*THE RAFFLES BULLETIN OF ZOOLOGY* 2002 Supplement No. **10**: 105-113


# GROWTH AND REPRODUCTION OF THE FINLESS PORPOISE IN SOUTHERN CHINA

**Thomas A. Jefferson**
*Ocean Park Conservation Foundation, Ocean Park, Aberdeen, Hong Kong and Southwest Fisheries Science Center, NOAA, NMFS, P.O. Box 271, La Jolla, CA 92038 USA*

**Kelly M. Robertson**
*Southwest Fisheries Science Center, NOAA, NMFS, P.O. Box 271, La Jolla, CA 92038 USA*

**John Y. Wang**
*7250 Yonge Street, Unit 310, Thornhill, Ontario L4J 7X1, Canada*

***ABSTRACT.*** – We studied the growth and reproduction of finless porpoises in southern China, based on 86 specimens collected as strandings or fisheries bycatches in Hong Kong, southern Fujian Province, and Taiwan. Specimens were aged by sectioning and staining thin layers in the teeth, and counting dentinal and cemental growth layer groups (GLGs). There is a general darkening of the colour pattern from neonates through adults, and adults become relatively more slender. Growth is rapid in the first year and thereafter begins to level-off. There is evidence of some sexual dimorphism, with males growing somewhat larger than females. There is a distinct calving peak from October to January. Limited data on age and length at attainment of sexual maturity suggest that females reach maturity at about 137-150 cm and 5-6 years, and males at 138-154 cm and 4-5 years. The growth and reproductive parameters found in this study are similar to those determined previously for other populations of finless porpoises.

***KEY WORDS.*** – Finless porpoise, Hong Kong, Taiwan, Fujian Province, life history, growth, reproduction, sexual maturity.

## INTRODUCTION

Despite our general lack of knowledge on the biology of the finless porpoise (*Neophocaena phocaenoides*), there has been quite a bit of work done on the growth and reproductive biology of the species, mainly in China and Japan. Growth and reproductive parameters have been estimated, based largely on animals taken in fisheries (and to a lesser extent, based on observations of captive and stranded animals) for populations in the Inland Sea of Japan (Kasuya & Kureha, 1979; Kasuya et al., 1986); the Kyushu area of Japan (Mizue et al., 1965; Shirakihara et al., 1993); Ise Bay of Japan (Furuta et al., 1989); the Yellow and Bohai seas of China (Zhang, 1992; Gao & Zhou, 1993; Chang & Zhou, 1995); the Yangtze River (Chen et al., 1982; Zhang, 1992; Gao & Zhou, 1993; Chang & Zhou, 1995); the South China Sea (Gao & Zhou, 1993); and the coast of Pakistan (Harrison & McBrearty, 1974).

Growth and reproduction have also been investigated in most other species of the family Phocoenidae, including the harbour porpoise, *Phocoena phocoena* (see Møhl-Hansen, 1954; Fisher & Harrison, 1970; van Utrecht, 1978; Read, 1990a, b; Read & Gaskin, 1990; Sorensen & Kinze, 1994; Read & Hohn, 1995; Lockyer, 1995), Burmeister's porpoise, *Phocoena spinipinnis* (see Reyes & Van Waerebeek, 1995), vaquita, *Phocoena sinus* (see Hohn et al., 1996), and Dall's porpoise, *Phocoenoides dalli* (see Kasuya, 1978; Newby, 1982; Kasuya & Shiraga, 1985; Ferrero & Walker, 1999). Only the spectacled porpoise, *Phocoena dioptrica,* has not been studied. Comparisons of finless porpoise studies with the above studies have shown that the finless porpoise is a typical phocoenid, characterized by rapid early post-natal growth, early attainment of sexual maturity, and a short lifespan (see Gaskin et al., 1984).

The growth and reproduction of finless porpoises in southern China was investigated as part of a large-scale, multi-faceted study of the conservation biology of the finless porpoise population that occurs in Hong Kong waters. This study represents the first time that specimens from Hong Kong have been used in studies of finless porpoise life history. The only previous study for the South China Sea used only specimens from near the Xiongdi Islands (southern Fujian Province) (Gao & Zhou, 1993). Although the population structure of finless porpoises in southern China has not yet been resolved, here we assume that finless porpoises from Hong Kong, Taiwan, and southern Fujian Province belong to the same population.

## MATERIALS AND METHODS

***Sampling and Data Collection.*** – The overall sample consisted of 86 finless porpoise specimens, from which a minimum of approximate total length had been collected (Table 1). Most of the specimens were collected as beach-cast strandings from the coast of Hong Kong and Taiwan. Some were taken as incidental catches and were obtained from fishermen of Taiwan and Dongshan, southern Fujian Province, PRC. Total length for each specimen was measured in a straight line, using a taut tape measure or calipers, from the tip of the upper jaw to the notch in the tail flukes (Norris, 1961). Two to three teeth were collected from the middle of the lower jaw (or nearby in some cases) and stored in water or alcohol. Reproductive tracts were examined, and gonads were collected and stored in 10% formalin.

Some stranded specimens were very badly decomposed (codes 4 or 5 of the ranking system described by Geraci & Lounsbury, 1993). For most of these, decomposition was too advanced to properly analyze reproductive status, but some specimens for which an accurate length could still be obtained were used in the growth analyses. For some of these decomposed specimens, genders were determined genetically. The sample of specimens with at least length/age data consisted of a total of 58 specimens. The composition of the sample is summarized in Table 1. The sample included specimens of all length categories, with modes for larger specimens 120-170 cm in length (Fig. 1).

***Age Determination.*** – We aged 58 specimens; teeth from 3 others were prepared, but sections were inadequate to obtain a reliable age. Tooth aging was conducted at the Southwest Fisheries Science Center (NOAA, NMFS, La Jolla, CA, USA), generally following the procedures described by Myrick et al. (1983) and Hohn & Lockyer (1995). Teeth were decalcified in RDO™, a commercial rapid-decalcifying agent. Because finless porpoise teeth are small, immersion times in the RDO™ were short, approximately 3-6 hours depending on the length of the animal. The decalcified teeth were sectioned longitudinally into 25 μm-thick sections using a sledge-type sliding microtome, after freezing onto the microtome stage with Tissue Tech™. Sections through the center of the tooth, and encompassing the entire pulp cavity, were stained with Mayer's hematoxylin stain and mounted on glass slides.

