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Developmental and sexual variation in the external appearance of Fraser's dolphins (*Lagenodelphis hosei*)

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Abstract

Sexual and age-related patterns in the coloration and external morphology of Fraser's dolphins (*Lagenodelphis hosei*) were examined, based on a sample of 50 specimens from throughout the range. Although sample sizes were small, there appears to be significant variation among different age and sex classes. The dorsal fin becomes more erect in older animals, especially males, and most mature males develop a moderate to large post-anal hump. The intensity and thickness of the eye-to-anus stripe also becomes more exaggerated in adult males. The set of facial stripe referred to as the 'bridle' reaches its greatest development in adults of both sexes, and in some animals the various stripes merge to form a 'bandit mask' in the facial area. The patterns of variation seen in this species are similar to those reported earlier for a number of other small cetacean species.

Introduction

The external appearance of many species of small cetaceans varies with age, sex, and geographic area. If these variations are consistent and can be documented, then it may be possible to determine the age or sex of animals at sea, or the locality of specimens of unknown origin. For these reasons, studies of the variation in coloration and external morphological characteristics of small cetaceans are very useful. Unfortunately, such studies are rare in the literature (however, see Sergeant, 1962 and Yonekura *et al*., 1980 on pilot whales *Globicephala* spp.; Nishiwaki *et al*., 1963 on sperm whales *Physeter macrocephalus*; Perrin, 1972, 1975 and Perrin *et al*., 1991 on spinner dolphins *Stenella longirostris*; Robineau, 1984 on Commerson's dolphins *Cephalorhynchus commersonii*; Heimlich-Boran, 1986 on killer whales *Orcinus orca*; and Jefferson, 1990 and Amano & Miyazaki, 1993 on Dall's porpoises *Phocoenoides dalli*). Most of these species show sexual dimorphism, with males larger than females and possessing several secondary sexual characteristics. Recently, Perrin (1997) has used a complex of facial stripes in delphinoid cetaceans to infer possible systematic relationships.

Many small cetaceans show sexual dimorphism in the following features: dorsal fin shape, tail stock shape, size of the post-anal hump of connective tissue, and fluke shape. The sexual dimorphism, however, is not well quantified by standard measurements that are often taken on cetaceans (Norris, 1961). So, the best way to examine these features is not to examine sets of standard measurements, but instead to design specific measurements intended to measure the features of interest. Alternatively, specimens can be classified into various categories from examination of photographs.

Very little is known about the biology of Fraser's dolphin (*Lagenodelphis hosei*) (Perrin *et al*., 1994; Jefferson & Leatherwood, 1994). However, there have been suggestions in the literature that some of the types of sexual dimorphism mentioned above are apparent in this species (Jefferson & Leatherwood, 1994; Amano *et al*., 1996; Perrin, 1997). Also, the great variation in the intensity and development of the various color pattern components has been thought to be related largely to age and sex (Amano *et al*., 1996). The present study was undertaken to examine these issues.

Materials and methods

Because we did not have access to large numbers of specimens of Fraser's dolphins, we attempted to obtain photographs of as many specimens as possible. We used photographs in the published and unpublished literature, and solicited additional

*Deceased. Dr Leatherwood passed away on 25 January 1997.

