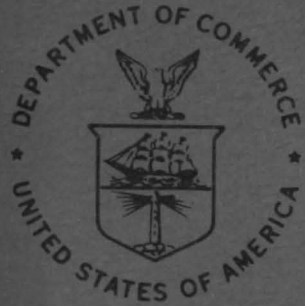443

NOAA Technical Report NMFS Circular 443

Synopsis of the Biological Data on Dolphin-Fishes, *Coryphaena hippurus* Linnaeus and *Coryphaena equiselis* Linnaeus

April 1982

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

NOAA Technical Report NMFS Circular 443

Synopsis of the Biological Data on Dolphin-Fishes, *Coryphaena hippurus* Linnaeus and *Coryphaena equiselis* Linnaeus

Barbara Jayne Palko, Grant L. Beardsley,
and William J. Richards

April 1982

FAO Fisheries Synopsis No. 130

CONTENTS

*No information available.

iv

Synopsis of the Biological Data on Dolphin-Fishes, *Coryphaena hippurus* Linnaeus and *Coryphaena equiselis* Linnaeus[1]

BARBARA JAYNE PALKO,[2] GRANT L. BEARDSLEY,[3] and
WILLIAM J. RICHARDS[3]

IDENTITY

1.1 Nomenclature

1.11 Valid name

Coryphaena hippurus Linnaeus, 1758 (Fig. 1).

Originally described by Linnaeus in the 10th edition of Systema Naturae (1758:261). Type locality listed as open seas. No type specimen.

Coryphaena equiselis Linnaeus, 1758 (Fig. 2).

Originally described by Linnaeus in the 10th edition of Systema Naturae (1758:261). Type locality: high seas. This species was derived from Osbeck (1757:308), who used the name *equisetis,* and most authors have corrected Linnaeus' supposed misprint to *equiselis.* Gibbs and Collette (1959), however, pointed out that the spelling in later editions of Systema Naturae was not corrected. Fowler (1906:122) pointed out that neither form is incorrect from an etymological standpoint. Gibbs and Collette (1959) recommended following original orthography, and this has been followed by some authors, but not all.

1.12 Objective synonymy

Coryphaena hippurus

Coryphaena hippurus Linnaeus, 1758 (see above).
Scomber pelagicus Linnaeus, 1758. Type locality: none listed.
Coryphaena fasciolata Pallas, 1770. Type locality: Amboina. Type specimen: unknown.
Coryphaena imperialis Rafinesque, 1810. Type locality: Sicily.
Lepimphis hippuroides Rafinesque, 1810. Type locality: Sicily.
Coryphaena immaculata Agassiz *in* Spix and Agassiz, 1829. Type locality: Atlantic, off Brazil.
Coryphaena marcgravii Valenciennes *in* Cuvier and Valenciennes, 1833. Type locality: America.

Coryphaena suerii Valenciennes *in* Cuvier and Valenciennes, 1833. Type locality: Philadelphia.
Coryphaena dorado Valenciennes *in* Cuvier and Valenciennes, 1833. Type locality: Brazil.
Coryphaena dolfyn Valenciennes *in* Cuvier and Valenciennes, 1833. Type locality: Antilles.
Coryphaena virgata Valenciennes *in* Cuvier and Valenciennes, 1833. Type locality: Martinique.
Coryphaena argyrurus Valenciennes *in* Cuvier and Valenciennes, 1833. Type locality: Sea of Coromandel.
Coryphaena vlamingii Valenciennes *in* Cuvier and Valenciennes, 1833. Type locality: seas of India.
Lampugus siculus Valenciennes *in* Cuvier and Valenciennes, 1833. Type locality: Sicily. Holotype: MNHN no. A5813.
Coryphaena scomberoides Valenciennes *in* Cuvier and Valenciennes, 1833. Type locality: South Sea.
Coryphaena nortoniana Lowe, 1839. Type locality: Madeira.
Ecterias brunneus Jordan and Thompson, 1914. Type locality: Japan.

Coryphaena equiselis

Coryphaena equiselis Linnaeus, 1758 (see above).
Coryphena aurata Rafinesque, 1810. Type locality: Sicily.
Coryphaena azorica Valenciennes *in* Cuvier and Valenciennes, 1833. Type locality: Azores. Holotype: MNHN no. A8189.
Coryphaena lessonii Valenciennes *in* Cuvier and Valenciennes, 1833. Type locality: India.
Lampugus neapolitanus Valenciennes *in* Cuvier and Valenciennes, 1833. Type locality: Naples. Holotype: ZMHU no. 1631.
Lampugus punctulatus Valenciennes *in* Cuvier and Valenciennes, 1833. Type locality: Atlantic at the Equator.

1.2 Taxonomy

1.21 Affinities

Suprageneric

Phylum Chordata
Subphylum Vertebrata
Superclass Gnathostomata
Class Osteichthyes
Subclass Actinopterygii
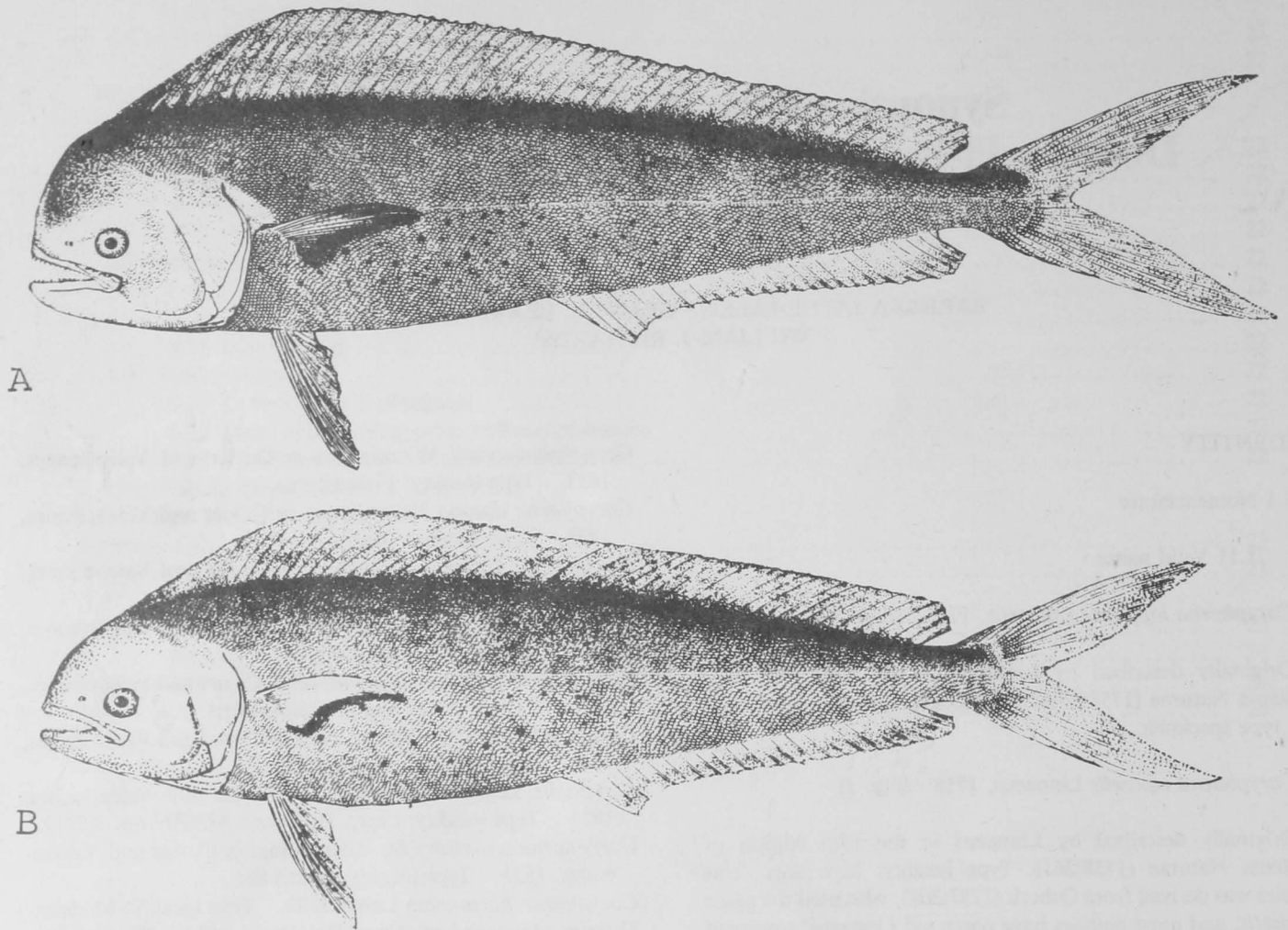Order Perciformes
Suborder Percoidei
Family Coryphaenidae

Figure 1.—Common dolphin, *Coryphaena hippurus* Linnaeus, 1758.   A) Adult males, ca. 600 mm TL, B) Adult female, ca. 612 mm TL (from Goode 1884, plate 109).
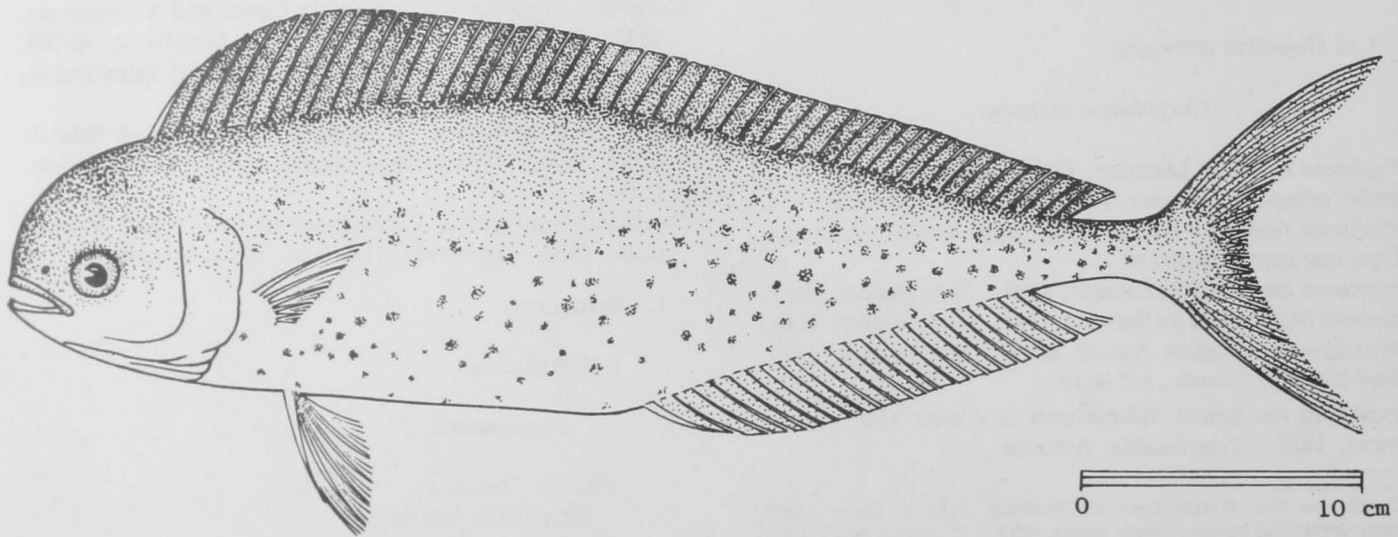

Figure 2.—Pompano dolphin, *Coryphaena equiselis* Linnaeus, 1758.

Generic

Genus *Coryphaena* Linnaeus, 1758 (ref.). Type species *Coryphaena hippurus* Linnaeus. Unquestioned.

Coryphaena is the only genus in the family Coryphaenidae and is composed of two species: *C. hippurus* and *C. equiselis*. The generic concept of *Coryphaena* as given below follows that of Gibbs and Collette (1959), Collette (1978), and Potthoff (1980).

Coryphaenids are elongate, compressed fishes with small cycloid scales. The mouth is large with many fine teeth in bands. The lateral line curves upward above the pectoral fin but is otherwise straight. The dorsal fin is very long, arising on the nape and continuing almost to the tail. It is composed of 52-66 soft rays in adults. The anal fin is also very long, arising behind the anus at or before the midpoint of the body and continuing almost to the tail with 23-30 soft rays. The pelvic fins are beneath the pectoral fins and fit into a groove on the body. The pectoral fin has 19-21 rays. The caudal fin has 17 principal rays and 10-14 upper and lower secondary caudal rays. The caudal fin is deeply forked. There are 31-33 vertebrae. Mature males are characterized by possessing a prominent bony crest on the front of the head. In life, the color of these animals is striking with golden hues on the sides, metallic blues and greens on the back and sides, with white and yellow on the underparts. There are also many small black spots on the head and body. Small specimens have pronounced vertical bars on the sides of the body.

Both species are very similar in appearance but characters to separate them are given below.

Specific

Coryphaena hippurus Linnaeus

As with the generic description, but the greatest body depth in adults is < 25% SL (standard length). This species has 58-66 dorsal fin rays (mean of 61.3), 25-31 anal fin rays (mean of 28.0), and 31 vertebrae. The anal fin is concave and the pectoral fin is more than half the length of the head. The tooth patch on the tongue is small and oval. In juveniles only the tips of the caudal fin are white and the pelvic fins are black.

Coryphaena equiselis Linnaeus

As with the generic description, but the greatest body depth in adults is > 25% SL. This species has 52-59 dorsal fin rays (mean of 55.0), 23-29 anal fin rays (mean of 26.0), and 33 vertebrae. The anal fin is convex and the pectoral fin is about half the length of the head. The tooth patch on the tongue is broad and square. In juveniles the entire margin of the caudal fin is white and the pelvic fins are not pigmented.

1.22 Taxonomic status

In recent years there has been no question about the taxonomic status of these two species. Both are valid and easily separable down to all but the smallest larval sizes. The accounts in section 1.21 clearly give the differences between the two. The family Coryphaenidae is monogeneric and its affinities within the percoid fishes are unclear at this time.

1.23 Subspecies

No subspecies are recognized.

1.24 Standard common names, vernacular names

The names capitalized are official or in more common use. Compiled from Quiznard (1973) and Okiyama[4].

Country	Coryphaena hippurus Common dolphin	Coryphaena equiselis Pompano dolphin
Algeria	Lámbug	
Cuba	Dorado	
Cyprus	Dakaunomoutas	
France	Coriphène	
French Polynesia	Mahimahi	
Greece	Kynigòs	
Israel	Raaman	
Italy	Lampuga	
Japan	Toohyaku	Ebisu-shiira
Korea	Man-sae-gi	Jul-man-sae-gi
Lebanon	Lämbukeh	
Libya	Lambuka	
Malta	Lampuka	
Monaco	Lampuga	
Morocco	Msi'a amerikano	
Philippines	Dorado	
Spain	Llampuga	
Sri Lanka	Rad hava	Diya vannava
Syria	Bakhti bakhti	
Tahiti	Mahimahi	
Taiwan	Fei Niau Fu	
Tunisia	Lambouqa	
United States	Dolphin, dophin-fish	pompano, blue dolphin
Hawaii and eastern Pacific	Mahimahi	"The other mahimahi"
North Vietnam	Cá nucheo	
South Vietnam	Cá Dūo	
Yugoslavia	Pucinka	

1.3 Morphology

1.31 External morphology

The coloration of the body and the shape and placement of fins are described in section 1.2. The change in number of fin rays has been well documented by Potthoff (1978), and tables on dorsal and anal fin development are given for the two species (Tables 1, 2). *Coryphaena equiselis* is always more advanced than equal sized *C. hippurus* during development of fin rays. Gibbs and Collette (1959) presented detailed information on the head spination, coloration, meristic characters, and relative growth of the two species, utilizing a large amount of data from young specimens.

3

Table 1.—Summary of dorsal fin ray development for 211 *Coryphaena hippurus* (5.0 mm NL-172 mm SL) and 161 *C. equiselis* (6.5 mm NL-230 mm SL) from Potthoff (1978).

Length mm SL	Dorsal fin rays				Standard error of the mean		Number of specimens	
	range		mean					
	C.h.	C.e.	C.h.	C.e.	C.h.	C.e.	C.h.	C.e.
5	0	—	0	—	0	—	3	—
6	0- 4	12	0.8	—	0.8	—	5	1
7	0-21	20-34	11.0	27.0	1.9	7.0	11	2
8	19-38	36-44	29.7	39.2	3.2	1.6	6	5
9	26-48	43-50	35.7	46.6	3.4	1.2	6	5
10	38-49	43-50	44.4	48.2	1.3	1.1	7	6
11	33-50	47-51	46.0	48.9	2.2	0.4	7	10
12	47-52	49-51	50.3	50.8	1.7	0.8	3	4
13	47-55	53	52.0	—	1.4	—	6	1
14	50-57	52	52.2	—	1.0	—	6	1
15	52-56	50	53.4	—	0.6	—	7	1
16	55-57	50-53	56.0	51.5	0.4	0.4	5	6
17	53-57	51-54	55.3	52.8	0.6	0.6	6	4
18	54-61	53-55	56.7	53.8	0.9	0.5	6	4
19	56-58	52-53	57.3	52.7	0.3	0.3	6	3
20	56-61	—	57.6	—	0.9	—	5	—
21	56-61	52-57	58.0	55.0	0.6	0.9	8	5
22	57-60	54-56	59.0	54.7	1.0	0.6	3	3
23	56-61	54-56	58.6	55.0	0.7	0.6	6	3
>23	58-66	52-59	61.3	55.0	0.2	0.2	99	97
(¹)	46-65	48-60	58.4	52.6	0.3	0.1	121	195

¹Data from figure 4 of Gibbs and Collette (1959).

Table 2.—Summary of anal fin ray development for 210 *Coryphaena hippurus* (C.h., 5.0 mm NL-172 mm SL) and 159 *C. equiselis* (C.e., 6.5 mm NL-230 mm SL) from Potthoff (1978).

Length mm NL or SL	Anal fin rays				Standard error of the mean		Number of specimens	
	range		mean					
	C.h.	C.e.	C.h.	C.e.	C.h.	C.e.	C.h.	C.e.
5	0	—	0	—	0	—	3	—
6	0-12	14	8.4	—	2.1	—	5	1
7	8-22	20-23	15.0	21.5	1.3	1.5	11	2
8	21-25	22-25	23.5	23.3	0.7	0.6	6	4
9	23-25	25-26	24.2	25.4	0.4	0.2	6	5
10	24-28	24-26	25.7	25.2	0.5	0.3	7	6
11	23-28	25-27	26.4	26.0	0.6	0.1	7	10
>11	25-31	23-29	28.0	26.0	0.1	0.1	165	131
(¹)	25-30	23-29	27.3	25.7	0.1	0.1	127	222

¹These counts were taken from Gibbs and Collette (1959), table 1. The lengths were not given by the authors but are assumed to be 12 mm SL and larger.

1.34 Internal morphology

Gregory (1933) described the skull of *C. hippurus,* Collette et al. (1969) reported on the number of vertebrae, and Potthoff (1980) described the development of fin rays and fin supports. Potthoff's (1980) account is a very detailed and complete description of the development of the fin rays and supports and should serve as a guide for further studies in that vein.

2 DISTRIBUTION

2.1 Total area

Dolphins are fast-swimming, primarily oceanic fishes, distributed worldwide in tropical and subtropical waters (Briggs 1960; Beardsley 1967; Rose and Hassler 1968a; Johnson 1978). Pompano dolphin are rarely captured in coastal waters; however, common dolphin are occasionally found in estuaries and harbors (Johnson 1978). In the western Atlantic, common dolphin have been reported as far north as Georges Bank, Nova Scotia (Vladykov and McKenzie 1935; Tibbo 1962), and as far south as Rio de Janeiro, Brazil (Ribeiro 1918; Shcherbachev 1973) (Fig. 3). They are rarely found, however, above lat. 41°N (Tibbo 1962) and are generally restricted by the 20°C isotherm (Gibbs and Collette 1959). There are few data on distribution of pompano dolphin; however, their distribution is probably similar to that of the common dolphin. Mather and Day (1954) stated that pompano dolphin are generally not found in waters with surface temperatures <24°C.

