Abstract.– The summer flounder *Paralichthys dentatus* spawned throughout the Mid-Atlantic Bight and Georges Bank during 1977–85. Spawning peaked in fall but extended from September through January. Planktonic larvae (2–13 mm) were most abundant in the Mid-Atlantic Bight September–May. At approximately 11–14 mm, some larvae entered New Jersey estuaries; but their occurrence, especially during winter and early spring, was sporadic. Young-of-the-year were more frequently collected after May. During the first summer inshore they grew rapidly and reached 160–320 mm TL. Young-of-the-year emigrated from the estuaries in fall and were most abundant on the shallow portions of the adjacent continental shelf. Some evidence suggests that young-of-the-year in the northern Mid-Atlantic Bight reach a larger size than those from the southern portion. An hypothesis to explain the observed rarity of small juveniles in northern estuaries in some years is that some juveniles utilize the continental shelf as a nursery and enter estuaries at a larger size. This hypothesis requires testing.

Manuscript accepted 18 September 1989.
Fishery Bulletin, U.S. 88:1-12.

Patterns of Summer Flounder *Paralichthys dentatus* Early Life History in the Mid-Atlantic Bight and New Jersey Estuaries

Kenneth W. Able
Institute of Marine and Coastal Sciences and Biological Sciences
Rutgers University, New Brunswick, New Jersey 08903
Present address: Marine Field Station, Rutgers University, Tuckerton, New Jersey 08087

R. Edmond Matheson
Institute of Marine and Coastal Sciences and Biological Sciences
Rutgers University, New Brunswick, New Jersey 08903
Present address: Florida Marine Research Institute
St. Petersburg, Florida 33701

Wallace W. Morse
Michael P. Fahay
Sandy Hook Laboratory, Northeast Fisheries Center
National Marine Fisheries Service, NOAA, Highlands, New Jersey 07732

Gary Shepherd
Woods Hole Laboratory, Northeast Fisheries Center
National Marine Fisheries Service, NOAA, Woods Hole, Massachusetts 02543

The summer flounder *Paralichthys dentatus* inhabits estuarine and continental shelf waters from Nova Scotia (Leim and Scott 1966) to Florida (Gutherz 1967). Over much of this range it supports important commercial and recreational fisheries (Grosslein and Azarovitz 1982). The economic importance of *P. dentatus* has prompted research on various aspects of its biology (see Scarlett 1982, Grosslein and Azarovitz 1982, Rogers and Van Den Avyle 1983), but the spatial and temporal patterns of spawning and the nursery areas are not well known. Our understanding of the timing and distribution of spawning in the Mid-Atlantic Bight is based on examination of adult gonads (Morse 1981) and larval surveys (Smith 1973, Smith et al. 1975, Morse et al. 1987). Spawning occurs at temperatures of 12–19°C (Smith 1973), eggs and larvae are pelagic, hatching in the laboratory occurs approximately 48–96 hours after fertilization at 15–21°C (Johns and Howell 1980, Johns et al. 1981), and the pelagic larvae begin transformation at 9–12 mm SL (Smith and Fahay 1970, Smigielski 1975).

Major nursery areas are assumed to occur in estuaries from Virginia and south (Poole 1966, Powell and Schwartz 1977, Grosslein and Azarovitz 1982), although juveniles also occur in estuaries in the northern Mid-Atlantic Bight (Poole 1961, Pearcy and Richards 1962, Pacheco and Grant 1973). Juveniles, presumably, leave estuaries in fall, migrate offshore to overwinter, and return to the estuaries in spring with the adults (Hamer and Lux 1962, Murawski 1970). Although some individuals have been found north and east of their estuarine and offshore tagging locations,

