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TR EL-82-4

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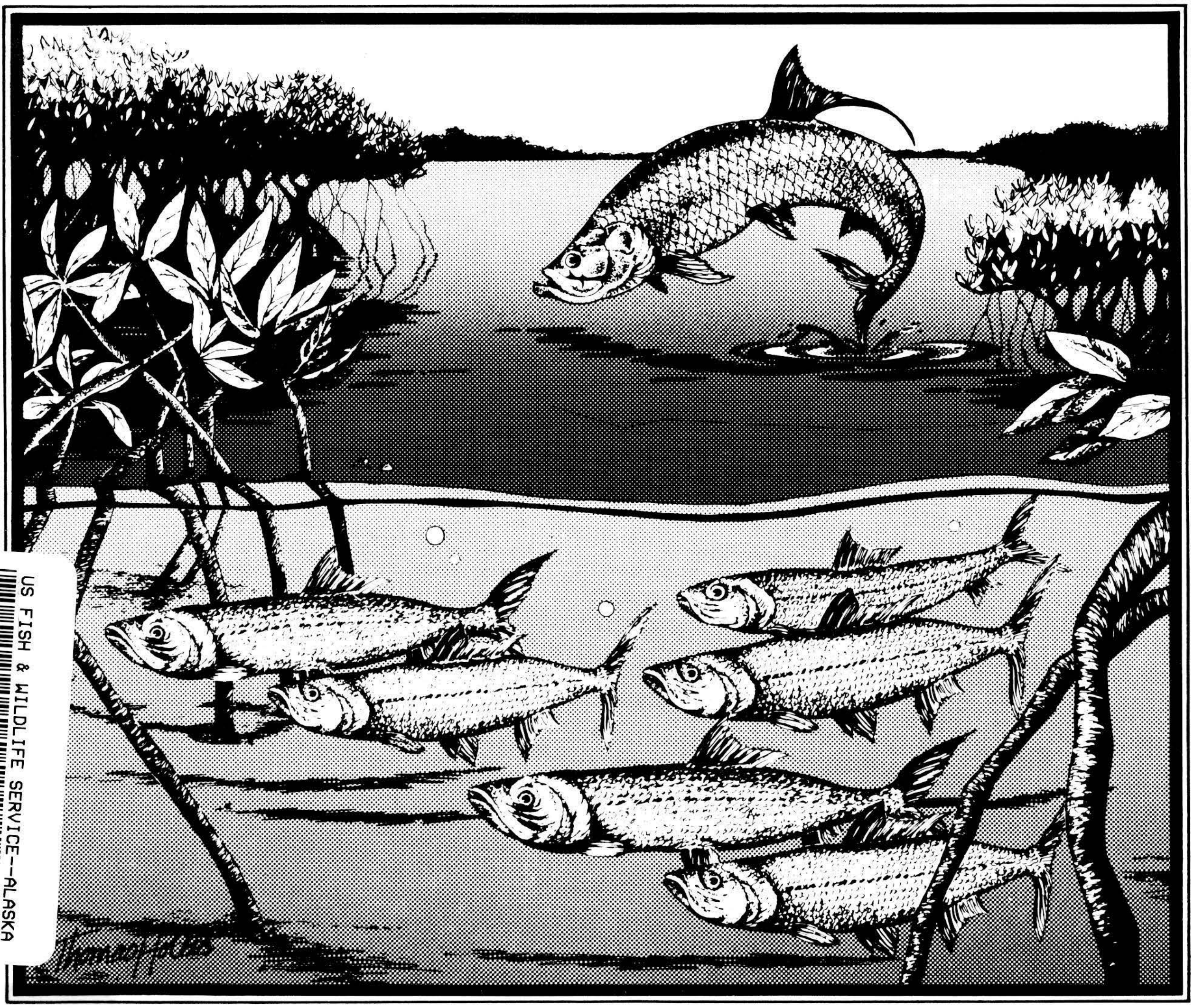
LADYFISH AND TARPON



and Wildlife Service
Department of the Interior

Coastal Ecology Group
Waterways Experiment Station
U.S. Army Corps of Engineers

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Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Florida)

LADYFISH AND TARPON

by

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Vicksburg, MS 39180

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PREFACE

This species profile is one of a series on coastal aquatic organisms, principally fish, of sport, commercial, or ecological importance. The profiles are designed to provide coastal managers, engineers, and biologists with a brief comprehensive sketch of the biological characteristics and environmental requirements of the species and to describe how populations of the species may be expected to react to environmental changes caused by coastal development. Each profile has sections on taxonomy, life history, ecological role, environmental requirements, and economic importance, if applicable. A three-ring binder is used for this series so that new profiles can be added as they are prepared. This project is jointly planned and financed by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service.

Suggestions or questions regarding this report should be directed to one of the following addresses.

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1010 Gause Boulevard
Slidell, LA 70458

or

U.S. Army Engineer Waterways Experiment Station
Attention: WESER-C
Post Office Box 631
Vicksburg, MS 39180

CONVERSION TABLE

Metric to U.S. Customary

Multiply	By	To Obtain
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
meters (m)	0.5468	fathoms
kilometers (km)	0.6214	statute miles
kilometers (km)	0.5396	nautical miles
square meters (m^2)	10.76	square feet
square kilometers (km^2)	0.3861	square miles
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters (m^3)	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (t)	2205.0	pounds
metric tons (t)	1.102	short tons
kilocalories (kcal)	3.968	British thermal units
Celsius degrees (°C)	1.8(°C) + 32	Fahrenheit degrees

U.S. Customary to Metric

Multiply	By	To Obtain
inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
statute miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet (ft^2)	0.0929	square meters
square miles (mi^2)	2.590	square kilometers
acres	0.4047	hectares
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28350.0	milligrams
ounces (oz)	28.35	grams
pounds (lb)	0.4536	kilograms
pounds (lb)	0.00045	metric tons
short tons (ton)	0.9072	metric tons
British thermal units (Btu)	0.2520	kilocalories
Fahrenheit degrees (°F)	0.5556 (°F - 32)	Celsius degrees

CONTENTS

ACKNOWLEDGMENTS

Drafts of this Species Profile were critically reviewed by Ed Rutherford, National Park Service, Everglades National Park, Florida; C. Richard Robins, University of Miami, Miami, Florida; and Paul H. Eschmeyer, Editorial Office, U.S. Fish and Wildlife Service, Fort Collins, Colorado. Sheila G. Johnson, Edmon Low Library, Oklahoma State University, provided exceptional assistance with literature searches and inter-library loan. H. Franklin Percival of the Florida Cooperative Fish and Wildlife Research Unit, University of Florida, Gainesville, and O. Eugene Maughan of the Oklahoma Unit provided administrative assistance.

