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MORPHOLOGICAL DIFFERENCES BETWEEN TWO CONGENERIC SPECIES OF PLEURONECTID FLATFISHES: ARROWTOOTH FLOUNDER, *ATHERESTHES STOMIAS*, AND KAMCHATKA FLOUNDER, *A. EVERMANNI*

The two flatfishes of the genus *Atheresthes* (family Pleuronectidae) are commonly caught in the eastern Bering Sea commercial trawl fishery. From 1977 to 1983, they comprised an estimated 10.03% of the total flatfish catch by the foreign trawl vessels in the Bering Sea/Aleutian Islands region (data compiled from U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center). However, these two species, the arrowtooth flounder, *A. stomias*, and Kamchatka flounder, *A. evermanni*, are morphologically similar and hence difficult to distinguish. As a result, fisheries workers in the field often lump the two species or misidentify them. Because the two species may have biological differences not presently known, it is important for management considerations and stock assessments to distinguish the species in fisheries surveys. The objective of this paper is to describe gross morphological differences between the two species more explicitly, so that the two can be accurately identified in the field.

Norman (1934) thought that these two species of *Atheresthes* were so similar that eventually they were shown to be identical. However, based on electrophoretic evidence, Ranck et al. (1986) concluded that *A. stomias* and *A. evermanni* are valid species. Wilimovsky et al. (1967) previously had reached this same conclusion by using a special morphological character index to separate the two species. This index is a function of caudal vertebrae number, gill raker number, distance from anterior eye margin to dorsal origin, and eye diameter. Unfortunately, the index is too complex to use in the field because it is based partly on characters that cannot easily be evaluated by gross external examination. This study describes a simpler method for differentiating the two species based on previously described external morphological characteristics and two new morphological characters.

Methods

Collections were made in the eastern Bering Sea in an area between lat. 54° and 59°N, long. 163° and 174°W (Fig. 1) aboard the National Marine Fisheries Service RV *Chapman* in summer 1984.

Specimens were unselectively sampled in the field from trawl catches containing *A. stomias* and *A. evermanni*. The fork length and sex of the fish along with location of sample were recorded, and each specimen was preserved in 3.7% seawater/formaldehyde solution.

In the laboratory, the following characteristics were examined:

1) Upper eye position: Specimens were first classified according to the position of the upper eye, following Norman (1934). If the orbit of the upper eye interrupted the profile of the head (Fig. 2A), the specimen was classified as *A. stomias*. If the upper eye did not interrupt the profile of the head (Fig. 2B) and was completely on the right side of the head, the specimen was classified as *A. evermanni* (Norman 1934; Wilimovsky 1967).

2) Gill raker counts: After initial separation of the specimens on the basis of the upper eye position, the four gill arches of the eyed side were removed and the gill raker count of each of the four arches recorded. Counts of the upper and lower limbs were recorded separately and the two counts were separated by a plus sign (for example, 4+12 means 4 rakers on the upper limb and 12 on the lower limb). If a gill raker straddled the angle of the arch, it was included in the count of the lower limb. In this study, only the lath-shaped structures were counted as gill rakers; the rudiments were not counted.

Results

A total of 251 fish was examined. Based on the upper eye position, 170 specimens were classi-