Table 1. Detailed breakdown of the sample, showing the types of data available for the study.

| Type of data | Males | Females | Unknown | Total |
|---|---|---|---|---|
| Length only | 11 | 11 | 7 | 29 |
| Length + age | 14 | 18 | 4 | 36 |
| Length + maturity | 0 | 1 | 0 | 1 |
| Length + age + maturity | 14 | 5 | 1 | 20 |
| Total | 39 | 35 | 12 | |

Tooth sections were examined under a compound microscope (4X-40X power), without reference to specimen length or other biological data. We assumed that 1 GLG represented 1 year. This assumption is supported by studies of captive porpoises of known age (Kasuya et al., 1986). Growth layer groups (GLGs) were counted in the post-natal dentine. For some older specimens, the pulp cavity was completely occluded, making the GLGs indistinct. In these specimens cementum layers were counted and generally were used to assess the age of the individual. The teeth were read independently by the first two authors 3-4 times on separate days. After the readings were complete, both readers compared their data and agreed on an age for each specimen. If the readers' GLG counts did not agree, tooth sections were re-examined simultaneously by both readers and a final age was decided upon.

***Fitting of Growth Curves.*** – We used standard logarithmic, as well as Gompertz three-parameter least squares models (Laird, 1966; Kaufman, 1981) to fit growth curves to the age-at-length data, using the software STATISTICA for the Macintosh (StatSoft, Inc., 1994). The Gompertz model takes the general form:

$$S = A \exp(-b \exp(-k\,t))$$

where S = size (in this case, total length),
A = asymptotic length,
b = constant of integration,
k = growth rate constant, and
t = age.

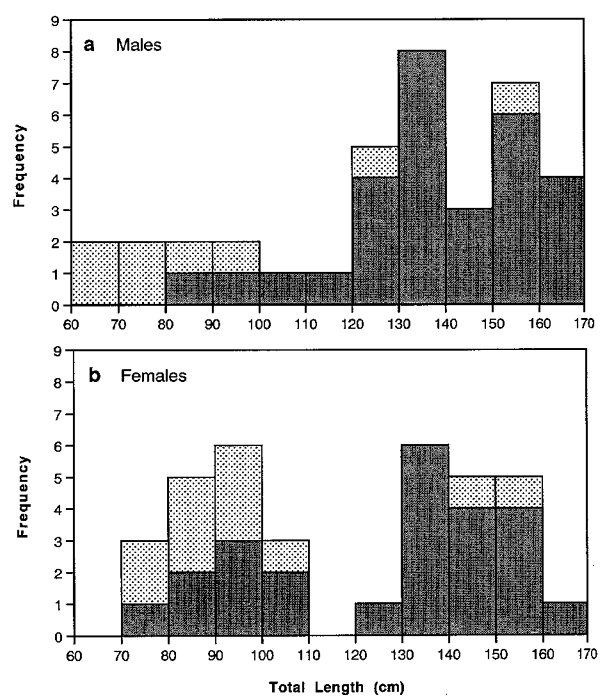


Fig. 1. Details of the sample used in this study. Light shading indicates unaged specimens and dark shading indicates aged specimens: males (a), and females (b).

Weight/length and other curves were fitted using a variety of models (including standard exponential and linear functions).

***Determination of Calving Seasonality.*** – Calving seasonality was determined by computing an estimated birthdate for each neonate (defined as < 100 cm in length) and fetus in the sample, based on the average length at birth along with fetal and early neonatal growth rates from the literature. Birthdates for neonates were estimated using 84 cm as the average length at birth, and the age at 1 year as 117 cm (after Gao & Zhou, 1993). Assuming linear growth in the first year, this translates to a first year growth rate of 2.75 cm/mo. For fetuses, linear growth was assumed during gestation. Assuming an 11 month gestation period (Gao & Zhou, 1993), this corresponds to a fetal growth rate of 7.64 cm/mo. The estimated month of birth was then calculated from the average length at birth and the appropriate growth rate.

***Assessment of Reproductive Status.*** – Ovaries and testes were processed according to the procedures described in Akin et al. (1993). Length and width measurements were taken with calipers to the nearest 0.1 cm and weight was obtained to the nearest 1.0 g. All corpora were counted and classified according to the system of Perrin et al. (1976), which is described in detail and figured in Akin et al. (1993). Sexual maturity for females was defined by the presence of at least one corpus luteum or corpus albicans, or the presence of a fetus in some females for which ovaries were not collected.

For males, a 1 $cm^2$ section was taken from the middle of the right testis and prepared histologically for detailed examination (Akin et al., 1993). Hematoxylin and Eosin stained slides were prepared by a commercial laboratory (A Cut Above Histology Lab, San Diego, CA). Stained testis sections were examined under a compound microscope (40X power), and sexual maturity was determined by the presence of products of spermatogenesis (stocytes, satids, and satozoa) and the size and shape of the seminiferous tubules and the interstitial space (see Hohn et al., 1985; Akin et al., 1993). Five tubule diameters were measured in microns at 40X using a micrometer disc (later converted to μm) for each specimen, and the mean of these five measurements was used as the average tubule diameter. Specimens were classified as immature (state 1), maturing/prepubescent (state 2), or mature (state 3), based on a subjective assessment of all of the above (after Collet & Saint Girons, 1984).

## RESULTS

***Growth.*** – Finless porpoises in southern China can be classified into a number of age/sex classes (Fig. 2). Neonates are characterized by relatively large flippers, a shallow forehead, lighter colour than adults, a very light patch around the lips, and a gape-to-flipper stripe (Fig. 2a). Very young newborns may still show prominent fetal folds. Juveniles have a steeper forehead, are light gray in colour (or sometimes fawn), and still show the prominent light lip patch and dark gape-to-flipper stripe (Fig. 2b). Subadults are nearly the size of adults, with steep foreheads, and show a varying darkness of body coloration; the light lip patch is less prominent, but the gape-to-flipper stripe may still be obvious (Fig. 2c,d). Adults are uniformly dark gray (almost black in some specimens), with no light lip patch, and with steep or overhanging foreheads (Fig. 2e). The increase in maximum girth slows down as specimens get larger (Fig. 3), which results in neonates and juveniles appearing relatively robust and large adults looking relatively slender. We found no evidence of sex-related differences in coloration or external morphology.