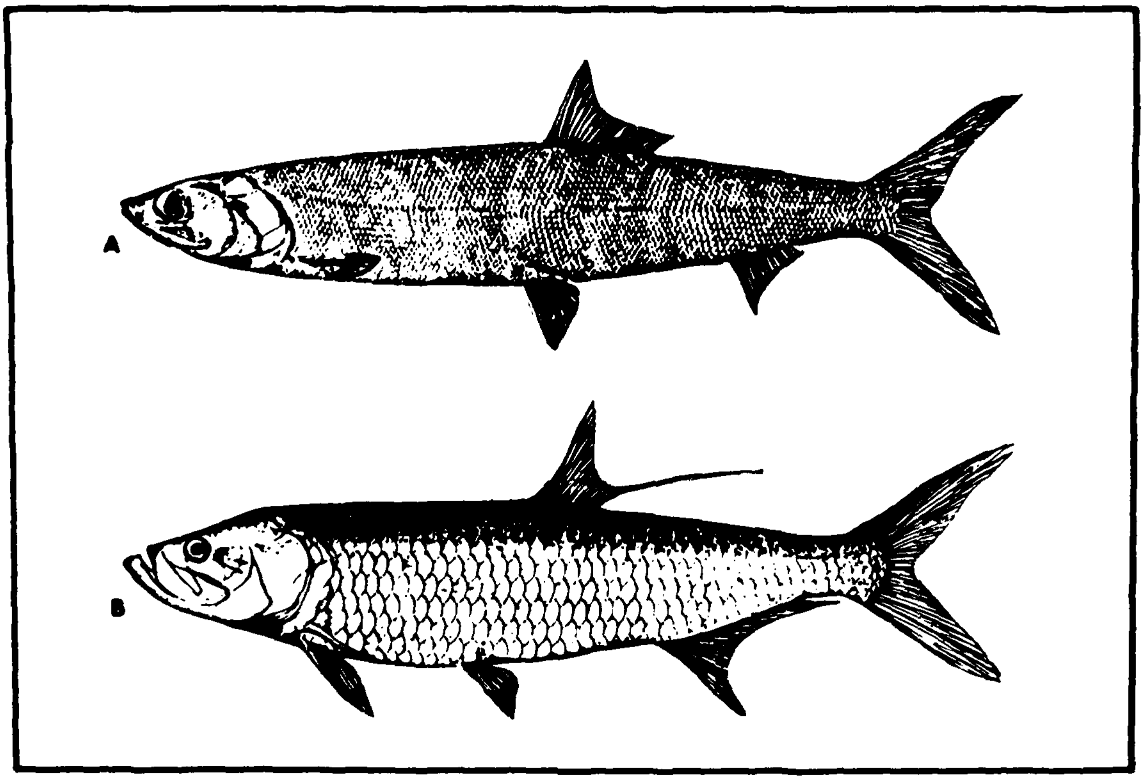

Figure 1. A: ladyfish; B: tarpon.

LADYFISH AND TARPON

NOMENCLATURE/TAXONOMY/RANGE

Scientific name .... Elops saurus Linnaeus (Robins et al. 1980)
Preferred common name .... ladyfish (Figure 1A)
Other common names .. bigeyed herring, bony-fish, chiro, Francesca, John Mariggle, Liza, matajuelo real, piojo, skipjack, tenpounder (Eldred and Lyons 1966; Jordan and Evermann 1969)
Class .... Osteichthyes
Order .... Elopiformes
Family .... Elopidae

Geographic range .... western Atlantic Ocean from Bermuda and southern New England (but uncommon north of Cape Hatteras) to Rio de Janeiro, Brazil, and throughout the Gulf of Mexico (Figure 2); also occurs in the Indian and western Pacific Oceans (Jordan and Evermann 1896; Bigelow and Schroeder 1953; Briggs 1958; Berra 1981). Marine and brackish estuarine (Eldred and Lyons 1966; Nelson 1984).

Scientific name .. Megalops atlanticus Valenciennes (Robins et al. 1980)