Common dolphin are abundant in the Gulf of Mexico (Baughman 1941; Springer and Bullis 1956; Pew 1957; Springer and Pirson 1958), in the Florida Current (Anderson et al. 1956 a, b; Beardsley 1967), off Central America (Migdalski 1958; Hunter and Mitchell 1967), Puerto Rico, and throughout the Caribbean Sea (Erdman 1956). When the Gulf Stream comes
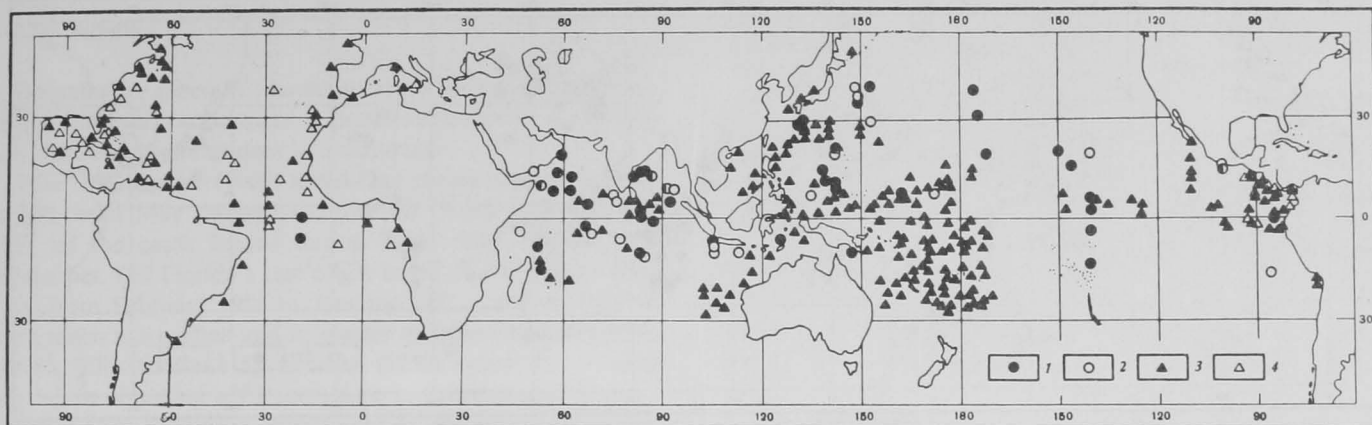
Figure 3.—Distribution of adult *Coryphaena hippurus* (1, 3) and *C. equisetis* (sic) (2, 4); 1) SL more than 350 mm; 2) SL more than 150 mm; 3, 4) published data (from Shcherbachev 1973, fig. 4 and caption).

close to the continental United States, sports fishermen catch them in large numbers. In North Carolina, Rose and Hassler (1969) felt that the common dolphin was the most important species in the offshore fishery and Ellis[5] found that the common dolphin was taken on more charter boat trips off Florida's east coast and in greater numbers than any other species.

The more pelagic pompano dolphin has been recorded off North Carolina (Linton 1905; Mather 1954; Migdalski 1958; Rose and Hassler 1968b), Florida (Beardsley 1964), Bermuda (Woods and Kanazawa 1951), and in the central tropical Atlantic (Potthoff 1971). Springer and Bullis (1956) recorded numerous captures of pompano dolphin throughout the Gulf of Mexico and Caribbean on research cruises by the U.S. Fish and Wildlife Service's RV *Oregon*. Erdman (1956) also stated that pompano dolphin are numerous off San Juan, Puerto Rico.

In the eastern Atlantic, the common dolphin is found between the Bay of Biscay and the mouth of the Congo River (Shcherbachev 1973) and has been reported as far south as the southern tip of Africa (Barnard 1927). The common dolphin inhabits the Mediterranean (Murat 1933; Shcherbachev 1973; Bannister 1976) and is common around the Balearic and Madeira Islands off the coast of Spain (Lowe 1849; Cabo 1961). In the Mediterranean, the common dolphin is one of the main fish taken in the "Kannizzati" fishery off Malta (Galea 1961).

Pompano dolphin are recorded in the eastern Atlantic from the Azores (Hilgendorf 1888), the Canaries (Steindachner 1868), Madeira (Lowe 1849), and Senegal (Cadenat 1950). They have also been reported from the Mediterranean (Shcherbachev 1973).

In the eastern Pacific, the common dolphin has been recorded off Oregon (Gosline and Brock 1960), California (Barnhart 1936; Berry and Perkins 1966), around the Galápagos Islands, along the shores of Peru (Shcherbachev 1973), and in Panama Bay (Meek and Hildebrand 1925; Hildebrand 1934).

Occurrences of pompano dolphin in the eastern Pacific between California and (approximately) lat. 5 °S (south of the Galápagos) and in the Peru Current around lat. 17 °20 'S have been reported by Nichols (1909), Clemens (1957), Hida (1973),

and Shcherbachev (1973). Pompano dolphin are common in Hawaiian waters (Gooding and Magnuson 1967; Magnuson and Heitz 1971). The largest numbers of juvenile pompano dolphin are taken in catches in the western and central areas of the Pacific and some adult fish are also found there but catches are infrequent (Shcherbachev 1973). Rothschild (1964) indicated that pompano dolphin occurred in the North Pacific Central and California Current Extension water types and further indicated that the pompano dolphin may be more abundant in the California Current Extension than in the North Pacific Central.

In the western Pacific, common dolphin are more widely distributed than pompano dolphin and are found between lat. 46 °N and 38 °S (Shcherbachev 1973). Common dolphin have been reported around the Philippine Islands by Herre (1945), along the 18 °-19 °C isotherm in the Sea of Japan (Kojima 1955), in waters adjacent to eastern Taiwan and the northeastern part of Batan Islands (Wang 1979), and in the Sea of Okhotsk (Birman 1965).

Pompano dolphin have been recorded as far north as Japan (around lat. 38 °N) and as far south as New Zealand and the New Hebrides and farther eastward through a wide latitudinal band to (approximately) long. 140 °W (Shcherbachev 1973). Kojima (1960a) listed the pompano dolphin as one of the species attracted to the bamboo rafts fishery.

Common dolphin have been collected off the coasts of Tanganyika and Kenya (Morrow 1954; Williams and Newell 1957) and throughout the northern and central Indian Ocean. Shcherbachev (1973) also reported the occurrence of common dolphin around the tip of Africa, even below lat. 35 °S.

Gallotti (1972-73) reported the occurrence of pompano dolphin in the Red Sea. Deraniyagala (1952, 1956) recorded the species from Guilifalu Island and the Maldive Islands. According the Shcherbachev (1973), the pompano dolphin is found throughout the northern and central areas of the Indian Ocean but does not penetrate beyond the southern tropics.

2.2 Differential distribution

2.21 Spawn, larvae, and juveniles

Larvae of both species occur in the tropical regions of all the oceans (Clemens 1957; Gibbs and Collette 1959; Kojima 1964a; Jensen 1967; Shcherbachev 1973) (Figs. 4, 5).

---

[5]Ellis, R. W. 1957. Catches of fish by charter boats on Florida's East Coast. Univ. Miami, Mar. Lab. Mar. Fish. Res. Spec. Ser. Bull. 14, 6 p. Rosenstiel School of Marine and Atmospheric Science, 4600 Rickenbacker Causeway, Miami, FL 33149.
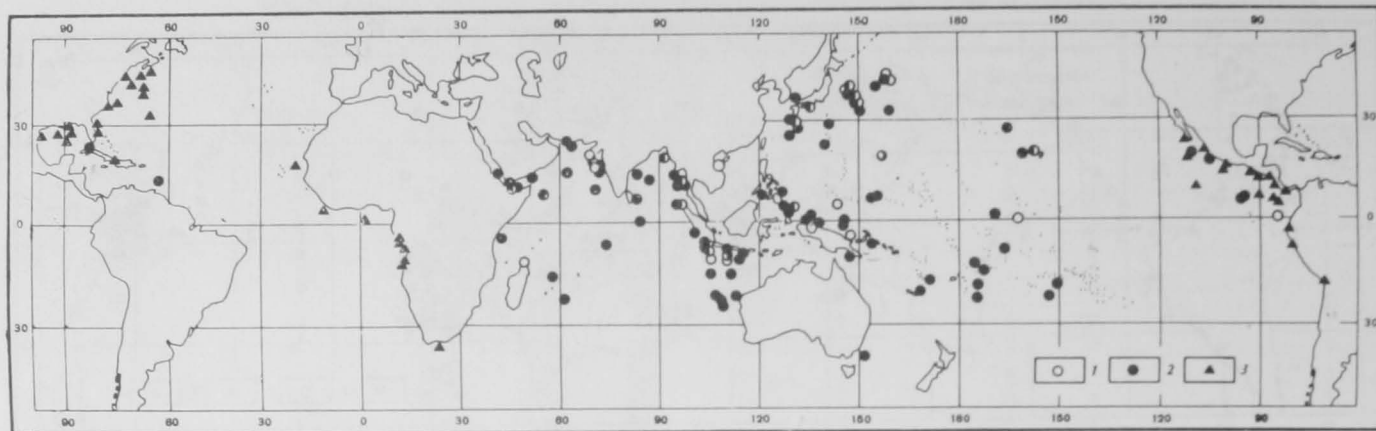
Figure 4.—Distribution of *Coryphaena hippurus* larvae and young: 1) SL up to 15 mm; 2) SL up to 350 mm; 3) published data (from Shcherbachev 1973, fig. 5 and caption).
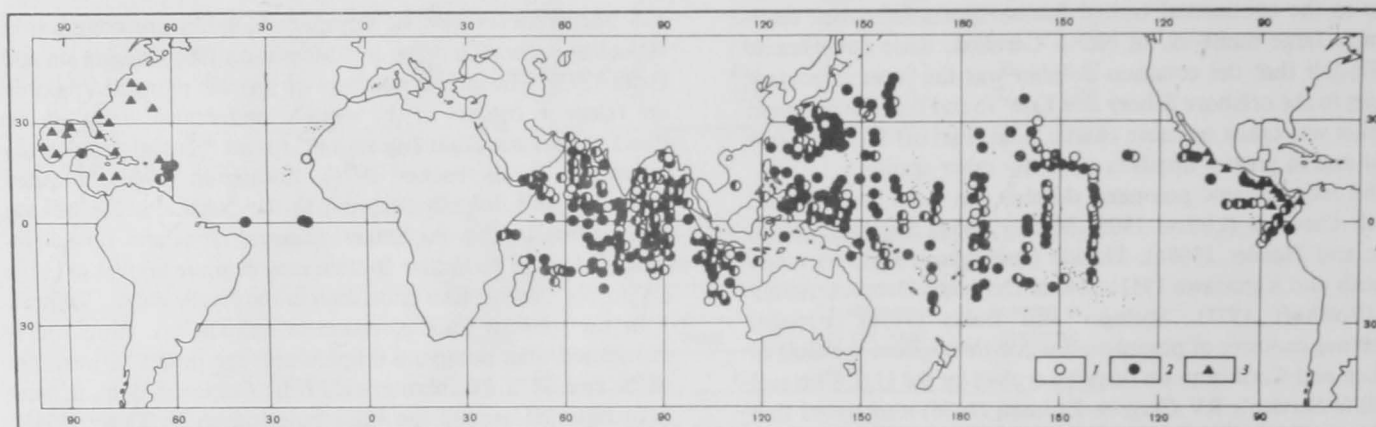

Figure 5.—Distribution of *Coryphaena equisetis* (sic) larvae and young: 1) SL up to 15 mm; 2) SL up to 150 mm; 3) published data (from Shcherbachev 1973, fig. 6 and caption).

In the Atlantic, Gibbs and Collette (1959) found young dolphins in the Florida Current at all seasons of the year but at peak abundance in early summer. Beardsley (1967) noted that young common dolphin were taken from November through May and in August off Florida and from July to September off the North Carolina coast. Anderson et al. (1956 a, b) collected dolphin < 102 mm in length off Cape Fear, N.C., in March and May, and Anderson and Gehringer (1957) collected dolphin of similar size south of Cape Fear in October. Juvenile dolphin are plentiful around Beaufort, N.C., in late summer (La Monte 1952). Pew (1957) reported captures of juvenile common dolphin in sizes from 32 to 73 mm TL (total length) off Rockport, Tex., during the summers of 1954-56 while Springer and Pirson (1958) collected juveniles in *Sargassum* off Port Aransas, Tex., in July. Gibbs and Collette (1959) found young common dolphin were not as easily obtained from the Gulf of Mexico as either adults or juveniles of the pompano dolphin.

Fahay (1975) collected larvae and juveniles of both common and pompano dolphins with surface-towed meter nets in the South Atlantic Bight between May 1967 and February 1968, and Potthoff (1971) collected juvenile pompano dolphin in February in the tropical mid-Atlantic. Gibbs and Collette (1959) felt that the young and intermediate-sized specimens of pompano dolphin were taken more commonly than larger ones in the

Atlantic. They further noted that whereas larger specimens of common dolphin are relatively easy to obtain and those of pompano dolphin are seldom seen, the young just reverse this picture. Potthoff (1971) noted this same apparent dichotomy in distribution in the tropical mid-Atlantic. He reported that large numbers of adult common dolphin aggregated at night around the research vessel; however, only juveniles of pompano dolphin were caught under the night light.

Small common dolphin have been reported in the eastern Pacific in Panama Bay by Meek and Hildebrand (1925) and Hildebrand (1934). Mito (1960) described egg development and hatched larvae from collections made around Kyushu in the western Pacific. Wang (1979) reported that common dolphin larvae occurred in eastern Taiwan waters annually. Shcherbachev (1973) showed the distribution of common dolphin larvae and juveniles in the Pacific and Indian Oceans (Fig. 4). He found the largest numbers of juvenile pompano dolphin were taken in catches in the western and central areas of the Pacific (Fig. 5). Takahashi and Mori (1973) collected pompano dolphin nearly year-round in the western Pacific. The smallest sizes (11-85 mm SL) were collected from November through February and the larger juveniles and adults from June through September. Gallotti (1972-73) reported two (40 and 42 mm) pompano dolphin from the Red Sea.

2.22 Adults

Dolphins are generally year-round residents over most of their range; however, pronounced seasonal variations in abundance and distribution are evident in most areas.

Rose and Hassler (1969) noted that common dolphin were caught from May through October off North Carolina with 99% of the catch landed during June, July, August, and September. Off Florida's east coast, based on 443 charter boat trips from February 1956 to January 1957, common dolphin were taken more often and in greater numbers than any other species (Ellis footnote 5). Erdman (1956) noted that dolphin were most abundant off Puerto Rico in February and March.

In the Gulf of Mexico, dolphin are caught almost exclusively during the summer months and catches show very sharp peaks during August (Springer and Pirson 1958). These peaks, however, may indicate migrations where fish are present in large numbers for short periods of time while they pass through a given area.

Galea (1961) found evidence that the common dolphin may be widely distributed in the Mediterranean and it is caught in appreciable quantities from August to November.

In the Pacific, Kojima (1960a) found that common dolphin made up 93-96% of the total catch in the "Shiira-zuke" fishery during the fishing season from June to October with larger dolphin less apparent in the catch as the season progressed. He felt the seasonal variation in size may be caused by ecological differences between the spawning schools (older fish) and the feeding schools (young fish).

In east African waters, common dolphin are caught from November to June; however, January to June is the main fishing season and March to May appears to be the period of maximum abundance (Williams and Newell 1957).

2.3 Determinants of distribution changes

In the Atlantic, Gibbs and Collette (1959) gave the 20°C isotherm as the normal boundary in the Northern Hemisphere, and Beardsley (1964) found dolphin most numerous in late spring and summer when surface water temperatures reached 26°-28°C. Erdman (1956) reported peak abundance off San Juan, Puerto Rico, in February and March when surface temperatures were about 25°C. Common dolphin did not occur in the tropical Atlantic in waters whose surface temperatures were below 21°C, while pompano dolphin were found only where surface temperatures exceeded 24°C (Mather and Day 1954). Dolphins appeared in Balearic waters when the water temperatures are from 25° to 26°C (July), and they disappeared in October or early November when water temperatures fell to 18°-20°C (Cabo 1961).

In the Pacific, Kojima (1955, 1964a) suggested that dolphin occur year-round in the area within lat. 30°N and 30°S. He noted that where dolphins were caught, the surface water temperatures ranged from 21° to 30°C, salinities were 31.0°/oo, and the water color in the 0-10 m layer influenced the catch. Birman (1965) noted the occurrence of dolphin in the Sea of Okhotsk in August when surface water temperatures were 16.1°C. Although this is an unusually low temperature for dolphin to be recorded, Birman felt that this might be a regular phenomenon with the fish moving into the Sea of Okhotsk from the Sea of Japan through the Straight of Laperuz. Wang (1979) reported that over 70% of the catch of common dolphin in the Taiwanese longline fishery was recorded where surface temperatures were 26°-27°C.

Off the east African coast, Williams and Newell (1957) found March to May to be the period of maximum concentration of dolphin when surface water temperatures approached 29°C and low salinities occurred. The migration period is between November and early June. They also noted that the occurrence of dolphin may be connected with the onset of seasonal plankton blooms; thus, the periods of dolphin occurrences coincided with the period of greatest fertility off the coastal waters. Wheeler and Ommanney (1953) noted a similar migration occurred in the Seychelles Islands.

2.4 Hybridization

In Hawaii, Hagood and Rothwell[6] hybridized female pompano dolphin with male common dolphin and got viable eggs and larvae. The hybrid larvae demonstrated faster growth than either normal *C. hippurus* or *C. equiselis* larvae under similar conditions. The authors suggested that this might be indicative of hybrid vigor.

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.11 Sexuality

Dolphins are heterosexual. Sexual dimorphism is expressed in both species in the shape of the head in profile—males have a very steep forehead and females have a more gently descending and streamlined forehead. Shcherbachev (1973) noted that sexual dimorphism in the pompano dolphin is noted only at a length of more than 35 cm SL and that at smaller sizes, males and females are externally indistinguishable. Beardsley stated that male common dolphin start to develop the "bullhead" appearance at approximately 400 mm FL (fork length).

3.12 Maturity

According to Beardsley (1967), in the Straits of Florida female common dolphin begin to mature at about 350 mm FL and at 550 mm FL 100% are mature. He found that the smallest male common dolphin with milt present in the testes was 427 mm FL and felt that female dolphin began to mature at a slightly smaller size than males. Both sexes reach sexual maturity in the first year of life (Beardsley 1967; Shcherbachev 1973). Williams and Newell (1957) stated that common dolphin reached maturity at < 535 mm SL in East African waters.

Takahashi and Mori (1973) examined ova diameters of two females and the gonad indices of 30 males and 55 females of the pompano dolphin and suggested that the species first spawns at a size of about 200 mm SL with gonad indices over 18 for ovaries and a maximum of 8 for testes.

3.13 Mating

Nakamura[7] stated that pairing of the sexes during spawning is

[6]Hagood, R. W., and G. N. Rothwell. 1979. Sea Grant interim project report - 1979. Aquaculture in tropical ocean—*Coryphaena* sp. Oceanic Institute, Makapuu Point, Waimanalo, HI 96795.

[7]Nakamura, E. L. 1971. An analysis of the catches and the biology of big

well known for dolphins, and Soichi (1978) stated that common dolphin held in aquaria spawn in pairs, although often the pair was accompanied by one to three others.

See section 3.16.

3.14 Fertilization

Fertilization is external.

3.15 Gonads

Beardsley (1967) described the gonads of common dolphin as follows: "The testes of immature fish are thin and unbroken, but the testes of mature males are marked with deep fissures which give a segmented appearance. The diameter of the ovaries is 3-4 mm in immature females and increases at maturity to 40-50 mm. The lumen extends the length of the ovary, opening to the exterior through a short oviduct and urogenital orifice. The ovaries unite posteriorly; the left ovary is slightly the longer."

Beardsley (1967) also classified the ovaries into the following maturity stages:

I Immature. Ovaries long, thin, hollow tubes; diameter 3-4 mm; eggs microscopic; ovary wine-red to pink.

II Early maturing. Ovary slightly enlarged; diameter 10-15 mm; eggs visible to the naked eye through the ovary wall, but no distinct size groups distinguishable; pale yellow.

III Late maturing. Ovary much enlarged; at least two distinct size groups of eggs easily visible to the naked eye; bright yellow to orange.

IV Ripe. Ovary distended, half filling the body cavity; lumen full of large, clear eggs which give the ovary a speckled appearance.

V Spent. Ovaries flaccid, hollow tubes; a few remnants of ripe ova may remain in the lumen or folds of the ovary, usually visible by microscopic examination; dull red and discolored, particularly at the posterior end; numerous blood clots.

Beardsley (1967) gave the following two stages for testes:

I Immature or resting. Testes small, firm to the touch; no milt extruded after cutting and squeezing.

II Mature. Testes enlarged; milt extruded after cutting and squeezing.

Schuck (1951a) estimated the number of eggs produced by an 8.5 kg fish to be 6,090,000 and the average for six females to be 2,655,500 eggs/fish with a weight range from 3 to 8.5 kg. Although the authors did not so state, we believe that their estimates included all of the eggs in the ovary rather than the most mature group. Beebe and Tee-Van (1928) estimated that a 2.7 kg dolphin contained 500,000 eggs, and that about one-third of these were noticeably larger than the rest. Beardsley (1967) found that fecundity increased sharply with size and assuming three spawnings a year, estimated that total egg production would vary from about 240,000 to almost 3 million eggs/yr for fish ranging in size from 500 to 1,100 mm FL. Shcherbachev

(1973) determined the individual fecundity of two specimens of the common dolphin (700,000 and 730,000) and three specimens of the pompano dolphin (66,000, 132,000, and 180,000).

Hagood and Rothwell (footnote 6) conducted spawning experiments on both *C. hippurus* and *C. equiselis* in Hawaii. Between October and 30 December, five separate spawnings were recorded for *C. hippurus* and nine spawnings for *C. equiselis*. The number of eggs released at each spawning was estimated. These estimates and additional data pertaining to these experiments are given in Table 3.

Table 3.—Spawning data for common and pompano dolphin. [Adapted from Hagood and Rothwell (text footnote 6).]

Spawn no.	Date	Tank no.	Population male	Population female	No. of eggs	Fertilization rate	Hatching rate
			Common dolphin				
1	8/6	3	0	2	NA[1]	0	0
2	8/7	3	1	2	40,000	5%	<1%
3	8/8	3	1	2	45,000	90%	70%
4	8/9	3	1	2	40,000	90%	70%
5	8/10	3	1	2	20,000	40%	NA
6	8/17	2	1	4	20,000	10%	NA
7	8/18	2	1	4	40,000	90%	70%
8	8/19	2	1	4	30,000	< 5%	NA
9	10/29		2	2	< 1,000	5%	NA
10	10/30		2	2	< 3,000	60%	11%
11	10/31		2	2	< 3,000	40%	NA
12	11/1		2	2	10,800	50%	75%
13	11/2		2	2	27,000	1%	50%
			Pompano dolphin				
1	10/29	14			< 2,000	1%	27%
2	10/30	14			< 2,000	50%	20%
3	10/31	14			5,000	50%	25%
4	11/2	14			2,000	NA	NA
5	11/5	14			32,000	50%	30%
6	11/6	13			24,000	50%	30%
7	11/14	11			30,000	30%	50%
8	11/15	11			10,000	50%	40%
9	11/16	11			3,000	50%	60%

[1]Not available.