Table 1. Summary of Fraser's dolphin specimens used in this study

Specimen no.	Origin	TL (cm)	Age/Sex	Mature?	Published reference(s)
N180	South Africa	221	IF	No	None
N395	South Africa	259	MM	Yes	None
N827	South Africa	226	IF	No	None
N831	South Africa	226	MF	Yes	None
N1773	South Africa	255	MM	Yes	None
N959	South Africa	240	MM	Yes	None
PBB71/3	South Africa	236	MF	Yes	Perrin *et al.* (1973)
PBB71/4	South Africa	264	MM	Yes	Perrin *et al.* (1973)
PBB72/2	South Africa	226	IF	No	Perrin *et al.* (1973)
JAMANOC	Japan	268	MM	Yes	Amano *et al.* (1996)
J72	Japan	244	MM	Yes	Amano *et al.* (1996)
J43	Japan	244	IM	No	Amano *et al.* (1996)
J1	Japan	235	MM	Unknown	Tobayama *et al.* (1973); Uchida (1982, 1994)
J2	Japan	208	IF	No	Uchida (1985, 1994); Kasamatsu & Miyashita (1991)
P12	Philippines	223	IM	Unknown	None
EMELDA	Philippines	224	MF	Yes	Leatherwood *et al.* (1992)
WFP745	Philippines	216	MF	Yes	None
WFP778	Philippines	218	MM	Yes	None
WFP779	Philippines	229	MM	Yes	None
WFP780	Philippines	109	C	No	None
WFP785	Philippines	108	C	No	None
WFP786	Philippines	222	MF	Unknown	None
WFP787	Philippines	232	MF	Yes	None
WFP788	Philippines	229	MF	Yes	None
WFP795	Philippines	240	MM	Yes	None
WFP799	Philippines	232	MM	Yes	None
WFP801	Philippines	104	C	No	None
WFP805	Philippines	195	IF	No	None
WFP806	Philippines	93	C	No	None
WFP826	Philippines	98	C	No	None
WFP831	Philippines	247	MM	Yes	None
WFP833	Philippines	228	MF	Yes	None
WFP834	Philippines	236	MF	Yes	None
4/19/91#14	Philippines	175	IM	Unknown	None
4/19/91#10A	Philippines	190	MF	Yes	None
2/12/92#9	Philippines	250	MF	Unknown	None
2/13/92#16	Philippines	210	IM	Unknown	None
TK452	W. Tropic. Pacific	184	IM	No	Miyazaki & Wada (1978); Kasuya (1984)
TK451	W. Tropic. Pacific	231	IF	No	Miyazaki & Wada (1978)
E1	E. Tropic. Pacific	ND	?	Unknown	None
LR22	E. Tropic. Pacific	226	UM	Unknown	Perrin *et al.* (1973)
LR23	E. Tropic. Pacific	110	C	No	Perrin *et al.* (1973, 1994); Leatherwood *et al.* (1976, 1982)
T1	Gulf of Mexico	235	IF	No	None
SV2LH	Caribbean Sea	226	UF	Unknown	Caldwell *et al.* (1976)
SV1	Caribbean Sea	210	IF	Unknown	Caldwell *et al.* (1976)
PR1	Caribbean Sea	227	IM	No	Mignucci (1989)
M1685	France	252	MF	Yes	Van Bree *et al.* (1986)
M1694	France	239	MF	Yes	Van Bree *et al.* (1986)
M1686	France	235	MM	Yes	Van Bree *et al.* (1996)
M1693	France	247	MM	Yes	Van Bree *et al.* (1986)

ones from colleagues who have had experience with this species (see Acknowledgements). We sorted the photographs and extracted those that had associated measurements and biological data, leaving a total of 50 specimens for analysis (Table 1).