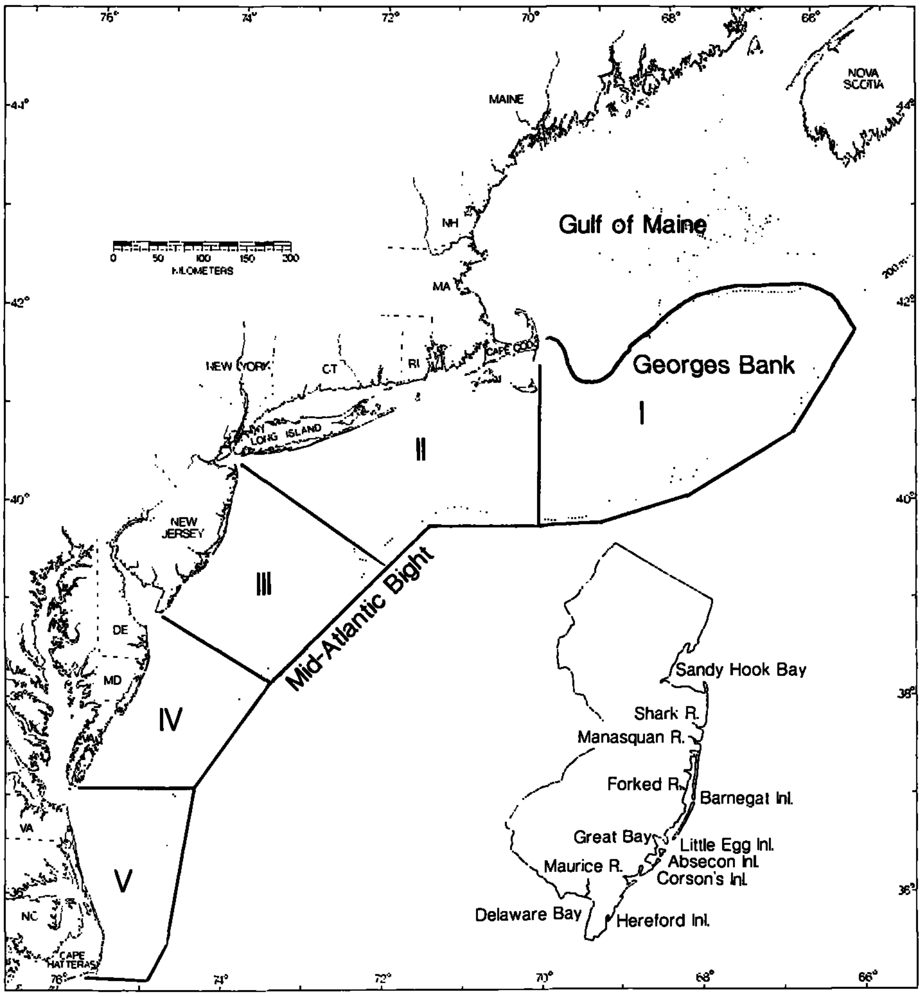

Figure 1
Study area with subarea boundaries and important localities mentioned in the text.

others returned to the original tagging locations in estuaries.

Conflicting evidence concerning the distribution of different stocks or subpopulations hampers interpretation of the patterns of reproduction and identification of nursery areas. Several authors have suggested that Mid-Atlantic Bight and North Carolina populations may be separate (Ginsburg 1952, Smith and Daiber 1977, Wilk et al. 1980). An alternate interpretation is that inshore populations from Virginia to North Carolina may form a separate population from those to the north and offshore (Delaney 1986).

Herein we attempt to clarify the patterns of reproduction and early life history of *P. dentatus* in the Mid-Atlantic Bight. Our interpretations are based on extensive collections of eggs, larvae, and first-year juveniles from continental shelf and estuarine waters.

Materials and methods

Data for eggs, larvae and first year juveniles of *P. dentatus* collected over the Mid-Atlantic Bight continental shelf and in New Jersey estuaries (Fig. 1) derive from sources given in Table 1 and from Marine Resources Monitoring, Assessment and Prediction (MARMAP) surveys (Sherman 1980, 1986) by the National Marine Fisheries Service (NMFS). These surveys were conducted at monthly to bimonthly intervals over the continental shelf from Cape Hatteras, North Carolina, to Cape Sable, Nova Scotia. Sampling methodology can be found in Sibunka and Silverman (1984) and Morse et al. (1987). Collections made with 61-cm bongo frames fitted with 0.505-mm mesh nets were corrected for the depth of tow and volume of water filtered and expressed as number per unit volume of sea surface. For graphic display of the egg and larval distribution and abundance, the catches per

Table 1

Summary and sources of *Paralichthys dentatus* data and specimens of young-of-the-year from New Jersey, reexamined for this study.