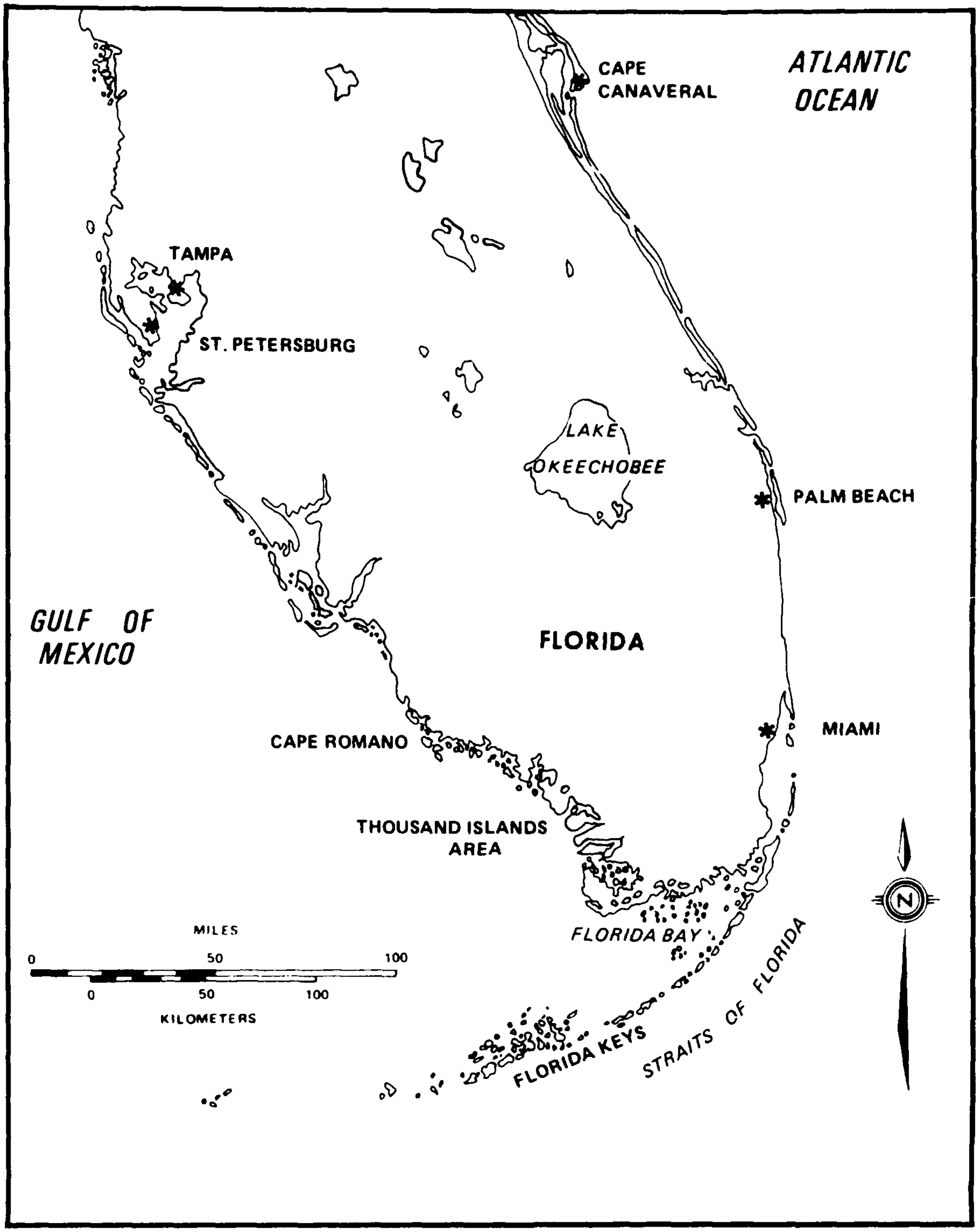

Figure 2. Ladyfish and tarpon are distributed along the entire coast of South Florida in the Continental Shelf and brackish estuarine waters; tarpon ascend rivers into freshwater also.

Preferred common name .... tarpon (Figure 1B)

Other common names .... big scale, caffum, grande ecaille, grande ecoy, jewfish, sabalo, sabilo real, sadina, savalle, savallo, savalo-real, savanilla, silver fish, silver king, tarpom, tarpum (Gill 1907; Hildebrand 1937; Babcock 1951; Wade 1962a; Jordan and Evermann 1969)

Class .... Osteichthyes

Order .... Elopiformes

Family .... Elopidae or Megalopidae

The tarpon was placed in the Elopidae by Gosline (1971) and Robins et al. (1980), whereas Greenwood et al. (1966), Forey (1973a, 1973b), and Nelson (1984) recognized the Megalopidae and Elopidae as separate families within the suborder Elopoidei. The issue is equivocal and unlikely to be resolved soon.

Geographic range .... Western Atlantic Ocean from Virginia to Brazil and Gulf of Mexico (Figure 2); eastern Atlantic off tropical Africa; chief centers of abundance are the West Indies, Florida, and Gulf of Mexico; stragglers recorded from Nova Scotia, Bermuda, Argentina, and the Pacific terminus of the Panama Canal (Hildebrand 1939; Wade 1962a, 1969; Nelson 1984). No evidence exists to suggest that tarpon have become established in the Pacific (Swanson 1946; Wade 1962a). Generally marine or brackish estuarine, but often ascends rivers into fresh water 1951; Wade 1962a; Robins 1978; Nelson 1984).

MORPHOLOGY/IDENTIFICATION AIDS

The ladyfish and tarpon are both herring-like in general appearance but are readily distinguished from clupeids by the presence of an elongate bony gular plate between the branches of the lower jaw and a much larger mouth; the jaw extends considerably posterior to the rear edge of the orbit (Bigelow and Schroeder 1953). The belly is not keeled or serrated as in herrings, but is relatively broad and covered with ordinary scales (Jordan and Evermann 1969).

The following description of the Elopidae (including the tarpon) is summarized from Jordan and Evermann (1969). Body elongate, somewhat compressed, and covered with silvery cycloid scales. No scales on head. Lateral line present. Mouth broad, lower jaw prominent. Premaxillaries short and nonprotactile; maxillaries form lateral margins of the upper jaw. Eye relatively large, with adipose eyelid. Bands of villiform teeth on jaws, vomer, palatines, pterygoids, tongue, and base of skull. Opercular bones thin, with expanded membranous margins. Gill membranes entirely separate and free from the isthmus; gillrakers long and slender. Dorsal fin inserted over or slightly behind the pelvics. Caudal fin forked, dorsal and anal fins depressible into scaly sheaths. No spines or adipose fin. Very long accessory scales at the pectorals and pelvics.

Ladyfish

Body very elongate and covered with small, thin, silvery scales. Head small and pointed, with very large terminal mouth; maxillary reaches far behind eye. Branchiostegal ray 30. Dorsal fin inserted slightly behind the pelvics. Dorsal, anal, and pelvic fin ray counts, 20, 13, and 15, respectively. Caudal lobes long and slender. Lateral line straight, with simple pores, 110 to 120 scales. Color silvery all over and bluish dorsally, with lower parts of sides and ventral surface yellowish or white. Dorsal and caudal fins dusky yellowish and silvery. Pelvics and pectorals speckled, yellowish, and dusky. Reaches a maximum length of about 1 m (usually less than 60 cm) and weight of several kilograms. Data from Bigelow and Schroeder (1953) and Jordan and Evermann (1969).

Tarpon

Body oblong, compressed, and covered with large, thick, silvery, cycloid scales. Mouth large and superior. Branchiostegal rays 23. Dorsal fin with 12 rays, inserted considerably behind the pelvics. Anal deeply falcate, 20 rays, about twice as long as dorsal, has greatly elongated last ray. Caudal widely forked and scaly. Lateral line nearly straight, 41 to 48 scales; its tubes radiate widely over the surface of the scales. Vertebral counts 53 to 57. Color bright silver, with dorsal surface somewhat darker than ventral. Reaches 2 to 2.6 m and over 90 kg. Data from Bigelow and Schroeder (1953), Jordan and Evermann (1969), and Nelson (1984).