Growth curves were constructed, based on age-at-length data for 56 specimens (28 males, 23 females, and 5 animals of unknown sex) (Fig. 4). Separate curves were plotted for males and females, and showed some evidence of sexual dimorphism, with males growing larger than females (Fig. 4a). Stratified sample sizes for each sex were relatively small (some specimens were unsexed), and the logarithmic curve did not fit the female data well for older specimens. Therefore, a single, sex-independent growth curve was also

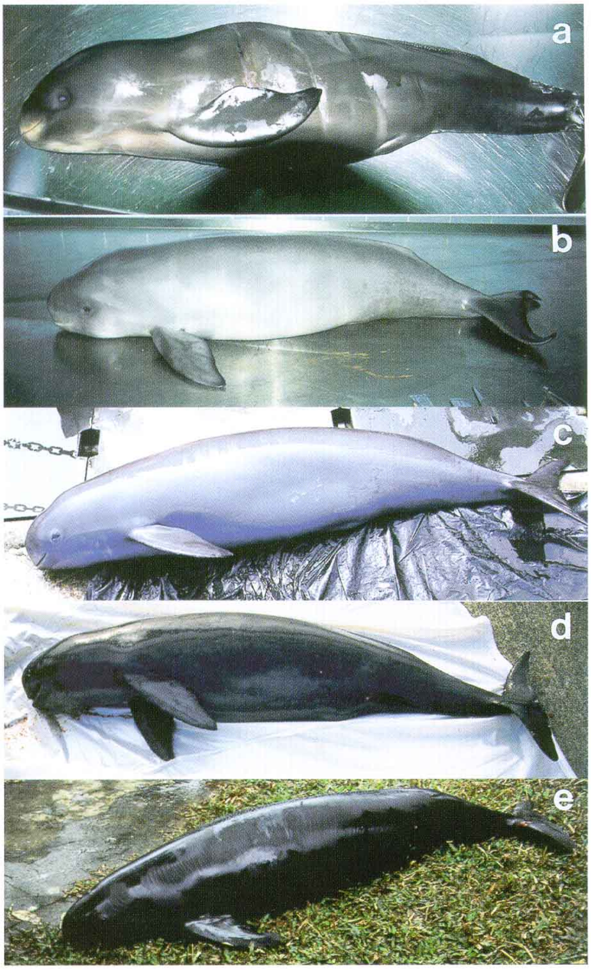


Fig. 2. Development of external appearance of finless porpoises from Hong Kong: 67-cm male neonate (NP96-23/01 - a); 84-cm male calf (NP96-25/04 - b); 124-cm, 2.5-year old juvenile male (NP00-12/02 - c); 137-cm, 4-year old subadult male (NP97-11/10 - d); and 168-cm, 13-year old adult male (NP96-12/01 - e).

constructed, using the combined male and female data, as well as data from several unsexed specimens (Fig. 4b). A Gompertz model (which assumes asymptotic growth) fit the pooled-sex data well. An asymptote was reached at 161 cm and 13 GLGs. Growth during the first year was extremely rapid and linear, and the growth rate decreased significantly after the first several years (Fig. 4). The oldest specimen in the sample (a female) was estimated to be 33 years old.

The length vs. weight relationship appeared to be linear (Fig. 5). Newborns appeared to weigh about 5 kg, and the maximum weight reached by specimens in the sample was 52 kg. Based on this curve, the largest specimens in the population (about 168-170 cm) probably reach weights of at least 60 kg.

***Reproduction.*** – The distribution of the estimated month of birth for neonates and fetuses showed clear evidence of reproductive seasonality (Table 2; Fig. 6). Although a few births occurred in other months, 77% (17 of 22) were estimated to occur in the late autumn and early winter months of October to January.

Data on sexual maturity for specimens over 120 cm in length were available for six females and 11 males (Table 3). For females, one specimen aged 5 years and 137 cm in length, was immature. The rest, all 6 years or older and at least 150 cm in length, were mature. This small sample suggests that females reach sexual maturity at ages between 5 and 6 and lengths between 137 and 150 cm.

For males, five specimens (aged 2-4 and 124-138 cm) were immature or maturing, and six others (aged 4.5-13 and 154-168 cm) were mature (Table 3). There was a rapid increase in testis weight between specimens < 140 cm and those > 154 cm (Fig. 7). All immature or maturing males had single testis weights < 30 g and all mature males had testis weights of > 200 g. Unfortunately, there were no specimens between 140 and 154 cm to allow us to define more precisely the length at which the rapid increase occurs. Immature and maturing male specimens had average seminiferous tubule diameters of < 80 μm, and mature males had diameters of > 130 μm (Fig. 8). Collectively, these data suggest that male sexual maturity is reached at between 4 and 5 years and between 138 and 154 cm.

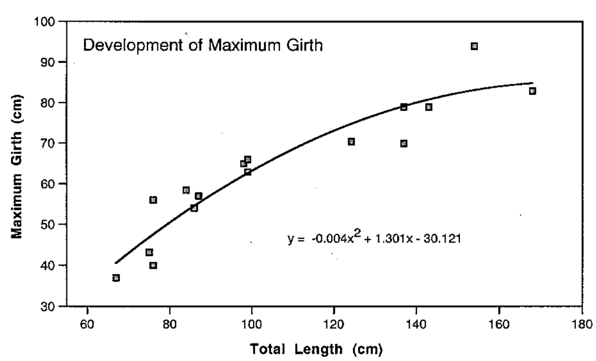


Fig. 3. Curve showing development of maximum girth for southern Chinese finless porpoises.

