HOFF, J. G., AND R. M. IBARA.
1977. Factors affecting the seasonal abundance, composition and diversity of fishes in a southeastern New England estuary. Estuarine Coastal Mar. Sci. 5:665-678.
HOFF, J. G., AND J. R. WESTMAN.
1966. The temperature tolerances of three species of marine fishes. J. Mar. Res. 24:131-140.
MERRIMAN, D.
1941. Studies on the striped bass (*Roccus saxatilis*) of the Atlantic coast. U.S. Fish Wildl. Serv., Fish. Bull. 50 (35), 77 p.
MULKANA, M. S.
1966. The growth and feeding habits of juvenile fishes in two Rhode Island estuaries. Gulf Res. Rep. 2:97-168.
NEEDLER, A. W. H.
1940. A preliminary list of the fishes of Malpeque Bay. Proc. Nova Scotia Inst. Sci. 20:33-41.
NEVES, R. J., AND L. DEPRES.
1979. The oceanic migration of American shad, *Alosa sapidissima*, along the Atlantic coast. Fish. Bull., U.S. 77:199-212.
RICHARDS, C. E., AND M. CASTAGNA.
1970. Marine fishes of Virginia's eastern shore (inlet and marsh, seaside waters). Chesapeake Sci. 11:235-248.
SHENKER, J. M., AND J. M. DEAN.
1979. The utilization of an intertidal salt marsh creek by larval and juvenile fishes: Abundance, diversity and temporal variation. Estuaries 3:154-163.
WARFEL, H. E., AND D. MERRIMAN.
1944. Studies on the marine resources of southern New England. I. An analysis of the fish population of the shore zone. Bull. Bingham Oceanogr. Collect., Yale Univ. 9(2):1-91.

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GROWTH DURING METAMORPHOSIS OF ENGLISH SOLE, *PAROPHRYS VETULUS*

Among fishes, the period of transformation from the larval to adult form is marked not only by changes in morphology, behavior and in some species, habitat (Jakóbczyk 1965; Sale 1969; Hoar 1976; Marliave 1977), but in growth rate as well. Ontogenetic changes in growth have not been well documented principally because a method for determining age of larvae and juveniles has not, until recently, been available. The discovery of daily growth rings on otoliths has made possible the precise determination of age, in days, of larval and juvenile fishes (Brothers et al. 1976). Changes in growth rates during different life history stages which could be correlated with behavioral and habitat changes were observed in the French grunt, *Haemulon flavolineatum* (Brothers and MacFarland in press). Struhsaker and Uchiyama (1976) observed an inflection point in the age-length plot of larval and juvenile nehu, *Stolephorus purpureus*, indicating a change in growth rate. This inflection point corresponded with the size when body depth began to increase in proportion to the length of the fish, but not with changes in diet or habitat that occur over the course of development.

Age estimates based on counts of otolith growth increments have now allowed us to determine growth during metamorphosis of the pleuronectid *Parophrys vetulus* Girard.

Methods

The results of this study are based on the standard length (SL) in millimeters and age in days of 127 pelagic larvae and transforming individuals of *P. vetulus* ranging 10-20 mm SL, and 106 benthic 0-age individuals from 18 to 35 mm SL. Pelagic specimens were collected off Newport, Oreg. (approximately lat. 44°37′N, long. 124°06′ W), from November 1977 through June 1978 with a 70 cm bongo net with 0.505 mm Nitex[1] mesh (see Laroche et al. 1982 for sampling details). Benthic *P. vetulus* were collected off Moolach Beach, Oreg., 10 km north of Newport, during September 1978 through September 1979 with a 1.5 m wide beam trawl (7 mm stretch mesh).

The removal and mounting of saccular otoliths from larvae followed the methods outlined in Methot and Kramer (1979) except that otoliths were mounted on rectangular glass cover slips to improve the optical properties of the preparation. Otolith growth increments were counted at 800 or 1250 × under bright-field illumination. A complete description of the counting technique and validation of the daily periodicity of the rings can be found in Laroche et al. (1982).

[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Otoliths from the benthic individuals were removed, mounted on glass microscope slides and ground to a sagittal thin section through the nucleus using 600 grit carborundum paper. Increment counts on these ground sections were made at 250-400 × using either bright-field or polarized illumination.

