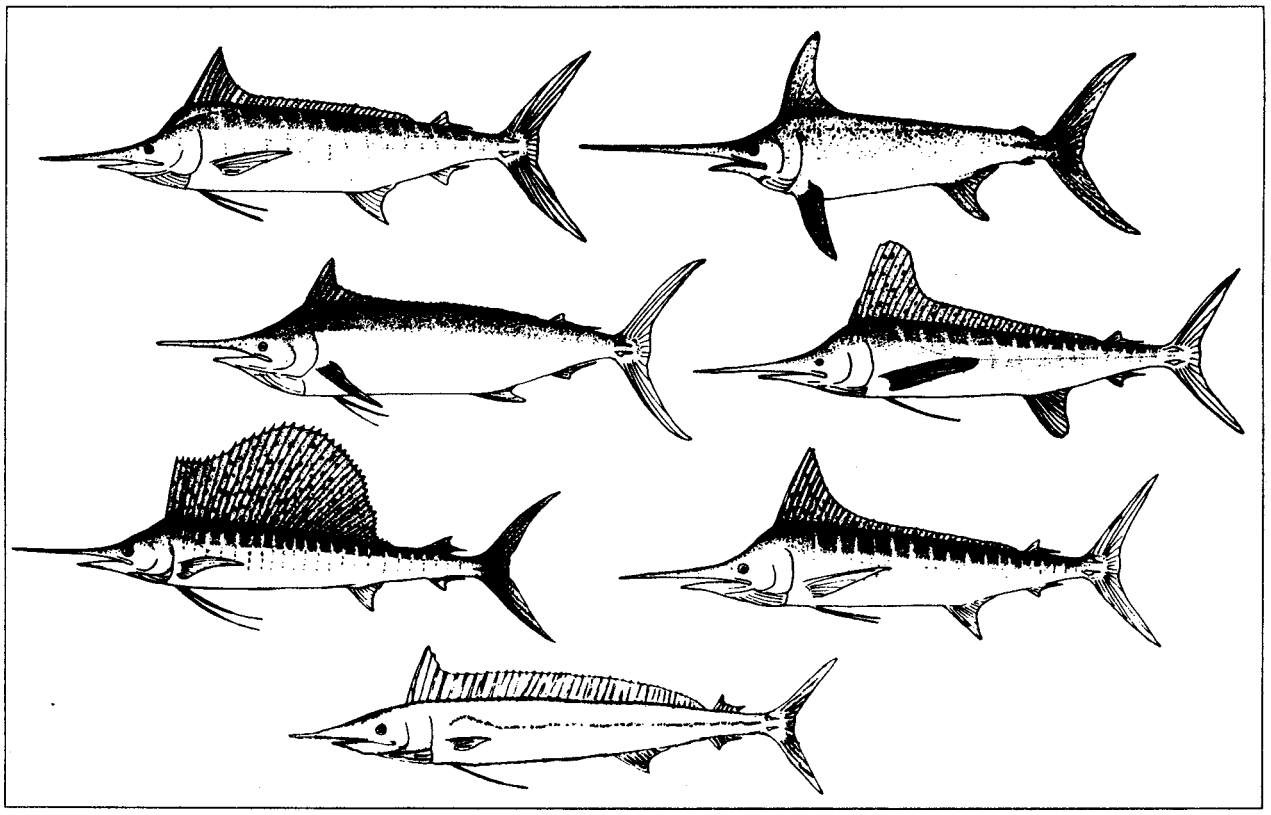
NOAA Technical Memorandum NMFS-SEFC-224

Annotated List of Selected References on Age and Growth Studies of Istiophoridae and Xiphiidae



May 1989

Dennis W. Lee

U. S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Center
Miami, Florida 33149

NOAA Technical Memorandum NMFS-SEFC-224

Annotated List of Selected References on Age and Growth Studies of Istiophoridae and Xiphiidae

BY
Dennis W. Lee

U. S. DEPARTMENT OF COMMERCE
Robert A. Mosbacher, Secretary

National Oceanic and Atmospheric Administration
William E. Evans, Administrator

National Marine Fisheries Service
James W. Brennan, Assistant Administrator for Fisheries

May 1989

NOTICE

This report should be cited as follows:

Lee, D. W. 1989. Annotated list of selected references on age and growth of Istiophoridae and Xiphiidae. NOAA Technical Memorandum NMFS-SEFC-224, 39p.

Copies may be obtained by writing:

National Marine Fisheries Service
Miami Laboratory
75 Virginia Beach Drive
Miami, Florida 33149

CONTENTS

ABSTRACT

This bibliography contains 83 annotated references with specific emphasis on ageing, ageing methods, growth rates, and regression and growth equation parameters that have been published on Istiophoridae and Xiphiidae. A subject index section is included following the annotations.

INTRODUCTION

This bibliography consists of 83 papers and reports which address the general topic of age determination and growth rates of eight species of billfishes. The species represented include blue marlin, Makaira nigricans; black marlin, M. indica; white marlin, Tetrapturus albidus; striped marlin, T. audax; longbill spearfish, T. pfluegeri; shortbill spearfish, T. angustirostris; sailfish, Istiophorus platypterus; and swordfish, Xiphias gladius. The Mediterranean spearfish, T. belone, and the roundscale spearfish, T. georgii, are not represented in this paper since the author was unable to locate literature pertaining to the subject matter. Billfishes are generally circumtropical in nature. Three species (X. gladius, M. nigricans, and I. platypterus) occur in the Atlantic, Pacific, and Indian Oceans, while the remaining species are found either in the Pacific and Indian Oceans or in the Atlantic Ocean and adjacent seas. The taxonomic classification billfishes have undergone many revisions and reports in the literature are often conflicting and confusing. For example, Nakamura (1985, in annotated citation) refers to the Pacific blue marlin as M. mazara and Atlantic sailfish as I. albicans. Another point of confusion involves a reference to white marlin caught in the Pacific Ocean as Marlina marlina. Additional references to this scientific name in the literature for white marlin were not uncovered. However, Marlina marlina did appeared in the literature for black marlin. This makes sense geographically because white marlin are only found in the Atlantic Ocean and the black marlin in the Pacific and Indian Oceans. Fischer et al.[1] made mention that after death the body of the black marlin turns greyish white, hence Japan calls the fish "Shirokajiki" which in English translation means white marlin. Therefore, misinterpretation of the common name may have occurred during

[1]Fischer, W., G. Bianchi, and W. B. Scott (editors), 1981. FAO Species Identification Sheets for Fishery Purposes. Eastern Central Atlantic; fishing areas 34, 47 (in part). Canada Funds-in-Trust. Ottawa, Department of Fisheries and Oceans Canada, by arrangement with the Food and Agriculture Organization of the United Nations, vols. 1-7: pag.var.

the translation of the Japanese paper into its English summary. Although this situation was not commonplace and since definitive genetic evidence for separating the Pacific and Atlantic blue marlin or sailfish into different species has not been documented, only the use of the scientific and common names as referenced by Robbins et al.[2] will be utilized in the annotations with special notation of the species actually cited in the published article.

The determination of age and rate of growth is an integral part of life history investigations and a critical component for stock assessment of these species. In the search through the literature, biological synopses referencing age and growth have been reported for each of the species at various times over the years, but no comprehensive collection for all the species together has ever been published. The objective of this manuscript is to review the billfish literature and select references for annotation if they provide estimates of age and growth based on analyses of skeletal structures, tag release-recapture data, or size frequencies. Inference to age or derivation of various growth parameters is also included.

Numerous references were not included because: (1) citations were in languages other than English and could not be translated within the restriction of this effort; (2) articles lacked English summaries or abstracts; and (3) documents were in such obscure publications that availability were severely limited. Any reference in the published articles to ageing methodologies, validation of ages, size and age ranges, growth equation parameters, or size-at-age tables are highlighted in the annotations. Weights referenced in the annotated text represent round or whole weights, unless otherwise noted. Length measurements were quite variable between and among species. Rivas[3] describes a variety of measurements taken for billfishes and those length measurements mentioned in the annotated text are defined here for convenience. Total length (TL) is the distance from the tip of the bill to the mid-point of an imaginary line drawn between the tips of the longest caudal rays. Eye-orbit fork length (EOFL) is the distance from the posterior orbit of the eye to the posterior margin of the middle caudal rays (called fork of tail). Lower-jaw fork length

---

[2]Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea, and W. B. Scott. 1980. A List of Common and Scientific Names of Fishes from the United States and Canada. American Fisheries Society, fourth edition, Bethesda, MD., Special publication 12: 174 p.

[3]L. R. Rivas, 1956. Definitions and Methods of Measuring and Counting in the Billfishes (Istiophoridae and Xiphiidae). Bull. Mar. Sci. Gulf Carib. 6(1): 18-27.

(LJFL) is the distance from the tip of the lower mandible to the fork of tail. Fork length (FL) is the distance from the tip of the bill to the fork of tail. Trunk length (TKL) is the distance from the posterior orbit of the eye to the anterior insertion of the caudal keels. Finally, an additional measurement referenced as operculum fork length (OFL) was defined for swordfish as the distance from the rear of the opercular groove to the anterior insertion of the caudal keel. The above mentioned measurements are used within the annotated text and any substitute measurement cited in the published articles are notated in parentheses.

References are arranged alphabetically by the author's surname. A subject index is also provided to facilitate location of a reference covering a specific area of interest.

ACKNOWLEDGMENTS

I thank Eric Prince and Lynn Pulos, SEFC, Miami Laboratory, for their support and editorial suggestions.

ANNOTATED BIBLIOGRAPHY

Anonymous.
1987. Report of the swordfish assessment workshop. Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap., Madrid, 26(2): 339- 395.

Workshop for assessing the status of the northwest Atlantic stock of swordfish, Xiphias gladius, was held at the Southeast Fisheries Center's Miami Laboratory in 1985. Participants reviewed previously published age and growth information based on anal spine cross section analysis, as well as mark-recapture data and modal progression analysis of size frequency samples. The workshop recommended the analysis of the mark-recapture data (66 observations) for estimating growth and its subsequent use in the age distribution of the catch. Anal spine age estimates were not used for the assessment because age validation of this method had not been achieved. Parameter estimates from the mark-recapture data were computed for the Gompertz growth model. Larval and adult distribution, migration movement, and spawning areas also discussed. Documents were presented describing sex ratio of the stock and length-weight parameters for converting LJFL, EOFL, and TL (cm) to dressed weight (without head, gut, or caudal fin, kg). Catch at age and size, virtual population analysis, indices of abundance, and other assessment parameters are discussed in detail.

