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IN MEMORIAM

John J. Mahoney

John J. Mahoney, Field Agent, Wildlife Conservation Board, passed away Friday, June 25, 1965.

Mr. Mahoney joined the Department of Fish and Game as a Junior Aquatic Biologist in the Inland Fisheries Branch immediately after receiving his B.S. degree from Oregon State College in June of 1955. He did an outstanding job from the outset, applying himself industriously to the many, diverse tasks assigned to him in the central office.

He was promoted to Fisheries Manager II on August 30, 1957, at which time he was assigned to the Water Projects Branch. He also worked in the Marine Resources Branch, during which time he was promoted to Fishery Biologist III. His duties in Marine Resources included coordinating the fish screen and ladder program as well as the salmon inventory program in the Central Valley streams. Since July 1, 1961, he had been employed as Field Agent with the Wildlife Conservation Board.

His work with the Wildlife Conservation Board carried considerable responsibility. John's wide knowledge and outstanding ability to carry out his responsibilities were instrumental in developing many of the WCB projects now under way or completed and in use by the public.

All of us extend our most sincere sympathies to his wife Helen and his two children.

R. J. Nesbit, Wildlife Conservation Board,
Department of Fish and Game

Calif. Fish and Game, 51 (4) : 229–247. 1965.

SYSTEMATICS AND ZOOGEOGRAPHY OF *MYRIPRISTIS* IN THE EASTERN TROPICAL PACIFIC [1]

DAVID W. GREENFIELD
College of Fisheries, University of Washington, Seattle, Washington

A new species of holocentrid fish, *Myripristis gildi*, is described from Clipperton Island. Four species of *Myripristis* are discussed, and a key to these is presented. Three of the four species, *M. leiognathos*, *M. clarionensis*, and *M. gildi* are endemic, while *M. murdjan*, an Indo-Pacific species, has crossed the Eastern Pacific barrier and occurs around the offshore islands. *M. leiognathos* is primarily a mainland form and has the widest distribution. *M. clarionensis* occurs around the Revillagigedo Archipelago and Clipperton Island, and is closely related to *M. leiognathos*. The relationship between these two species and a possible explanation of their mode of speciation is discussed. *M. gildi* is endemic to Clipperton Island and lives sympatrically with its close relative *M. murdjan*. A hypothesis for the derivation of *M. gildi* from *murdjan*-like stock is presented.

Myripristis is a circumtropical genus of the fish family Holocentridae which has long been a source of confusion to ichthyologists throughout the world. Collections of fishes made in the eastern tropical Pacific by Clemens (1955, 1957) and by Clemens & Nowell (1963), have shown that the larvae of holocentrids are abundant in the tuna fishing grounds. Since larval holocentrids constitute a forage fish for our tuna stocks (Iversen, 1962; King and Ikehara, 1956), and are a component of the ecosystem in which tunas live, an understanding of the taxonomy of this group is needed. After 1775, when Försskal described the first species of *Myripristis* (*Sciana murdjan*), 49 other species have been described, but many of these are apparently not valid. Most workers have had available only small numbers of specimens from local areas, and this has resulted in the same widespread species being named from several different localities.

The confused species problems in *Myripristis* can be resolved by two types of evidence: (i) information must be obtained on the holotypes, many of which are in European museums, because the original descriptions are frequently of little or no value; and (ii) numerous specimens from the entire circumtropical range must be examined in order to obtain information on geographic variation within species. It is with these two points in mind that I am now undertaking a world-wide revision.

Generally, the species of *Myripristis* are found throughout the Indo-Pacific Ocean, and only small pockets of endemism are evident. However, the eastern tropical Pacific appears to be a rather distinct zoogeographical area, and for this reason it is being handled as a separate unit. Since this work is the first portion of a complete generic revision, a redescription and synonomy of the genus has been included.

[1] Submitted for publication, March 1965. Contribution No. 203, College of Fisheries, University of Washington, Seattle, Washington.

Seven species of *Myripristis* have been named from the eastern tropical Pacific, and it is my purpose in this paper to examine these species critically to determine which are valid, and to provide an adequate description of these.

A total of 287 specimens has been examined from nine institutions: United States National Museum (USNM); Chicago Natural History Museum (CNHM); Natural History Museum of Stanford University (SU); Scripps Institution of Oceanography (SIO); Rijksmuseum Van Natuurlijke Historie, Leiden (RVNH); Museum National D'Histoire Naturelle (MNH); University of British Columbia (BC); University of California at Los Angeles (UCLA); Bureau of Commercial Fisheries, San Diego (BCF). The letters in parens after each name refer to the museum abbreviations I have used in my "material examined" sections.

ACKNOWLEDGMENTS

I am greatly indebted to the following persons and institutions for loaning specimens or for providing information: Madame M. L. Bauchot, Museum National D'Histoire Naturelle; G. F. Mees, Rijksmuseum Van Natuurlijke Historie, Leiden; Jorgen Nielsen, Universitets Zoologiske Museum, Denmark; N. J. Wilimovsky, University of British Columbia; B. W. Walker and W. J. Baldwin, University of California at Los Angeles; R. H. Rosenblatt, Scripps Institution of Oceanography; J. R. Hunter and S. Kato, Bureau of Commercial Fisheries, San Diego; L. P. Woods, Chicago Natural History Museum; W. I. Follett, California Academy of Sciences; G. S. Myers, Stanford University; and the staff of the U.S. National Museum. A. D. Welander, University of Washington, suggested the problem and has reviewed the manuscript; Raymond C. Simon, Bureau of Commercial Fisheries, Seattle, provided genetic information; and J. D. McPhail, University of Washington, has read the manuscript and offered many valuable suggestions during the tenure of this research.

Figures 1 through 4 were provided by W. R. Taylor, U.S. National Museum. Figure 5 was photographed by K. Bonham, University of Washington.

This research was supported in part by the Karl P. Schmidt Fund, Chicago Natural History Museum.

METHODS

All counts and measurements follow Hubbs and Lagler (1958) with several exceptions: The lateral line scale count includes only the pored lateral line scales; the modified scale row along the dorsal fin base is considered as a half row; head length is taken as the straight line distance from the longest spine on the opercle to the snout, including the premaxillary in a closed position; postorbital distance is the straight line distance from the longest spine on the opercle to the posterior bony edge of the orbit; and all rudiments of the gill rakers are included in my counts. Standard length was measured on a nondigit bias board to the nearest millimeter. Other body measurements were made with a pair of fine-point dividers and recorded to the nearest one-half millimeter.

GENERIC SYNONOMY

MYRIPRISTIS CUVIER 1829

Myripristis Cuvier, 1829, Regne animal, ed. 2, vol. 2, (Fishes etc.), p. 150; Cuv. and Val., *Histoire Naturelle des Poissons*, vol. 3, p. 160. Type, by subsequent designation, *M. jacobus* Cuvier (D.S. Jordan, 1917, *The Genera of Fishes*, p. 127).

Rhynchichthys Valenciennes, January, 1831, *Histoire Naturelle des Poissons*, vol. 7, p. 504. Type, by monotypy, *R. pelamidis* Val.

Rhinoberyx Gill, 1862. "Remarks on the Relations of the Genera and other Groups of Cuban Fishes," *Proc. Acad. Nat. Sci., Phila.*, p. 237. Type, by original designation, *Rhynchichthys brachyrhynchus* Bleeker.

Rhamphoberyx Gill, 1863, "Catalogue of the Fishes of Lower California—Collected by Mr. J. Xantus," *Proc. Acad. Nat. Sci., Phila.*, vol. 15, p. 87. Type, by original designation, *R. poecilopus* Gill.

Myriopristis (Cuvier) Gill, 1863, "Catalogue of the Fishes of Lower California—Collected by Mr. J. Xantus," *Proc. Acad. Nat. Sci., Phila.*, vol. 15, p. 87 *(lapsis calimi)*.

Neomyripristis Castelnau, May 10, 1873, "Contributions to the Ichthyology of Australia," *Proc. Zoological and Acclimatisation Society of Victoria*, Vol. 2, p. 99. Type, by original designation, *N. amaenus* Castelnau.

GENERIC DESCRIPTION

Myripristis have oblong, compressed bodies with greatest width occurring at dorsal origin. Ventral and dorsal profile with equal convexity; greatest body depth under origin of third or fourth dorsal spine. Interorbital space flat to slightly convex, frontals with large to small mucus cavities, separated by expanded ornamented, or simple, narrow ridges. Anterior profile of head bent abruptly down in front of eyes making a short, blunt snout. Dorsal profile ascending from snout to nape where it is slightly angulated, running backward at greater inclination to front of spinous dorsal. Profile from front of spinous dorsal to front of soft dorsal descending very slightly, then abruptly curved downward to caudal peduncle. Both dorsal and ventral outlines of peduncle concave. Mouth large, oblique, lower jaw slightly longer than upper (upper jay considerably exceeded by tip of lower jaw in very large specimens). Maxillary expanded moderately posteriorly, often possessing maxillary teeth on the antro-ventro edge. Supplemental maxillary large and projecting a little beyond the posterior end of maxillary. When mouth closed, the supplemental maxillary fits under suborbital series. Maxillary reaching a vertical between posterior of pupil to posterior edge of orbit. Villiform bands of teeth on entire length of premaxillary with enlarged conical teeth (3–5) often present on anterior portion. Lower jaw with villiform bands, with small, round cluster of 5–10 short, heavy teeth on each side of symphysis. A second set of tooth clusters, below those on symphysis, present in some species (*M. hexagonus* Lacépède). Villiform teeth present on palatines and vomer, sometimes reaching onto vomerine shaft in juveniles. Angle of opercle with a short, blunt spine. Opercle, interopercle, and preopercle serrate. Subopercle with 3 or 4 serrations on ventral edge. No enlarged spine at angle of preopercle. Opercular membrane bordering posterior edge of opercle, subopercle and interopercle. Suborbital finely serrate (without enlarged antrorse or recurved spines). Branchiostegals 8. Pelvic fins I,7, thoracic. Pectoral rather pointed, upper rays longest (ii, 11–14). Caudal forked, lobes equal and bluntly rounded, branched caudal rays usually 9–8. Dorsal fin deeply emarginate, dorsal spines usually X-1, last spine part of soft dorsal. Soft dorsal elevated, somewhat falcate, much higher than spinous dorsal. Anal spines usually IV, third generally more robust than fourth, either third or fourth spine longest, soft anal similar to soft dorsal. Lateral line nearly horizontal anteriorly, with slight downward curve on caudal peduncle. Lateral line scales each with a conspicuous pore, small unpored scales posterior to lateral line scales on caudal peduncle. Body covered with large ctenoid scales, 2½–3½ rows above lateral line. Scales ending abruptly at nape. Scales present on opercle, preopercle, caudal fin, base of soft dorsal and anal (in one species, *M. jacobus* Cuvier, scales are continued onto rays of soft anal and dorsal). Pseudobranch large, gill arches 4, with a slit behind fourth. Gill rakers long and lanceolate. Vertebrae usually 26, 11 abdominal and 15 caudal, first haemal arch on eighth vertebra, parapophyses on fifth vertebra. First and second haemal spine not depressed, first shorter than second, its tip touching. Basioccipital bears prominent process directed backward and downward. Open space present just behind ethmoid. Shape of opening of area of cartilage in auditory capsule resembles inverted "U." Prootic bears prominent lateral process. Anterior parasphenoid rhombic, posterior broad and flattened (Hotta, 1962). Swim bladder with antero-lateral projections extending forward on either side of posterior cranium, medial walls of projections thinned effecting intimate contact with laterally facing membranous areas of enlarged auditory bullae. Opisthotic bone incorporated into postero-lateral wall of auditory capsule region of cranium (Nelson, 1955). Sagittae: "outline relatively high, anteroventral slope curved inward, posteroventral slope curved outward, ventral margin sharply rounded; caudal keel of sulcus excavated, anterior division of cauda long; posterodorsal dome very slightly developed; dorsal margin incurved; ostium reniform" (Frizzell & Lamber, 1961).

KEY TO THE EASTERN PACIFIC SPECIES OF HOLOCENTRIDAE

The family Holocentridae is represented by three genera in the eastern tropical Pacific, *Holocentrus*, *Holotrachys*, and *Myripristis*. I have placed the first two in the key for the sake of completeness, but have not included detailed accounts. Meristic counts are presented in Table 1.

A. Angle of the preopercle with a conspicuously enlarged spine. D. XI-13-14; A. IV, 9; pored scales in lateral line 36-39; gill rakers 6+12; Range, Baja California to Ecuador, Galapagos, Clipperton, and Cocos Islands.

Holocentrus suborbitalis Gill

AA. Angle of preopercle without a conspicuously enlarged spine.

B. Dorsal spines XII, the last not part of the soft dorsal; scales with rather rough surface, consisting of long slender spines; D. XII-15; A. IV, 11; pored scales in lateral line 40; gill rakers 7+14; Range, Cocos Island.

Holotrachys lima (Valenciennes)

BB. Dorsal spines X-I, the last being part of the soft dorsal; scales relatively smooth, their spines short.
.... *Myripristis* Cuvier

C. Pored lateral line scales 28-30; Range, Cocos, Galapagos, and Clipperton Islands.
.... *M. murdjan* (Forsskål)

CC. Pored lateral line scales 32-47.

D. Three and one-half scale rows between lateral line and origin of spinous dorsal; Range, Revillagigedos and Clipperton Islands.
.... *M. clarionensis* Gilbert

DD. Two and one-half scale rows between lateral line and origin of spinous dorsal.

E. Total gill rakers 28-34; inner face of pectoral axil without distinct dark mark; no dark color on opercular membrane; Range, San Pedro Nolasco Island (Gulf. Calif.) to La Plata Island (Ecuador), Cocos and Galapagos Islands.
.... *M. leiognathos* Valenciennes

EE. Total gill rakers 34-37; inner face of pectoral axil with distinct dark mark; opercular membrane dark; Range, Clipperton Island.
.... *M. gildi* sp. nov.

TABLE I

Meristic Counts Made on Four Eastern Pacific Species of *Myripristis*

Species	Pored Lateral Line Scales																			
	28	*29*	*30*	*31*	*32*	*33*	*34*	*35*	*36*	*37*	*38*	*39*	*40*	*41*	*42*	*43*	*44*	*45*	*46*	*47*
clarionensis													5	12	17	25	10	3	2	1
leiognathos							6	14	43	44	28	4	1							
gildi					3	1	2	1												
murdjan	2	58	5																	

Species	Anal Rays			Dorsal Rays			
	11	*12*	*13*	*12*	*13*	*14*	*15*
clarionensis	1	78			2	72	5
leiognathos	8	131	2	2	8	131	
gildi	1	5	1			6	1
murdjan	1	64			2	63	

Species	Number of Gill Rakers on First Arch: Upper Part of Arch					Lower Part of Arch								
	9	*10*	*11*	*12*	*13*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*
clarionensis	18	55	3					9	43	22	2			
leiognathos	89	51				1	12	58	56	12	1			
gildi			2	5						1	2	4		
murdjan			17	43	4					4	24	28	6	2

Species	Total Gill Rakers												
	28	*29*	*30*	*31*	*32*	*33*	*34*	*35*	*36*	*37*	*38*	*39*	*40*
clarionensis			2	19	31	17	4						
leiognathos	1	10	44	48	28	8	1						
gildi							1		4	2			
murdjan							2	10	22	20	8	1	1

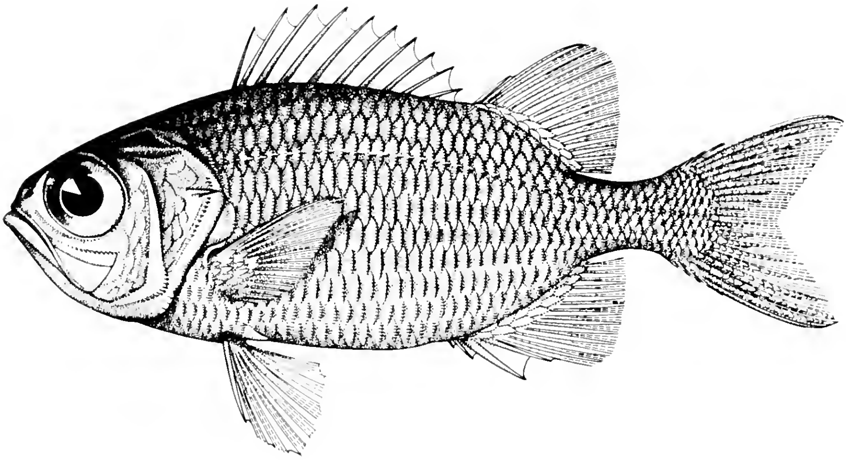

FIGURE 1

MYRIPRISTIS LEIOGNATHOS VALENCIENNES

SYNONYMY:

Myripristis leiognathos Valenciennes, Voy. Venus, Zool., Ichth., 1855, p. 315-318; 1846, pl. 4, fig. 1 (Galapagos Islands).

Myripristis occidentalis Gill, Proc. Ac. Nat. Sci. Phila., 1863, p. 87 (Cape San Lucas); Jordan, Cont. Bio. Hopkins Lab. Bio., no. 1, Stanford, 1895, p. 427; Jordan and Evermann, Bull. U.S. Nat. Mus., no. 47, pt. 1, 1896, p. 847; Gilbert and Starks, Mem. Cal. Acad. Sci., vol. 4, 1904, p. 65; Snodgrass and Heller, Proc. Wash. Acad. Sci., vol. 6, 1905, p. 354-5; Kendall and Radcliffe, Mem. Mus. Comp. Zool., vol. 35, no. 3, 1912, p. 90, pl. 2, fig. 1; Meek and Hildebrand, Field Mus. Pub., no. 215, Zool. Ser., vol. 15, pt. 1, 1923, p. 296; Borodin, Bull. Vanderbilt Marine Mus., vol. 1, art. 1, 1928, p. 15; Jordan, Evermann and Clark, Rept. U.S. Comm. Fish for 1928, pt. 2, 1930, p. 235; Breder, Bull. Bingham Oc. Coll., vol. 2, art. 3, 1936, p. 6; Herre, Field Mus. Pub., no. 353, Zool. Ser., vol. 21, 1936, p. 77-78; Fowler, Acad. Nat. Sci. Phil., Mon. 2, 1938, p. 28 and 253 (non-Gill); Fowler, Acad. Nat. Sci. Phil., Mon. 6, 1944, p. 495; Clemens, Calif. Fish and Game, vol. 41, no. 1, 1955, p. 165; Clemens, Calif. Fish and Game, vol. 43, no. 4, 1957, p. 304; Ricker, Mus. Cont. 3, Institute Fisheries, Univ. British Columbia, 1959, p. 6; Gosline and Brock, Handbook of Hawaiian Fishes, 1960, p. 321-22; Frizzell and Lamber, Univ. Missouri School Mines & Metal. Bull. 100, 1961, p. 8; Clemens and Nowell, Calif. Fish and Game, vol. 49, no. 4, 1963, p. 257.

Rhamphoberyx poecilopus Gill, Proc. Ac. Nat. Sci. Phila., 1863, p. 87 (Cape San Lucas); Jordan, Cont. Bio. Hopkins Lab. Bio., no. 1, Stanford, 1895, p. 427.

Rhamphoberyx leucopus Gill, Proc. Ac. Nat. Sci. Phila., 1863, p. 88 (Cape San Lucas); Jordan, Cont. Bio. Hopkins Lab. Bio., no. 1, Stanford, 1895, p. 427.

Myripristis poecilopus Jordan and Evermann, Bull. U.S. Nat. Mus., no. 47, pt. 1, 1896, p. 847; Gilbert and Starks, Mem. Calif. Acad. Sci., vol. 4, 1904, p. 65; Meek and Hildebrand, Field Mus. Pub., no. 215, Zool. Ser., vol. 15, pt. 1, 1923, p. 296; Borodin, Bull. Vanderbilt Marine Mus., vol. 1, art. 1, 1928, p. 15; Jordan and Evermann and Clark, Rept. U.S. Comm. Fish for 1928, pt. 2, 1930, p. 235; Fowler, Acad. Nat. Sci. Phil., Mon. 6, 1944, p. 394 and 495; Clemens and Nowell, Calif. Fish and Game, vol. 49, no. 4, 1963, p. 257.

Myripristis scalei Jenkins, Bull. U.S. Fish Comm., vol. 22, 1903, p. 439-40, fig. 13.

MATERIAL EXAMINED[2]

MNH A.2687 [1] (holotype, *M. leiognathos* Valenciennes), USNM 6269 [1] (lectotype, *M. occidentalis* Gill), USNM 7453 [1] (paratype *M. occidentalis* Gill), USNM 6350 [37] (paratypes, *M. occidentalis* Gill), USNM 6348 [29] (paratypes, *M. occidentalis* Gill), USNM 6352 [7] (paratypes, *M. occidentalis* Gill), USNM 198176 [12] (paratypes, *M. occidentalis* Gill), USNM 93275 [2] (lectotypes, *Rhamphoberyx poecilopus* Gill), USNM 50708 [1] (holotype, *Myripristis sealei* Jenkins), SU 23298 [2] (paratypes, *Myripristis sealei* Jenkins).

Galapagos Islands—SU 6489[3], BC 54–379B[3], BC 56–424[4], BC 56–421[4].

Cocos Island—BC 56–329[13].

Revillagigedos—BC 57–156[1], BC 61–189[1].

Baja California—SU 17565[1], SIO 62–105–31A[7], BC 61–158[12], BC 61–166[14], BC 59–229[12].

Mexico—BC 60–464[3], BC 59–264[17], BC 61–148[15], BC 60–467[12], BC 57–104[23], BC 60–17[11], BC 61–129[9].

Panama to Ecuador—BC 53–399[4], SU 6966[2], CNHM 50890[5], CNHM 50889[21].

DIFFERENTIAL DIAGNOSIS: May be distinguished from *M. clarionensis* by the 2½ scale rows above the lateral line (3½ in *clarionensis*); from *M. murdjan* by having more than 30 pored lateral line scales (34–40); from *M. gildi* by having 28–34 gill rakers, and no dark mark on the pectoral axil (*M. gildi* has 34–37 gill rakers, and a dark mark on the pectoral axil.)

DESCRIPTION: Dorsal X–I, 12–14 (usually 14); anal IV, 11–13 (usually 12); pored lateral line scales 34–40 (usually 37); gill rakers 9–10 + 19–24, total gill rakers 28–34 (usually 9 + 21); scale rows between lateral line and spinous dorsal 2½; head in standard length 2.64–3.43; greatest depth in length 2.40–2.85; interorbital in head 3.60–4.30; orbit in head 2.10–2.50; postorbital in head 2.41–2.71; snout in head 6.33–8.20.

Pectoral axil lacking scales on inner face, black pigment very light, not forming a definite spot. Third anal spine shorter than fourth. Frontals with lateral surfaces concave (from dorsal view), not forming a distinct shelf over the antro-dorsal portion of the eye. Four simple, longitudinal frontal ridges, separated by large mucus cavities. Enlarged symphysial teeth of lower jaw, when present, separated by a distance of one tooth patch diameter or more. Symphisial teeth do not fit into a deep notch in the upper jaw.

COLOR IN ALCOHOL: Back and sides yellowish; top of head brown; increased brown pigment spots where longitudinal rows of scales overlap producing a vague striped effect; dorsal, caudal, anal, pectorals, and pelvics immaculate; opercular flap not dark but yellowish; pectoral axil without a distinct dark patch.

REMARKS: This species is endemic to the eastern tropical Pacific, and ranges from Magdalena Bay, on the outer coast of Baja California (San Pedro Nolasco Island in the Gulf of California), to La Plata Island, Ecuador, and the vicinity of Cocos Island and the Galapagos Islands. Two specimens of *M. leiognathos* have also been taken from the Revillagigedos Archipelago. These small specimens were mixed

[2] The number in brackets after the museum number indicates the number of specimens.

with collections of *M. clarionensis* taken on Socorro Island (BC 61–189 and BC 57–156) and constitute an extension to the range of *M. leiognathos*. However, this species apparently has not established a population in this island group.

The possibility of geographic variation among the specimens from the Galapagos Islands, Cocos Island, the coast from Mazatlan to Ecuador, and Baja California coast was investigated, but no statistically significant variation could be found.

Myripristis leiognathos was described by Valenciennes in the *Voyage of the Venus* (1846) from the Galapagos Islands. Günther (1859) incorrectly listed *M. leiognathos* from New Ireland with the result that subsequent authors have cited Günther's type locality. The pored lateral line scale count for *M. leiognathos* was reported by Valenciennes as 38, and the illustration shows a typical *M. occidentalis*, except for the 11 spines in the dorsal instead of the typical 10. This abnormal dorsal spine number has occurred in several species of *Myripristis*. Loren P. Woods (pers. comm.) informs me this is not an unusual occurrence in other genera of Holocentridae. Madame M. L. Bauchot kindly provided photographs and made counts for the holotype of *M. leiognathos*, confirming *M. leiognathos* as the senior synonym of *M. occidentalis*. Since the name *M. leiognathos* has appeared in the literature several times within the past 50 years, it is not possible to retain *M. occidentalis* under Section VI, Article 23b of the International Code of Zoological Nomenclature (ICZN, 1961) (pers. comm., W. I. Follett); therefore, *M. leiognathos* has priority over *M. occidentalis*.

The original description of *M. leiognathos* consists of a figure published in 1846 (Plate IV, Fig. 1) and labeled as *M. leiognathos*. The text of this work was published in 1855 and, in this case, the name was spelled *M. leignathos*. W. I. Follett informs me that under Article 16 (a)(vii) the figure constitutes an indication, and therefore the name should be spelled *leiognathos*.

Rhamphoberyx leucopus Gill is apparently the young of *M. leiognathos* (Jordan, 1895). *Rhamphoberyx poecilopus* Gill was described from young specimens ($1\frac{3}{4}$ inches to $2\frac{1}{8}$ inches long) collected by J. Xantus at Cape San Lucas, Baja California. Since the types of *M. poecilopus* (USNM 6273) were missing from the collection at the U.S. National Museum, L. P. Schultz separated two specimens from USNM 6350 (J. Xantus collection from Cape San Lucas) and considered these types of *M. poecilopus*. Both of these specimens (48 and 52mm SL) have 37 pored lateral line scales, 12 anal rays, 14 dorsal rays, and gill raker counts of 8 + 19 and 9 + 21. The vomer is anchor-shaped with a long shaft possessing teeth, and the pelvics are black.