The age of each fish was defined as the number of daily otolith growth increments plus five, the age at first increment formation for this species (Laroche et al. 1982).

In order to characterize changes in body form during metamorphosis, body depth, snout to anus length, lower jaw length, and the distance of migration of the left eye, of 65 larvae and 0-age benthic specimens were measured to the nearest 0.1 mm.

Results and Discussion

A plot of the length-at-age of *P. vetulus* larvae and juveniles taken in both pelagic and benthic collections exhibits a prominent plateau between 60 and 120 d of age and between 18 and 22 mm SL (Fig. 1). This plateau shows that there is a period of reduced growth in body length when these fish are undergoing metamorphosis. Plots of body depth and snout to anus length versus standard length both have a well-defined inflection point between 18 and 22 mm SL (Figs. 2, 3). Other morphometric measurement plots (lower jaw length and distance of migration of the left eye) (not shown) also contain an inflection between 18 and 22 mm SL, but less clearly. Changes in body morphology during the growth plateau are illustrated by examining a developmental series just prior to metamorphosis (Fig. 4A) and comparing individuals of similar sizes within the plateau (Fig. 4B). Changes in body depth are most pronounced, but eye migration and changes in head morphology are also evident.

The definition of two distinct growth stanzas separated by a plateau conforms to several of the criteria outlined by Ricker (1979). However, as he points out, the timing of the inflection points on the size-at-age plot depends on whether length or weight is measured. We have not measured weight in this study.

Due to the shape of the length-at-age plot we might expect the length-weight relationship for this species to be complex in form over the interval considered here.

The age of 18-20 mm SL *P. vetulus*, taken in

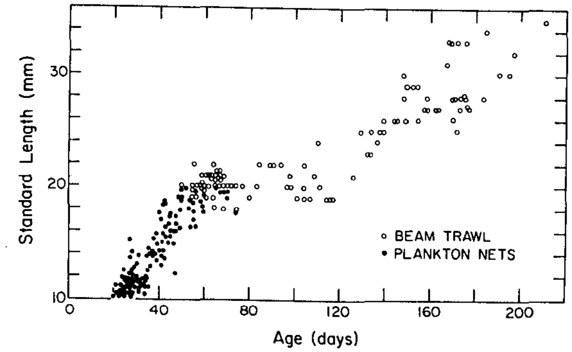

FIGURE 1.—Standard length versus age of *Parophrys vetulus* larvae and juveniles caught in plankton net and beam trawl collections.

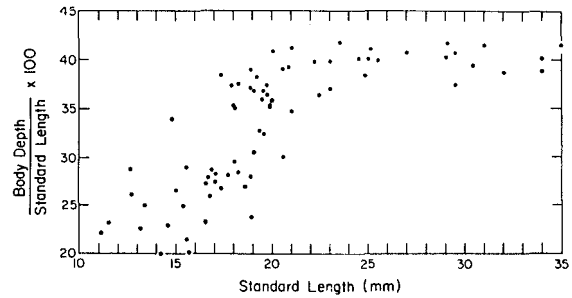

FIGURE 2.—Body depth as a percentage of standard length versus standard length of *Parophrys vetulus*.

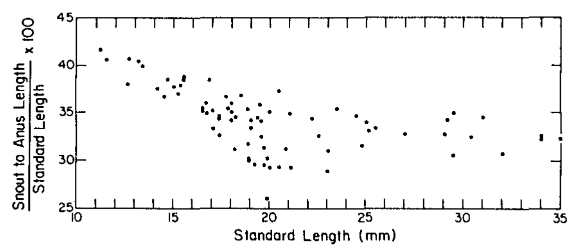

FIGURE 3.—Snout to anus length as a percentage of standard length versus standard length of *Parophrys vetulus*.

plankton samples, was 41-74 d (about 1.4-2.4 mo) and those caught by the beam trawl, 49-116 d (about 1.6-3.9 mo; Fig. 1). The exact duration of transformation cannot be determined because of this large range. This is also illustrated by Figure 4B. The range in age of 11 pelagic specimens, 17.6-20.0 mm SL, whose left eye had begun migration, but was still on the left side of the body, was 49 d. However, if resumption of growth in body length is used to mark the end of metamor-