Study area	Collection method	Collection period	Number of individuals	Length range (mm TL)	Source
Southern New Jersey estuaries and Delaware Bay	Miscellaneous trawls, seines	1930s–1972	538	10–320	Allen et al. 1978 de Sylva et al. 1961 Milstein and Thomas 1976 Acad. Nat. Sci. Phila. collections
New Jersey inlets	1-m plankton net (0.5 mm mesh), trawls	1962–72	380	5–21	Festa 1974
Maurice River and vicinity of Atlantic City	1-m plankton net (0.5 mm mesh)	1975–77	6	15–19	Himchak 1982
Barnegat Bay	Power plant screens, trawls	1976–80	1091	10–330	Vouglitois 1983 Tatham et al. 1977
Great Bay	Recreational fishery creel survey	1967–76	1905	230–300	Festa 1979
New Jersey offshore	Otter trawl	1985	173	16–300	Halgren and Scarlett 1985
Manasquan River	Trawl	1984–86	128	35–320	Scarlett 1989

10 m^2 within each 25-km^2 block in the survey area were averaged for all years combined. Additional *P. dentatus* collections were made with a 0.5-m net (1.8 mm mesh) during 1987 from Little Sheepshead Creek which is immediately adjacent to Little Egg Inlet, New Jersey (Fig. 1). Lengths of larvae (Table 4) were recorded as millimeters (mm) notochord length (NL) or standard length (SL). Lengths for transforming individuals and larger young-of-the-year (YOY) (Figs. 4, 5) are presented as total length (TL). For purposes of comparison, SL = 0.650 + 0.778 TL.

Our assignment of *P. dentatus* specimens to the YOY group from inshore and offshore data sets was based on size frequencies and ages derived from scales. Ageing criteria were based, in part, on the protocol developed by Smith et al. (1981). Data for YOY collected over the continental shelf were taken during fall bottom-trawl surveys conducted by the Northeast Fisheries Center, NOAA. Sampling methodology for these surveys is described by Azarovitz (1981).

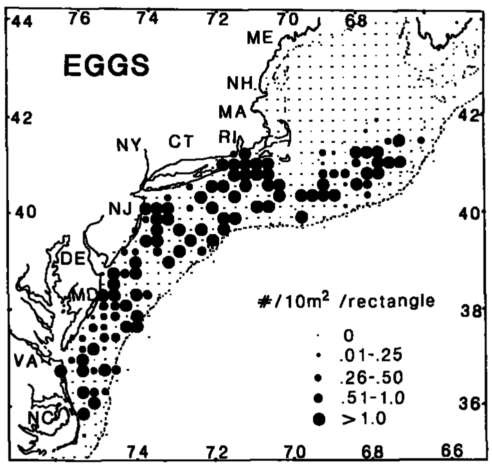

Figure 2

Distribution and abundance (cumulative mean no./10 m^2 of sea surface) of *Paralichthys dentatus* eggs from MARMAP collections during 1979–81, 1984, and 1985.

Results

Offshore egg distribution

Composite collections of *Paralichthys dentatus* eggs during 1979–85 indicate that spawning occurs from Georges Bank to Cape Hatteras from nearshore to the edge of the continental shelf (Fig. 2). Eggs were most abundant in samples from subareas II–V (Fig. 1, Table 2). Eggs were collected as early as September (except in subarea I) and as late as December and January in subareas I, II, and IV, although the number of stations sampled was small (subarea III) or zero (subareas IV and V) in December (Table 2). In all subareas the highest frequency of occurrence and greatest abundance occurred in October and November (Table 2).

Offshore larvae distribution

The spatial distribution of larvae was similar to that of the eggs except that larvae were much less numerous in subarea I (Fig. 3, Table 3). In general, larvae were most abundant in subareas II, III, and V (Table 3).

Table 2

Abundance of *Paralichthys dentatus* eggs (mean no./100 m^2 of sea surface) from MARMAP surveys during 1979–81, 1984, and 1985, by subarea and month. occ = number of stations where eggs occurred; nst = number of stations sampled; dash indicates no eggs collected; ns indicates no samples.