3.16 Spawning

Dolphins have an extended spawning season and multiple spawning may be common among both males and females (Beardsley 1967; Johnson 1978). Soichi (1978) reported spawning under laboratory conditions occurred mainly at the surface and that spawning occurred between 1535 and 1745 h. However, Hagood and Rothwell (footnote 6) recorded 20 separate spawnings from dolphin held in aquaria in Hawaii and all spawnings were at night. Shcherbachev (1973) stated that dolphins were intermittent spawners which apparently spawn year-round in tropical waters but on the periphery of their range confine spawning to the warm period of the year.

The occurrences of young dolphin in the Florida Current also indicate that spawning may be almost year-round (Gibbs and Collette 1959; Beardsley 1967; Shcherbachev 1973; Fahay 1975). Rose (1966) stated that spawning was most intense off North Carolina during June and July in the offshore waters of the Gulf Stream, and Schuck (1951a) reported on dolphin that appeared to be ripe in May and June off the same coast. Gibbs and Col-

lette (1959) noted ripe dolphin off Ocean City, Md., in July and August and stated that dolphin caught in the Gulf Stream in June were ripe or nearly ripe.

Beardsley (1967) indicated that the spawning season in the Florida Current extends over 9 mo (November-July) with peak spawning in January, February, and March. He also suggested that fish which are spawned early in the season are maturing by the end of the spawning season, although they may not actually spawn until the following winter. Anderson et al. (1956a, b) indicated that in the Florida Current most dolphins caught by trolling in April and May were very close to spawning condition, whereas those caught in July and August were not. Dooley (1972) also felt that common dolphin spawn in late November and late March in the Florida Current based on the smallest specimens captured.

Erdman (1956) found common dolphin ovaries with eggs in the most advanced state of development in February in Puerto Rico. Migdalski (1958) reported small common dolphin off Bermuda in September and October, and he stated that spawning took place in the spring in the West Indies. Johnson (1978) said spawning probably occurs in response to rising surface water temperatures and thus takes place earlier in the Caribbean than in the Florida Current or Gulf Stream. However, there are reports of ripe fish off the Virgin Islands as late as August (Mather as cited in Gibbs and Collette 1959).

Gibbs and Collette (1959) collected a ripe pompano dolphin (205 mm SL) in March in the Atlantic. Erdman (1956) reported catches of pompano dolphin in August off San Juan, Puerto Rico, that had well-developed gonads and well-formed eggs in the ovaries. Potthoff (1971) inferred from size data of larvae and juveniles that pompano dolphin spawn in the tropical mid-Atlantic during January and February. Gibbs and Collette (1959) believed that the pompano dolphin spawns in the Gulf of Mexico throughout the spring and summer. They felt, however, there was some evidence of spawning of pompano dolphin at all seasons including winter in the Florida Current and the Bahamas region. They also stated that the species did not breed within the immediate influence of the Gulf Stream, but that the fall influx of young into the Gulf Stream comes from another breeding ground.

In the Pacific off southern Japan, the common dolphin spawns in July and August (Okada 1955). Based on the occurrence of eggs and larvae and the examination of gonads, Mito (1960) felt that the spawning season around Kyushu seemed to extend from late May to late August. Kojima (1955) reported that dolphin caught at the beginning of the season (June, July) in the raft fishery in the Sea of Japan were large (80-120 cm) and almost all had mature eggs. The smaller fish occurred in August and September; however, October brought a mixture of large and small fish. He deduced from the distribution of the mature fish before and after the spawning season and the fact that juveniles were collected 48-65 km offshore, that dolphin spawn not only in southern waters but also in the western part of the Sea of Japan and that the season is from July to September. Soichi (1978) recorded 20 spawnings under laboratory conditions from common dolphin from April to July in water that was controlled between 15.4° and 22.8°C. Based on frequency distribution, Wang (1979) indicated two spawnings each year, one in April and one in September, off eastern Taiwan.

In the western Pacific, based on the presence of different stages of ovarian eggs, Takahashi and Mori (1973) suggested that pompano dolphin spawn more than once during a given season.

In the Indian Ocean, Williams and Newell (1957) gave March to early June as the spawning season for dolphin in East African waters and suggested that the eggs ripen and are spawned inshore. Williams (1953), referencing unpublished data of Wheeler and Ommanney, stated that ripening females occurred in March based on samples from a Mauritius-Seychelles fishery survey. In the western Indian Ocean, the spawning period coincides with the time of lower salinities (April and May) according to Williams and Newell (1957).

3.17 Spawn

Mito (1960) described the ova of common dolphin as buoyant, colorless, spherical, measuring 1.2-1.6 mm in diameter, with a single yellow oil globule measuring 0.3-0.4 mm in diameter (Fig. 6a, b, c). Soichi (1978) indicated that ripe ova were 1.4-1.65 mm in diameter and that hatching occurred within 60 h after fertilization at a water temperature of 24°-25°C. Hassler and Rainville[8] noted that in early stage eggs neither the melanin pigment nor the segmentation of the yolk is obvious; however, in older stage eggs both the embryo and oil globule are mottled with melanophores and the yolk is segmented. Hagood and Rothwell (footnote 6) conducted experiments on both *C. hippurus* and *C. equiselis* under controlled conditions in large aquaria. A detailed account of the development of the egg and embryo for both species is presented in Tables 4 and 5.

3.2 Preadult phase

3.21 Embryonic phase

According to Mito (1960), during the course of egg development many melanophores and xanthophores appear on the embryonal body, yolk, and oil globule (Fig. 6c, also see Tables 4, 5).

3.22 Larval phase

See section 3.23.

3.23 Adolescent phase

Dolphin gradually metamorphose from larvae to adults; therefore, all descriptive phases will be discussed as a single section. The development of the fertilized egg to the juvenile is displayed in Figure 6. The newly hatched common dolphin larvae (Fig. 6d) were described by Mito (1960) as "3.95 mm in total length, with the oil globule situated at the posterior part of the yolk and the anus opened somewhat posteriorly to the middle of the body. The myotome number was 17 + 15 = 32 . . . . Melanophores and xanthophores were scattered nearly all over the body, yolk and oil globule, but on the marginal fin there were observed only the xanthophores. Soon after hatching, the chromatophores became larger and approached each other, and the xanthophores on the marginal fin shifted to its margin. In 4 days after hatching, the yolk and oil globule were entirely consumed and the larva attained 5.70 mm [TL]. The xanthophores of the marginal fin became faint. The myotome number and the position of the anus remained unchanged . . . "

[8]Hassler, W. W., and R. P. Rainville. 1975. Techniques for hatching and rearing dolphin, *Coryphaena hippurus*, through larvae and juvenile stages. Univ. North Carolina Sea Grant Program Publ. UNC-SG 75-31, 17 p.

Table 4.—*Coryphaena hippurus* embryonic development at 26 °C. [Adapted from Hagood and Rothwell (text footnote 6).]

Stage	Time h	Time min	Description
Fertilized egg	0	00	Central mass present, yolk with fission lines
2 cell	0	40	First cell division
4 cell	0	50	
8 cell	1	10	
16 cell	1	30	
32 cell	2	00	Cell arrangement irregular; cell size reduced
64 cell	2	30	
128 cell	3	00	Blastodisc well formed; blastulation underway
Blastula	6	00	Cells organized; dark spot under cell mass
Gastrula	7	30	Germ ring present; gastrulation beginning
	10	10	Head fold present; invagination of blastomere complete
Neurula	12	00	Neural groove present
	13	00	Tail expanded; somatic segmentation beginning
Developing embryo	17	00	Embryo length approximately ½ circumference of egg; optic vesicle present; 13-14 somatic segment melanophores present on yolk sac
	18	00	Melanophores present on dorsal and lateral surfaces of embryo
	26	00	Developing larvae now ⅔ circumference of egg; body movement beginning; optic vesicle well developed; fin folds present; heart beginning to beat
	28	00	Tail free of yolk sac
	30	00	Tail near head; embryo changing position in egg
	37	00	Tail overlaps head; movement common
Free larvae	40	40	

Table 5.—*Coryphaena equiselis* embryonic development at 26 °C. [Adapted from Hagood and Rothwell (text footnote 6).]

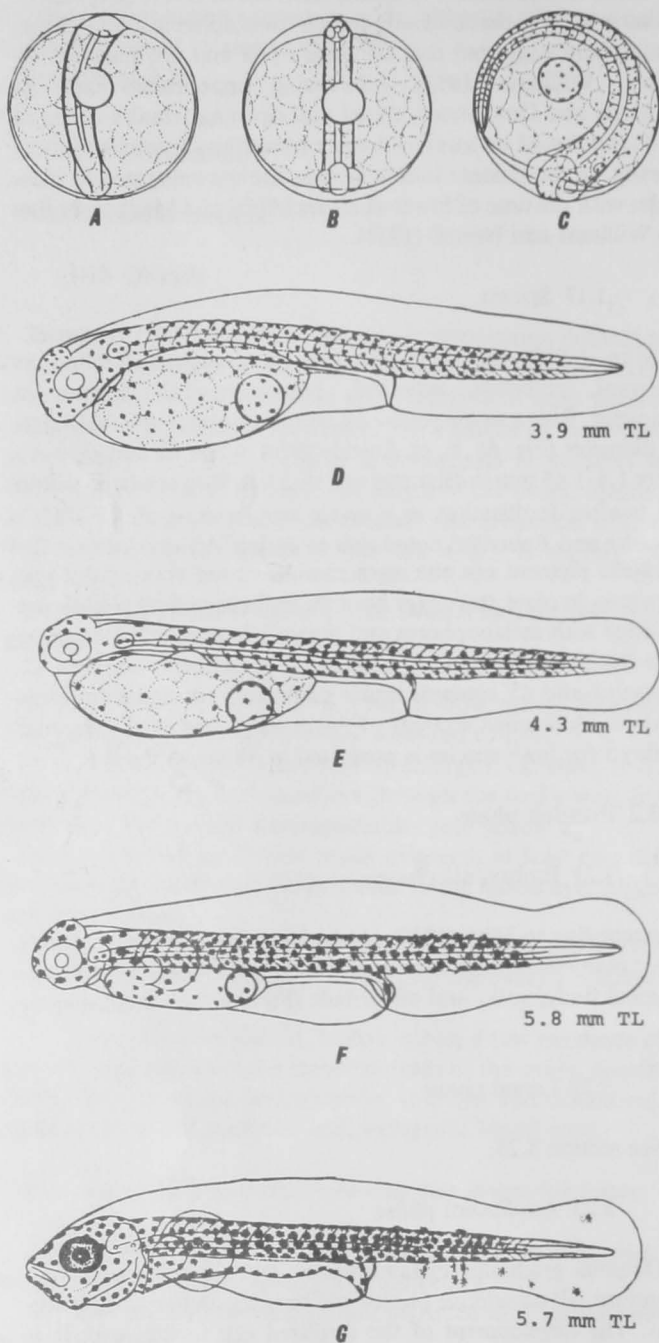| Stage	Time (h)	Description
Fertilized egg	0	Central mass, oil droplet, yolk with fission lines
2 cell	0.4	First cell division
4 cell	0.5	Egg diameter 1.35 mm
8 cell	0.7	
16 cell	1.0	
32 cell	1.25	Cell arrangement less regular; cells reduced in size
64 cell	1.75	
128 cell	2.25	Blastodisc well formed; blastulation beginning
Blastula	4.5	Cells organized; dark spot under cell mass
Gastrula	9.0	Germ ring present; gastrulation beginning
Late gastrula	11.5	Head fold present
Neurula	12.5	Neural groove present
	15.0	Blastopore almost closed; optic lobe forming
	15.7	Blastopore closed; somatic segmentation beginning
Developing embryo	17.0	20 somatic segments
	18.0	Head to tail 50% egg circumference
	23	Melanophores present on yolk sac and embryo heart beginning to beat; body movements starting
	27.5	Body approximately ¼ circumference of egg; body movement common; melanophores numerous
	31.0	Tail almost to head and free of yolk sac; body twisting in egg
	37.0	Tail overlaps head; movement frequent
Free larvae	38.0	

Figure 6.—Eggs and larvae of common dolphin, *Coryphaena hippurus*. A) Egg, 5.3 hrs after capture; B) egg, 8.3 hrs after capture; C) egg, 19.3 hrs after capture; showing developed embryo with melanophores and xanthophores; D) yolk-sac larvae, newly hatched, 3.9 mm TL; E) yolk-sac larva, 5-7 hrs after hatching, 4.3 mm TL; F) yolk-sac larva, 1 day after hatching, 5.8 mm TL; G) larva, 4 days after hatching, 5.7 mm TL (from Mito 1960, fig. 1 and caption).

Hassler and Rainville (footnote 8) described 1-d-old common dolphin larvae reared under laboratory conditions as "approximately 3 mm long, with melanin blotches scattered over the body and yolk. The yolk sac is large and conspicuous. A single fin extends dorsally from the head and ventrally from the yolk sac posteriorly around the caudal tip of the body." They further described 15-d and 30-d-old dolphin: "At 15 days, dolphin larvae are approximately 15 mm long. The blunt snout characteristic of the adult is already evident. Distinct dorsal, anal, caudal, pectoral, and pelvic fins are present. The dorsal fin arises posterior

to the head and ends just before the caudal fin. The anal fin begins just posterior to the anus and also runs to the caudal fin. Musculature is evident throughout the body. The eye and mouth are prominent and fully developed. Melanin chromatophores form approximately 13 lateral bands which continue onto the dorsal and anal fins and give the larva a brown appearance. The 30-day dolphin are approximately 30 mm in length and very similar to the 15-day larvae. The lateral banding is not as distinct on the body except during times of excitement. The juveniles appear brown although a few silver-colored individuals were noted. The eye is very large, and the caudal fin is more distinctly forked. . . ."

Gibbs and Collette (1959) felt that juveniles of the common and pompano dolphins are so distinctly patterned that identification is possible without reference to counts or measurements within the 9 to 200 mm size range. The principal differences are in the pattern of the sides and of the dorsal, anal, pelvic, and caudal fins. They describe them as follows:

Juvenile common dolphin "tend to have the entire sides of the body marked with a pattern of alternating dark and light bars. This is particularly evident at very small sizes (10-20 mm standard length), where specimens with erected dorsal and anal fins resemble minature feathers. The bars are continued onto the dorsal and anal fins, except for the rear rays of each, where the dark coloration forms a more or less solid patch [Fig. 7] ...At larger sizes, however, the bars become more obscure, and are lacking in many specimens."

Juvenile pompano dolphin "when very small tends to be uniformly dark on the sides [Fig. 7]. The fins, while sometimes displaying weak bars, never show these as prominently as *C. hippurus*. Ordinarily the dorsal fin is relatively clear, often having, in addition to any weak bars, a concentration of pigment near the middle of the fin and in the posterior membranes. The anal fin is quite clear except for a posterior darkened area. The pelvic fin of *C. hippurus* is usually dark, while that of *C. equiselis* is clear. ...In young of *C. hippurus* the [caudal] fin is pigmented except for the tips of each lobe. In *C. equiselis* the unpigmented region extends in a band along the entire margin of the fork."

3.3 Adult phase

3.31 Longevity

Common dolphin grow rapidly throughout their life (Beardsley 1967; Rose and Hassler 1968a) and their maximum life span is about 4 yr (Beardsley 1967). Observations on specimens in artificial enclosures also indicated that the life span may be < 5 yr (Hinton 1962). In a sample of 738 common dolphin off North Carolina, no fish were found that were older than age 3 (Rose and Hassler 1968a). Tag recoveries add little additional information. In the Atlantic, only three tagged and released dolphin have been recaptured; the maximum time at large was 56 d (Mather as cited in Rose and Hassler 1968a). In the Pacific, Kojima (1965) reported that 36 recaptures were recorded from 132 releases; 94.5% of the recaptures were made within 20 d of release. There is no information on the longevity of pompano dolphin; however, it is likely that their lifespan is even less than the common dolphin's.

3.32 Hardiness

Not much is known about the hardiness of the two species of dolphins. Presumably, adult dolphins are relatively adaptable to changes in their environment and in their ability to utilize different food items. Common dolphin held in pens in estuarine waters were found to tolerate salinities ranging from 16 to 26 % and temperatures ranging from 15° to 29.4 °C (Hassler and Hogarth 1977).

3.33 Competitors

Dolphins presumably compete with other pelagic predators for the same organisms in the food chain. There is no information, however, on the effect this competition has on their survival. That effect is probably not very serious as dolphin are capable of feeding on a variety of foods and are opportunistic top-level predators.

3.34 Predators

All the life stages of dolphins serve as prey for oceanic fishes, including members of their own kind (Kojima 1961; Beardsley 1971; Shcherbachev 1973; Rose and Hassler 1974).

In the Atlantic, Murphy (1914) noted the capture of a large albacore, *Thunnus alalunga*, with young common dolphin in its stomach. Matthews et al. (1977) found both common and pompano dolphin in the stomach contents of yellowfin tuna, *T. albacares*, in the western North Atlantic. Sund and Girigorie (1966) reported the sighting of a marlin in the Caribbean Sea with a 3-ft female common dolphin impaled on its spear. Farrington (1949) stated, " . . . a great sight to see a big blue marlin [*Makaira nigricans*] knock 25- and 30-pound dolphin around as if they were matchsticks. Many dolphin have been caught with holes in them pierced by marlin bills."

Dragovich and Potthoff (1972) found common dolphin in the stomach contents of yellowfin tuna off the west coast of Africa, and Penrith (1963) reported common dolphin as a food source of yellowfin tuna caught off South Africa.

Erdman and Roman (1959) noted pompano dolphin in the stomach contents of blue marlin caught off Puerto Rico.

In the western Pacific, Takahashi and Mori (1973) reported blue marlin; black marlin, *Makaira indica*; yellowfin tuna; and sailfish, *Istiophorus platypturus*, as predators of common dolphin. They also noted that pompano dolphin were preyed upon by skipjack tuna, *Katsuwonus pelamis*; yellowfin tuna; swordfish, *Xiphias gladius*; sailfish; blue marlin; black marlin; striped marlin, *Tetrapturus audax*; and the shortbill, *T. angustirostris*, and longbill spearfishes, *T. pfluegeri*.

Gorbunova (1969) reported that dolphin larvae are a significant food source for swordfish larvae in the Pacific and Indian Oceans.

3.35 Parasites, diseases, injuries, and abnormalities

Rose (1966) observed three internal parasites within the digestive tract of common dolphin captured off North Carolina: the isopod *Livoneca ovalis*; the nematode *Contracaecum* which was extremely abundant; and an unidentified acanthocephalan that was found encysted on the stomach wall of one fish. He also reported that the copepod, *Lernacenicus longiventris*, was attached to the base of the dorsal fin of numerous fish and stated this was a distinctive parasite commonly associated with dolphin. Linton (1905) examined one common and three pompano dolphins in North Carolina waters and listed one acanthocephalan, four nematodes, three cestodes, and four
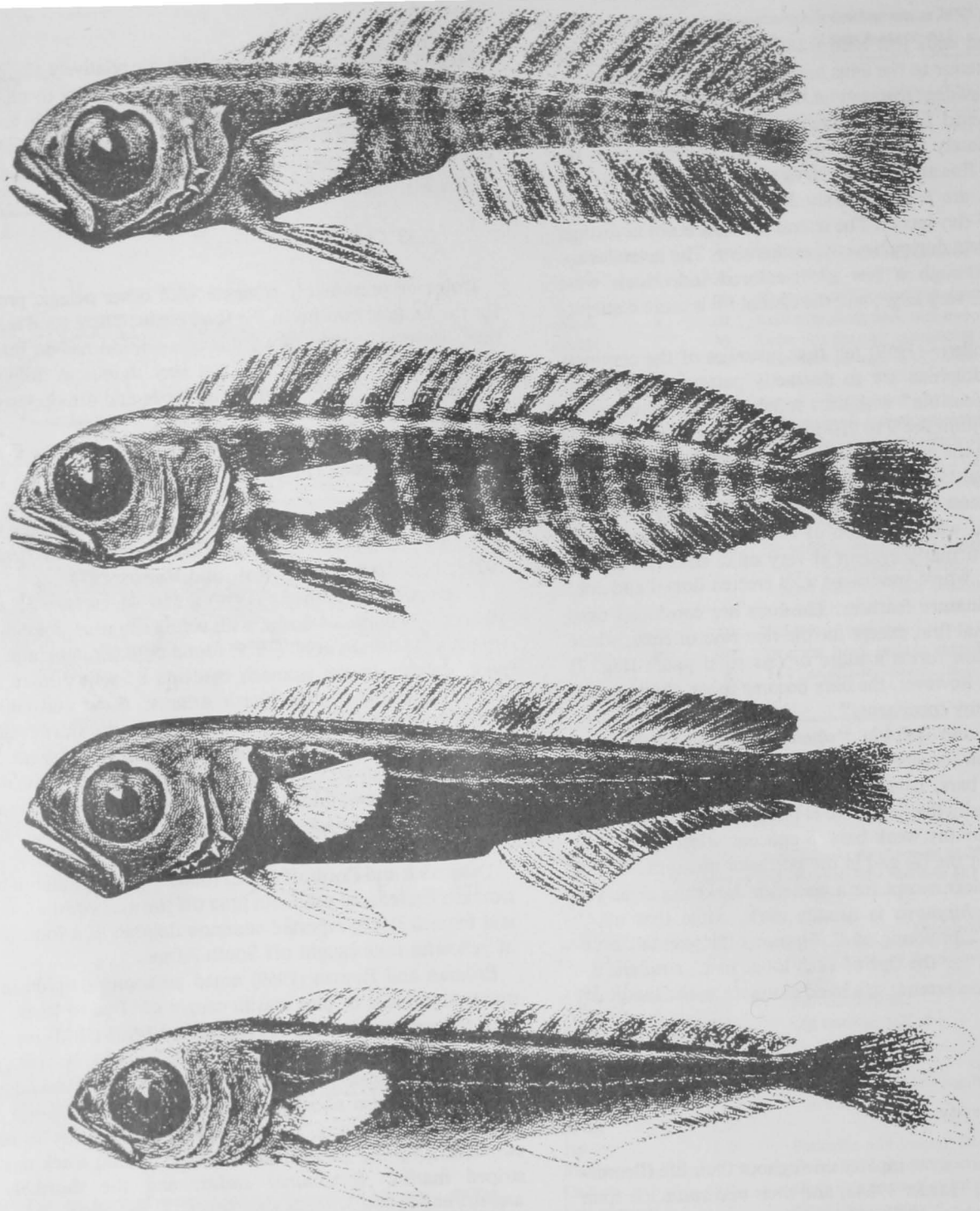
Figure 7.—Upper two, *C. hippurus.* Lower two, *C. equiselis.* Upper figure of each species was drawn with modifications from specimens ca. 15 mm standard length from M/V *Oregon* station 1298 in the northern Gulf of Mexico; lower figures from specimens ca. 35 mm from *Oregon* station 1313 in the northern Gulf and from 12°00′N, 76°00′W (R/V *Crawford* collection), respectively (from Gibbs and Collette 1959, fig. 1 and caption).

trematodes as occurring in common dolphin and one nematode, one cestode, seven trematodes, and two parasitic copepods as occurring on pompano dolphin.