Arata, G. F., Jr.
1954. A contribution to the life history of the swordfish, Xiphias gladius Linnaeus, from the South Atlantic coast of the United States and the Gulf of Mexico. Bull. Mar. Sci. Gulf Caribb. 4: 183-243.

Detailed morphometric and meristic description of larval swordfish, Xiphias gladius, presented for specimens ranging in size from 6.1 mm to 192.1 mm (FL, referenced as standard length) and collected along the south Atlantic coast of the United States and in the Gulf of Mexico. Estimated ages of 4, 9, and 13 days assigned to swordfish larvae of sizes 4.0, 5.5, and 8.0 mm, respectively, as well as larval growth rate calculated based on analysis of data from previously published studies. Examination of adult-size fish morphometric data also discussed. Time of spawning, spawning location, and larval distribution were discussed in relation to the estimated ages of the larvae.

Arfelli, C. A. , and A. F. de Amorim.
1981. Estudo biologico-pesqueiro do agulhao-vela, Istiophorus platypterus (Shaw and Nodder, 1791), no sudeste e sul do Brasil (1971 a 1980). (In Portuguese, English abstract).

B. Inst. Pesca 8: 9-22.

General life history parameters described for Atlantic sailfish, Istiophorus platypterus, based on examination of the species caught by Brazilian longliners fishing in the South Atlantic Ocean during 1971-80. Parameter estimates from the regression analysis of EOFL (cm) to dressed weight (kg; bill, tail, and viscera removed), including the log transformed variables, provided based on 25 fish measured (122-175 cm). Movement, spawning season, and reproductive stages of the sailfish also discussed.

Arfelli, C. A. , A. F. de Amorim, and J. C. Galhardo-Amado.
1986. Analysis on Tetrapturus albidus Poey (1861), caught off south and southeast of Brazil (1971-1984). Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap., Madrid, 25: 202-217.

Catches of white marlin, Tetrapturus albidus, landed by Brazilian longline vessels operating off the coast of southeast Brazil during 1971-84 were analyzed. Length (EOFL, cm) to dressed weight (kg; without gill, viscera, bill, and caudal fin) equation parameters were provided based on measurement data from 504 white marlin. Length-weight curve and frequency histograms of the catch also provided. Sexual maturation, sex ratio, and size class analysis were discussed.

Baglin, R. E.
1979. Sex composition, length-weight relationship, and reproduction of the white marlin, Tetrapturus albidus, in the western North Atlantic Ocean. Fish. Bull.,U.S. 76(4): 919-926.

Length (LJFL, cm) and round weight (kg) data analyzed from the recreational catches of white marlin, Tetrapturus albidus, captured in the Gulf of Mexico (1971-76) and in the Atlantic Ocean (1972-76). Length-weight regression coefficients derived for both sexes for the Gulf of Mexico and the Atlantic Ocean, and differences between regressions of the two areas discussed. Sex ratio, ovum diameter frequencies, fecundity estimates, and spawning season also discussed.

Barse, A. M.
1988. A contribution to the biology of white marlin, Tetrapturus albidus, off the Delaware and Maryland coast (U.S.A.) with special emphasis on feeding ecology and helminth parasites. M. S. Thesis, University of Maryland, College Park, MD, 92p.

Ecological investigation presented for the Atlantic white

marlin, Tetrapturus albidus, based on examination of stomach content and presence of parasites. Contents of the alimentary tract and a variety of morphometric measurements were collected from 60 white marlin caught by sportfishermen in 1985 and 1986 off of Maryland and Delaware coasts. Age and growth and other life history parameters reviewed based on previously published studies of the species. Regression equation parameters of length (LJFL, cm) and round weight (kg) derived from the analysis of 23 male (142-184 cm) and 20 female (144-171 cm) white marlin. The presence of parasites (4 helminth taxa) were observed in the alimentary tract and their diversity and relevance as biological tags discussed. Stomach content also described in detail.

Beardsley, G. L.
1972. Size, distribution, and abundance of Atlantic billfishes. In Fifteenth annual international gamefish research conference. p. 87-102. University of Miami, Rosenstiel School of Marine and Atmospheric Science, Miami, FL.

Sportfish catch and effort data discussed for sailfish, Istiophorus platypterus, white marlin, Tetrapturus albidus, and blue marlin, Makaira nigricans, caught in the Atlantic Ocean and adjacent seas from 1961 to 1972. Size (age) groups derived from frequency analysis of round weight (kg) presented for white and blue marlin and the growth rates between each size group discussed for both species. Assignment of age to the size groups was not provided.

Beardsley, G. L. (editor).
1978. Report of the swordfish workshop held at the Miami Laboratory, Southeast Fisheries Center, Miami, Florida, June 7-9, 1977. Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap., Madrid 7(1): 149-158.

General overview of the historical development of the various fisheries for swordfish, Xiphias gladius, in the Pacific and Atlantic Oceans described. Published reports concerning the biology and ecology of the species also reviewed. An age-mean weight (kg, undefined dressed weight) table for estimated ages 1-5 years presented based on size frequency analyses of commercial catches and tagging results. Von Bertalanffy growth equation parameters given for stocks in the Pacific and the Atlantic. Pacific stocks were indicated as having slower growth rate and growth to a smaller asymptotic size than the Atlantic stock. Maximum estimated age of 9 years suggested based on recruitement age (2 years old) and time-at-large from tagging studies. Recommendations for continued refinement of age determination studies discussed.

Beardsley, G. L. Jr. , N. R. Merrett, and W. J. Richards.
1975. Synopsis of the biology of the sailfish, Istiophorus platypterus (Shaw and Nodder, 1791). In R. S. Shomura and F. Williams (editors), Proceedings of the international billfish Symposium, part 3. Species synopses, p. 95-120. U. S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-675.

Detailed summary of life history parameters presented for sailfish, Istiophorus platypterus. Review of previously published studies on age and growth rates discussed. Size (TL, cm, and round weight, kg) at estimated ages 1-4 months through 3 years provided based on length frequency anaylsis of almost 9000 young and adult Atlantic sailfish. Sailfish caught in the Indian and Pacific Oceans inferred as being older than 3 years of age and having a longer life span.

Beardsley, G. L. , R. J. Conser, A. M. Lopez, M. Brassfield, and D. McClellan.
1979. Length and weight data for western Atlantic swordfish, Xiphias gladius. Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap., Madrid, 8(2): 490-495.

Length-weight measurements for swordfish, Xiphias gladius, analyzed based on 168 tournament and 49 commerically caught specimens landed during 1977-78. Tabularized listing of TL (cm, referenced as overall length), FL (cm, referenced as bill-fork), LJFL (cm), OFL (cm), and round weight (kg) is provided. Regression equations parameters and regression curves for LJFL and OFL to round weight and LJFL to OFL also presented.

Beckett, J. S.
1974. Biology of swordfish, Xiphias gladius L. , in the northwest Atlantic Ocean. In R. S. Shomura and F. Williams (editors), Proceedings of the international billfish symposium, part 2. Review and contributed papers, p. 154-159. U. S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-675.

Distribution, spawning, tagging results and estimation of age and growth discussed for swordfish, Xiphias gladius, of the northwest Atlantic Ocean. Estimates of growth by weight (kg; weight undefined) for ages 1-5 years presented for female swordfish based on analysis of modal size frequencies, vertebral ring counts, and tagging records. Conversion factor for dressed to round weight (kg) also given.

Berkeley, S. A., and E. D. Houde.
1980. Swordfish, Xiphias gladius, dynamics in the Straits of Florida. Int. Counc. Explor. Sea, CM 1980/H:59, Pelagic fish committee: 12p.

Estimations of age and growth rate determined for swordfish, Xiphias gladius, caught in the Straits of Florida based on apparent annular marks on anal fin spines. Analysis of 200 fin sections resulted in age estimations of 1-11 years; however, only estimated ages 1-8 years critically examined. Von Bertalanffy growth equation parameters derived for both sexes. Tables of mean observed round and dressed weight (kg; dressed weight undefined) at each age as well as mean back-calculated and predicted lengths (LJFL, cm) presented. Mortality estimates and age composition of catch also discussed.

Berkeley, S. A. , and E. D. Houde.
1981. Population parameter estimates and catch-effort statistics in the broadbill swordfish (Xiphias gladius) fishery of the Florida Straits. Int. Counc. Explor. Sea, CM 1981/H:35, Pelagic fish committee: 11p.

Investigation conducted during 1979-80 on the commercial longline fishery in the Florida Straits and the biology described for the swordfish, Xiphias gladius. Determination of the age and growth rate based on analyses of cross sections of over 400 anal spines presented. Mean back-calculated LJFL (cm; referenced as forklength) by sex for estimated ages 1-8 years tabularized. Von Bertalanffy growth equation parameters derived for both sexes. Males were found to be shorter-lived and reach a smaller asymptotic size than females. Conversion factors for dressed weight (kg; dressed weight undefined) to round weight (kg) provided along with results of the anal spine radius to fish size relationship.

Berkeley, S. A. , and E. D. Houde.
1983. Age determination of broadbill swordfish, Xiphias gladius, from the Straits of Florida, using anal fin spine sections. In E. D. Prince and L. M. Pulos (editors), Proceedings of the international workshop on age determination of oceanic pelagic fishes: tunas, billfishes, and sharks, p. 137-143. U. S. Dep. Commer., NOAA Tech. Rep. NMFS 8.

Estimations of age and growth rate determined for swordfish, Xiphias gladius, collected from the Straits of Florida during 1978-80 based on growth band analysis of anal fin spines. Methodology for selecting and sectioning the second anal fin described. Section analysis of the marginal growth indicated 1 band forming per year during the winter quarter. Age estimates of 1-11 years determined from examination of 439 swordfish spines, although only age groups 1-8 years were critically analyzed. Von Bertalanffy growth equation parameters determined for each sex and length-age growth curve presented. Table of mean back-calculated and

predicted length-at-age (LJFL, cm) for estimated ages 1-8 years also presented and discussed.

Caddy, J. F.
1976. A review of some factors relevant to management of swordfish fisheries in the northwest Atlantic. Can. Fish. Mar. Serv. Tech. Rep. 633: 36p.

Historical review of the Canadian and Atlantic-wide fisheries for swordfish, Xiphias gladius. Information on biololgical and statistical data of all fisheries for swordfish in the northwest Atlantic sunMarized. Estimation of age and rate of growth based on modal progressions and vertebral ring analysis from a previously published study presented showing LJFL (cm; referenced as fork length) and dressed weight (kg; head, viscera, and caudal fin removed) ranges for estimated ages 1-6 years. Length-weight regression parameter estimates and round weight conversion factor also provided.