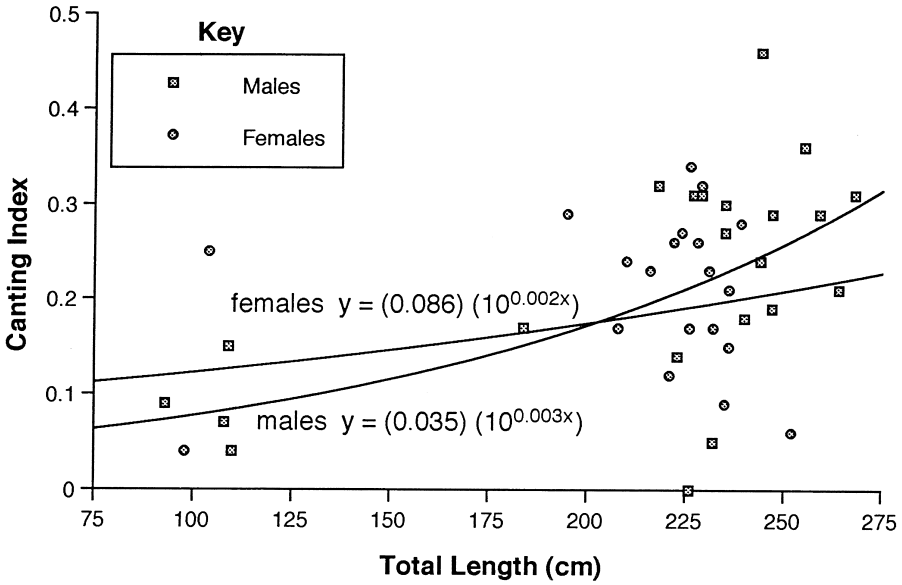

Figure 1. Development of the Canting Index in Fraser's dolphins.

Each specimen was assigned a unique specimen number and data on the intensity and degree of development of various aspects of the color pattern and body shape were scored on standard data sheets by TAJ. This scoring was done 'blind', i.e., without reference to the measurements or biological data. Relative measurements of the dorsal fin to calculate the Canting Index (following Jefferson, 1990) were taken from photographic prints or from projected slides, using rulers and dial calipers.

The terminology of Mitchell (1970) was used for color pattern components. Fraser's dolphins have essentially the same set of facial stripes as do common dolphins (*Delphinus* spp.). These are (with abbreviations from Fig. 2 of Mitchell, 1970): eye patch (ep), eye-to-apex stripe (eabs), apex-to-blowhole stripe (abbs), beak blaze (bb), lip patch (lp), and flipper stripe (fs). The facial stripes in Fraser's dolphins form a complex pattern, parts of which were called the 'bridle' by Mitchell (1970).

Because the facial stripes in Fraser's dolphins appear to be of similar level of intensity and development in any individual specimen, and often merge together, we analyzed them as a group. We call this complex the bridle, even though Mitchell (1970) reserved this term only for the eye-to-apex and apex-to-blowhole stripes.

Each specimen was placed into one of five age/sex classes: calf (C), immature female (IF), immature male (IM), mature female (MF), or mature male (MM). For most specimens, this was based on examination of gonads, but for some without reproductive data, we placed them into a class based on body length. Mature females were considered to be those over 215 cm, and mature males over 225 cm (see Amano *et al.*, 1996). Calves were classified as less than 150 cm, the approximate length at one year of age (see Amano *et al.*, 1996). Chi-square tests were used to test for statistical significance within age/sex classes; testing was only attempted for cases with sample sizes of 10 or greater.

Results

Although there was a great deal of variability, the dorsal fin became more canted in larger animals, especially so in males (Fig. 1). In adult males, the dorsal fin was usually erect, while in other age/sex classes it was generally falcate (Fig. 2a).

In all age/sex classes, except adult males, the post-anal hump tended to be either not present or only slightly developed. In adult males, it was always present and was slight to large in size; however the difference was not significant (Fig. 2b).

One of the most characteristic features of Fraser's dolphins is the dark, wide stripe that often runs from the eye to the anus (eye-to-anus stripe of Mitchell, 1970). In young animals, this was often not present or was faintly to moderately expressed and was thin to moderate in thickness (Fig. 3). Mature males had a stripe that appeared to be much darker and of moderate to thick width. In adult females, this feature was quite variable, and mature females could have dark, thick stripes, no stripes, or any combination in between (Fig. 3).

