea grass on the fin. The hope of this research is not to determine why individuals engage in pectoral fin contact, but if by engaging in this behavior an individual shows a preference for which fin is used. Assumptions can then be made as to the significance of each contact. The intent is to identify whether or not the population at the Roatan Institute for Marine Sciences, like humans, show a dominant right or left pectoral fin when engaging in contact behaviors.

An Overview of Behavioral Lateralization

Brain Lateralization and Handedness

Behavioral lateralization, for the intents of this thesis, is the behaviors present in an individual based on the lateralization of the cerebral hemispheres of the brain. Most all vertebrates – human and animal alike - share a similar brain structure in that the brain is split into two hemispheres known as the cerebral hemispheres (Torrice, 2009). These two hemispheres have been known to present themselves in three distinct ways when it comes to exploring behavioral lateralization for the intents of this thesis (Torrice, 2009):

1. The cerebral hemispheres function symmetrically.

2. The cerebral hemispheres function asymmetrically where the left hemisphere has dominant control over motor coordination.
3. The cerebral hemispheres function asymmetrically where the right hemisphere has dominant control over motor coordination.

Behavioral lateralization is defined by the distinct functions performed by the two separate sides of the brain (Holder, 2005). Each hemisphere has "*functional specializations*: some function whose neural mechanisms are localized primarily in one half of the brain (Holder, 2005)." In humans, the functions that the two hemispheres control have mostly been localized (Stout). In people presenting right hand dominance, the left hemisphere handles processes of analytical thought such as abstractions, rules, physical activity, and the right side of the body. In right hand dominant people as well, the right hemisphere is responsible for emotions, impulsivity, motor skills, and the left side of the body (Stout). In individuals prescribed as left hand dominant, these actions are controlled by the reverse hemisphere.

Behavioral lateralization, for the purpose of this thesis, is focused on the motor coordination of the external limbs of the hands where one hand shows dominance or more usage. This type of dominance is known as *handedness*. Handedness can be described as the "hand" that an individual prefers to use to accomplish tasks (Holder, 2005). In humans, this identifies people as being right handed or left handed. For dolphins, handedness is measured by usage of the pectoral fins as their external limb to communicate or accomplish tasks.

An individual that is considered showing a strong preference for handedness is defined as displaying the unequal distribution of that individual's fine motor coordination between the left and right hands (Dunham, 2012). It is evident, especially in people, that handedness is not dominated by any one preference 100 % of the time (Balter, 2009). It's also known that the human population is not evenly divided by left and right hand dominant individuals, but a 30/70 split (Holder, 2001). While there is inconsistency in individuals designated as being right or left handed, it is clear that hands serve different but equally important roles (Balter, 2009).

While the causes of an individual falling into one of the three aforementioned categories have yet to be isolated outside of the broad scheme of cerebral lateralization, there are several theories (Lyle, Hanaver-Torrez, Hacklander, & Edlin, 2012; Vallortigara, 2000). Connections between behavior and the brain have been shown to be the most complex relationship one could study in psychology (Bever). However, these theories will only be discussed briefly in the realm of cetaceans as all others are outside the scope of this thesis.

What Purpose Does Lateralization Serve?

The study of behavioral lateralization allows researchers the ability to unlock unknown cognitive processes. While there are no universal answers as to the advantages of behavioral lateralization, research has pointed to individual advantages in different species. In the domestic chick, it has been found that their lateralization has created enhanced cognitive abilities by "finding food and being vigilant for predators" simultaneously (Rogers, Zucca, and Vallortigara, 2004). This study suggests that this visual multitasking may offer insight into how the brain manages taking in visual cues as perceived threats.

In horses, it has been shown that they will view novel stimuli out of their right eye and objects they perceive as negative out of their left eye (De Boyer, Richard – Yris, Henry, Ezzaouïa, & Hausberger, 2008). This visual following suggests a hierarchy of cognitive functioning that may offer insight into how the brain processes information.

In research on primates, Rogers hypothesizes that dominant limb preference correlates with stress levels in animals and feels that further investigation may lead to better management in animal welfare (2010). When in a relaxed state, the preferred limb of the animal is used to pick up objects. Rogers hypothesizes that the welfare of these domesticated animals can be increased by focusing on developing the dominant and non-dominant hemispheres of the brain.