## DISCUSSION

***General Discussion.*** – Overall, the growth and reproductive parameters determined in this study fit in well with other

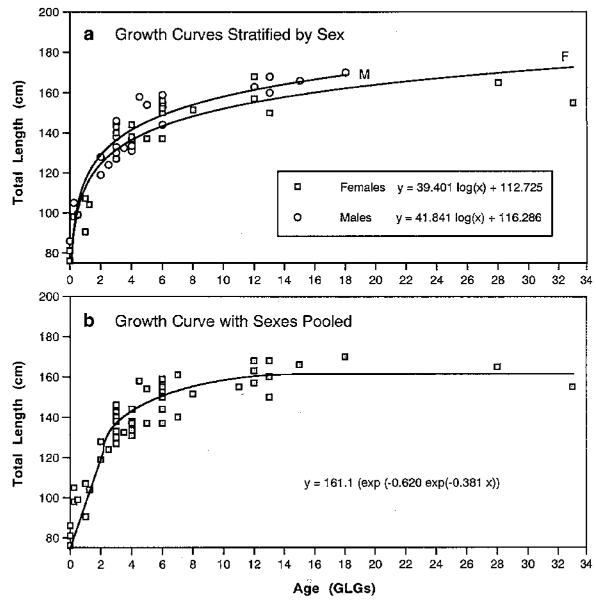


Fig. 4. Growth curves for southern Chinese finless porpoises, with the sexes stratified (a), and with both sexes pooled along with unsexed specimens (b).

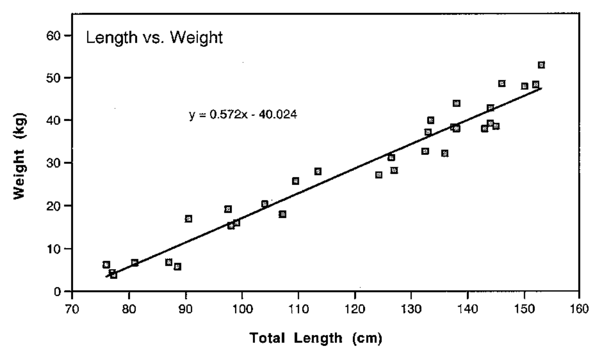


Fig. 5. Length vs. weight relationship for southern Chinese finless porpoises.

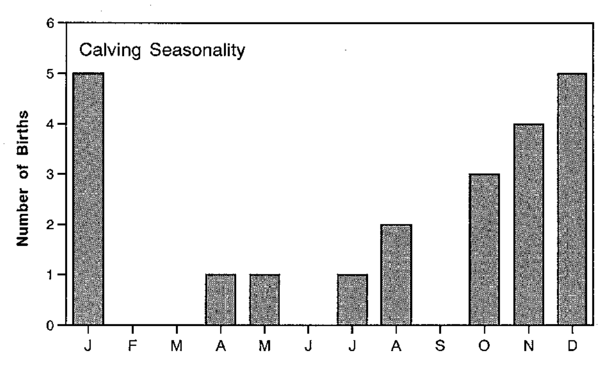


Fig. 6. Bar graph showing the predicted month of birth for southern Chinese finless porpoise fetuses and neonates.

studies of finless porpoises, and with studies of porpoises (family Phocoenidae) in general. Phocoenids are known to be relatively short-lived, with early development and relatively 'r-selected' growth and reproductive features.

One finding of particular interest is the presence in the sample of two old individuals (28 and 33 years). An examination of the literature on phocoenid age and growth (see review in Gaskin et al., 1984) suggests that these are the two oldest specimens ever recorded in the family Phocoenidae. This finding may suggest that finless porpoises live longer than other species in the family. However, we suggest that the explanation may lie, at least partially, in sampling bias. Most previous studies of porpoise life history have been of populations that had been exploited by fisheries for many years, which might result in few animals reaching their maximum possible longevity. Our sample of finless porpoise specimens, on the other hand, contained a large proportion of stranded specimens. As such, we might expect that our sample would have a higher chance of containing older individuals. We should caution the reader that this is only one possible explanation, and there are certainly others.

It should be cautioned that our estimate of asymptotic length is based on both sexes pooled, and we consider it to be highly preliminary. There were no old males in the sample (the oldest was 17 years), and therefore a reliable estimate of the sex-stratified asymptotic length is not possible at this point. This is something that will be examined in future studies based on larger samples, but in the mean time we present the sex-pooled asymptotic length estimate (161 cm) as a tentative figure.

Table 2. Summary of fetuses and neonates, and estimates of their date of birth.

| Collection Locality | Age Class | Length (cm) | Collection Date | Estimated Birth |
|---|---|---|---|---|
| Hong Kong | Fetus | 70 | 1 October | November |
| Hong Kong | Fetus | 87 | 15 November | November |
| Hong Kong | Neonate | 67 | 23 January | January |
| Hong Kong | Neonate | 67 | 7 January | January |
| Hong Kong | Neonate | 75 | 4 January | January |
| Hong Kong | Neonate | 76 | 15 December | December |
| Hong Kong | Neonate | 76 | 10 October | October |
| Hong Kong | Neonate | 77 | 26 May | May |
| Hong Kong | Neonate | 77.3 | 12 January | January |
| Xiamen | Neonate | 82 | January | January |
| Hong Kong | Neonate | 83 | 2 November | November |
| Hong Kong | Neonate | 84 | 25 April | April |
| Hong Kong | Neonate | 86 | 14 January | December |
| Hong Kong | Neonate | 87 | 15 January | December |
| Hong Kong | Neonate | 87 | 21 November | October |
| Hong Kong | Neonate | 88.5 | 31 August | July |
| Xiamen | Neonate | 90.5 | February | December |
| Hong Kong | Neonate | 94 | 9 March | November |
| Xiamen | Neonate | 96 | December | August |
| Hong Kong | Neonate | 98 | 4 January | August |
| Hong Kong | Neonate | 99 | 18 May | December |
| Hong Kong | Neonate | 99 | 9 April | October |

We were surprised to find that a linear function fit the length vs. weight data better than an exponential or power curve (Fig. 5). However, this may be explained by the fact that finless porpoises become proportionately more slender as they grow (Fig. 3). Thus, as the animals get longer, their increasing slenderness may counteract the tendency for weight to increase exponentially. It should also be recognized that our largest specimens in the analysis were < 155 cm, and that larger specimens may show more evidence of a power relationship. We plan to examine this in the future with a larger dataset.

