pharyngeal dentition. Three pairs of dorsal pharyngeal tooth plates are present, associated with the pharyngobranchial elements of branchial arches I, II, and III, with one tooth plate of each pair being located on either side of the dorsal midline. Each tooth plate is slightly curved with a posteriorly directed dentigerous surface. In the 126- and 137-mm SL checkered puffers, the four tooth plates in the anterior two pairs were each 4 mm long and those in the posterior pair were each 3 mm long. In the 108- and 118-mm SL bandtail puffers, the four tooth plates in the anterior two pairs were each 3 mm long and those in the posterior pair were each 2 mm long. The dorsal pharyngeal tooth plates of both puffer species bear upon the pair of ventrally located, and nondentigerous, fifth ceratobranchial (lower pharyngeal) bones. The pharyngeal tooth apparatuses likely function to pull flesh from and to further grind and break crab and mollusc shells. The smooth puffer, *Lagocephalus laevigatus*, also has strong beaklike jaw teeth but has dentigerous tooth plates associated with the pharyngobranchial elements of only the II and III branchial arches (Tyler 1962). In general, fishes in the Order Plectognathi have very strong jaw teeth and comparatively weak pharyngeal dentition (Al-Hussaini 1947).

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CORRELATES OF MATURITY IN THE COMMON DOLPHIN, *DELPHINUS DELPHIS*

Maturity of the gonads in mammals is closely related to other aspects of physical development. Therefore, a simple method for estimating an individual's proximity to sexual maturity would be to evaluate appropriate morphometric data. However, the morphometrics traditionally collected on cetaceans are less than ideal for this task.

Studies on cetacean growth patterns have typically used data collected in a cross-sectional manner and have used large samples which included all age-classes. Unfortunately, individual rates and patterns are indistinct when values are averaged using this method (Sinclair 1973). If a large change in growth or development takes place over a short period of time and the beginning of this change does not occur at exactly the same age in each individual, the data acquired from a group of individuals will imply that the change takes place at a slower rate and over a greater period of time than is actually the case for an individual.

The present study used parameters which indicated the proximity of an individual to its own mature condition, not the average mature condi-

tion of the population. In *Delphinus delphis*, an individual's proximity to sexual maturity can be accurately assessed using appropriate morphometric data.

Materials and Methods

I used 35 male and 52 female *Delphinus delphis* specimens collected in southern California waters from 1971 to 1974.

The body weight in kilograms, body length in a straight line to the nearest centimeter from tip of the snout to the anterior portion of the fluke notch, dentine layers, bone development in the flippers, testes weights, and the numbers of scars on the ovaries were recorded.

Teeth were usually from the posterior one-third of the left mandibles; otherwise the largest teeth available were used. A longitudinal section 0.368 mm thick was cut from the center of each tooth, and samples were cleaned in a weak solution of ammonia. After rinsing with water, the sections were etched in 1-2% formic acid at room temperature until the dentine growth layers were distinct, usually 6-12 h. Sections were mounted on microscope slides in an ethanol solution and examined with transmitted light.

One light and one dark band were considered as one dentine layer. The interval for dentine laminar deposition is unknown for the *D. delphis* in the present study but I assume that the bands were laid down at regular intervals. *Delphinus delphis ponticus* Barabash of the Black Sea are reported to have two sets of alternating layers each year (Kleinenberg and Klevezal 1962).