In the Straits of Florida, Burnett-Herkes (1966, 1974) studied parasites from the gill and buccal areas of 145 common dolphin. He found one species of digenetic trematode and seven different species of copepods. He noted that as host size increased there was also an increase in parasite mix, incidence, and intensity of infestation. He also found no significant relationship between those conditions and the sex of the host. He found the plerocer-

cus stage of the order Trypanorhyncha occurring in 53% of common dolphin caught by fishermen off Miami, Fla. Manter (1947) listed the following digenetic trematodes found in the intestines, stomach, and body cavity of common dolphin sampled at Dry Tortugas, Fla.: *Stepanostomum coryphaenae, Dinurus tornatus, D. breviductus, D. longisinus, D. barbatus, Hirudinella ventricosa,* and *Tetrochetus coryphaenae.*

Greer (1976) reported a hemiurid trematode, *Lecithocladium,* and a larval tapeworm (Order Trypanorhyncha) taken from the stomach of a pompano dolphin in the Atlantic.

In the Mediterranean, Dollfuss (1927), in describing the metacercaria of *Certopsis monstrosa,* assumed the host of the adult trematode to be the common dolphin. He further noted the occurrence of *Dinurus notatus* in the gut of adult common dolphin. Cabo (1961) reported only one ectoparasite, an isopod, *Anilocera physodes,* commonly occurring in the waters off the Balearic Islands. Guiart (1935) reported five parasitic cestodes found in dolphin west of the Azores and in the Atlantic off Gibraltar.

In the Pacific, Yamaguti (1953) listed *Bathycotyl coryphaenae* as infesting the gills of common dolphin from Japan, and Gooding and Magnuson (1967) noted ectoparasitic juvenile and adult copepods on dolphin in Hawaii. Jones (1971) commented on crater wounds on a large common dolphin from the central Pacific caused by a squaloid shark, *Isistius brasiliensis.* Beardsley found that crater wounds are relatively common on dolphins in the Atlantic off Florida.

Markowski (1971) first described *Bothriocephalus janikii* from specimens collected from the stomach of a dolphin caught on the 1925 *Discovery* Cruise at lat. 24°05′S, 15°46′N. (Authors' note: this must be an error in the location and should read long. 15°46′W, which would be in the south central Atlantic.) Devi (1975) also reported this pseudophyllidean cestode as occurring in the intestines of the common dolphin in the Bay of Bengal. Data on parasites of common and pompano dolphin are shown in Table 6.

Suzuki et al. (1973) reported head deformities in common dolphin kept in aquaria. They further stated that feeding, vitamin deficiency, water flow, and surface area of the tank played important roles in morphological abnormalities of fishes reared in tanks.

3.36 Physiology and biochemistry

There are numerous references in the literature (Ali and Heumann 1970; Hughes 1970; Ovcharov 1970; Magnuson and Heitz 1971; Bannister 1972; Smirnov and Brusynina 1973; Hochachka 1974; Hochachka et al. 1975; Munz and McFarland 1975; Ali 1976; Ali and Anctil 1976; Bannister and Anastasi 1976; Bannister and Bannister 1976; Bannister et al. 1976; Masuno and Katsuyama 1976) dealing with physiology and biochemistry where dolphins were included among the test specimens. None of these references, however, contribute significantly to the knowledge of the biology of the two dolphin species, and we have chosen not to summarize these works.

3.4 Nutrition and growth

3.41 Feeding

Dolphins are top-level predators, very agile, and capable of taking fast-moving prey. The common dolphin is well known for its association with drifting flotsam and jetsam, and in the Florida Current and Gulf Stream they take much of their food from fishes and crustaceans associated with *Sargassum* windrows (Gibbs and Collette 1959; Beardsley 1967). Adult common dolphin frequently pursue smaller fishes located beneath drifting objects (Hunter and Mitchell 1967). Kojima (1956, 1961, 1963a, b) felt that there is a greater availablility of food near floating objects and that common dolphin only leave them when there is food nearby. However, later studies by Kojima (1967) indicated that dolphin were attracted to floating objects by factors other than food.

Gibbs and Collette (1959) indicated that selectivity was not a major factor in the feeding habits of common dolphin in the Atlantic, and Ronquillo (1953) also noted that common dolphin were seemingly nonselective, feeding on any living organism available. Magnuson and Heitz (1971), however, felt that common dolphin were selective but that regardless of the mode of selection (anatomical, behavioral, or perceptual), the selective capabilities appeared to be associated with the anatomy of the gill raker apparatus. Vision and apparently the lateral line statoacoustic organs are involved in the search for food by dolphins (Shcherbachev 1973).

Rose and Hassler (1974) noted that males in their samples contained a greater amount of food in the stomachs than females. They felt that this was an indication that males were more active feeders than females of similar length. They further theorized that since males are substantially heavier than females of similar age, a greater amount of food is required to sustain body metabolism and this requirement for additional food causes more voracious feeding.

Gibbs and Collette (1959) surmised that feeding in common dolphin was inhibited at night. However, Rothschild (1964), based on his examination of stomachs of dolphin caught at night in the Pacific, felt it probable that dolphin feed actively on bright moonlit nights, and this feeding activity supplies an example of a mechanism by which elements of bathypelagic fauna contribute to the food levels of epipelagic forms. Shcherbachev (1973) concluded from an analysis of the stomach contents that both species of dolphins feed round the clock, but that the rhythm of feeding and possibly the rate of digestion are different between the two.

3.42 Food

According to Shcherbachev (1973) the diet of dolphins alters in the course of growth with larvae feeding mainly on crustaceans, the greater part of which are Copepoda, especially members of the family Pontellidae. He noted that fish larvae appear in the stomachs of dolphin >20 mm SL. He felt that all the food items of dolphins are either permanent inhabitants of the subsurface layer or are migrants that usually ascend to the surface at night. For example, species of Copepoda which make vertical migrations and which are concentrated near the surface at night, were found in the stomachs of dolphins caught at night.

Rose (1966) and Rose and Hassler (1974) found flyingfish (Exocoetidae) made up almost 25% of the total weight of food items in 373 adult common dolphin examined off the coast of North Carolina (Fig. 8). Gibbs and Collette (1959) examined 46 common dolphin from the Gulf Stream and found 32 species of fishes from 19 families; one species of crab, *Portunus sayi;* one shrimp; four cephalopods; and *Sargassum;* however, flyingfish were not found. Rose and Hassler (1974) found *Sargassum,* which was present in 28% (111 of 396) of the stomachs sampled, occurred most frequently in stomachs of small female dolphin. Although *Sargassum* appears frequently in the stomach contents of dolphins, it is likely that *Sargassum* is ingested incidentally while dolphins are feeding on small fishes and crustaceans that make up the *Sargassum* community.

Rose and Hassler (1968b) reported fish, shrimp remains, and *Sargassum* in the stomach contents of pompano dolphin caught in North Carolina waters. Gross analysis of stomach contents of pompano dolphin in the Atlantic by Greer (1976) showed flyingfish composed the bulk of their diet. In addition, three small

Table 6.—Parasites of common and pompano dolphin.

Parasite	Georgraphic region	Site of infestation	Reference
		Common dolphin	
Monogenetic trematodes			
Capsula laevis	Atlantic	gills	Silas (1967)
	Brazil	skin	Guiart (1935)
Tentacularia bicolor	Atlantic	peritoneum, mesentary stomach, alimentary canal	Silas (1967)
T. coryphaena	Atlantic		Silas (1967)
	Atlantic	intestine	Guiart (1935)
Digenetic trematodes			
Bathycotyl coryphaenae	Japan	gills	Yamaguti (1938)
	Gulf of Mexico		Sparks (1958, 1960)
	Straits of Florida	gill filaments	Burnett-Herkes, Jr. (1966, 1974)
Benedenia hendorffi	Chile	skin	Linstow[1]
Dinurus barbatus	Curaçao	stomach	Nahhas and Cable (1964)
	Gulf of Mexico	stomach	Manter (1947)
	Ghana	stomach	Fischthal (1972)
	Ghana	stomach	Fischthal and Thomas (1972b)
D. breviductus	Gulf of Mexico	stomach	Manter (1947)
	Curaçao, Jamaica	stomach	Nahhas and Cable (1964)
	Ghana, Senigal	stomach	Fischthal (1972)
	Senegal	stomach	Fischthal and Thomas (1972b)
D. coryphaenae	Pacific	stomach	Ku and Shen (1968)
D. longisinus	Gulf of Mexico	stomach	Manter (1947)
	Puerto Rico	stomach	Siddiqi and Cable (1960)
	Hawaii		Yamaguti (1970)
D. notatus	Mediterranean	gut	Dollfuss (1927)
D. turnatus	Gulf of Mexico	stomach	Manter (1947)
	Gulf of Panama, Bimini	stomach	Sogandares-Bernal (1959)
	Curaçao	stomach	Nahhas and Cable (1964)
	Ghana	stomach	Fischthal (1972)
	Ghana	stomach	Fischthal and Thomas (1927b)
Didymozoides sp.	Gulf of Aden	intestine	Nikolaeva (1965)
Helicometrina nimia	eastern Pacific	intestine	Arai (1962)
Hirudinella sp.	Curaçao	intestine	Nahhas and Cable (1964)
Hirudinella clavata	Atlantic	intestine	Murphy (1914)
H. spinulosa	Europe	stomach	Silas (1967)
H. ventricosa	Gulf of Mexico	intestine	Manter (1947)
Stepanostomum coryphaenae	Gulf of Mexico	intestine	Manter (1947)
	Ghana		Fischthal (1972)
	Tema, Ghana	small intestine	Fischthal and Thomas (1972a)
Tetrochetus coryphaenae	Gulf of Mexico	body cavity	Manter (1947)
	Hawaii		Yamaguti (1970)
Thoracoctyle coryphaenae	Pacific	gills	Yamaguti (1938)
Nematodes			
Contracaecum sp.	Atlantic		Rose (1966)
	Formosa		Myers and Kuntz (1962)
Anisakis sp.	Pacific		Sakaguchi and Katamine (1971)
Anisakis salaris	Pacific		Yamaguti (1934)
Isopods			
Anilocara physodes	Mediterranean	body surface	Cabo (1961)
Idothea metallica	Atlantic	mouth	Murphy (1914)
Livoneca ovalis	Atlantic		Rose (1966)
Cestodes			
Bothriocephalus janikii	Atlantic		Markowski (1971)
	Bay of Bengal		Devi (1975)
Dibothriorhynchus attenuatus	west of Azores	intestine wall	Guiart (1935)
D. claviger	west of Azores	stomach	Guiart (1935)
D. stenocephala	west of Azores	intestine wall	Guiart (1935)
Plerocercoides lonchophorus	west of Azores	intestine wall	Guiart (1935)
Scolex polymorphus	Pacific		Yamaguti (1934)
Acanthocephalans			
Rhadinorhycyus katsuwonis	Japan	small intestine	Kamegai (1963)
R. pristis	Curaçao		Cable and Linderoth (1963)
Copepods			
Branchiella coryphaenae	Gulf of Mexico	gills	Pearse (1952)
Caligus belones	Woods Hole		Wilson (1932)
	USSR		Markewitsch (as cited in Burnett-Herkes, Jr. (1966
	Mediterranean		Delmare-Deboutteville and Nuñes-Ruivo (1958)
	Pacific		Yamaguti (1958)
	Atlantic,		
	Straits of Florida	inner surface operculum	Burnett-Herkes, Jr. (1966, 1974)

14

Table 6.—Continued.

Parasite	Georgraphic region	Site of infestation	Reference
C. bonito	Straits of Florida	inner surface operculum	Burnett-Herkes, Jr. (1966, 1974)
C. constrictus	Yamaguti (1963) suggested Wilson (1937) misidentified his specimens		Richiardi (1880)
			Brian (1899; 1903; 1906)
C. coryphaenae			Richiardi (1880)
	Atlantic		Steenstrup and Lütken (1861)
			Brian (1899; 1903; 1908)
			Yamaguti (1936)
			Heegaard (1949)
			Pearse (1952)
			Capart (1959)
	Atlantic, Pacific		Shiino (1959a, b, c; 1960; 1963)
	Indian, Mediterranean		
	Formosa	body surface	Ho (1963)
	Straits of Florida	buccal cavity, operculum skin, gills	Burnett-Herkes, Jr. (1966, 1974)
			Lewis (1967)
	Indian Ocean	external surface	Lewis et al. (1969)
C. patulus	Straits of Florida	inner surface of operculum	Burnett-Herkes, Jr. (1966, 1974)
C. productus	Atlantic, Pacific		Shiino (1959a, b, c)
	Mexico		Causey (1960)
	Mediterranean		Yamaguti (1963)
	Straits of Florida	inner surface of operculum	Burnett-Herkes, Jr. (1966, 1974)
			Lewis (1967)
	Indian Ocean	gill cavity	Lewis et al. (1969)
C. quadratus	Pacific, Atlantic		Shiino (1954b; 1959b, c; 1960)
	Indian	opercle	Pillai (1964)
	Pacific	branchial cavity	Kabata and Gusev (1966)
	Straits of Florida	buccal cavity, gill filaments, inner surface operculum	Burnett-Herkes, Jr. (1966, 1974)
			Lewis (1967)
	Indian	gill cavity	Lewis et al. (1969)
Charopinopsis quaternius			Wilson (1936)
	Gulf of Mexico	gills	Silas and Ummerkutty (1967)
	Straits of Florida	gills and gill filaments	Burnett-Herkes, Jr. (1966, 1974)
			Lewis (1967)
Elytrophora coryphaenae	Gulf of Mexico	inside operculum	Pearse (1952)
Euryphorous nordmanni	Indian Ocean	gill cavity	Lewis et al. (1969)
E. nympha	Atlantic, Pacific		Milne-Edwards (1840)
			Steenstrup and Lütken (1861)
	Indian Ocean		Shiino (1954a, 1958, 1959b)
	Pacific, Indian Ocean,		Silas and Ummerkutty (1964)
	Gulf of Mexico, Atlantic		
	Formosa	inner surface operculum	Ho (1963)
	South India	branchial cavity	Pillai (1964)
	Pacific	skin	Kabata and Gusev (1966)
	Straits of Florida	inner surface of skin, gills, operculum	Burnett-Herkes, Jr. (1966, 1974)
Lernacenicus longiventris	Louisiana		Silas and Ummerkutty (1967)
	N.W. Atlantic		Rose (1966)
Pseudocycnus appendiculatus	Atlantic	gills	Heller (1865)
			Silas and Ummerkutty (1967)
P. thynnus	Atlantic	gills	Silas and Ummerkutty (1967)
Other parasites			
Eutyphis faba	Atlantic	mouth	Murphy (1914)

Pompano dolphin

|			
Dinurus longisinus	France		Hutton (1964)
D. tornatus	France		Hutton (1964)
Lecithochirium microstomum	France		Hutton (1964)
Tentacularia bicolor	Atlantic	peritoneum, mesentary stomach, alimentary canal	Silas (1967)
Euryphorus nordmanni	Indian Ocean	gill cavities	Lewis et al. (1969)
Caligus belones			Wilson (1905)
C. productus	Indian Ocean	gill and buccal cavity, external surface	Lewis et al. (1969)
C. quadratus	Indian Ocean		Lewis et al. (1969)
Order Trypanorhyncha	Atlantic	stomach	Greer (1976)

[1]As cited in Sproston (1946).
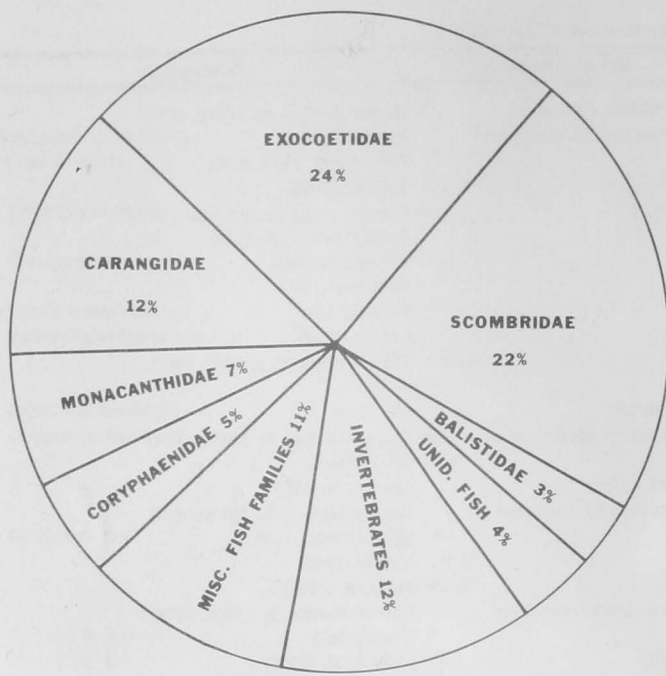
Figure 8.—Stomach contents of 373 dolphin (common) showing important groups of food items by relative weight (from Rose 1966, fig. 26 and caption).

ocean sunfish, *Mola lanceolata*, were found in one stomach, and a small octopus (suborder Octopoda) in another.

In the Mediterranean, Bannister (1976) found flyingfish, mackerels (Scombridae), other smaller dolphins, pilot fish (Carangidae), crustaceans, and unidentified species of medusae in the stomach contents of common dolphin. Off the Balearic Islands, Cabo (1961) reported flyingfish, *Sardinella aurita, Engraulis encrasicholus,* and *Trachurus trachurus* as the main food items of common dolphin.

In the central Pacific, Rothschild (1964) confirmed that common dolphin are piscivorous. Flyingfish were not only the most numerous organism found in the stomach contents, but also comprised a large portion of the total volume. He noted other important food items were gempylids and penaeid shrimps. Tester and Nakamura (1957) further verified the importance of flyingfish both in volume and occurrence. In addition, they noted cephalopods and crustaceans together formed < 3% of the total volume of stomach contents in common dolphin caught off Hawaii.

In the Pacific off Japan, Suyehiro (1942) noted common dolphin were not only carnivorous but very voracious (swallowing whole large flyingfish), and when dolphin did not come in contact with their prey in the open ocean, they fed on species that are found on and around logs and floating objects.

Kojima (1955; 1956; 1960a, b; 1961; 1963a, b; 1964a, b; 1965; 1966a, b, c; 1967) and Uchida and Shojima (1958) studied the biology and ecology of dolphin sampled from anchored attracting devices called "tsuke" rafts in the western Sea of Japan. One investigation (Kojima 1961) examined stomach contents of 1,103 adult common dolphin ranging in length from 35 to 105 cm. Fishes made up 85% of the food items in frequency of occurrence and 95% by weight. He also noted that the food items ranged in length from 1 to 34 cm but appeared for the most part to fall into two groups: 2-4 cm and 10-15 cm.

Shcherbachev (1973) felt that crustaceans were an appreciable part of the diet of pompano dolphin in the Pacific and Indian

oceans. Rothschild (1964) examined the stomach contents from pompano dolphin and found bramids were the most common item in the stomachs. However, he noted that 39 dolphins from the sample were taken from the same school and stomach contents might not be representative. He further noted, in contrast to common dolphin, that flyingfish were not a common item in the diet of this species.