Subarea	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
I Georges Bank												
	—	—	—	45.2	42.8	2.0	0.9	—	—	—	—	—
(occ)	0	0	0	42	17	1	1	0	0	0	0	0
(nst)	149	176	79	345	143	97	109	80	191	252	121	75
II Southern New England												
	—	—	1.3	171.8	97.1	19.8	—	—	—	—	—	—
(occ)	0	0	1	46	27	3	0	0	0	0	0	0
(nst)	152	116	35	143	63	58	74	13	183	109	49	57
III New Jersey												
	—	—	2.8	4.4	133.7	—	—	—	—	—	—	—
(occ)	0	0	2	25	15	0	0	0	0	0	0	0
(nst)	102	64	39	83	54	5	38	57	118	76	40	61
IV Delmarva Peninsula												
	—	—	14.3	86.3	83.2	ns	1.2	—	—	—	—	—
(occ)	0	0	12	10	21		1	0	0	0	0	0
(nst)	97	62	79	34	64		42	84	110	71	43	67
V Virginia Capes to Cape Hatteras												
	—	—	1.6	48.2	121.0	ns	—	—	—	—	—	—
(occ)	0	0	2	5	17		0	0	0	0	0	0
(nst)	64	71	58	25	48		34	66	83	137	162	74

Table 3

Abundance of *Paralichthys dentatus* larvae (mean no./100 m^2 of sea surface) from MARMAP surveys during 1977–85, by subarea and month. occ = number of stations where larvae occurred; nst = number of stations sampled; dash indicates no larvae collected; ns indicates no samples.

Subarea	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
I Georges Bank												
	—	—	—	7.0	15.6	5.9	1.8	1.8	—	—	—	—
(occ)	0	0	0	20	12	7	2	2	0	0	0	0
(nst)	162	184	31	371	164	137	106	118	200	241	225	109
II Southern New England												
	—	—	5.9	75.5	177.7	112.6	4.7	11.4	0.2	—	—	—
(occ)	0	0	3	73	26	54	3	6	1	0	0	0
(nst)	169	170	29	186	49	113	49	56	207	184	154	124
III New Jersey												
	—	—	0.3	13.4	141.7	47.9	—	5.9	0.6	—	—	—
(occ)	0	0	1	26	23	10	0	5	2	0	0	0
(nst)	141	122	44	116	64	30	79	119	160	144	135	128
IV Delmarva Peninsula												
	—	—	—	53.8	52.9	27.3	—	2.3	0.1	0.7	0.2	—
(occ)	0	0	0	13	23	6	0	7	1	2	1	0
(nst)	91	113	83	46	65	17	79	130	154	93	129	103
V Virginia Capes to Cape Hatteras												
	—	—	—	3.7	176.8	ns	—	1.3	3.6	17.7	3.4	—
(occ)	0	0	0	4	30		0	3	8	14	8	0
(nst)	65	80	72	34	48		79	113	103	56	97	73