Because different bones fuse at different times in the spotted, *Stenella attenuata*, and the spinner *S. longirostris*, porpoises (Perrin 1972), I used the development of the epiphyses and their fusion to the diaphyses of the flipper bones as the indicator for physical maturity of the specimens. Each flipper was assigned an index by scoring the degree of epiphyseal fusion visible in radiographs: 0 when no epiphysis had been formed; 1 when the epiphysis had been formed but had not started its fusion to the diaphysis; 2 when the epiphysis and diaphysis were in the process of fusing; and 3 when the epiphysis and diaphysis were fused. The distal ends of the radius, ulna, metacarpals, and phalanges of each flipper were scored (Figure 1). The
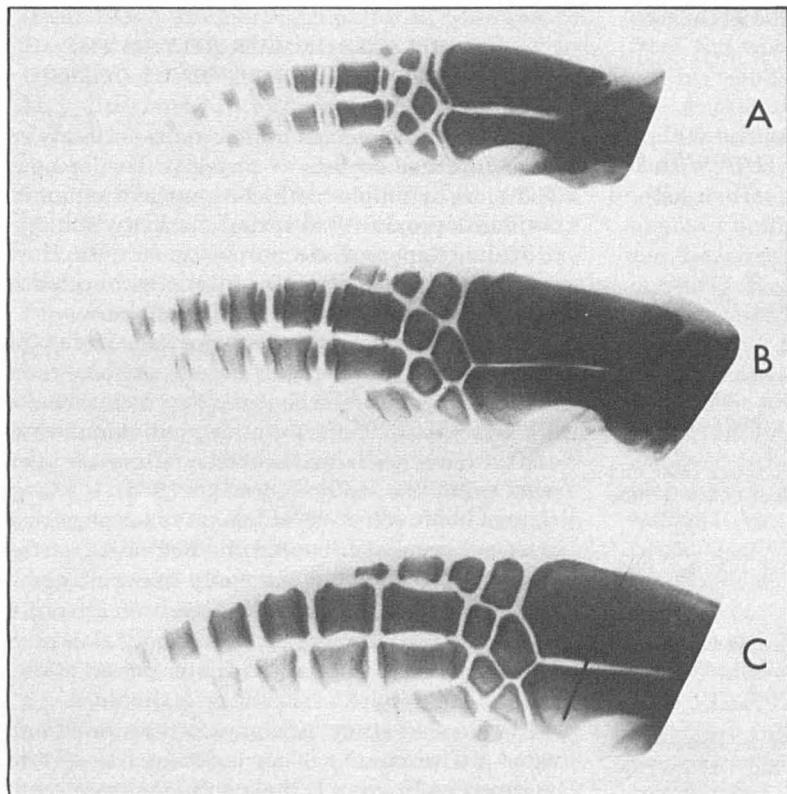

FIGURE 1.—Process of fusion of the epiphyses to the diaphyses in the flipper of *Delphinus delphis*. The flipper labeled A has a score (see text) of 18; B, 49; and C, 72.

sum of the individual epiphyseal fusion scores for both flippers composed the Flipper Index (FI) for that animal. When one of the flippers was damaged, the score for the undamaged flipper was doubled.

The combined weights of the testes with the epididymus removed were used as a measure of sexual maturity in males. In this study, a pair of testes was considered mature at 350 g.

Just as menarche in human females does not mean ovulation but the final developmental stages for the ability to ovulate, delphinid ovarian scars are here inferred to indicate ovulatory capacity. The presence on the surface of at least one corpus albicans or a corpus luteum indicated sexual maturity. However, each ovary also was sliced into sections 1 mm thick and examined for internal corpora.

All statistical tests are described in Sokal and Rohlf (1969).

Results

Development of right and left flippers did not differ significantly in 27 males and 55 females ($P \geqslant 0.05$, t-test for paired comparisons).

There was no significant difference ($P \geqslant 0.05$) in weight between the left and right testes of 34 specimens (t-test for paired comparisons).

In all but 2 of 25 mature cases, the left ovary had more scars.

Dentine layers are a poor indicator of sexual development in *D. delphis*. The numbers of dentine layers and ovarian corpora are not significantly related ($P > 0.10$, Kendall's rank correlation test). Both sexually mature and immature females occur with 7-14 dentine layers (Figure 2). Testes weights are so variable in the range of 7-12 dentine layers that they cannot be estimated (Figure 3), although significantly correlated over the entire range of data ($P \leqslant 0.001$, Kendall's rank correlation).

Body length is a poor indicator of sexual development. Over body lengths 175-190 cm, testes apparently undergo a transitional stage of growth. Gonad weight cannot be accurately estimated from body length over this range (Figure 4) although the two are significantly correlated over the entire range of data ($P \leqslant 0.001$, Kendall's rank correlation). Body length and ovarian scarring are poorly correlated ($P > 0.10$, Kendall's rank correlation). Body lengths 165-182 cm include both sexually mature and immature females (Figure 5).
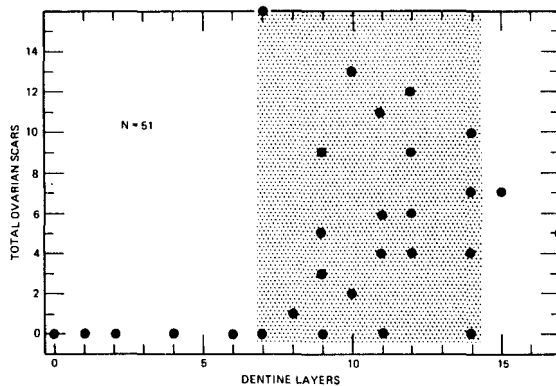