The two species are easily distinguished (Jordan and Evermann 1969). The ladyfish has large pseudobranchs and small scales. The last ray of the dorsal is not elongated, and the anal fin is smaller than the dorsal. Conversely, the tarpon has large scales and no pseudobranchs. The last ray of the dorsal is elongated, its free portion being as long as, or longer than, the height of the fin. The anal fin is larger than the dorsal.

REASON FOR INCLUSION IN THIS SERIES

The tarpon is the premier inshore big-game fish of the Florida coast (McLane 1974; Robins 1978). Esteemed for its stamina, strength, and especially its leaping prowess, it is avidly sought by anglers. Numerous annual tournaments are directed specifically at this species. Tourist revenues generated by the fishery are formidable. The ladyfish is also sought by anglers; it has the sporting attributes of the tarpon, but comes in a smaller package suitable for light tackle. Both species are considered inedible in the United States because of the boniness of the flesh, and therefore do not support commercial fisheries. However, they are eaten in limited quantities elsewhere (Hildebrand 1939; Babcock 1951).

LIFE HISTORIES

Spawning locations of ladyfish are unknown, but have been inferred to be offshore throughout most of the range of the species, as judged by the locations of capture of early larvae (Hildebrand 1943; Gehringer 1959a; Eldred and Lyons 1966). Similarly, tarpon are believed to spawn throughout most of their range in offshore waters (Wade 1962a; Hildebrand 1963; Eldred 1967). Eldred (1967, 1968, 1972) inferred from larval capture locations that spawning took place in the Florida Straits, Gulf Stream, and Caribbean. Smith (1980) provided strong evidence (based on the collection of very young larvae) that tarpon spawn off the Caribbean coast of Mexico near Cozumel and Banco Chinchorro (Yucatan Channel), off west-central Florida, and off the southern part of Veracruz, Mexico. The presence of small larvae off Georgia (Gehringer 1959b) and North Carolina (Berrien et al. 1978) indicates that spawning occurs there also, and probably to some extent along the entire coast from Florida to Cape Hatteras.

Fecundity of a tarpon 2 m long was estimated to be about 12,200,000 (Babcock 1951). Sexual maturity is attained at a total length (TL) of about 120 cm (Breder 1944). Fecundity and size at sexual maturity of ladyfish are unknown.

Eggs of neither tarpon nor ladyfish have been described, nor are yolk-sac larvae of the ladyfish known. Smith (1980) described and illustrated late yolk-sac larvae of tarpon. His smallest specimen, 5.7 mm in notochord length (NL), retained only trace amounts of yolk, indicating that the yolk-sac stage ends at about 6 mm NL. Eggs and yolk-sac larvae that Breder (1944) believed to be tarpon were erroneously identified (Eldred 1972).

Post yolk-sac larval development in both species progresses through three distinct stages (terminology from Wade 1962a, modified by Jones et al. 1978). Stage I is an initial period of length increase that culminates in the development of a fully formed leptocephalus larva. The leptocephalus is characterized by a long, ribbon-like, colorless, transparent body; large fang-like teeth; a very small head; and small fins. It lacks gills and red blood cells, and its gut is not open (Robins 1978). Oxygen and nutrients are absorbed through the skin. In Stage II, the larva decreases markedly in length and gradually loses the ribbon-like leptocephalic morphology. Stage III is a second period of length increase that terminates with the beginning of the juvenile stage. Late in Stage II and throughout Stage III the larva undergoes pronounced changes in body form, including increases in body depth, snout length, head length, dorsal and anal fin height, and pectoral fin size. Late in Stage III, the body starts to become opaque and silvery. Juveniles resemble adults in general appearance. Early life history stages of tarpon were described by Hildebrand (1934), Hollister (1939), Harrington (1958), Gehringer (1959b), Wade (1962a), Eldred (1967, 1968, 1972), Mercado and Ciardelli (1972), Jones et al. (1978), and Smith (1980). Descriptions of larval and juvenile ladyfish were published by Hildebrand (1943), Alikunhi and Rao (1951), Gehringer (1959a), Eldred and Lyons (1966), and Jones et al. (1978).

Ladyfish grow to a maximum standard length (SL) of about 40-45 mm during Stage I, shrink to about 18-20 mm SL during Stage II, and metamorphose into juveniles at about 30-35 mm SL at the end of Stage III (Hildebrand 1943; Alikunhi and Rao 1951; Gehringer 1959a; Jones et al. 1978). Durations of about 29 days for Stage II and 42 days for Stage III were reported by Gehringer (1959a) for larvae reared in the laboratory. Alikunhi and Rao (1951) reported the duration of Stages II and III combined as only 9 days in the laboratory; concurrent field collections provided supporting evidence for this rapid rate of change. No records of water temperature accompanied the data for either study.

Sizes of Stage I tarpon range from 6 mm NL to 28 mm SL (Mercado and Ciardelli 1972; Smith 1980). Duration of Stage I is estimated to be 2 to 3 months in the ocean (Smith 1980). Larval tarpon shrink to about 14 mm SL during Stage II and become juveniles at about 40 mm SL after Stage III (Wade 1962a). Duration of Stage II was 20-25 days in the laboratory (Mercado and Ciardelli 1972). On the basis of Harrington's (1966) data, we estimate duration of Stage III to be about 7-8 weeks.

Spawning of ladyfish appears to extend throughout most of the year, perhaps peaking in fall, as judged by the occurrence of Stage I larvae. Alikunhi and Rao (1951) collected late Stage I larvae from October to December in coastal Indian waters. Hildebrand (1943) collected Stage I larvae off Beaufort, North Carolina, from October through May; off Texas in February, March, April, and November; off the Florida Keys in November; and off Cuba in May. Offshore collections of Stage I larvae were made by Gehringer (1959a) off Florida and Georgia in October, off South Carolina in May, and off North Carolina in November. Arnold et al. (1960) collected leptocephali from early March to mid-May near Galveston, Texas. Tabb and Manning (1961) reported that larvae were abundant in Florida Bay from September through December. Eldred and Lyons (1966) reported collecting Stage I leptocephali off Florida in January, February, May, June, August, October, and December.