In the histological examination of testes and ovaries, we found that the advanced level of decomposition of some specimens (codes 3 and 4) did not seriously hinder our ability to assess their reproductive status. This was a welcome finding, as we are limited mostly to stranded specimens for

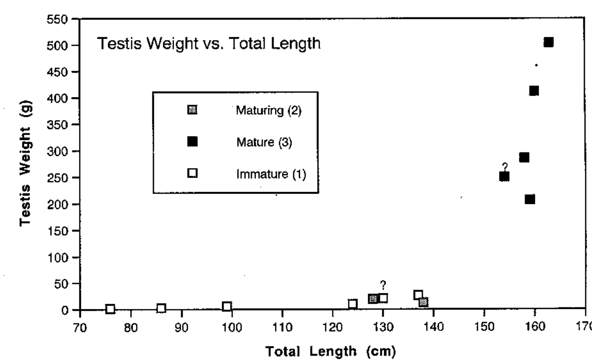


Fig. 7. Plot showing development of testis weight with length for southern Chinese finless porpoises. The two symbols with question marks indicate specimens in which maturity was not evaluated based on histological examination of gonads.

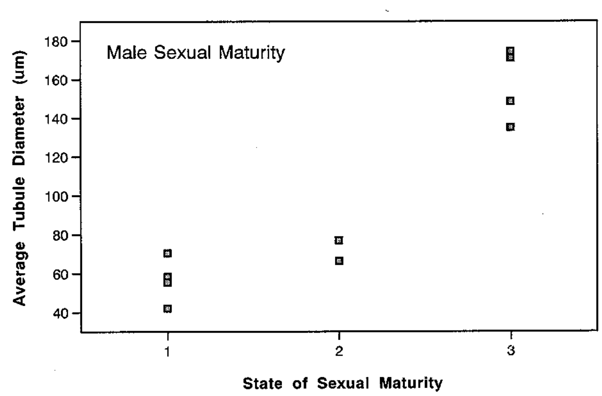


Fig. 8. Seminiferous tubule diameter vs. state of sexual maturity for southern Chinese finless porpoises. Maturity states: 1 = immature, 2 = maturing, and 3 = mature. Since our criteria for determining state of sexual maturity was based partly on average tubule diameter, there may be some element of circularity.

Table 3. Summary of finless porpoise specimens >120 cm in length, in which sexual maturity was assessed by examination of reproductive tracts.

| Specimen # | Age (GLGs) | Length (cm) | Status | Comments |
|---|---|---|---|---|
| | | | FEMALES | |
| NP96-08/03 | 5 | 137 | Immature | No *corpora* on ovaries |
| N14 | 6 | ca. 150 | Mature | Pregnant |
| NP97-23/01 | 12 | 157 | Mature | Large *corpus luteum* (13.9 X 8.8 mm) |
| NP98-15/11 | 12 | 168 | Mature | Pregnant |
| NP96-13/01 | 13 | 150 | Mature | Uterus enlarged and engorged with blood |
| NP97-26/01 | nd | 150 | Mature | Uterus enlarged and engorged with blood |
| | | | MALES | |
| NP96-13/03 | 2 | 128 | Maturing | Testis weight = 20 g |
| NP00-12/02 | 2.5 | 124 | Immature | Testis weight = 10 g |
| NP96-08/01 | 3 | 138 | Maturing | Testis weight = 13 g |
| NP98-23/06 | 3 | 130 | Immature or maturing? | Testis weight = 21 g |
| NP97-11/10 | 4 | 137 | Immature | Testis weight = 27 g |
| NP98-06/03 | 4.5 | 158 | Mature | Testis weight = 286 g |
| NP99-16/07 | 5 | 154 | Mature? | Testis weight = 250 g |
| NP99-17/02 | 6 | ca. 159 | Mature | Testis weight = 207 g |
| NP99-17/11 | 12 | 163 | Mature | Testis weight = 504 g |
| NP99-30/01 | 13 | 160 | Mature | Testis weight = 412 g |
| NP96-12/01 | 13 | 168 | Mature | Testis weight = >500 g<br>Testis length = 28 cm |

life history studies, and these specimens are often badly decomposed.

***Geographical Variation in Growth and Reproductive Parameters.*** – A comparsion of some finless porpoise growth and reproductive parameters among populations is presented in Table 4. Although some apparent differences may simply reflect different study techniques and biases, some aspects show apparent geographical variation among different populations of this species. For instance, the maximum length from each area (except for Pakistan) is based on a relatively large sample, so these differences are probably real. As noted by Kasuya (1999), these differences follow a predictable pattern, with the largest size reached by the northernmost populations along the northern China coast, and the smallest apparently reached by the more tropical populations in Hong Kong and probably Pakistan.

There is some question as to whether the maximum size of 155 cm from Pakistan is indeed typical of growth in the Indian Ocean populations. To examine this, we searched the literature for records of finless porpoises from the Indian Ocean and Southeast Asia south of China, in which the total lengths of specimens were reported. Reported lengths (n = 75) ranged from 58-180 cm (Murray, 1884; Keswal, 1886; van Bemmel, 1939; Dawson, 1959; Pilleri & Gihr, 1972, 1974; Harrison & McBrearty, 1974; Al-Robaae, 1975; Balan, 1976; Thomas, 1983; Tas'an & Leatherwood, 1984; James & Lal Mohan, 1987; James et al., 1987; Leatherwood & Reeves, 1989; Ganapathy, 1992; Nammalwar et al., 1994; Lal Mohan, 1995; Muthiah, 1995; Mahakunlayanakul, 1996; Robineau & Fiquet, 1996; Rudolph et al., 1997; Andersen & Kinze, 1999; Chantrapornsyl et al., 1999; TAJ unpubl. data). However, only two specimens were reported to be over 158 cm in length, both from India; they were both reported to be 180 cm (Thomas, 1983). Both of these measurements are highly suspect, however. It is possible that the measurements were taken over the curve of the body, rather than in a straight line. Also, the measurements reported in Thomas' (1983) paper were almost all in 5-cm intervals. Thus, it is likely that these were simply estimates (or were at least rounded), rather than true measurements. We think these measurements should be treated as inaccurate. If we exclude these two questionable lengths, the longest specimen reliably measured from the Indian Ocean and tropical southeast Asia appears to be 158 cm.