The Xantus collection from Cape San Lucas, from which Gill described *M. occidentalis*, consists of 137 paratypes (USNM 6269, 6348, 6350, 6352, 7453). Since no type was designated, I have selected a lectotype from collection USNM 6269. The remaining specimens in the bottle have been given the new number USNM 198176.

Jordan (1895) has stated that it is not impossible that *R. poecilopus* Gill is the very young of *Holocentrus suborbitalis*. However, Gill (1863) indicated the spine at the angle of the preoperculum is not enlarged in *R. poecilopus*, so this excludes it from *Holocentrus*. This, combined with the fact that *H. suborbitalis* has 9 anal rays, instead of 11 as described for *R. poecilopus,* would indicate that Gill was not describing the young of *H. suborbitalis.* In separating *M. poecilopus* and *M. leiognathos,* Gilbert and Starks (1904) reported lateral line scale counts of 39–40 for *M. leiognathos* and 34–35 for *M. poecilopus* which are, in fact, the extremes of the range for *M. leiognathos.* Gilbert and Starks (1904) also stated that the vomerine patch is lance-shaped in *M. leiognathos* while is is anchor-shaped in *M. poecilopus.* I found that the types of both *M. poecilopus* and *M. occidentalis* have a long vomerine shaft covered with teeth, and none of the numerous adult specimens I examined from the northern to the southern limits of the range of *M. leiognathos,* had an anchor-shaped vomerine patch, or teeth on the shaft of the vomer. Specimens identified by Gilbert as *M. poecilopus* (SU 6966) also lack the long anchor-shaped vomer, and are typical young *M. leiognathos.* It appears that the long vomerine shaft covered with teeth is present in the young of *M. leiognathos,* but that the teeth are lost and the vomer is more lance-shaped in adults. The black coloration on the pelvics of *M. poecilopus* must be considered a juvenile character since no adults with black pelvics have been found.

I have examined the type of *M. scalei* Jenkins (USNM 50708) and two paratypes (SU 23298), and I am in full agreement with Gosline and Brock (1960) who indicate that *M. scalei* is a perfectly normal specimen of *M. leiognathos,* and that the original specimens were probably not from Hawaii, but from the west coast of America.

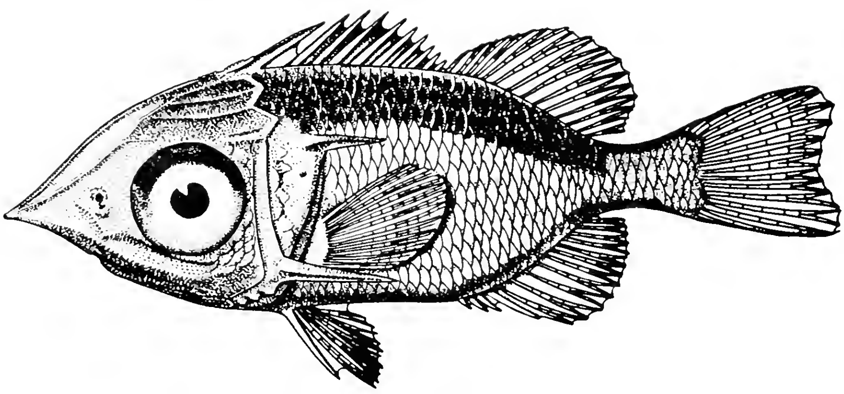

FIGURE 2—Rhynchichthys or pelagic stage of *Myripristis leiognathos.*

Valenciennes (in Cuv. & Val., 1831) described a larval *Myripristis* from the Indian Ocean as *Rhynchichthys pelamidis,* thus giving rise to the term "rhynchichthys-stage." This stage is characterized by a long rostrum and a large preopercular spine, as well as several spines on the head. As the larva develops into a juvenile, these characters are all lost. Allometric growth of the rostrum results in a wide range of snout length in head measurements.

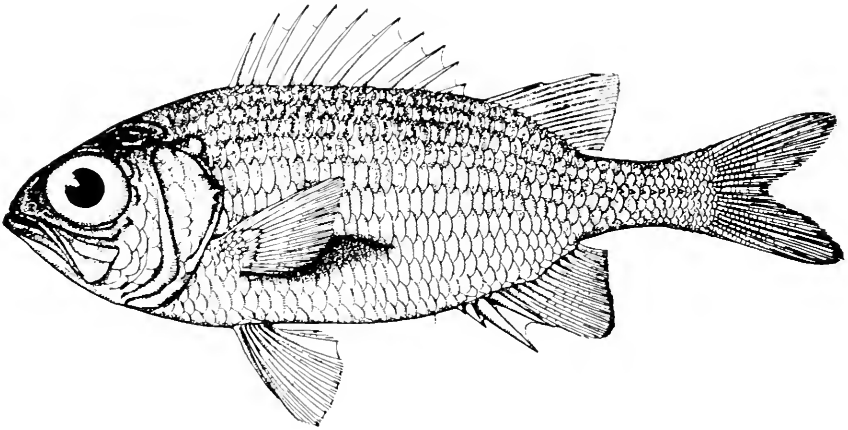

FIGURE 3

MYRIPRISTIS CLARIONENSIS GILBERT

SYNONOMY:

Myripristis clarionensis Gilbert, Proc. U.S. Nat. Mus., vol. 19, 1897, p. 441–2; Jordan and Evermann, U.S. Nat. Mus., Bull. 47, vol. 3, 1898, p. 2842; Jordan and McGregor, Rep. U.S. Fish Comm. 1898 (1899), p. 275; Schultz, U.S. Nat. Mus., Bull. 180, 1943, p. 64; Ricker, Mus. Cont. 4, Institute of Fisheries, Univ. British Columbia, 1959, p. 2; Frizzell and Lamber, Univ. Missouri School Mines & Metal., Bull. 100, 1961, p. 8; Quast, Proc. Calif. Acad. Sci., 4th ser. vol. 31, no. 21, 1965, p. 566 & 579.

MATERIAL EXAMINED:

USNM 47746[1] (holotype, *M. clarionensis* Gilbert)

Clarion Island—BC 59–254[13], BC 59–251[13], BC 58–383[15].

Socorro Island—BC 57–156[9], BC 61–184[14], BC 61–181[12], BC 61–189[14], SIO 58–142–31A[2], SU 5910[1].

San Benidicto Island—SU 5921[2].

DIFFERENTIAL DIAGNOSIS: May be distinguished from all other species of *Myripristis* in the eastern Pacific by the 3½ rows of scales above the lateral line (all others have 2½).

DESCRIPTION: Dorsal X–I, 13–15 (usually 14); anal IV, 11–12 (usually 12); pored scales in lateral line 40–47 (usually 43); gill rakers 9–10 + 20–22 (usually 10 + 22), total gill rakers 30–34; scale rows between lateral line and spinous dorsal 3½; head in standard length 2.90–3.50; greatest depth in length 2.50–3.41; interorbital in head 4.01–5.12; orbit in head 2.10–2.61; postorbital in head 2.20–2.40; snout in head 5.78–7.20. Pectoral axil lacking scales on inner face, black pigment very light, not forming a definite spot. Third anal spine shorter than fourth. Frontals with lateral surfaces concave (from dorsal view), not forming a distinct shelf over the antro-dorsal portion of the eye. Four simple, longitudinal frontal ridges, separated by large mucus cavities. Enlarged symphysial teeth of lower jaw, when present, separated by a distance of one tooth patch diameter or more. Symphysial teeth do not fit into a deep notch in the upper jaw.

COLOR IN ALCOHOL: Back and sides yellowish; top of head brown; increased brown pigment spots where longitudinal rows of scales overlap producing a slight striped effect; opercular flap brown, both above and below opercular spine; dorsal, caudal, anal, pectorals, and pelvics immaculate; pectoral axil without distinct dark patch.

REMARKS: *M. clarionensis* is the only American *Myripristis* having 3½ scale rows between the lateral line and the base of the spinous dorsal, all other species have 2½. This species is endemic to the eastern tropical Pacific, but unlike *M. leiognathos* it is restricted to the Revillagigedo Archipelago and Clipperton Island.

In light of the statement by Ricker (1959) that Clarion Island demonstrates a definite faunal isolation from the other islands in the Revillagigedo Archipelago, I investigated the possibility of geographic variation between the specimens from Clarion Island and the other islands but no statistically significant variation between these areas could be found.

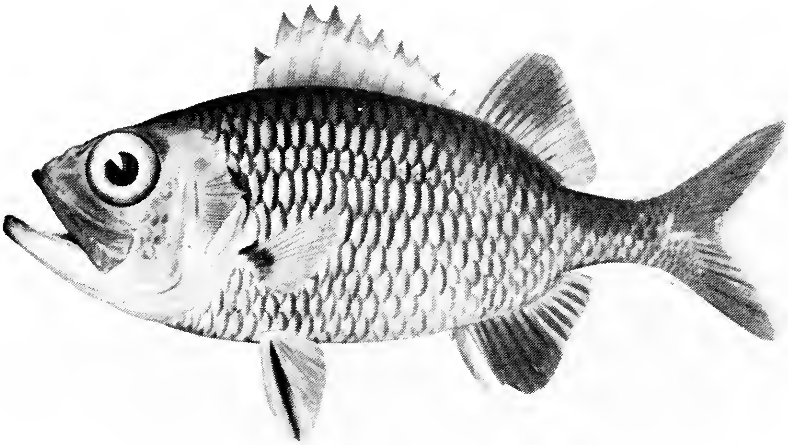

FIGURE 4

MYRIPRISTIS MURDJAN (FORSSKÄL)

SYNONOMY:

Sciana murdjan Forsskål, Desc. Anim., 1775, p. 48, (Red Sea)
Perca murdjan Block and Schneider, Syst. Ichth., 1801, p. 86.
Myripristis murdjan Rüppell, Atlas Reise Nordl. Afrika, Fische Rothen Meeres. 1828, p. 86, pl. 23, fig. 2; Günther, Fische der Südsee, 1873–75, vol. 2, p. 92, pl. 61; Day, Fishes of India, 1878–88, p. 170, Supplement. p. 788, pl. 41, fig. 2; Jenkins, Bull. U.S. Fish Comm. for 1902 (1903), p. 440 (Hawaiian Islands); Jordan and Evermann, Bull. U.S. Fish Comm., 1905, pt. 1, p. 152, pl. V, (Hawaiian Islands); Snodgrass and Heller, Proc. Wash. Acad. Sci., vol. VI, 1905, p. 356–358 (Galapagos Id. and Cocos Id.); Borodin, Bull. Vanderbilt Marine Mus., vol. 1, art. 1, 1928, p. 15 (Cocos); Herre, Field Mus. Pub., no. 353, Zool. Ser., vol. 21, 1936, p. 73–74 (Cocos); Briggs, Evolution 15(4), 1961, p. 545–554; Briggs, Copeia, 4, 1964, p. 706–708.

MATERIAL EXAMINED:

Clipperton Island—SIO 59–7–31A[16], UCLA W58–269[1], UCLA W56–297 [20], UCLA W56–237[10].

Cocos Island—BC 54–402[3], BC 56–329[5], UCLA W63–145[3], UCLA W58–378[6], BCF[1], CNHM 17960[1].

Galapagos Islands—BC 56–421[1].

DIFFERENTIAL DIAGNOSIS: May be separated from all other species of *Myripristis* in the eastern Pacific by the low lateral line scale count (28–30 for *M. murdjan*, 32–47 for all others).

DESCRIPTION: Dorsal X–I, 13–14 (usually 14); anal IV, 11–12 (usually 12); pored scales in lateral line 28–30 (usually 29); gill rakers 11–13 + 23–27, total gill rakers 34–40 (usually 12 + 25); scale rows between lateral line and spinous dorsal 2½; head in standard length 2.96–3.21; greatest depth in length 2.43–2.49; interorbital in head 4.0–4.95; orbit in head 2.11–2.64; portorbital in head 2.09–3.04; snout in head 4.94–10.00 (wide range due to allometric growth of snout). Scales usually present on lower half of the inner face of the pectoral axil, black pigment present on the upper half of axil. Third anal spine shorter than fourth. Frontals with lateral surfaces concave (from dorsal view), not forming a distinct shelf over the antro-dorsal portion of the eye. Four simple, longitudinal frontal ridges separated by large mucus cavities. Enlarged symphysial teeth of lower jaw, when present, separated by a distance of one tooth patch diameter or more. Symphysial teeth do not fit into a deep notch in the upper jaw.

COLOR IN ALCOHOL: Back and sides yellowish; top of head not notably darker than rest of body; scales above lateral line with faint brown posterior margins; lower sides with five or six longitudinal light lines following middle of scales; opercular flap very dark, at least to ventral edge of notch below opercular spine, sometimes reaching to a line opposite the origin of the pectoral; first dorsal immaculate; soft dorsal, anal, caudal, and pelvics with broad terminal bands in the young specimens. In adults, bands on pelvics are lost; the caudal, soft dorsal, and anal ray bands are reduced to dusky areas on the basal portion of the anterior rays or lost.

REMARKS: The specimens here referred to *M. murdjan* agree with the description given by Forsskål (1775), and with other specimens collected at the type locality. The holotype of *M. murdjan*, on deposit at the Universitets Zoologiske Museum, Denmark, is in such poor condition that identification to species is impossible (the entire anterior portion is missing). In a future paper, this species will be reviewed and a neotype described.

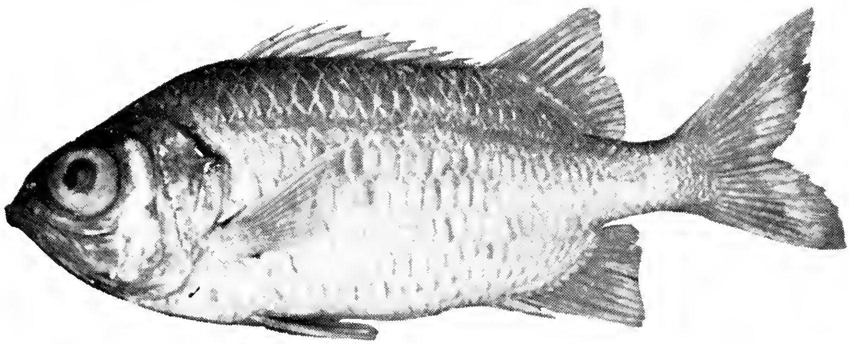

FIGURE 5

MYRIPRISTIS GILDI SP. NOV.

DIFFERENTIAL DIAGNOSIS: May be distinguished from *M. murdjan* by having 32–35 pored scales in the lateral line (28–30 in *M. murdjan*) and by possessing less-intense coloration on the opercular membrane and pectoral axil. It is also separable from the species called *M. murdjan* by Woods (1953) by having a lower gill raker count. It is distinguished from *M. clarionensis* by having 2½ scale rows above the lateral line (3½ in *M. clarionensis*); from *M. leiognathos* by having a gill raker count of 34–37 and a dark mark on the pectoral axil (*M. leiognathos* has a gill raker count of 28–34, and lacks the dark mark on the pectoral axil). The only other species with which *M. gildi* could be confused is *M. amaenus* Castelnau from which it differs by having an interorbital width of 4.0–4.90 in the head instead of 3.05–3.92. Although *M. gildi* possesses knobs of teeth on either side of the symphysis, it differs from *M. melanostictus* Bleeker in lacking the second set of turbercular teeth below those on the symphysis. *M. gildi* also differs from *M. melanostictus* in having 32–35 pored lateral line scales instead of 28. The type of *M. melanostictus* was kindly furnished for comparison by G. F. Mees of the Rijksmuseum Van Natuurlijke Historie, Leiden.

DESCRIPTION: Counts and measurements of the holotype are given first, followed by counts for the six paratypes in parentheses. Dorsal X-I, 14 (14–15); anal IV, 12 (11–13); pored lateral line scales 34 (32–35); gill rakers 12 (11–12) on upper limb, lower limb 25 (23–25); total gill rakers 37 (34–37); scale rows between lateral line and spinous dorsal origin 2½; scale rows between lateral line and origin of anal fin 7½; predorsal scales 10 (9–10); branchiostegals 8; pectoral ii,13 (13–14); pelvic I,7; standard length for holotype 207mm. Standard length for paratypes—214, 189, 187, 185, 179, 151 mm; head in standard length 3.45 (3.14–3.45); greatest depth in length 2.49 (2.42–2.59); body proportions in length of head; interorbital 4.00 (4.00–4.91); snout 5.45 (4.83–6.56); orbit 2.50 (2.30–2.76); postorbital 2.14 (2.14–2.27); least depth of caudal peduncle 2.82 (2.82–3.06); length of caudal peduncle 1.88 (1.77–1.88); greatest length of pelvic fin 1.58 (1.35–1.69); greatest length of pectoral fin 1.35 (1.27–1.39); length of upper caudal lobe 1.07 (1.07–1.22); length of lower caudal lobe

1.19 (1.07–1.23); length of longest dorsal spine (third or fourth) 2.34 (2.00–2.37); length of longest dorsal ray 1.72 (1.58–2.13); length of longest anal spine (fourth) 2.82 (2.42–3.05); length of longest anal ray 1.55 (1.39–1.74); depth of caudal peduncle in its length 1.50 (1.50–1.73); teeth in upper jaw small and conical, in lower jaw, small, conical except for a raised knob of teeth (9 or 10) one either side of the symphysis; enlarged symphysial teeth separated by a distance of one tooth patch diameter or more; symphysial teeth do not fit into a deep notch in the upper jaw; villiform teeth present on the palatines and vomer; scales absent from the inner face of the pectoral axil; frontals with lateral surfaces concave (from dorsal view), not forming a distinct shelf over the antro-dorsal portion of the eye; four simple, longitudinal frontal ridges separated by large mucus cavities.

COLOR IN ALCOHOL: Back and sides yellowish; top of head light brown; scales above the lateral line with a dusky posterior margin; pectoral axil with a distinct dark patch, but not as intense as in *M. murdjan;* opercular flap dark at least to ventral edge of notch below opercular spine, color fading out below this, again color is not as intense as in *M. murdjan;* all fins immaculate.

DEPOSITION OF TYPES: Holotype—U.S. National Museum 258201-F1; paratypes—British Museum (Natural History) 1964.11.27.1 [1]; University of Washington Fish Museum 18498[1]; University of California at Los Angeles UCLA W56-237[4].

REMARKS: The specimens of *M. gildi* were collected on Clipperton Island, just northwest of a wreck on the northeast side of the island, by Conrad Limbaugh and party in October 1956, and were kindly furnished for study by Boyd W. Walker and W. J. Baldwin of UCLA. *M. gildi* appears to be endemic to Clipperton Island.

This species is named for my wife, Gildi Greenfield, whose efforts in translating numerous foreign publications have added considerably to this revision.

ZOOGEOGRAPHY

The distribution of the species of *Myripristis* presents several interesting problems in the zoogeography of the eastern tropical Pacific. Schaefer (1961) defines the geographic limits of the eastern tropical Pacific, and indicates it is characterized by a fluctuating situation with a winter and fall regime. The extremes in these fluctuations occur in March and September. The major currents affecting these areas are: the California Current, North Equatorial Current, Equatorial Counter Current, and the South Equatorial Current (Figure 6). For a detailed account of these currents, *see* Cromwell and Bennet (1959).

The eastern tropical Pacific contains four species of *Myripristis*, three of which are endemic. The most widespread of the endemic is *M. leiognathos* which ranges from Magdalena Bay, Baja California, to Ecuador, and is also found on the offshore islands of Cocos, Socorro, and the Galapagos. Although *M. leiognathos* maintains a population on two of the offshore islands, it is apparently primarily a mainland form. The presence of this species in Panama Bay, which is basically a mud bottom shore environment, emphasizes its ability to survive in areas lacking rough volcanic or coral features.

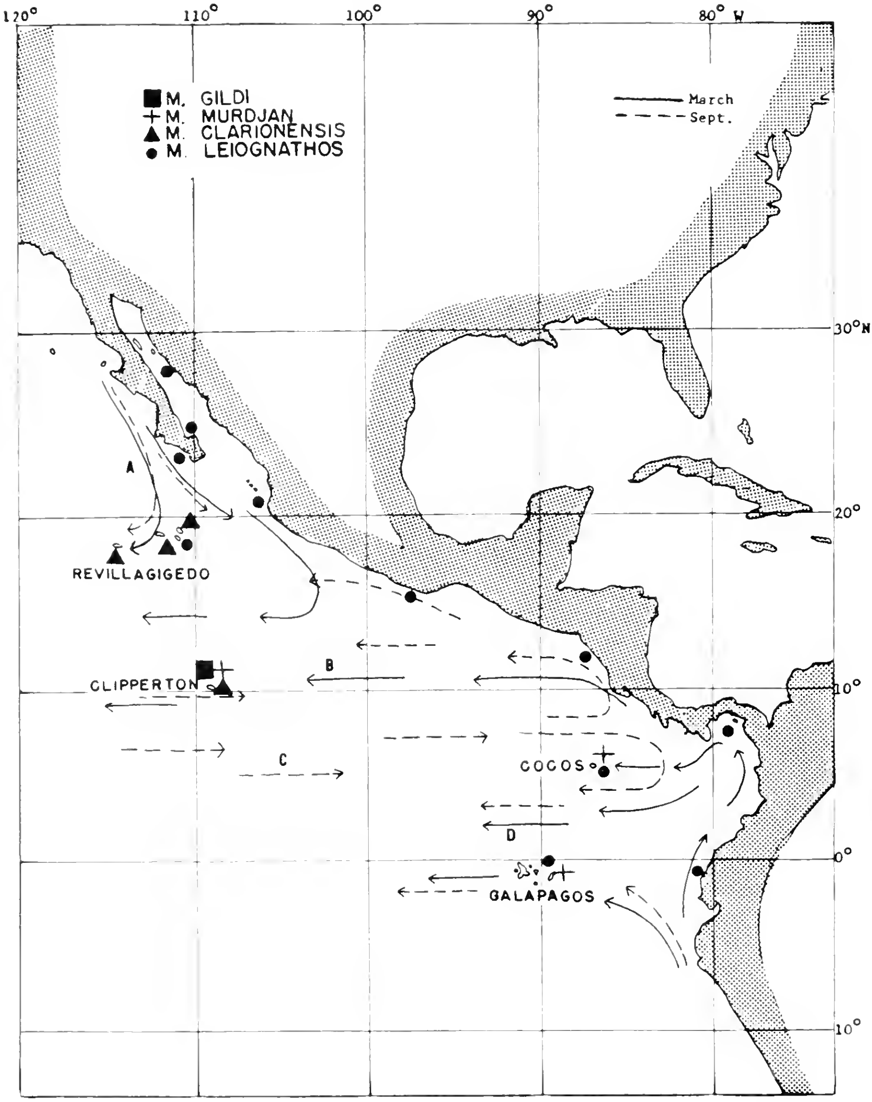

FIGURE 6—Major currents affecting the eastern tropical Pacific (A. California Current, B. North Equatorial Current, C. Equatorial Counter Current, and D. South Equatorial Current) and the distribution of *Myripristis* within the area.

M. clarionensis occurs around the Revillagigedo Archipelago, a group of four islands—Socorro, Roca Partida, San Benedicto, and Clarion—the closest (San Benedicto) lying 275 miles southwest of Cape San Lucas, Baja California, and 350 miles west of Cape Corrientes, Mexico. Clarion Island, although part of the archipelago, is almost 200 miles west of Socorro and demonstrates a definite faunal isolation from the other islands (Ricker, 1959). *M. clarionensis* has also established populations further to the south on Clipperton Island.

In all of the collections from the Revillagigedos that I examined, only two small specimens of *M. leiognathos* were found. These were mixed with collections of *M. clarionensis* taken on Socorro Island and constitute an extension to the known range of *M. leiognathos.*

Although the presence of *M. leiognathos* on Socorro Island clearly demonstrates that the pelagic larvae of *M. leiognathos* are able to reach the Revillagigedo Archipelago, probably via the California Current from Baja California, or by the northward drift at the eastern terminus of the Equatorial Counter Current, this species has apparently been unable to establish a significant population on the islands. This may be due to the fact that *M. clarionensis* is filling a major ecological niche, thus preventing *M. leiognathos* from surviving in this area. The absence of *M. leiognathos* from Clipperton Island, even though the North Equatorial Current could easily carry larvae from the mainland, further emphasizes this incompatibility.

Both *M. clarionensis* and *M. leiognathos* are true endemics to the eastern tropical Pacific. They differ from the other two species found in this area both in size and in meristic features. The largest *M. clarionensis* examined was 183 mm SL, and the largest *M. leiognathos,* 154 mm. The other two species are considerably larger, with the largest specimens having a standard length of 231 mm for *M. murdjan* and 214 mm for *M. gildi.* C. Kurt Lamber, in examining holocentrid otoliths, has found that sagittae of both *M. leiognathos* and *M. clarionensis* have a subostial line which is apparently not found in any of the other species (pers. comm.).

The similarity in size of *M. clarionensis* and *M. leiognathos,* their distinctive sagittae, and the gradation and overlap of many of their meristic characters, suggest these two species are closely related. *M. clarionensis* is characterized by having higher meristic counts than *M. leiognathos*, as demonstrated by the number of pored lateral line scales (Table 1). These increased counts provide a key character for separating *M. leiognathos* and *M. clarionensis*, an extra scale row between the lateral line and the dorsal origin in the latter.

A possible explanation for the isolation of *M. clarionensis* on the archipelago is that this species was derived from an ancestoral *M. leiognathos*-like stock which reached the archipelago from the mainland. Hubbs (1948, 1960) discusses the isolation of northern fish forms in the upper part of the Gulf of California, and suggests that they reflect a connection, or connections, of this area with cooler waters in the past. The time of this cooling period is estimated by Hubbs, on the basis of the level of differentiation of these relicts from their California counterparts, to have occurred in the Pleistocene. This suggestion is supported by the generally accepted fact that southward displacements occurred during the glacial periods.

The presence of cooler waters around the archipelago, and resulting ecological changes could well have set the scene for the emergence of *M. clarionensis* from *M. leiognathos*-like stock. The higher meristic characters of *M. clarionensis* might be a reflection of the colder environment on the archipelago in the past, or perhaps a simple reflection of reproductive isolation. Past studies (Seymour, 1956) have indicated the presence of higher meristic features in fish populations from colder waters, compared to the same species in a warmer environment, and the tendency for the mean differences to be retained when the stocks from the cold and warm water areas are reared under identical conditions. These groups are an expression of the extremes of the range of variation allowed by the gene pool of the entire species. There is some definite connection with colder water and higher counts, which might be a result of pleiotrophy, with the alleles controlling the meristic features also being related to some physiological factor necessary for survival in cooler waters, or the genes controlling meristic features and those controlling the physiological factors falling on the same chromosomes and being inherited in a block.