Even studies focused on humans allow for researchers to begin isolating the advantages of studying behavioral lateralization and limb preference. One such study by Denny (2009) and Schiff and Lamon (1994) hypothesizes that certain limb usage is associated with mental differences such as depressive symptoms. These few highlighted studies offer a glimpse of the importance of studying behavioral lateralization in an attempt to understand our cognitive world.

Behavioral Lateralization in Dolphins

The importance of studying behavioral lateralization in dolphins helps support research investigating the asymmetrical functioning of their cognitive abilities (Sakai, Hishii, Takeda, & Kohshima, 2006). Most current research on dolphin lateralization has been focused on visual lateralization or swimming patterns due to the comparative ease of utilizing empirical research to gain accurate results (Dawkins, 2011). However, studies of pectoral fin contact and assumptions to what it represents are on the rise.

The topics of research focused on pectoral fin rubbing are various and profound. In a study by Sakai et al, he reported findings of a population-level left-side bias for pectoral fin contact (2006). In Commerson's dolphins (*Cephalorhynchus commersonii*), one managed care study found a left fin preference for contact; however, this may be due to the saw toothed edge most left fins have which is assumed to aid in sexual contact (Johnson, & Moewe, 1999). Dudzinski et al suggests that pectoral fin contact is similar to allogrooming in primates in that contact is based on a history of reciprocal altruism of the individuals interacting (2009; Seyfarth and Cheney, 2007). Kaplan and Conner found that there were various differences in tactile behavior based on the sex of the Atlantic spotted dolphins (*Stenella frontalis*) of the Bahamas (2007). Another study focused on the probability that dolphins may initiate pectoral fin contact in order to restore relationships following bouts of aggression (Tamaki, Morisaka, & Taki, 2006).

It seems that throughout the literature, though, that there may be a consensus that pectoral fin rubbing is a driven by social behaviors (Dudzinski, Gregg, Ribic, & Kuczaj 2009). Pectoral fin rubbing events have been documented in juveniles learning social behaviors (Kaplan & Connor, 2007; Mann & Smuts, 1999), individuals engaging in socio-sexual behavior (Nelson & Lien, 1994; Sakai, Hishii, Takeda, & Kohshima, 2006), and other forms of social interactions between dolphins of all ages. While this thesis focuses on the Atlantice bottlenose dolphin (*Tursiops truncatus*), the Atlantic spotted dolphin (*Stenella frontalis*) and the Atlantic white-sided dolphin (*Lagenorhynchus acutus*) are also popular in relevant literature.

Literature Review

In relation to available literature, it seems as though the pectoral fin provides a pivotal function in garnishing social behavior. Whether that fin used has dominant motor control or is ambidextrous are questions that this research hopes to open the door to. Pectoral contact has been observed between dolphins in both the managed care and wild setting with some noticeable differences between the two environments (Dudzinski, 2010).

In a comparative study compiled by Kathleen Dudzinski, she notes the difference in pectoral fin contact between her studies of managed care dolphins and wild dolphins (2010). In her study of the natural environment, it seems as though tactile exchanges have three major functions: greeting another dolphin, requesting contact for hygienic reasons, or providing information (Dudzinski, 2010). Since wild dolphins live in fission-fusion communities, pectoral fin greetings may be of significant importance in welcoming back new or returning pod members. In open waters, dolphins may elicit contact from another for hygienic reasons like helping to remove something that has found its way onto an animal. Dudzinski also notes in an earlier study that contact to a specific area, for instance the peduncle, may be a sign of the initiating dolphin requesting assistance in future scuffles (Dudzinski et al., 2009; Dudzinski, 2010).

During her managed care study, Dudzinski has noted that the behaviors of those in the wild are not completely consistent with dolphins in managed care. In one of her studies, she surveyed trainers about the behaviors that the dolphins in their care exhibited (Dudzinski et al., 2010; Dudzinski, 2010). These observations stated that pectoral fin contact was not used as a method of greeting like their counterparts in the wild. However, they did express more instances of tactile exchanges for appeasement or to gain a response from an individual (Dudzinski, 2010). Essentially, those in managed care used pectoral rubbing with individuals more for social bonding or pleasure since their pod is not typically changing.