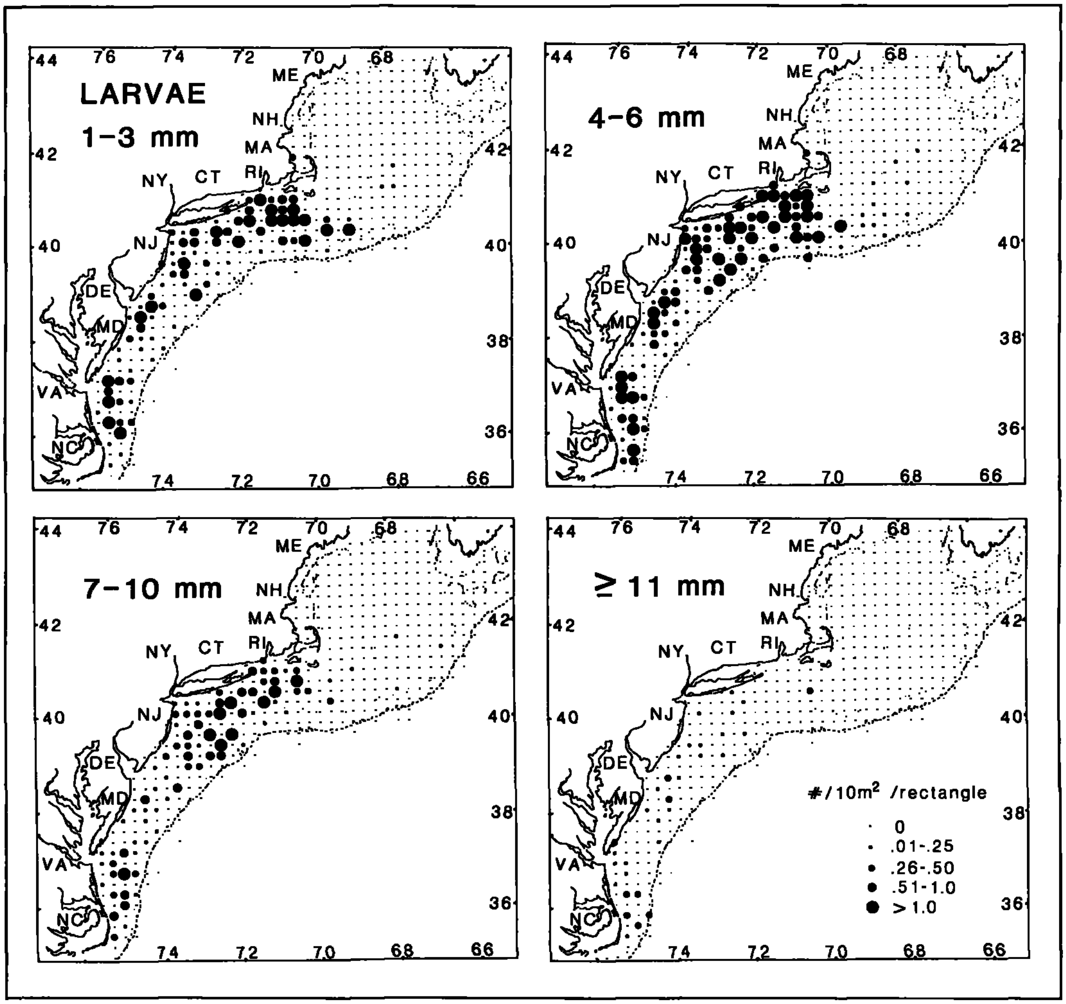

Figure 3

Distribution and abundance (cumulative mean no./10m^2 of sea surface) of *Paralichthys dentatus* larvae by length during 1977–84.

Small larvae (<6 mm) were clumped in three regions (Fig. 3): Subarea II to northern subarea III, northern subarea IV, and subarea V. The northern and southernmost of these groupings are also apparent for larvae of 7–10 mm, but there is no well defined pattern for larger larvae.

Larvae were collected September–May, depending on location, but in most subareas the peak abundance occurred in November (Table 3). Larvae were captured as early as September in subareas II and III. The latest captures were during May in subareas IV and V. Larvae occurred over 5–7 months within the study area (Table 3). The shortest duration of occurrence was in subarea I (October–February), and the longest was in subareas IV and V (October–May). For most subareas, larval catches were low or zero in January followed by a slight increase in February. The most southerly subarea (V) showed a smaller peak in April. Individual years (see Morse et al. 1987) revealed similar patterns in timing and location of eggs and larvae as found in the composite data (Table 3).

As expected from the timing of peak egg abundance, the smallest larvae (<6 mm) were most abundant October–December (Table 4). Small larvae (4–8 mm) occurred in April, although we collected no eggs February–April which could have accounted for these larvae. The largest larvae (≥11 mm) were abundant November–May with peaks in November–December and March–May.

Inshore occurrence of larvae and juveniles

Transforming *P. dentatus* have been collected from most of the major inlets adjacent to subarea III along the New Jersey coast. Reexamination of data collected in New Jersey estuaries (Table 1) and our own collecting efforts indicate transforming larvae have occurred

Table 4

Abundance (mean no./100 m² of sea surface) of *Paralichthys dentatus* larvae from MARMAP surveys during 1977–85, by month and length.