Summarizing various references on the occurrences of larval tarpon, Robins (1978) and Smith (1980) noted that Stage I larvae occur from mid-May to late August, and Stage II larvae from late June to early October; they inferred that spawning occurs in late spring or early summer.

Early Stage I larvae of ladyfish were captured offshore (Gehringer 1959a) at 28.5 ppt and 28.1 °C (Eldred and Lyons 1966). Late Stage I larvae occur inshore (Gehringer 1959a) at 26.3-38.5 ppt and 17.5-29.0 °C (Eldred and Lyons 1966). Older early-life stages (Stage II and III larvae and juveniles) inhabit coastal beaches, canals, bayous, lagoons, tidal ponds, creeks, rivers, and mosquito control impoundments (Erdman 1960; Zilberberg 1966; Dahlberg 1972; Govoni and Merriner 1978; Gilmore et al. 1981; Thompson and Deegan 1982; Snelson 1983). They live in water of a wide range of salinities and temperatures: 14-45 ppt and 24-32 °C (Harrington 1958); 17.5-39.0 ppt (Harrington and Harrington 1961); 34.3-34.6 ppt and 18-23 °C (Eldred and Lyons 1966); 1.4-11.2 ppt and 21-30 °C (Herke 1969); 0.1-28.7 ppt and >19.9 °C (Dahlberg 1972); 10-20 ppt and <35 °C (Rose et al. 1975); 5.6-5.8 ppt (Theiling and Loyacano 1976); 2.2-6.1 ppt (Govoni and Merriner 1978); 0.0-8.8 ppt and 16-28 °C (Thompson and Deegan 1982). Rose et al. (1975) reported a pH range of 6.8-8.7 for a coastal impoundment inhabited by juvenile ladyfish. Adult ladyfish usually live in relatively open inshore and coastal habitats (Dahlberg 1972; Gilmore et al. 1981; Snelson 1983) but may ascend rivers for considerable distances (Tagatz 1967).

Habitats of Stage I tarpon larvae are clear, warm, oceanic waters (Gehringer 1959b; Robins 1978) within 100 m of the surface (Wade 1962a). Surface water temperatures at collection sites ranged from 26.0 to 30.0 °C and salinities from 33.6 to 36.0 ppt (Wade 1962a; Berrien et al. 1978; Smith 1980). Estimated temperature and salinity ranges at depth of capture were 22.2-28.4 °C and 33.6-36.7 ppt (Wade 1962a).

Stage II and III tarpon larvae and juveniles live in salt marsh and mangrove ponds, tidal creeks, rivers, ditches, beaches, and mosquito-control impoundments (Storey and Perry 1933; Breder 1944; Simpson 1954; Moffett and Randall 1957; Erdman 1960; Harrington and Harrington 1960, 1961; Wade 1962a, 1969; Rickards 1968; Dahlberg 1972; Tagatz 1973; Gilmore et al. 1981; Snelson 1983). These habitats are typically shallow (<1 m), have a sandy mud or mud substrate with no rooted submerged vegetation, are lined by reeds or mangroves, usually have turbid or dark-stained waters, and may be either stagnant or have considerable current (Beebe 1927; Breder 1933; Simpson 1954; Wade 1962a, 1969; Rickards 1968). In such habitats, larvae and juveniles are able to withstand environmental conditions deleterious to many other fishes. Juvenile tarpon have been collected at widely varying salinities: 31.8 ppt (Simpson 1954), 18.8-33.4 ppt (Moffett and Randall 1957), 14-45 ppt (Harrington 1958), 17.5-39.0 ppt (Harrington and Harrington 1961), 0.0-22.3 ppt (Rickards 1968), 0-47 ppt (Wade 1969), and 15-21 ppt (Gilmore et al. 1982). Most larval and juvenile tarpon live at relatively high temperatures: 36.6 °C (Moffett and Randall 1957), 36.0 °C (Rickards 1968), and 40 °C (Wade 1969). Because tarpon respire aerially (by gulping air) at least as early as the beginning of Stage III (Harrington 1966), low dissolved oxygen concentrations are not deleterious to survival. The strong odor of hydrogen sulfide at capture sites, indicative of poor tidal flushing, has been reported by various investigators (e.g., Beebe 1927; Breder 1933, 1944; Rickards 1968; Wade 1969). Juvenile tarpon are often collected from isolated marsh ponds that are connected to the estuary only during spring tides. Wade (1969) collected juvenile tarpon at pH's of 6.8 to 8.2.

In eastern Florida marshes, Wade (1969) found Stage III larvae in ditches at the headwaters of small creeks. Small juveniles (40-80 mm SL) lived in larger ditches and creeks, especially in the deeper pools. Large juveniles were found in larger canals and rivers. Juvenile tarpon eventually emigrate from marsh and mangrove habitats and enter coastal waters when they reach about 600-800 mm TL (Robins 1978). In Georgia, tarpon are unable to overwinter in marsh habitats; juveniles left marshes, presumably to migrate south, by late October, when they had attained about 160 mm SL (Rickards 1968). Adults live in bays, lagoons, and coastal habitats (Breder 1944; Dahlberg 1972; Gilmore et al. 1981; Snelson 1983) or may cruise the open ocean (Robins 1978).

GROWTH CHARACTERISTICS

Age and Growth

Moffett and Randall (1957), who examined length-frequency distributions of juvenile tarpon from a south Florida mangrove pond, reported that modal lengths increased from 75-80 mm FL in early September to 110-115 mm FL at the end of the month, and inferred a length increase of about 1.4 mm/day; rates declined by about 50% in October. Five marked juvenile tarpon (301-376 mm FL when tagged) in a south Florida drainage ditch grew an average of 1.0 mm/day (range, 0.7-1.4 mm/day) from 22 August to 20 October (Moffett and Randall 1957). Over the same period, modal lengths of tarpon in this population increased by 1.4 mm/day. In a Georgia salt marsh, juvenile tarpon grew at a rate of about 30 mm/month (Rickards 1968).