Dudzinski hypothesizes that the differences between the two may have to do with their environment (2010). Since pods in the wild change group members often, such pectoral fin greetings may have importance in maintaining group dynamics. Since dolphins in managed care typically do not experience group changes, there is little need for this type of interaction to occur. Regardless of this difference, both remain tactile creatures that engage in similar pectoral contact (Dudzinski, 2010).

In a study presented by Nelson and Lien, they accessed the behavioral patterns of a male and female Atlantic white-sided dolphin (*Lagenorhynchus acutus*) in managed care (1994). With 42 hours of data, they studied many different behavioral patterns, but for the purpose of this review the focus will be on pectoral fin contact. What Nelson and Lien noticed was that the female dolphin was typically the initiator during encounters where pectoral fin contact was recorded. During 15 minute intervals, she initiated 40% of the rubbing occurrences in comparison to the 7% of initiations done by the male.

Something Nelson and Lien noticed during these interactions was that the dolphins would swim together with pectoral fins touching (1994). It is hypothesized that this type of behavior may be a form of bonding (Defran & Pryor, 1980). They also make note that prior to sexual behaviors, the dolphins would engage in some type of stroking behavior with the pectoral fin (Nelson & Lien, 1994). Their findings parallel a similar study where this stroking behavior was hypothesized to be the “least vigorous and energetic type of sexual activity” (Tavolga & Essapian, 1957). Together, the study by Nelson and Lien shows that pectoral fin rubbing is used in bonding and sexual activities (1994).

In another comparative study completed by Tadamichi Morisaka, an interesting point is raised about the possibility of pectoral rubbing being used to defuse aggressive behaviors (2009). The first study focuses on Sakai, Hishii, Takeda, and Kohshima investigation of a pod of wild Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) near the Mikura Island in Japan (2006). Based on the observations made, Sakai et al. believes like most that the behavior is a social bonding one. In this study, the most frequent cases of rubbing occurred between mother/calf pairs and pairs of the same sex and age, not individuals of the opposite sex as seen in other managed care studies (Morisaka, 2009).

The other observations mentioned in the comparative study by Morisaka were done by Tamaki, Morisaka himself, and Taki (2006). This study focused on the pectoral rubbing of three managed care dolphins in relation to aggressive behaviors. Pectoral contact occurred frequently between pairs that had engaged in aggressive behaviors roughly ten minutes *after* an aggressive interaction versus during a control period (Morisaka, 2009). Also, it seemed as though this pectoral contact caused a delay in successive aggressive interactions between individuals. Tamaki et al. suspected that this may mean that post-pectoral fin contact reduces the chance of conflict reoccurrences (2006). Additionally, it was noted that when a party member would initiate contact between aggressive individuals more frequently than during a control period. It can be implied that this contact eases tension or can be seen as a displacement behavior by an aggressive individual. Although more focused data is needed to support their findings, it could be suggested that pectoral contact may be used to repair and maintain social relationships (Morisaka, 2009).

A study by Kaplan and Connor focused specifically on the gender differences in tactile encounters among juvenile Atlantic spotted dolphins (*Stenella frontalis*) (2007). Footage of a wild population of nine males and ten females resulted in 499 recorded instances of contact over a six week period. Sex differences in the initiator of tactile contact were discovered in this study (Kaplan & Connor, 2007). It was found that males were more likely to initiate contact with the head area than females were. Females were more likely to specifically use their pectoral fin for contact, which is concurrent with the study previously mentioned by Nelson and Lien. Males had a higher tendency to use their full bodies in contact during aggressive behaviors, but not during neutral states (Kaplan & Connor, 2007). It is interesting to note that sex differences were not statistically different for the individual receiving the tactile contact. While the study includes various forms of contact, for the purpose of this thesis it is interesting to reiterate that it is females using their pectoral fins for contact more than males.

Also in the study by Kaplan and Connor, they assessed the overall preference in body parts during tactile contact (2007). When focusing on the pectoral fin, it was found that juveniles used it to initiate significantly more than any other body part. To recap their statistical data, “juveniles received contact to their pectoral fins in 16.2% ± 9.7% of pectoral fin contact events and initiated contact with their pectoral fins in 68.3% ± 13.8% of these events…” based on the Mann–Whitney *U* tests (Kaplan & Connor, 2007).