Caddy, J. F.
1977. Some approaches to elucidation of the dynamics of swordfish (Xiphias gladius) populations. Biol. Stn., St. Andrews. Fish. Mar. Serv. M. S. Rep. 1439: 10p.

Analysis of swordfish, Xiphias gladius, data collected from Canadian commercial fisheries during 1959-69 in the northwest Atlantic Ocean. Parameter estimates of the von Bertalanffy growth equation from previous published studies of size frequency analysis presented for Pacific swordfish, striped marlin, Tetrapturus audax, and the blue marlin, Makaira nigricans. These parameters were compared to the previously published growth estimates of the Atlantic swordfish based on modal progressions and vertebral ring analysis. Tagging studies suggest swordfish maximum longevity to be at least 9 years. Mortality rates and yield per recruit values also presented and discussed.

Conser, R. J.
1982. Recreational/commercial conflicts in the Atlantic billfish fishery. In R. H. Stroud (editor), Proceedings of the seventh annual recreational fisheries symposium, p. 87-99. Sport Fishing Institute, Wash. D.C.

Overview of the Atlantic billfish fishery. Life history parameters reviewed for sailfish, Istiophorus platypterus, white marlin, Tetrapturus albidus, and blue marlin, Makaira nigricans, based on previously published studies. Maximum estimated age of 10 years suggested for sailfish based on studies analyzing dorsal spines and otoliths. White marlin considered to be a long-lived species with tagging records indicating a life span in excess of 10 years. Blue marlin

mentioned as being long-lived; however, no reference to age was indicated. Improvement concerning basic billfish data acquisition from all fisheries and further life history investigations discussed, including the lack of validated age and growth data.

Conser, R. J.
1984. Yield per recruit analysis of sailfish, Istiophorus platypterus, in the western Atlantic Ocean. Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap., Madrid 20(2): 448-464.

Yield per recruit analysis discussed based on a variety of assumptions concerning growth rates of western Atlantic sailfish, Istioohorus olatvpterus. Back-calculated length-at-age data taken from a previously published ageing study was utilized for calculating von Bertalanffy and Gompertz growth equation parameter estimates for both sexes. Growth curves derived from the calculated growth parameters showing length (LJFL, cm) at various estimated ages (1-9 years) were provided and appropriateness of the growth models discussed.

Conser, R., P. L. Phares, J. J. Hoey, and M. I. Farber.
1986. An assessment of the status of stocks of swordfish in the Northwest Atlantic Ocean. Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap., Madrid, 25: 218-245.

Life history parameters reviewed and subsequently utilized in the stock assessment of the swordfish, Xiphias gladius, fishery in the northwest Atlantic Ocean. Three published studies utilizing analysis of skeletal hardparts and mark-recapture data for age determination of swordfish were reviewed. Parameter estimates for each sex were computed for the Gompertz and von Bertalanffy growth models based on the ageing study, which analyzed anal spine sections. Length (LJFL, cm) and round weight (kg) regression equation parameters, as well as round weight (kg) to dressed weight (kg; head, viscera, and caudal fin removed) and LJFL to age (in years) conversion equations provided. Results of the cohort analysis, virtual population analysis, estimates of natural mortality, and recruit analysis discussed in detail.

Cyr, E. C., J. M. Dean, I. Jehangeer, and M. Nallee.
In press. Age, growth, and reproduction of blue and black marlin from the Indian Ocean. In R. Stroud (editor), Proceedings of the international billfish symposium II, Aug. 1-5, 1988, Kailua-Kona, HA: 21p.

Analysis of age, rate of growth, and reproductive biology conducted for blue marlin, Makaira nigricans (referenced as

M. mazara), and black marlin, M. indica, caught off the island of Mauritius in the Indian Ocean by recreational fishermen from 1985 to 1988. Sample size, as well as length (LJFL, cm), round weight (kg) and otolith (sagitta) weight (mg) ranges for each species and sex provided. Estimated ages for male and female blue marlin ranged from 1-21 and 2-21 years, respectively, while male and female black marlin ranged from 5-13 and 1-20 years, respectively. The assigned ages (years) for both species were not validated in this study, although the otolith microsturcture observed as being similar to the growth zones validated for sailfish in a previously published study was inferred. Regression equation parameter estimates for LJFL (cm) and pectoral girth (cm) to round weight (kg), as well as round weight and otolith weight (mg) to age for both blue marlin sexes provided. Parameter estimates of the von Bertalanffy growth equation for both species were also presented.

Davie, P. S. and I. Hall.
In press. Potential of dorsal and anal spines and otoliths for assessing the age structure of the recreational catch of striped marlin from New Zealand. In R. Stroud (editor), Proceedings of the international billfish symposium II, Aug. 1-5, 1988, Kailua-Kona, HA: 21p.

Estimates of age presented based on the analysis of dorsal and anal spines and otoliths (sagittae) from Pacific striped marlin, Tetrapturus audax, caught by the recreational fishery from 1985 to 1988 off the northeast coast of the North Island of New Zealand. Methodology of skeletal hardpart collection and preparation for analysis described. Using sections from the third dorsal spine as the primary ageing structure, 173 striped marlin ranging from 36 to 188 kg (round weight) were assigned estimated ages of 2 to 8 years. Dorsal spine band counts were found to be strongly correlated to round weight, LJFL, and spine width. Examination of sections of the third dorsal and second anal spines and the otolith microstructure of 8 striped marlin yielded no significant differences in growth zone counts between structures. No direct validation of the ageing methodology was indicated. It was suggested that striped marlin appeared to grow faster around New Zealand than in other regions. Age structure of the New Zealand landing (1985-88) based on the ageing results was also briefly examined and discussed.

De Amorim, A. F.
1977. Informe preliminar sobre las investigaciones del pez espada (Xiphias gladius) in el sudeste sur del Brasil, en el periodo de 1971-1976. (In Portuguese, English summary) Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap., Madrid, 6(2): 402-407.

Length-weight frequencies analyzed based on swordfish, Xiphias gladius, samples obtained during conMercial offloading and various scientific cruises in the southwest Atlantic Ocean from 1971 to 1976. Based on 865 samples, length-weight parameter estimates were derived for LJFL (cm; referenced as body length) and dressed weight (kg; gilled and gutted). Parameter estimates were also established for converting round weight (kg) to dressed weight (kg) based on 127 specimens examined during the scientific cruises.

De Amorim, A. F., and C. A. Arfelli.
1984. Estudo biologico-pesqueiro do espadarte, Xiphias gladius Linnaeus, 1758, no sudeste do sul do Brasil (1971 a 1981). (In Portuguese, English abstract). B. Inst. Pescu., Sao Paulo 11: 35-62.

Life history parameters presented for the swordfish, Xiphias gladius, based on biological data collected from the Brazilian longline fishery operating in the south Atlantic Ocean during 1971-81. Analysis of size frequency data provided regression parameter estimates for EOFL (cm) and dressed weight (kg; head, tail and viscera removed) as well as a conversion for dressed weight to round weight (kg). Sexual maturity and spawning season also discussed.

De Amorim, A. F. and C. A. Arfelli.
1987. Analysis on Makaira nigricans Lacèpéde, 1802, caught off south and southeast Brazil (1971-1985). Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap., Madrid, 26: 409-425.

Catches of blue marlin, Makaira nigricans, landed by Brazilian longline vessels operating off the coast of southeast Brazil during 1971-85 were analyzed. Length (EOFL, cm) to dressed weight (kg; gill, viscera, bill, dorsal and caudal fins removed) equation parameters were derived based on measurement data from 91 fish collected from 1974 to 1984. Length-weight curve and frequency histograms of the catches for each year and month were also provided. Annual catch, average weight, and CPUE treads were discussed.

De Sylva, D. P.
1957. Studies on the age and growth of the Atlantic sailfish, Istiophorus americanus (Cuvier), using length-frequency curves. Bull. Mar. Sci. Gulf Carib. 7(1): 1-20.

Estimation of age classes presented based on length frequency analysis of 8,630 Atlantic sailfish, Istiophorus platypterus (referenced as I. americanus), caught during 1939-56 in coastal waters of southern Florida, the Bahamas, and the Gulf of Mexico. Table of length (TL, in.) and mean

round weight (lb) provided for estimated ages 6-42 months as well as length-weight curves given. Growth rates of young (4 and 7 months) and adult size fish discussed. Analysis of landing data suggested that most of the population consisted of fish less than age 3 years. Maximum age of at least 4 years inferred.

De Sylva, D. P. (Abstract)
1974. Life history of the Atlantic blue marlin, Makaira nigricans, with special reference to Jamaican waters. In R. S. Shomura and F. Williams (editors), Proceedings of the international billfish symposium, part 2. Review and contributed papers, p. 80. U. S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-675.

Age suspected of exceeding 15 years for Atlantic blue marlin, Makaira nigricans. Brief highlights of life history parameters also mentioned.

De Sylva, D. P., and W. P. Davis.
1963. White Marlin, Tetrapturus albidus, in the Middle Atlantic Bight, with observations on the hydrography of the fishing grounds. Copia 1963(1): 81-99.

Recreational tournament catch data of white marlin, Tetrapturus albidus, caught in the Middle Atlantic Bight from 1936 to 1960 were analyzed and mean size compared to data from other Atlantic regions. Modal analysis of landing weights of a strong year-class occuring from 1957 to 1959 was examined and annual growth discussed. Length (LJFL, in.) and round weight (lb) regression parameter estimates presented for both sexes based on analysis of 245 white marlin samples collected during 1959 and 1960. General life history information also discussed.

Ehrhardt, N. M.
In press. The potential of using allometric growth characters for resolving routine size and age estimation of billfish. In R. Stroud (editor), Proceedings of the international billfish symposium II, Aug. 1-5, 1988, Kailua-Kona, HA: 23p.

New analytical approach presented in which evaluation of 12 allometric growth measurements obtained from computer digitized video images of Atlantic sailfish, Istiophorus platypterus, were separated into discriminate age classes. Methodology for collection of biological data and video recording of whole sailfish caught by the recreational fishery off of the Florida Keys in 1988, as well as selection and processing of the fifth dorsal spine for age determination described. Multivariate analyses of the measurements using the unvalidated age data from the dorsal spine sections resulted in separation of 7 distinctive age

group categories (2-8 years). The results indicated the potential of using discriminate function analyses to also routinely group unaged sailfish landings into age categories. It was suggested that this procedure could be used on other fish species showing allometric growth.