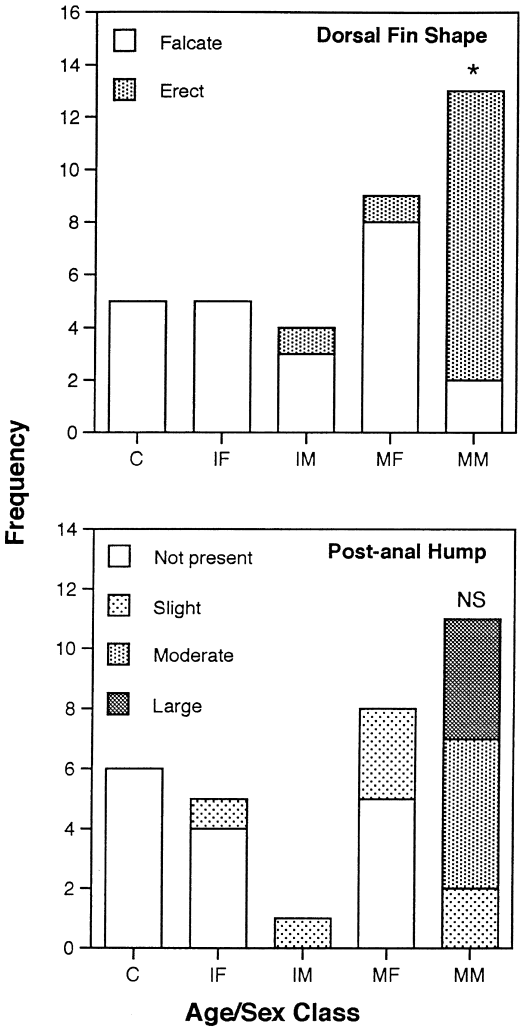

Figure 2. Dorsal fin shape and post-anal hump size in Fraser's dolphins.

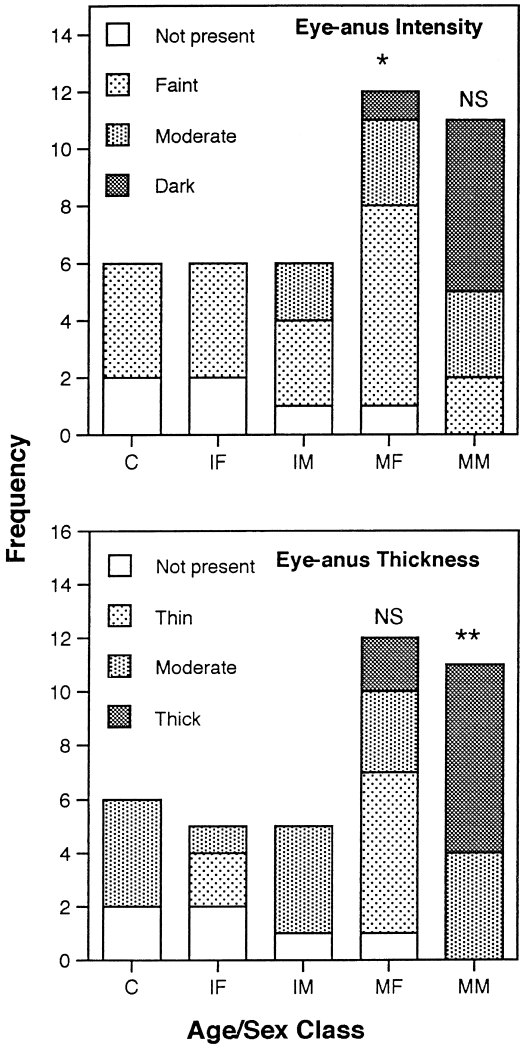

Figure 3. Intensity and thickness of the eye-to-anus stripe in Fraser's dolphins.

A prominent bridle could not be located on any of the six calves examined, but in most other specimens it was present (Fig. 4). In immature specimens it was only slightly to moderately developed, but in mature females it was more often dark. Adult males usually had thick and dark facial stripes, and this difference was significant (Fig. 4).

The development of the facial stripes reached their peak in some adults, in which they were so extensive as to have the various stripes merge with the eye-to-anus stripe to form a 'bandit mask' in the facial area (Fig. 5). In adult females, this was variable, but in adult males it was much more consistent.