In a situation where low temperature tolerance is necessary for survival and successful reproduction, this factor, along with its linked high meristic character, would be selected for, and ultimately would result in an equilibrium differing from the original population. With the return of warmer water at a much later time, the equilibrium did not revert to the original mean as might be expected for short term environmental changes.

There are, of course, other explanations. It is well known that small isolated populations are capable of a rapid accumulation of genetic differences, and that these are supplemented by local environmental conditions which exert their selective pressures (Mayr, 1963).

M. murdjan (Forsskål) is found throughout the Indo-Pacific Ocean, and also occurs in the eastern tropical Pacific, but only in the vicinity of the offshore islands of Cocos, Clipperton, and the Galapagos. Apparently it is unable to survive on the mainland. In the rest of the Indo-Pacific, *M. murdjan* is adapted to a coral reef life, which would tend to explain its inability to establish a significant population on the mainland. Many authors, starting with Darwin (1897), have stated that there are no true coral reefs in the eastern tropical Pacific with the exception of Clipperton. From this statement, others have inferred there are no coral-like environments in the eastern tropical Pacific, but more recent studies (Squires, 1959) have indicated that corals and coral reefs are present, although not to the extent of the optimal tropical atoll reefs.

The Revillagigedo Archipelago is volcanic and the volcanoes are still active (Richards, 1959). The shore is probably of a rough volcanic character and differs greatly from the mainland environment. This is also true for both Cocos Island and the Galapagos Islands.

Clipperton Island is the only true atoll in the eastern tropical Pacific (Sachet, 1962), and it provides a good coral reef environment, as indicated by the numerous Indo-Pacific species (Hubbs and Rosenblatt, 1961).

The presence of *M. murdjan* in the eastern tropical Pacific is another exception to Ekman's (1953) Eastern Pacific Barrier. *Myripristis* in its pelagic, larval rhynchichthys stage could be carried across the great expanse of water freely or accompanying flotsam. The closest islands which are directly in the patch of the equatorial countercurrent are the Christmas-Fanning group, a distance of about 4,500 miles (Briggs, 1961). However, the larvae could have originated from the Marquesas Islands, only 3,200 miles away. Hubbs (1961) states that "surface swimming early stages would not likely utilize the Cromwell Current or other undercurrents." This leaves the distribution of Indo-Pacific forms to the Equatorial Countercurrent. Hubbs further points out that the distribution of Indo-Pacific forms tends to support this means of transport when the number of Indo-Pacific species is correlated with the proximity to the Equatorial Countercurrent.

Although Cocos lies directly in the path of the countercurrent, Clipperton is about 50 miles north most of the time; however, when the countercurrent moves toward the north, it occasionally passes the island. Also, much of the water mass of the countercurrent is deflected northwestward at the Central American coast, and flows westward with the North Equatorial Current (Sachet, 1962).

The Galapagos Islands are far south of the countercurrent, but they are fed by its clockwise flow into the Panama Bight and then out to the islands, where it joins the South Equatorial Current (Cromwell and Bennet, 1959).

The fourth species, *M. gildi,* is endemic to Clipperton Island and lives sympatrically with its close relative *M. murdjan.* This endemic species could have resulted from a discontinuous flow of *M. murdjan*–like stock across the Eastern Pacific Barrier to Clipperton Island. An early arrival of *M. murdjan*–like stock could have given rise to the endemic form, due to isolation and differing ecological conditions. Reinvasion of *M. murdjan* at a later time would result in two sympatric species. That the number of larval *Myripristis* reaching the eastern tropical Pacific would be extremely small, combined with the fact that the currents and water temperatures were subjected to considerable change in past eras, tend to support this theory.

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FISHES COLLECTED BY MIDWATER TRAWLING FROM CALIFORNIA COASTAL WATERS, MARCH 1963[1]

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Twenty-seven fish species (15 families, 25 genera) were collected in 15 tows of a midwater trawl in the vicinity of Pt. Conception, California, during March 1963. Geographic and bathymetric distributions are indicated for these collections.

The California Department of Fish and Game research vessel *N. B. Scofield* was used for an exploratory fishing cruise covering portions (midwater and bottom) of the Santa Barbara Channel and coastal waters off San Luis Obispo Bay from March 8 to 27, 1963 (Best, 1963). Our intermediate-sized midwater trawl had a working gape approximately 35 feet square. The net utilized 4½-inch stretched mesh in the wings and body, and the intermediate was tapered with 3-, 2-, and 1-inch mesh (in that order) to a cod-end of ½-inch mesh. Nylon netting and ropes were used throughout; the webbing in the wings being 15-thread, and that of the intermediate and cod-end 5-thread (Heimann, 1962). Bottom stations were sampled with conventional otter trawls, but are not covered in this report.

Two transects were made across the Santa Barbara Channel: (i) six stations from the vicinity of Gaviota to Santa Rosa Island over water depths of 50 to 300 fathoms; and (ii) five stations from Point Conception to San Miguel Island over water depths of 50 to 250 fathoms (Figure 1). In addition, four stations, at water depths of 49, 102, 240 and 302 fathoms, were occupied offshore between San Luis Obispo Bay and the Santa Lucia Ridge, a distance of 36 miles (Figure 1). All 15 hauls were made during daylight hours (Table 1).

RESULTS

Tests in shallow water with a bathykymograph and wire-angle scope-ratio calculations indicated four units of towing warp were needed to attain one unit of depth. This 4:1 ratio was used to determine the length of warp needed to reach approximately mid-depths at each station. After shooting the predetermined warp, the net was towed for 30 minutes before being retrieved.

Tracings made with the bathykymograph in shallow water indicated that the net fished in a parabolic arc. The net continued to sink after the towing warp was shot. Thus, in a 30-minute haul, little time was spent towing the net horizontally at the desired depth. Increased weight of the trawling warp at the lengths used and variable conditions of wind and sea made it highly probable that all stations were fished deeper than planned. The capture of some benthic fishes, of such genera

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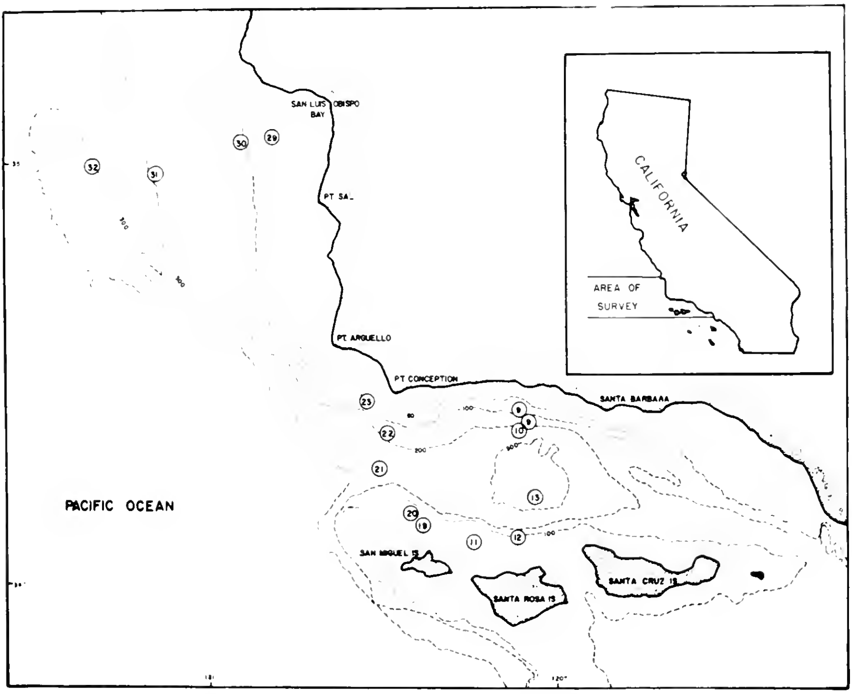

FIGURE 1. Location of March 1963 midwater trawling stations off California coast.

as *Parmaturus*, *Squalus*, *Zaniolepis*, and *Porichthys*, could be considered as circumstantial evidence of fishing near the bottom. However, all could have been taken well above the bottom; for instance, the stomachs of some of the *Parmaturus* contained such mid-depth species as the squid *Abraliopsis* and myctophid fishes. All flatfishes and rockfishes were post-larvae or early juveniles which have pelagic habits.

TABLE 1

List of Midwater Trawling Stations

Station	Lat.	Long.	Date	Time * net set	Water (depth in fathoms)
8	34°25′	120°06′	14 Mar 63	0932	50
9	34°24′	120°05′	14 Mar 63	1054	106
10	34°22′	120°06′	14 Mar 63	1250	234
11	34°06′	120°15′	16 Mar 63	0837	53
12	34°07′	120°07′	16 Mar 63	1012	127
13	34°12′	120°03′	16 Mar 63	1218	307
19	34°08′	120°23′	20 Mar 63	1030	53
20	34°11′	120°25′	20 Mar 63	1555	72–95
21	34°17′	120°31′	20 Mar 63	1830	256
22	34°23′	120°29′	21 Mar 63	0907	125
23	34°26′	120°33′	21 Mar 63	1114	57
29	35°04′	120°49′	24 Mar 63	1302	49
30	35°03′	120°54′	24 Mar 63	1454	102
31	34°59′	121°09′	25 Mar 63	0829	302
32	35°00′	121°20′	25 Mar 63	1152	240

* Pacific Standard Time.

Twenty-seven species of 18 families were collected from these 15 mid-depth hauls (Table 2). Collecting data have been arranged to indicate the geographic and bathymetric distributions within the survey area (Table 3).

TABLE 2

Fishes Collected by *N. B. Scofield*, March 1963

Station number, *(number of specimens)*, and standard lengths in millimeters are listed

SCYLIORHINIDAE–cat sharks

Parmaturus xaniurus (Gilbert): 13(*4*) no lengths taken.

SQUALIDAE–dogfish sharks

Squalus acanthias Linnaeus: 10(*1*) 230.

ENGRAULIDAE–anchovies

Engraulis mordax Girard: 29(*100+*) no lengths taken.

BATHYLAGIDAE–deepsea smelts

Bathylagus stilbius (Gilbert): 13(*2*) 40–73; 21(*3*) 61–77.

STERNOPTYCHIDAE–lightfishes

Argyropelecus lychnus Garman: 32(*2*) 21–29.
Cyclothone signata Garman: 31(*17*) 21–32, 32(*6*) 20–27.
Ichthyococcus irregularis Rechnitzer & Böhlke: 32(*1*) 29.

MELANOSTOMIATIDAE–scaleless dragonfishes

Tactostoma macropus Bolin: 31(*2*) 100–140.
Bathophilus indicus (Brauer): 31(*2*) 91–98.

MALACOSTEIDAE–loosejaws

Aristostomias scintillans (Gilbert): 31(*1*) 96.

CHAULIODONTIDAE–viperfishes

Chauliodus macouni Bean: 31(*1*) 99, 32(*1*) 33.

IDIACANTHIDAE–blackdragons

Idiacanthus antrostomus Gilbert: 31(*1*) 146, 32(*2*) 157–165.

MYCTOPHIDAE–lanternfishes

Diaphus theta Eigenmann & Eigenmann: 10(*2*) 30–38, 21(*2*) 32–34, 31(*2*) 27–36, 32(*11*) 29–60.
Protomyctophum crockeri (Bolin): 32(*2*) 20–21.
Lampanyctus leucopsarus (Eigenmann & Eigenmann): 10(*45*) 40–70, 21(*53*) 37–73, 31(*8*) 52–71, 32(*9*) 37–79.
Lampanyctus mexicanus (Gilbert): 10(*1*) 75.
Lampanyctus ritteri Gilbert: 31(*2*) 40–54.
Tarletonbeania crenularis (Jordan and Gilbert): 10(*10*) 40–61, 19(*3*) 45–65, 21(*2*) 53–61, 22(*13*) 57–72, 31(*40*) 40–74, 32(*17*) 35–63.

GADIDAE–cods and hake

Merluccius productus (Ayres): 31(*2*) 460–540, 32(*1*) 410.

TRACHIPTERIDAE–ribbonfishes

Trachipterus altivelis Kner: 12(*1*) 307, 13(*1*) 258.

BOTHIDAE–lefteye flounders

Citharichthys stigmaeus Jordan & Gilbert: 19(*44*) 17–29, 20(*58*) 16–30, 30(*3*) 21–27, 32(*26*) 20–29.
Citharichthys sordidus (Girard): 19(*2*) 22–23, 32(*2*) 17–33.

PLEURONECTIDAE–righteye flounders

Microstomus pacificus (Lockington): 19(*1*) 26.

STROMATEIDAE–butterfishes

Icichthys lockingtoni Jordan and Gilbert: 23(*1*) 33.

SCORPAENIDAE–rockfishes

Sebastodes spp. 12(*1*) 28, 23(*1*) 30, 32(*1*) 30.

ZANIOLEPIDAE–combfishes

Zaniolepis frenata Eigenmann: 10(*1*) 165.

BATRACHOIDIDAE–toadfishes

Porichthys notatus Girard: 22(*1*) 210.

TABLE 3

Geographic and Bathymetric Distribution of Specimens Collected by *N. B. Scofield*, March 1963

Depth of water is listed, fishing was carried out at approximately mid-depth

Species	Santa Rosa Island			San Miguel Island			San Luis Obispo Bay			
	100 fath.	200 fath.	300 fath.	50 fath.	100 fath.	200 fath.	50 fath.	100 fath.	200 fath.	300 fath.
Trachipterus altivelis	1		1							
Squalus acanthias		1								
Zaniolepis frenata		1								
Lampanyctus mexicanus		1								
Parmaturus xaniurus			4							
Bathylagus stilbius			2			3				
Sebastodes spp.	1			1					1	
Tarletonbeania crenularis		10		3	13	2			17	40
Diaphus theta		2				2			11	2
Lampanyctus leucopsaurus		45				53			9	8
Microstomus pacificus				1						
Icichthys lockingtoni				1						
Porichthys notatus					1					
Citharichthys stigmaeus				14	58			3	26	
Citharichthys sordidus				2					2	
Engraulis mordax							100+			
Ichthyococcus irregularis									1	
Argyropelecus lychnus									2	
Protomyctophum crockeri									2	
Cyclothone signata									6	17
Chauliodus macouni									1	1
Idiacanthus antrostomus									2	1
Merluccius productus									1	2
Tactostoma macropus										2
Bathophilus indicus										2
Aristostomias scintillans										1
Lampanyctus ritteri										2

ACKNOWLEDGMENT

We wish to express our appreciation to John E. Fitch for identifying most of the bathypelagic forms. Specimens were deposited in the ichthyological collection of the University of California, Los Angeles, with the exception of the collections of *Parmaturus* which were given to the Bureau of Commercial Fisheries Ichthyological Field Station, Stanford, California, for examination.

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OBSERVATIONS ON BIGEYE TUNA CAUGHT IN THE SURFACE TUNA FISHERY IN THE EASTERN PACIFIC OCEAN, 1951–1964[1]

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Data collected from 1951 to 1964 by the Inter-American Tropical Tuna Commission on the catches and size distribution of bigeye tuna in the eastern Pacific Ocean have been assembled and summarized. Bigeye tuna have been taken by the surface fishery in four general areas in the eastern Pacific—off Baja California, off Colombia, off Ecuador-Peru, and at the Galapagos Islands. The ranges in length of the bigeye taken by the surface and the longline fisheries are about the same (460–1,980 and 390–2,090 mm), but bigeye smaller than 1,000 mm made up more than half the catch by the surface fishery and less than one-twentieth that by the longline fishery, during portions of the period studied.

Sporadic catches of bigeye tuna *Thunnus obesus* (Lowe) are made incidentally while fishing for yellowfin tuna (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*) in the eastern Pacific Ocean. These catches of bigeye are recorded by the fishermen in their logbooks; in some cases, they are recorded as yellowfin. These logbook records have been obtained by the Inter-American Tropical Tuna Commission as a consequence of its monitoring of the yellowfin and skipjack fishery. Bigeye tuna, because of the small catches, are not recorded *per se* in the statistical system of the California Department of Fish and Game, but are combined with the statistics for yellowfin tuna. However, the estimates of the catch afforded by the rather complete coverage of the surface fishery by the Tuna Commission's logbook system are believed to be fairly representative of the total catch. Bigeye tuna in some of these catches have been measured for their scientific interest in the course of the Commission's measurement program for the other two species.

The recent expansion of the Japanese tuna longline fishery into the eastern Pacific has been discussed by Suda and Schaefer (1965); among the more important tunas contributing to the Japanese subsurface fishery are bigeye. Because of the movement of the longline fleet into this area, information concerning bigeye caught to date by the surface fishery in the eastern Pacific is of interest. All data collected by the Tuna Commission on the catches and size distribution of the bigeye tuna have been assembled and are summarized in this report. Some of these data have been given in a different form by

[1] Submitted for publication March 1965.
[2] Susumu Kume was a visiting scientist at the Inter-American Tropical Tuna Commission when this report was written.

Alverson and Peterson (1963), but this report includes catch data for recent years, and gives a detailed presentation of the length-frequency data.

Franklin G. Alverson and Bruce M. Chatwin were responsible for the collection of many of the data; their help is gratefully acknowledged.

CATCH

The annual combined landings of yellowfin and skipjack tunas in the eastern Pacific surface fishery from 1951 to 1964 have ranged from approximately 135,000 to 192,000 short tons. During the same period, the recorded annual catch of bigeye tuna by the same fishery has ranged from "a few" to about 300 tons (Table 1), which indicates the incidental nature of the bigeye fishery. One hundred and thirty-four vessels have reported catches of bigeye since 1951, 130 tuna baitboats and 4 tuna purse-seiners.

TABLE 1

Catch Record (Tons-Boats) of Bigeye Tuna Taken by the Surface Fishery in the Eastern Pacific, 1951–1964

		Area				
Year	Quarter	Off Baja California	Off Ecuador-Peru	At Galapagos Islands	Off Colombia	Annual total
1951	I			15-2		
	II		32-1			
	III		23-6			
	IV		X*-1			
	Subtotal		55-8	15-2		70-10
1952	III				X*-1	X*-1
1953	I		3-1			
	II		20-2			
	IV		X*-1		24-4	
	Subtotal		23-4		24-4	47-8
1954	I			104-3		
	II		75-1	10-1		
	III			52-4		
	IV		37-3	25-3		
	Subtotal		112-4	191-11		303-15
1955	III			127-3		
	IV		2-5			
	Subtotal		2-5	127-3		129-8
1956	III	1 fish-1		10-1		
	IV		2-2	32-2		
	Subtotal	1 fish-1	2-2	42-3		44-6
1957	I			5-2		
	II		X*-1		47-5	
	III			21-3		
	IV		X*-1	2-1		
	Subtotal		X*-2	28-6	47-5	75-13

TABLE 1—Continued

Catch Record (Tons-Boats) of Bigeye Tuna Taken by the Surface Fishery in the Eastern Pacific, 1951–1964

Year	Quarter		Area: Off Baja California	Off Ecuador-Peru	At Galapagos Islands	Off Colombia	Annual total
1958	I				X*-2	2-1	
	II					22-2	
	III		3-1	20-1			
	IV			104-8	104-5	1-1	
		Subtotal	3-1	124-12	104-7	25-4	256-24
1959	I			3-1			
	II				20-1	20-2	
	III		5-2	53-4	30-3		
	IV			X*-2	34-6		
		Subtotal	5-2	56-7	84-10	20-2	165-4
1960	I				4-5		
	II				166-3		
	III				32-1		
		Subtotal			202-9		202-9
1961	III				X*-1		
	IV				6-1‡		
		Subtotal			6-2		6-2
1962	II			X*-1‡	119-2‡ 29-2		
	III				46-2		
	IV				110-2		
		Subtotal		X*-1	304-8		304-9
1963	IV				82-3		82-3
1964	I				55-3		
	II				6-1		
	III				17-1		
		Subtotal			78-5		78-5
		Grand total	8-4	374-45	1,263-69	116-16	1,761-134

* Some catch, but amount not known.
‡ Taken by purse-seine vessels; remaining catch by baitboats.

The distribution of these catches is shown in Figure 1. Because the few bigeye are often recorded as yellowfin tuna, and because the location of the surface fishery is determined primarily by the areas of concentration of yellowfin and skipjack tuna, the distribution shown is not necessarily representative of the actual bigeye distribution. Numbers in each one-degree area given the estimated tons captured in that area, by quarters of the year, for all years combined.

Bigeye tuna have been taken by the surface fishery in four general areas of the eastern Pacific—off Baja California, off Colombia, off Ecuador-Peru, and in the vicinity of the Galapagos Islands. They have been captured in most of the tropical region in all seasons of the year but have been taken only in the summer in the temperate area off Baja California. These catches were made in August 1958 and August 1959

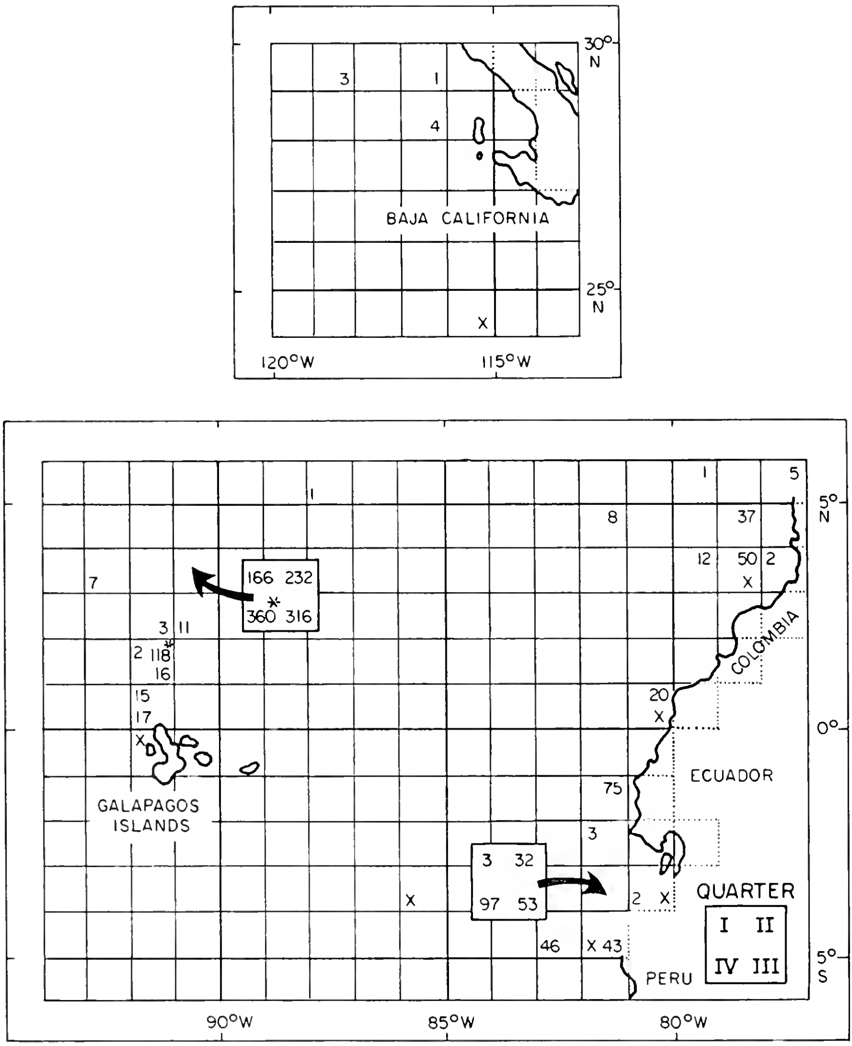

FIGURE 1. Distribution of bigeye tuna catch by the surface fishery, 1951–1964. Numbers shown are the estimated short tons captured in each area, by quarters of the year, for all years combined. *—includes purse-seine catch; x—some bigeye were caught. Some bigeye were also taken near lat. 09°S., long. 79°W. (not shown in figure).

and coincide with the presence of warmer-than-average water and good skipjack fishing in that area, noted since 1951, only in those 2 years (Broadhead and Barrett, 1964).

Of the total catch reported in the logbook system, more than one half was made at a bank at lat. 03°20′N, long. 81°45′W ("Cadillac" bank) and about one-tenth at Guayaquil Bank (lat. 03°30′S, long. 81°10′W).

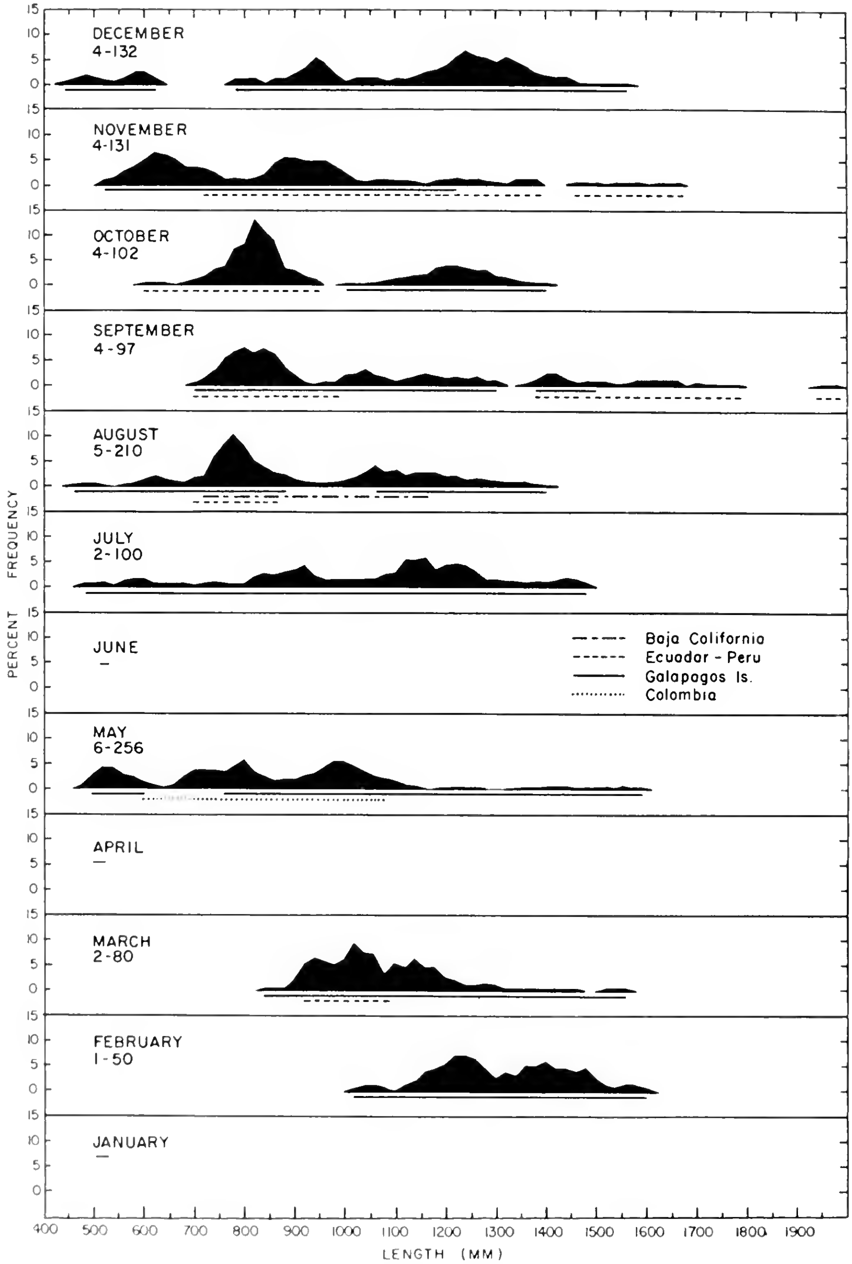

FIGURE 2. Monthly percentage length-frequency distributions of bigeye sampled from the catch by the surface fishery, for all areas, gears and years combined, 1955–1964.