Farber, M. I.
1981. Analysis of Atlantic billfish tagging data: 1954-80. Working document. Int. Comm. Conserv. Atl. Tunas, June 1981. NOAA, NMFS, Southeast Fisheries Center, Miami, FL: 50p.

Tagging data obtained for white marlin, Tetrapturus albidus, blue marlin, Makaira nigricans, and sailfish, Istiophorus platypterus released since 1954 and subsequently recaptured through 1980 were analyzed for growth and mortality rates and species movement. Various analytical methodologies were utilized in computing the von Bertalanffy growth parameters (L_∞ ,W_∞ ,and k) at various minimum days at liberty for each species and the results compared to known life history information. Evidence from tag returns indicated that white marlin and sailfish live at least 10 years and 6 years, respectively. Blue marlin longevity could not be derived because of insufficient data for time at-large. Estimates for the growth parameter, k, derived from the tagging data were considered to be unreasonable for the three species. Mortality rates derived for white marlin and sailfish were discussed. The extent of migration and movement for all three species also briefly mentioned.

Farber, M. I.
1985. A brief review of the life history and population dynamics parameters of the Atlantic swordfish. NMFS, Miami Laboratory, contribution number ML1-85-09: 19p.

Population dynamic parameters and life history information summarized from previously published studies on the Atlantic swordfish, Xiphias gladius. Tables of size and age of sexual maturity, conversion factors for various morphometric measurements to LJFL (cm), length-weight regression parameter estimates, and von Bertalanffy equation parameters summarized for this species. Size ranges (LJFL and EOFL, cm, and round weight, kg) at estimated age tabularized from published age and growth studies, which utilized size frequency, anal spine, and otolith analyses.

Farber, M. I., and E. D. Prince.
1985. An evaluation of recent ageing techniques and growth models with implications for stock assessment of the Atlantic swordfish. NMFS, Miami Laboratory, contribution number ML1-85-11: 17p.

Three published studies on age and growth determination of the Atlantic swordfish, Xiphias gladius, reviewed. Ageing techniques used in the analysis of otoliths and anal spines were compared. Sample size and specimen size ranges also compared along with discussion of any age validation techniques used. Table of length-at-age estimates (LJFL, cm) derived for each sex from the available growth equation parameters. Von Bertalanffy and Gompertz growth curves presented for the three studies shown and the models compared. Rational for using the Gompertz growth model for stock assessment discussed.

Garces, A. G., and J. C. Rey.
1984. La pesqueria Espanola del pez espada (Xiphias gladius), 1973-1982. (In Spanish, English summary) Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap., Madrid 20(2): 419-427.

Catch, effort, and catch-per-unit-effort data presented for swordfish, Xiphias gladius, caught in the Atlantic and Mediterranean waters of Spain. Parameter estimates for the relationship of LJFL (cm) and weight (kg; round weight minus the bill) derived.

Guitart-Manday, D.
1964. Biologia pesquera del emperador o pez de espada, Xiphias gladius Linnaeus (Teleostomi: xiphiidae) en las aquas de Cuba. (In Spanish, English synopsis). Poeyana, Series B(1): 1-37.

General life history investigation conducted on swordfish, Xiphias gladius, caught in coastal waters of Cuba during 1961-63. Growth information is described by general body morphologies and size catagories denoted as larval stage, young fish (30.5-111.8 cm, TL) and adult fish (>137.2 cm, TL). Total length (cm) and round weight (kg) regression parameter estimates provided based on analysis of 242 samples. Reference made that most of the local stock was considered older that two years of age.

Hedgepeth, M. Y. and J. W. Jolley, Jr.
1983. Age and growth of sailfish, Istiophorus platypterus, using cross sections from the fourth dorsal fin spine. In E. D. Prince and L. M. Pulos (editors), Proceedings of the international workshop on age determination of oceanic pelagic fishes: tunas, billfishes, and sharks, p. 131-135. U. S. Dep. Commer., NOAA Tech. Rep. NMFS 8.

Cross-sections of the fourth dorsal spine from 1071 Atlantic sailfish, Istiophorus platypterus, caught during 1970-80 in waters off southeast Florida analyzed for estimations of age and rate of growth. Methodology of sectioning and analysis

of dorsal spines discussed. Sections from 569 specimens (53%) were considered legible and estimated ages of 1-7 years determined. Von Bertalanffy growth equation parameter estimates derived for both sexes. Table of mean observed, back-calculated and theoretical growth in length (TKL and TL, cm) presented and discussed. Maximum age exceeding 7 years proposed. Age and growth results compared to other ageing studies previously published.

Hill, K. T.
1986. Age and growth of the Pacific blue marlin, Makaira nigricans: a comparison of growth zones in otoliths, vertebrae and dorsal and anal spines. M. S. Thesis, California State University, Stanislaus, CA, 106p.

Estimates of age and rate of growth determined for Pacific blue marlin, Makaira nigricans, based on analysis of otoliths, vertebrae, dorsal and anal spines and morphometric data collected at various billfish tournaments in Hawaii from 1982 to 1984. Methodologies for enhancing and analyzing growth zonations of the various skeletal structures described. Regression analysis of skeletal structure size and EOFL (cm) of fish as well as comparison of estimated ages between structures were presented and discussed. Regression parameters of various morphometric measurements (EOFL, LJFL, and TL) for both sexes were also given. No direct evidence was provided on validation of the periodicity of the growth zonations found in the skeletal structures. Longevity of blue marlin males was indicated to be at least 18 years, whereas females appeared to exceed 30 years. Tables of mean length-at-age (EOFL, cm) derived from otolith and dorsal and anal spine analyses provided. Attempts to fit growth parameter estimates to the von Bertalanffy growth model and its subsequent rejection were discussed.

Hill, K. T., G. M. Cailliet, and R. L. Radtke.
In press. A comparative analysis of growth zones in four calcified structures of Pacific blue marlin, Makaira nigricans. Fish. Bull., U. S.

Estimates of age and growth presented for Pacific blue marlin, Makaira nigricans, based on analyses of anal and dorsal spines, otoliths (sagittae), and vertebrae. Hardparts and morphometric data were taken from 211 male (19.1-170.3 kg, round weight) and 105 female (20.9-748.0 kg, round weight) blue marlin caught off the Hawaiian coast during billfish tournaments held from 1982 to 1984. Methodologies described for processing and analyzing the second anal and sixth dorsal spines, sagittae, and caudal vertebrae (22 and 23). Statistical replacement of the early missing growth bands in anal and dorsal spine sections of

large blue marlin based on visable bands present in smaller, younger fish was also discribed. Regression analysis of ageing structure size to band count and average percent error analysis were determined to test age variability between hardparts and the precision in growth band counts between and among the two readers. Estimated ages ranged from 3 to 18 years for males and 5 to 26 years for females based on band counts from anal spine sections (the primary ageing structure). Longevity estimates extending beyond 20 years for males and 30 years for females mentioned. No direct evidence for validation of age provided.

Hurley, P. C. F., and T. D. Iles.
1981. A review of the Canadian swordfish fishery. Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap., Madrid, 15(2): 348-360.

Historical description of the Canadian fishery for swordfish, Xiphias gladius, in the northwest Atlantic Ocean reviewed along with a summary of life history parameters published in previous studies. Larval growth rate, as well as age-at-mean length (EOFL, cm) for 1-8 years and age-at-mean weight (kg; undefined weight) for 1-5 years presented from previously published ageing studies using size frequency analysis and tagging data. Published reports that derived length-weight parameters using data from various fisheries also mentioned.

Jolley, J. W., Jr.
1974. On the biology of Florida east coast Atlantic sailfish (Istiophorus platypterus). In R. S. Shomura and F. Williams (editors), Proceedings of the international billfish symposium, part 2. Review and contributed papers, p. 81-88. U. S. Dep, Comm., NOAA Tech. Rep. NMFS SSRF-675.

Determination of age and growth of Atlantic sailfish, Istiophorus platypterus, presented based on analysis of cross sections of the fourth dorsal spine. Methodology for preparing and sectioning spines described. Analysis of 64 spines provided estimated ages of 0-7 years. Length-weight relationship (TKL, cm, and round weight, kg) presented and equation parameter estimates calculated. Fecundity and reproduction of sailfish also discussed.

Jolley, J. W., Jr.
1977. The biology and fishery of Atlantic sailfish, Istiophorus platypterus, from southeast Florida. Fla. Mar. Res. Publ. 28: 31p.

Estimation of age and growth rate determined for Atlantic sailfish, Istiophorus platypterus, caught during 1970-74 based on analysis of the fourth dorsal spine sections.

Methodology for processing and sectioning spines described. Sections from 149 spines (24%) were found legible and analysis resulted in estimated ages of 0-8 years with maximun estimated age of 9-10 years proposed. Evaluation of the translucent zone occurrence for marginal growth suggested annual formation of the zones in spines. This analysis was considered inconclusive by the author due to small sample size (N=402) and sectioning technique. Age-round weight (kg) regression parameter estimates for both sexes tabulated. Age-weight curve developed and compared to previously published data. Reproduction, size and age of maturity, and spawning behavior also discussed.

Kanehara, H., Y. Takaki, S. Yada, T. Okaza, and T. Senta.
1985. Experimental operations of marlin long lines in the Gulf of Thailand. Bull. Fac. Fish. Nagasaki Univ. 58: 95-103.

Catch results presented from Japanese exploratory longlining operations conducted in the Gulf of Thailand in 1982. Biological examination and measurements of 24 Pacific black marlin, Makaira indica, were reported from their catches. A conversion factor for LJFL (cm; referenced as fork length) to EOFL was provided. Regression equation parameters for LJFL (cm) and weight (kg; weight undefined) for male, female, and combined sexes were also presented. Stomach content, sex ratio, and sexual maturity discussed.

Koto, T.
1963. Some considerations on the growth of marlins, using size frequencies in commercial catches. 3. Attempts to estimate the growth of striped marlin, Tetrapturus audax (Philippi), in the western North Pacific Ocean. (In Japanese, English abstract). Rep. Nankai Reg. Fish. Res. Lab. 17: 63-85.

Estimation of growth rate determined for striped marlin, Tetrapturus audax, based on length (EOFL, cm; referenced as body length) frequencies obtained from commercial longline vessels in the western North Pacific Ocean during 1949-60. Two methods of analyzing length frequency data mentioned. Analysis of data resulted in 6 modal groups assigned as age groups n to n+5. Annual growth rates for each modal group was also described. Each age group inferred as being 1 year older than the previous age.