3.43 Growth rate

Growth in common dolphin appears to be rapid and its life span short. Both Beardsley (1967) and Rose and Hassler (1968a) examined scales from common dolphin taken from the western North Atlantic. Beardsley (1967) examined 511 common dolphin taken off southern Florida ranging in size from 475 to 1,525 mm FL. He found 121 1-yr-olds ranging in size from 475 to 1,175 mm FL ($\bar{x}$ = 725 mm), 9 2-yr-olds ranging from 1,025 to 1,325 mm ($\bar{x}$ = 1,175 mm), 1 3-yr-old (1,425 mm), and 1 4-yr-old (1,525 mm). Both authors believed that the maximum life span was about 4 yr. The 4-yr-old specimen examined by Beardsley (1967) weighed 35 kg, at that time the all-tackle sport fishing record. Larger dolphin have been taken, however, and in 1979 a male dolphin weighing over 46 kg was captured off Puerto Rico (Florida Sportsman 1979). Beardsley (1967) believed that the wide size range of yearling dolphin resulted from the extended spawning sason (possibly all year long) combined with rapid growth.

Rose and Hassler (1968a) examined scales from 738 common dolphin taken off North Carolina during the summer months. They found 593 age 0 dolphin ranging in size from about 400 to 725 mm FL ($\bar{x}$ = 572 mm), 117 1-yr-olds ranging from about 650 to 1,100 mm FL ($\bar{x}$ = 868 mm FL), 20 2-yr-olds ranging from about 900 to 1,300 mm FL ($\bar{x}$ = 1,108 mm FL), and 8 3-yr-olds ranging from about 1,100 to 1,430 mm FL ($\bar{x}$ = 1,269 mm FL).

Although he did not state how ages were determined, Kojima (1966c) indicated that in the Pacific, common dolphin reached about 38 cm FL in length the first year, 68 cm FL the second year, 90 cm FL the third year, 108 cm FL the fourth year, and 122 cm FL the fifth year.

Additional evidence for rapid growth in common dolphin is available from various sources. Herald (1961) reported that two common dolphin grew from approximately 0.7 to 14.5 and 16.8 kg in about 7.5 mo in a large aquarium at Marineland in Florida. Beardsley (1967) reported on a male dolphin that weighed about 0.5 kg when placed into a large aquarium at the Miami Seaquarium. Eight months later, at its death, this fish weighed 16.3 kg. Soichi (1978) held 36 common dolphin (35-50 cm TL) collected off Japan in September-October 1975 in a large aquarium. Eleven specimens survived until April 1976, at which time they had increased in length to about 100 cm. Wang (1979) indicated a growth rate of 10 cm/mo FL with 1-yr-old common dolphin off eastern Taiwan.

Hassler and Hogarth (1977) conducted feeding experiments on common dolphin held in pens in estuarine waters in North Carolina. Two separate experiments resulted in food conversion ratios of 3.54 and 3.44 (wet weight). Another experiment resulted in an average weight gain of 0.39 kg/wk with a range of 0.14-0.59 kg/wk. They noted that growth was rapid at water temperatures from 23.9° to 29.4°C. Feeding decreased at temperatures below 23.0°C and ceased entirely at temperatures of about 18.3°C. Both Beardsley (1967) and Rose and Hassler (1968a) believed that the check marks on dolphin scales that they interpreted as annuli were caused by a decrease in growth

rate associated with a decrease in water temperature in the winter months.

Beardsley (1967) and Rose and Hassler (1968a) indicated that males were heavier than females at almost all lengths and this difference increased as length increased. Rose and Hassler cited a 1,268 mm FL female that weighed 12.1 kg compared with a 1,256 mm FL male that weighed 21.6 kg. Gibbs and Collette (1959), however, felt that there were no sexual differences in weight up to about 900 mm, but that males were heavier than females above this size.

The length-weight relationships for male and female common dolphin are shown in Table 7.

3.44 Metabolism

Lipskaya (1974) studied the metabolic rates in some juvenile tropical fish species, including both species of dolphins, and concluded that high metabolic rates were a feature of pelagic fishes of the epipelagic zone such as dolphins. A clear relationship was established between metabolic rate and body weight using an exponential equation of the type $Q = aW^k$ and differences in metabolic levels were associated with the different mode of life of the fishes investigated.

3.5 Behavior

3.51 Migrations and local movements

There is little published information about migrations of either the common dolphin or pompano dolphin. Mather (as cited in Rose and Hassler 1968a) reported on the recapture of three tagged dolphin off the Florida coast. One was recaptured on the same day, one was recaptured 97 km north 2 d after tagging, and one was recaptured 56 d after release, having traveled 260 km to the north. Beardsley (1967) felt the possibility was strong that common dolphin migrate northward during the spring and summer. Gibbs and Collette (1959) concluded from

data of Mather (as cited in Gibbs and Collette 1959) in the Virgin Islands and Erdman (1956) in Puerto Rico that the spring abundance of common dolphin in the Caribbean may be a prespawning migration, mainly of females.

In the Pacific, Kojima (1965) reported that 132 dolphin were tagged and released in 1962 and 1963 from the "Shiira-zuke" fishery off Japan. By January 1964, 36 recaptures had been recorded. Seventy-two percent of the recaptures were made within 10 d of release, and 80% of the recaptures were made < 160 km from the release point. All of the recaptured dolphin were caught from beneath floating bamboo rafts or other floating objects. Kojima believed that dolphin in the Sea of Japan make a northward migration until September and then return to the south.

Williams and Newell (1957) noted that common dolphin make a migration into East African coastal waters between November and early June each year. Wheeler and Ommanney (1953) noted a similar migration occurring in the Seychelles Islands.

Indications are that occasionally migrations and movements of dolphin may be controlled by the movement of drifting objects on the high seas with which dolphin are closely associated. Beardsley (1967) stated that large groups of young dolphin have been reported to follow *Sargassum* concentrations northward from the lower Florida Keys to Palm Beach, a distance of about 370 km. Greer (1976) reported pompano dolphin following a sailboat for 19 d as well as one "marked" pompano dolphin that traveled 1,690 km with the vessel. Gooding and Magnuson (1967) also commented on dolphin staying with a raft while it was towed 48 km down the coast and then set adrift.

3.52 Schooling

Rose and Hassler (1974) noted differential schooling behavior at an early age among small common dolphin with small females more predominantly associated with tide lines where clumps of *Sargassum* were present. However, the sex ratio was not so definitely in favor of females when small dolphin were captured

Table 7.—Length-weight relationships of common dolphin, *Coryphaena hippurus*. Sexes are combined unless otherwise noted. The form of the equation is $Y = ax^b$.

Author	Measurement	Range in length	n	A	b
Schuck (1951a) (western Atlantic)	Fork length (cm) Weight (lb)	ca. 66-97	18	14.4×10^{-6}	3.231
Morrow (1954) (Indian Ocean)	Fork length (cm) Weight (lb)	58-82	14	9.82×10^{-8}	3.67
Williams and Newell (1957) (Indian Ocean)	Standard length (cm) Weight (lb)	ca. 55-105	64	8.86×10^{-6}	3.164
Tester and Nakamura (1957) (Pacific)	Fork length (cm) Weight (lb)	41-121	133	1.573×10^{-4}	2.7111
Kojima (1966c) (Pacific)	Fork length (cm) Weight (k)	2-29	9,799	3.9×10^{-2}	2.688
Beardsley (1967) (western Atlantic) Males Females	Fork length (mm) Weight (kg)	550-1,300 500-1,225	19 40	2.62×10^{-4} 2.35×10^{-4}	2.66570 2.62796
Rose and Hassler (1968a) (western Atlantic) Males Females	Fork length (mm) Weight (kg)	ca. 275-1,350 ca. 310-1,275	176 325	0.5×10^{-7} 1.27×10^{-7}	2.75 2.59
Bannister (1976) (Mediterranean) Males Females	Fork length (mm) Weight (gm)	222-543 224-545	169 251	1.637×10^{-5} 2.094×10^{-5}	2.952 2.919

in the open ocean away from tide lines. They hypothesized that small female dolphin congregate around tide lines, while males of the same length tend to be found in the open ocean along with larger males and females.

Dolphin also tend to segregate by sex as well as by size (Gibbs and Collette 1959; Kojima 1966b; Beardsley 1967; Nakamura footnote 7). Kojima (1966b) felt the seasonal variation in the size of a dolphin school may be caused by the ecological differences between the spawning schools (adults) and the feeding schools (young fish). He further noted that older dolphin decreased in number and young fish replaced them in the catch as the fishing season progressed.

Beardsley (1964) noted that adult pompano dolphin were collected in a large school of common dolphin, indicating that the two species at least occasionally form mixed schools. Shcherbachev (1973), however, felt that pompano dolphin shun common dolphin and used as an example an experience aboard the research vessel *Baikal* when a large school of pompano dolphin that had stayed close to the vessel immediately disappeared at the approach of a few common dolphin.

3.53 Responses to stimuli

Common dolphin show no fear of boats (Beardsley 1967), and one of the aspects of the ecology of dolphins is the close association they maintain with floating and drifting objects on the high seas. Early research by Kojima (1956) suggested that dolphins took shelter under floating objects because of the greater availability of food. In later research (1964b, 1966c, 1967), however, he felt dolphins were attracted to floating objects by factors other than food. Hunter and Mitchell (1967) felt it was possible that young dolphins were attracted to drifting material because the objects function as schooling companions and provide visual stimulation in an optical void.

Adult dolphins commonly chafe against the bottom of rafts, skiffs, and other floating objects (Heyerdahl 1950; Roig and Maza 1952; Gooding and Magnuson 1967; Hunter and Mitchell 1967). This behavior could remove parasites or relieve skin irritations (Gooding and Magnuson 1967).

Williams and Newell (1957) felt that temperature might act as an environmental stimulus since common dolphin appeared in coastal waters off East Africa and shallow waters around the Seychelles during periods of maximum surface water temperatures (29°-30°C). They felt that common dolphin moved north and south with the surface isotherms over the year. The occurrence of dolphin may also be connected with seasonal plankton outbursts, i.e., the period of greatest fertility of the coastal water. They also felt there may be a connection between the appearance of dolphin and the period of maximum *Sargassum* accumulation.

4 POPULATION

4.1 Structure

4.11 Sex ratio

Rose and Hassler (1974) noted that sex ratios of common dolphin caught off Hatteras, N.C., changed according to size. Males constituted a majority (61%) of dolphin in the 801-1,275 mm FL group; no significant deviation from a 1:1 sex ratio occurred in the 601-800 mm FL group, while females made up a majority (71%) of dolphin between 450 and 600 mm FL and constituted the bulk of the dolphin catch each year (Table 8). They felt that observed sex ratios lent credibility to the hypothesis of differential schooling and feeding patterns between small and large dolphin. Gibbs and Collette (1959) found essentially a 50:50 sex ratio in the Gulf Stream while Mather's data (as cited in Gibbs and Collette 1959) from winter records in the Virgin Islands indicates a preponderance of females, about a 65:35 ratio.

Nakamura (footnote 7) sampled dolphin catches by recreational anglers in the Gulf of Mexico from 1966 to 1970 and found that males predominated in the catch. He suggested, however, that this may be a sampling artifact since males are more frequently brought in by anglers for weigh-ins because male dolphins attain greater weights than females. If it is not an artifact, Nakamura felt this may indicate differences in schooling behavior between sexes or a difference in migrational patterns between sexes during nonspawning periods.

Table 8.—Relationship between sex ratio and length[1] of 1,249 dolphin captured by trolling in the western Atlantic Ocean off Hatteras, N.C., during 1961-63, and chi-square analyses testing the hypothesis of a 1:1 sex ratio (Rose and Hassler 1974).

Dolphin length (mm)[2]	Number of specimens								Expected number of each sex assuming a 1:1 sex ratio	Chi-square values[3]
	1961		1962		1963		Total			
	Female	Male	Female	Male	Female	Male	Female	Male		
450-600 (small dolphin)	224	94	211	49	250	138	685	281	483.0	168.12** females
601-800 (medium dolphin)	53	45	33	23	11	17	97	85	91.0	0.66 ns
801-1,275 (large dolphin)	20	31	13	18	6	13	39	62	50.5	4.79* males

[1]Sex of medium and large dolphin was determined by the presence or absence of a vertical frontal profile. Sex of small dolphin was determined by applying a 6% correction rate (representing males that lacked a vertical profile) to results obtained by external observation. The corrected data appear in this table.

[2]Most dolphin measuring 450-600 mm were young-of-the-year fish. Most dolphin measuring between 601-800 mm were in age-group I. Dolphin measuring over 800 mm were members of age-groups I, II, and III.

[3]Chi-square values were calculated with Yates' (1934) correction for continuity. Tabulated chi-square value for a 0.05 error rate and a 1 degree of freedom is 3.84. Hence, significant departure from the null hypothesis of a 1:1 sex ratio is indicated in the 450-600 mm length group (females dominating) and in the 801-1,275 mm length group (males dominating).

In a study carried out between August and December 1974 in the Mediterranean Sea around the Maltese Islands, Bannister (1976) sampled 420 common dolphin: 169 were males and 251 were females. Cabo (1961) reported a very slight preponderance of females to males (47% females, 45% males, and 8% immature) for common dolphin around the Balearic Islands.

In Hawaiian waters, Tester and Nakamura (1957) stated that common dolphin showed a significant deviation from the 1:1 sex ratio, with males (28.5%) much less numerous than females (71.5%). They also noted there was a considerable diversity in the proportion of males and females between schools. Kojima (1966c) stated that during the early part of the fishing season in the western Pacific, females outnumbered males. However, during the spawning season later in the year, sex ratios were about equal.

Off East Africa, Williams and Newell (1957) reported a sex ratio of 1:4 (19 males and 79 females) in samples taken from Janaury 1952 to December 1965. Williams (1956) showed a male to female ratio of about 1:15 from personal observations in Zanzibar fish markets from 1952 to 1954. He also reported (Williams 1953) on a study from September 1951 to August 1952 which had a catch of 24 females and 3 males. Morrow (1954), sampling off Kenya, reported catches of 8 males, 14 females, and 2 immatures.

4.12 Age composition

Beardsley (1967) and Rose and Hassler (1968a) used interpretations of markings on scales to estimate the age of common dolphin. In the Florida Current, Beardsley (1967) found only 11 fish out of 511 examined with two or more annuli. Five females and 4 males were in age-group II, 1 male in age-group III, and 1 male in age-group IV (Fig. 9). In North Carolina waters, Rose and Hassler (1968a) segregated 738 dolphin by sex into 50 mm length intervals (176 males and 325 females) and found all of the 3-yr-old and 15 of the 2-yr-old fish were males. Sexes were equally represented in age-group I, while females predominated in age-group 0 (Fig. 10).

4.13 Size composition

Length-weight relationships for common dolphin have been reported by numerous authors (Schuck 1951a; Morrow 1954; Williams and Newell 1957; Tester and Nakamura 1957; Kojima 1966c; Beardsley 1967; Rose and Hassler 1968a; Bannister 1976). These relationships are summarized in Table 7.

Gibbs and Collette (1959) combined their own data, that of Mather which included pompano dolphin, and that in the literature (Bonham 1946; Schuck 1951a, b; Morrow 1954; Anderson et al. 1956a, b) and stated that in common dolphin up to 950 mm in length there appeared to be no apparent difference in weight by sex (Fig. 11). Above that size, males were heavier than females and weight varied considerably as shown by two large males, 1,180 and 1,175 mm FL, which weighed 18.2 and 13.9 kg, respectively. In the Atlantic, Rose and Hassler (1968a) plotted lengths and weights for 176 male and 325 female common dolphins and found males were heavier than females throughout their length range (Fig. 12), and this phenomenon was most apparent in large fish: a 1,268 mm female weighed 12.1 kg while a 1,256 mm male weighed 21.6 kg. Beardsley (1967) measured 59 dolphin from the Florida Current and found the fitted curve indicated that males were heavier than females at all lengths down to about 450 mm, the lower limit of the data.
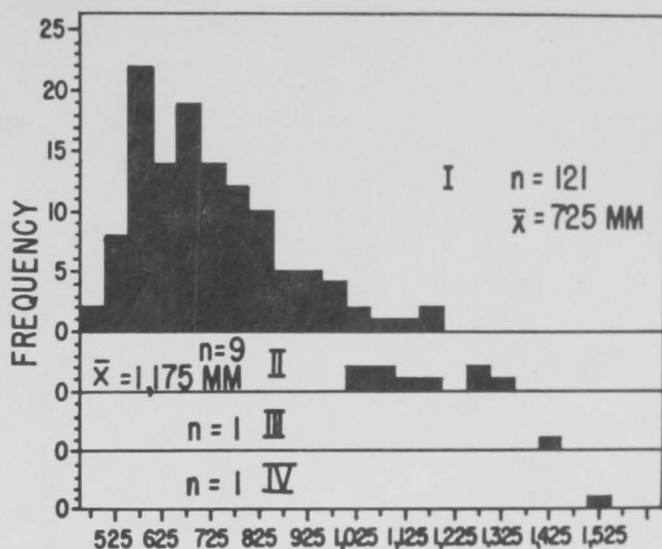

Figure 9.—Length-frequency distribution of four age groups (excluding age-group 0) of common dolphin collected off Florida (number of fish represented indicated on figure) (from Beardsley 1967, fig. 5 and caption).
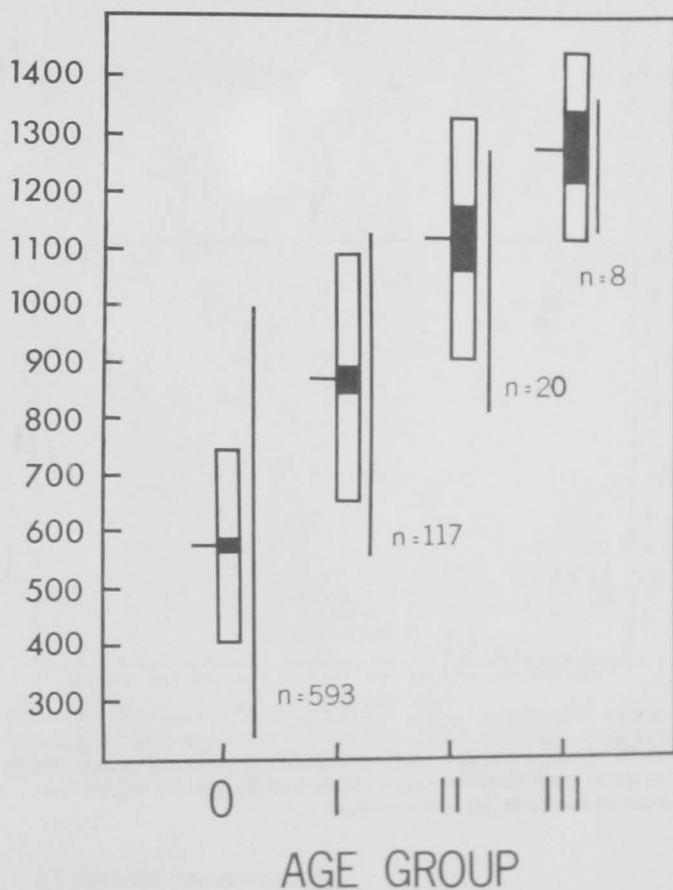

Figure 10.—Length distribution of age groups of dolphin (common) captured off the North Carolina coast, June, July, August, 1961-63. The vertical line represents the range; the light rectangle represents two standard deviations, and the solid rectangle represents two standard errors on either side of the mean described by the horizontal line (from Rose and Hassler 1968a, fig. 3 and caption).
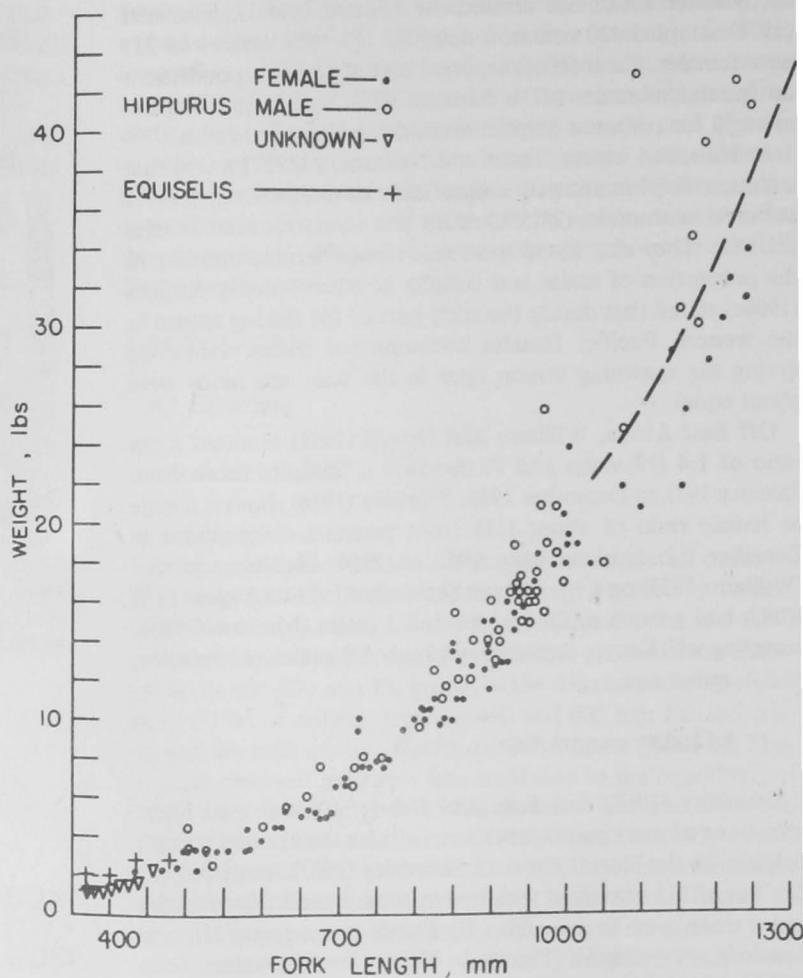
19

Figure 11.—Length-weight relationship in *Coryphaena* (principally *C. hippurus*). Dashed line emphasizes the difference in weight of males and females over 1,000 fork length (from Gibbs and Collette 1959, fig. 11 and caption).
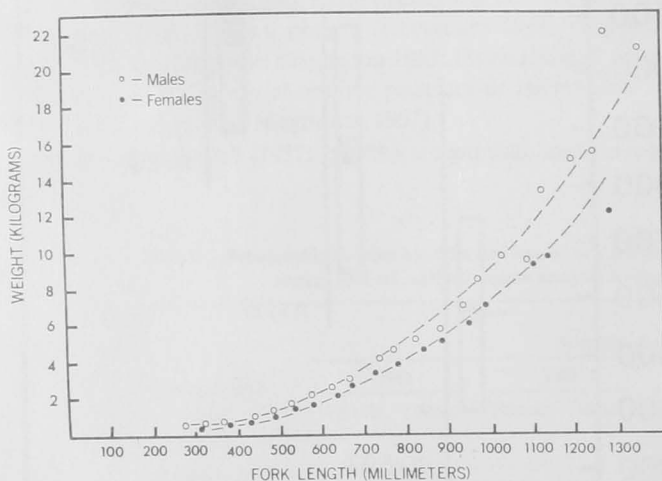

Figure 12.—Length-weight relations for male and female dolphin (common). The curves represent the calculated weights and the dots the empirical weights (from Rose and Hassler 1968a, fig. 1 and caption).