FIGURE 2.—Ovarian corpora in relation to dentine layers in *Delphinus delphis*. The stippled region indicates the range of dentine layers over which sexually mature animals are indistinguishable from immature.
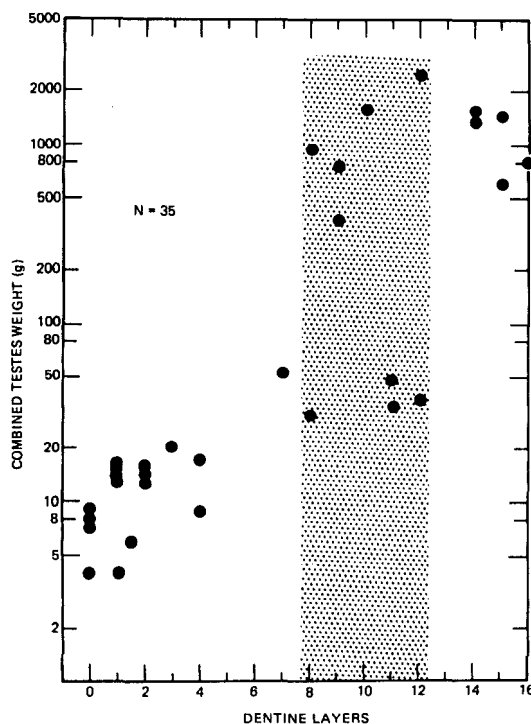

FIGURE 3.—Testis weight in relation to dentine layers in *Delphinus delphis*. The stippled region indicates the range of dentine layers over which testes of mature and immature weights overlap.

The FI is significantly correlated with testes weights ($P \leqslant 0.001$, Kendall's rank correlation) although data are missing in a narrow range (Figure 6). However, inactive ovaries occur in a wide
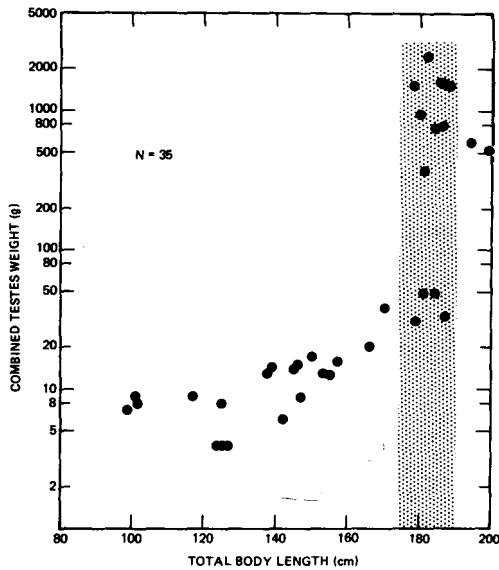
FIGURE 4.—Testes weights in relation to body length. The stippled area indicates the region of overlap for mature and immature testes weights.
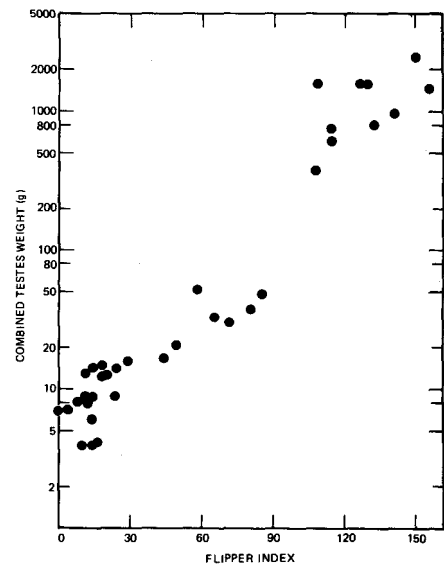

FIGURE 6.—Development of testes related to epiphyseal development of the pectoral appendages in *Delphinus delphis* as indicated by the Flipper Index. The best interpretation of the present data is that two linear phases are separated by a stage of rapid change.
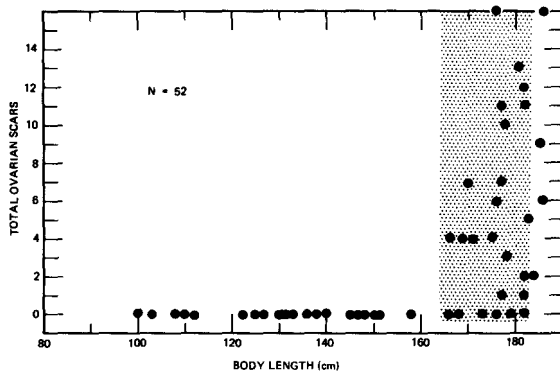

