A COMPUTER PROGRAM FOR ANALYSIS OF POLYMODAL FREQUENCY DISTRIBUTIONS (ENORMSEP), FORTRAN IV

Program ENORMSEP (Extended Normal Separator Program) separates a polymodal frequency distribution into its component groups where aging studies have not been or cannot be performed. The program calculates preliminary estimates of the number of size groups and their points of overlap using probit analysis and polynomial regression techniques. These preliminary estimates are then entered into NORMSEP (Normal Separator Program) (Hasselblad 1966), used as a subroutine, in order to complete the analysis.

Output data are generated both as listings and punched cards. Listings include at the option of the user: 1) table of values of the standardized normal distribution; 2) table of values of probabilities, standardized normal variables, and probits; 3) polynomial regressions and analyses of variance of probits; 4) table of residuals for the final regression; 5) table of roots corresponding to all regressions after taking second derivative; 6) tables for analyses for the separation of modes; 7) plots of observed and predicted values for the final regression; and 8) plot of the original frequency distribution. Punched card output includes the number of observed frequency distributions with their intervals and probits and regression coefficients for the polynomials.

Input data require the observed size frequency together with values for identification and control purposes. No more than nine size groups may be separated because of limits on the efficiency of parameter estimate in the polynomial regression.

This computer program was developed on an IBM 360/65I computer[1] using release 20.7 MVT/HASP system at the Statistical and Computing Center at the University of Hawaii. This computer program is capable of processing multiple sets of data. For a "typical" problem, the program takes about 1 min of central processing unit time and a total machine unit time of 1.5 min to run a single problem "individually." The requirement for core storage is 168K, where K is 1,024 bytes and where a byte is an address collection consisting of eight binary bits or binary digits.

A description of the program, including program listing as well as input and output for two examples, is available from the authors upon request.

[1]Reference to this particular computer system does not imply endorsement of the product by the National Marine Fisheries Service, NOAA, but is given to provide the reader with a base for determining the cost of performing jobs with the particular computer system at his disposal.

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RECORDS OF LARVAL, TRANSFORMING, AND ADULT SPECIMENS OF THE QUILLFISH, *PTILICHTHYS GOODEI*, FROM WATERS OFF OREGON

This report extends the southern range of the quillfish, *Ptilichthys goodei* Bean 1881, in the northeast Pacific to waters off the central coast of Oregon where larval, transforming, and adult specimens have been collected. The previously reported range of this species in the North Pacific was from the Okhotsk and Bering seas to northern Washington and Puget Sound (DeLacy et al. 1972; Quast and Hall 1972; Hart 1973). The life history of the quillfish is poorly understood and nothing is known of the early stages (Walker 1953; Makushok 1958; Grinols 1965; Hart 1973).

Materials and Methods

Three larvae (20.3, 24.7, 36.0 mm SL–standard length) and one transforming specimen (114 mm SL) of *P. goodei* came from plankton collections made with large-mouth (0.7 m) bongos having 0.571-mm mesh nets. Tows were made in a step-oblique or oblique manner from near the bottom or 150 m (at deeper stations) to the surface at a vessel speed of 2 knots. Tow times were 16 to 25 min. The specimens were fixed in 10% and stored in 5% buffered Formalin.[1]

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

Two adults (272, 309 mm SL) of *P. goodei* came from otter trawl (5-m headrope, 4-cm stretch mesh body, 1.25-cm mesh cod end liner) collections. The trawl was towed on the bottom for 15 min at a speed of 2 to 3 knots. The specimens were fixed in 10% Formalin and stored in 40% isopropyl alcohol.

Body measurements were made as described by Hubbs and Lagler (1958). For larvae, standard length was measured from snout tip to notochord tip. The point of reference used to determine notochord tip in larvae of *P. goodei* is indicated by an arrow in Figure 1. It is the point near the end of the tail, at the posterior edge of the region having no pigment on the ventral margin. This point was determined from the tail tip of the 114-mm specimen which had been stained with alizarin red S.

Meristic counts were made on unstained larval and transforming specimens and radiographs of the adults.