Breder (1944), who determined growth rates of captive juvenile tarpon, wrote that 12 fish maintained at the old New York Aquarium for 113 to 314 days grew an average of 0.088 mm/day (range, 0.048-0.186 mm/day); initial and final length ranges were 94-145 and 110-176 mm TL. Three tagged fish (355-365 mm TL) confined in natural ponds in southern Florida did not grow in 133 to 152 days (August to January). Two others (tagged in July) grew from 345 to 390 and from 370 to 380 mm TL in 258 and 167 days, respectively. Four juvenile tarpon (originally 230-350 mm TL) maintained in laboratory pools grew 13 to 179 mm (mean increment, 97 mm) in 15 months; a fifth grew from 436 to 465 mm TL in 6 months.

Ten tarpon raised by Harrington (1966) in the laboratory from Stage III larvae (18.1-22.7 mm SL; mean, 21.4 mm) for 1 year grew to 55.4-105.3 mm SL (mean, 67.2 mm SL).

Although scales of adult tarpon have distinct rings resembling annuli (Breder 1944; Moffett and Randall 1957), these marks have not been validated as annuli and should be considered with extreme caution. Back-calculated mean lengths at the formation of these putative annuli are shown in Figure 3. Maximum age based on these checks was 16 years (Moffett and Randall 1957); however, larger fish have been captured.

Gehringer (1959a) reared ladyfish in the laboratory from early Stage II to the juvenile phase. Rates of change in standard length during the first part of Stage II (from about 35-40 mm to 25 mm SL) averaged -1.061 mm/day. Further shrinking to about 20-21 mm SL proceeded at about -0.342 mm/day. Initial length increase during early Stage III, from about 20 to 25 mm SL, averaged 0.140 mm/day. Growth rates of late Stage III larvae and early juveniles (<60 mm SL) were about 0.626 mm/day. Larger juveniles grew an average of 0.628 mm/day. Field collections suggested a faster rate of growth (about 2 mm/day) under natural conditions (Gehringer 1959a). No information is available on growth of adult ladyfish.

Morphometric Relations

Breder (1944) presented the following length-weight relation for adult tarpon in Florida:

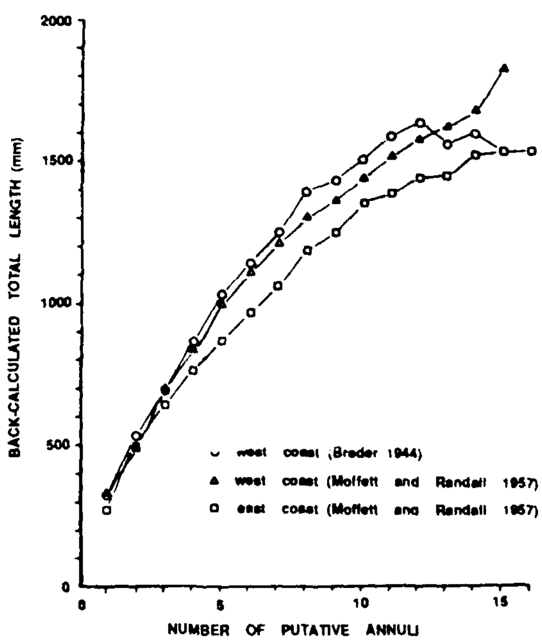

Figure 3. Back-calculated mean lengths of tarpon from the west and east coasts of Florida, at putative annuli on scales.

$$W = 9 \times 10^{-6}\ TL^3$$

where W = weight in grams and TL = total length in millimeters.

Harrington (1958) derived the following length-weight relation for 154 tarpon, 16.0-45.5 mm SL:

$$W = 0.05514 \times 1.069^{SL} - 0.15$$

where W = weight in grams and SL = standard length in millimeters. The relation is valid only for fish within the stated size range.

On the basis of a graph presented by Moffett and Randall (1957), we derived the following relation between total length (TL) and fork length (FL) for tarpon:

$$TL = 1.10\ FL.$$

Harrington (1958) developed the following conversions between fork length (FL), total length (TL), and standard length (SL) in millimeters for tarpon 25-54 mm SL:

$$FL = 1.1282SL - 1;$$
$$TL = 1.3333SL - 2.$$

Sekavec (1974) derived the following length-weight formula from 295 juvenile ladyfish 45-201 mm FL from Louisiana:

$$\log_{10} W = -5.3295 + 3.1123 \log_{10} FL$$

where W = weight in grams and FL = fork length in millimeters. Mean condition factor (K, where $K = [W/(FL)^3] \times 10^6$; Lagler 1956) of these fish was 8.1 (range 6.6-8.9).

FISHERY

The tarpon and ladyfish fisheries are solely recreational; no commercial fishery exists for either species in the United States. Neither species is recorded in the National Marine Recreational Fisheries Survey and regional catch data are nonexistent (Grant L. Beardsley, Senior Scientist for Recreational Fisheries, National Marine Fisheries Service, Southeast Fisheries Center, Miami, Florida; pers. comm.).

Tilmont et al. (unpublished) summarized recreational fishery statistics for tarpon and ladyfish in Everglades National Park, Florida, from 1958 through 1984. Tarpon were sought by less than 3% of anglers and made up an average of 0.2% of the reported recreational catch annually. Mean annual catch rates varied from 0.1 to 0.4 fish/h. Less than 10% of the tarpon caught were harvested, primarily for trophy mounts. Tarpon accounted for 1% of the catch, 0.4% of the harvest, and 7% of the effort in the professionally guided fishery in the park. Reported catch rates suggested that stocks of tarpon in the park were relatively stable.

Ladyfish were commonly caught but infrequently harvested by anglers in Everglades National Park (Tilmont et al., unpublished). Ladyfish made up about 5% of the total reported catch but less than 0.4% of the harvest. Few anglers (0.02%) considered the fish a preferred species. Mean annual catch rates varied from 0.25 to 0.67 fish/h. Ladyfish population abundances in the park were cyclic, peaking about every five years. However, a general increase in ladyfish abundances in the park occurred from the late 1960's through the early 1980's.

ECOLOGICAL ROLE

Feeding Behavior/Food Habits

Stage I tarpon and ladyfish larvae do not forage; nutrients are obtained directly from seawater by integumentary absorption (Pfeiler 1986).