Overall, their study offers an interesting perspective as to why contact may be higher among females (Kaplan & Connor, 2007). It is thought that males and females may be using separate strategies when interacting among same sex juveniles. As females change reproductive partners, it seems that it may be important for the females to establish bonds with same sex individuals of the same age so that there is an individual to help with alloparenting during their child bearing years. Pectoral contact may help to build and maintain these bonds with other females (Kaplan & Connor, 2007).

In Mann and Smuts study, the focus of pectoral fin contact was concentrated specifically on bonding between mother and calves (1999). They defined two differences in pectoral fin contact: “petting” was used primarily for grooming, while “rubbing” was defined as gentle contact. In 22 of 26 recorded instances of pectoral petting, the infants were receiving the action whereas they were noted as the active petter only four times. Rubbing, it seems, was noted as the most frequent form of socialization for the newborns. Infants initiated nearly all rubbing interactions with their mothers. During the first eight weeks of life, 48% of contact focused on the mother’s head area while 26% of contact focused on the mother’s lateral sides. While this study going into further depth about various types of non-pectoral interactions, the general consensus of the article is that pectoral fin rubbing is extremely important in the socializing of infants (Mann & Smuts, 1999).

While the research on cetaceans is various and numerous, these reviewed studies highlight the constant and varied uses that cetaceans may use their pectoral fins for. The overarching theme is that the pectoral fins seem to aid in building and maintaining different social relationships. While the focus of this thesis is not to determine the cause of contact, it is important to build an understanding as to why cetaceans use their pectoral fins.

Methods

Roatan Institute of Marine Sciences

The Roatan Institute of Marine Sciences (RIMS) is located at the Anthony’s Key Resort in Roatan, Honduras. This learning institute opened its doors in 1989 (Anthony’s Key Resort). The facility is located on Bailey’s Key with a fencing system encapsulating half of the islands surrounding ocean, allowing natural water and wildlife to circulate through the dolphin enclosure. This allows for a natural filtration system that replicates life in the wild. These dolphins are able to hunt and use the various plant life in their habitat for enrichment. The water level in this facility can be anywhere from beach wash to nearly 30 feet deep (Anthony’s Key Resort).

Along with the natural setting created at the Roatan Institute of Marine Sciences, the facility is also unparalleled in the way its dolphins interact. During the facility’s operating hours, males are separated from mom and calf pairs for encounter programs; however, once the facility is closed all of the dolphins are able to interact as they are not kept isolated from one another. This allows for natural social interactions to occur and relationships to be established similar to what would be seen without human interference. While this is a managed care facility, these dolphins thrive in their unparalleled environment.

The population began with a few wild collected dolphins but has grown over the years with several successful on-site births. This population is unique in that researchers have the additional opportunity to look at the family relationships. The maternal family tree of this population is depicted in *Appendix A*.

Research on dolphins from the Roatan Institute of Marine Sciences in comparison to wild dolphins shows consistent similarities in their behaviors (Dudzinski, Gregg, Ribic, & Kuczaj, 2009; Dudzinski, 2010; Dudzinski, Gregg, Melillo-Sweeting, Seay, & Kuczaj, 2012; Greene, Melillo-Sweeting, & Dudzinski, 2011;). The hope is that research on these dolphins will be able to assist future studies since results are so similar to their wild counterparts.

Participants

The participants of this thesis were 27 Atlantic bottlenose dolphins (*Tursiops truncatus*) housed at the Roatan Institute of Marine Sciences. Over a time period of 2010 – 2012, video footage was collected on these dolphins by individuals in the Marine Mammal Behavior and Cognition Laboratory from the University of Southern Mississippi during various trips to Honduras. Each dolphin is accounted for and identified in the footage by their distinct dorsal fin, flukes, rake marks, sex, size, and individual characteristics. Dolphins in the footage that are identified have been matched with known photos and sketches to support identification.