Length (mm SL)	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
2		73.6	53.0	7.2					
3	9.5	1048.0	815.6	141.1					
4		563.1	853.0	291.7		2.2		6.5	
5		238.1	509.7	308.6	4.5	12.1		12.5	6.5
6	4.6	106.8	461.5	213.9	8.9	13.7		4.6	
7		75.7	318.2	194.6	4.5	29.0		28.9	
8	4.6	46.8	117.8	166.0	10.0	94.1	8.9	4.5	8.8
9		1.9	11.8	80.6	4.5	23.0	5.0	12.6	
10			22.1	56.5	5.6	30.6	15.7	4.0	
11		1.9	3.5	12.9	4.4	3.8	14.0	16.9	12.1
12						3.5	9.1	3.4	5.4
13			5.3	3.1			1.7	11.8	2.0
>13				14.7					1.5

in Sandy Hook Bay, Shark River Inlet, Manasquan Inlet, Barnegat Bay, Little Egg Inlet, Absecon Inlet, Corson's Inlet, and the Maurice River (Fig. 1). These larvae were in the range 8–21 mm ($n = 378$), but most were 11–14 mm. In Manasquan Inlet larval abundance was quite high, with counts per half-hour set reaching 31 larvae on 24 October 1967, 44 on 28 November 1963, 34 on 2 December 1966, and 64 on 5 December 1963 (Festa 1974).

Movement of transforming individuals through inlets in New Jersey occurs primarily October–December (Fig. 4). However, a few larvae have been collected as late as February (15–17 mm TL, $n = 2$) in Little Sheepshead Creek inside Little Egg Inlet (this study); in March and May (15.0–19.0 mm TL, $n = 4$) in the Maurice River off Delaware Bay; in March in Manasquan Inlet ($n = 1$) and Corson Inlet ($n = 1$); and February, March, and April in Absecon Inlet (10.6–13.8 mm TL, $n = 7$) (Table 1). The extensive collections in the Manasquan and Shark River inlets (Festa 1974) produced relatively large numbers that are depicted as the first peak of 10–20 mm individuals in October in Figure 4. Other collections suggest that some of these individuals may attain a size of 30–50 mm by December, but these occurrences have been sporadic. During 1975–80, *P. dentatus* of 30–50 mm only occurred in winter 1975. The available data are sparse for YOY January–April (Fig. 4). This same cohort was represented by a few individuals in May (30–50 mm and perhaps up to 90 mm), more individuals in June (30–140 mm) and accounts for the dominant peak July–October when they reach a size of 160–320 mm. As a result, in October there were two well-defined length-frequency modes: a mode around 10 mm that represents transforming individuals, and a larger mode (160–320 mm) that represents individuals 1 year older. In a subsample ($n = 111$) of *P. dentatus* collected during the period September– November (larger mode in Figure 4), 97% of the scales lacked an annulus; thus, by convention (Smith et al. 1981), they are considered to be YOY, although they are 1 year older than the transforming specimens (smaller mode in Figure 4).

Fall distribution of YOY

Young-of-the-year (160–320 mm) apparently move out of estuaries in fall with adults. By November, YOY are less abundant inshore (Fig. 4) but are well represented in NMFS continental shelf trawl surveys (Fig. 5). This same size class appeared as a definite peak (~200–270 mm) in September 1985 trawl collections off the coast of New Jersey (Halgren and Scarlett 1985). YOY individuals are distributed inshore from Long Island to south of Cape Hatteras at this time of the year (Fig. 6) with larger individuals apparently more abundant north of Delaware Bay (Fig. 7).