Stage II and III tarpon larvae and small juveniles (<125 mm SL) feed primarily on zooplankton (e.g., copepods and ostracods) and secondarily on insects and small fishes; larger juveniles continue to feed on zooplankton, but progressively increase consumption of insects, fishes (especially poeciliids and cyprinodontids), crabs, and grass shrimps of the genus *Palaemonetes* (Beebe 1927; Breder 1933; Moffett and Randall 1957; Harrington and Harrington 1960, 1961; Rickards 1968). Juvenile tarpon are typically crepuscular and nocturnal foragers (Robins 1978).

In laboratory settings, early Stage II ladyfish larvae ate live plankton (Alikunhi and Rao 1951) and live brine shrimp (*Artemia*) nauplii (Gehringer 1959a). Stage III larvae ate small live *Fundulus* and *Gambusia* and pieces of shrimp and fish. Under natural conditions, Stage II and III ladyfish larvae (<50 mm SL) feed almost exclusively on zooplankton; consumption of zooplankton by juveniles is progressively reduced as ingestion of small fishes and shrimps increases (Harrington and Harrington 1961). Ladyfish <100 mm long feed especially on insects, copepods, and other arthropods (Fyfe 1986).

Adult tarpon and ladyfish are strictly carnivorous and feed primarily on mid-water prey (Hildebrand 1963; Sekavec 1974). Food is swallowed whole (Sekavec 1971).

Adult ladyfish feed primarily on fish; fish constituted 94%, 82%, and 34% of food items found in ladyfish stomachs by Sekavec (1974), Darnell (1958), and Knapp (1949), respectively. In Sekavec's (1974) study, juvenile Gulf menhaden (*Brevoortia tyrannus*) composed 72% of the identifiable fish consumed.

Decapod crustaceans are also important foods of ladyfish. Linton (1904) reported that diets of 12 ladyfish from North Carolina consisted exclusively of shrimp. Knapp (1949) found that 78.2% of stomach contents of ladyfish from the Texas coast were crustaceans. Decapods made up 5.5% (Sekavec 1974) and 10% (Darnell 1958) of the diets of ladyfish from Louisiana.

Adult tarpon feed both nocturnally and diurnally (Wade 1962a) on a variety of organisms including mullets (*Mugil* spp.), pinfish (*Lagodon rhomboides*), ariid catfishes, Atlantic needlefish (*Strongylura marina*), sardines (*Harengula* spp.), shrimp, and crabs (Babcock 1951; Wade 1962a).

Predators

Predation by carnivorous zooplankters and small fishes undoubtedly causes high mortality of eggs and larvae of both ladyfish and tarpon before the larvae enter coastal nursery marshes. In marshes, juvenile tarpon are probably immune to piscine predation other than that by juvenile ladyfish or tarpon (Beebe 1927; Moffett and Randall 1957; Rickards 1968; Wade 1969). Both species are probably preyed upon by piscivorous birds (Beebe 1927; Rickards 1968), and adult tarpon are occasionally eaten by sharks, porpoises, and alligators (Wade 1962a, 1962b).

Parasites

The digenetic trematode *Lecithochirium microstomum* occurs in the stomach of tarpon (Manter 1947). The isopods *Nerocila acuminata* and *Cymothoa oestrum* are external parasites (Babcock 1951; Pearse 1952). Causey (1953) reported the copepod *Paralebion pearsei* from tarpon. The trematode *Bivescula tarponis* is present in the pyloric caecae and along the entire length of the intestine (Sogandares-Bernal and Hutton 1959). Though not parasitic, remoras (*Remora remora*) are commonly observed attached to large tarpon (Babcock 1951; Wade 1962a).

Trematodes of the genera *Bucephalus* and *Prosorhynchus* have been reported from the intestine of ladyfish (Corkum 1959).

ENVIRONMENTAL REQUIREMENTS

Temperature

The tarpon and ladyfish are distinctly thermophilic fishes. Both have been reported in cold-related fish kills in Florida (Storey and Gudger 1936; Storey 1937; Snelson and Bradley 1978). At Port Aransas, Texas, annual tarpon abundances are correlated with yearly water temperature regimes (Moore 1975). Tarpon concentrate around heated power-plant effluents during winter in the Indian River, Florida (Snelson 1983).

Early Stage I larvae of both species occur only in warm oceanic waters (22.2-30.0 °C; Wade 1962a; Eldred and Lyons 1966; Eldred 1967, 1968, 1972; Berrien et al. 1978; Smith 1980), and it appears probable that such temperatures are necessary for proper development of eggs and early larvae.

Moffett and Randall (1957) exposed juvenile tarpon (72-130 mm FL) held at 25-27 °C to high temperatures in laboratory trials. Fish were warmed from maintenance to test temperatures in 3 hours. Fish subjected to 39.4-39.6 °C survived the 24-h trials; those exposed to 40.5-41.9 °C did not. In a series of cold-tolerance trials, juvenile tarpon (71-130 mm FL) died within 24 h at temperatures of 14.8-18.0 °C; others survived trials at 14.8-19.7 °C (Moffett and Randall 1957). Tabb (personal communication in Wade 1962a) reported mortality of tarpon in Everglades National Park when water temperature decreased from 24 to 11 °C within a few hours. Rickards (1968) collected sluggish juvenile tarpon in a Georgia salt marsh in late November when water temperature was 16.0 °C. Concurrently, several juveniles maintained in a steel holding tank died overnight when water temperatures dropped from 21.0 to 12.0 °C. However, Wade (1969) collected juvenile tarpon at temperatures as low as 12 °C, and Gilmore et al. (1982) collected tarpon at 14 °C from a mosquito control impoundment in eastern Florida. Robins (1978) stated that the lower lethal temperature of tarpon is abcut 10 °C.

Ladyfish appear to be slightly more tolerant of low temperatures than tarpon, judging by the lower frequency of fish-kills (Storey 1937); they have been collected at temperatures of 11.0 to 35.0 °C (Harrington 1958; Tagatz 1967; Dahlberg 1972; Rose et al. 1975).

Salinity

Throughout most of their life stages, tarpon and ladyfish tolerate a wide range of salinities. However, early Stage I larvae of both species have been collected only at oceanic salinites of 28.5-39.0 ppt (Wade 1962a; Eldred and Lyons 1966; Eldred 1967, 1968, 1972; Berrien et al. 1978; Smith 1980), and it is likely that such concentrations are required by eggs, yolk-sac larvae, and early Stage I larvae of both species for proper development.