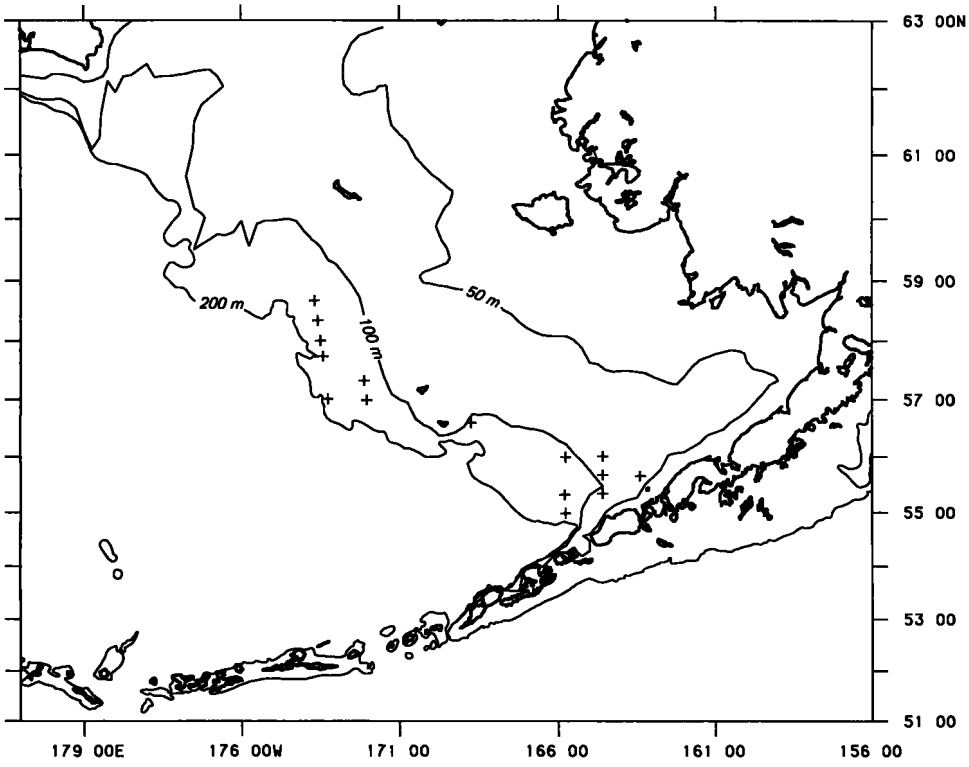

FIGURE 1.—Bering Sea collecting localities.

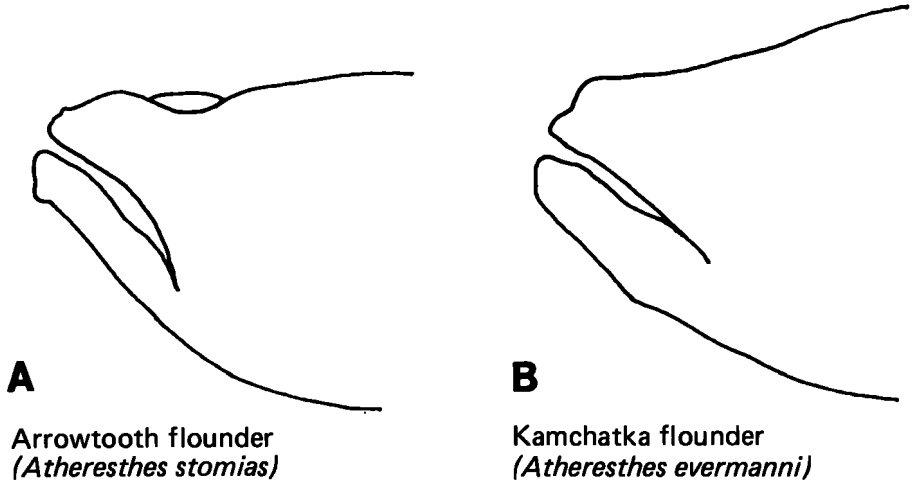

FIGURE 2.—Blind side view of head profiles of *Atheresthes stomias* (A) and *A. evermanni* (B).

fied as *A. stomias*, and 81 as *A. evermanni*. Gill rakers decreased in number from the first to the third gill arches in both species. Neither species had gill rakers on the fourth gill arch (though they did have rudiments).

First Gill Arch

In general, *A. stomias* had more gill rakers (on both the upper and lower limbs) on the first gill arch than did *A. evermanni*; however, the counts did overlap both in arrangement of gill rakers and total numbers (Table 1). Of the *A. stomias* examined, 75.2% had 4 or more rakers on the upper limb and none had fewer than 3. On the other hand, no *A. evermanni* had 4 or more gill rakers, and 49.4% had 2 rakers on the upper limb on the first gill arch.

Second Gill Arch

As was the case of the first gill arch, *A. stomias*, in general, had more gill rakers on the second gill arch than did *A. evermanni*. There were minor overlaps (1.8%) between these two species in the total gill raker counts and in the distribution of the gill rakers (Table 2). In addition to having different gill raker counts and patterns, all of the *A. evermanni* examined had 1 gill raker on the upper limb of the second gill arch, whereas 98.2% of the *A. stomias* had 2 gill rakers on the upper limb of the second gill arch (Table 2).

Third Gill Arch

In general, *A. stomias* had more gill rakers on the third gill arch than did *A. evermanni*. The range of total raker counts for *A. stomias* was 3 to 7, with most (85.3%) having 4 or 5. Total raker counts for *A. evermanni* ranged from 2 to 5, with 64.2% having 3. The most frequent arrangements of gill rakers on the third gill arch of *A. stomias* were 0+4 (43.5%) and 0+5 (41.2%), and the most frequent arrangement for *A. evermanni* was 0+3 (64.2%). Only three (1.8%) *A. stomias* had one gill raker on the upper limb of the third gill arch. The rest (98.2% *A. stomias* and all *A. evermanni*) had no gill rakers on the upper limb of the third gill arch.