Discussion

Timing and location of spawning and development

The geographical patterns of reproduction observed during 1979–85, as measured by the distribution and abundance of eggs (Fig. 2), were similar to those reported for 1965–66 (Smith 1973). An exception is the report (possibly a result of misidentifications) of spawning in July in Narragansett Bay (Herman 1963). Our sampling in 1980–86 extended farther north and east

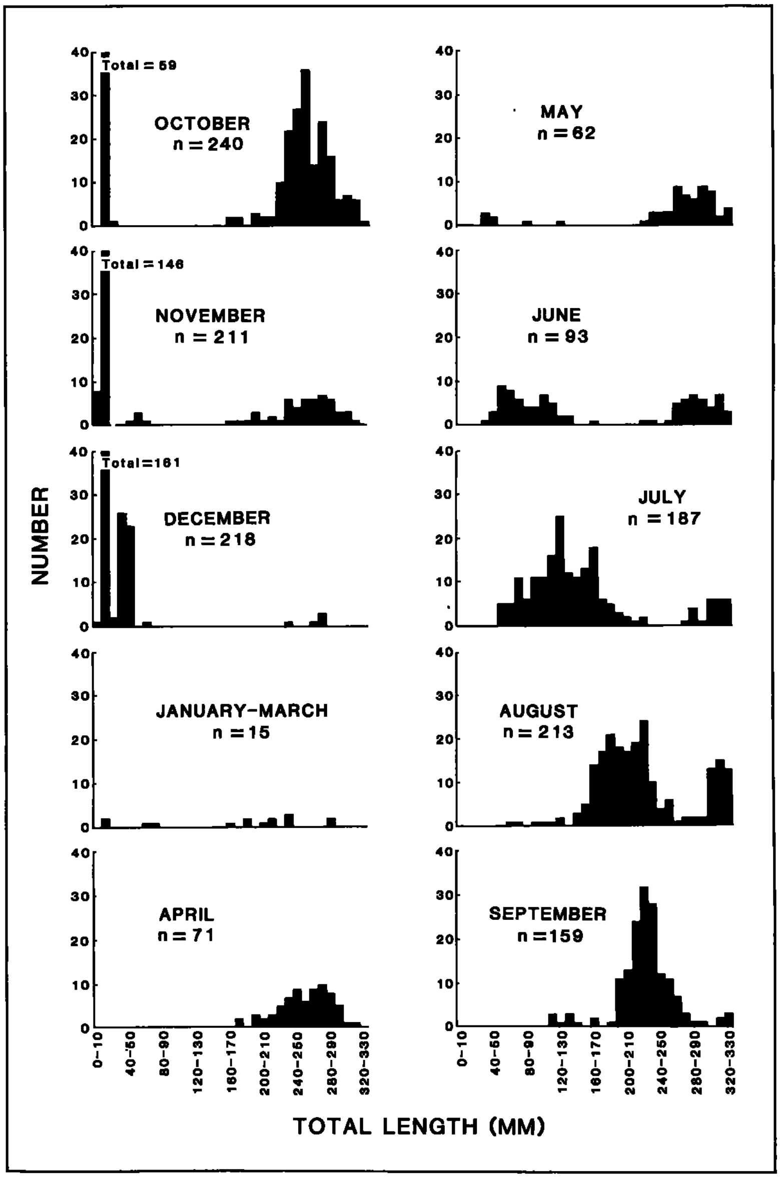

Figure 4

Cumulative monthly length frequencies of juvenile *Paralichthys dentatus* from northern New Jersey (Barnegat Bay and north) estuaries over several years. See Table 1 for data sources.

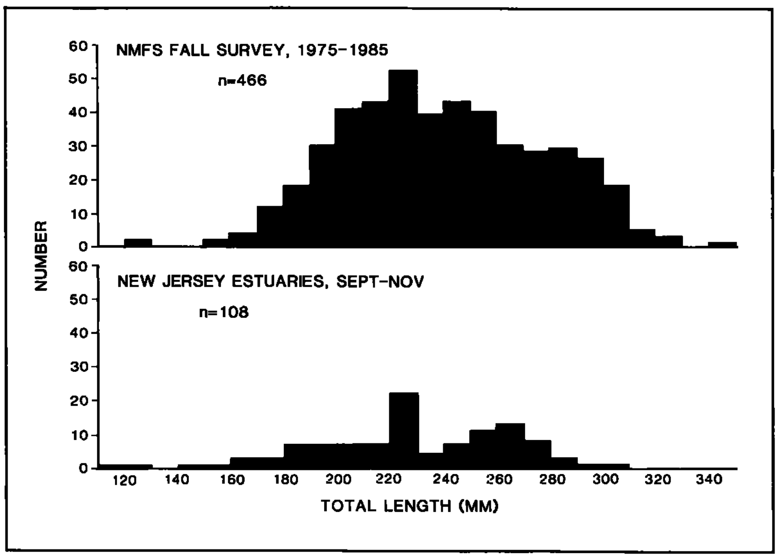

Figure 5

Length-frequency distribution of juvenile (0 age) *Paralichthys dentatus* from the Mid-Atlantic Bight continental shelf (NMFS September–November bottom-trawl surveys) and New Jersey estuaries.