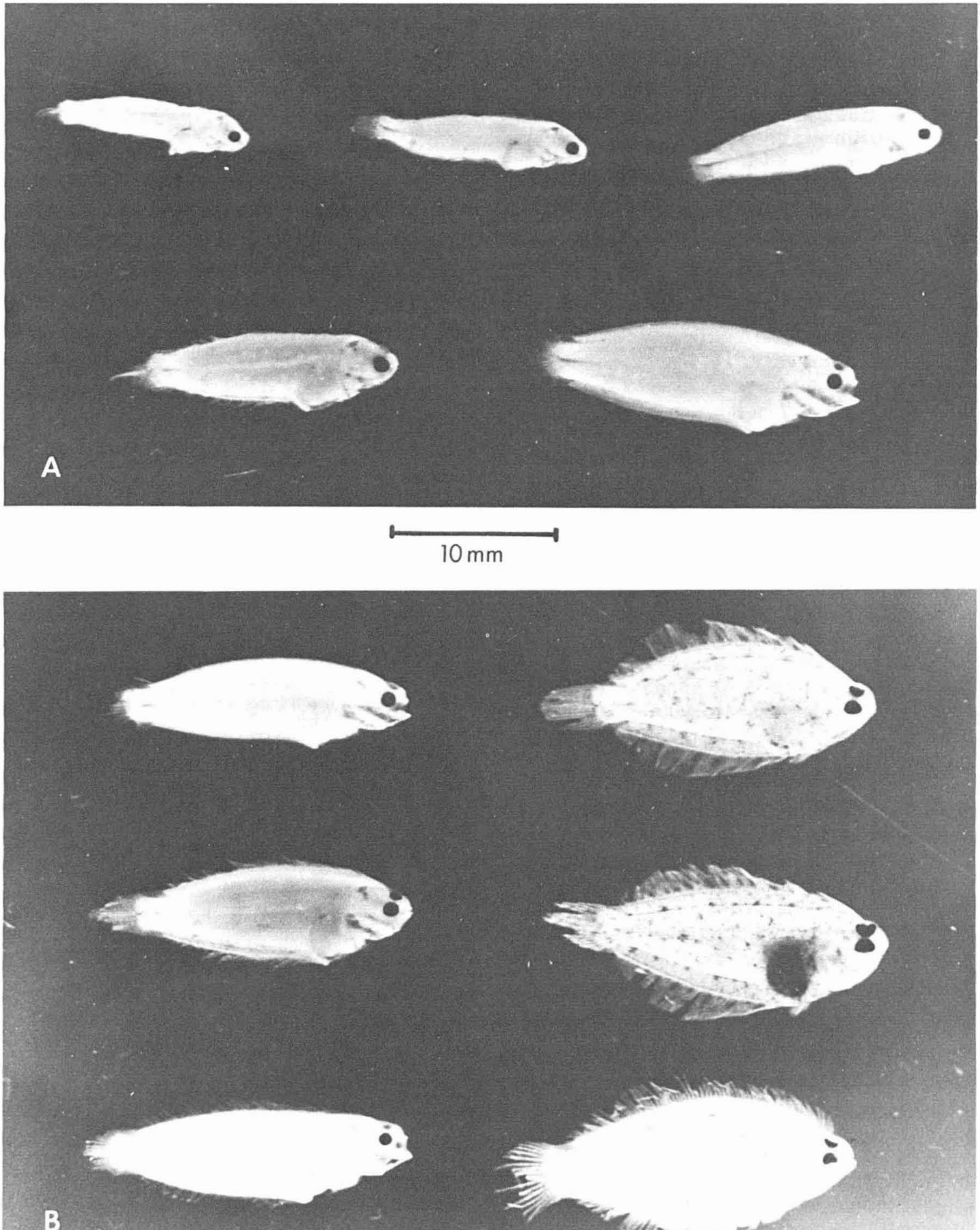

FIGURE 4.—A. Developmental series of *Parophrys vetulus* larvae. Top row, left to right, 11, 13, 14.9 mm SL; bottom 17, 19 mm SL. B. Pairs of *Parophrys vetulus* of similar lengths in different states of transformation. Top 18.0, 18.0 mm SL; middle 19.0, 19.1 mm SL; bottom 19.9, 20.0 mm SL.

phosis, then most *P. vetulus* had completed transformation by about 120 d old or 4 mo. The influence of substrate and water depth on rate of transformation in this species could be clarified only with laboratory experiments. A detailed description of body morphology versus age, as opposed to length would yield useful information on the variability in the timing of transformation. Unfortunately, we do not have such data.