The longline and surface fisheries for bigeye tuna overlap in the fishing grounds north of the Galapagos Islands (Figure 1). The simultaneous occurrence of bigeye in both fisheries is of interest, especially in respect to the size distribution of the catch by each (see below).

The smoothed (by 3's) monthly percentage length-frequency distributions of the bigeye tuna sampled in the Tuna Commission's measurement program are shown in Figure 2, for all areas, gears and years combined. The figure is based on length measurements of 1,158 fish from 32 samples (Table 2), measured from 1955 to 1964; the numbers of samples and of specimens measured are shown on the left side of each panel within the figure. The general areas from which the samples were taken and the ranges in length of the fish in the samples are shown by the lines under the distributions.

TABLE 2

Numbers, Ranges in Length, and Areas and Dates of Collection of Bigeye Tuna Taken by the Surface Tuna Fishery in the Eastern Pacific

Date	Area	Number of fish	Range in length (mm)
1955 August	off Ecuador-Peru	10	720– 860
September	off Ecuador-Peru	29	720– 880
September	at Galapagos Islands	18	720–1500
October	off Ecuador-Peru	34	620– 900
1957 May	off Colombia	50	780–1080
1958 August	off Baja California	50	740–1000
October	off Ecuador-Peru	18	700– 920
November	off Ecuador-Peru	33	720–1640
November	at Galapagos Islands	48	600–1220
December	at Galapagos Islands	11	580–1220
1959 May	at Galapagos Islands	50	500– 760
May	off Colombia	50	780–1080
August	off Baja California	50	920–1160
September	off Ecuador-Peru	32	740–1980
September	at Galapagos Islands	18	880–1280
1960 May	at Galapagos Islands	50	780–1240
1961 August	at Galapagos Islands	50	500– 880
1962 March	off Ecuador-Peru	16	920–1080*
March	at Galapagos Islands	64	860–1540
May	at Galapagos Islands	56	760–1580*
July	at Galapagos Islands	50	500–1340
August	at Galapagos Islands	50	480–1380
October	at Galapagos Islands	50	1020–1380
December	at Galapagos Islands	50	1160–1540
1963 November	at Galapagos Islands	50	540– 920
December	at Galapagos Islands	71	460–1500
1964 February	at Galapagos Islands	50	1040–1580
July	at Galapagos Islands	50	580–1460

* Taken by purse-seine vessels; remaining samples from baitboats.

Modes and apparent modal progressions in some groups of succeeding months can be seen; however, because of the paucity of our data, definite conclusions concerning age, growth, or other features cannot be drawn.

The lengths of bigeye taken by the surface and the Japanese longline fisheries extend over approximately the same range—460 to 1980 mm for the surface fishery and 390 to 2090 mm for the longline fishery

(Kume, unpublished). There is, however, a striking difference between the size composition of the catches by the two gears. Bigeye smaller than 1000 mm made up more than half those sampled from the catches of the surface fishery in the eastern Pacific from 1955 to 1964 but less than one-twentieth of those taken by the Japanese longline fishery east of 130° W from 1958 to 1964 (Table 3; data for longline gear from Kume, unpublished). This capture by the surface fishery of the smaller bigeye was particularly evident when the two gears were operating at the same time in the fishing grounds north of the Galapagos Islands (Table 3).

TABLE 3

Percent of Bigeye Smaller Than 1,000 mm Taken by the Surface and Longline Fisheries in the Eastern Pacific

Fishery	Area	Date	Number of fish in sample	Fish <1000 mm Number	Fish <1000 mm Percent
Surface	N. of Galapagos Isl.	1962–II	156	123	78.8
Longline	East of 130°W	1958–1964	63,133	2,826	4.5
Surface	N. of Galapagos Isl.	1962–II	156	123	78.8
Longline	N. of Galapagos Isl.	1962–II	239	10	4.2
Surface	N. of Galapagos Isl.	1963–IV	230	118	51.3
Longline	N. of Galapagos Isl.	1963–IV	364	1	0.3

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DIETS OF FOUR WARMWATER GAME FISHES IN A FLUCTUATING, STEEP-SIDED, CALIFORNIA RESERVOIR [1]

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A food habits study at Pine Flat Lake in 1963 and 1964 revealed a seasonal abundance of cladocerans, chironomids, terrestrial arthropods, and threadfin shad in the diets of game fishes. Largemouth bass fed principally upon shad the year around, although small bass also ate cladocerans. Crappie ate mostly shad except in the spring, when small crappie ate chironomid larvae, cladocerans, and copepods. Catfish consumed chironomid larvae in the spring, shad in late summer and fall, and filaree, a terrestrial plant, in winter. Small catfish ate chironomid larvae from March through October. Bluegill ate all the seasonally abundant foods plus fish eggs in the spring.

INTRODUCTION

Most of California's recently impounded warmwater reservoirs afford a peculiar environment to common aquatic organisms. They are deep, steep-sided, void of aquatic plants, and have submerged trees and brush in only the deep limnetic areas. Water levels fluctuate widely, being highest in late spring and lowest in the fall. This study was initiated to determine which organisms provide important forage to game fish in one of the representative waters—Pine Flat Lake, Fresno County, a 5,970-acre, 1,000,000 acre-foot impoundment on the Kings River.

This paper presents the results of analyzing stomach contents collected from largemouth bass, *Micropterus salmoides*, black crappie, *Pomoxis nigromaculatus*, bluegill, *Lepomis macrochirus*, and white catfish, *Ictalurus catus*, from March 1963 through February 1964. Common forage species in the lake include threadfin shad, *Dorosoma petenense*, golden shiner, *Notemigonus crysoleucas*, mosquitofish, *Gambusia affinis*, and Sacramento squawfish, *Ptychocheilus grandis*. The last named is also a predaceous rough fish.

METHODS

Over 90 percent of the fish used in the study were caught by anglers. The others were captured in gill nets, traps, and seines. The stomach of each fish was emptied into a prelabeled jar by species, size group, and month. Contents from as many as 40 fish were placed in some jars to facilitate use of a rapid analysis technique described by Borgeson (1963). Borgeson's method involves combining stomach contents in the field rather than wrapping each stomach separately for laboratory analysis later. He reasoned that analyses of stomach contents are usually combined in most publications and his method saves a great deal

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of time by doing so at the outset. In the laboratory, large organisms were identified and counted, while a sample of the invertebrates usually was sufficient. Resulting numbers, and volumes determined by water displacement, were used to estimate preingested volumes. Multiple jars can be used for various size groups, periods of time, or both.

The preingested volumes of forage fishes were estimated, using a modification of the technique employed by McConnell and Gerdes (1964). Body volumes and fork lengths were determined for representative sizes of five fish species. The combined length of the 10 caudal vertebrae preceding the hypural plate of each fish was measured from X-rays. The formula, Log $V = \log a + n \text{ Log } L$, describes the volume-length relationship where V is the body volume in milliliters and L either the fork length or vetebral length in millimeters. Log a and n were calculated for the body-volume/fork-length and body-volume/vertebrae-length relationships (Table 1).

TABLE 1

Constants for Volume/Fork-Length and Volume/Vertebrae-Length Relationships of Five Pine Flat Lake Fish

Fish species	Fork length relationships		Vertebrae length relationships	
	Log a	n	Log a	n
Threadfin shad	−4.6733	2.9007	−1.8401	2.4843
Sacramento squawfish	−4.3921	2.7706	−2.0623	2.8536
Golden shiner	−4.8844	3.0266		
Bluegill			−3.0880	3.4469
Largemouth bass	−5.4801	3.2546		

As the stomach contents were analyzed, fish remains were identified and either their fork length or vertebrae length measured. Their preingested volumes were then estimated by solving the appropriate formula. Some fish were unidentifiable and, since most of these appeared to be cyprinids, their volumes were estimated from squawfish length-volume constants. An insignificant number of fish could be neither identified nor measured.

Preingested volumes of most arthropods were estimated from whole specimens found in stomach samples by determining the number of organisms of a given kind necessary to displace a milliliter of water (Table 2). Volumes of less-frequently encountered organisms, such as lizards and some arthropods, were approximated from remains of the organisms.

TABLE 2

Volume Displacements of Five Fish Food Organisms from Pine Flat Lake

Organisms	Number of organisms displacing 1 ml of water
Chironomid larvae and pupae	240
Culicid larvae	200
Cladocerans	1,100
Copepods	1,700
Terrestrial arachnids	48

The number of each type of invertebrate present in a jar was estimated by Borgeson's rapid analysis technique. These numbers were multiplied by the appropriate volume index to estimate the preingested volume. The results for each species of game fish were tallied by month and size group, and then combined by seasons for which food habits were similar. To offset differences in sample size, the results are presented as percentages. Numerical estimates are presented to allow comparisons, but conclusions are based on volume estimates.

RESULTS

Largemouth Bass

Stomachs from 312 largemouth bass taken throughout the year contained food. Forty-seven bass under 6 inches long taken from July to October consumed 3,744 organisms, including 3,688 cladocerans. By volume, threadfin shad constituted 72.5 percent and cladocerans 26.2 percent of the diet. Some midge and mayfly larvae were eaten.

Six- to 9.9-inch bass relied heavily on fish throughout the year (Table 3). From March to June, unidentified fish constituted 44.9 percent, golden shiners 11.2 percent, and threadfin shad almost 40 percent of the diet. During the remainder of the year, threadfin shad constituted almost the entire diet.

Bass over 10 inches long relied even more on fish (Table 4). Shad contributed 61 to 72 percent of the diet throughout the year, and unidentified fish were again the second most important food item. Though not of great volume, unidentified fish eggs and largemouth bass were consumed during the March–June and July–October periods, respectively.

Black Crappie

The diet of black crappie was similar to that of largemouth bass, but crappie ate more arthropods in the March-to-June period. During this period, 6.0- to 9.9-inch crappie consumed large quantities of midge larvae, cladocerans, and copepods (Table 5). These totaled over 45 percent of the diet. Golden shiners were the most important single item in the diet with threadfin shad again important. The results may be biased, since fishing pressure for crappie was extremely heavy at this time and golden shiners were used extensively for bait. During the remainder of the year, threadfin shad dominated the diet, although a few chironomid larvae were eaten. Chironomids became less important as the year progressed.

No black crappie over 10 inches long were sampled in the spring, but 30 taken from July through February contained 141 organisms. Shad constituted 57 percent numerically and 93 percent volumetrically of the contents. Besides shad, crappie ate largemouth bass and midge larvae.

TABLE 3

Stomach Contents of 6.0- to 9.9-inch Largemouth Bass, March 1963 to February 1964

Food organism	March–June		July–October		November–February		Total	
	Percentage of total number organisms	Percentage of total volume organisms	Percentage of total number organisms	Percentage of total volume organisms	Percentage of total number organisms	Percentage of total volume organisms	Percentage of total number organisms	Percentage of total volume organisms
Fish								
Lamprey (*Lampetra*)			Tr.	Tr.			Tr.	Tr.
Threadfin shad (*Dorosoma*)	1.9	38.8	68.5	87.3	71.0	99.9	32.6	82.2
Golden shiner (*Notemigonus*)	Tr.*	14.2	1.0	3.6			Tr.	4.0
Unidentified fish	1.2	44.9	3.1	8.4			1.6	12.5
Insects								
True flies (Diptera)								
Midge larvae and pupae (Chironominae)	93.5	3.4	17.5	Tr.	15.1	Tr.	58.5	Tr.
Miscellaneous	2.1	1.3					1.3	Tr.
Wasps, bees, ants, etc. (Hymenoptera)	Tr.	Tr.	8.2	Tr.			2.5	Tr.
True bugs (Hemiptera)	Tr.	Tr.	1.0	Tr.			Tr.	Tr.
Mayflies (Ephemeroptera)					11.0	Tr.	2.1	Tr.
Unidentified insects	Tr.	Tr.					Tr.	Tr.
Miscellaneous invertebrates	Tr.	Tr.						Tr.
Centipedes (chilopoda)								Tr.
Mussels, snails (Mollusca)							Tr.	Tr.

	March–June	July–October	November–February	12-month total
Total number food organisms	312	194	93	629
Total volume food organisms (ml)	39.29	124.43	60.94	221.66
Number of fish in sample	29	72	23	124

* Tr. equals less than 1.0 percent.

TABLE 4

Stomach Contents of Largemouth Bass Longer Than 10.0 Inches, March 1963 to February 1964

Food organism	March–June: Percentage of total number organisms	March–June: Percentage of total volume organisms	July–October: Percentage of total number organisms	July–October: Percentage of total volume organisms	November–February: Percentage of total number organisms	November–February: Percentage of total volume organisms	Total: Percentage of total number organisms	Total: Percentage of total volume organisms
Reptiles								
Fence lizard (*Sceloporus*)	Tr.*	5.2					Tr.	1.1
Fish								
Lamprey (*Lampetra*)			Tr.	Tr.			Tr.	Tr.
Threadfin shad (*Dorosoma*)	5.9	71.7	59.8	65.3	58.2	61.2	16.7	66.5
Golden shiner (*Notemigonus*)					1.5	1.8	Tr.	Tr.
Largemouth bass (*Micropterus*)			Tr.	4.5			Tr.	2.6
Bluegill (*Lepomis*)			Tr.	Tr.			Tr.	Tr.
Unidentified fish	1.4	22.8	6.2	29.9	9.0	36.9	2.5	28.9
Unidentified fish eggs	91.7	Tr.					72.9	Tr.
Insects								
True flies (Diptera)								
Midge larvae and pupae (Chironominae)	1.3	Tr.	32.1	Tr.	31.3	Tr.	9.6	Tr.
Crustaceans								
Waterfleas (Cladocera)	Tr.	Tr.					Tr.	

	March–June	July–October	November–February	12-month total
Total number food organisms	718	117	67	902
Total volume food organisms (ml)	192.42	409.44	97.91	699.77
Number of fish in sample	29	93	19	141

* Tr. equals less than 1.0 percent.

TABLE 5

Stomach Contents of 6.0- to 9.9-inch Black Crappie, March 1963 to February 1964

Food organism	March-June		July-October		November-February		Total	
	Percentage of total number organisms	Percentage of total volume organisms	Percentage of total number organisms	Percentage of total volume organisms	Percentage of total number organisms	Percentage of total volume organisms	Percentage of total number organisms	Percentage of total volume organisms
Fish								
Threadfin shad (*Dorosoma*)	Tr.*	9.4	13.0	96.3	82.5	99.95	2.0	76.0
Golden shiner (*Notemigonus*)	Tr.	42.1					Tr.	12.9
Unidentified fish	Tr.	1.8			8.8	?	Tr.	Tr.
Insects								
True flies (Diptera)								
Midge larvae and pupae (Chironominae)	64.2	42.1	86.9	3.7	8.8	Tr.	65.7	11.9
Crustaceans								
Waterfleas (Cladocera)	21.7	3.1					19.5	Tr
Copepods (Copepoda)	14.1	1.3					12.7	Tr.
Miscellaneous invertebrates								
Terrestrial spiders (Arachnida)	Tr.	Tr.					Tr.	Tr.
							12-month total	
Total number food organisms	7,387		745		80		8,212	
Total volume food organisms (ml)	46.75		72.48		68.37		187.60	
Number of fish in sample	42		65		25		132	

* Tr. equals less than 1.0 percent.

White Catfish

Catfish were divided into two size groups: 4.0 to 7.9 inches and 8.0 inches or larger. Nineteen of the smaller fish collected from March to October contained 258 organisms, of which 91 percent numerically and 93 precent volumetrically were midge larvae. Cladocerans, mosquito larvae, and terrestrial spiders were the other items eaten.

Catfish over 8 inches long relied on midge larvae during the March–June period. They also consumed a few unidentified fish eggs and cladocerans (Table 6). From July–October threadfin shad constituted over 97 percent of their diet by volume. Most of the fish sampled during this period came from one group of fishermen who fished in a single area; consequently, these results may not represent the diet of catfish in the lake as a whole. During the November–February period only seven of the fish captured contained food. These had consumed a few midge larvae, but an annual terrestrial plant, filaree (*Erodium* sp.), was the main food.

Bluegill

Bluegill of the two size groups studied had similar diets throughout the 12-month period (Tables 7 and 8). During the March–June season both the 4.0- to 5.9-inch and the 6.0- to 9.9-inch fish consumed large amounts of unidentified fish eggs and midge larvae. Other important items for the smaller fish were cladocerans, beetles, miscellaneous hemipterans, aphids, and dragonfly larvae. Reflecting the preference of larger food, the 6.0- to 9.9-inch fish consumed fewer cladocerans, more dragonfly larvae, and more beetles plus terrestrial spiders.

From July–October, dragonfly larvae, chironomid larvae, and cladocerans were still important for both size groups, but terrestrial insects were their diet mainstay. Beetles, miscellaneous dipterans, hymenopterans, hemipterans, and terrestrial spiders were the main food items. The 6.0- to 9.9-inch fish contained a few unidentified fish eggs and relied more heavily on terrestrial spiders than did the smaller bluegills.

From November–February smaller bluegill ate chironomid larvae and cladocerans exclusively. Larger fish consumed large quantities of these organisms and miscellaneous dipterans were also important. Threadfin shad constituted a main portion of the diet for some of the larger fish.

DISCUSSION

These results approximate those reported for other waters (Lagler, 1956; Kimsey, Hagy, and McCammon, 1957). More important, the results indicate that in Pine Flat Lake game fish subsist principally upon seasonally abundant cladocerans, chironomid larvae, terrestrial arthropods, and threadfin shad.

Cladocerans are available all year but are consumed in largest numbers in the winter and spring.

TABLE 6

Stomach Contents of White Catfish Longer Than 8.0 Inches, March 1963 to February 1964

Food organism	March-June		July-October		November-February		Total	
	Percentage of total number organisms	Percentage of total volume organisms	Percentage of total number organisms	Percentage of total volume organisms	Percentage of total number organisms	Percentage of total volume organisms	Percentage of total number organisms	Percentage of total volume organisms
Fish								
Threadfin shad (*Dorosoma*			89.5	97.5			11.5	91.0
Unidentified fish			1.7	2.4			Tr.	2.2
Unidentified fish eggs	1.1	Tr.*					1.2	Tr.
Insects								
True flies (Diptera)								
Midge larvae and pupae (Chironominae)	97.7	99.5	8.7	Tr.	30.0	Tr.	83.0	2.6
Beetles (Coleoptera)			Tr.	Tr.			Tr.	Tr.
Crustaceans								
Waterfleas (Cladocera	Tr.	Tr.					Tr.	Tr.
Plants								
Filaree (Geraniaceae)					70.0	99.9	Tr.	4.1

	March-June	July-October	November-February	12-month total
Total number food organisms	2,135	416	10	2,561
Total volume food organisms (ml)	8.75	317.61	14.01	340.37
Number of fish in sample	22	49	7	78

*Tr. equals less than 1.0 percent.

TABLE 7

Stomach Contents of 4.0- to 5.9-inch Bluegill, March 1963 to February 1964

Food organism	March–June		July–October		November–February		Total	
	Percentage of total number organisms	Percentage of total volume organisms	Percentage of total number organisms	Percentage of total volume organisms	Percentage of total number organisms	Percentage of total volume organisms	Percentage of total number organisms	Percentage of total volume organisms
Fish								
Unidentified fish eggs	51.1	21.7					48.3	13.2
Insects								
True flies (Diptera)								
Midge larvae and pupae (Chironominae)	16.9	15.3	35.6	9.0	15.2	45.0	17.7	32.3
Miscellaneous	Tr.*	Tr.	14.0	56.6			Tr.	20.2
Wasps, bees, ants, etc. (Hymenoptera)			5.6	2.2			Tr.	Tr.
True bugs (Hemiptera)								
Aphids (Aphidae)	Tr.	1.2					Tr.	Tr.
Miscellaneous	Tr.	7.8	3.9	11.7			Tr.	8.9
Beetles (Coleoptera)	Tr.	Tr.	2.7	2.7			Tr.	Tr.
Dragonflies and damselflies (Odonata)	Tr.	6.8	1.7	8.6			Tr.	7.2
Crustaceans								
Waterfleas (Cladocera)	25.5	14.9	28.1	1.5	81.7	55.0	29.1	11.2
Copepods (Copepoda)	2.5	1.0	2.7	Tr.			2.1	Tr.
Miscellaneous invertebrates								
Terrestrial spiders (Arachnida)			5.7	7.5			Tr.	2.7
Centipedes (Chilopoda)	Tr.	Tr.					Tr.	Tr.
Earthworms (Annelida)					Tr.	Tr.	Tr.	Tr.

	March–June	July–October	November–February	12-month total
Total number food organisms	31,509	1,751	2,055	35,318
Total volume food organisms (ml)	49.10	28.95	2.89	80.94
Number of fish in sample	75	56	21	152

*Tr. equals less than 1.0 percent.

TABLE 8

Stomach Contents at 6.0- to 9.9-inch Bluegill, March 1963 to February 1964

Food organism	March–June: Percentage of total number organisms	March–June: Percentage of total volume organisms	July–October: Percentage of total number organisms	July–October: Percentage of total volume organisms	November–February: Percentage of total number organisms	November–February: Percentage of total volume organisms	Total: Percentage of total number organisms	Total: Percentage of total volume organisms
Fish								
Threadfin shad (*Dorosoma*)					Tr.	57.3	Tr.	13.8
Unidentified fish eggs	68.1	17.7	27.9	2.0			21.5	2.0
Insects								
True flies (Diptera)								
Midge larvae and pupae (Chironominae)	21.6	38.9	31.1	11.4	16.2	9.9	26.1	10.9
Miscellaneous	Tr.*	4.6	5.8	43.5	2.0	18.8	4.2	36.3
Wasps, bees, ants, etc. (Hymenoptera)			9.8	7.3			6.1	5.3
True bugs (Hemiptera)			Tr.	4.3			Tr.	3.1
Moths, butterflies, etc. (Lepidoptera)					Tr.	Tr.	Tr	Tr.
Beetles (Coleoptera)	2.5	17.0	3.3	6.3	Tr.	1.1	2.3	5.1
Dragonflies and damselflies (Odonata)	Tr.	11.1	Tr.	4.7			Tr.	3.8
Crustaceans								
Waterfleas (Cladocera)	5.4	2.0	13.2	1.3	78.6	10.3	30.0	3.5
Seed shrimp (Ostracoda)			Tr.	Tr.			Tr.	Tr.
Copepods (Copepoda)					1.5	Tr.	Tr.	Tr.
Miscellaneous invertebrates								
Terrestrial spiders (Arachnida)	Tr.	8.5	7.3	17.6	Tr.	1.6	4.6	13.5
Water mites (Hydracarina)	Tr.	Tr.					Tr.	Tr.
Earthworms (Annelida)					Tr.	Tr.	Tr.	Tr.

	March–June	July–October	November–February	12-month total
Total number food organisms	643	3,915	1,682	6,240
Total volume food organisms (ml)	1.53	35.23	11.69	48.15
Number of fish in sample	20	60	40	120

*Tr. equals less than 1.0 percent.

Immature chironomids are also available the year around, but are most abundant during the late spring and early summer. Chironomids appear well adapted to the lake's artificial and changing environment, and may prove to be the most important invertebrate food organism in fluctuating, steep-sided reservoirs. Spot checks of crappie diets in five southern California reservoirs indicate that midge larvae are important there, too (Goodson, unpublished manuscript).

Adult terrestrial arthropods were consumed in quantity only during the July-to-October season and then mainly by bluegill. Annual grasses (primarily *Hordeum* sp.), blue oak (*Quercus Douglasii*), and Digger pine (*Pinus Sabiniana*) cover the surrounding shores and probably harbored these organisms.

Threadfin shad were consumed in quantity by virtually all fish large enough to handle them—including bass under 6 inches long. Since 1954, shad have been introduced in many waters throughout California and Arizona. A recent study indicated that shad do not provide adequate forage for yearling centrarchids in Pena Blanca Lake, Arizona, where shad have a single, short, spawning period (McConnell and Gerdes, 1964). Shad were too large to be readily eaten by yearling centrarchids during the spring and fall months. At these times, no shad under 50 mm total length were observed. However, shad in Pine Flat Lake and in nearby Millerton Lake probably have a longer spawning season. At Millerton Lake on September 25, 1963, Charles E. von Geldern and I observed large numbers of shad approximately 25 mm long. These should be ideal forage for bass and crappie young of the year and yearlings through the fall and early winter. Shad were more heavily utilized in Pine Flat Lake than in Pena Blanca Lake, possibly for this reason.

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INTRODUCTION OF THE BONNEVILLE CISCO (*PROSOPIUM GEMMIFERUM* SNYDER) INTO LAKE TAHOE, CALIFORNIA AND NEVADA [1]

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Bonneville cisco were introduced into Lake Tahoe in 1964 to improve the food supply for lake trout and possibly other species of trout. Few forage fishes occur naturally in Tahoe's deep water areas during summer, and we expect the Bonneville cisco to fill this gap. This cisco is a small, active, plankton feeder, widely distributed and abundant in its native habitat. It lacks parasites, spawns on lakeshores, and prefers colder waters the year around. At Bear Lake, Utah-Idaho, it provides an important dipnet sport fishery.