He also noted that this difference in weight for a given length seemed to increase gradually with an increase in length.

Bannister (1976) plotted lengths and weights for 169 male common dolphin and 251 female dolphin captured in the Mediterranean ranging in length from 222 to 545 mm FL. He found no obvious trend for males to be heavier than females.

In Hawaiian waters, Tester and Nakamura (1957) studied length-weight relationships of common dolphin (Fig. 13). They examined 133 specimens and felt that beyond 68 cm in length (2.7 kg), males tended to be heavier for a given length than females.

Williams and Newell (1957) plotted lengths and weights for 64 common dolphin captured in the Indian Ocean and found that males were significantly heavier than females at a given length.

Hassler and Rainville (footnote 8) determined a length-weight relationship for larval and fingerling common dolphin grown in aquaria. Body weight of dolphin increased exponentially between the 15th and 83d day of growth. This increase is represented by the expression:

$$\text{Log } W = 3.4852 \log X - 2.7358$$

where $\log W$ = log to the base 10 of the weight in milligrams

$\log X$ = log to the base 10 of the age in days.

The length range was from 15 to 107 mm and the weight range was from 34 to 9,255 mg.

Rothschild (1964) and Potthoff (1971) studied pompano dolphin in the central Pacific and tropical Atlantic, respectively, and plotted size frequencies (Figs. 14, 15).
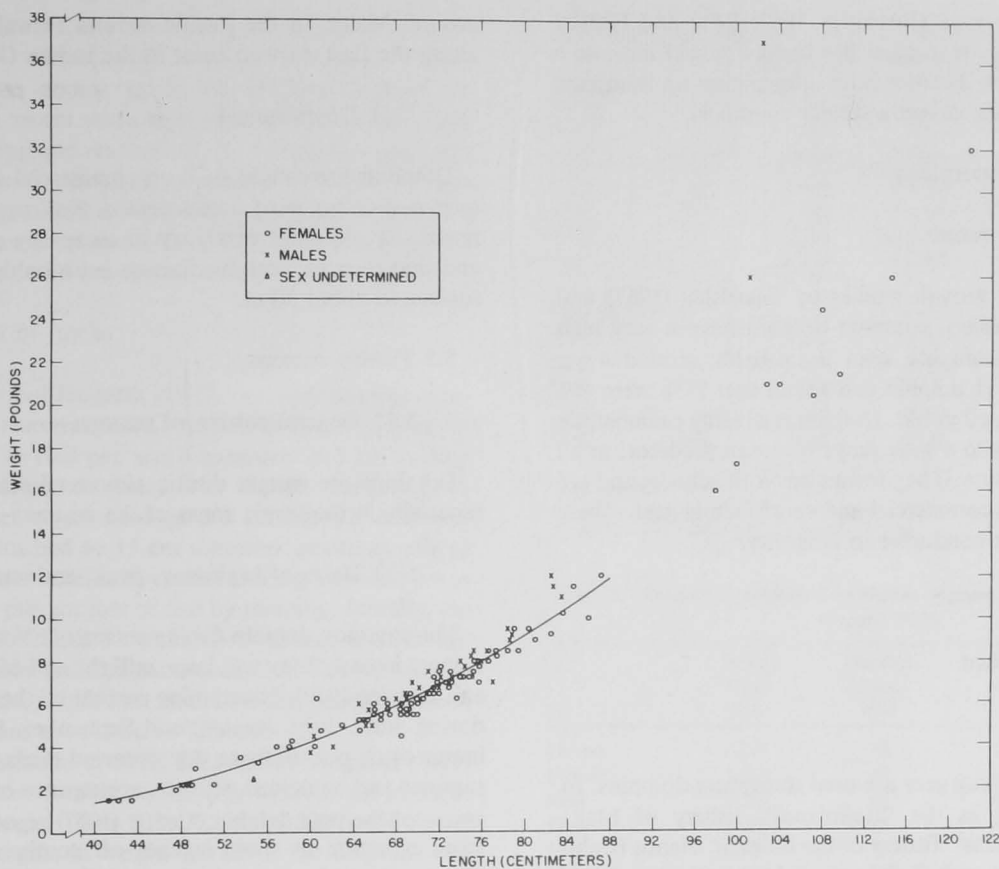
Figure 13.—Weight-length relation of dolphin (common) (from Tester and Nakamura 1957, fig. 9 and caption.   Authors' note: length is fork length).
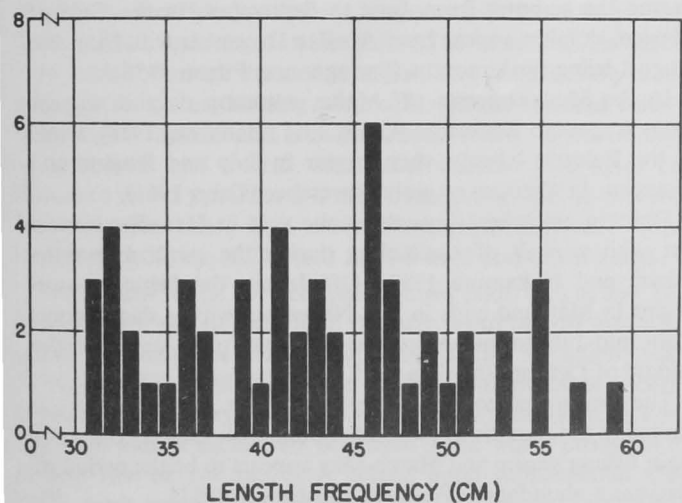

Figure 14.—Length-frequency distribution (FL) of 53 *C. equiselis* taken in central Pacific, January-February 1963 (from Rothschild 1964, fig. 1 and caption).
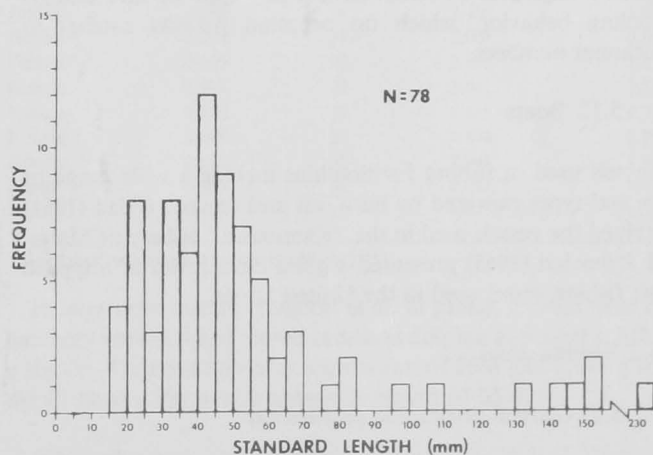
Figure 15.—Size-frequency distribution of *Coryphaena equiselis* which were attracted to the night light and caught in dip net during ATEX aboard the R/V *Discoverer*, February 1969 (from Potthoff 1971, fig. 3 and caption).

4.14 Subpopulations

In the Pacific, Kojima (1966c) stated that because the seasonal migrations of common dolphin in the Southern Hemisphere show a reverse tendency to that in the Northern Hemisphere, there are apparently two stocks of dolphin separated by the Equator.

4.3 Natality and recruitment

4.31 Reproduction rates

Common dolphin have an extended spawning season, a very early age at maturity, a voracious appetite, a cosmopolitan diet,

and a very short life span (Beardsley 1967; Rose and Hassler 1968a). These conditions in their life history would indicate a high reproductive rate. There is little information on pompano dolphin, but one might expect a similar condition.

4.4 Mortality and morbidity

4.41 Mortality rates

Based on age and growth studies by Beardsley (1967) and Rose and Hassler (1968a), common dolphin have a very high mortality, and maximum life span is probably around 4 yr. Beardsley examined 511 dolphin and found that 75% were <1 yr old and 98% were <2 yr old. Dolphin are highly cannibalistic and also serve as prey to a wide range of ocean predators at all stages in their life history. They form close-knit schools and are easily caught by both commercial and sport fishing gear. These characteristics are not conducive to longevity.

5 EXPLOITATION

5.1 Fishing equipment

5.11 Gears

Various types of fishing gear are used to capture dolphins. In several fisheries such as the "Kannizzati" fishery of Malta (Galea 1961), the "Matas" fishery of the Balearic Islands (Cabo 1961), and the "Shiira-zuke" fishery of Japan (Kojima 1956; 1960a, b; 1965; 1966a, b, c; 1967), attracting devices such as floating bundles of bamboo reeds or cork planks are used to accumulate dolphin before the nets are set. Other fisheries use various types of hook and line gear, taking advantage of the dolphin's eagerness to strike almost any type of lure and its schooling behavior, which on occasion permits catches in substantial numbers.

5.12 Boats

Vessels used in fishing for dolphins include a wide range of sizes and types powered by both sail and engine. Galea (1961) described the vessels used in the "Kannizzati" fishery of Malta, and Rybovich (1965) presented a good description of a typical sport fishing vessel used in the United States.

5.2 Fishing areas

5.21 General geographic distribution

See section 5.22.

5.22 Geographic ranges

Within the distributional range of common dolphin, the areas of maximum fishing effort may be correlated with the density of the neighboring human population and may or may not coincide with the areas of greatest density of dolphin.

Fisheries for common dolphin are located around the edges of the continental shelf in most tropical and subtropical areas of the world. Important fisheries in the Atlantic are concentrated off North Carolina and southeastern Florida, the Bahamas and Caribbean, and along the coast of Spain. Other important fisheries are located in the Gulf of Mexico, in the Mediterranean

around Malta, in the Pacific around Hawaii and Japan, an[d] along the East African coast in the Indian Ocean.

5.23 Depth ranges

Dolphins are caught by both commercial and sport fisherie[s] over a wide range of ocean depths. Kojima (1966c), howeve[r] noted that dolphins rarely try to escape by diving downward and that their vertical distribution is probably limited from th[e] surface to about 30 m.

5.3 Fishing seasons

5.31 General pattern of seasons

Dolphins are caught during almost all seasons of the yea[r] especially in the tropic zones of the oceans.

5.32 Dates of beginning, peak, and end of seasons

The common dolphin fishing season off North Carolina com[-] mences in early May and lasts until the end of September (Ros[e] and Hassler 1969). Ninety-nine percent of the catch was lande[d] during June, July, August, and September. In all areas, ma[x]imum catch per offshore day occurred during middle and la[te] summer and coincided with the appearance of large schools o[f] young-of-the-year dolphin. Gentle (1977) reported dolphin we[re] more common in sport catches off southern Florida durin[g] March through August than during September throug[h] Feburary. Erdman (1956) stated that common dolphin we[re] especially abundant in Puerto Rican waters in January-Marc[h] with February and March being peak time. Few are caugh[t] during the summer from June to September. In the Gulf o[f] Mexico, dolphin appear from April to December with May an[d] August being peak months (Springer and Pirson 1958).

In the Mediterranean off Malta, common dolphin appea[r] from August to December (Galea 1961; Bannister 1976), whi[le] in the Balearic Islands, they appear in July and August an[d] disappear in October or early November (Cabo 1961).

Dolphin are taken throughout the year in Hawaiian wate[rs] but with a peak of availability during the summer month[s] (Tester and Nakamura 1957). Off Japan, the fishing seaso[n] begins in May and ends in mid-November with a slack perio[d] from mid-July to mid-August and a peak from August to t[he] middle of October (Kojima 1955, 1966c).

The capture of common dolphin in East African waters [is] limited to the months of November-June with January-June t[he] main fishing season and March-May appears to be the period [of] maximum abundance (Williams and Newell 1957).

5.33 Variations in date and duration of seasons

Williams and Newell (1957) felt it was most probable that a[ll] environmental factors contribute in varying degrees to an e[x]planation of the seasonal occurrence of common dolphin sin[ce] all are interlinked, no one factor being independent of th[e] prevailing oceanographic conditions. They noted that the perio[d] of maximum abundance of common dolphin off East Afric[a] coincided with the time of high surface temperature and lo[w] salinity, that the southeast monsoon season and its variation i[n]fluenced plankton growth, and this could also influence the oc[-] currence of dolphin while the northern monsoon and i[ts] associated *Sargassum* windrows could also contribute.

7 CULTURE

Common dolphin appear to be an excellent animal for mariculture and in recent years significant advancements have been made in holding and rearing both common and pompano dolphins. Dolphins are a highly desirable food fish, spawn almost all year long, have a rapid growth rate (captive dolphins have an even greater growth rate than wild specimens), can be harvested in 3-4 mo, and are easy to handle.

7.1 Procurement of stocks

In 1972, Hassler and Hogarth (1977) captured juvenile common dolphin off Hatteras, N.C., and held them in pens in estuarine waters. The first pen was 3 m square and 1.5 m deep and made of plastic-coated screen wire (2.5 cm bar mesh). A larger pen was later constructed of 2.5 cm bar stainless-steel chain-link fence attached to 15 cm diameter creosoted pilings and was 6 × 9 m in area. Plastic-coated fencing extended 2.1 m above the water to prevent loss of fish by jumping. Initially, the juveniles were fed fresh fish which had been filleted and cut into cubes. Later, artificial pelleted food soaked in fish oil was offered. Eventually, the fish fed on unadulterated pellets. Growth and food conversions are shown in Table 9.

In a second experiment in 1972, Hassler and Hogarth (1977) captured 21 common dolphin which they held for up to 73 d. Gains in weight ranged from 80% (22 d) to 300% (34 d, see Table 10). Average gain in weight for all of the dolphins was 0.390 kg/wk, and the range was 0.141-0.585 kg/wk. Fish grew rapidly at water temperatures between 23.9° and 29.4°C and tolerated salinities ranging from 16 to 26‰.

Hagood and Rothwell (footnote 6) captured 18 common dolphin for broodstock culture in Hawaii. All fish were caught by hook and line and ranged in size from 35 to 70 cm FL. Fish that were hooked through the mouth or jaw, brought in quickly, and placed in temporary holding tanks with minimal handling usually survived capture and transportation. Newly captured fish were isolated and treated with either Furacin (2-3 ppm) or Furanace (0.5-1 ppm) for 1 h on 3 consecutive days to prevent bacterial epizootics. Fish carrying parasitic copepods were treated with Dylox (0.25 ppm) for 1 h on 3 consecutive days.

Water flow in the covered, plastic-lined pools (3.6 m and 7.2 m diameter) was 20 liters/min. A water depth of 1 m was adequate. Temperatures ranged from 26.0° to 28.5°C, salinity was 31‰, and dissolved oxygen was usually at saturation or greater because of algal oxygen production (8 ppm). Broodstock diet consisted almost exclusively of frozen squid which produced a growth rate of 3-4 mm/d. A gelatin bond supplemental diet (55% fresh squid; 18% MR-20, a dry commercial diet; 25% water-gelatin; a multivitamin mix; and Furanace at 4 mg/kg fish) was fed three times weekly in place of one-third to one-half of the normal squid diet. Fish were fed daily to satiation (feeding rate was 5-8% body weight/d). However, small fish weighing approximately 2 kg have consumed over 350 g at one feeding.

Adult dolphin were handled with clear plastic net-bags or black plastic transfer slings which minimized injury and stress. Most mortalities among adult broodstock (60%) were the result of management failures, fish jumping out, or fish being stranded when a standpipe came loose. Only one mortality was due to parasites and other mortalities were attributed to capture stress and injuries and usually occurred shortly after capture.

Table 9.—Growth and food conversion of dolphin, *Coryphaena hippurus*, 1970-71, adapted from Hassler and Hogarth (1977).

Initial weight (kg)	Number of days held	Final weight (kg)	Weight gain (kg)	Food fed (kg)	Food conversion
0.397	32	1.843	1.446	3.969	2.75
0.397	45	1.956	1.559	6.500	4.17
0.397	45	2.126	1.729	6.500	3.76
0.567	7	0.794	0.227	0.603	[1]2.68
Total for 1970			4.961	17.572	3.54
1.588	18	3.289	1.701	3.856	2.226
2.041	42	5.330	3.289	10.773	3.27
2.041	42	5.330	3.289	11.539	3.50
2.268	48	5.216	2.948	11.226	3.80
2.268	48	5.556	3.288	12.614	3.83
Total for 1971			14.515	50.008	3.44

[1]Authors' note: actual value should be 2.66.

Table 10.—Growth of dolphin, *Coryphaena hippurus*, 1972 (from Hassler and Hogarth 1977).

Sex	Initial weight (kg)	Number of days held	Final weight (kg)	Weight gain (kg)
Female	1.247	73	4.763	3.515
Female	1.021	67	3.402	2.381
Male	1.589	45	4.763	3.175
Female	1.247	45	4.649	3.402
Male	1.361	45	4.082	2.722
Male	0.907	38	2.893	1.987
Female	0.680	38	2.495	1.814
Male	0.794	34	3.175	[1]2.835
Female	0.454	34	1.134	0.680
Female	1.134	34	3.856	2.722
Female	1.021	34	3.629	2.608
Female	1.021	34	3.175	2.155
Female	0.680	34	2.495	1.814
Female	1.134	31	2.041	0.907
Female	0.680	22	2.495	1.814
Female	0.907	22	2.041	1.134
Female	0.680	22	1.415	0.735
Female	0.680	22	1.474	0.794
Female	0.680	22	2.041	1.361
Female	0.907	22	2.041	1.134
Female	0.680	22	2.041	1.361

[1]Authors' note: actual value should be 2.381.

In later experiments (Hagood et al. in press), growth rates of hatchery spawned and reared common dolphin averaged 1,303.5 g for the F_1 generation over a grow-out of 85 d and 1,144 g for the F_2 generation over a grow-out period of 65 d.

7.3 Spawning

Soichi (1978) collected 36 common dolphin 35-50 cm TL during September and October 1975 off the coast of Japan. They were kept in a large tank (17 m × 12 m × 3.5 m). The water temperature was controlled between 22.8° and 25.4°C. Eleven specimens survived to about 100 cm TL when spawning behavior was observed. Twenty spawnings occurred from 22 April to 13 July 1976, with spawning taking place at the water's surface by a pair of adults. Fertilized eggs hatched out about 60 h after fertilization at 24°-25°C. After 4 d, the larvae began to eat *Branchionus plicatilis*, but all died within 9 d after hatching.

Hagood and Rothwell (footnote 6) reported 13 spawnings of common dolphin from August to December 1979, and nine

pompano dolphin spawnings (Table 3). All spawnings occurred at night (approximately 0300). Five of the common dolphin spawnings occurred from four fish (two males and two females) and three of the fish were >70 cm FL; the fourth was a 45 cm FL female. The pompano dolphin (26.2 cm FL average) spawned in October and November and produced eggs with multiple oil globules. In December, however, three female pompano dolphin were placed in a tank with a male common dolphin and six spawnings occurred which produced fertilized eggs and hatched viable larvae.

Rearing

Hassler and Rainville (footnote 8) collected naturally spawned common dolphin eggs in plankton tows made off Miami, Fla., in March and April 1974 and off Hatteras, N.C., from May to September 1974. Larvae were reared in 38 liter and 76 liter all-glass aquaria in semistatic and subgravel filtered tanks. Water changes of 10%/d were done while the dolphin were still in the larval form. *Anacystis* sp. algae were also used to aid in water conditioning and removal of waste products. The rearing tanks were continuously aerated and illuminated. Larvae were initially fed wild zooplankton, and the size of the food organism was increased as the dolphin larvae increased in size. By the 25th day, they were being fed small mosquitofish, *Gambusia affinis holbrookii*. Temperatures ranged from 24° to 29°C and salinity was maintained at 35°/oo. The larvae were successfully reared for 83 d.