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Literature Cited

BROTHERS, E. B., AND W. N. MACFARLAND.
In press. Correlations between otolith microstructure growth and life history transitions in newly recruited French grunt, *Haemulon flavolineatum*. Rapp. P.-V. Réun. Cons. Int. Explor. Mer.

BROTHERS, E. B., C. P. MATHEWS, AND R. LASKER.
1976. Daily growth increments in otoliths from larval and adult fishes. Fish. Bull., U.S. 74:1-8.

HOAR, W. S.
1976. Smolt transformation: evolution, behavior, and physiology. J. Fish. Res. Board Can. 33:1233-1252.

JAKÓBCZYK, J.
1965. Investigations on the metamorphosis of *Rhombus maximus* L. (*Pleuronectiformes*). Zool. Pol. 15:191-211.

LAROCHE, J. L., S. L. RICHARDSON, AND A. A. ROSENBERG.
1982. Age and growth of a pleuronectid, *Parophrys vetulus*, during the pelagic larval period in Oregon coastal waters. Fish. Bull., U.S. 80:000-000.

MARLIAVE, J. B.
1977. Substratum preferences of settling larvae of marine fishes reared in the laboratory. J. Exp. Mar. Biol. Ecol. 27:47-60.

METHOT, R. D., JR., AND D. KRAMER.
1979. The growth of northern anchovy, *Engraulis mordax*, larvae in the sea. Fish. Bull., U.S. 77:413-423.

RICKER, W. E.
1979. Growth rates and models. *In* W. S. Hoar, D. J. Randall, and J. R. Brett (editors), Fish physiology, Vol. VIII, p. 677-743. Acad. Press, N.Y.

SALE, P. F.
1969. A suggested mechanism for habitat selection by the juvenile manini *Acanthurus triostegus sandvicensis* Streets. Behaviour 35:27-44.

STRUHSAKER, P., AND J. H. UCHIYAMA.
1976. Age and growth of the nehu, *Stolephorus purpureus* (Pisces: Engraulidae), from the Hawaiian Islands as indicated by daily growth increments of sagittae. Fish. Bull., U.S. 74:9-17.

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OBSERVATIONS ON LARGE WHITE SHARKS, *CARCHARODON CARCHARIAS*, OFF LONG ISLAND, NEW YORK

Fishermen report sightings of large white sharks, *Carcharodon carcharias*, off Long Island and southern New England every year. A popular book on shark fishing (Mundus and Wisner 1971), reported encounters with 23 large white sharks between 1958 and 1966 off Montauk Point, N.Y. Five of these were landed and weighed or estimated to range from 660 to 2,025 kg. Bigelow and Schroeder (1948) noted the occurrence of a few white sharks in southern New England waters. Otherwise most documented captures of white sharks off eastern North America are from coastal locations north of Cape Cod, Mass. (Schroeder 1938, 1939; Bigelow and Schroeder 1948, 1953, 1958; Scattergood et al. 1951; Scattergood and Coffin 1957; Scattergood and Goggins 1958; Scattergood 1959, 1962; Skud 1962; Templeman 1963; Arnold 1972). Information in these reports is limited to location sightings and morphometric observations.

We report here our detailed examinations of two white sharks landed off Long Island, N.Y., in 1964 and 1979. We also describe the feeding behavior of white sharks that were near a dead fin whale, *Balaenoptera physalus*.

Material Examined

One of us (J. G. Casey) caught a 406 cm TL (total length) immature female white shark on rod and reel 7.2 km south of Amagansett, N.Y., (lat. 40°53′ N, long. 72°06′ W) on 5 October 1964. When landed, its stomach was everted. Weight was estimated at 1,500 lb (680 kg) and morphometric measurements were taken to the nearest millimeter.