FIGURE 5.—Ovarian corpora related to body length in *Delphinus delphis*. The range of body lengths in which sexually mature and immature animals cannot be distinguished is indicated by the strippled area.
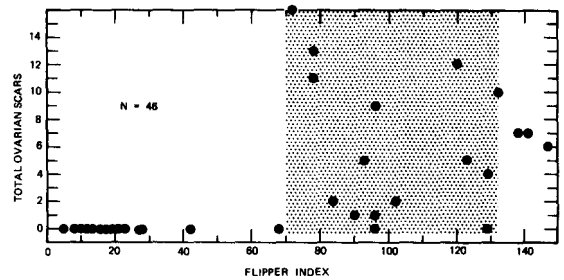

FIGURE 7.—Ovarian corpora related to pectoral epiphyseal development (Flipper Index) in *Delphinus delphis*. The shaded area indicates the range in Flipper Index over which sexually mature and immature animals overlap.

range of FI scores (Figure 7) and there is no significant relationship between the number of ovarian scars and the FI ($P > 0.10$, Kendall's rank correlation).

Robustness is here defined as the body length in centimeters divided by body weight in kilograms. Regardless of body length, only the most robust individuals are sexually mature. Sexual maturity occurs when the male's length/weight ratio de-

clines to about 2.6 (Figure 8). Mature females had length/weight ratios lower than about 3.0 (Figure 9). Of the 24 females with ovarian scars in this study, 16 were pregnant. Assuming the weight of the amniotic sack is nearly equal to that of the fetus, twice the weight of the fetus was subtracted from the gross weight of the mother, leaving the weight of the nonpregnant female for calculations of robustness. The robustness of the pregnant females is not separable from the sexually mature nonpregnant females.
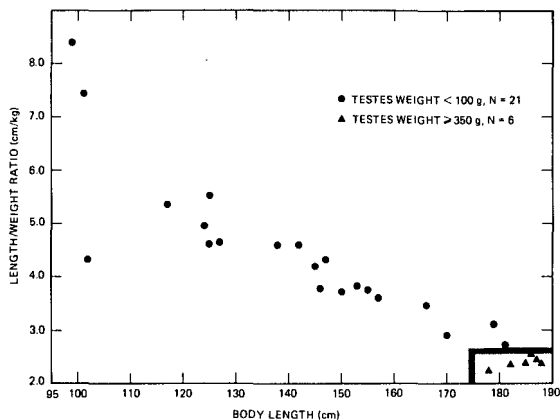
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FIGURE 8.—The body length/weight ratio as related to body length in male *Delphinus delphis*. Individuals with combined testes weights of 350 g are considered to be undergoing spermatogenesis. The shading designates the weight/length ratio in which males apparently are sexually mature.
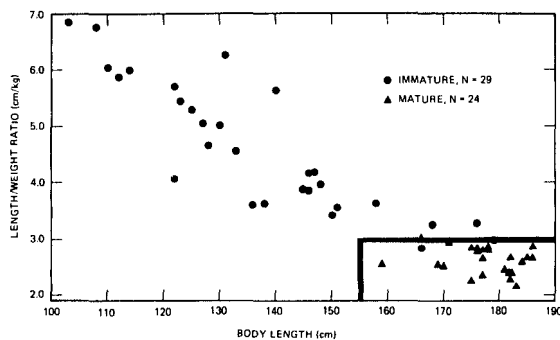

FIGURE 9.—Relationship of the body length/weight ratio to body length in female *Delphinus delphis*. Triangles represent individuals with at least one ovarian corpus. The shaded area denotes length/weight ratios in which sexually mature dolphins predominate.

Discussion

The data indicate that sexual development is better correlated with parameters which indicate the individual's proximity to physical maturity than with fixed morphometric values. A large increase in combined testes weight from <80 g to almost 400 g corresponds with rapid skeletal growth in the individual dolphin (Figure 6). Consequently, the FI is better correlated with sexual maturity in males than dentine layers or body length. Robustness is also highly correlated with sexual development in males but the sample size is small.