Results

Descriptions

The larvae of *P. goodei* are characterized by their slender, elongate form; gut length (35-40% SL, decreasing with growth); myomere numbers, (55 to 57) + (170 to 174) = 225 to 229; and pigment pattern (Figure 1). Morphometrics and meristics are in Table 1. Compared with adults, the larvae have a short snout (17-18% HL—head length) and no fleshy protrusion of the lower jaw. The mouth is oblique. Dorsal and anal fin rays are evident in the 36-mm specimen but the adult numbers have not been attained. The spines of the first dorsal and the rays of the second dorsal begin to form at the posterior and anterior ends of the fins respectively. Development then proceeds anteriorly in the first dorsal fin and posteriorly in the second dorsal. The anal fin rays begin to form slightly anterior to the center of the fin with development proceeding anteriorly and posteriorly. Pectoral fin rays were not formed and pelvic fins were absent in the size range examined.

Pigmentation (Figure 1) on the three larval specimens is similar. Head pigmentation consists of that on the lower jaw, anterior part of the upper jaw, throat, and internally at the base of the hindbrain. Gut pigmentation is mostly restricted to the dorsal and ventral surface with some additional melanophores scattered over the anterior region. The melanophores on the ventral gut sur-

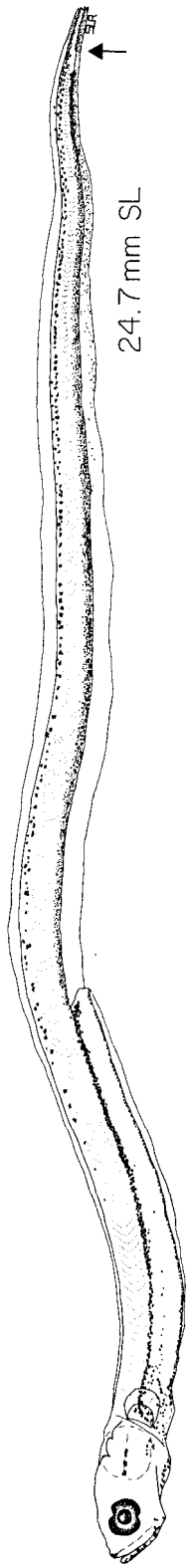

FIGURE 1.—Larva of *Ptilichthys goodei* from waters off Oregon (arrow indicates point of reference for SL).

TABLE 1.—Morphometrics (mm) and meristics of *Ptilichthys goodei* from Oregon waters.

Morphometrics										Meristics								
													P_1			Myomeres		
SL	TL[1]	Snout length	Eye diameter	Head length	Upper jaw length	Lower jaw length	Snout to anus	Depth at pectoral base	Depth at anus	DI	DII[2]	A[2]	Left	Right	Branchiostegals	Preanal	Postanal	Total
Larvae:																		
20.3	21.0	0.4	0.7	2.3	0.8	1.1	8.0	0.9	0.9	—	—	—	—	—	—	55	174	229
24.7	25.5	0.4	0.6	2.2	0.7	1.1	9.3	1.1	1.1	—	—	—	—	—	—	55	170	225
36.0	36.9	0.5	0.7	2.7	0.9	1.1	12.5	1.1	1.1	40	~80	~113	—	—	5	57	170	227
Transforming:																		
114	117	1.6	1.1	6.1	1.8	2.6	32.2	2.0	2.0	83	148	179	13	13	5	55	172	227
																	Vertebrae	
Adults:																Abdominal	Caudal[3]	Total
272	276	5.2	2.8	17.0	3.8	5.0	81	5.5	7.0	83	144	180	13	13	5	53	174	227
309	313	6.3	3.0	19.0	4.2	6.0	91	6.0	7.7	88	142	181	13	13	5	53	174	227

[1]Total length is given for comparison with other publications, although the long caudal filament was not intact.
[2]Dorsal and anal fin ray counts include possible caudal fin elements dorsal and ventral to the fleshy caudal extension respectively.
[3]One fused caudal vertebra found in each adult specimen was counted as one vertebra.

face form a single row on the anterior one-fourth to one-half the length of the gut and a double row along the remaining length. Body pigmentation is concentrated dorsally and ventrally. From a dorsal view, the dorsal melanophores appear somewhat as a double row, one on each side of the dorsal midline, extending from a point over the middle of the gut to near the tail tip (arrow in Figure 1). These dorsal melanophores are larger than the ventral ones. Ventrally, a heavy concentration of melanophores lines the body margin from the hindgut to near the tail tip. Posterior to this ventral body pigment is a small unpigmented area. Posterior to the ventral unpigmented area (arrow in Figure 1) is the fleshy caudal extension characteristic of the species. Pigment on this extension is distinct from that on the rest of the body. It is scattered rather evenly dorsally and ventrally on the body and out on to the finfolds. The lateral midline of this area remains unpigmented.