BASIS FOR INTRODUCTION

Bonneville cisco were introduced into Lake Tahoe in January 1964 as a forage fish for lake trout, *Salvelinus namaycush*, after studies showed that lake trout lacked forage during the summer (Lake Tahoe Fisheries Study, unpublished data).

During the summer, lake trout inhabit depths from 100 to 500 feet. An important forage fish, the Piute sculpin, *Cottus beldingii*, is most abundant then at depths less than 100 feet, with smaller numbers found down to 300 feet, and very few deeper. Other forage fishes such as the tui chub, *Siphateles bicolor*, Lahontan redside, *Richardsonius egregius*, and Tahoe sucker, *Catostomus tahoensis*, favor shallow, warmer waters from mid-May through October. At this time, lake trout under 15 inches fork length eat plankton primarily, followed by sculpin. By frequency of occurrence, these remain the most important food items in fish up to 20 inches long.

A literature survey and correspondence with other fisheries workers showed that rapid lake trout growth is associated with abundant forage fish populations (Martin, 1952; Cuerrier, 1954; McCaig and Mullan, 1960). In the Great Lakes and large, deep Canadian lakes, ciscos (although of the genus *Coregonus*) are the most abundant forage fishes and often comprise the bulk of lake trout diets (Rawson, 1961). Bonneville cisco may prove to be a better forage fish than ciscos found in these lakes because they are smaller and have an extremely low incidence of parasitism. This species, like others in the cisco-whitefish complex, seeks colder waters the year around. Seasonal movements, except for spawning migrations, correspond to those of lake trout. However, they are also abundant in the open water or limnetic zone.

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Snyder (1919) and later Perry (1943) discussed their potential as a forage fish for trout.

An abundant cisco population may, at least during their winter inshore spawning migration, supplement the food supply of rainbow trout, *Salmo gairdnerii,* and brown trout, *Salmo trutta.* Apart from the mid-May through October period, we believe existing Tahoe forage fishes remain relatively dormant close to the cover of rocks and submerged aquatic plants. The cisco moves widely during the colder months and thus should be more available.

The vast limnetic zone of Tahoe is devoid of fish life except for relatively few rainbow trout and a small population of kokanee salmon, *Oncorhynchus nerka.* This area supports unusually low densities of zooplankton, but the plankton that is present occurs commonly to 300 feet and in lesser numbers to 500 feet. Rainbow now feed mostly on surface insects. With the cisco as forage, a trophy rainbow fishery may develop.

One potential problem is that cisco might compete with lake trout for food and space, especially with small trout. We believe this risk is minimal, since the studies mentioned earlier showed that lake trout do well in the presence of abundant forage.

Another potential drawback is that Bonneville cisco may not become established in Lake Tahoe because of habitat differences between Tahoe and Bear Lake, Utah-Idaho, their native habitat. Both waters are cold and have dissolved oxygen suitable for trout at all depths and seasons. But Tahoe is extremely oligotrophic (McGauhey *et al,* 1963), while Bear Lake is only moderately so (McConnell *et al,* 1957). Bear Lake is also considerably smaller and shallower than Tahoe (maximum depth of 208 feet compared to 1,645 feet).

THE BONNEVILLE CISCO

The cisco is one of three whitefishes endemic to Bear Lake (Snyder, 1919). It is found nowhere else and this is the first attempted extension of its range.

The cisco is small, slender and typically whitefish-like in appearance except for a distinctly long and sharply pointed snout (Figure 1). The sides are bright and silvery except during the spawning season when they develop longitudinal gold and bronze bars. One of the smallest North American coregonids, it attains a maximum total length of under 8.5 inches. Growth is relatively rapid the first 3 years and then abruptly levels off. According to Perry (1943), total length in inches at the end of each year of life approximates 2.1, 4.1, 5.7, 6.5, 7.0, and 7.2, and a 10-year-old cisco may be only 7.7 inches long. However, Bangerter (1964) found that fish from 3 to 7 years old in the dip-net fishery had average total lengths of 6.5, 7.1, 7.5, 7.8, and 8.1 inches. Perry (1943) believed genetic rather than environmental factors controlled growth rate.

Cisco feed almost entirely on plankton with heavy year-round reliance on the copepod *Epischura* except during spring, when the cladocerans, *Bosmina* and *Chydorus*, and the copepod, *Cyclops*, increase in importance (Perry, 1943). Along with the rotifer *Conochilus, Epis-*

FIGURE 1. Bonneville cisco. Photograph by Ted C. Frantz.

chura is the most abundant and widely distributed zooplankter in Bear Lake (Perry, 1943; McConnell *et al*, 1957). During the spawning run, cisco feed heavily on their own eggs (Bangerter, 1962). Sigler (1962) states, "Bottom dwelling invertebrates are taken more commonly by the cisco in the winter months when the ciscos are in close to shore."

Unlike other species of cisco and whitefish, this form has an extremely low incidence of parasitism (Perry, 1943).

Numerically the Bonneville cisco is the most abundant species in Bear Lake (Sigler, 1962). This was determined by gill nets set in open water (Perry, 1943) and on the bottom (Loo, 1960; Hassler, 1960). Distribution has been correlated with depth, temperature, and zooplankton abundance. Loo (1960) believed temperature exerted the controlling influence while Sigler and Miller (1963) stated that food was probably the prime factor. The most dense cisco concentrations are found along the steep east shore (Loo, 1960). Perry (1943) found cisco widely distributed throughout Bear Lake except during the summer when they remained in and below the thermocline and seemed to prefer temperatures less than 59° F. Using bottom gill nets, McConnell *et al* (1957) reported cisco numbers increased with depth. However, Loo (1960) and Hassler (1960) found cisco most concentrated at 50 and 100 feet, with lesser numbers at 150 feet; they reported a similar distribution for lake trout.

Food habit studies of Bear Lake game fishes have been few and the samples small. Smart (1958) examined 28 lake trout stomachs and found, "Sculpin were in the majority of stomachs except during December and January when cisco was more common. This was due to the inshore spawning schools of cisco which made them more available to the lake trout." Cisco and sculpin were the most important foods in 24 cutthroat *(Salmo clarkii)* stomachs, while 67 rainbow stomachs yielded primarily surface insects. Examination of additional cutthroat and rainbow stomachs showed about the same food habits picture (McConnell *et al*, 1957).

Cisco spawn along a rocky 2-mile section on the east shore of Bear Lake between North and South Eden creeks which is adjacent to the only steep slope in the lake (Bangerter, 1962, 1963, and 1964). Spawning generally covers a 2-week period in January but sometimes extends into February. During the past five spawning seasons (1961–1965) an ice cover was present only once. Eggs are dispersed over a rock and rubble substrate in shallow water, sometimes less than a foot deep. The maximum spawning depth has not been established. The sex ratio on the spawning ground has averaged from 2.4 to 6.4 males per female with daily ratios often exceeding 10 to 1. The sex ratio at other times of the year is close to 1 to 1. The cisco matures in either the 2nd or 3rd year of life. Five- and 6-year-old fish dominate the spawning runs followed by 4– and 7–year–olds. Water temperatures during spawning and egg incubation range from 32 to 39° F, but are usually 34 or 35° F. Ten female cisco were spawned and averaged 1,301 eggs each.

Despite severe winter conditions, a very popular and productive dip-net sport fishery takes place during the spawning period. Sportsmen harvested 159,292 fish in 1962, 118,728 in 1963, and 106,863 in 1964 (Bangerter 1962, 1963, 1964). Fishing is good with or without an ice cover. Cisco are considered a delicacy and some fishermen traveled over 400 miles round trip to get them.

COLLECTION AND TRANSPORTATION

Lightweight, 18-inch diameter circular dip nets with ½-inch stretched mesh and 10-foot aluminum handles were efficient collecting tools. Most cisco were collected between 7 and 10 A.M. They were placed in holding pens in the lake and were later transferred in 5-gallon containers to two, 1,000-gallon (700-gallon carrying capacity) fish-planting trucks. Although the fish tanks and pipes were insulated, lake water (33° F) introduced into the units froze in the pump system unless motors were operated or preheated with warmer water.

The two trucks hauled 3,500 and 5,000 cisco. The trips took 24 and 27 hours, respectively. Each utilized combination spray and oxygen aeration. Temperatures were maintained between 42 and 50° F.

Part of each load was released over rubble substrate at Cave Rock on the east side of the lake and part at Pebble Beach on the west side where the substrate is similar to the spawning area at Bear Lake.

Approximately 4,600 males and 900 females were released alive. Mortality was 41 percent for the first load and 31 percent for the second. Of the dead fish, 55 percent were females and 45 percent males. A check of dead females revealed that only 6 percent were spent. In January 1962, experimental hauling from Bear Lake to Battle Mountain, Nevada, resulted in only 13 percent mortality. Hours in transport and fish per gallon of water on this haul were similar to the first 1964 load. The higher 1964 mortality probably centered around netting and loading techniques at Bear Lake. Losses could be substantially reduced by decreasing the time interval from capture to placement in the tank, by eliminating overcrowding in holding pens and 5-gallon buckets, and by maintaining tank temperatures during loading similar to lake temperatures. In the planting tank, losses probably can be reduced by decreasing water agitation and carrying less than five fish per gallon of water.

About 45,000 eggs were taken and fertilized from angler-caught fish. They were placed in two, 1-gallon "thermos" jugs and transported by truck at temperatures ranging from 32.5 to 42° F for a period of 22 to 27 hours.

Approximately 5,000 eggs were placed in hatchery incubator trays. Some hatched but none of the fry lived longer than 23 days. An estimated 40,000 eggs were dispersed through a syringe held under water in two rocky areas at Lake Tahoe: off Rocky Point on the northwest shore, and south of Sand Harbor on the east shore. The eggs were distributed over depths from 6 inches to 3 feet. Success of development is unknown.

Some green eggs were put in cheesecloth sacks and placed in Lake Tahoe under rocks in about 12 inches of water. Thirty-one days later several eggs had reached the eyed-stage. Some eggs were alive after 45 days but survival was low. Loss of sacks ended the test before any eggs hatched. During this period, water temperatures varied from 36 to 50° F.

ACKNOWLEDGMENTS

We are indebted to the Utah State Department of Fish and Game for their cooperation in obtaining Bonneville cisco from Bear Lake. Particular appreciation is extended to Arnold Bangerter, Utah Fishery Biologist, for his sincere interest, cooperation, and long hours in the field which made this venture successful. We thank personnel of Nevada's Washoe Rearing Station who handled the actual transportation. The editorial assistance of H. K. Chadwick, California Inland Fisheries Research Supervisor, is gratefully acknowledged.

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PHYSIOLOGICAL EFFECTS OF DDT ON PHEASANTS[1]

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The effects of DDT on penned pheasants was studied. The insecticide was offered to test birds in pelleted and wheat diets. Diets were contaminated at levels of 10, 100, and 500 ppm DDT.

Data were obtained on the influence of the contaminated diets on egg production, fertility and hatchability and the survival rate of chicks. Chronic toxicity of the DDT diets to breeding pheasants was recorded.

Results demonstrated that 500 ppm diets were highly toxic to breeder pheasants. All hens fed DDT-contaminated diets passed residues into their eggs. Egg production, fertility, and hatchability were not affected at the contaminated diet levels fed. Chick mortalities were highest among young from parents receiving 500 ppm diets. Evidence was obtained suggesting DDT residue levels in the brain may be used as an indicator of DDT intoxication in pheasants.

DDT and other chlorinated hydrocarbon insecticides are widely used by the agricultural industry in California. This use has resulted in the accumulation of residues in wildlife inhabiting many farm areas. There is a growing demand for basic information that can be used to evaluate the significance of pesticide residues in wildlife and the environment.

Our research applies specifically to pheasants, but the results will have broad application to other birds. Specific aims of the study were to investigate: (i) the rate of build-up of DDT residues in female pheasants under various feeding patterns; (ii) the rate and amounts of residue transferred from the female to the eggs; (iii) the influence of ingesting DDT during the egg-laying period on the residue levels found in eggs; (iv) the effects of residues on hatchability of the eggs and viability of the young; (v) the evidence of pathological effects on vital organs of test birds; and (vi) the possibility of using residue levels in the brain in diagnosing death of wild pheasants from DDT intoxication.

Trials with penned pheasants (Genelly and Rudd, 1956 and DeWitt 1955 and 1958) indicated that the ingestion of sublethal amounts of DDT had an adverse effect on the reproductive capabilities of pheasants. However, these studies did not include comprehensive residue data to support the biological findings.

In California, in field studies by the Department of Fish and Game during 1962, DDT residues were found in the tissues of all pheasants examined (Hunt and Keith, 1963). It was further demonstrated that high levels of DDT residues occurred in the fatty tissues of wild female pheasants under certain conditions of exposure. These studies indicated that high levels were associated with increased crippling and

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lowered viability of the progeny. Egg production as well as fertility and hatchability of the eggs were not measurably affected. These studies were subject to many unmeasured variables including lack of precise information on the intake of DDT.

In the present study, the intake of insecticide was recorded and the effects of DDT on test pheasants and their progeny measured. The results were supported by a program of residue analysis.

This paper presents the results obtained during the first year of the investigation.

MATERIALS AND METHODS

Test Birds

During January 1964, test birds were obtained from the state game farm at Yountville, California. The same strain of pheasants (*Phasianus colchicus torquatus*) had been maintained at Yountville for at least 12 years and was used in prior pheasant-pesticide studies by Genelly and Rudd (1956).

Penned pheasants may be expected to obtain small amounts of DDT from commercially prepared food. A composite fat sample from test birds taken at the beginning of the feeding trials contained less than .01 parts-per-million (ppm) DDT.

All study birds were banded. Each pheasant was weighed at the inception of the study and birds sacrificed were weighed prior to autopsy.

Diets

DDT was added to wheat diets and incorporated into pelleted feed. The wheat diets were formulated at the Department of Fish and Game, Field Station in Sacramento. Measured amounts of DDT were dissolved in acetone. Fifty ml of the solutions were applied to 1 kg batches of wheat. These components were agitated in 1-gallon jars, then spread on metal trays to air dry.

Pelletted diets were prepared at the Denver Wildlife Research Laboratory of the United States Fish and Wildlife Service. Designated quantities of DDT powder were mixed with 1 to 2 pounds of feed that had been passed through a 50-mesh screen. This mixture was then added to feed that had passed through a 30-mesh screen and the resulting product cut with sufficient unscreened feed to produce 5 to 8 pounds of concentrate. The concentrate was mixed in a Y-blender with enough ground feed to make batches of 100 to 200 pounds. These mixtures were pelleted and spread on paper to dry. Diets were prepared to contain 10, 100, and 500 ppm DDT. These values were used to determine the total amount of DDT consumed by birds on each dietary level. Quality control analysis showed that these concentrations were attained within ±10 percent.

The DDT used to prepare contaminated feed was a technical grade wet-table powder which contained 74.11 percent actual insecticide. The active ingredient was comprised of three isomers of DDT in the following proportions: p,p′ isomer—75.7 percent; o,p′ isomer—17.4 percent; o,o′ isomer—6.0 percent. Unidentified ingredients were present at a level of 0.9 percent.

Feeding Regimen

The food supply, either wheat or pellets, was weighed and placed in a metal hopper in each pen daily. Spilled feed and feed remaining in the hopper from the previous day were collected and weighed. The weight of unused feed was subtracted from the amount provided on the previous day to determine daily feed consumption.

Uncontaminated 27 percent protein turkey starter crumbles were given all chicks for a period of 46 days after hatching.

Feeding Trials

The feeding trials were conducted in three phases. The first phase began on February 20 and extended until egg-laying began on March 26. At the inception of the feeding trials, groups of pheasants were placed on wheat and pellet diets containing the three levels of DDT. Control birds received similar diets with no DDT added. All birds fed 500 ppm diets were taken off the contaminated diet on March 13 because of mortality. These birds were fed uncontaminated food until March 24. At this time, they were placed on a 500 ppm diet 1 day a week for the remainder of this phase of the study. On the other 6 days of the week these birds received uncontaminated diets.

The second phase of the feeding trials coincided with the egg-laying period which extended from March 26 through June 3. At the beginning of this period, one-half of the birds receiving contaminated feed were placed on uncontaminated diets. The other half continued to receive the same level of DDT in their diets. The change in feeding patterns was accompanied by the separation of breeding pheasants into eight groups consisting of 10 females and 1 male per pen. The following categories resulted: two groups were used as controls, three groups that had previously received DDT in their diets were placed on uncontaminated diets, and three groups continued to receive DDT at levels of 10, 100, and 500 ppm for the remainder of the egg-laying period. The schedule previously adopted of feeding 500 ppm diets 1 day a week was continued through the egg-laying period.

On March 28, two males and two females were taken from each of the eight dietary groups. However, only two males were still alive from the groups fed the 500 ppm DDT diets. These birds were placed in 12- by 24-foot pens in pairs, retaining the dietary pattern of the group from which they were separated. This was done to facilitate collecting and identifying eggs from an individual hen.

The third phase of the feeding trials started June 25 and continued until the breeding cycle began again in February. Twenty chicks were selected from the progeny of parents that had received the three DDT contaminated diets during the egg-laying period. Twenty chicks were taken from progeny produced by breeders from the control groups. These chicks were used as controls for an overwintering feeding trial. The chicks from the parents with a history of contaminated diets were separated into two groups. One of these groups received feed containing 10 ppm DDT, and the other feed containing 100 ppm DDT.

Production Trials

The eggs from birds penned in groups were used to determine hatching success and chick survival. Eggs were collected daily, marked, and stored at 55 to 60° F. Egg storage varied from 1 to 7 days. Soft-shelled, cracked, and small eggs were not incubated but were saved for residue analysis. Ninety-four percent of the eggs collected were set.

Incubation of eggs started April 1, 1964. Eggs were set once a week for 9 consecutive weeks. A forced-draft incubator (Jamesway 2940) was used for the first 21 days of incubation. The eggs were then transferred to pedigree cages and placed in a still-air incubator (Buffalo #6) for hatching. Four still-air incubators were used. Successive lots of eggs were placed in different still-air incubators to mask any possible effect of the incubators on hatchability. Temperatures in the forced-draft incubators were maintained between 99 and 100° F and in the still-air incubators from 101 to 105° F. Humidity was controlled during the first 21 days so that the weight lost by the incubating eggs was from 14.7 to 16.5 percent.

Shortly after hatching, the chicks were removed from the incubators, counted and marked as to parental group. Marking was done by clipping the hind toe(s), injecting black India ink into the wing webbing, or both. Chicks were placed in Jamesway battery brooders for 30 days. Standard brooding practices were used. Heat (80 to 90° F) was provided for the first 10 days.

Month-old birds were placed in outdoor rearing pens. At age 46 days they were sexed, counted, and segregated into groups corresponding to the dietary group of their parents. Some of these subadults were sacrificed and others placed on DDT contaminated diets.

Statistical evaluations were made of data pertaining to egg production, egg fertility, egg hatchability, and chick survival. The significance of the differences observed were determined by Chi Square and Student T tests.

Sampling

Eggs from penned pairs were collected daily, marked for identification, frozen, and retained for pesticide residue analysis. Analyses were made of all of the eggs laid by two females. The residues were determined in 13 to 25 percent of the eggs from the other females in this category. Females of each dietary group were sacrificed after they had laid 40 to 45 eggs, and tissue samples were taken for residue analysis.

Pheasants of breeding age were sacrificed at the beginning and end of the egg-laying period. Samples obtained were used for residue analysis and pathological examination. Samples for residue analysis were taken from all adults that died during the study. Samples of chicks that died within 1 week after hatching were analyzed. These young were from parents fed the three dietary levels of DDT.

Residue Analysis

Entire chicks, minus feet, were analyzed; if yolks were still present, these too were removed. When analyzing eggs, only yolks were used. Fat samples from adults were selected from either visceral or subcutaneous fat, or both. Brain samples comprised the whole brain.

Fresh tissue samples were weighed, mixed with anhydrous sodium sulfate, and extracted with hexane. Hexane extracts were cleaned-up of interfering substances such as fats, waxes, and pigments. The first step involved a partitioning process with dimethylformamide as described by DeFaubert, Maunder *et al.*, (1964). Finally, the pesticide-hexane samples were cleared of interfering substances by filtering through a chromatographic column as described in the A.O.A.C. method for DDT. Considerable difficulty was encountered in obtaining solvents free of electron-capturing substances.

Two Wilkens Hy-Fi, Model 600C, gas chromatographs were used: one fitted with a 5 percent Dow-11 column, the other with a 5 percent QF-1 column. The purpose of the two instruments with different columns was to allow for analysis of DDT isomers and isomeric metabolic products of DDT.

Gas chromatographic results were quantitated by the "peak-height" method. The results were calculated on a tissue fresh-weight basis. DDT residue values reported represent the sum of the p,p′ and o,p′ isomer values obtained. Standard pesticide solutions were chromatographed along with samples to take into account daily changes that occurred in detector cell response. Replicates of standards and test samples indicated a 5 to 10 percent variation in detector cell response during this study. Our tests indicated that overall pesticide recovery was approximately 80 percent. This value is well within accepted analytical recovery values as stated by other workers in the field.

RESULTS

Feeding Trials

Food Consumption

From February 20 until the 2nd week of egg production (46 days), DDT contaminated feed taken by pheasants on the 10 ppm diets consisted of 39 percent wheat and 61 percent pellets. Pheasants on 100 ppm diets consumed 10 percent wheat and 90 percent pellets, and those on 500 ppm DDT diets ate 9 percent wheat and 91 percent pellets. For the same period, the feed intake of the control birds was 7 percent wheat and 93 percent pellets. Wheat was not fed after the 2nd week of egg production.

DDT treated feeds were accepted on a parity with uncontaminated feeds. For groups fed contaminated feed through the egg-laying period, about 105 days, the approximate amount of DDT ingested per bird prior to egg-laying was: 15.3, 175, and 437 mg, by the 10, 100, and 500 ppm DDT dietary groups, respectively. During the egg-laying period, the quantity of DDT taken per bird was about 32.5, 350, and 270 mg, for the three diet levels. Groups receiving contaminated diets until the start of egg-laying (33 days) and none thereafter consumed approximately the following amounts of DDT per bird: 10 ppm groups—15 mg; 100 ppm group—151 mg; 500 ppm group—484 mg (Figure 1). The consumption of prepared feeds, contaminated and uncontaminated, was reduced between March 19 and April 4. This was caused by the disturbance of moving the pheasants from Yountville to Vacaville. The availability of fresh green feed in the Vacaville pens also cut down intake of prepared feed.

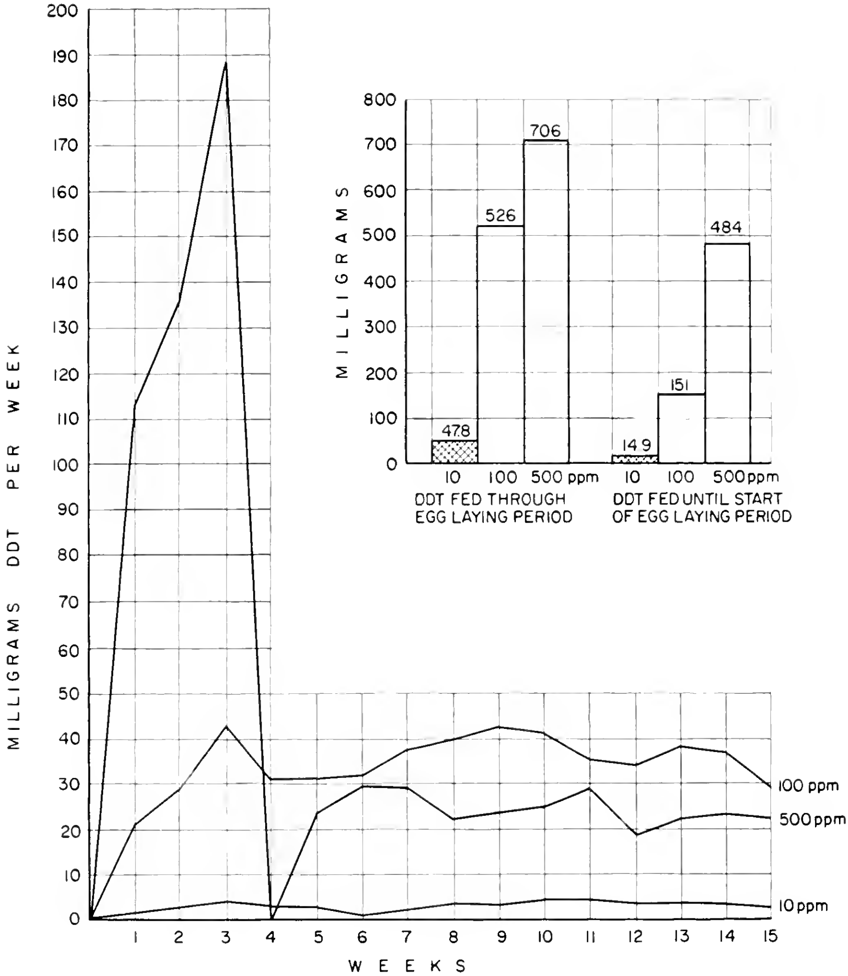

FIGURE 1. Line graph represents average weekly intake of DDT per pheasant for three levels of contaminated feed. Bar graph illustrates total intake of DDT per bird.

Breeder Mortality

Losses of breeders fed contaminated diets began 22 days after these feeds were first offered. For birds fed contaminated diets through egg-laying, mortalities among the 500 ppm DDT group were six males (100 percent) and one female (6 percent); and among the 100 ppm group, two males (33 percent) and one female (6 percent). There were no losses in the group fed the 10 ppm diets. For pheasants fed with DDT until the start of egg-laying, losses in the 500 ppm group were six males (100 percent) and five females (29 percent). In the 100 ppm group, one female (6 percent) succumbed. There were no deaths in the 10 ppm group. All males from the 500 ppm groups died within

63 days after the start of the trials. This necessitated placing males from the 100 ppm groups in the pens with females of the 500 ppm DDT groups.

Prior to death most birds were observed trembling or having difficulty walking, flying, or maintaining equilibrium. These are symptoms commonly associated with DDT intoxication.

Production Trials

Eggs

There was a direct relationship between egg-laying and quantity of feed consumed (Figure 2). However, the concentrations of DDT in the diets had little if any effect on egg production. Production ranged from 0.769 (a 10 ppm group) to 0.956 (control group) eggs per hen day (Table 1). In only the group receiving the 10 ppm diet through egg-laying did egg production and the egg-laying rate differ significantly from the controls at the 5 percent level ($P < .05$) (Figure 3).