Koto, T., and K. Kodama.
1962a. Some considerations on the growth of marlins, using size frequencies in commercial catches. I. Attempts to estimate the growth of sailfish. (In Japanese, English abstract). Rep. Nankai Reg. Fish. Res. Lab. 15: 97-109.

Estimation of age and growth on Pacific sailfish, Istiophorus platypterus, based on length (EOFL, cm, referenced as body length) frequency analysis of Japanese commercial catches in the East China Sea during 1952-55. Estimates of annual growth rate given for 3 age groups.

Koto, T., and K. Kodama.
1962b. Some considerations on the growth of marlin, using size frequencies in commercial catches. II. Attempts to estimate the growth of the so called white marlin, Marlina marlina, (J. and H.). (In Japanese, English abstract). Rep. Nankai Reg. Fish. Res. Lab. 15: 109-126.

Estimation of growth determined for black marlin, Makaira indica (referenced as white marlin, Marlina marlina), based on length (EOFL, cm; referenced as body length) frequencies obtained from commercial longline vessels in the East China Sea during 1952-56. Two methods of analyzing length frequency data discussed. Analysis of data resulted in 3 modal groups in the commercial catches and annual rates of growth discussed. Age was not assigned to the model groups but separation by 1 year intervals inferred.

Kume, S., and J. Joseph.
1969. Size composition and sexual maturity of billfish caught by the Japanese longline fishery in the Pacific Ocean East of 130^0 W. Bull. Far Seas Fish. Res. Lab. (Shimigu) 2: 115-162.

Distribution, size composition of catches, and population structure discussed for Pacific blue marlin, Makaira nigricans (referenced as M. mazara), swordfish, Xiphias gladius, shortbill spearfish, Tetrapturus angustirostris, striped marlin, T. audax, and sailfish, Istiophorus platypterus. Size frequencies (EOFL, cm) analyzed for each species based on data collected during 1963-67 aboard Japanese longline vessels fishing in the eastern Pacific Ocean. Of the species examined, swordfish between 62 and 165 cm (EOFL) were found to have a growth rate of 38 cm per year. Comparison of growth rates in previously published studies also discussed. Regression parameter estimates for EOFL and weight (kg; round and gilled and gutted) tabularized for the five species of billfish.

Lenarz, W. H., and E. L. Nakamura.
1974. Analysis of length and weight data on the three species of billfish from the western Atlantic Ocean. In R. S. Shomura and F. Williams (editors), Proceedings of the international billfish symposium, part 2. Review and contributed papers, p. 121-125. U. S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-675.

The relationship of various length and weight measurements analyzed from recreational catches of blue marlin, Makaira nigricans, white marlin, Tetrapturus albidus, and sailfish, Istiophorus platypterus, landed from the Gulf of Mexico and northwest Atlantic Ocean. Parameter estimates of the regression relationships among round weight (kg), TL (cm), FL (cm), LJFL (cm, referenced as body length), and EOFL (cm) tabularized. Derivation and usefullness of the regression equations to permit conversion of one length to another as well as predict round weight from EOFL discussed for the three species.

Maksimov, V. P.
1971. The biology of the sailfish [Istiophorus platypterus (Shaw et Nodder)] in the Atlantic Ocean. J. Ichthy. 11(6): 850-855.

Life history investigation conducted for sailfish, Istiophorus platypterus, based on examination of 312 specimens caught by commercial vessels fishing in the Atlantic Ocean during 1965. Biological data from previously published life history studies reviewed and discussed. Analyses of length (EOFL, cm) frequency data from the commercial catches substantiated the assumption that sailfish survive 1-2 years after reaching sexual maturity. Estimated maximum age suggested to be about 5 years based on sexual maturity of the species occurring in the third year of life.

Mather, F. J., III., A. C. Jones, and G. L. Beardsley, Jr.
1972. Migration and distribution of white marlin and blue marlin in the Atlantic Ocean. Fish. Bull., U. S. 70(2): 283-298.

Migration and distribution discussed for white marlin, Tetrapturus albidus, and blue marlin, Makaira nigricans, based on tag recapture and Japanese Atlantic longline fishery data. Review of previously published studies suggested that white marlin may be relatively long-lived. Analysis of the tagging records was thought to support this opinion based on tag recaptured white marlin at liberty for 3-4 years. Reduction in growth rate of white marlin after recruitment into the fishery as determined from tagging records was also briefly discussed. No information on longevity or growth rate was reported for blue marlin.

Mather, F. J., III., H. L. Clark, and J. M. Mason, Jr.
1975. Synopsis of the biology of the white marlin Tetrapturus albidus Poey (1861). In R. S. Shomura and F. Williams (editors), Proceedings of the international billfish symposium, part 3. Species synopses, p. 55-94. U. S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-675.

Life history information presented for the Atlantic white marlin, Tetrapturus albidus. Analysis of round weight (lb) frequency distributions from previously published studies along with tagging records suggested that white marlin life span sometimes exceeds 6 years. Length-weight regression equation parameters for LJFL (in.; referenced as FL) for each sex and TL (in.) for all sexes combined were provided from previously published studies.

Merrett, N. R.
1971. Aspects of the biology of billfish (Istiophoridae) from the equatorial western Indian Ocean. J. Zool., London (1971) 163: 351-395.

Life history parameters presented for sailfish, Istiophorus platypterus, striped marlin, Tetrapturus audax, shortbill spearfish, T. angustirostris, black marlin, Makaira indica, and blue marlin, M. nigricans, caught by longline in the equatorial western Indian Ocean during the period 1964-67. Various morphometric measurements including length (FL and EOFL, cm), round weight (kg), and sex data were collected for all five species (N=256) of billfish. Estimates of length-weight regression parameters derived for sailfish and striped marlin by sex. Conversion of FL (cm) to EOFL (cm; referenced as body length) was derived for each species for comparison to other previously published data. Analysis of length and weight frequency data for striped marlin indicated four age groups. No attempt was made to establish the absolute age of these groups. Sample size was insufficient for the other species to discuss growth rates.

Nakamura, I.
1975. Synopsis of the biology of the black marlin, Makaira indica (Cuvier), 1831. In R. S. Shomura and F. Williams (editors), Proceedings of the international billfish symposium, part 3. Species synopsis, p. 17-27. U. S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-675.

Life history parameters summarized for the black marlin, Makaira indica, caught in the Pacific and Indian Oceans. Rate of annual growth by length (EOFL, cm) described for 3 size classes based on previously published study.

Nakamura, I.
1985. Billfishes of the world--An annotation and illustrated cataloque of marlins, sailfishes, spearfishes and swordfishes known to date. FAO Fisheries Synopsis 5(125): 65p.

Taxonomic and life history parameters for all the known species of billfishes found in the Atlantic, Pacific, and Indian Oceans and adjacent seas. Information pertaining to

maximum length (cm, measurements varied for each species) and weight (kg) provided for sailfish, Istiophorus platypterus, black marlin, Makaira indica, blue marlin, M. nigricans, striped marlin, Tetrapterus audax, white marlin, T. albidus, shortbill spearfish, T. angustirostris, longbill spearfish, T. pfluegeri, and swordfish, Xiphias gladius. Conversion ratios (percent) for EOFL to LJFL (cm) given for Pacific sailfish, striped marlin, and swordfish. Brief discussion also given to speciation nomenclature problems since the author recognized 12 separate species of billfishes depending on the oceanic location.

Ovchinnilov, V. V.
1970. Swordfishes and billfishes in the Atlantic Ocean. Ecology and functional morphology. Translation from Russian. Israel program for scientific translation. TT71-50011: 77p.

General life history parameters presented primarily for Atlantic swordfish, Xiphias gladius, but included other billfishes in the Istiophoridae (referenced as Xiphiidae) family. Estimated ages and rate of growth presented for swordfish and sailfish, Istiophorus platypterus (referenced as Histiophorus americanus), based on previously published studies. Length (cm; measurement undefined) ranges for swordfish 1-3 years presented with reference that the estimated age composition of Atlantic catches was mostly ages 4-5 years. Age-length (TL, cm) and age-round weight (kg) curves also presented for sailfish 1-3 years based on previously published study. Inference that sailfish live about 5 years also mentioned.

Ovchinnilov, V. V., M. E. Grudtsev, and S. V. Kholodkova.
1980. Length-age composition of the tropical Atlantic swordfishes (Xiphias gladius, L). Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap., Madrid, 9(3): 620-623.

Estimation of age and growth rate determined for swordfish, Xiphias gladius, based on length frequency data of 3,266 fish caught in the tropical Atlantic during 1965-76. Fish length (EOFL, cm) frequencies analyzed for age using Petersens curve and probability paper methods. Estimated ages of 1-8 years derived and results compared to other published studies. Length-age table also provided.

Palko, B. J., G. L. Beardsley, and W. J. Richards.
1981. Synopsis of the biology of the swordfish, Xiphias gladius Linneaus. U. S. Dep. Commer., NOAA Tech. Rep. NMFS Cir. 441: 21p.

Detailed review of life history parameters presented on the biology of the swordfish, Xiphias gladius. Age estimates

and rates of growth summarized from previously published studies. Larval growth rate also mentioned. Age-weight (kg; undefined dressed welght) table for 1-5 years presented for female Atlantic swordfish. Maximum age considered to beat least 9 years based on tagging records.

Powers, J. E.
1983. Report of the Southeast Fisheries Center stock assessment workshop. NOAA Tech. Mem. NMFS-SEFC-127: 229p.

Stock assessments and research status reports summarized for Atlantic fishery stocks (particularly billfishes) under evaluation by the NMFS Southeast Fisheries Center. White marlin, Tetrapturus albidus, growth rate derived from tagging data was discussed and a life span of at least 12 years mentioned. Von Bertalanffy growth equation parameter estimates presented for swordfish, Xiphias gladius, based on length (LJFL, cm) frequency data from the Canadian fishery and anal fin spine analysis of fish caught in the Straits of Florida. Other Atlantic billfish species mentioned without reference of growth rate or age estimates.

Prince, E. D., and L. M. Pulos (editors).
1983. Proceedings of the international workshop on age determination of oceanic pelagic fishes: tunas, billfishes, and sharks. NOAA Tech. Rep. NMFS 8: 211p.