Anomalous Specimens

Three specimens had the upper eye interrupting the profile of the head but had only 1 gill raker on the upper limb of the second gill arch. These fish were probably *A. stomias* with anomalous gill raker counts. One of the three had gill raker patterns of 4+11, 1+9, and 0+4 on the first, second, and third gill arches, respectively. The gill raker patterns on the blind side of this specimen were 3+11 on the first gill arch, 2+9 on the second, and 0+4 on the third. Thus, because this specimen had 4 gill rakers on the upper limb of the first gill arch on the eye

TABLE 1.—Gill-raker arrangements and their percentages (%) of frequency of occurrence (FO) on the first gill arches (eyed side) of *Atheresthes stomias* and *Atheresthes evermanni* collected from eastern Bering Sea.

	stomias		*evermanni*	
Pattern	FO	%	FO	%
5+11	2	1.2	0	0
4+13	1	0.6	0	0
4+12	59	34.7	0	0
4+11	65	38.1	0	0
4+10	1	0.6	0	0
3+13	1	0.6	0	0
3+12	11	6.5	0	0
3+11	29	17.1	4	4.9
3+10	1	0.6	32	39.5
3+9	0	0	5	6.2
2+11	0	0	3	3.7
2+10	0	0	29	35.8
2+9	0	0	8	9.9
Total	170	100	81	100
Mean	15.1		12.4	

TABLE 2.—Gill-raker arrangements and their percentages (%) of frequency of occurrence (FO) on the second gill arches (eyed side) of *Atheresthes stomias* and *Atheresthes evermanni* collected from the eastern Bering Sea.

	stomias		*evermanni*	
Pattern	FO	%	FO	%
3+10	1	0.6	0	0
2+11	3	1.8	0	0
2+10	54	31.8	0	0
2+9	108	63.4	0	0
2+8	1	0.6	0	0
1+9	3	1.8	8	9.9
1+8	0	0	61	75.3
1+7	0	0	11	13.6
1+6	0	0	1	1.2
Total	170	100	81	100
Mean	11.3		8.9	
2 or more rakers on upper limb	167	98.2	0	0
1 raker on upper limb	[1]3	1.8	81	100

[1]All of these *A. stomias* have two gill rakers on the upper limbs of the second gill arches of the blind side. Their patterns are either 2+10 or 2+9.

side and 2 gill rakers on the upper limb of the second gill arch on the blind side, it is referred to *A. stomias*. The other two anomalous specimens also had 2 gill rakers on the upper limbs of the second gill arch of the blind side and were also recorded as *A. stomias*.

Discussion

From this study, it is evident that the two species of *Atheresthes* can most easily be distinguished by eye position. The number of gill rakers on first and second gill arches can be used to assist and verify identification.

When identifying specimens, eye position should be examined first. If the upper eye interrupts the profile of the head, this specimen is *A. stomias*; if the upper eye does not interrupt the profile of the head, the specimen is *A. evermanni*. If the head is in bad shape (e.g., damaged during the trawl operation) or if the examiner has difficulty using eye position and head profile to identify a specimen, the gill arches must be examined. Two or more gill rakers on the upper limb of the second gill arch indicates that the specimen is *A. stomias*; if there is only 1 gill raker, the specimen is *A. evermanni*.

The number of gill rakers on the first gill arch has generally been used to distinguish the two species of *Atheresthes*. However, this study demonstrated a greater overlap between the two species in number of rakers on the first gill arch than the second gill arch (Tables 1, 2), indicating that the second gill arch is a better character for assigning individuals to the species.

The study also suggests that the number of gill rakers on the upper limb of the first gill arch is species specific. If there are 4 or more gill rakers, the specimen is *A. stomias*; 2 or fewer gill rakers indicate the specimen is *A. evermanni*.

The uncertainty in examining the first gill arch is when there are 3 gill rakers on the upper limb. Approximately 25% of *A. stomias* and 50% of *A. evermanni* samples had 3 gill rakers on the upper limb of the first gill arch. Thus, when 3 gill rakers are present on the upper limb of the first gill, the second gill arch must also be examined to distinguish the two species.

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PREDATION OF KARLUK RIVER SOCKEYE SALMON BY COHO SALMON AND CHAR

The number of sockeye salmon, *Oncorhynchus nerka*, in Alaska's Karluk River (Fig. 1) declined from millions to thousands during the early part of the present century. Rounsefell (1958) discussed alternative explanations for the decline including a general loss of fertility of the system as the number of salmon carcasses declined, competition, overfishing, subtle changes in climate, and predation; he concluded that the combined effect of predation and fishing was the most probable explanation. Later, Van Cleave and Bevan (1973) suggested that the weir constructed in the river each year to facilitate counting the fish as they entered the system was the most probable cause of the decline. It prevented free movement of both adults and juveniles in the river. All of these hypotheses remain as potential explanations for the decline.

Fredin et al. (1974) described a relation that showed two equilibrium regions between the spawning stock and the resultant run for sockeye salmon in the Kodiak area. We developed a stock-recruitment curve (Fig. 2) for sockeye salmon in the Karluk River basin that also showed two equilibrium regions, and suggested that the population had "col-