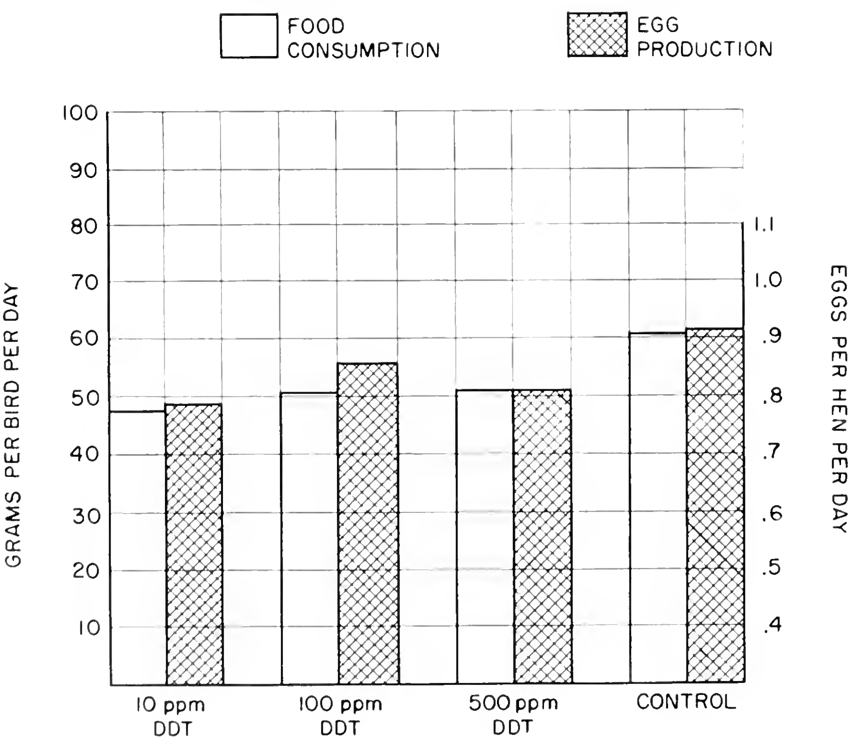

FIGURE 2. Relationship of pheasant egg production to food consumption for four diets.

Fertility in the male or female pheasants was not affected by ingestion of the DDT contaminated diets. This was demonstrated by two findings: (i) the percent of fertile eggs from birds on contaminated diets generally fell between the levels of fertility of eggs from the two control groups (Table 1), and (ii) fertile eggs were laid by females of

TABLE 1

Pheasant Egg Production, Fertility, and Hatchability

	DDT in feed (ppm)	Hen days	Eggs laid	Eggs hen day	Eggs incubated	Eggs fertile	Percent fertile	Young hatched	Percent hatched	Chicks per hen
DDT fed through egg-laying	10	580	446	.769	420	411	97.9	320	77.9	32.0
	100	580	498	.859	473	452	95.6	330	73.0	33.0
	500	580	468	.807	444	437	98.4	353	80.8	35.3
DDT fed until start of egg-laying	10	580	497	.857	468	462	98.7	376	81.4	37.6
	100	580	475	.819	453	445	98.2	341	76.6	34.1
	500	522	453	.868	420	396	94.3	297	75.0	33.0
Control #1		592	518	.875	475	428	90.1	336	78.5	33.6
Control #2		565	540	.956	508	500	98.4	381	76.2	38.1

one group for 24 days after the only male in the group died from DDT intoxication. This is the normal fertility carry-over period for pheasants (Twining, Hjersman, Macgregor, 1948).

The overall hatching success of eggs ranged from 73.0 to 81.4 percent for the groups fed DDT, and was 77.3 percent for the controls. Differences in hatching success between the control groups and groups fed DDT did not differ significantly at the 5 percent level ($P > .05$). However, there was significant lowering of hatching success from the first half of the laying period (77.3 percent) to the second half (66.6 percent) for the group fed the 100 ppm diets through the egg-laying period (Figure 4). Hatching success for the first half of the laying period for control eggs was 75.7 percent, for the second half 84.6 percent. The group receiving the 100 ppm diet received the largest amount of DDT (about 350 mg) during the egg-laying period.

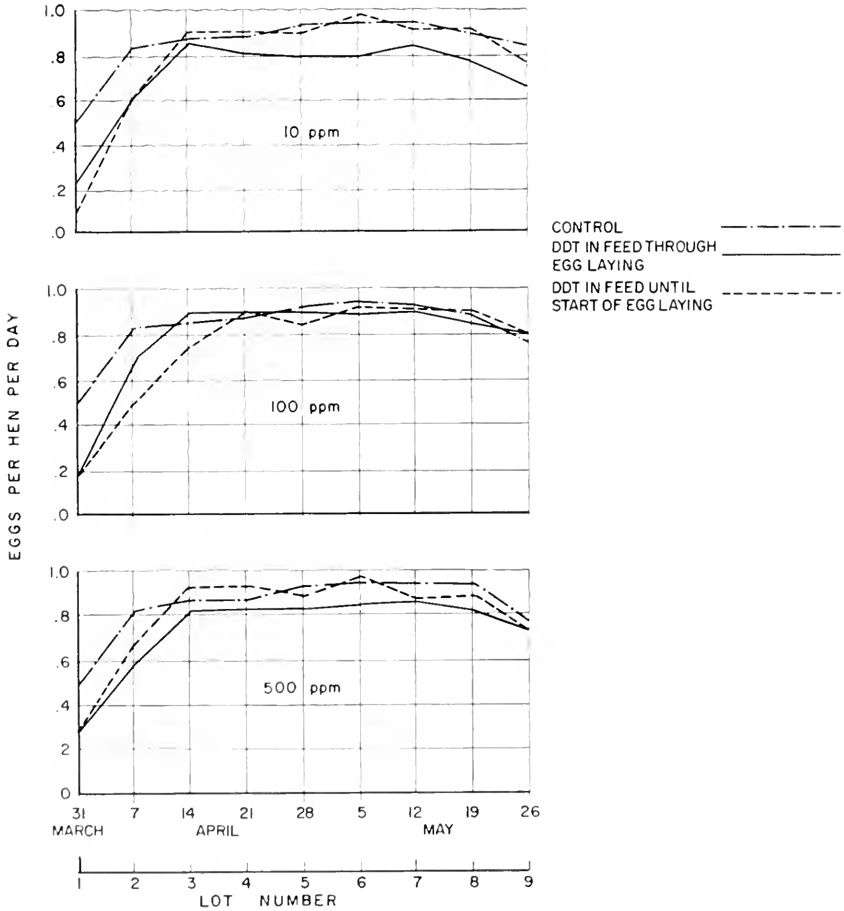

FIGURE 3. Weekly egg production for pheasants on DDT contaminated diets.

Chick Mortalities

Mortalities during the first half of the production period of chicks from parents fed DDT throughout egg-laying were 15.5, 10.5, and 25.2 percent for the 10, 100, and 500 ppm groups, respectively. For parental groups fed DDT until the start of egg-laying, chick mortalities were 8.9, 12.5, and 35.8 percent for the 10, 100, and 500 ppm groups. Losses of chicks from the controls were 14.2 percent for the same period. The first half of production, losses of chicks from the 500 ppm groups differed significantly ($P<.01$) from the controls. Losses of chicks from the 10 and 100 ppm groups did not differ significantly from the controls at the 5 percent level ($P<.05$).

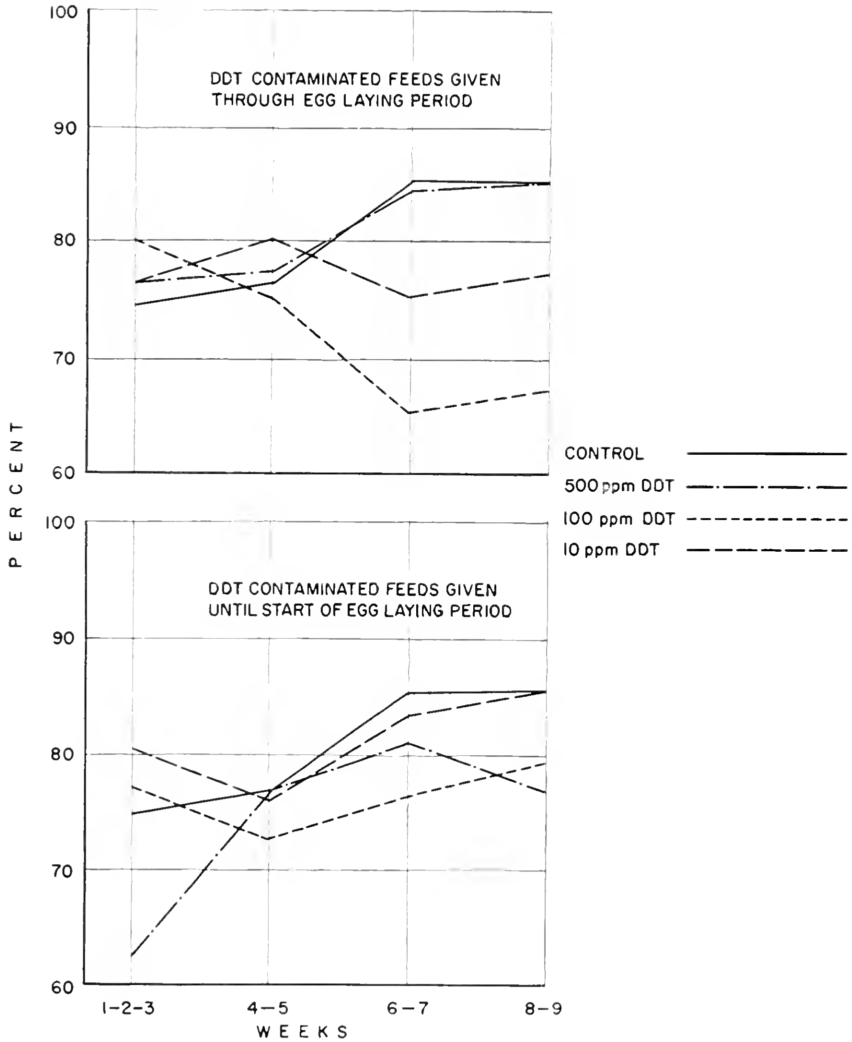

FIGURE 4. Hatching percent of fertile pheasant eggs related to intake of DDT contaminated feed.

During the second half of the production period, chick losses were 14.3, 12.8, and 14.8 percent, respectively, for chicks from groups fed DDT through egg-laying, and 5.6 percent for the controls. These mortalities were significantly greater than the control losses at the 1 percent level ($P<.01$). Chick losses were 7.8, 4.4, and 8.3 percent, respectively, for groups receiving DDT until the beginning of egg-laying. These mortalities did not differ significantly from the control ($P<.05$). Total losses of chicks from parents fed DDT contaminated diets throughout egg-laying were: 10 ppm group, 14.4 percent; 100 ppm group, 10.8 percent; and 500 ppm group, 19.3 percent. For groups fed contaminated diets until the start of egg-laying, the loss percentages were: 10 ppm group, 10.1 percent; 100 ppm group, 8.3 percent; and 500 ppm group, 21.2 percent. Chick losses for the controls were 9.9 percent. Only the chicks from the 500 ppm groups suffered losses significantly different from controls at the 5 percent level ($P<.05$).

The first lots hatched from all test groups suffered the heaviest mortalities (Figure 5).

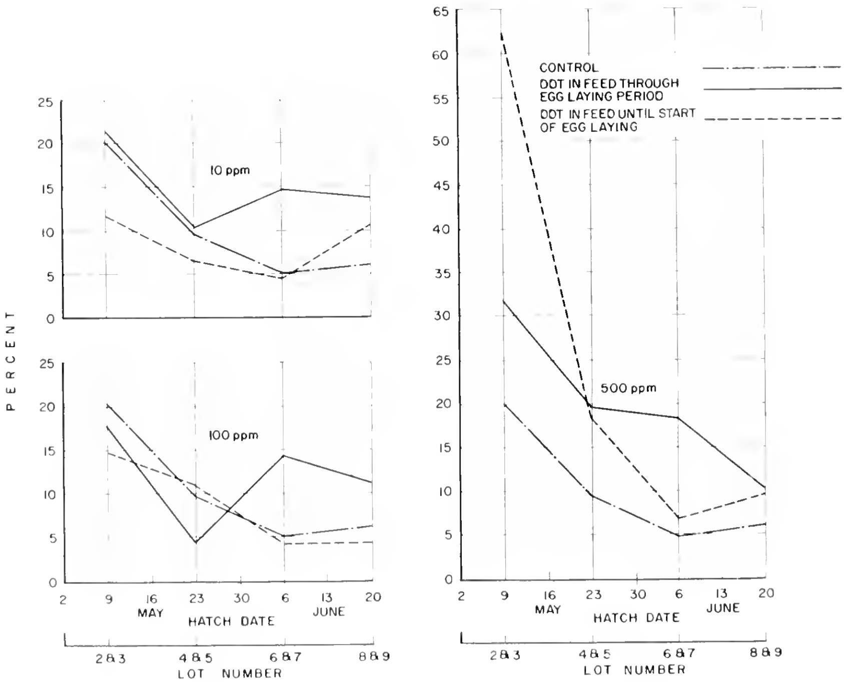

FIGURE 5. Pheasant chick mortality by lots for the posthatch period.

Chick Survival

The first 7 days after hatching was the most critical period for chick survival (Figure 6). The survival rate during this period was 86.8 percent for young from birds fed the 500 ppm diets, and 97.5 percent for the controls. This survival rate difference is significant at the 0.1

percent level ($P<.001$). The difference in survival rate of young for the first 7 days from adults fed the 10 and 100 ppm diets through egg-laying was 90.6 and 92.4 percent ($P<.001$). There were no significant differences ($P>.05$) between the survival percentages of young from the controls, and from parents fed 10 and 100 ppm diets until the start of egg-laying. From the 8th to the 46th day after hatching, survival of young from the test groups did not differ significantly from the controls ($P>.05$).

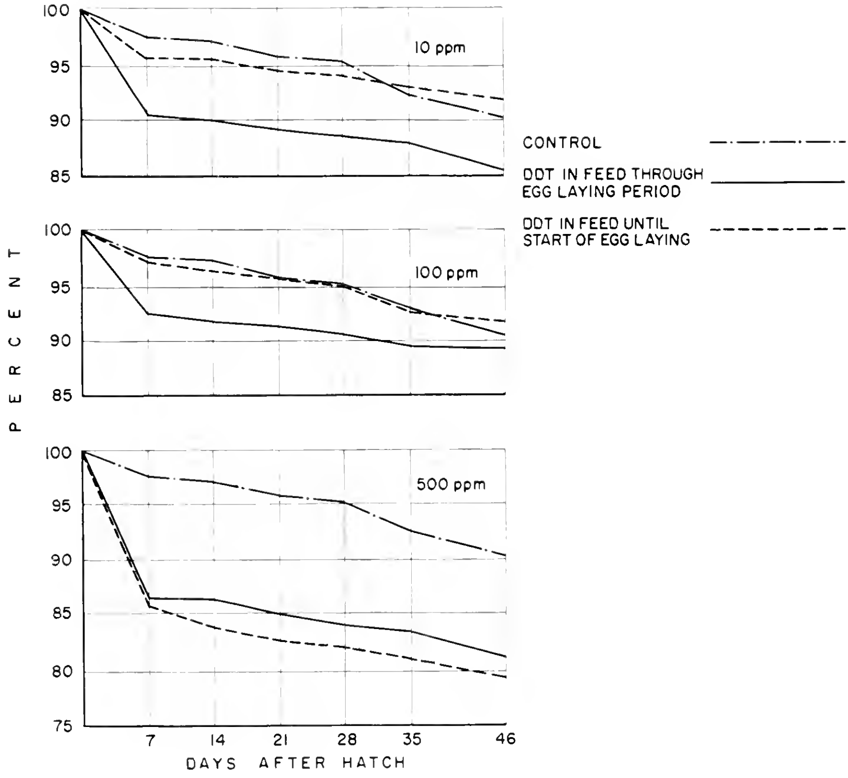

FIGURE 6 Pheasant chick survival for 46-day period after hatching.

Residue Analysis

For pheasants fed DDT contaminated diets, residues in the brain ranged from undetected amounts to 49.1 ppm (Table 2). Highest residue levels were found in brain tissues from male pheasants that died after being fed the 500 ppm diets. All males and four of the six females that died exhibited symptoms of DDT intoxication. In males that died, residues in the brain ranged from 22.8 to 49.1 ppm—the mean was 34.4 ppm. For females that died, the range was from an undetected amount to 28.6 ppm, and the mean was 13.2 ppm. In females that were sacrificed, residues varied from undetected amounts to 2.8 ppm, with a mean of 0.7 ppm. Residues were not detected in the

TABLE 2

DDT Residue in Brain and Fat of Test Pheasants

	Diet (ppm)	Bird number and sex	Total DDT in brain			Total DDT in fat (ppm)	Days exposure to DDT	Date sacrificed or died, 1964
			ppm	Mean (ppm)	Micrograms			
DDT in diet through egg-laying	10	6113 ♀	ND			52.2	101	S 6-13
		6118 ♀	ND			40.1	86	S 5-21
	100	6507 ♀	1.6		5.3	432	88	S 5-19
		6509 ♀*	ND				21	D 3-13
		6515 ♀	1.7		7.6	460	105	S 6-3
	500	6202 ♂	48.2		193		23	D 3-28
		6203 ♂	22.8	34.2	70.1		23	D 3-27
		6205 ♂	37.6		165		22	D 3-20
		6223 ♂	27.9		126		22	D 3-17
		6207 ♀	2.8		10.6		33	S 6-8
		6210 ♀	13.8		40.0	1280	26	D 4-19
DDT in diet until start of egg-laying	10	6417 ♀	ND			1.8	33	S 6-4
		6406 ♀	trace		1.0	9.8	33	S 5-19
	100	6010 ♀	ND			496	35	S 5-19
		6014 ♀	ND			218	35	S 6-3
		6015 ♀*	1.6		5.6		28	D 3-20
	500	4419 ♂	49.1		152		23	D 3-28
		4420 ♂	32.1		122		22	D 3-14
		4122 ♂	24.0	34.8	98.4		22	D 3-20
		4423 ♂	33.8		135		23	D 3-28
		4404 ♀†	26.7		90.8		23	D 4-23
		1408 ♀	28.6	24.5	112		22	D 3-23
		4410 ♀	18.3		65.9		22	D 3-18
		4412 ♀‡	4.0		10.4		23	D 5-12
		1415 ♀				394	23	S 5-27
Control		5812 ♀	ND			ND		S 6-13
		5818 ♀	ND			trace		S 5-19

ND - No residue detected, less than .01 ppm.
trace - .02 to .05 ppm.
S - Sacrificed.
D - Died.
* Did not exhibit symptoms of DDT intoxication.
† Sacrificed while dying.
‡ Died following head injury.

brain tissues of two females from a control group sacrificed at the end of the egg-laying period.

During the 9 weeks of egg production, there was a general decline in the amount of DDT in the fatty tissues of females in all groups except those fed 100 ppm diets through egg-laying (Table 3). The reduction in residue levels in the other groups receiving contaminated diets through egg-laying was from 29.1 to 19.6 ppm in the 10 ppm group, and from 1,290 to 515 ppm for the 500 ppm group. Residue levels increased in the 100 ppm group from 400 to 468 ppm. The amount of DDT in the fat of birds fed DDT until egg-laying started decreased from 124 to 6.2 ppm in the 10 ppm group, from 413 to 84.8 ppm in the 100 ppm group, and from 1,940 to 145 ppm in the 500 ppm group. The fatty tissue of the control birds contained small amounts (1.9 ppm) of DDT at the end of the egg-laying period.

Fat analyses were made of composite samples taken from three to six birds in each group.

TABLE 3

DDT Residue in Fat of Test Pheasants

		Sacrificed at start of egg-laying				Sacrificed after egg-laying			
	Diet (ppm)	Number of birds ♂	Number of birds ♀	DDT in fatty tissue (ppm)	Days exposed to DDT in diet	Number of birds ♂	Number of birds ♀	DDT in fatty tissue (ppm)	Days exposed to DDT in diet
DDT in diet through egg-laying	10	2	4	29.1	35	0	2	19.6	100
	100	1	4	400	39	0	3	468	105
	500	0	5	1290	23†	0	3	515	33*
DDT in diet until start of egg-laying	10	2	3	124	33	0	2	6.2	33
	100	0	4	413	35	0	10	84.8	35
	500	0	3	1940	23†	0	8	145	23

* February 20, to June 8, 1964.
† February 20, to March 30, 1964.

All females fed contaminated diets passed detectable amounts of DDT into the egg yolk (Table 4). The residue levels in egg yolks reflected the dietary regimen of the females. The residue levels of 100 individual pheasant egg yolks were determined. Exploratory analysis of egg white and egg shell proved negative (<.01 ppm) for DDT. For birds fed diets with DDT through egg-laying, the amount of DDT in the egg yolk ranged from 5.6 to 46.2 ppm (mean 20.6) for the 10 ppm group, from 79.9 to 214 ppm (mean 129) for the 100 ppm group, and from 149 to 650 ppm (mean 390) for the 500 ppm group. Residues in the egg yolks of the groups fed DDT contaminated diets until start of egg-laying were for the 10 ppm group from 2.0 to 7.3 ppm (mean

TABLE 4

DDT Residue in Pheasant Eggs

	Diet	Bird number	Number of eggs analyzed	Parts-per-million Range	Parts-per-million Mean	Micrograms Range	Micrograms Mean
DDT through egg-laying	10	6113	6	12.9 - 46.2	29.1	129 - 430	279
		6118	7	5.6 - 28.6	13.3	47.6 - 257	115
	100	6507	7	79.9 - 170	125	719 - 1,420	1,100
		6515	7	89.8 - 214	133	817 - 2,330	1,330
	500	6207	6	149 - 530	331	1,350 - 4,930	3,140
		6210	8	178 - 650	435	2,370 - 6,500	4,250
DDT until start of egg-laying	10	6406	7	2.2 - 6.1	4.3	22.2 - 62.0	41.5
		6417	8	2.0 - 7.3	5.2	19.0 - 73.4	48.8
	100	6010	6	45.9 - 125	82.5	159 - 1,080	751
		6014	6	27.0 - 126	70.7	275 - 1,250	686
	500	4101	14	241 - 891	473	2,120 - 7,750	4,310
		4412	5	123 - 621	263	785 - 3,680	2,110
Control		5812	6	ND - Trace*			
		5818	7	ND - Trace*			

* Trace <.05 ppm.
ND—No residue detected.

4.8), for the 100 ppm group 27.0 to 126 ppm (mean 76.6) and for the 500 ppm group from 123 to 891 ppm (mean 418).

Chicks that died within 7 days after hatching were examined for DDT in their body tissues. Sixty chicks were pooled into 16 samples for analysis. Residue values for chicks from parents fed DDT diets through egg-laying ranged from 2.54 to 17.3 ppm (mean 13.9), for the 10 ppm group; from 31.8 to 70.3 ppm (mean 53.4), for the 100 ppm group; and from 59.4 to 116 ppm (mean 86.9) for the 500 ppm group. Chicks from parents fed 500 ppm DDT diets until the start of egg-laying had DDT residues of 61.8 to 119 ppm (mean 93.2). No analyses were made of chicks from parents fed 10 and 100 ppm diets until the start of egg-laying or from the controls.

Pathology

The result of the examination of brain tissue from two birds that died from chronic DDT poisoning was inconclusive. Tissues from 37 chicks representing each of the dietary levels were obtained when the chicks were sacrificed at 6 weeks of age. No pathological changes were observed in the brain, lung, liver, kidney, gonad, heart, or skeletal muscle tissues.

DISCUSSION

Reproductive success in pheasants is subject to many variable interdependent environmental and inherent factors. For example, the egg-laying process is sensitive to such influences as the amount and quality of feed, confinement, physical condition, heredity, weather, etc. (Romanoff and Romanoff, 1949). The determination that observed variations in the reproductive process of an animal represent the effects of a single influence can be subject to error. This problem was ameliorated by using two control groups, by maintaining breeding groups under nearly the same environmental conditions, by using birds from a long established strain, and by collecting and hatching eggs over a relatively long period. Our use of two control groups aided in determining the range of values for the various reproductive phases that occurred under the test conditions.

The average DDT residue in fat reflected the dietary levels of DDT: the higher the dietary level the greater the DDT residue. Average amounts of DDT in the fatty tissues of pheasants fed the 500 ppm diets, and sacrificed at the start of egg-laying, where higher than the average residue values found in wild pheasants (Hunt and Keith, 1963). However, the range of residue values in fat was greater for wild birds than for the test pheasants.

Ten percent or more of the daily intake of DDT may be voided by females in their eggs. This could be an important factor in the reduction of the amount of ingested DDT placed into fat stores during egg-laying.

The first result of feeding diets with 500 ppm DDT was the death of male and female pheasants. Male pheasants could not be maintained for more than 2 months during the breeding season on feeds with 500 ppm DDT. If the stresses of breeding were removed, males could possibly survive for longer periods on these diets. No female pheasants were lost during the egg-laying period among breeding groups receiving the 500 ppm diets, but three of four paired females on 500 ppm diets died before the end of the egg-laying period. Two of these latter deaths were due to DDT intoxication intensified by the stresses of solitary confinement in small pens.

Minimum residue values of 50 μg of DDT/g of brain (50 ppm) have been reported in robins *(Turdus migratorius)* dying from DDT poisoning (Bernard 1963, Wurster, *et al.*, 1965). For house sparrows *(Passer domesticus)*, 60 μg of DDT g of brain (60 ppm) was the minimum residue value associated with deaths probably caused by DDT intoxication. Approximately 23 ppm was the lowest residue level found in the brains of male pheasants dying from DDT intoxication. For female pheasants the lowest residue level in the brain of birds that succumbed to DDT poisoning was 13.8 ppm. Thus, the minimum residue levels found in the brains of pheasants dying from DDT intoxication are about one-quarter to one-half of the minimum levels reported for robins and house sparrows. The highest levels of DDT found in brains of sacrificed females was 2.8 ppm. The amounts of DDT found in brain tissue shows promise as an indicator of DDT intoxication.

The results of the statistical evaluation of our data should be considered relative to the overall reproductive success. Differences may be highly significant statistically, but so small in magnitude as to be of little consequence. For example, the chick survival data presented earlier indicate that highly significant differences occurred between the survival rates of chicks from a 100 ppm dietary group and chicks from the control birds. The difference was about 5 percent, so for 100 eggs laid the number of chicks surviving to 46 days of age would be lowered from 67 to 64.