Workshop attended by 65 scientists from various countries was held for the purpose of presenting papers and exchanging ideas on age and growth research on oceanic pelagic species (tunas, billfishes, and sharks). A total of 25 papers were presented. Five billfish papers presented age estimates based on the analyses of dorsal and anal spines and otoliths. The species examined in these studies included the sailfish, Istiophorus platypterus, and blue marlin, Makaira nigricans, from the Pacific and Atlantic Oceans, Atlantic swordfish, Xiphias gladius, black marlin, M. indica, striped marlin, Tetrapturus audax, longbill spearfish, T. pfluegeri, and the Pacific shortbill spearfish, T. angustirostris. Papers on other pelagic species (tunas and sharks) were presented describing age and growth estimations based on analysis of dorsal spines, otoliths and vertebrae. Regression analysis of the skeletal hardpart size and size of fish, growth equation parameter estimates, and methodologies for hardpart analysis provided for most species.

Prince, E. D., and D. W. Lee.
In press. Development of length regressions for Atlantic Istiophoridae. Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap., Madrid, SCR5/88/43: 14p.

Regression analysis of four length measurements for estimating LJFL (cm) presented for several Atlantic istiophorids species (blue marlin, Makaria nigricans, white marlin, Tetrapturus albidus, and sailfish, Istiophorus platypterus). Measurements for each species and sex were collected by port samplers along the Atlantic and Gulf coast of the U. S. and the Caribbean Sea during 1987 and 1988. The relationships of EOFL (cm), pectoral insertion to fork length (PFL, cm), pectoral insertion to anterior insertion of second dorsal finlet (PDL, cm), and anterior dorsal spine to fork length (DFL, cm) were compared to LJFL (cm). Coefficient of determination (R2) ranged from 0.93 to 0.64. Analysis of PDL vs. LJFL was weakest for all species categories.

Prince, E., D. Lee, and R. Conser.
1987. Estimating age and growth rate of Atlantic blue marlin (Makaira nigricans): progress and future work plan. Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap., Madrid 26(2): 426-435.

Progress of research for estimating age and growth of Atlantic blue marlin, Makaira nigricans, using dorsal spine sections and sagittae otoliths discussed. A u t h o r s highlighted 9 factors contributing to the difficult task of ageing this particular species. Examination of sagittae sections from 14 blue marlin (4.3-67.1 kg; round weight) provided estimates of age ranging from 89 to 568 days based on presumed daily increments. Back-calculated fertilization dates based on the estimated ages of the two smallest specimens supported the interpretation that zones were formed once a day. Growth was found to be nearly linear and suggested a very rapid growth rate for the size interval sampled. Preliminary marginal increment analysis (MIA) was applied to 416 dorsal spine sections (representing all 12 months), but no significant seasonal distribution of growth or occurrence of band formation could be detected statistically. In addition, estimated ages (years) from both the otolith and spine sections of 20 blue marlin ranging in size from 4.3 to 33.0 kg were compared between the two structures, as well as the two readers of the the spine sections. Results indicated that, although both readers were precise in their band counts of the spine sections, spine sections tended to provide higher ages than otoliths. Factors influencing these results were discussed. Although validation of the estimated ages was not conclusively achieved, recommendations and new innovative ideas were provided.

Prince, E. D., D. W. Lee, and S. A. Berkeley.
1988. Use of marginal increment analysis to validate the anal spine method for ageing Atlantic swordfish and other

alternatives for age determination. Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap., Madrid, 27: 184-201.

Using marginal increment analysis (MIA), 508 anal spine sections were examined from swordfish, Xiphias gladius, caught in the Straits of Florida (1979-80) and the Caribbean Sea (1986) in the attempt to validate the accuracy of the anal spine method for estimating age. Although all twelve months of the year were represented, MIA did not provide conclusive evidence of time of band formation for validating the spine section method for ageing. In addition, sagittae otoliths from five juvenile swordfish (17.9-40.0 cm, LJFL) were also examined and estimated ages of 32 to 50 days were obtained based on counts of presumed daily growth increments. Back-calculated birthdates were provided for the specimens which agreed with spawning occurrence described in other published papers. Growth was very rapid for juvenile fish within the size ranges studied and similar to the preliminary growth rate published for small blue marlin.

Prince, E. D., D. W. Lee, C. A. Wilson, and J. M. Dean.
1984. Progress in estimating age of blue marlin, Makaira nigricans, and white marlin, Tetrapturus albidus, from the western Atlantic Ocean, Caribbean Sea, and Gulf of Mexico. Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap., Madrid 20(2): 435-447.

Estimates of age presented for blue marlin, Makaira nigricans, and white marlin, Tetrapturus albidus, caught during 1980-83 in the Atlantic Ocean and adjacent seas based on a preliminary analysis of otoliths and dorsal spines. Methodology described for selection and sectioning the fifth dorsal spine, the preparation of otoliths (sagittae), and the measurement of the growth bands. Selected spine sections and otoliths from 57 blue marlin (95-343 cm, LJFL) and 53 white marlin (106-202 cm, LJFL) examined. Relationships of length of fish to hardpart size and growth band counts for both species and sexes compared between the two hardpart structures. The relationship between estimated band counts in otoliths and dorsal spines for both species also discussed.

Prince, E. D., D. W. Lee, C. A. Wilson, and J. M. Dean.
1986. Longevity and age validation of a tag-recaptured Atlantic sailfish, Istiophorus platypterus, using dorsal spines and otoliths. Fish. Bull.,U. S. 84(3): 493-502.

A tagged Atlantic sailfish, Istiophorus platypterus, at-large for 10 years and 10 months was recaptured and dorsal spines (3-6) and otoliths (sagittae) were collected for age analysis and validation. Approximate age ranged

from 13 to 15+ years based on age/size at release derived from previously published papers plus tagging records. Dorsal spines 3-6 substantially underestimated age known from tagging records. Analysis of the internal microstructure and external ridge counts of the sagitta otolith gave an estimated age of 13 years. The data suggested that sagittae, rather than dorsal spines, should be used as the source of age and growth information in older, larger sailfish (≥ 5 years, 22.7 kg) Maximum estimated longevity was revised upward from 7 years as previously reported to 13 to 15+ years.

Prince, E. D., D. W. Lee, J. R. Zweifel, and E. B. Brothers.
In press. Estimating age and growth of young Atlantic blue marlin, Makaira nigrican, from otolith microstructure. In R. Stroud (editor), Proceedings of the international billfish symposium II, Aug. 1-5, 1988, Kailua-Kona, HA: 29p.

Estimation of age and rate of growth of young Atlantic blue marlin, Makaira nigrican, presented based on the analysis of daily growth increments on sagittae otoliths. Methodology for otolith preparation and analysis discussed. Sagittae from 18 larvae (5-10 mm, notochord length) and 77 juvenile and young adult blue marlin (4.3-212 cm, LJFL) provided estimated ages of 9-495 days. Analysis of otolith microstructure could not be applied with confidence to blue marlin older that 495 days because of the difficulty of counting and discriminating daily increments. Strong indirect validation of the daily increment otolith method was presented based on comparison of the microstructure characteristics of zonations to those found in other species where age validation was proven and the distribution of back-calculated fertilization dates to the known spawning season. Precision of daily counts also presented. Growth equation parameters for the Gompertz, von Bertalanffy and Logistics models derived and rates of growth compared to other fast growing species. Analysis of the Gompertz model estimated the fastest absolute growth rate of a blue marlin at 40 cm (LJFL) to be about 16.2 mm per day, indicating this species as one of the fastest growing teleosts during the early stages of development. Length (LJFL, cm) and weight (kg) regression parameters also provided.

Radtke, R. L.
1981. Age resolution of billfishes (Istiophoridae and Xiphiidae). In Proceedings of the western association of fish and wildlife agency Honolulu, HA., 13-17 July 1981: 58-74.

Preliminary discription of billfish sagitta otolith morphology discussed for blue marlin, Makaira nigricans, black marlin, M. indica, striped marlin, Tetrapturus audax,

white marlin, T. albidus, longbill spearfish, T. pfluegeri, shortbill spearfish, T. angustirostris, sailfish, Istiophorus platypterus, and swordfish, Xiphias gladius. Methodology for extraction of otoliths and their examination using scanning electron microscopy briefly described. The presence of distinct ridges on the rostral lobe of the sagittae from each species and an increase of ridge counts with fish size were found. An attempt to validate external ridge deposition as an annual event for blue marlin otoliths was made based on data from a single tag recaptured specimen and its correlation to ridge counts made from 8 blue marlin otoliths. Counts of internal micro-increments (presumed daily events) and external ridges (presumed annual events) made on all the billfish sagittae were found to be closely related. Age estimates for Atlantic and Pacific blue marlin provided.

Radtke, R. L.

1983. Istiophorid otoliths: extraction, morphology, and possible use as ageing structures. In E. D. Prince and L. M. Pulos (editors), Proceedings of the international workshop on age determination of oceanic pelagic fishes: tunas, billfishes, and sharks, p. 123-130. U. S. Dep. Commer., NOAA Tech. Rep. NMFS 8.

Estimations of age based on counts of the external surface ridges of otoliths (sagittae) from seven species of billfishes was investigated. Species examined from both the Atlantic and Pacific Oceans included blue marlin, Makaira nigricans, black marlin, M. indica, sailfish, Istiophorus platypterus, striped marlin, Tetrapturus audax, white marlin, T. albidus, longbill spearfish, T. pfluegeri, and shortbill spearfish, T. angustirostris. Methodology for extraction and examination of otoliths using scanning electron microscopy described. Indirect supportive evidence of annual ridge deposition for blue marlin based on a single tag recaptured specimen discussed. Formation of external ridges assumed to be annual for other species examined. Tables showing specimen weight and ridge count ranges as well as sample size for each species provided. Estimated ages of species common to both geographical regions also discussed.

Radtke, R. L., and J. M. Dean.

1981. Morphological features of the otoliths of the sailfish, Istiophorus platypterus, useful in age determination. Fish. Bull., U. S. 79(2): 360-367.

Morphological characteristics of otoliths from the Atlantic sailfish, Istiophorus platypterus, described and usefulness of the structure for age determination discussed. Methodologies for otolith extraction and examination given.

Analysis of sagittae external ridge counts from 64 sailfish (5.0-27.7 kg, round weight) were found to be highly correlated to fish weight. Estimates of otolith ages (1-7 years) compared to other previously published ageing studies of sailfish. The lapillus and asteriscus also examined.

Radtke, R. L., and P. R. C. Hurley.
1983. Age estimation and growth of broadbill swordfish, Xiphias gladius, from the northwest Atlantic based on external features of otoliths. In E. D. Prince and L. M. Pulos (editors), Proceedings of the international workshop on age determination of oceanic pelage fishes: tunas, billfishes, and sharks, p. 145-150. U. S. Dep. Commer., NOAA Tech. Rep. NMFS 8.