For unknown reasons, ovulation is better correlated with the length/weight ratio than with body length, dentine layers, or flipper bone development. Similarly, in studies of humans, it was found that girls who attained early menarche also had greater weight for height than their chronological peers who attained maturity at a later time (Simons and Greulich 1943). Data from *S. attenuata* (Perrin et al. 1976) also show ovarian corpora to be poorly correlated with age and length.

Induced ovulation is a distinct possibility for *D. delphis*. Harrison and Ridgway (1971) concluded that ovulation in *Tursiops truncatus* is induced but the mechanism is unknown. The present data imply that some *D. delphis* females never ovulate, supporting the findings of Harrison et al. (1972).

Oliver's[1] examination of *Delphinus* from the eastern tropical Pacific showed that the smallest testes with spermatogenesis weighed 140 g. For the present study, specimens with combined testes weights >350 g were collected in March, April, July, September, October, November, and December. The large testes weights throughout the year indicate that there is no seasonal rut, supporting the findings of Harrison et al. (1969).

Gaps in the data occur immediately prior to male *D. delphis* sexual maturity: FI scores 85-105 (Figure 6), body lengths 158-177 cm (Figure 4), 4-8 dentine layers (Figure 2). These gaps appear to be the prepuberty ranges for those indicators. Behavior patterns may account for the absence of data in these regions. Young males of *Physeter catodon* (Ohsumi 1971) and *Tursiops truncatus* (Evans and Bastian 1969) frequently herd separately from the rest of the population. Alternatively, these animals may have a greater capacity to escape nets. Female specimens also are lacking in the length, age, and FI ranges just prior to the demonstration of ovarian scars. Preadolescent females, like the males, may easily escape nets, or have a social structure separate from the main herd.

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[1]C. W. Oliver, Inter-American Tropical Tuna Commission, La Jolla, CA 92037. Unpubl. data.

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LARVAL DEVELOPMENT OF *GOBIESOX RHESSODON* (GOBIESOCIDAE) WITH NOTES ON THE LARVA OF *RIMICOLA MUSCARUM*

Seven species of clingfishes of the genera *Gobiesox* and *Rimicola* occupy the rocky inter- and subtidal areas along the California coast. Extreme modification of the pelvic fins into a suction disc enables them to cling to rock and algal substrates. Although all clingfish species are listed as being uncommon to rare in California by Miller and Lea (1972), clingfish larvae are collected on a regular basis (although in low numbers) by monitoring programs dealing with fish larvae (Brewer,[1] McGowen,[2] and White[3]). Of the seven species recorded in southern California, adults of only two, *G. rhessodon* and *R. muscarum*, are usually encountered (pers. obs.).

Knowledge of larval stages of eastern Pacific (especially Californian) fishes is largely limited to pelagic species of those coastal species with protracted pelagic larval periods (Ahlstrom 1965; Moser et al. 1977). Larvae of many nearshore, coastal fishes are undescribed. Recent concern over the affects of harbor development and thermal discharge and entrainment from power plants on fish populations has intensified the need for proper identification of fish eggs and larvae.

The principal systematic work to date on the adults of eastern Pacific clingfishes was carried out by Briggs (1955). No previous works on the larvae of eastern Pacific clingfishes have been carried out, although the eggs and larvae of an Atlantic clingfish, *G. strumosus*, are well known (Runyan 1961; Dovel 1963).

Descriptions of a larval series of *G. rhessodon* and early larvae of *R. muscarum* are presented here as taxonomic aids to larval fish investigators working in the California coastal region.

Methods and Materials

Eggs and adults of *G. rhessodon* and *R. muscarum* were collected in June 1977 from the intertidal zone at low tide at Catalina Harbor and Little Harbor, Santa Catalina Island, Calif. Adults with their eggs were transported to the Catalina Marine Science Center (CMSC) operated by the University of Southern California and maintained in tanks with running seawater. The failure of hatched larvae to feed (probably due to lack of suitable food) precluded culturing past 2 days (4.0 mm). Additional specimens of *G. rhessodon* utilized in the series were obtained by vertical plankton tow under a night-light at the CMSC dock in Big Fisherman's Cove (4.7 mm) in June 1977; by horizontal tow in King Harbor, Redondo

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[1]Gary D. Brewer, Institute for Marine and Coastal Studies, University of Southern California, Los Angeles, CA 90007. Pers. commun. June 1977.
[2]Gerald E. McGowen, Southern California Edison (Occidental College), Redondo Beach, Calif. Pers. commun. June 1977.
[3]Wayne S. White, U.S. Fish and Wildlife Service, Laguna Niguel, Calif. Pers. commun. August 1977.