Discussion

Fraser's dolphins have several other morphological and coloration features that may show sexual and developmental variation. For instance, Miyazaki & Wada (1978) suggested that the color pattern surrounding the urogenital opening may be sexually dimorphic. We attempted to examine this, but there were not enough photographs showing the ventral area to quantify it. However, we are of the opinion that this feature is individually variable, and may not be a reliable indicator of sex in this species.

There is an additional part of the facial stripe complex that may show significant variation. The stripes on the dorsal surface of the head (the

Figure 4. Intensity and thickness of the facial stripe complex in Fraser's dolphins.

blowhole and beak stripes) run from the blowhole to the tip of the rostrum (between the beak blazes). It is clear that there is much variation in their extent and intensity, but like Perrin (1997), we did not have enough information to examine quantitatively whether this variation was sexual or age-related.

Finally, the shape of the flukes shows variation, and from what we know of other species of cetaceans, such as sperm whales and Dall's porpoises (Nishiwaki *et al.*, 1963; Jefferson, 1990), we might expect this variation to be age and sex related. However, again the data and photographs available for this study were inadequate to properly quantify it. All of the above features should be examined in any future studies of external morphology and coloration of Fraser's dolphins.

The appearance of typical individuals in the various age/sex classes are illustrated in Fig. 6. The calves and immatures (especially females) tend to have a muted color pattern with only very slight expression of the eye-to-anus stripe and delphinid facial stripes. The dorsal fin tends to be falcate and there is generally little evidence of a post-anal hump. As the animals approach adulthood, these features tend to become more pronounced.

In mature females, the dorsal fin generally remains falcate and the post-anal hump is generally poorly-developed. The bridle becomes darker, but the lines are still relatively thin. The development of the eye-to-anus stripe in adult females appears to be highly variable. In some individuals (possibly younger ones) it does not appear to develop past its extent in immature females, but in others (possibly older ones) it becomes dark and relatively thick (although apparently it does not become as exaggerated as it does in adult males).

In mature males, the dorsal fin becomes erect (although apparently not canted forward, as in some spinner dolphins, killer whales, and Dall's porpoises) and the post-anal hump becomes more exaggerated. The eye-to-anus stripe reaches its greatest level of development, almost always being very dark and wide. Also, the facial stripes become wider and darker (see Perrin, 1997), and at the height of their development they may merge together and join the eye-to-anus stripe to form a so-called 'bandit mask'. A bandit mask such as this appears to be a good indication that the specimen is an adult.

The present study is highly preliminary. It has several shortcomings that should be discussed. First, it is not based on a homogeneous sample, but rather on dolphins from throughout the tropics, and the data and photographs were taken by many different individuals, thus increasing the possible effects of interobserver variability. Also, post-mortem darkening and lack of photographic quality may have made detection of some coloration features difficult. The latter is almost definitely a factor. Perrin (1997) mentioned that Fraser's dolphin calves show an 'eye spot' (=eye patch); however, we could not find this in our photographs of calves. Finally, the sample sizes are very small, and much larger sample sizes would be needed to increase the statistical power for detecting minor differences.

Despite the problems, some very clear trends are apparent in the patterns of coloration and external morphology examined. It seems probable that a study using a large sample of dolphins from the same geographical population, which minimized