Estimation of age and growth rate determined for Atlantic swordfish, Xiphias gladius, caught during 1980 based on analysis of external surface ridge counts of otoliths (sagittae). Methodology of extracting and analyzing otoliths described. External surface ridge count of 268 otoliths from fish measuring 80-280 cm (LJFL) resulted in estimated ages of 2-14 years for males and 2-32 years for females. Von Bertalanffy growth equation parameter estimates derived for both sexes. Internal and external morphology of sagitta discussed. Annual ridge deposition suggested based on analysis of 2 sagittae in which total counts of finely spaced internal increments (presumed daily events) were closely correlated to the ages estimated by total surface ridge counts.

Radtke, R. L., M. Collins, and J. M. Dean.
1982. Morphology of the otoliths of the Atlantic blue marlin (Makaira nigricans) and their posible use in age estimation. Bull. Mar. Sci. 32(2): 498-503.

Estimates of age for Atlantic blue marlin, Makaira nigricans, determined based on analysis of external surface ridges of the sagitta otolith. Methodology for extraction of otoliths and their examination using scanning electron microscopy described. Examination of otoliths from 8 marlin (34-147 kg, round weight) yielded external ridge counts ranging from 2 to 7. The positive correlation of the two parameters and the implication of the ridges being an indicator of age and/or growth discussed.

Rey, J. C., and A. G. Garces.
1979. Nuevos datos sobre la pesqueria Espanola de pez espada, Xiphias gladius, biologia y morfometria. (In French, English summary). Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap., Madrid 8(2): 504-509.

Various morphometric measurements analyzed for the Spanish

catches of swordfish, Xiphias gladius, from the Atlantic Ocean and Mediterranean Sea. Regression parameter estimates derived from weight (kg; referenced as eviscerated weight) and LJFL (cm) presented for both geographic bodies of water.

Robins, C. R.
1975. Synopsis of biological data on the longbill spearfish, Tetrapturus pluegeri, Robins and de Sylva. In R. S. Shomura and F. Williams (editors), Proceedings of the international billfish symposium, part 3. Species synopses, p. 28-38. U. S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-675.

General life history parameters presented for the Atlantic longbill spearfish, Tetrapturus pflugeri. Estimated ages 0-3 years determined based on size frequency analysis of sportfishing catch data. Ranges of length (LJFL, cm) and round weight (kg) given for each age. Maximum age indicated as less than 4 years with no appreciable growth between 3-4 years.

Royce, W. R.
1957. Observations on the spearfishes of the central Pacific. Fish. Bull. Fish Wildl. Ser. 57(124): 497-554.

Analysis of billfish morphometric data collected for blue marlin, Makaira nigricans (referenced as M. ampla), black marlin, M. indica (referenced as Istiompax marlina), striped marlin, Tetrapturus audax (referenced as M. audax), sailfish, Istiophorus platypterus (referenced as I. orientalis), shortbill spearfish, T. angustirostris, and swordfish, Xiphias gladius, during scientific longline cruises in the central tropical Pacific Ocean (1952-54). Regression parameter estimates for FL (cm) to round weight (lb; referenced as live weight) and EOFL (cm) to FL (cm) provided for blue marlin, black marlin, and striped marlin. Identification characteristics, geographical distribution, and general life history for each species discussed.

Sanzo, L.
1922. Uova e larve di Xiphias gladius L. R. Comit. Talassogr. Ital. Mem. LXXIX: 17p.

Detailed description of enbryonic and larval development of Atlantic swordfish, Xiphias gladius, reared in captivity. Developmental characteristics and measurements (TL, mm) given for just hatched, 5 day, 9 day, and 13 day old larvae. Growth briefly discussed for each stage of the larvae sampled.

Skillman, R. A., and M. Y. Y. Yong.
1974. Length-weight relationships for six species of

billfishes in the central Pacific Ocean. In R. S. Shomura and F. Williams (editors), Proceedings of the international billfish symposium, part 2. Review and contruibuted papers, p. 126-137. U. S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-675.

Length-weight regression parameter estimates derived for black marlin, Makaira indica, blue marlin, M. nigricans, sailfish, Istiophorus platypterus, shortbill spearfish, Tetrapturus angustirostris, striped marlin, T. audax, and swordfish, Xiphias gladius, based on central Pacific recreational and commercial catches collected from 1950 to 1971. Fork length (cm) and round weight (kg) examined using log-linear and nonlinear regression models. Allometric and isometric growth also discussed.

Skillman, R. A., and M. Y. Y. Yong.
1976. Von Bertalanffy growth curves for striped marlin, Tetrapturus audax, and blue marlin, Makaira nigricans, in the central North Pacific Ocean. Fish. Bull., U. S. 74(3): 553-566.

Estimated ages and rates of growth determined for striped marlin, Tetrapturus audax, and blue marlin, Makaira nigricans, based on analysis of size frequency data of fish caught by Hawaiian longline fishery in the North Pacific Ocean during 1960-70. Methodology of statistical analyses and transformation of data described. Von Bertalanffy growth parameter estimates derived for each species and sex using modal length (FL, cm) analysis of the data. Estimated ages of 1-5 years for striped marlin and 1-8 years for blue marlin presented in tables showing mean lengths for all years combined. Accuracy of the estimations discussed.

Taning, A. V.
1955. On the breeding areas of the swordfish (Xiphias). Mar. Biol. Oceanog., Deep Sea Res., Supplemental to vol. 3: 438-450.

Distribution, spawning area and season, and age and growth information provided for swordfish, Xiphias gladius, based on the collection of 60 postlarval stage specimens (5-46 mm, all measurements undefined) obtained during Danish oceanographic expeditions in the Atlantic and Pacific Oceans during 1921-22 and 1928. Although it was indicated that spawning occurs during all months, maximal spawning was thought to be February-April and later in the year in the Mediterranean Sea. A major breeding ground was indicated for the Caribbean Sea. No validation of age or growth rate was provided, but it was suggested that post-larvae less than 20 mm were less than a month old. In addition, specimens measuring 5-8 cm were representative of 1 year and

a specimen at 19.2 cm was about 2 years old. The author indicated this rate of growth appeared to be far to slow for this species. Optimum water salinity and temperature for spawning and larval survival also discussed.

Tibbo, S. N., L. R. Day, and W. F. Doucet.
1961. The swordfish (Xiphias gladius L.), its life-history and economic importance in the northwest Atlantic. Bull. Fish. Res. Bd. Can. 130: 47p.

General account of swordfish, Xiphias gladius, life history and description of the fishery in the northwest Atlantic Ocean presented based on investigations conducted during 1958-1959 by Canadian scientists. Estimation of growth in weight (lb; weight undefined) during first year of life and seasonal weight variations discussed. Conversion factor of dressed weight (lb; head, viscera, fins and tail removed) to round weight determined.

Tinsley, J. B.
1964. The sailfish, swashbuckler of the open seas. Rose Printing Company, Inc., Tallahassee, FL, 216p.

A book written in layman's terms providing interesting and documentated facts about the life history and fishing methods for the Atlantic sailfish, Istiophorus platypterus. Reference to length (TL, in.) and round weight (lb) mentioned for ages 1-3 years based on previously published studies conducted on age and growth of the species. Maximum age of 4 years suggested.

Ueyanagi, S., and P. G. Wares.
1975. Synopsis of biological data on striped marlin, Tetrapturus audax (Philippi), 1887. In R. S. Shomura and F. Williams (editors), Proceedings of the international billfish symposium, part 3. Species synopses, p. 132-156. U. S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-675.

Life history parameters reviewed for Pacific striped marlin, Tetrapturus audax. Age classes and growth of 6 modal groups (n to n+5) discussed based on previously published analysis of length frequency data of northwestern Pacific catches. Table of length (EOFL, cm) and annual growth changes presented. Maximum size and variation in annual growth (length) between geographical regions discussed. Maximum estimated age suggested to be at least 10 years.

Voss, G. L.
1972. A survey of the biology of the sailfish, Istiophorus platypterus, from the western Atlantic. In Proceedings of the fifteenth annual international gamefish research conference, Dec. 1972, Miami, FL: 1-13.

Review of life history parameters of the Atlantic sailfish, Istiophorus platypterus, summarized from previously published studies. Size (TL, ft, and round weight, lb) at estimated ages (1-3 years) presented using previous published ageing studies analyzing size frequency data. Maximum age of 3-4 years indicated with few fish attaining an age beyond 4 years.

Wares. P. G., and G. T. Sakagawa.
1974. Some morphometrics of billfish from the eastern Pacific Ocean. In R. S. Shomura and F. Williams (editors), Proceedings of the international billfish symposium, part 2. Review and contributed papers, p. 107-120. U. S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-675.

Analysis of length-weight and derivation of length conversion formulae presented for Pacific striped marlin, Tetrapturus audax, sailfish, Istiophorus platypterus, and blue marlin, Makaira nigricans. Morphometric data gathered from recreational landings during 1967-70. Regression parameter estimates tabularized for each species by sex for EOFL (cm), and LJFL (cm, referenced as snout-fork length) measurements.

Wilson, C. A.
1984. Age and growth aspects of the life history of billfish. Ph.D. dissertation, Department of Biology, University of South Carolina, Columbia, S. C., 180p.

Detailed life history investigation of Pacific and Atlantic blue marlin, Makaira nigricans, Atlantic swordfish, Xiphias gladius, and Atlantic white marlin, Tetrapterus albidus, presented. Estimates of age and rate of growth also determined for each species based on analysis of otoliths (sagittae) collected during 1980-84. Methodology for extraction and analyses of the sagittae using light and scanning electron microscopy techniques described. Description of the internal and external morphology of the sagittae also given. Estimation of the von Bertalanffy growth equation parameters derived for each species and compared to parameters from previously published studies. Estimated ages for the 3 species ranged as follows (both sexes combined) : (1) Pacific blue marlin, 1-21 years; (2) Atlantic blue marlin, 1-19 years; (3) white marlin, 1-16 years; and (4) swordfish, 1-16 years. Age estimates (years) were not validated; however, indirect evidence indicating growth zones were annual events was discussed for each species.

Wilson, C. A., and J. M. Dean.
1983. The potenial use of sagitta for estimating age of Atlantic swordfish, Xiphias gladius. In E. D. Prince and L. M. Pulos (editors), Proceedings of the international workshop on age determination of oceanic pelagic fishes: tunas, billfishes, and sharks, p. 151-156. U. S. Dep. Commer., NOAA Tech. Rep. NMFS 8.