The research began with 25 dolphins in 2010, and then expanded with the addition of two females born in 2012. Of the overall 27 dolphins identified in the 2010 - 2012 period, only one instance of mortality has occurred. Included in the overall summary of the data collected are 14 females and 13 males all ranging from calf to adult.

Data

Recorded video footage of the Atlantic bottlenose dolphins housed at the Roatan Institute for Marine Sciences spawned 445 instances of pectoral fin contact. While more instances were recorded, every initiating and receiving dolphin is identified in the 445 instances so that no dolphin is unaccounted for. As footage was analyzed, specific information was recorded about each instance of pectoral fin contact. Included is the clip's file name, the time the instance occurred, the initiating dolphin, whether the right or left pectoral fin is initiating, the dolphin or object being touched by the pectoral fin, the area touched on the dolphin, and any comments about the behavioral status of the touch's occurrence. Any additional comments about the contact that may be important were also documented.

Pectoral fin contact was determined by an individual making an *intention* to touch another individual. This means that contact with another dolphin must be clear and concise. Sexual contact where both pectoral fins were constantly engaged or instances where behavior may have been influenced by outside forces where not recorded. A common example of outside influence is when several dolphins would swarm the camera upon its entry into the water and crowd the area. Other examples may include dolphins engaged in chase or aggression and ramming into one another. Most instances of pectoral fin contact occur when an individual clearly takes its pectoral fin and engages it on a part of another individual without other forces influencing the contact.

In this thesis, dolphins are identified as either the *initiator* or *receiver*. The *initiator* is the dolphin that makes first contact with his or her pectoral fin. The *receiver* is the dolphin or object that is touched on his or her body by the pectoral fin of the initiator. Of the 27 dolphins, only one female was recorded as being the *receiver* and never the *initiator*.

Contact on the receiver has been localized to the following places: head, topside, dorsal, lateral side, pectoral fin, underside, peduncle, and flukes. These areas are identified in *Figure 1*.

Pectoral fin contact is recorded based on where the interaction first occurs. For example, is determined to have occurred on the head since that is where the initial contact was made although contact may end on the receiver's lateral side. When it was noted that a pectoral fin was carrying an object (ie: seagrass), that specific fin was recorded.

Measures

After all data was collected, the summary in *Table I* was comprised of left and right pectoral fin initiations.

The measure for this data was Chi Square Goodness of Fit (One Sample Test). The null hypothesis is that there will be an even distribution of right and left handedness.

Results

Using chi square for the overall *Males*, it was found that: (x^2 = .192), our predetermined alpha level of significance (0.05), and our degrees of freedom (df =1). This shows that we can accept the null hypothesis that there is not dominance with either the left or right hand as there is an even statistical distribution. *Table II* shows these results.

Using chi square for the overall *Females*, it was found that: (x^2 = 1.03), our predetermined alpha level of significance (0.05), and our degrees of freedom (df =1). This shows that we can accept the null hypothesis that there is not dominance with either the left or right hand as there is an even statistical distribution. *Table III* shows these results.

Using chi square for the overall *Population*, it was found that: (x^2 = .99), our predetermined alpha level of significance (0.05), and our degrees of freedom (df =1). This shows that we can accept the null hypothesis that there is not dominance with either the left or right hand as there is an even statistical distribution. *Table IV* shows these results.

Discussion

Statistically, it seems that there may not be evidence of handedness within the population housed at the Roatan Institute for Marine Sciences. Those findings may have to do more with the approach to research than the true behavior of the dolphins. Regardless of the findings, this data may still open up a window into the unconscious functions of their behaviors.

While similar studies have found different results, I feel like there are a few issues with this project that could influence the results. With this study, there is an uneven distribution of pectoral fin contact between individuals. Ideally there would be an even number of pectoral fin contacts for each dolphin, but coding video footage is much more opportunistic than following the behaviors of each dolphin until a certain amount of contact could be attained. Each animal behaves differently, and some are more desensitized to the recording equipment utilized than others which causes there to be little footage for some animals versus others.

Personally, I feel that this seemingly ambidextrousness opens research up for a plethora of questions. This ambidextrousness may open research up for questions regarding their sleeping patterns. While sleep is still in research, it is known that cetaceans will shut down half of their brain during sleep and keep the other half awake. While one half of the body is getting restorative energy, the other half is on the alert for any sudden changes. Having a dominant pectoral fin could be disadvantageous for cetaceans during such a vulnerable state.

