NOTES

THE SEX RATIO AND GONAD INDICES OF SWORDFISH, *XIPHIAS GLADIUS*, CAUGHT OFF THE COAST OF SOUTHERN CALIFORNIA IN 1978

In the tropical and subtropical Pacific, swordfish, *Xiphias gladius*, about to spawn are found throughout the year but are most abundant from March to July (Palko et al. 1981). There is, however, little information on the reproductive potential of swordfish during their summer and autumn migrations into the Southern California Bight, a temperate region encompasing the principal U.S. west coast swordfish fishing grounds. In 1978 scientists from the Southwest Fisheries Center collected the gonads of swordfish harpooned in the Bight (from Point Conception to the United States-Mexico border) in order to determine sex ratios, gonad indices, and the reproductive condition of these fish.

Methods

Ninety swordfish were sampled from 25 August through 20 November 1978. After capture their gonads were preserved in 10% Formalin[1] and, in the laboratory, were weighed to the nearest gram and their sex determined visually. Ovarian sections used in the histological analysis were obtained from segments removed from the centers of the ovaries. Segments were imbedded in Paraplast and 8 μm sections were cut, stained in iron hematoxylin, and counterstained in eosin.

Two gonad indices were calculated for each pair of ovaries to permit comparisons with two existing studies on the sexual maturity of Pacific swordfish. The first (from Uchiyama and Shomura 1974) is simply the percentage of the fresh weight of the ovaries to the total weight of the fish:

$$GI = \frac{WT\text{-}O}{WT\text{-}F} \times 100 \qquad (1)$$

where GI = gonad index,
$WT\text{-}O$ = fresh weight of both ovaries, and
$WT\text{-}F$ = fresh weight of whole fish.

The second index (from Kume and Joseph 1969) is

$$GI = (W/L^3) \times 10^4 \qquad (2)$$

where GI = gonad index,
W = fresh weight of both ovaries in grams, and
L = post-orbital fork length in centimeters.

Because the gonads used in this study were preserved, and thus subject to shrinkage and loss of weight, it was necessary to estimate their fresh weight using the relationship (from Uchiyama and Shomura 1974):

$$Y = e^{\frac{\ln X - 0.155}{0.969}} \qquad (3)$$

where Y = estimated fresh weight of ovaries, and
X = weight of preserved ovaries.

The estimated weight loss due to preservation was as high as 7%.

Results and Discussion

All 90 swordfish collected were mature with fork lengths ranging from 133 to 218 cm. Of these, 23 (26%) were males and 67 (74%) were females for a sex ratio of 0.34:1 (M:F). Although the proportion of females varied among months, our sample sizes were too small to demonstrate such variation.

Female swordfish in our sample all had gonad indices that were considerably lower than those of comparable studies. Uchiyama and Shomura (1974) collected 16 pairs of ovaries from swordfish caught near Hawaii and found three pairs to be ripe. These had gonad indices (from Equation (1)) of 6.4, 8.4, and 9.8 whereas our highest value (from Equations (1) and (3)) was 1.0. Kume and Joseph (1969) examined 362 pairs of ovaries from swordfish captured in the eastern Pacific (east of long. 130°W) and found two ripe specimens whose gonad indices (from Equation (2)) were 10.8 and 11.1. By comparison, the highest from our study (from Equations (2) and (3)) was 1.8. These results indicate swordfish in the Southern California Bight during our sampling period were not spawning.

A histological analysis was performed on a subset of 16 pairs of ovaries from our sample. Histological analyses can be used to determine not only if a fish

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

is in spawning condition but, also, if it has recently spawned (Hunter and Macewicz 1985). Ovaries from our sample contained no mature oocytes and, in addition, did not contain abundant atretic oocytes indicative of the resorption process. Instead the ovaries were in the regressed stage and contained primary oocytes lining connective tissue septa. These results indicate that the swordfish were reproductively inactive during the sampling period and for at least a month or two before capture. Although this conclusion does not preclude the possibility of spawning early in the year, swordfish then are scarce. Also water temperatures favorable for spawning (Palko et al. 1981) are not widespread in the summer and autumn, and are virtually nonexistant the remainder of the year.

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GROWTH OF DOLPHINS, *CORYPHAENA HIPPURUS* AND *C. EQUISELIS*, IN HAWAIIAN WATERS AS DETERMINED BY DAILY INCREMENTS ON OTOLITHS

The dolphin, *Coryphaena hippurus*, and pompano dolphin, *C. equiselis*, are widely distributed pelagic fishes in tropical and subtropical oceans (Beardsley 1967; Rose and Hassler 1968; Shcherbachev 1973). In Hawaiian waters *C. hippurus* is caught throughout the year, but its abundance fluctuates. Small fish (<2.3 kg) are plentiful in summer and large fish (13.6-18.1 kg) are more abundant from February to April (Squire and Smith 1977). *Coryphaena hippurus* is important to the commercial and recreational fisheries; *C. equiselis*, a smaller fish with a maximum length of 74 cm (Herald 1961), is occasionally caught by recreational fishermen. Although much is known about the life history of *C. hippurus* in the Atlantic (Palko et al. 1982), the biology of the Hawaiian population has been only sketchily investigated. Little is known about *C. equiselis*.

At least three age and growth studies on *C. hippurus* have been reported. Annual marks on scales have been used to age *C. hippurus* off Florida (Beardsley 1967) and North Carolina (Rose and Hassler 1968) in the western North Atlantic Ocean. Wang (1979) used monthly modal progression of length-frequency distributions to estimate the growth rate of *C. hippurus* off eastern Taiwan in the western Pacific Ocean. The estimated growth rates of *C. hippurus* off Florida and North Carolina differed slightly, but the growth rate of *C. hippurus* in the western Pacific Ocean was reported to be about twice as great as those in the western North Atlantic Ocean.

The purpose of this study was to validate estimates of age and growth of larval and juvenile *C. hippurus* and *C. equiselis* based on microstructure of otoliths (sagittae) from fish of known age reared in captivity. Otoliths from wild specimens captured in Hawaiian waters were also used as a source of age and growth information and these data were fitted to the von Bertalanffy growth model. Ages of cultured and captured wild specimens were estimated by enumerating presumed daily increments on the sagitta following Pannella (1971). The daily nature of the increments was validated by counts from sagittae of fish reared in captivity and whose age was known. Knowledge of growth rates of both species of dolphins are useful to mariculturists who would like to compare the growth rates of wild and cultured individuals. Information on the growth rate of *C. hippurus* can also be of use to managers of Hawaiian fishery resources.