The effects of DDT ingestion on pheasants may be evaluated on the basis of impact upon reproductive success (Figure 7). The range of reproductive success was from 51 to 72 percent for birds fed DDT, and 65 percent for the controls. Although certain phases of reproduction are adversely affected by the ingestion of DDT, reproductive success is only slightly lowered. The fact that these effects are relatively minor is evident when we realize that annual mortality rates as high as 73 percent are considered normal for stable pheasant populations in the wild (Mallette and Harper, 1964).

The results of our first year's study suggest that a dietary regimen with DDT that can be tolerated by adult pheasants during the breeding season, would probably not have gross adverse effects on reproductive success.

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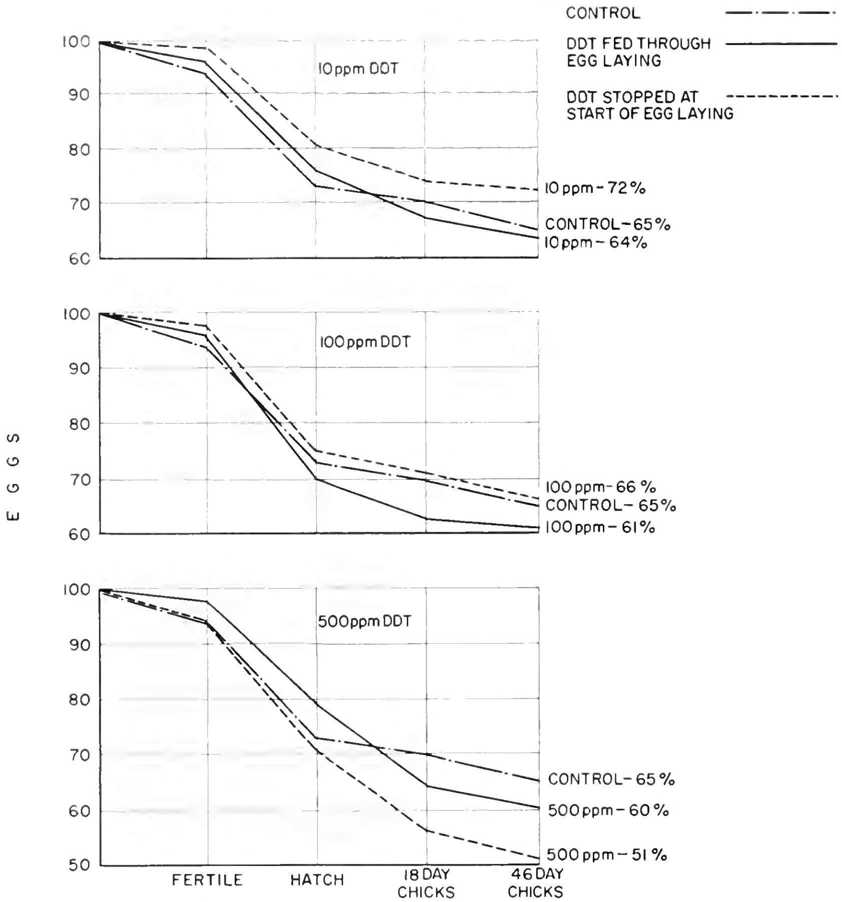

FIGURE 7. Reproductive success based on the production of 100 eggs by pheasants fed different DDT-contaminated diets.

gratefully acknowledged. Frederick L. Delano, Fred J. Roth, and George Root, California Department of Agriculture conducted confirmatory residue sample analyses. C. D. Ercegovich, Geigy Chemical Corporation, provided the DDT isomers used in residue analysis. Guidance in methods for inoculation of pheasant eggs was obtained from Ursula Abbott and Roger M. Craig, Department of Poultry Husbandry, University of California, Davis.

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SUMMARY

Technical DDT was fed to six groups of pheasants for 5 weeks prior to egg-laying, and to three of these groups through the 9 weeks of egg-laying. Two groups of pheasants were given uncontaminated feeds.

Adult pheasants could not be maintained on diets containing 500 ppm DDT for more than 2 weeks without heavy mortalities. Males were more susceptible to DDT intoxication than females.

Egg production and fertility were not affected by the DDT in the diets. Hatching success of eggs from parents receiving DDT and the controls did not differ significantly ($P > .05$).

Chick mortalities were highest among young from parents fed the 500 ppm DDT diets and differed significantly from the controls ($P < .01$).

The range of residue levels for egg yolks was 2.0 to 891 ppm; for fat, 6.2 to 1,940 ppm; for brain, trace (< .01 ppm) to 49.1 ppm; and for whole chicks, 2.5 to 119 ppm. Generally the lowest levels were found in samples associated with birds fed 10 ppm diets, and highest levels in samples from birds given 500 ppm diets.

The only insecticide residues found in control birds were 1.9 ppm DDT in a fat sample and a trace of DDT in one egg yolk.

Hens fed DDT passed residues into their eggs for 9 weeks even though the ingestion of DDT was terminated at the beginning of egg-laying.

Evidence suggests DDT residue levels in the brain may be used as an indicator of DDT intoxication in pheasants.

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NOTES

SLEEPER SHARKS *(SOMNIOSUS PACIFICUS)* OFF TRINIDAD, CALIFORNIA, WITH LIFE HISTORY NOTES

The sleeper shark reputedly ranges from Japan to the Bering Sea and southward to southern California (Bigelow and Schroeder, 1944), but neither of the two California records we have found was from southern California. N. B. Scofield (1920) reported a 7-foot specimen trawled off Pt. Reyes, Marin County, on February 20, 1920, and a 13-foot female was caught off Fort Bragg, Mendocino County, from 245 fathoms on May 12, 1952 (Phillips, 1953).

We recently examined the third and fourth California specimens: a 12-foot female (Figure 1) caught by George Saubert, captain of the *San Vito,* while trawling on May 12, 1964, in 130 fathoms west of Trinidad, Humboldt County, lat. 41° 03′ N., long. 124° 23′ W., and a 45-inch female (114 cm TL) weighing 19.8 pounds caught by Jack McCauley, captain of the trawler *Winga,* on May 11, 1965, in 145 fathoms 12 miles west-southwest of Trinidad, lat. 41° 01′ N., long. 124° 24′ W. Thus, Point Reyes represents the southernmost range of the sleeper shark in the eastern north Pacific.

When captured, the 1964 Trinidad specimen regurgitated about 300 pounds of fish, mostly rex sole (*Glyptocephalus zachirus*) and Dover sole (*Microstomus pacificus*), but included were three king salmon (*Oncorhynchus tshawytscha*) weighing 3 to 5 pounds each, and a 10-pound Pacific halibut (*Hippoglossus stenolepis*). The stomach of the sleeper shark caught in 1965 contained beaks from five cephalopods (three *Moroteuthis robusta,* one unknown squid, and one unknown octopus) and an unidentified tapeworm.

Both sharks were females, the ovaries of the 12-footer contained 300 large unfertilized eggs and many small undeveloped ova. Diameters of the large eggs ranged from 45 to 58 mm, averaging 52.4. The oviduct was 3 inches in diameter; it had many lateral folds and appeared capable of distention. The ovaries of the smaller shark were immature.

The jaws and an egg sample from the 1964 Trinidad specimen were donated to California Academy of Sciences (CAS 27082) as was the shark caught in 1965 (CAS 27084). While removing the jaws from the 12-footer, we found a halibut hook embedded in the shark's tongue.

The smooth-edged teeth of both sharks were similar to those described and depicted by Phillips (1953). The teeth are in two functional rows on both jaws. The upper jaw teeth are slender and pointed, but when an attempt was made to count them from the 12-footer, only a few were still *in situ.* The upper jaw in the small female contained 33 rows of teeth in the process of development, but the rows could not be distinguished too clearly nor was the symphysis discernable. Lower jaw teeth are triangular with the broad base exposed and the tips pointed laterally and posteriorly (Figure 2). The left upper and lower functional rows of the large female's lower jaw contained 26 teeth each (Figure 3); as did the right upper and lower functional rows with the

FIGURE 1. Biologist Tom Jow, who is 5 feet 7 inches tall, is less than one-half the length of the Trinidad sleeper shark. *Photograph by Daniel W. Gotshall, May 1964.*

exception of 1 aberrant tooth adjoining the symphysis. There are 27 teeth in the upper and lower functional rows on the left and right lower jaw of the smaller female plus 1 aberrant tooth adjoining the symphysis. Maximum width and height measurements for some of the larger sleeper shark's functional lower jaw teeth are: 1st tooth left upper row, 16.6 mm high, 9.2 mm wide; 1st tooth left lower row, 18 mm high, 9.7 mm wide; 10th tooth left lower row, 16.2 mm high, 11.3 mm wide; 10th tooth right lower row, 16 mm high, 10.4 mm wide; 26th tooth left lower row, 7.2 mm high, 10.7 mm wide. The 2nd tooth left of the symphysis in the upper functional row of the upper jaw measured 13 mm in greatest height and 5.3 mm in greatest width.

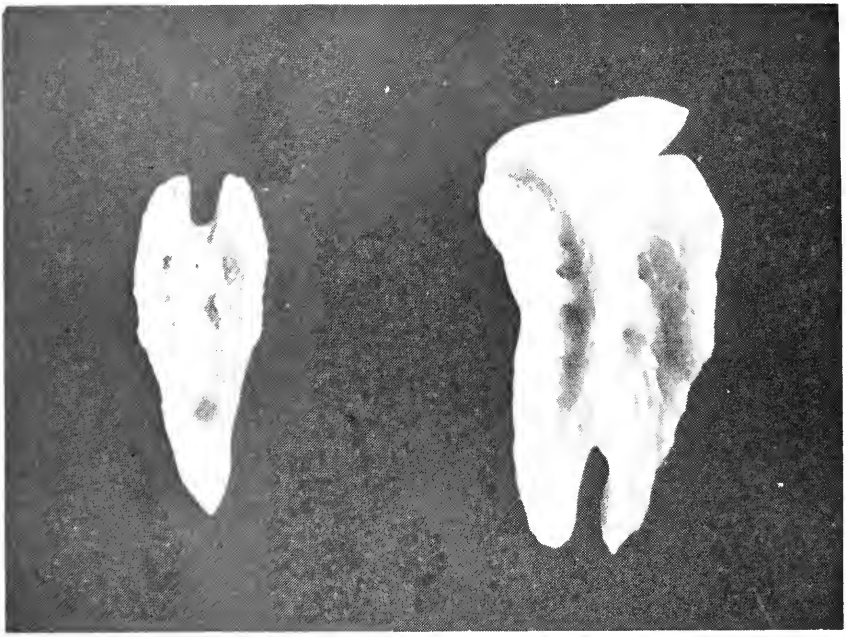

FIGURE 2. Teeth from Trinidad sleeper shark: (**left**), upper jaw tooth, position indeterminable, greatest height 13 mm, greatest width 5.3 mm; (**right**) 1st tooth, lower functional row, lower left jaw, greatest height 18 mm, greatest width 9.7 mm. *Photograph by W. I. Follett, January 1965.*

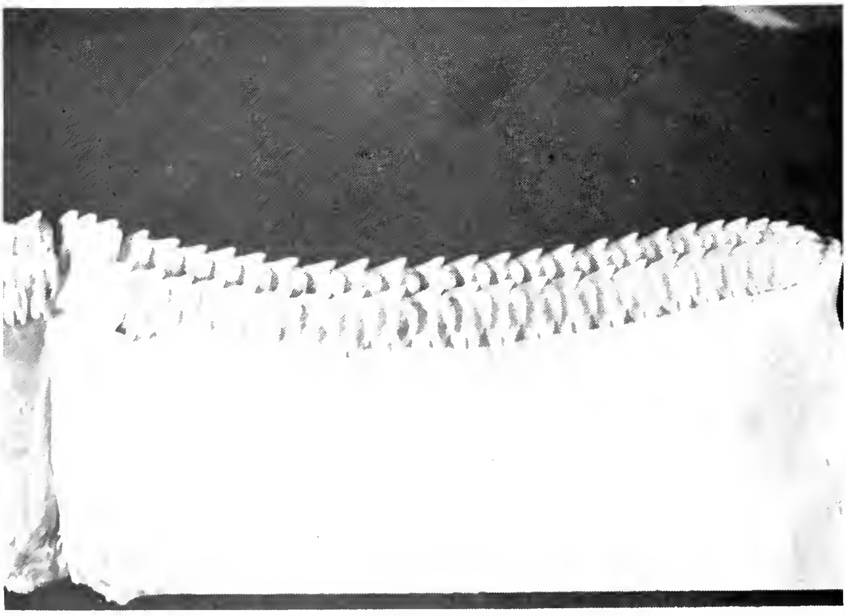

FIGURE 3. Left lower jaw of Trinidad sleeper shark showing upper and lower rows of functional teeth; the dentigerous area is 205 mm long. *Photograph by W. I. Follett, December 1964.*

LIFE HISTORY NOTES

Reproduction

Embryological development of the sleeper shark has been questionable. Walford (1935) stated they were oviparous, while others (Roedel and Ripley, 1950; Clemens and Wilby, 1961) have reported it was not known whether they bore live young or deposited eggs.

We hypothesize that *Somniosus pacificus* is ovoviviparous as are its close relatives, *S. rostratus* of the Mediterranean (Bigelow and Schroeder, 1948) and *S. microcephalus* of the Atlantic (Bjerken and Koefoed, 1957). Ovarian eggs of the 12-foot Trinidad sleeper shark were similar to those described for *S. microcephalus* (Bigelow and Schroeder, 1948). Furthermore, a prominent shell gland, typical of oviparous elasmobranchs, was not discernible on its oviduct.

Food

Sleeper sharks taken off California are fish and cephalopod predators. They are known to eat shortspine channel rockfish, *Sebastolobus alascanus*, (Phillips, 1953), sole, salmon, Pacific halibut, and squid. Bright (1959) reported that the stomach of a 155-incher caught at Cook Inlet, Alaska, contained portions of three harbor seals (*Phoca vitulina*), three complete octopuses (*Octopus* spp.), fragments and complete individuals of the tanner crab (*Chionectes bairdi*), and fragments of the hairy triton (*Fusitrition oregonensis*).

Sleeper sharks reportedly attain 25 feet in length (Roedel and Ripley, 1950), but the 13-foot male taken off Fort Bragg (Phillips, 1953) is the largest caught off California.

Habits and Importance

Sleeper sharks are considered to be sluggish bottom dwellers. They have no commercial value. They may take hooked salmon and halibut from trolling gear or long lines, but on the other hand, based upon the report of Bright (1959), they sometimes prey upon harbor seals which also are destructive to hooked and netted fish, and apparently are much more abundant in commercial fishing areas than are sleeper sharks.

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—*Daniel W. Gotshall and Tom Jow, Marine Resources Operations, California Department of Fish and Game, March 1965.*

THE PACIFIC BONITO, *SARDA CHILIENSIS* (CUVIER), IN PUGET SOUND, WASHINGTON

The Pacific bonito is uncommon north of Point Conception, California (Radovich, 1961), although it is known to occur in Alaskan waters at about lat. 60° N. (Quast, 1964). This fish has been taken infrequently off the west coast of Vancouver Island, and two have been recorded from inland marine waters of British Columbia (Clemens and Wilby, 1961); it has seldom been reported from Puget Sound.

Kincaid (1919) noted that the Pacific bonito occurred rarely in Puget Sound but he did not mention numbers, locations, or season of occurrence. In 1962, two specimens were caught in salmon gill nets, the first in October about 4 miles north of Seattle, and the second in November about 3 miles west of Seattle (Fishermen's News, 1963*a*). The latter fish was placed in the University of Washington Ichthyological Museum (UW 16529). In September 1963, two bonito were taken from a gill net which had been set for salmon off Carkeek Park, Seattle (Fishermen's News, 1963*b*).

The most recent capture of a Pacific bonito, and the one which prompted preparation of this note, was made by John W. Michaels while fishing commercially for salmon. It was taken off Point Monroe, the northern tip of Bainbridge Island, 5 miles west of Seattle, on November 22, 1964, between 10 PM and midnight, in the upper half of a 5½-inch, stretch-mesh gill net fished at a maximum depth of 25 feet. The specimen, a female, weighed 4.3 kg and was 67.3 cm fork length. The paired ovaries weighed 74 gm, and the stomach was devoid of food or parasites. Fifty of the larger ova had a mean diameter of 0.38 mm, ranging from 0.30 to 0.50 mm. The fish was deposited in the University of Washington Ichthyological Museum (UW 18499). Other fishes caught in the gill net with it included 200–300 spiny dogfish (*Squalus acanthias*), 40–50 Pacific hake (*Merluccius productus*), and 20 chum salmon (*Oncorhynchus keta*).

The water temperature was not measured at the location of the catch, but was probably 47°–50° F, estimated from measurements made in nearby portions of Puget Sound. This is about 10° F colder than November temperatures immediately south of Point Conception, California, and up to 32° F colder than off Baja California (Johnson, 1961), in an area where the bonito is common. The salinity of central Puget Sound during the autumn, according to data from earlier years, is between 29 and 30.5‰ (McLellan, 1954), as compared with oceanic salinities off southern California of 33–34‰ (Reid *et al.*, 1958). Bonnot (1931) reported a bonito from waters which were probably of even lower salinity, but he did not give a salinity value.

The occurrence of bonito in Puget Sound reflects the general preference of fish of the genus *Sarda* for coastal waters (Fitch and Craig, 1964). Fitch (pers. commun.) states that at times bonito are abundant in harbors and bays of southern California, and that they are taken by sportsmen fishing from docks or along shore.

It is interesting that five Pacific bonito were captured within 6 miles of Seattle at about the same time of the year. All were taken in salmon gear, as was the one reported at Sooke, British Columbia (Clemens and Wilby, 1961).

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—*Benjamin G. Patten, Duane T. Rodman, and Kenneth D. Waldron, U.S. Bureau of Commercial Fisheries, Seattle, Washington, March 1965.*

A LAHONTAN REDSIDE, *RICHARDSONIUS EGREGIUS* (GIRARD), LACKING PELVIC FINS

A Lahontan redside which lacked pelvic fins was collected from Independence Lake, Sierra and Nevada Counties, California, on 1 July 1964. Independence Lake is at the headwaters of a tributary of the Little Truckee River, which is part of the Lahontan drainage system. The specimen measured 72.9 mm SL and weighed 7.6 g. It appeared normal in all respects except fro the missing pelvic fins. An X-ray revealed that the basipterygia were absent. Scales completely covered the body where the pelvic fins normally occur, and no scars or abberrations were observed in this region. The specimen, X-rays, photographs, and field data are deposited in the Ichthyological collection of the California Academy of Sciences, catalog number CAS 23718.

—*Robert N. Lea, Department of Zoology-Fisheries, University of California, Berkeley, California.*

BOOK REVIEWS

Dangerous to Man: Wild Animals, a Definitive Study of Their Reputed Dangers to Man

By Roger A. Caras, Chilton Company Publ., Philadelphia, 1964; xix + 433 p., illustrated; $10.

I like this book! It's the first I've seen that presents an unemotional account of the assorted vetebrate and invertebrate animals which have been reported as dangerous or potentially dangerous to man. Bacteria, viruses, and similar items which can not "be seen with the naked eye" have not been included, with two exceptions, i.e. discussions of rabies and ciguatera poisoning.

Twenty-seven chapters cover the six broad categories of mammals, birds, reptiles, amphibians, fishes, and invertebrates. In the section on mammals, separate chapters cover the great cats, wolves, bears, the leopard seal and walrus, the killer whale, elephants, venomous mammals, and other mammals. Similar complete coverage is given in the five other general sections, although several groups don't contain many dangerous or potentially dangerous members.

I was very happy to see the "killer" clam *(Tridacna)* and killer whale so thoroughly debunked. It seems about time these much-maligned animals "got a fair shake" from a writer of non-fiction. I was equally pleased to see (by their absence) that abalones hadn't trapped any abalone pickers and caused them to drown on an incoming tide.

The authorities who were consulted are about as good as there are, but there still was a bit too much reliance (in a few places) upon the printed word. Thus the blue shark is "marketed as swordfish" (p. 224), the electric ray, *Torpedo,* attains 200-pounds (p. 259), a 35-foot octopus is known (p. 314), and so on. Italics got out of hand in a few places, a few specific names were abbreviated with capital letters (p. 127), and the "leopard shark" on p. 219 should have been a lemon shark. Generally, though, the author "did himself proud."

One unmentioned danger from an octopus is that of a skindiver (free diver), a sizeable octopus, and a rubble bottom. The skindiver grabs the octopus, and the octopus grabs the skindiver and several armsful of rocks. In this situation (and it has happened many times in the Pacific northwest), the diver finds it impossible (without help) to regain the surface and a breath of air with all that weight clinging to him. With a solid bottom, he can at least plant his feet firmly, and with the extra leverage, stand a better-than-even chance of pulling free.

A final comment seems called for regarding the illustrations liberally sprinkled throughout this volume—generally they are superb!—*John E. Fitch.*

Fishes of the Western North Atlantic. Part IV—Order Isospondyli, in Part (Argentinoids, Stomiatoids, Esocoids, Bathylanconoids) and Order Giganturoidei

Henry B. Bigelow, Editor-in-chief, Sears Foundation for Marine Research, New Haven, Conn., 1964; xx + 599 p., illustrated; $27.50.

Eight of this country's foremost authorities on these orders and suborders of soft-rayed bony fishes have submitted portions dealing with their specialties. The volume has been dedicated to the memory of Marion Grey, who, in addition to her excellent past contributions, was responsible for one of the major segments in this work (Gonostomatidae, p. 78–240). I was especially pleased that she covered the fossil record for this family; none of the other authors seems to have felt a need to report upon fossils.

The first section (Argentinoidea, p. 1–70, by Daniel M. Cohen) includes the usual excellent coverage which typifies *Fishes of the Western North Atlantic,* and presents keys to families, subfamilies, and genera of the world; however, the various species keys include only those forms which are known to frequent waters within the geographic limits of the western north Atlantic.

While examining the treatment given the Argentinoidea, I was amazed to find that distributional reports for some genera and species were extremely aberrant, to say the least. *Macropinna* was listed (p. 50) as being known only from "Monterey Bay, California; Gulf of Alaska to British Columbia; [and] Kurile-Kamchatka

Trench"; *Bathylychnops* (p. 51) was restricted to the "North Pacific between the Aleutian and Hawaiian Islands"; and *Dolichopteryx longipes* was known from the eastern Pacific by "a specimen taken . . . at the Galapagos Islands" (p. 58). The fact that other contributors to this volume have done the same injustice to other widely-distributed forms indicates this is an editorial policy, and not just the author's prerogative. Apparently the editors will not accept a distributional record unless it has been published. Such a shortsighted policy can hardly be justified on the grounds that it insures accuracy. I would much rather trust Dr. Cohen's decision that *Dolichopteryx* occurs throughout the eastern Pacific (based upon his first-hand knowledge of the abundant deep-sea collections of Scripps Institution of Oceanography, Allan Hancock Foundation, and others) than a published report by some lesser authority that a specimen seems to have been taken at this or that locality. I sincerely hope the policy which inhibits complete, accurate, up-to-date reporting is relegated to the scrap heap, and soon!

James E. Morrow, Jr. submitted material on suborder Stomiatoidea, and families Chauliodontidae, Stomiatidae, Malacosteidae, and Melanostomiatidae (the last-named family with Robert H. Gibbs, Jr.).

In addition to his joint effort on Melanostomiatidae, Robert H. Gibbs, Jr., contributed on families Astronesthidae and Idiacanthidae. The report of family Sternoptychidae (Leonard P. Schultz) was lifted verbatim from Dr. Schultz's 1961 publication. The last three major sections, suborders Esocoidea and Bathylaconoidea, and order Giganturoidei, were capably handled by Myvanwy M. Dick, Henry B. Bigelow, and Vladimir Walters, respectively.

Although there is room for improvement in this and previous volumes, the usefulness of part four grows with each perusal of its contents. The overall quality is excellent, treatment to the generic level is complete, and the many specific details of structure, life-history, synonymy, etc., are extremely helpful. In view of the recent great expansion in deep-sea research, this volume is especially timely.—*John E. Fitch.*

Records of North American Big Game (1964 Edition)

Compiled by the Records Committee of the Boone and Crockett Club; Holt, Rinehart and Winston, Inc., New York, 1964; xvii + 398 pages, illustrated; $15.

The immediate impression one gains on opening this book is that of beautiful photography. There are 81 illustrations, including a colored frontispiece, covering such subjects are hunting lodge interiors, trophy rooms, and sporting-book libraries, as well as record big game heads. These do much to enliven the many pages of tabulated trophies.

This book is the fifth in the series of *Records of North American Big Game* and is the first published since 1958. There are 5,072 listings of 28 native North American big game groups.

The records list all known big game heads including some picked up in the field and several obtained from Indians or Eskimos. The manner of take is recorded, however, and all sportsmen must certify that their entries were taken in accord with the Boone and Crockett Club code of ethics.

Actually, the lists make intriguing reading for anyone interested in big game. One can find the significant areas that produce record animals or ponder the fact that, while in seven of the classes the best head was taken in the last six years, others just don't grow like they did in the old days. No one comes close to the pronghorn killed in 1887. It is also something of a shock to find that grizzly bear rank 71, taken in 1859, respresents the now extinct race of California grizzly.

Probably the most important contribution to the sport of hunting made by the Boone and Crockett Club, is their Credo of Fair Chase. First set forth by member Theodore Roosevelt in 1893, the definition of Fair Chase has been expanded to cover modern situations. As it is now worded, the Fair Chase Code prohibits the direct use of airplanes and other motorized vehicles in the pursuit of big game.

The book has several chapters covering the history of the club, the official scoring system, the care of trophies, and a number of short accounts of the hunts that led to record trophies.

This is a beautiful book, well edited and of broader interest than its title indicates. —*James D. Stokes.*

The Lives of Desert Animals in Joshua Tree National Monument

By Alden H. Miller and Robert C. Stebbins, University of California Press, Berkeley, 1964; vi + 452 p., black & white plus color illustrations; $10.

During various parts of 7 different years between 1945 and 1960, the authors and other scientific personnel spent a great deal of time in Joshua Tree National Monument studying its flora and fauna. The results of these excursions are evident in the accuracy and completeness of detail presented in this book.