One can wonder if the behaviors occurring with the pectoral fins *need* a specialized fin. Among other cetaceans, research is looking at a broader scope of behavioral dominance such as if turning the body clockwise or counterclockwise reveals a preference instead of something so specialized as the pectoral fin (Marino & Stowe, 1997). Research is also on the rise about eye dominance and the influence it may have on behavior (Sakai et al., 2006). Overall, cetaceans present an incredible amount of behaviors for researchers to study and decode in the relatively young field of cetacean behavioral research.

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Tables

Initiator	Left Contact	Right Contact
Male	131	124
Female	102	88
Population	233	212
Males		
Anthony	9	6
Bill	5	4
Cortez	16	16
Dixon	4	7
French	6	6
Han	13	10
Hector	9	7
Ken	4	3
Mickey	14	13
Paya	6	6
Ritchie	5	4
Ronnie	5	4
Vin	26	23
Female		
Alita	10	10
Bailey	9	5
Carmella	0	0
Cedena	4	1
Fiona	9	8
Gracie	9	7
Luna	1	3
Margarita	9	11
Maury	7	8
Mika	7	4
Mrs. Beasley	6	0
Pigeon	18	14
Polly	7	6
Tilly	6	11

Table I: Left and Right Pectoral Fin Contact

Tables

	Observed	Expected
Left Hand	131	127.5
Right Hand	124	127.5
Sums	255	255

Table II: Chi Square Results of Pectoral Fin Contact for Males

	Observed	Expected
Left Hand	102	95
Right Hand	88	95
Sums	190	190

Table III: Chi Square Results of Pectoral Fin Contact for Females

	Observed	Expected
Left Hand	233	222.5
Right Hand	212	222.5
Sums	445	445

Table IV: Chi Square Results of Pectoral Fin Contact for Population

Figures

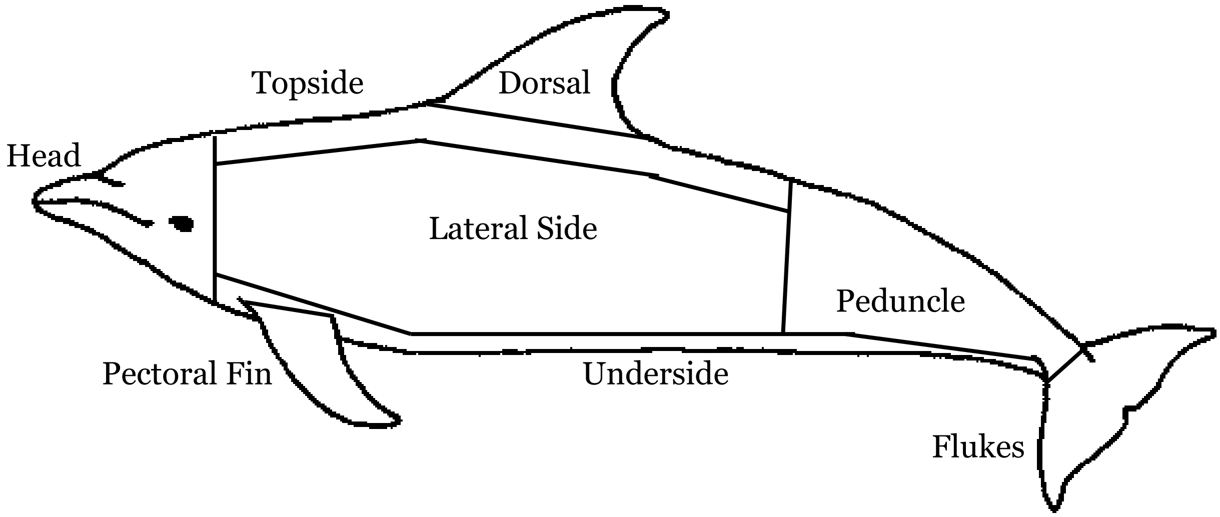

Figure 1: Atlantic bottle-nose dolphin Anatomy Diagram

Appendix A

Maternal Family Tree

Offspring arranged from oldest to youngest.