Identification of the larvae was possible because of the link to the adults provided by the 114-mm SL transforming specimen captured in the same area. The 114-mm specimen has meristics (Table 2), hooked dorsal spines, and a fleshy protrusion of the lower jaw characteristic of adult *P. goodei* and pigmentation similar to the larvae described above. The fleshy caudal extension is more distinct than in the larvae. Gut length (28% SL) is proportionately shorter and snout length (26% HL) proportionately longer. Additional pigment occurs on the dorsal surface of the head posterior to the eye, on the snout, and in a line along the margin of the preopercle extending posteriorly from the angle of the lower jaw. The ventral gut melanophores are in a single row along the entire gut length. Body pigmentation is less pronounced than in the larvae but still distinct.

Adults of *P. goodei* are characterized by their extremely elongate body, the absence of a distinct caudal fin, and the presence of a fleshy protrusion at the tip of the lower jaw. When alive, the two Oregon specimens were brightly colored. The body was light green dorsally shading to yellow ventrally and orange on the throat. Two dark maroon, horizontal stripes were present laterally with maroon spots scattered over the entire dorsal surface. Several dashed maroon lines radiated posteriorly from the snout. A distinct maroon-colored, horizontal bar extended anteriorly from the margin of each eye half the distance to the snout tip. Morphometrics and meristics appear in Table 1. Gut length (29% SL) is similar to that for the transforming specimen, but the snout length (31-33% HL) is greater. Both specimens exhibited a vertebral anomaly in which the centra of two adjacent vertebrae were fused to form a single element with two neural and two hemal spines. In the 309-mm SL specimen the 160th vertebra was fused and in the 272-mm SL specimen it was the 169th element.

Occurrence

Collection data for *P. goodei* from Oregon waters is presented in Table 2. All specimens came from waters off the central coast of Oregon between March and August. All but one was captured during daylight. All but one was taken in water greater than 120 m deep on the continental shelf 18 km or closer to shore where the bottom was primarily gray sand.

TABLE 2.–Collection data for *Ptilichthys goodei* from Oregon waters.

SL (mm)	Date	Location		Km from coast	Coastal reference	Time	Bottom depth (m)	Tow depth (m)	Gear	Bottom type[1]	Surface temp. (°C)
		Lat. N	Long. W								
Larvae:											
20.3	25 Mar. 1973	44°00′	124°22.1′	18	Siuslaw River	1526-1542	117	100-0	Bongos	Gray sand-green mud	11.0
24.7	20 Apr. 1973	44°00′	124°22.1′	18	Siuslaw River	0235-0300	109	75-0	Bongos	Gray sand-green mud	10.4
36.0	14 May 1971	44°39.1′	124°17.7′	18	Newport	1621-1641	80	75-0	Bongos	Gray sand	11.2
Transforming:											
114	29 June 1971	44°39.1′	124°52.7′	65	Newport	1128-1153	340	150-0	Bongos	(Slope)	14.5
Adults:											
272	7 Aug. 1973	44°42′	124°7′	5	Moolach Beach	0945-1007	52	52	Otter trawl	Gray sand	9
309	3 July 1973	44°45′	124°14′	13	Cape Foulweather	1010-1028	80	80	Otter trawl	Gray sand	10

[1]From USC&GS Charts No. 5702 and No. 5802.

The larval and transforming specimens reported here are the only representatives of *P. goodei* found in 847 small-mouth (0.2 m) bongo and 413 large-mouth (0.7 m) bongo samples analyzed to date from waters off Oregon. The samples are part of an ongoing project to study seasonal and annual variations in distribution and abundance of larval fishes. Other studies of larval fishes off Oregon (Richardson 1973; Pearcy and Myers 1974) yielded no *P. goodei*.

The two adult specimens are the only ones recovered from 23 trawl samples taken during the summer of 1973 in conjunction with an ecological baseline study of the nearshore region of the mid-Oregon coast in the vicinity of Yaquina Head. Although they were taken with a bottom trawl, it is possible that the specimens entered the net shortly before it was brought on board. Thus, they may have been in near surface water rather than on the bottom as their presence in trawl samples would suggest.