One reproductive parameter that appears to be highly variable is the calving season. In various populations, calving apparently peaks in summer, spring, or winter. This is considered to be a real difference, and is probably related to local conditions (calving presumably peaking at a time of year that is favorable for newborn calves and mothers with greater nutritional requirements). The gestation period, on

Table 4. Summary of reproductive parameters estimated for various finless porpoise populations. Zhang (1992) is not included, because that study mixed information from the Yangtze River and North China coastal populations. ASM refers to age at sexual maturity and LSM length at sexual maturity.

| Parameter | Japan | N. China Coast | Yangtze River | Hong Kong/ S. China Sea | Southern China | Pakistan |
|---|---|---|---|---|---|---|
| Neonatal length (cm) | 79 [a]<br>78 [b]<br>75-85 [c] | 77 | 73 | 84 [d] | 70-75 [d] | > 77 [d] |
| Min. male ASM (yr.) | 3 [a]<br>4 [b] | 5.5 | 5.8 | 4 | 4 [d] | — |
| Min. female ASM (yr.) | < 4 [a]<br>5 [b] | 5 | 5.5 | 5 | 5 [d] | — |
| Min. male LSM (cm) | 145 [a]<br>135 [b] | 132 | 136 | 151 | 138 [d] | 140 [d] |
| Min. female LSM (cm) | < 140 [a]<br>135 [b] | 132 | 135 | 145 | 137 [d] | 120 [d] |
| Asymptotic length female (cm) | 157.7[b] | ca. 152 | ca. 146 | ca. 158[e] | ca. 161[e] | — |
| Asymptotic length male (cm) | 165.5[b] | — | — | ca. 158[e] | ca. 161[e] | — |
| Maximum length (cm) | 194 [a]<br>175 [b]<br>194 [c] | 227 | 177 | 171 | 168 | 155 [d] |
| Maximum age (yr.) | 23 | 25 | 18 | 22 | 33 | — |
| Gestation period (mo.) | 10.6-11.2 | 10.4-11.1 | 10.1-10.8 | 10.9-11.5 | — | — |
| Calving season | Apr.-Aug. [a]<br>Nov.-Dec. [b]<br>April [c] | Apr. | Mar.-May | Jun.-Mar. | Oct.-Jan. | — |
| Reference(s) | Kasuya & Kureha, 1979; Kasuya et al. 1986; Furuta et al., 1989; Shirakihara et al., 1993; Kasuya, 1999 | Chang & Zhou, 1995; Wang, 1989 | Chang & Zhou, 1995 | Gao & Zhou 1993 | This study | Harrison & McBrearty, 1974 |

a Estimate for Inland Sea population.
b Estimate for Kyushu populations (Omura Bay and Tachibana/Araike Sound).
c Estimate for Ise Bay population.
d Estimate is based on a very small sample, and should therefore be considered preliminary.
e Estimate for both sexes pooled.

the other hand, does not appear to be highly variable (see Perrin & Reilly, 1984).

This study has provided some detailed information on life history of the finless porpoise in the northern South China Sea off southern China, a previously poorly-studied part of its range. The descriptions we provide of finless porpoise age and sex classes may be of use in future ecological and behavioral studies. While this study has clarified many aspects of growth and reproduction of these animals in this area, the limitations of the sample (small to moderate sample sizes, and advanced level of decomposition of many of the specimens) have prevented us from examining many finer details. We hope that the increased interest in the finless porpoise in recent years will result in additional studies and the availability of fresher specimens. These in turn will hopefully be used to effectively manage and conserve the populations of this species.

## ACKNOWLEDGEMENTS

This study was funded by the Hong Kong Agriculture, Fisheries and Conservation Department. We thank E. C. M. Parsons for collecting some of the Hong Kong specimens, and for his assistance with the age determination work. Thanks also to Z. Huang, and W. Liu for providing data and specimens collected from fishermen in Fujian Province, and to L. S. Chou and her students for providing data and specimens from Taiwan. We are grateful to S. Chivers for aiding us in the examination of histological slides to determine sexual maturity, and to A. Rosenberg for assistance with genetic gender determination. Many people were involved in collection of the data and samples, and we would like thank them all. In particular, I. Beasley, M. Torey, S. Hung, and L. Law, were heavily involved. S. Chivers and T. Kasuya reviewed an earlier draft of the manuscript.

## LITERATURE CITED

Akin, P. A., K. M. Peltier & R. B. Miller, 1993. Techniques for the preparation and examination of reproductive samples collected from dolphins in the eastern tropical Pacific. *NOAA Tech. Memo. NMFS SWFSC,* **192**: 26 pp.

Al-Robaae, K., 1975. *Neophocaena phocaenoides* Asiatic black finless porpoise: a new record for the Arab Gulf. *Bull. Basrah Nat. Hist. Mus.*, **2**: 47-49.

Andersen, M. & C. C. Kinze, 1999. Annotated checklist and identification key to the whales, dolphins, and porpoises (order Cetacea) of Thailand and adjacent waters. *Nat. Hist. Bull. Siam Soc.*, **47**: 27-62.

Balan, V., 1976. A note on a juvenile Indian porpoise *Neomeris phocaenoides* (Cuvier) caught off Calicut. *Indian J. Fish.*, **23**: 263-264.

Bemmel, A. C. V. van, 1939. De Indische bruinvisch. *De Tropische Natuur*, **28**: 91-94 (in Dutch).

Chang, Q. & K. Zhou, 1995. The growth and reproduction of finless porpoise, *Neophocaena phocaenoides*, in the Yangtze River and Yellow/Bohai Sea. *J. Nanjing Normal Univ. (Nat. Sci.)* **18** (Suppl.): 114-124.

Chantrapornsyl, S., K. Adulyanukosol & K. Kittiwattanawong, 1999. Stranded cetaceans from Thailand. *IBI Rep.*, **9**: 55-72.

Chen, P., R. Liu & R. J. Harrison, 1982. Reproduction and reproductive organs in *Neophocaena phocaenoides* from the Yangtze River. *Aquat. Mamm.*, **9**: 9-16.

Collet, A. & H. St. Girons, 1984. Preliminary study of the male reproductive cycle i common dolphins, *Delphinus delphis*, in the eastern North Atlantic. *Rep. Int. Whal. Comm. Spec. Iss.*, **6**: 355-360.