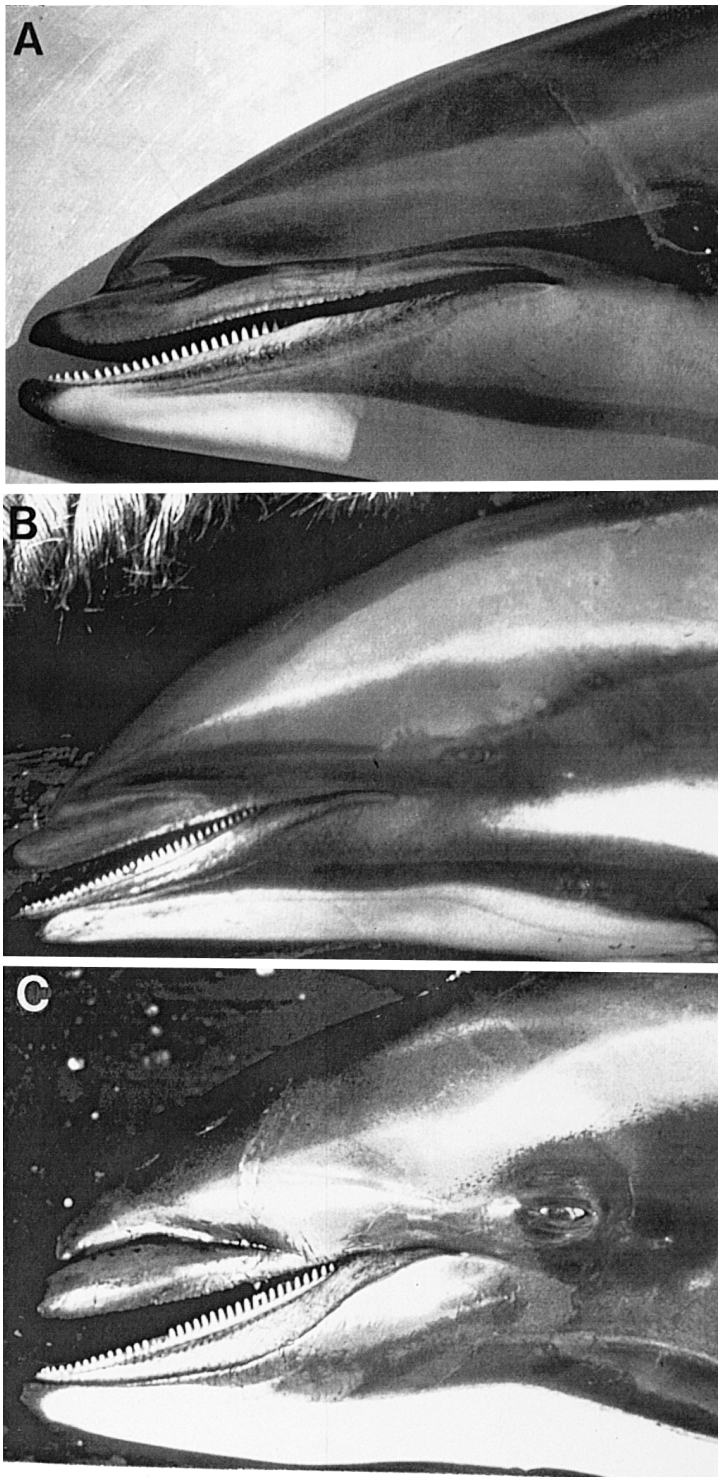

Figure 5. Extent and intensity of the facial stripe complex in an immature (A), adult female (B), and adult male (C) Fraser's dolphin, showing the formation of a 'bandit mask' in adults.