Age and growth rate estimated for Atlantic swordfish, Xiphias gladius, based on otoliths and anal spines collected during 1981 aboard commercial vessels fishing off the southeast United States. Methodology for collection of both skeletal structures and processing for sectioning and examination described. Length (LJFL, cm) and round weight (kg) data fitted to a power function showed significant differences between sexes. Counts of the internal microstructure (presumed daily increments) of juvenile and young swordfish (1-2 years old) supported the assumption of annual zone deposition. In addition, presumed annual increment counts of sagittae and the second anal spine sections from the same swordfish (N=45) were highly correlated. Age estimates from otolith analysis ranged from 50 days to 15 years, with maximim ages of 9 years for males and 15 years for females. Von Bertalanffy growth parameter estimates derived from otoliths data.

Yabe, H., S. Ueyanagi, S. Kikawa, and H. Watanabe.
1959. Study on the life-history of the swordfish, Xiphias gladius Linnaeus. (In Japanese, English summary). Rep. Nankai Reg. Fish. Res. Lab. 10: 107-150.

Estimation of age and growth rate determined for swordfish, Xiphias gladius, based on length (EOFL, cm; referenced as body length) frequencies obtained from commercial longline vessels in the Pacific Ocean and adjacent seas during 1947-58. Length-at-age measurements given for estimated ages 1-3 years. Growth curve also provided for estimated ages 2-54 months. Maximum age of 5-6 years inferred.

Yeo, R. N.
1978. Fecundity, reproductive biology and some aspects of growth in the Atlantic blue marlin, Makaira nigricans, Lacèpéde 1802. M. S. Thesis, University of Miami, Miami, FL, 257p.

Investigation of the reproductive biology of the Atlantic blue marlin, Makaira nigricans, presented. Estimates of the length-weight regression parameters for both sexes provided for 5 geographical areas based on analysis of 1,267 length (LJFL, cm) and weight (kg) measurements of blue marlin caught in the Atlantic Ocean and adjacent seas during sportfishing tournaments between 1971 and 1976. Size

composition and size ranges of the catches of blue marlin and other billfish species documented in previously published studies compared to investigation results and those parameters discussed.

SUBJECT INDEX

Tibbo et al. 1961
Wilson 1984
Wilson and Dean 1983

Pacific swordfish
Xiphias gladius

Nakamura 1985
Palko et al. 1981
Skillman and Yong 1974
Taning 1955
Yabe et al. 1959

Atlantic sailfish
Istiophorus platypterus

Arfelli and de Amorim 1981
Beardsley 1972
Beardsley et al. 1975
Bertolino et al. 1985
Conser 1982, 1984
De Sylva 1957
Ehrhardt In press
Farber 1981
Hedgepeth and Jolley 1983
Jolley 1974, 1977
Lenarz and Nakamura 1974
Maksimov 1971
Nakamura 1985
Ovchinnilov 1970
Prince and Pulos 1983
Prince and Lee In press
Prince et al. 1986
Radtke 1981, 1983
Radtke and Dean 1981
Tinsley 1964
Voss 1972
Wares and Sakagawa 1974

Pacific sailfish
Istiophorus platypterus

Koto and Kadama 1962a
Kume and Joseph 1969
Merrett 1971
Nakamura 1985
Prince and Pulos 1983
Skillman and Yong 1974

Pacific black marlin
Makaira indica

Cyr et al. In press
Kanehara et al. 1985
Koto and Kadama 1962b
Merrett 1971
Nakamura 1975, 1985
Prince and Pulos 1983
Radtke 1981, 1983
Royce 1957
Skillman and Yong 1974

Atlantic longbill spearfish
Tetrapterus pfluegeri

Nakamura 1985
Prince and Pulos 1983
Radtke 1981, 1983
Robins 1975

Pacific shortbill spearfish
Tetrapterus angustirostris

Kume and Joseph 1969
Merrett 1971
Nakamura 1985
Prince and Pulos 1983
Radtke 1981, 1983

Pacific striped marlin
Makaira audax

Caddy 1977
Davie and Hall In press
Koto 1963
Kume and Joseph 1969
Merrett 1971
Nakamura 1985
Prince and Pulos 1983
Radtke 1981, 1983
Skillman and Yong 1974, 1976
Wares and Sakagawa 1974

AGE DETERMINATION

Anonymous 1987
Barse 1988

Beardsley 1978
Beardsley et al. 1975
Beckett 1974
Berkeley and Houde 1980, 1981, 1983
Bertolino et al. 1985
Caddy 1976
Conser et al. 1986
Cyr et al. In press
Davie and Hall In press
Hedgepeth and Jolley 1983
Hill 1986
Hill et al. In press
Hurley and Ilse 1981
Jolley 1974, 1977
Maksimov 1971
Merrett 1971
Ovchinnilov 1970
Ovchinnilov et al. 1980
Palko et al. 1981
Prince and Pulos 1983
Prince et al. 1984, 1986, 1987, 1988, In press
Radtke 1983
Radtke and Dean 1981
Radtke and Hurley 1983
Radtke et al. 1982
Robins 1975
Skillman and Yong 1976
Taning 1955
Tinsley 1964
Ueyanagi and Wares 1975
Voss 1972
Wilson 1984
Wilson and Dean 1983
Yabe et al. 1959

GROWTH RATES

Arata 1954
Beardsley 1972, 1978
Cyr et al. In press
De Sylva and Davis 1963
Farber 1981
Guitart-Manday 1964
Koto 1963
Koto and Kadama 1962a, 1962b
Kume and Joseph 1969
Merrett 1971
Nakamura 1975
Ovchinnolov 1970
Ovchinnolov et al. 1980
Palko et al. 1981
Prince et al. 1987, 1988, In press
Sanzo 1922
Skillman and Yong 1974
Taning 1955
Tibbo et al. 1961
Ueyanagi and Wares 1975
Wilson 1984

AGEING ANALYSIS

Spines

Anonymous 1987
Berkeley and Houde 1980, 1981, 1983
Bertolino et al. 1985
Conser et al. 1986
Davie and Hall In press
Ehrhardt In press
Farber 1985
Farber and Prince 1985
Hedgepeth and Jolley 1983
Hill 1986
Hill et al. In press
Jolley 1974, 1977
Powers 1983
Prince and Pulos 1983
Prince et al. 1984, 1986, 1987, 1988
Wilson and Dean 1983

Vertebrae

Beckett 1974
Caddy 1976, 1977
Hill 1986
Hill et al. In press

Otoliths

Bertolino et al. 1985
Conser et al. 1986
Cyr et al. In press
Davie and Hall In press
Farber 1985
Farber and Prince 1985

Hill 1986
Hill et al. In press
Prince and Pulos 1983
Prince et al. 1984, 1986, 1987, 1988, In press
Radtke 1981, 1983
Radtke and Dean 1981
Radtke and Hurley 1983
Radtke et al. 1982
Wilson 1984
Wilson and Dean 1983

TAG RELEASE-RECAPTURE

Anonymous 1987
Barse 1988
Beardsley 1978
Beckett 1974
Bertolino et al. 1985
Caddy 1977
Conser et al. 1986
Hurley and Iles 1981
Mather et al. 1972, 1975
Powers 1983
Prince et al. 1986
Radtke 1983

SIZE FREQUENCY ANALYSIS

Anonymous 1987
Arata 1954
Arfelli and de Amorim 1981
Arfelli et al. 1986
Baglin 1979
Beardsley 1978
Beardsley et al. 1975, 1979
Beckett 1974
Caddy 1976, 1977
De Amorim 1977
De Amorim and Arfelli 1984
De Sylva 1957
De Sylva and Davis 1963
Farber 1985
Hurley and Iles 1981
Koto 1963
Koto and Kadama 1962a, 1962b
Kume and Joseph 1969
Maksimov 1971
Mather et al. 1975
Merrett 1971
Ovchinnilov et al. 1980
Powers 1983
Robins 1975
Skillman and Yong 1976
Tibbo et al. 1961
Ueyanagi and Wares 1975
Voss 1972
Yabe et al. 1959
Yoe 1978

REGRESSION PARAMETERS

Anonymous 1987
Arfelli and de Amorim 1981
Arfelli et al. 1986
Barse 1988
Beardsley et al. 1979
Beckett 1974
Caddy 1976
Conser et al. 1986
Cyr et al. In press
De Amorim 1977
De Amorim and Arfelli 1984, 1987
Farber 1985
Garces and Rey 1984
Guitart-Manday 1964
Hill 1986
Hurley and Iles 1981
Jolley 1974
Kanehara et al. 1985
Kume and Joseph 1969
Lenarz and Nakamura 1974
Mather et al. 1975
Merrett 1971
Nakamura 1985
Prince and Lee In press
Prince et al. In press
Rey and Garces 1979
Royce 1957
Skillman and Yong 1974
Tibbo et al. 1961
Wares and Sakagawa 1974
Wilson 1984
Wilson and Dean 1983
Yoe 1978

GROWTH EQUATION PARAMETERS

Anonymous 1987
Beardsley 1978

Berkeley and Houde 1980, 1981, 1983
Caddy 1977
Conser 1984
Cyr et al. In press
Farber 1985
Farber and Prince 1985
Hedgepeth and Jolley 1983
Powers 1983
Prince et al. In press
Radtke and Hurley 1983
Skillman and Yong 1976
Wilson 1984
Wilson and Dean 1983

GROWTH CURVES

Anonymous 1987
Conser 1984
Conser et al. 1986
Jolley 1977
Prince et al. In press
Yabe et al. 1959

MAXIMUM AGE

Beardsley 1978
Berkeley and Houde 1980, 1981, 1983
Bertolino et al. 1985
Caddy 1977
Conser 1982
De Sylva 1957
Hill 1986
Hill et al. In press
Hedgepeth and Jolley 1983
Jolley 1977
Maksimov 1971
Mather et al. 1975
Ovchinnilov 1970
Palko et al. 1981
Powers 1983
Prince et al. 1986
Robins 1975
Tinsley 1964
Ueyanagi and Wares 1975
Voss 1972
Wilson and Dean 1983
Yabe et al. 1959

AGE VALIDATION

Anonymous 1987
Berkeley and Houde 1983
Bertolino et al 1985
Conser et al. 1986
Farber and Prince 1985
Jolley 1977
Prince et al. 1986, 1987, 1988, In press
Radtke 1983
Radtke and Hurley 1983
Wilson 1984