Dawson, E., 1959. On a large catch of the finless black porpoise *Neomeris phocaenoide* (Cuvier). *J. Mar. Biol. Assoc. India*, **1**: 259-260.

Ferrero, R. C. & W. A. Walker, 1999. Age, growth, and reproductive patterns of Dall's porpoise (*Phocoenoides dalli*) in the central North Pacific Ocean. *Mar. Mamm. Sci.*, **15**: 273-313.

Fisher, H. D. & R. J. Harrison, 1970. Reproduction in the common porpoise (*Phocoena phocoena*) of the North Atlantic. *J. Zool.*, **161**:471-486.

Furuta, M., T. Kataoka, M. Sekido, K. Yamamoto, O. Tsukuda & T. Yamashita, 1989. Growth of the finless porpoise *Neophocaena phocaenoides* (G. Cuvier, 1829) from the Ise Bay, central Japan. *Ann. Rep. Toba Aquarium*, **1**: 89-102.

Ganapathy, A., 1992. On a porpoise (*Neophocaena phocaenoides*) stranded along Palk Bay coast, near Thondi, Tamil Nadu. *Cent. Mar. Fish. Inform. Serv., Tech. Exten. Ser.,* **117**: 17.

Gao, A. & K. Zhou, 1993. Growth and reproduction of three populations of finless porpoise, *Neophocaena phocaenoides*, in Chinese waters. *Aquat. Mamm.*, **19**: 3-12.

Gaskin, D. E., G. J. D. Smith, A. P. Watson, W. Y. Yasui & D. B. Yurick, 1984. Reproduction in porpoises (Phocoenidae): implications for managment. *Rep. Int. Whal. Comm. Spec. Iss.*, **6**: 135-148.

Geraci, J. R. & V. J. Lounsbury, 1993. *Marine Mammals Ashore: A Field Guide for Strandings.* Texas A&M Sea Grant, 305 pp.

Harrison, R. J. & D. A. McBrearty, 1974 (1973). Reproduction and gonads of the black finless porpoise, *Neophocaena phocaenoides. Invest. Cetacea*, **5**: 225-230.

Hohn, A. A., S. J. Chivers & J. Barlow, 1985. Reproductive maturity and seasonality of male spotted dolphins, *Stenella attenuata*, in the eastern tropical Pacific. *Mar. Mamm. Sci.*, **1**: 273-293.

Hohn, A. A. & C. Lockyer, 1995. Protocol for obtaining age estimates from harbour porpoise teeth. *Rep. Int. Whal. Comm. Spec. Iss.*, **16**: 494-496.

Hohn, A. A., A. J. Read, S. Fernandez, O. Vidal & L. T. Findley, 1996. Life history of the vaquita, *Phocoena sinus* (Phocoenidae, Cetacea). *J. Zool.*, **239**: 235-251.

James, P. S. B. R. & R. S. Lal Mohan, 1987. The marine mammals of India. *Mar. Fish. Inform. Serv.*, **71**: 1-13.

James, P. S. B. R., A. P. Lipton, J. P. Karbari, M. Mohan, R. S. Lal Mohan, M. S. Rajagopalan, G. Gopakumar, M. E. Rajapandian, S. Krishna Pillai, M. Sivadas, P. Nammalwar & G. Radhakrishnan, 1987. Investigations on whales, dolphins and dugongs (FB/PR/14). *Central Mar. Fish. Res. Inst., Cochin, Ann. Rep.*, **1986-87**: 29-30.

Kasuya, T., 1978. The life history of Dall's porpoise with special reference to the stock off the Pacific coast of Japan. *Sci. Rep. Whales Res. Inst.*, **30**: 1-63.

Kasuya, T., 1999. Finless porpoise *Neophocaena phocaenoides* (G. Cuvier, 1829). In: S. H. Ridgway & R. Harrsion (ed.), *Handbook of Marine Mammals, Vol. 6: The Second Book of Dolphins and the Porpoises*. Pp. 411-442. Academic Press.

Kasuya, T. & K. Kureha, 1979. The population of finless porpoise in the Inland sea of Japan. *Sci. Rep. Whales Res. Inst.*, **31**: 1-44.

Kasuya, T. & S. Shiraga, 1985. Growth of Dall's porpoise in the western North Pacific and suggested geographical growth differentiation. *Sci. Rep. Whales Res. Inst.*, **36**: 139-152.

Kasuya, T., T. Tobayama, T. Saiga & T. Kataoka, 1986. Perinatal growth of delphinoids: information from aquarium reared bottlenose dolphins and finless porpoises *Sci. Rep. Whales Res. Inst.*, **37**: 85-97.

Kaufmann, K. W., 1981. Fitting and using growth curves. *Oecologia*, **49**: 293-299.

Keswal, 1886. Waters of western India. Part II.-Konkan and coast. *J. Bombay Nat. Hist. Soc.*, **1**:153-175.

Laird, A. K., 1966. Postnatal growth of birds and mammals. *Growth*, **30**: 349-363.

Lal Mohan, R. S., 1995. Age determination of dolphins entangled in gillnets along the Kerala coast. *J. Bombay Nat. Hist. Soc.*, **92**: 77-80.

Leatherwood, S. & R. R. Reeves, 1989. Marine mammal research and conservation in Sri Lanka 1985-1986. *UNEP Mar. Mamm. Tech. Rep.*, **1**, 138 pp.

Lockyer, C., 1995. Investigation of aspects of the life history of the harbour porpoise, *Phocoena phocoena*, in British waters. *Rep. Int. Whal. Comm. Spec. Iss.*, **16**: 189-198.

Mahakunlayanakul, S., 1996. *Species distribution and status of dolphins in the inner Gulf of Thailand*. Master's Thesis, Chulalongkorn University, Bangkok, Thailand, 130 pp.

Mizue, K., K. Yoshida & Y. Masaki, 1965. Studies on the little toothed whales in the west sea area of Kyusyu-XII. *Neomeris phocaenoides*, so-called Japanese "SUNAMERI", caught in the caost of Tachibana Bay, Nagasaki Pref. *Bull. Fac. Fish., Nagasaki Univ.*, **18**: 7-29.