Hagood and Rothwell (footnote 6) reared common and pompano dolphin as well as a hybrid cross in Hawaii. Eggs were incubated in 400 liter cylindroconical rearing tanks with continuous water exchange (40 liters/h) and light aeration. Water temperatures were 26.5°-27.5°C, salinity 30-31°/oo, pH 8.1, and dissolved oxygen at 7.5-8.3 ppm. Larvae were initially fed rotifers, *Branchionus plicatilis*, cultured in static seawater, and fed dry yeast. Rotifers were introduced to larval tanks at 10-15/ml 24 h before larval feeding commenced. The diatom, *Chaetocerus*, was also added at a density of 40-100,000 cells/ml. The algae aided in maintaining water quality and also served as a food source for rotifers. *Artemia* nauplii were offered on day 9-10 at a density of 4-6/ml until day 20 when adult *Artemia* were used. Other foods offered were tubifer worms, copepods, mosquito larvae, and small mosquitofish. Partial water changes were done from day 10 until the end of the rearing trial. Biological filtration was also employed. Descriptions of embryonic development for common and pompano dolphins are shown in Tables 4 and 5.

Hagood et al. (in press) described grow-out experiments on F_1 and F_2 generations. Grow-out was conducted in circular pools varying in diameter from 4.5 to 14.0 m and in depth from 0.7 to 4.0 m. Grow-out of the F_1 generation took place between May and August and the F_2 generation between October and December.

LITERATURE CITED

ALI, M. A.
1976. Retinal pigments, structure and function and behaviour. Vis. R 16:1197-1198.

ALI, M. A., and M. ANCTIL.
1976. Retinas of fishes: An atlas. Springer-Verlag, N.Y., 284 p.

ALI, M. A., and W. R. HEUMANN.
1970. Distribution of vitamins A₁ and A₂ in the retinas of some mar fishes from the Gulf of California. Vis. Res. 10:1307-1310.

ANDERSON, W. W., and J. W. GEHRINGER.
1957. Physical oceanographic, biological, and chemical data, South Atlan coast of the United States, *Theodore N. Gill* Cruise 3. U.S. Dep. Int Fish Wildl. Serv., Spec. Sci. Rep. Fish. 210, 208 p.

ANDERSON, W. W., J. W. GEHRINGER, and E. COHEN.
1956a. Physical oceanographic, biological, and chemical data, So Atlantic coast of the United States. M/V *Theodore N. Gill* Cruise 1. U Dep. Inter., Fish Wildl. Serv., Spec. Sci. Rep. Fish. 178, 160 p.
1956b. Physical oceanographic, biological, and chemical data, South Atl tic coast of the United States, *Theodore N. Gill* Cruise 2. U.S. D Inter., Fish Wildl. Serv., Spec. Sci. Rep. Fish. 198, 270 p.

ARAI, H. P.
1962. Trematodos digeneos de peces marinos de Baja California, Mexi An. Inst. Biol., Univ. Nac. Mexico 33:113-130.

BANNISTER, J. V.
1972. Multiple forms of haemoglobin in the dolphin *Coryphaena h purus* (L.). Comp. Biochem. Physiol. 43B:29-31.
1976. The length-weight relationship, condition factor and gut contents the dolphin-fish *Coryphaena hippurus* (L.) in the Mediterranean. J. F Biol. 9:335-338.

BANNISTER, J. V., and A. ANASTASI.
1976. The effect of fructose 1,6-diphosphate on pyruvate kinase from wh muscle of three species of Mediterranean fish. Comp. Biochem. Phys 55B:449-451.

BANNISTER, J. V., and W. H. BANNISTER.
1976. Isolation and general characterization of myoglobin from the dolp fish *Coryphaena hippurus* L. Comp. Biochem. Physiol. 53B:57-60.

BANNISTER, J. V., W. H. BANNISTER, P. ASCENZI, A. FOCESI, and M. BRUNORI.
1976. Oxygen and carbon monoxide binding to myoglobin from the dolp fish *Coryphaena hippurus*. FEBS (Fed. Eur. Biochem. Soc.) Lett. 361-364.

BARNARD, K. H.
1927. A monograph of the marine fishes of South Africa. Ann. S. A Mus. Part II, 21:419-1065.

BARNHART, P. S.
1936. Marine fishes of Southern California. Univ. Calif. Press, Berkel 209 p.

BAUGHMAN, J. L.
1941. On a heavy run of dolphin, *Coryphaena hippurus*, off the Tex coast. Copeia 1941:117.

BEARDSLEY, G. L.
1964. Contribution to the biology of the dolphinfish, *Coryphaena h purus*, in the Straits of Florida. M.S. Thesis, Univ. Miami, Miam Fla., 79 p.
1967. Age, growth, and reproduction of the dolphin, *Coryphaena h purus*, in the Straits of Florida. Copeia 1967:441-451.
1971. Dolphin spectacular. Sea Front. 17:194-201.

BEEBE, W., and J. TEE-VAN.
1928. The fishes of Port-au-Prince Bay, Haiti. Zoologica (N.Y.) 10:1-279

BERRY, F. H., and H. C. PERKINS.
1966. Survey of pelagic fishes of the California current area. U.S. F Wildl. Serv., Fish. Bull. 65:625-682.

BIRMAN, I. B.
1965. Occurrence of *Corphaena hippurus* L. in the Okhotsk Sea. Russ.] Vopr. Ikhtiol. 36:557-558.

BONHAM, K.
  1946. Measurements of some pelagic commerical fishes of Hawaii. Copeia 1946:81-84.
BRIAN, A.
  1899. Di alcuni crostacei parassiti dei pesci dell' Isola d'Elba. Atti. Soc. Ligust. Sci. Nat. Geogr. 10:3-10.
  1903. Sui copepodi parassiti di pesci marini dell' Isola d'Elba, 4a Nota. Boll. Mus. Zool. Anat. Comp. R. Univ. Genova 121:1-8.
  1906. Copepodi parassiti dei pesci d'Italia. Genoa, Ital., 190 p.
  1908. Note preliminaire sur les copépodes parasites des poissons provenant des compagnes scientifiques de S.A.S. le Prince Albert Ier des Monaco ou déposés dans les collection due Musée Océanographique. Bull. Inst. Oceanogr. (Monaco) 110:1-19.
BRIGGS, J. C.
  1960. Fishes of worldwide (circumtropical) distribution. Copeia 1960: 171-180.
BURNETT-HERKES, J. N., Jr.
  1966. An ecological study of the parasite infesting the gills and buccal cavity of the dolphin-fish, Coryphaena hippurus Linnaeus, caught in the Miami area. M.S. Thesis, Univ. Miami, Miami, Fla., 162 p.
  1974. Parasites of the gills and buccal cavity of the dolphin, Coryphaena hippurus, from the Straits of Florida. Trans. Am. Fish. Soc. 103:101-106.
CABLE, R. M., and J. LINDEROTH.
  1963. Taxonomy of some Acanthocephala from marine fishes with reference to species from Curaçao, H.A., and Jamaica, W.I. J. Parasitol. 49:706-716.
CABO, D. F. L.
  1961. Biometria, biología, y pesca de la lampuga (Coryphaena hippurus L.) de las isla Baleares. Memorias de la Real Ácademia de Ciencias Exactas, Fisicas y Naturales de Madrid, Series de Ciencias Naturales - Tomo XXI, 93 p.
CADENAT, J.
  1950. Poissons de mer du Sénégal. Inst.-Fr. Afr. Noire, Initiations Africaines, III, 345 p.
CAPART, A.
  1959. Copépodes parasites. Result. Scient. Extéd. Océanogr. Belg. Eaux Côt. Afr. Atlant. Sud (1948-1949), 3:55-126.
CAUSEY, D.
  1960. Parasitic Copepoda from Mexican coastal fishes. Bull. Mar. Sci. Gulf Caribb. 10:323-337.
CLEMENS, H. B.
  1957. Fish collected in the tropical eastern Pacific, 1954. Calif. Fish Game 43:299-307.
COLLETTE, B. B.
  1978. Family Coryphaenidae. In W. Fischer (editor), FAO species identification sheets for fishery purposes. Western Central Atlantic (Fishing area 31), Vol. II, unpaginated. FAO, Rome.
COLLETTE, B. B., R. H. GIBBS, and G. E. CLIPPER.
  1969. Vertebral numbers and identification of the two species of dolphin (Coryphaena). Copeia 1969:630-631.
CUVIER, G., and A. VALENCIENNES.
  1833. Histoire naturelle des poissons, Vol. 9, 512 p. F. G. Levrault, Paris.
DELAMARE-DEBOUTTEVILLE, C., and L. NUNES-RUIVO.
  1958. Copépodes parasites des poissons Méditerranéens. Vie Milieu 9:215-235.
DERANIYAGALA, P. E. P.
  1952. A colored atlas of some vertebrates from Ceylon. Vol. I—Fishes. Ceylon. Gov. Press, 149 p.
  1956. Zoological collecting at the Maldives in 1932. Spolia Zeylan. 28:5-15.
DEVI, P. R.
  1975. Pseudophyllidean cestodes Bothriocephalidae from marine fishes of Waltair coast, Bay of Bengal, India. Riv. Parassitol. 36:279-286.
DOLLFUSS, R. P.
  1927. Sur une métacercaire progénétique d'Hemiuridae. Bull. Biol. Fr.-Belg. 61:49-58.
DOOLEY, J. K.
  1972. Fishes associated with the pelagic sargassum complex, with a discussion of the sargassum community. Contrib. Mar. Sci. 16:1-32.
DRAGOVICH, A., and T. POTTHOFF.
  1972. Comparative study of food of skipjack and yellowfin tunas off the coast of West Africa. Fish. Bull., U.S. 70:1087-1110.
ERDMAN, D. S.
  1956. Recent fish records from Puerto Rico. Bull. Mar. Sci. Gulf Caribb. 6:315-349.

FAHAY, M. P.
  1975. An annoted [sic] list of larval and juvenile fishes captured with surface-towed meter net in the South Atlantic Bight during four RV Dolphin cruises between May 1967 and February 1968. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-685, 39 p.
FARRINGTON, S. K., Jr.
  1949. Fishing the Atlantic offshore and on. Coward-McCann, Inc., N.Y., 312 p.
FISCHTHAL, J. H.
  1972. Zoogeography of digenetic trematodes from West African marine fishes. Proc. Helminthol. Soc. Wash. 39:192-203.
FISCHTHAL, J. H., and J. D. THOMAS.
  1972a. Additional hemiurid and other trematodes from fishes of Ghana. Bull. Inst. Fond. Afrique Noire, Ser. A, 34:9-25.
  1972b. Digenetic trematodes of marine fishes from Senegal. Bull. Inst. Fond. Afrique Noire, Ser. A, 34:292-322.
FLORIDA SPORTSMAN.
  1979. In the wake. Fla. Sportsman, June, p. 123.
FOWLER, H. W.
  1906. New, rare or little known scombroids, No. 3. Proc. Acad. Nat. Sci. Phila. 58:114-122.
GALEA, J. A.
  1961. The "Kannizzati" fishery. Proc. Gen. Fish. Counc. Mediterr. Tech. Pap. 6:85-91.
GALLOTTI, A. M.
  1972-73. Osservazioni intorno ad alcuni pesci ossei del mar rosso. Ann. Mus. Civ. Stor. Nat. 'Giacomo Doria' 79:27-31.
GENTLE, E. C., III.
  1977. The charterboat sport fishery of Dade County, Florida, March 1976 to February 1977. M.S. Thesis, Univ. Miami, Miami, Fla., 162 p.
GIBBS, R. H., Jr., and B. B. COLLETTE.
  1959. On the identification, distribution, and biology of the dolphins Coryphaena hippurus and C. equiselis. Bull. Mar. Sci. Gulf Caribb. 9:117-152.
GOODE, G. B.
  1884. The fisheries and fishery industry of the United States. Section 1. Natural history of useful aquatic animals with an atlas of two hundred and seventy-seven plates. U.S. Comm. Fish Fish., Wash., D.C., 895 p.
GOODING, R. M., and J. J. MAGNUSON.
  1967. Ecological significance of a drifting object to pelagic fishes. Pac. Sci. 21:486-497.
GORBUNOVA, N. N.
  1969. Breeding grounds and food of the larvae of the swordfish [Xiphias gladius Linne (Pisces, Xiphiidae)]. In Russ.] Vopr. Ikhtiol. 9:474-488. (Transl. in Prob. Ichthyol. 9:375-387.)
GOSLINE, W. A., and V. E. BROCK.
  1960. Handbook of Hawaiian fishes. Univ. Hawaii Press, Honolulu, 372 p.
GREER, J. K.
  1976. Activities of blue dolphins in the Atlantic Ocean. Tex. J. Sci. 27:245.
GREGORY, W. K.
  1933. Fish skulls. A study of the evolution of natural mechanisms. Trans. Am. Philos. Soc. 23:75-481.
GUIART, J.
  1935. Résultats des campagnes scientifiques accumplies sur son yacht par Albert Ier prime souverain de Monaco. Cestodes Parasites 91:3-115.
HAGOOD, R. W., G. N. ROTHWELL, M. SWAFFORD, and M. TOSAKI.
  In press. Preliminary report on the aquacultural development of the dolphin fish, Coryphaena hippurus (Linneaus). Proc. World Maricult. Soc.
HASSLER, W. W., and W. T. HOGARTH.
  1977. The growth and culture of dolphin, Coryphaena hippurus, in North Carolina. Aquaculture 12:115-122.
HEEGAARD, P.
  1949. Notes on parasitic copepods. Vidensk. Medd. Dan. Naturhist. Foren. Kbn. 111:235-245.
HELLER, C.
  1865. Crestaceen. Reise der Österreichischen Fregatte Novara um die Erde in den Jahren 1857, 1858, 1859. Zool. Theil. 2, 280 p.
HERALD, E. S.
  1961. Living fishes of the world. Doubleday and Co., Inc., Garden City, N.Y., 304 p.
HERRE, A. W. C.
  1945. Additions to the fish fauna of the Philippine Islands. Copeia 1945:146-149.

HEYERDAHL, T.
1950. Kon-Tiki: Across the Pacific by raft. Rand McNally and Co., Chicago, 304 p.

HIDA, T. S.
1973. Food of tunas and dolphins (Pisces: Scombridae and Coryphaenidae) with emphasis on the distribution and biology of their prey *Stolephorus buccaneeri* (Engraulidae). Fish. Bull., U.S. 71:135-143.

HILDEBRAND, S. F.
1934. On the occurrence of the dolphin fish, *Coryphaena hippurus* Linneaus, in Panama Bay. Copeia 1934:192.

HILGENDORF, F.
1888. Zur kenntniss der Azorenfauna. II. Die Fische der Azoren. Arch. Naturgesch. 54:205-213.

HINTON, S.
1962. Longevity of fishes in captivity, as of September, 1956. Zoologica (N.Y.) 47:105-116.

HO, J.-S.
1963. On five species of Formosan parasitic copepods belonging to the suborder Caligoida. Crustaceana 5:81-98.

HOCHACHKA, P. W.
1974. Temperature and pressure adaptation of the binding site of acetylcholinesterase. Biochem. J. 143:535-539.

HOCHACHKA, P. W., K. B. STOREY, and J. BALDWIN.
1975. Design of acetylcholinesterase for its physical environment. Comp. Biochem. Physiol. 52B:13-18.

HUGHES, G. M.
1970. Morphological measurements on the gills of fishes in relation to their respiratory function. Folia Morphol. (Prague) 18:78-95.

HUNTER, J. R., and C. T. MITCHELL.
1967. Association of fishes with flotsam in the offshore waters of Central America. U.S. Fish Wildl. Serv., Fish. Bull. 66:13-29.

HUTTON, R. F.
1964. A second list of parasites from marine and coastal waters of Florida. Trans. Am. Microsc. Soc. 83:439-447.

JENSEN, A. C.
1967. Observations on pelagic fishes off the west coast of Africa. Bull. Mar. Sci. 17:42-51.

JOHNSON, G. D.
1978. Development of fishes of the Mid-Atlantic Bight. An atlas of egg, larval, and juvenile stages. Vol. IV Carangidae through Ephippidae. U.S. Dep. Inter., Fish Wildl. Serv., Biol. Serv. Prog. FWS/OBS-78/12, Jan. 1978:123-128.

JONES, E. C.
1971. *Isistius brasiliensis*, a squaloid shark, the probable cause of crater wounds on fishes and cetaceans. Fish. Bull., U.S. 69:791-798.

JORDAN, D. S., and W. F. THOMPSON.
1914. Record of the fishes obtained in Japan in 1911. Mem. Carnegie Mus. 6:205-313.

KABATA, Z., and A. V. GUSEV.
1966. Parasitic copepoda of fishes from the collection of the Zoological Institute in Leningrad. J. Linn. Soc. Lond. Zool. 46:155-207.

KAMEGAI, S.
1963. Studies on Acanthocephala (9). On some Acanthocephala found in marine fishes. Meguro Kiseichu Kan Geppo 55/56:6-10.

KOJIMA, S.
1955. Studies of dolphin fishing conditions in the western Sea of Japan.—I. [In Jpn.] Bull. Jpn. Soc. Sci. Fish 20:1044-1049. (Transl. W. G. Van Campen, Bur. Comm. Fish. Biol. Lab., Honolulu, Hawaii, 1962.)
1956. Studies of dolphin fishing conditions in the western Sea of Japan—II. "Tsuke" rafts and their attraction for the fish. [In Jpn.] Bull. Jpn. Soc. Sci. Fish. 21:1049-1052. (Transl. W. G. Van Campen, Bur. Comm. Fish. Biol. Lab., Honolulu, Hawaii, 1962.)
1960a. Studies of dolphin fishing conditions in the western Sea of Japan—V. On the species of fish attracted to "Tsuke" rafts. [In Jpn.] Bull. Jpn. Soc. Sci. Fish. 26:379-382. (Transl. W. G. Van Campen, Bur. Comm. Fish. Biol. Lab., Honolulu, Hawaii, 1962.)
1960b. Studies of dolphin fishing conditions in the western Sea of Japan—VI. On the ecology of the groups of fish congregating around "Tsuke" rafts. [In Jpn.] Bull. Jpn. Soc. Sci. Fish. 26:383-388. (Transl. W. G. Van Campen, Bur. Comm. Fish. Biol. Lab., Honolulu, Hawaii, 1962.)
1961. Studies of dolphin fishing conditions in the western Sea of Japan—III. On the stonach contents of dolphins. [In Jpn.] Bull. Jpn. Soc. Sci. Fish. 27:625-629. (Transl. W. G. Van Campen, Bur. Comm. Fish. Biol. Lab., Honolulu, Hawaii, 1963.)
1963a. Studies on fishing conditions of the dolphin, *Coryphaena hippurus* L., in the western region of the Sea of Japan—VII. Relationship between the stomach contents and the pelagic fauna of juveniles. [In Jpn., Engl. abstr.] Bull. Jpn. Soc. Sci. Fish. 29:407-414.
1963b. Studies on fishing conditions of the dolphin, *Coryphaena hippurus* L., in the western region of the Japan Sea—VIII. Comparison of juvenile fish fauna in the sea and in the stomachs of dolphin. [In Jpn., Engl. abstr.] Bull. Jpn. Soc. Sci. Fish. 29:507-513.
1964a. On the distribution of the dolphin, *Coryphaena hippurus* L., in the Pacific Ocean and the Indian Ocean. [In Jpn., Engl. abstr.] Bull. Jpn. Soc. Sci. Fish. 30:472-477.
1964b. Studies on fishing conditions of the dolphin, *Coryphaena hippurus* L., in the western regions of the Sea of Japan—IX. Quantitative analysis on stomach contents. [In Jpn., Engl. abstr.] Bull. Jpn. Soc. Sci. Fish. 30:619-623.
1965. Studies on fishing conditions of the dolphin, *Coryphaena hippurus* L., in the western regions of the Sea of Japan—X. Results on tagging experiment. [In Jpn., Engl. abstr.] Bull. Jpn. Soc. Sci. Fish. 31:573-578.
1966a. Studies on fishing conditions of the dolphin, *Coryphaena hippurus*, in the western regions of the Sea of Japan—XI. Schools of dolphins accompanying various kinds of flotages. [In Jpn., Engl. abstr.] Bull. Jpn. Soc. Sci. Fish. 32:647-651.
1966b. Studies on fishing conditions of the dolphin, *Coryphaena hippurus*, in the western regions of the Sea of Japan—XII. The size of a dolphin school. [In Jpn., Engl. abstr.] Bull. Jpn. Soc. Sci. Fish. 32:652-654.
1966c. Fishery biology of the common dolphin, *Coryphaena hippurus* L., inhabiting the Pacific Ocean. [In Jpn., Engl. Summ.] Bull. Shimane Prefectural Fish. Exp. Stn. No. 1, 108 p.
1967. Studies on fishing conditions of the dolphin, *Coryphaena hippurus* L., in the western regions of the Sea of Japan—XIII. 'Tsukegi' as a source of food for dolphins. [In-Jpn., Engl. abstr.] Bull. Jpn. Soc. Sci. Fish. 33:320-324.

KU, C.-T., and C.-W. SHEN.
1968. A study of the sub-family Dinurinae of family Hemiuridae. Comm. Chinese S. Abstr. 2:leaf 97. (Transl. Abstr. Rep. 30 Anniv. Sc. Conf. China Zool. Soc., Dec. 1965) June 20.

LA MONTE, F.
1952. Marine game fishes of the world. Doubleday & Co., Inc., Garden City, N.Y., 190 p.

LEWIS, A. G.
1967. Copepod crustaceans parasitic on teleost fishes of the Hawaiian Islands. Proc. U.S. Natl. Mus. 121 (3574), 204 p.