Discussion

Vertebral counts, (53 to 55) + (172 to 174) = 227, of the transforming and adult Oregon specimens are lower than those, (58 to 59) + (179 to 182) = 238 to 240, reported by Makushok (1958), presumably for Bering Sea specimens. The counts are also lower than those, 236 to 240, given by Hart (1973), presumably for British Columbia specimens. This could indicate clinal variation with the southern specimens having fewer vertebrae. On the other hand, the lower number of both abdominal and caudal vertebrae of the Oregon specimens could indicate the presence of an undescribed species. Additional Oregon specimens are needed to determine the range of variation in vertebral number and to compare with northern specimens to see if they are actually the same species.

Reasons why quillfish have not previously been reported from Oregon waters are speculative. A partial explanation may be the lack of major sampling efforts in Oregon's coastal zone until recent years. Rarity (Makushok 1958; Hart 1973), inaccessibility, avoidance, and escapement also offer explanations. It is possible the adults bury themselves in the bottom (Makushok 1958) and are thus inaccessible to conventional types of gear. Behavior exhibited by one of the adults taken off Oregon suggests the quillfish may readily avoid and/or escape from trawl gear. Immediately after the trawl was brought aboard, the slender fish wriggled through the meshes of the net onto the deck of the vessel. It demonstrated great agility with snakelike undulations. The larvae may remain on or near the bottom, or they may spend all or part of the time in the neuston. Either situation would make them inaccessible to most plankton gear. The large size of the larvae indicates good avoidance capabilities.

Acknowledgments

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EFFECT OF CROWDING ON STOCK AND CATCH IN *TILAPIA MOSSAMBICA*

In a previous report (Silliman 1972) I described the effect of crowding on the relation between exploitation and yield in *Tilapia macrocephala*. Subsequently I performed a similar experiment with *T. mossambica*. Since the results were somewhat different for the latter species and because of its wide use in pond culture, a brief report of the second experiment seems justifiable.

Apparatus and Procedures

Most of the procedures and apparatus were identical with those reported by Silliman (1972). Essentially the approach was to raise the populations in two conventional aquariums, one (L) with a volume of 155.2 liters and the other (S) with 77.6 liters so that S had exactly one-half the capacity of L. Aeration was by airstones and illumination by overhead fluorescent lamps. Rectangular spaces at the ends of the aquariums were fenced off with rods placed 3 mm apart, providing refuges for the young. Further shelter was provided by floats with suspended cords and by fiber brush shelters. Covering part of the aquarium walls with black plastic furnished shaded areas for spawning. Water condition was maintained by filtration and weekly partial water changes. Water temperature was 24° ± 2°C to month 5.7 and 30° ± 2°C thereafter. Feeding details are given in Table 1.

Populations were counted and weighed at approximately 2-mo intervals. Since *T. mossambica* is a mouthbreeder, it was desirable not to handle the fish more often than this. The 2-mo period includes 1.0 to 2.6 of the brood intervals reported by various authors (Kelly 1957, 30-40 days; Swingle 1960, 30-40 days; Uchida and King 1962, 23-61 days). Exploitation consisted of removing each 10th fish. In weighing, fish were drained in a net and placed in a previously weighed container of water; fish weight was total weight less the tare.

Table 1.—Food (in g) placed in tanks.

Day of week	Trout pellets		Tropical fish food		Total
	Moist	Dry	A[1]	B[1]	
Sun.	4.0	1.5	0.5	1.0	7.0
Mon.	5.5	1.5	0.5	1.5	9.0
Tues.	5.5	1.5	0.5	1.5	9.0
Wed.	5.5	1.5	0.5	1.5	9.0
Thurs.	5.5	1.5	0.5	1.5	9.0
Fri. A.M.	5.5	1.5	0.5	1.5	9.0
Fri. P.M.[2]	5.5	1.5	0.5	1.5	9.0
Total	37.0	10.5	3.5	10.0	61.0

[1]Commercial makes of dry food.
[2]This was combined with the Friday A.M. feeding in 35 out of 131 wk and with the Sunday feeding once.

Results and Conclusions

The two populations were started 10 July 1970 (Table 2, Figure 1). Recruitment (estimated from counts as in Silliman 1972) occurred after the temperature increase at month 5.7 and readjustment of the sex ratios at month 6.9 (Table 2). As was true for *T. macrocephala*, recruitment was greater in tank L (62) than in tank S (20). Some