I did not count the species treated in the text, but according to information on the dust jacket they consist of 42 mammals, 166 birds, 36 reptiles, and 5 amphibians. To a certain extent, the authors assume a prior knowledge on the part of the reader as to what the species in question looks like, because not all are illustrated, but many are—some even in color. The art work, by Gene M. Christman, is commendable and for the most part depicts the animal in a natural setting.

Typical of the coverage given a species is a brief sketch of its description, range, and occurrence in the monument. These basic data are followed by short to lengthy reports on natural history, habits, habitat, behavior, etc. These insights into the lives of the various animals, to me, are the most interesting and worth-while parts of the book. Since they represent actual field observations, they are not stereotyped, and if one were taking a vacation in Joshua Tree National Monument, experiences such as these would be the dividends he could hope for.

There are a few keys in the book, e.g. shorebirds (p. 73), and flycatchers (p. 113), but most groups are handled without such aids. In the very beginning, the authors have included four chapters which discuss the solution of problems of desert life, the environments, the plan and scope of their field study, and a faunal analysis. A "literature cited" section and a fine index complete the volume.—*John E. Fitch.*

The Ecology of Rocky Shores

By J. R. Lewis; The English Universities Press Ltd., London, 1964; xii + 323 p.; color plus black-and-white illustrations; 42 shillings.

In the preface, Dr. Lewis states that "Few major habitats are so accessible and so rewarding in richness and variety of life as rocky shores, . . . Although several admirable books deal with the general biology of shore life there has been no attempt either to present a general account of the ecology of British shores or to bring the many aspects of this field to the attention of senior pupils and students. These are the two aims of this book." In my opinion, the author has reached, and even surpassed, these goals in this excellent volume. Although the book deals entirely with the ecology of British shores, studying it will enable both students and professional workers better to understand the ecology of all the rocky shores.

Dr. Lewis treats both plants and animals as equally important and integral parts of rocky shore communities. The introductory chapters describe two contrasting British shorelines: one sheltered from waves, the other exposed to them. This is followed by a discussion of the various physical and geographical factors affecting zonation and distribution. In the main descriptive portions of the book, the author discusses the major types of shorelines, with emphasis on the principal types of communities, and the conditions under which they exist. The final chapters discuss the fine points of the subject, and some of the problems that still await solution. These are, perhaps, the most rewarding portions of the book. The text would have been more useful if the author had dealt more extensively with life cycles, physiology, and behavior.

The volume is illustrated throughout with high quality photographs and drawings. The text is well-indexed and has excellent bibliographies accompanying each of the major sections. The author has included some American references, but most are from British sources. A diligent search failed to turn up any typographical errors.

In view of the reasonable price and excellent quality of this volume, I would recommend it to all students and professional workers who are interested in "*The Ecology of Rocky Shores.*"—*Michael L. Johnson.*

America's Favorite Fishing

By F. Philip Rice; Outdoor Life—Harper & Row, New York, 1964; xiv + 285 p., illustrated; $4.95.

Author Rice has gathered from state fish and game agencies and his own observations, life history data and methods used to catch 20 species of fish referred to as pan fish.

Some 115 pages are devoted to basic information regarding each species, including habits, growth rates, food preferences, and other pertinent data. Although the book is written for the fisherman, those working with or managing waters containing these species will find this section worthwhile reading.

The four chapters covering spin-, fly-, bait-, and ice-fishing are concise but thorough. A chapter appropriately follows, discussing methods of preparing fish for the table.

The writing style allows for easy reading, and is neither oversimplified nor too technical. The word "ctenoid" may present a problem to those unfamiliar to icthyological nomenclature. A brief discussion explaining this type of scale, when first mentioned, would eliminate confusion.

The illustrations by Charles Berger are well done and descriptive, particularly those of the various pan fish. Dr. Rice is to be complimented in using only one photograph of a happy angler holding up a string of unhappy fish; too often authors become repetitious in this respect. Maps with shaded areas indicate the distributions of each species. Generally, these are accurate but may be misleading since occasionally the fish is found only in a few waters in the state and, where the species is present, it is sometimes not indicated.

America's Favorite Fishing is concluded with a report from each state naming the best panfishing waters. Free state publications on fishing are also listed.

Fishery workers will find this a handy basic reference, as will sportsmen who wish to increase their knowledge of fish and subsequently their catch.—*James A. St. Amant.*

Better Ways of Pathfinding

By Robert S. Owendoff. The Stackpole Co., Harrisburg, Pa., 1964; 96 p., illustrated; $2.95.

Mr. Owendoff originated the shadow-tip method of pathfinding, and features this technique throughout his small book.

There is no question that shadow-tip pathfinding is an interesting and easily understood method. Direction can be quickly determined, day or night.

In discussing some of the other techniques, the author leads the reader through not-too-easy-to-explain directions. Not infrequently, we finally learn that the particular method under discussion is really a rather deficient technique in the first place.

In other respects, this is a complete and valuable book.

Don't expect to read it through at a sitting, unless you are already an expert.—*Parke H. Young.*

Bibliography of Snake Venoms and Venomous Snakes

By Findlay E. Russell and Richard S. Scharffenberg, Bibliographic Associates, Inc., West Covina, Calif., 1964; viii + 220 p.; $9.80, cloth; $8.80, paper.

I did not count the entries, but the authors state that this volume contains 5,829 citations. These are arranged alphabetically by author within each of 19 categories—each introduced by an informative paragraph or two.

First of the 19 major categories is "Articles prior to 1850," a section containing 163 entries. A select few of the other categrories are: (i) general biology of venomous snakes, (ii) venom apparatus, (iii) general biological effects of snake venoms, (iv) snakebite, (v) use of snake venoms, and (vi) folklore, myths, superstitions, and primitive treatment and uses.

The section containing references on general biology is subdivided on a regional basis: (i) North America, (ii) South and Central America, (iii) Europe, (iv) Africa, (v) Asia, (vi) Australia and Pacific, and (vii) sea snakes. Those portions dealing with biological, chemical, and physiological aspects of venom have been categorized according to family (snake) groupings.

An appendix lists 71 references which the authors were unable to examine either for content or for accuracy of citation. A 20-page index of senior authors completes the volume.

It would be difficult for any student of herpetology to perform serious research without having ready access to this publication.—*John E. Fitch.*

Florida: Polluted Paradise

By June Cleo and Hank Mesouf; Chilton Books, Philadelphia, 1964; x + 183 p., illustrated; $4.25.

The word "Florida" is to many people a magic word, associated with all the desirable features of a true paradise. It is thoroughly debunked in this account of Florida's many ills.

The book is not restricted to pollution problems, as might be implied by the title, but includes numerous other man-made as well as natural problems afflicting the state.

The authors' subject matter can be grouped into three broad categories: (i) man's despoiling of Florida's natural features; (ii) man's abuse of other men, both resident and tourist; and (iii) Florida's natural environmental adversities.

According to the authors the despoiling of nature includes pollution from sewage, pulp mills, citrus processing, and chemical plants. Natural habitat is destroyed by swamp drainage, bulkheading and fill projects which eliminate fish and bird breeding grounds, cause beaches to erode, and increase pollution by preventing tidal flushing.

The authors lament man's inconsiderateness of his fellowman. Emphasis is given to the lack of access to the few remaining public beaches. Complaint is made of exorbitant rates for rent, meals, entertainment, etc. Slipshod housing developments are deplored, along with poor schools, tourist traps, a strict caste system, gambling, and other rampant vices.

Among Florida's natural disadvantages the book discusses sweltering heat, high humidity, frequent hurricanes and attendant flooding with often contaminated water, vicious alligators, poisonous snakes, and hordes of noxious and disease carrying insects. The authors state that Florida is the bug capital of the United States and accordingly nickname it the "Cockroach State." Added to this are the "red tides," a natural phenomenon which may be augmented by nourishment from man's abundant waste discharges.

The book seriously indicts Florida's publicity bureaus for the grossly misleading information they dispense.

Many of the blights the book discusses are man made and preventable, yet little indication is given that curative measures are being taken.

The book is not without exaggeration, e.g., the hazard from maneating alligators is overdone.

The authors complain about the misuse of pesticides, and while misuse undoubtedly occurs, their criticism of the use of malthion in Mediterranean fruit fly erradication is totally unjustified. Malthion is a degradable insecticide of low mammalian toxicity. Its selection and use in bait sprays, which reduce dosage to a minimum, and for eradication of an extremely serious pest is fully justified.

The authors are both professional writers. The book is interestingly written, is non-technical, and for popular consumption. It is especially recommended for prospective Florida tourists and retired people contemplating moving to Florida.—*Walter Thomsen.*

Hunting Secrets of the Experts

Edited by Vlad Evanoff; Doubleday & Company, Inc., New York, 1964; 251 p., illustrated; $4.95.

Vlad Evanoff has compiled and edited a book that will be of interest for the experienced hunter as well as the neophyte. Each of the book's 20 chapters deals with a different subject and is authored by a recognized expert in the area about which he writes. Mr. Evanoff has made sure that what each author has written is simple, non-technical, and easy-to-read.

Each chapter is loaded with valuable tips on hunting a particular species. Most of the hunting secrets revealed by these experts were learned through years of trial and error experiences of their own while pursuing the particular species being discussed. Anyone going afield can better prepare himself by reading the chapter concerning the wildlife he is going to hunt.

I feel that every hunter can find new techniques to use while hunting, as well as some enjoyable reading in *Hunting Secrets of the Experts.*— *Dick Laursen.*

The Sportman's Notebook and Tap's Tips

By H. G. Tapply; Holt, Rinehart and Winston, Inc., New York, 1964; x + 333 p., illustrated; $7.95.

Those who have read *Field and Stream* regularly will recognize this book as a collection of articles published in that magazine as "Tap's Tips on the Sportman's Notebook."

It is one of the best compilations I have seen of practical information directed toward helping the average angler and hunter become more proficient. A great variety of subjects is covered in a clear straight-forward style. The author's thorough explanations convince the reader that he speaks with authority based upon experience.

The first half of the book discusses freshwater fishing for all important species, as well as many kinds of tackle and how to use them. The second half, on hunting, covers upland game, waterfowl, and deer with excellent chapters on guns, dog training, and general outdoor camping.

Illustrations are simple, but effective, line drawings. All in all, this is an excellent, strictly non-technical book for every sportsman's library.—*Willis A. Evans.*

Wildlife Biology

By Raymond F. Dasmann; John Wiley & Sons, Inc., New York, 1964; 231 p., illustrated; $5.95.

I believe this book will become a classic in the game management field. It is an outstanding contribution.

In the preface, Dr. Dasmann states that he used much of the material in this book while teaching beginning classes in wildlife conservation at the University of California and Humboldt State College. He goes on to say that the students in these classes helped improve the manuscript with their questions, comments, or evidence of sheer boredom. As one of those students in his first class at Humboldt State College, I feel I qualified in all three areas. My wish now is that I had had this book for a text at that time. Future students will certainly have an advantage.

As most workers in the natural resources field will recognize, this is not the author's first literary venture. One of Dr. Dasmann's previous books, *The Last Horizon*, has achieved literary fame. *Wildlife Biology* may well do the same.

Wildlife Biology is not light reading; it is a very thought-provoking book. It handles such subjects as ecological ideas, interrelationships of wildlife species and habitat, population dynamics, and carrying capacity. These sound like subjects only the professional worker or advanced student could digest, but this is not so. The book is written in a clear, straight-forward manner which makes it easy to read, and most important—easy to understand and comprehend. The reasons for game management programs, with many specific examples, are given clearly so that a layman would be able to visualize the magnitude and complexity of the field of wildlife management.

After showing the history of wildlife and the present management programs, Dr. Dasmann directs the reader to the possible future of wildlife. He punctuates this thought with the fact that "Game management costs money. It will not be done unless those who will benefit from it will pay the cost." He also explains the present correlation of the increasing human population and the decreasing wildlife population, and what this means for the future.

It is my sincere belief that anyone interested in wildlife, and especially those who are making a career in wildlife or other natural resource work would benefit greatly by reading *Wildlife Biology.*—*Dick Laursen.*

Course for Apprentice Fishermen

Compiled and edited by the Staff of World Fishing; Grampian Press, Ltd., London, 1964; 82 pages, illustrated; 8s 6d (paper).

Course for Apprentice Fishermen fills a long-felt need by the world fishing industry. Many books have been published on rules of general seamanship and navigation, but few have been written on the specialized field of commercial fishing. This book was compiled from a series of articles appearing in the magazine *World Fishing* between October 1960 and January 1963. The articles proved so popular and were requested from so many parts of the world that the decision was made to publish them as a single edition. The original articles were expanded to include a chapter on modern stern trawling, as this type of fishing is becoming increasingly popular throughout the world.

The book, divided into 23 chapters, runs the full gamut of the duties performed by the modern trawl fisherman. Although the course was prepared with the apprentice trawl fisherman in mind, it can be applied to the general diversified fishing industry.

The book begins by illustrating and describing the rigging and deck gear of a typical side trawler. Following chapters are devoted to: (i) the basic trawl and its associated gear; (ii) the ropes and twines used aboard the trawler, with details on their care and maintenance; (iii) shooting and hauling, or the mechanics of side and stern trawling; and (iv) the dangers to be found aboard a trawler and methods by which accidents may be avoided.

Chapters 8 through 12 cover the basic fundamentals of the fishing trade. Such subjects as net mending, "Bends, Hitches, and Knots," "Blocks and Tackles," and "The Net Store" are covered.

Chapter 13 "Gutting, Stowing, and Icing," although very short is one of the most important in the book. The chapter emphasizes that the catch, if not properly handled, will deteriorate rapidly and all of the other hard and dangerous work of the fisherman will be for nothing. The high operating cost of the modern fishing fleet makes it doubly important to land the catch in the best possible condition if the fisherman is to make a decent wage.

The final chapters of the book are devoted to handling the ship at sea and the general principles of navigation. The knowledge acquired in these chapters is applicable to any powered vessel and is very easy to understand. The section on modern navigational aids is very helpful in that the theory of their operation is explained in a manner in which the basic functions can be quickly grasped. Understanding of the modern navigational aids is vitally important to the fisherman so that the limit of their usefulness and limitations can be defined.

The book is well written and concise and should be required reading for all apprentice fishermen, deckhands, and fishery workers intending to do work aboard a commercial fishing or oceanographic research vessel.—*Emil J. Smith, Jr.*

The Bountiful Sea

By Seabrook Hull; Prentice-Hall, Inc., Publ., Englewood Cliffs, New Jersey, 1964; xii + 340 p., illustrated; $6.95.

This is another book written for popular consumption and designed to cash in on the recent popularity of ocean sciences. In his attempt to cover all facets of ocean study, the author has compiled a large number of brief facts, without documentation, that leave the reader frustrated in understanding and with no possibility to pursue the subject.

The first chapters on the history of ocean exploration, from the time of the Phoenicians, is the most enjoyable and readable section of the book. A large part of the text is devoted to problems associated with the development of deep-submergence vehicles and anti-submarine warfare. In the concluding chapters on the harvesting of the resources of the world ocean, the author shows a lack of understanding of marine biology in general, and fisheries biology in particular. All in all this book has little to offer to the general public and nothing for the technical reader. —*E. A. Best.*

Advances in Ecological Research, Volume II

Edited by J. B. Cragg, Academic Press, Inc., London, 1964; xi+264 p., illustrated; $9.50.

The aim of *Advances in Ecological Research* is "to present comprehensive accounts of selected topics of ecological research in such a way that biologists with a general interest in ecology as well as specialists in ecology can obtain a balanced picture of what is taking place."

Volume II contains four articles: (i) "Analysis of processes involved in the natural control of insects" by M. E. Solomon, (ii) "The use of statistics in phytosociology" by J. M. Lambert and M. B. Dale, (iii) "Litter production in forests of the world" by J. Roger Bray, and (iv) "Forty years of genecology" by H. Heslop-Harrison.

The last two papers are amply described by their titles. Authors Lambert and Dale in their contribution refer not to probability statistics so much as to objective methods of putting the mass of data gathered during a plant survey into understandable form.

Mr. Solomon's paper probably will be the most useful to *California Fish and Game* readers. I found it a fascinating description of the types of processes that influence abundance, how they operate, and how to detect and access them. Mr. Solomon is not concerned here with field methods nor with constructing mathematical models of populations. He is concerned with conveying to his reader an understanding upon which such models are (or should be) built.—*D. W. Kelley.*

Biology of the Antarctic Seas

Edited by Milton O. Lee; American Geophysical Union, Washington, D.C., 1964; xi + 186 p., illustrated; $10.

This volume is the first in a series dealing with the biological and physical nature of the Antarctic. A grant by the National Science Foundation to the American Geophysical Union during 1963 initiated the series.

This composite publication involves a wide variety of Antarctic, biological research papers. The first three deal with primary productivity: "Primary organic production in the Drake Passage and Bransfield Strait," by Sayed Z. El-Sayed *et al.*, concerns the open waters of these two regions. "Primary productivity under sea ice in Antarctic waters, 1, Concentrations and photosynthetic activity of microalgae in the waters of McMurdo Sound, Antarctica," and "Primary productivity under sea ice in Antarctic waters, 2, Influence of light and other factors on photosynthetic activity," are both by J. S. Bunt.

"Respiratory metabolism and ecological characteristics of some fishes in McMurdo Sound, Antarctica," by Donald E. Wohlshlag, covers several species of stenothermal, cold-adapted fishes. M. A. McWhinnie's paper "Temperature responses and tissue respiration in Antarctic Crustacea with particular reference to the krill *Euphausia superba*," investigates euphausiid metabolic adaptations to temperature. "Antarctic foraminiferal zonation" by Orville L. Bandy and Ronald J. Echols, is based upon sediment analyses.

"Improved techniques for benthic trawling at depths greater than 2000 meters," by Robert J. Menzies, reviews deep-sea trawling devices dating from the *Porcupine* (1869) to the *Eltanin* (1962). The last paper in this volume "Catalogue of Antarctic and sub-antarctic benthic marine algae," by George F. Papenfuss, is also the longest (70 pages); it brings together the scattered and pertinent references on the marine algae of these regions.

In total, this type of publication fills a necessary gap in disseminating scientific information. Biological research is just now commencing to accelerate our understanding of the biology of aquatic organisms. Publications such as this help that acceleration.—*Arlo W. Fast*

Wondrous World of Fishes

Edited by Melville Bell Grosvenor; National Geographic Society, Washington, D.C., 1965; 367 p., illustrated; $8.75.

Wondrous World of Fishes was written for the general public. As such, it provides something for everybody: marine or freshwater fisherman, commercial and sportfisherman, skin-diver, aquarist, oceanarium spectator, and a chapter on fish cookery. These diverse fields are brought into focus by means of an introductory chapter on "Fishes and how they live" by Leonard P. Schultz, Curator of Fishes, Smithsonian Institution.

Lavish use of color photos throughout provides an entertaining format for serious reading or browsing. The American Fisheries Society's *List of Common and Scientific Names of Fishes from the United States and Canada* has been followed in identifying fish referred to in the text, with only a few exceptions.

Criticism of this book is indeed difficult. Inquiries of fisheries agencies, at least on the Pacific Coast, could have provided recent information and made this volume a little more correct. On page 209, *Panulirus*, and on page 218, *Astroscopus*, are misspelled.

These minor points do not detract from the book, and it will be a welcome addition to the bookshelf of the professional ichthyologist and the amateur naturalist.—*E. A. Best*

Fishes of the Great Lakes Region

By Carl L. Hubbs and Karl F. Lagler; The University of Michigan Press, Ann Arbor, 1964 edition; xv + 135 p., illustrated; $6.95.

This is the third revision of this classic text that started out as the *Guide to the Fishes of the Great Lakes and Tributary Waters* (Bull. 18, Cranbrook Institute of Science, 1941). Typographical errors have been corrected and there is a revised preface, otherwise, it is a reprint of the 1958 edition. Subjects in this volume include: the waters of the Great Lakes region and their fish associations, zoogeography, postglacial dispersal, field study and the collecting of fishes, preservation of fishes for study, and the identification of fishes.

Twenty-nine families with 231 species and subspecies are discussed and described. The characteristics and general life histories of each family are given, and ranges and general habitats are discussed for each species and subspecies. Excellent family and species keys are included in the text. The 45 color plates, 206 black-and-white photos, and numerous drawings and diagrams, are of excellent quality and clarity. The continued high quality and moderate cost should insure this volume a place in the library of all freshwater fishery biologists who do not possess the 1958 edition.—*Michael L. Johnson*

Mechanization of Small Fishing Craft

By Fishing News (Books) Ltd., London; 1964; 112 p., illustrated; $5.

The publishers have selected many of the papers introduced at a symposium organized by the Fisheries Agricultural Organization and the Indo-Pacific Fisheries Council in Korea in 1962. Additional papers by various authors are also included and contribute to the subjects presented at the symposium.

The book is divided in four sections: (i) installation and operation of outboard motors, (ii) inboard engines in open craft, (iii) inboard engines in decked craft, and (iv) service and maintenance.

The problems of expanding fishing success in less developed countries are considered. The discussions include the conversion of indigenous fishing craft and new designs for larger, more-efficient craft. Local conditions, customs, needs, and availability of materials and craftsmen are considered in each suggested design. Guidelines for optimum engine selection and maintenance are also presented.

Statistics on the development and achievements of the various agencies and governments exemplify the success of the program of fishing boat mechanization.

The vessel designs and examples appearing in the book make it a valuable reference for prospective fisheries workers in the Peace Corps or other overseas developmental agencies.—*J. Gary Smith*

Happier Family Camping

By George S. Wells; Stackpole Books, Harrisburg, Pa., 1965; 96 pages, $2.95.

Getting Out of Outdoor Trouble

By W. K. Merrill; Stackpole Books, Harrisburg, Pa., 1965; 96 pages, $2.95.

Here are two more small volumes in the Stackpole series of outdoor books. *Happier Family Camping* is, perhaps, best described as having been written for the first-time camper, or to encourage the second-timer who was discouraged by his first experience. There are descriptions of gear to fit most budgets, from bare essentials to the most luxurious, and also, the author's solutions to some of the worst outdoor living problems that one's children, fellow man, and Mother Nature can contrive or bestow upon the average camper.

Getting Out of Outdoor Trouble, written by an experienced ex-forest ranger, describes briefly how the outdoorsman can survive in the wilds when trouble becomes a reality. This handy, pocket-sized book provides helpful survival tips to those encountering trouble in situations from boating accidents to snake bites, and from airplane crashes to quicksand.—*William L. Craig.*

A Guide to Fresh and Salt Water Fishing

By George S. Fichter and Phil Francis, a Golden Handbook, Golden Press, New York, 1965; 160 p., illus., $1, paper.

This is one of a series of Golden Handbooks covering such subjects as sailing, photography, camping, guns, etc. It contains a tremendous amount of information about fishes and fishing in its well-organized compact format.

The colored illustrations which are profusely scattered throughout add to its attractiveness.

About one-third of the book describes and pictures the common North American fresh- and salt-water gamefish. Following sections concern all types of equipment used in the sport.

Technically, it is not bad; only a few insignificant errors were noted. It is a good buy for anyone honest enough to call himself a beginner in the art of fishing. *Willis A. Evans.*

Wild Cats

By C. B. Colby; Duell, Sloan, & Pearce, New York, 1964; 120 p., illustrated; $3.95.

C. B. Colby shows his love for the outdoors, and his diversified knowledge of wild life in this book of wild cats of the world.

The book is far from a scientific treatise on felines; it is written to give the reader a general knowledge of the 17 most common wild cats. All of the well known ones (e.g. lion, tiger, and jaguar) are mentioned as well as many of the lesser known breeds (e.g., margay, serval, and jaguarundi).

The introduction contains general information on cats, and covers a brief history through their past ancestors, and up to the present-day families as we know them.

The remainder of the book is divided into 17 chapters, one devoted to each species of cat. For the cat lover and those who would like a general informative book on some of the world's wild felines, the author makes it very interesting and readable. —*Hugh H. Thomas.*

Readings in Population and Community Ecology

By William E. Hazen; W. B. Saunders Company, Philadelphia and London, 1964; x + 388 p.; $4.75.

This book is a result of Dr. Hazen having collected source material for teaching introductory courses in field biology so he would be able "to introduce the student to the literature of ecology as soon as they begin their study." In all, 25 papers were sifted for material. His success in selecting and logically organizing these papers into a useful and valuable teaching and reference tool is commendable.

The book is organized into five parts. The introduction, "The Concept of Pattern in Ecology," by G. E. Hutchinson, is followed by increasingly complex relationships which are as follows: "Part II, Single species populations: Patterns in space and time. Part III, Relationships between species: Competition and predation. Part IV, Community Metabolism: Energetics and productivity. Part V, Community structure."

The book includes such classic papers as Lindeman's "The trophic-dynamic aspect of ecology," and Deevey's "Life tables for natural populations of animals," to name but two. Most of the papers are recent and expose the reader to the ideas of some of the world's finest ecologists.

The need for adequate theoretical models, laboratory experiments, and field studies is brought out by the various authors. The reader is made aware of many of the pitfalls to be avoided in investigating complex ecological relationships. Although the book may be somewhat difficult for the undergraduates, for whom it is intended, it will surely expose the reader to a wealth of ideas and information, and to an excellent bibliography bearing on some of the broader concepts and problems in ecology. —*Lee W. Miller.*

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Notice is hereby given, pursuant to Sections 206, 207, and 208 of the Fish and Game Code, that the Fish and Game Commission shall meet on October 1, 1965, at 10 AM, in Room 1138, New State Building, 107 South Broadway, Los Angeles, California, to receive recommendations from its own officers and employees, from the Department of Fish and Game and other public agencies, from organizations of private citizens, and from any interested person as to what, if any, regulations should be made relating to fish, amphibia, and reptiles, or any species or subspecies thereof.

Notice is hereby given, pursuant to Section 206 of the Fish and Game Code, that the Fish and Game Commission shall meet at 10 AM, on November 12, 1965, in Room B-109, State Building, 1350 Front Street, San Diego, California, for open public discussion of, and presentation of objections to, the proposals presented to the Commission in October and to announce publicly the regulations it proposes to make relating to fish, amphibia, and reptiles for the 1966 angling season.

Notice is hereby given, in accordance with Section 206 of the Fish and Game Code, that the Fish and Game Commission shall meet on December 10, 1965, at 10 AM, in the Auditorium, Resources Building, 1416 Ninth Street, Sacramento, California, to hear and consider any objections to its determinations and proposed regulations in relation to fish, amphibia, and reptiles for the 1966 angling season, such determinations and orders resulting from hearings held on October 1 and November 12, 1965.

Fish and Game Commission
Monica O'Brien
Secretary to the Commission

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