LEWIS, A. G., J. DEAN, and E. GILFILLAN III.
1969. Taxonomy and host associations of some parasitic copepods (Crustacea) from pelagic teleost fishes. Pac. Sci. 23:414-437.

LINNAEUS, C.
1758. Systema naturae. Regnum animale, 10th ed. Photographic facsimile printed by Br. Mus. Nat. Hist. 1956, 824 p.

LINTON, E.
1905. Parasites of fishes of Beaufort, North Carolina. Bull. U.S. Bur. Fish. 24:321-428.

LIPSKAYA, N. Ya.
1974. Metabolic rates in the young of some tropical fish species. [In Russ.] Vopr. Ikhtiol. 94:1976-1086. Transl. in J. Ichthyol. 14:934-943.

LOWE, R. T.
1839. "A supplement to a synopsis of the fishes of Madeira." Proc. Zool. Soc. Lond. 7:76-92.
1849. Supplement to "A synopsis of the fishes of Madeira." Trans. Zool. Soc. Lond. 3:1-20.

MAGNUSON, J. J., and J. G. HEITZ.
1971. Gill raker apparatus and food selectivity among mackerels, tunas, and dolphins. Fish. Bull., U.S. 69:361-370.

MANTER, H. W.
1947. The digenetic trematodes of marine fishes of Tortugas, Florida. Am. Midl. Nat. 38:257-416.

MARKOWSKI, S.
1971. On some species of parasitic worms in the 'Discovery' collections obtained in the years 1925-1936. Bull. Br. Mus. (Nat. Hist.) Zool. 21:53-65.

MATHER, F. J., III.
1954. Northerly occurrences of warm water fishes in the western Atlantic. Copeia 1954:292-293.

MATHER, F. J., III, and C. G. DAY.
1954. Observations of pelagic fishes of the tropical Atlantic. Copeia 1954:179-188.

MATSUNO, T., and M. KATSUYAMA.
1976. Comparative biochemical studies of carotenoids in fishes-IX. On the nineteen species of fishes in the division Percichthyes. [In Jpn. Engl. abstr.] Bull. Jpn. Soc. Sci. Fish. 42:645-649.

MATTHEWS, F. D., D. M. DAMKAER, L. W. KNAPP, and B. B. COL-
LETTE.
1977. Food of western North Atlantic tunas (*Thunnus*) and lancetfishes
(*Alepisaurus*). U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-706,
19 p.
MEEK, S. E., and S. F. HILDEBRAND.
1925. The marine fishes of Panama, Part II. Field Mus. Nat. Hist.,
Publ. No. 226, Zool. Ser. 15:331-707.
MIGDALSKI, E. C.
1958. Angler's guide to the salt water game fishes Atlantic and Pacific.
The Ronald Press Co., N.Y., 506 p.
MILNE-EDWARDS, H.
1840. Histoire naturelle des crustaces, comprenent l'anatomie, la physiologie
et la classification de ces animaux. Crustaces Vol. 3, 638 p.
MITO, S.
1960. Egg development and hatched larvae of the common dolphin-fish
Coryphaena hippurus Linné. Bull. Jpn. Soc. Sci. Fish. 26:223-226.
MORROW, J. E.
1954. Data on dolphin, yellowfin tuna, and little tuna from East Africa.
Copeia 1954:14-16.
MUNZ, F. W., and W. N. McFARLAND.
1975. Part I: Presumptive cone pigments extracted from tropical marine
fishes. Vis. Res. 15:1045-1062.
MURAT, M.
1933. Sur la capture d'une coryphene (*Coryphaena hippurus* L.) dans la
Baie de Castiglione. Bull. Trav. Stn. Agric. Pêche, Castiglione 1933:
59-71.
MURPHY, R. C.
1914. Notes on pelagic fishes. Copeia 6:1-2.
MYERS, B. J., and R. E. KUNTZ.
1962. Nematode parasites from vertebrates taken on Lan Yü, Formosa. II.
Nematodes from fish, amphibians, reptiles, birds. Can. J. Zool. 40:
135-136.
NAHHAS, F. M., and R. M. CABLE.
1964. Digenetic and aspidogastrid trematodes from marine fishes of Curaçao
and Jamaica. Tulane Stud. Zool. 11:168-228.
NICHOLS, J. T.
1909. A note on the dolphins (*Coryphaena equisetis* and *Coryphaena
hippurus*). Bull. Am. Mus. Nat. Hist. 26:131-133.
NIKOLAEVA, V. M.
1965. On the developmental cycle of trematodes belonging to the family
Didymozoidae (Monticelli, 1888) Poche, 1907. [In Russ., Engl. summ.]
Zool. Zh. 44:1317-1327.
OKADA, Y.
1955. Fishes of Japan. Maruzen Co., Ltd., Tokyo, 462 p.
OSBECK, P.
1757. Reise nach Ostindien und China (1765, German transl. from
Swedish by J. G. Georgi). Rostock, 522 p. [Orig. ed. (Swedish) 1757,
Engl. transl. 1771.]
OVCHAROV, O. P.
1970. Hydrodynamic role of the branchial system in fishes under the
passive way of respiration. [In Russ., Engl. summ.] Zool. Zh.
49:1583-1585.
PALLAS, P. S.
1770. Spicilegia Zoologica 1(8):1-54, Berlin.
PEARSE, A. S.
1952. Parasitic Crustacea from the Texas coast. Publ. Inst. Mar. Sci.,
Univ. Tex. 2(2):5-42.
PENRITH, M. J.
1963. The systematics and biology of the South African tunas. M.S.
Thesis, Univ. Cape Town, Cape Town, Union, S. Afr., 216 p.
PEW, P.
1957. Occurrence of young dolphin, *Coryphaena hippurus*, in a Texas
bay. Copeia 1957:300.
PILLAI, N. K.
1964. A miscellaneous collection of copepods parasitic on South Indian
fishes. J. Mar. Biol. Assoc. India 6:61-83.
POTTHOFF, T.
1971. Observations on two species of dolphin (*Coryphaena*) from the
tropical mid-Atlantic. Fish. Bull., U.S. 69:877-879.
1978. Development and structure of the fins and fin supports in the two
dolphin fishes *Coryphaena hippurus* and *C. equiselis* (Pisces, Cory-
phaenidae). M.S. Thesis, Univ. Miami, Miami, Fla., 120 p.
1980. Development and structure of the fins and the fin supports in the dol-
phin fishes *Coryphaena hippurus* and *Coryphaena equiselis* (Coryphaenidae).
Fish. Bull., U.S. 78:277-312.

QUIZNARD, J. P.
1973. FAO species identification sheet for fishery purposes, Mediterranean
and Black Sea, Fishing Area 31. Vol. 1, unpaginated. FAO Rome.
RAFINESQUE, C. S.
1810. Caratteri di alcuni nuovi generi e nuove specie di animali (princi-
palmente di pesci) e piante della Sicilia con varie osservazioni sopra i
medisimi. Palermo, 105 p. (Reprint, 1967, Asher-Amsterdam.)
RIBEIRO, A. de M.
1918. Fauna Brasiliense (Peixes). Tomo V Eleutherobranchios Aspiro-
phoros. Physoclisti. Archiv. Mus. Nac. Rio de Janeiro 21, 227 p.
RICHIARDI, S.
1880. Contribuzione alla fauna d'Italia I, Catalogo systematico di crostacei
che Vivono sul corpo di animali acquatici. Catalogo degli Espositioni e
delle cosa Esposte, Esozitione Internazionale di Pesca in Berlino, p. 147-
152.
ROIG, M. A., and F. G. de la MAZA.
1952. La pesca en Cuba. Minist. Agri. Rep. Cuba, La Habana, 272 p.
RONQUILLO, I. A.
1953. Food habits of tunas and dolphins based upon the examination of
their stomach contents. Philipp. J. Fish. 2:71-83.
ROSE, C. D.
1966. The biology and catch distribution of the dolphin, *Coryphaena
hippurus* (Linnaeus), in North Carolina waters. Ph.D. Thesis, North
Carolina State Univ. at Raleigh, 153 p.
ROSE, C. D., and W. W. HASSLER.
1968a. Age and growth of the dolphin, *Coryphaena hippurus* (Linnaeus),
in North Carolina Waters. Trans. Am. Fish. Soc. 97:271-276.
1968b. Occurrence of the pompano dolphin, *Coryphaena equiselis* (Lin-
naeus), in North Carolina waters. J. Elisha Mitchell Sci. Soc. 84:350.
1969. Application of survey techniques to the dolphin, *Coryphaena
hippurus*, fishery of North Carolina. Trans. Am. Fish. Soc. 98:94-103.
1974. Food habits and sex ratios of dolphin *Coryphaena hippurus* captured
in the western Atlantic Ocean off Hatteras, North Carolina. Trans. Am.
Fish. Soc. 103:94-100.
ROTHSCHILD, B. J.
1964. Observations on dolphins (*Coryphaena* spp.) in the Central Pacific
Ocean. Copeia 1964:445-447.
RYBOVICH, J.
1965. Sportfishermen (boat). *In* A. J. McClane (editor), McClane's
Standard Fishing Encyclopedia, p. 851-862. Holt, Rinehart, and Winston,
N.Y.
SAKAGUCHI, Y., and D. KATAMINE.
1971. Survey of Anisakid larvae in marine fishes caught from the east
China Sea and the south China Sea. Nettai Igaku (Trop. Med.)
13:159-169.
SCHUCK, H. A.
1951a. Notes on the dolphin (*Coryphaena hippurus*) in North Carolina
waters. Copeia 1951:35-39.
1951b. New Gulf of Maine record for occurrence of dolphin, *Coryphaena
hippurus*, and data on small specimens. Copeia 1951:171.
SHCHERBACHEV, YU. N.
1973. The biology and distribution of the dolphins (Pisces, Coryphaenidae).
[In Russ.] Vopr. Ikhtiol. 13:219-230. Transl. in J. Ichthyol. 13:182-191.
SHIINO, S. M.
1954a. Copepods parasitic on Japanese fishes. 4. The family Euryphoridae.
[In Engl.] Rep. Fac. Fish. Prefect. Univ. Mie 1:273-290.
1954b. Note on *Caligus quadratus* n. sp., a copepod parasitic on the fish,
Neothynnus macropterus (T. & S.) Bull. Jpn. Soc. Sci. Fish. 20:26-29.
1958. Parasitic copepods from fishes collected in Indian Ocean. [In Engl.]
Annu. Rep. Pref. Univ. Mie 2:98-113.
1959a. Ostpazifische parasitierende Copepoden. [In Ger.] Rep. Fac.
Fish. Pref. Univ. Mie 3:267-333.
1959b. Revision der auf goldmakrele, *Coryphaena hippurus* L., schmarot-
zenden caligidenarten. [In Ger.] Annu. Rep. Pref. Univ. Mie 3:1-34.
1959c. Sammlung der parasitischen Copepoden in der Präfekturuniversität
von Mie. [In Ger.] Rep. Fac. Fish. Pref. Univ. Mie 3:334-374.
1960. Copepods parasitic on the fishes collected on the coast of Province
Shima, Japan. [In Engl.] Rep. Fac. Fish. Pref. Univ. Mie 3:471-500.
1963. Parasitic copepods of the Eastern Pacific fishes. 1. Records of the
known species. [In Engl.] Rep. Fac. Fish. Pref. Univ. Mie 4:335-
347.
SIDDIQI, A. H., and R. M. CABLE.
1960. Digenetic trematodes of marine fishes of Puerto Rico. Sci. Surv.
Puerto Rico and Virgin Islands 17:257-369.

SILAS, E. G.
  1967. Parasites of scombroid fishes. Part I. Monogenetic trematodes, digenetic trematodes, and cestodes. Proc. Symp. Scombroid Fishes, Part 3, Mar. Biol. Assoc. India, Symp. Ser. 1:799-875.

SILAS, E. G., and A. N. P. UMMERKUTTY.
  1967. Parasites of scombroid fishes. Part II. Parasitic Copepoda. Proc. Symp. Scombroid Fishes, Part 3. Mar. Biol. Assoc. India, Symp. Ser. 1:876-993.

SMIRNOV, V. S., and I. N. BRUSYNINA.
  1973. Relationship between body weight and brain weight in fishes. [In Russ.] Sjecah 3:195-294 (1972). (Transl. in Soviet J. Ecol. 3:209-214.)

SOGANDARES-BERNAL, F.
  1959. Digenetic trematodes of marine fishes from the Gulf of Panama and Bimini, British West Indies. Tulane Stud. Zool. 7:69-117.

SOICHI, M.
  1978. Spawning behavior of the dolphin, *Coryphaena hippurus*, in the aquarium and its eggs and larvae. [In Jpn., Engl. summ.] Jpn. J. Ichthyol. 24:290-294.

SPARKS, A. K.
  1958. Some digenetic trematodes of fishes of Grand Isle, Louisiana. Proc. La. Acad. Sci. 20:71-82.
  1960. Some aspects of the zoogeography of the digenetic trematodes of shallow-water fishes of the Gulf of Mexico. Lib. Hom. E. Caballero y C. (Mexico):285-298.

SPIX, J. B., and L. AGASSIZ.
  1829. Selecta genera et species piscium quos in itinere per Brasiliam annis 1817-20. Monachii, 138 p.

SPRINGER, S., and H. R. BULLIS, Jr.
  1956. Collections by the *Oregon* in the Gulf of Mexico. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 196, 134 p.

SPRINGER, V. G., and J. PIRSON.
  1958. Fluctuations in the relative abundance of sport fishes as indicated by the catch at Port Aransas, Texas, 1952-1956. Publ. Inst. Mar. Sci. Univ. Tex. 5:169-185.

SPROSTON, N. G.
  1946. A symposia of the monogenetic trematodes. Trans. Zool. Soc. Lond. 25:185-600.

STEENSTRUP, J. J., and C. F. LÜTKEN.
  1861. Bidrag til kundskab om det aabne havs snyltekribs og hernaur samtom nogle andre nye eller hidtil kum ufuldstaedigt kjendte parasitiske Copepoder. Vid. Selsk. Skrft-Ser. 5 Natuur. Math. Afd. 5:343-432.

STEINDACHNER, F.
  1868. Ichthyologischer Bericht über eine nach Spanien und Portugal unternommene Reise. Sitzungsber. Kaiserlichen Akad. Wissensch. 57: 351-424.

SUND, P. N., and H. GIRIGORIE.
  1966. Dolphin impaled on marlin's bill. Sea Front. 12:326.

SUYEHIRO, Y.
  1942. A study on the digestive system and feeding habits of fish. Jpn. J. Zool. 10:1-303.

SUZUKI, K., H. KISHIMOTO, and Y. TANAKA.
  1973. Head deformity in tunas kept in the aquarium. [In Jpn., Engl. summ.] Jpn. J. Ichthyol. 20:113-119.

TAKAHASHI, M., and K. MORI.
  1973. Studies on relative growth in body parts compared in *Coryphaena hippurus* and *C. equiselis*, and notes on gonadal maturation in the latter species. [In Jpn., Engl. summ.] Bull. Far Seas Fish. Res. Lab. 8:79-113.

TESTER, A. L., and E. L. NAKAMURA.
  1957. Catch rate, size, sex, and food of tunas and other pelagic fishes taken by trolling off Oahu, Hawaii, 1951-55. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. 250, 25 p.

TIBBO, S. N.
  1962. New records for occurrence of the white-tip shark, *Pterolamiop longimanus* (Poey), and the dolphin, *Coryphaena hippurus* L., in th northwest Atlantic. J. Fish. Res. Board Can. 19:517-518.

UCHIDA, K., and Y. SHOJIMA.
  1958. Studies of drifting sea weed: Larval and juvenile fishes accompanyin drifting sea weed—I. Investigations in the vicinity of Tsuyazaki in Fisca Year 1957. [In Jpn.] Bull. Jpn. Soc. Sci. Fish. 24:411-415. (Transl. W G. Van Campen, Bur. Comm. Fish. Biol. Lab., Honolulu, Hawaii, 1962.)

VLADYKOV, V. D., and R. A. McKENZIE.
  1935. The marine fishes of Nova Scotia. Proc. Nova Scotian Inst Sci. 19:17-113.

WANG, C.-H.
  1979. A study of population dynamics of dolphin fish (*Coryphaen hippurus*) in waters adjacent to eastern Taiwan. [In Taiwanese, Eng abstr.] Acta Oceanogr. Taiwan. 10:233-251.

WHEELER, J. F. G., and F. D. OMMANNEY.
  1953. Report on the Mauritus-Seychelles fisheries survey, 1948/49. Color Off. Fish. Publ. 1(3) Pt. 1:1-57.

WILLIAMS, F.
  1953. Catches of *Coryphaena hippurus* (L.) in the western India Ocean. Nature (Lond.) 171:703-704.
  1956. A report on a preliminary survey of the pelagic fishes of Ea Africa. Colon. Off. Fish. Publ. 8, 68 p.

WILLIAMS, F., and B. S. NEWELL.
  1957. Notes on the biology of the dorade or dolphin-fish (*Coryphaen hippurus*) in East African waters. E. Afr. Agric. J. 1957:113-118.

WILSON, C. B.
  1905. North American parasitic copepods belonging to the family Caligida Pt. I.—The Caliginae. Proc. U.S. Natl. Mus. 28:479-672.
  1932. The copepods of the Woods Hole region, Massachusetts. Bul U.S. Natl. Mus. 158, 635 p.
  1936. Parasitic copepods from the Dry Tortugas. Carnegie Inst. Wash Publ. 452:329-347.
  1937. Some parasitic copepods from Panama Bay. J. Wash. Acad. Sci 27:423-431.

WOODS, L. P., and R. H. KANAZAWA.
  1951. New species and new records of fishes from Bermuda. Field iana Zool. 31:629-644.

YAMAGUTI, S.
  1934. Studies on helminth fauna of Japan. Part 4. Cestodes of fishes Jpn. J. Zool. 6:1-112.
  1936. Parasitic copepods from fishes of Japan. Pt. 2. Caligoida, I Publ. by author, Japan, 22 p.
  1938. Parasitic copepods from fishes of Japan. 3. Caligoida. II. Publ by author, Tokyo, 21 p.
  1953. Systema helminthum. Part I. Digenetic trematodes of fishes. Publ by author, Tokyo, 405 p.
  1958. Systema helminthum. Vol. 1. The digenetic trematodes of vertebrate —Part I. Intersci. Publ., Inc., N.Y., 979 p.
  1963. Parasitic Copepoda and Branchiura of fishes. Intersci. Publ., Inc. N.Y., 1104 p.
  1970. Digenetic trematodes of Hawaiian fishes. Keigaku Publ. Co. Tokyo, 436 p.

YATES, F.
  1934. Contingency tables involving small numbers and the χ^2 test. J. R Stat. Soc. Lond. Suppl. 1:217-235.

FISHERIES SYNOPSES

This series of documents, issued by FAO, CSIRO, INP, and NMFS, contains comprehensive reviews of present knowledge on species and stocks of aquatic organisms of present or potential economic interest. The Fishery Resources and Environment Division of FAO is responsible for the overall coordination of the series. The primary purpose of this series is to make existing information readily available to fishery scientists according to a standard pattern, and by so doing also to draw attention to gaps in knowledge. It is hoped that synopses in this series will be useful to other scientists initiating investigations of the species concerned or of related ones, as a means of exchange of knowledge among those already working on the species, and as the basis for comparative study of fisheries resources. They will be brought up to date from time to time as further information becomes available.

The documents of this series are issued under the following titles:

		Symbol
FAO	Fisheries Synopsis No.	FIR/S
CSIRO	Fisheries Synopsis No.	DFO/S
INP	Sinopsis sobre la Pesca No.	INP/S
NMFS	Fisheries Synopsis No.	NMFS/S

Synopses in this series are compiled according to a standard outline described in Fib/S1 Rev. 1 (1965). FAO, CSIRO, INP, and NMFS are working to secure the cooperation of other organizations and of individual scientists in drafting synopses on species about which they have knowledge, and welcome offers of help in this task. Additions and corrections to synopses already issued will also be most welcome. Comments on individual synopses and requests for information should be addressed to the coordinators and editors of the issuing organizations, and suggestions regarding the expansion or modification of the outline to FAO:

FAO:

Fishery Resources and Environment Division
Aquatic Resources Survey and Evaluation Service
Food and Agriculture Organization of the United Nations
Via delle Terme di Caracalla
00100 Rome, Italy

INP:

Instituto Nacional de Pesca
Subsecretaria de Pesca
Secretaria de Pesca
Secretaria de Industria y Comercio
Carmona Y Valle 101-403
Mexico 7, D.F.

CSIRO:

CSIRO Division of Fisheries and Oceanography
Box 21
Cronulla, N.S.W. 2230
Australia

NMFS:

Scientific Editor
Northeast Fisheries Center Sandy Hook Laboratory
National Marine Fisheries Service, NOAA
Highlands, NJ 07732
U.S.A.

Consolidated lists of species or groups covered by synopses issued to date or in preparation will be issued from time to time. Requests for copies of synopses should be addressed to the issuing organization; except for NMFS/S copies, these can be purchased from National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22151.

The following synopses in this series have been issued since January 1980:

NMFS/S 118	Synopsis of biological data on bonitos of the genus *Sarda*	May 1980
NMFS/S 121	Synopsis of biological data on striped bass, *Morone saxatilis* (Walbaum)	June 1980
NMFS/S 124	Synopsis of biological data on frigate tuna, *Auxis thazard*, and bullet tuna, *A. rochei*	January 1981
NMFS/S 127	Synopsis of the biology of the swordfish, *Xiphias gladius* Linnaeus	November 1981