Beyond Stage I, tarpon and ladyfish are decidedly euryhaline. Juvenile tarpon can withstand direct transfer from salt - to freshwater and vice-versa (Breder 1944; Moffett and Randall 1957). Habitats occupied by tarpon range from fresh to hypersaline, or 0 to 47 ppt (Hildebrand 1939; Simpson 1954; Moffett and Randall 1957; Harrington 1958; Harrington and Harrington 1961; Rickards 1968; Wade 1969; Dahlberg 1972; Tagatz 1973; Tucker and Hodson 1976).

Alikunhi and Rao (1951) collected late Stage I ladyfish larvae from brackish water (10.4 ppt) and successfully transferred them directly to freshwater (0.08 ppt). Juvenile ladyfish have been collected at salinities ranging from 0.0 to 45.0 ppt (Harrington 1958; Harrington and Harrington 1961; Herke 1969; Dahlberg 1972; Govoni and Merriner 1978; Thompson and Deegan 1982).

Adult ladyfish also tolerate a wide range of salinities, but appear less likely than tarpon to occupy freshwater. We found no reference in the literature specifically reporting adults from truly freshwater. One of us (A.V.Z.) has captured ladyfish in the Lake George section of the St. Johns River, Florida, at salinities of 0.5-2.0 ppt. This area is often assumed (by compilers evaluating salinity requirements of fishes) to be freshwater because of its distance from the mouth of the river (about 190 km), but numerous salt springs maintain relatively high salinities. Tagatz (1967) collected ladyfish as far upstream as Palatka, Florida (135 km from the mouth) and reported salinity there to be 0 ppt; however, he recorded all salinities less than 1.0 ppt as 0 ppt. It is likely that appreciable salinities (perhaps >0.5 ppt) are, if not required, then at least preferred by ladyfish.

Dissolved Oxygen

Tarpon are obligate air breathers (the swimbladder contains alveolar tissue; Shlaifer 1941) and are frequently seen "rolling" at the surface gulping air; when prevented from reaching the surface, they die within 7 to 128 h, even in highly oxygenated water (Shlaifer 1941). Air breathing is imitatively mediated by visual cues; juveniles in a school come to the surface in rapid succession (Shlaifer and Breder 1940; Shlaifer 1941), perhaps to reduce individual susceptibilities to predation by fish-eating birds (Kramer and Graham 1976). The frequency of air breathing is inversely correlated with dissolved oxygen concentration (Shlaifer and Breder 1940; Shlaifer 1941). Air-breathing precludes mortality in anoxic waters and allows tarpon to survive under conditions deleterious to most fishes. Tarpon have this ability at least as early as the beginning of Stage III (Harrington 1966).

Air breathing has not been reported for ladyfish, and it is unlikely that it occurs. "Rolling" has not been reported in the literature. Dissolved oxygen requirements of ladyfish are unknown, but it is likely that the species is relatively tolerant of hypoxic conditions, as it is often found with tarpon in poorly oxygenated habitats. Ladyfish inhabited a coastal impoundment in Louisiana in which dissolved oxygen concentrations reached a minimum of 1.0 mg/l (Rose et al. 1975).

Contaminants

Aerial spraying and ground fogging for nuisance insect control are widely practiced in Florida's coastal zone, and agricultural pesticides and herbicides used in south Florida enter coastal waters. Robins (1978) reported that tarpon are extremely susceptible to contaminants. Application of dieldrin pellets in a Florida salt marsn for the control of larval sandflies (Culicoides) resulted in mortality of ladyfish and tarpon (Harrington and Bidlingmayer 1958).

Turbidity

Stage I larvae of both ladyfish and tarpon occur only in clear offshore waters. Subsequent life history stages appear to be tolerant of high turbidities. Habitats occupied, especially by juveniles, are generally described as turbid and dark-stained.

Wetlands Destruction and Degradation

Offshore and coastal habitats of very young and adult tarpon and ladyfish are relatively immune to human-induced degradation. Conversely, the estuaries, salt marshes, and coastal mangroves used as nurseries by larval and juvenile ladyfish and tarpon in Florida are highly vulnerable to changes induced by development. Robins (1978) discussed the various activities that are degrading tarpon nursery grounds in Florida; his comments are also applicable to early life history stages of ladyfish, which share these habitats. Among factors resulting in the destruction of nursery wetlands, he listed filling of wetlands, canalization, bulkheading, construction of water-line right-of-ways and steep-sided boat-access finger-canals, and impoundment of wetlands for mosquito control. Progress has recently been made in ameliorating the effects of impoundment for mosquito control because impoundment does not necessarily result in the destruction of wetlands. Rather, impounded wetlands, if properly managed, can retain the beneficial characteristics of natural wetlands while providing adequate mosquito control (Clements and Rogers 1964; Provost 1973). However, access to these wetlands (and subsequent opportunities for egress) by larval and juvenile tarpon and ladyfish is precluded or severely curtailed by reduced or nonexistent exchange with estuarine waters (Wade 1969; Gilmore et al. 1982; Harrington and Harrington 1982). Improved impoundment management strategies, aimed at enhancing exchange rates, have been proposed by Clements and Rogers (1964), Provost (1973), Montague et al. (1985), and Lewis et al. (1985).

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15. Supplementary Notes

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16. Abstract (Limit: 200 words)

Species profiles are literature summaries of the taxonomy, morphology, distribution, life history, habitats, and environmental requirements of coastal species of fishes and aquatic invertebrates. They are designed to assist in environmental impact assessment. The tarpon and ladyfish are popular gamefishes. Adults spawn offshore. Larval and juvenile stages inhabit coastal marshes and mangroves. Both species are thermophilic (preferring warm water), euryhaline (tolerant of a wide range of salinity), and are capable of surviving at low oxygen concentrations. Wetlands destruction and degradation negatively affect these species by reducing nursery areas.

17. Document Analysis a. Descriptors

Fishes
Estuaries
Feeding habits
Growth
Fisheries
Temperature
Salinity
Oxygen
Life cycles

b. Identifiers/Open-Ended Terms

Tarpon
Megalops atlanticus
Ladyfish
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Trophic ecology
Spawning
Environmental requirements

c. COSATI Field/Group

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