Møhl-Hansen, U., 1954. Investigations on reproduction and growth of the porpoise (*Phocaena phocaena* L.) from the Baltic. *Vidensk. Medd. Dansk Foren.*, **116**: 369-396.

Murray, J. A., 1884. A contribution to the knowledge of the marine fauna of Kurrachee. *Ann. Mag. Nat. Hist.*, **13**: 348-352.

Muthiah, C., 1995. Baleen whale and a porpoise stranded at Ullal, near Mangalore. *Cent. Mar. Fish. Inform. Serv., Tech. Exten. Ser.,* **140**: 10.

Myrick, A. C., A. A. Hohn, P. A. Sloan, M. Kimura & D. D. Stanley, 1983. Estimating age of spotted and spinner dolphins (*Stenella attenuata* and *Stenella longirostris*) from teeth. *NOAA Tech. Memo. NMFS*, **30**, 17 pp.

Nammalwar, P., A. P. Lipton, S. Krishna Pillai, G. Maheswarudu, C. Kasinathan, M. Bose, N. Ramamoorthy & P. Thillairajan, 1994. Instances of finless black porpoise, *Neophocaena phocaenoides* caught in Mandapam region along the Palk Bay coast in Tamil Nadu. *Cent. Mar. Fish. Inform. Serv., Tech. Exten. Ser.,* **127**: 16-17.

Newby, T. C., 1982. Life history of Dall porpoise (*Phocoenoides dalli*, True 1885) incidentally taken by the Japanese high seas salmon mothership fishery in the northwestern North Pacific and western Bering Sea, 1978 to 1980. Ph.D. dissertation, University of Washington, 157 pp.

Norris, K. S. (ed.), 1961. Standardized methods for measuring and recording data on the smaller cetaceans. *J. Mamm.*, **42**: 471-476.

Perrin, W. F. & S. B. Reilly, 1984. Reproductive parameters of dolphins and smallwhales of the family Delphinidae. *Rep. Int. Whal. Comm. Spec. Iss.*, **6**: 97-133.

Perrin, W. F., J. M. Coe & J. R. Zweifel, 1976. Growth and reproduction of the spotted porpoise, *Stenella attenuata*, in the offshore eastern tropical Pacific. *Fish. Bull.*, **74**: 229-269.

Pilleri, G. & M. Gihr, 1972. Contribution to the knowledge of the cetaceans of Pakistan with particular reference to the genera *Neomeris*, *Sousa*, *Delphinus* and *Tursiops* and description of a new Chinese porpoise (*Neomeris asiaorientalis*). *Invest. Cetacea*, **4**: 107-162.

Pilleri, G. & M. Gihr, 1974 (1973). Contribution to the knowledge of the cetaceans of southwest and monsoon Asia (Persian Gulf, Indus Delta, Malabar, Andaman Sea and Gulf of Siam). *Invest. Cetacea*, **5**: 95-150.

Read, A. J., 1990a. Reproductive seasonality in harbour porpoises, *Phocoena phocoena*, from the Bay of Fundy. *Can. J. Zool.*, **68**:2 84-288.

Read, A. J., 1990b. Age at sexual maturity and pregnancy rates of harbour porpoises, *Phocoena phocoena*, from the Bay of Fundy. *Can. J. Fish. Aquat. Sci.*, **47**: 561-565.

Read, A. J. & D. E. Gaskin, 1990. Changes in growth and reproduction of harbour porpoises, *Phocoena phocoena*, from the Bay of Fundy. *Can. J. Fish. Aquat. Sci.*, **47**: 2158-2163.

Read, A. J. & A. A. Hohn, 1995. Life in the fast lane: the life history of harbor porpoises from the Gulf of Maine. *Mar. Mamm. Sci.*, **11**: 423-440.

Reyes, J. C. & K. Van Waerebeek, 1995. Aspects of the biology of Burmeister's porpoise from Peru. *Rep. Int. Whal. Comm. Spec. Iss.*, **16**: 349-364.

Robineau, D. & P. Fiquet, 1996. The Cetacea of the Jubail Marine Wildlife Sanctuary, Saudi Arabia. In: Krupp, F., A. H. Abuzinada & I. A. Nader (ed.), *A Marine Wildlife Sanctuary for the Arabian Gulf. Environmental Research and Conservation Following the 1991 Gulf War Oil Spill*. Pp. 438-458. Riyadh and Senckenberg Research Institute.

Rudolph, P., C. Smeenk & S. Leatherwood, 1997. Preliminary checklist of Cetacea in the Indonesian archipelago and adjacent waters. *Zoologische Verhandelingen, Leiden*, **312**: 1-48.

Shirakihara, M., A. Takemura & K. Shirakihara, 1993. Age, growth, and reproduction of the finless porpoise, *Neophocaena phocaenoides*, in the coastal waters of western Kyushu, Japan. *Mar. Mamm. Sci.*, **9**: 392-406.

Sorensen, T. B. & C. C. Kinze, 1994. Reproduction and reproductive seasonality in Danish harbour porpoises, *Phocoena phocoena. Ophelia*, **39**: 159-176.

StatSoft, 1994. *STATISTICA® For the Macintosh v4.1*. StatSoft, Inc.

Tas'an & S. Leatherwood, 1984. Cetaceans live-captured for Jaya Ancol Oceanarium, Djakarta, 1974-1982. *Rep. Int. Whal. Comm. Spec. Iss.*, **34**: 485-489.

Thomas, P. A., 1983. *Casual landings of porpoises and dolphins from the inshore area off Goa during the period 1973 to 1979*. Paper presented at the Symposium on Marine Mammals of the Indian Ocean, Colombo, Sri Lanka (unpublished report).

Utrecht, W. L. van, 1978. Age and growth in *Phocoena phocoena* Linneaus, 1748 (Cetacea, Odontoceti) from the North Sea. *Bijdragen tot de Dierkunde*, **48**: 16-28.

Wang, Z., 1989. A rarely seen finless porpoise off the coast of Qingdao. *Mar. Fish.*, **1989**: 85 (in Chinese).

Zhang, X., 1992. Studies on the age determination, growth and reproduction of finless porpoise *Neophocaena phocaenoides*. *Acta Hydrobiol. Sinica*, **16**: 289-298.