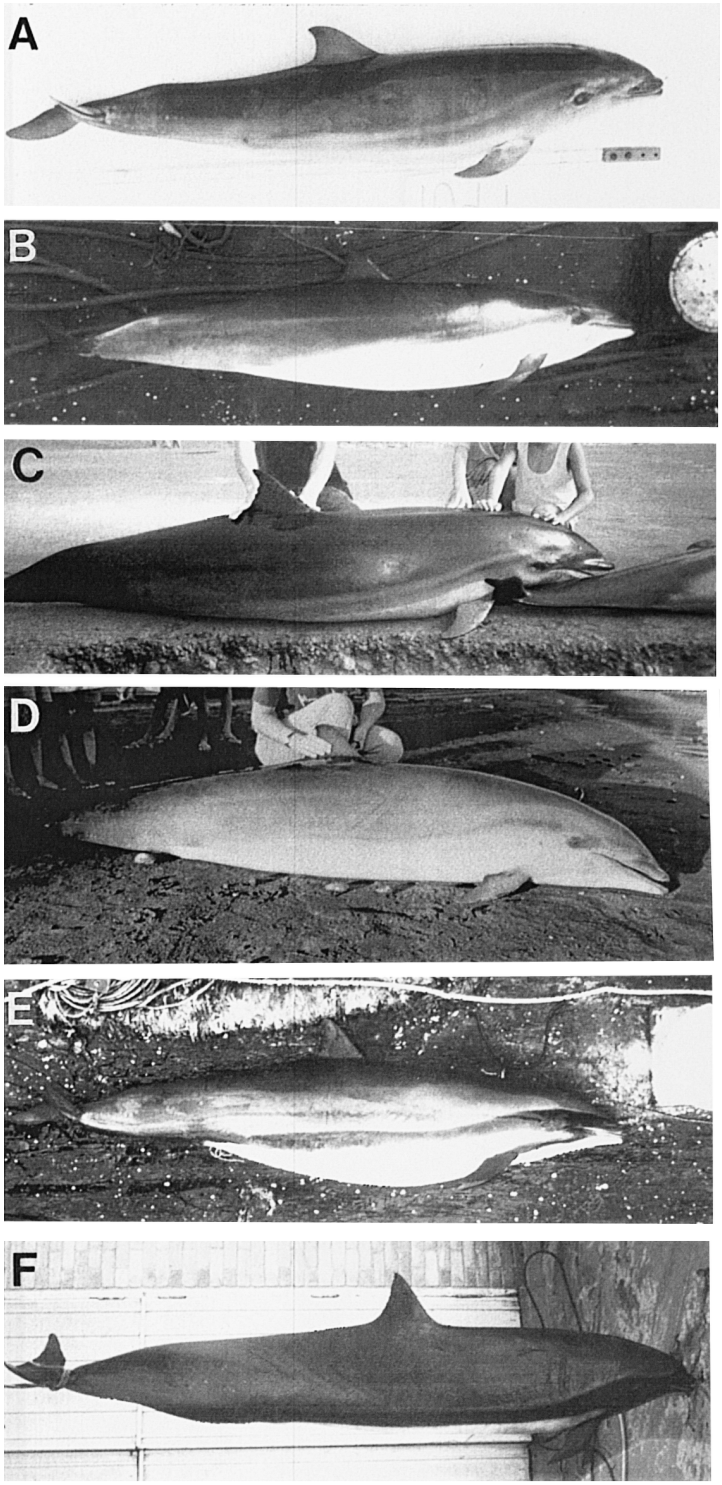

Figure 6. Typical appearance of different age/sex classes of Fraser's dolphins: calf (A), immature female (B), immature male (C), mature females (D and E), and mature male (F).

interobserver variability, would find even stronger patterns than are apparent here.

It is clear that the same type of sexual dimorphism as is found in a variety of other species of small cetaceans (see Jefferson, 1990; Amano *et al*., 1996) occurs in Fraser's dolphins. In particular, color pattern and morphological development and patterns of sexual dimorphism seem to be very similar to those in common dolphins (see Heyning & Perrin, 1994). This further supports the supposition of a close relationship between *Lagenodelphis* and *Delphinus* (Fraser, 1956). Perrin (1997) has stated that the pattern of head stripes suggests a close relationship between spinner, Clymene (*Stenella clymene*), common, and Fraser's dolphins.

It is probably possible to recognize adult male Fraser's dolphins reliably in sightings at sea, based on their sexually dimorphic color pattern and morphology components. If this is confirmed by future studies, using larger sample sizes, then this will be highly valuable in sighting surveys for Fraser's dolphins, and also in any future studies of social organization and behavioral ecology.

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