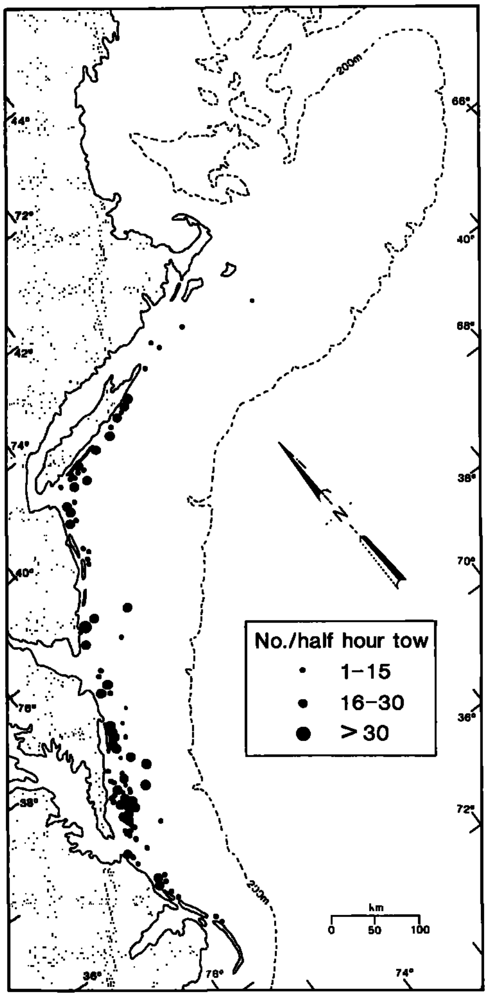

Figure 6
Geographical distribution of young-of-the-year (0 age) *Paralichthys dentatus* (NMFS September–November bottom-trawl surveys), 1982–86, expressed as number per half-hour tow.

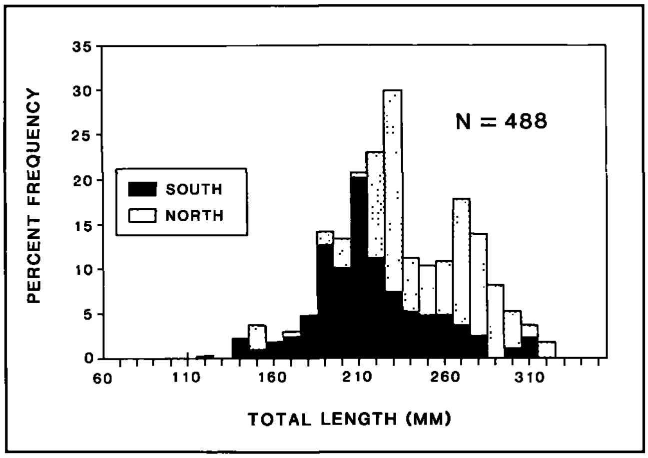

Figure 7
Length-frequency distribution of young-of-the-year *Paralichthys dentatus* in NMFS fall bottom-trawl surveys north and south of Delaware Bay.

than Smith's (1973), thus we can confirm that extensive spawning during this period occurred in subarea II, and extended to subarea I (Fig. 2, Table 2). In fact, subarea II (Fig. 1) provided the largest collections of eggs (Table 2) and larvae (Table 3). Although Smith (1973) reported the center of abundance to be off New Jersey and New York in 1965–1966, we found extensive reproduction during 1980–1986 occurred from New York to Massachusetts. Spawning was most pronounced in fall, with the earliest in the northern and the latest in the southern subareas (Table 2). The spawning period observed in this study is consistent with that of other studies (Hildebrand and Schroeder 1928, Smith 1973, Smith et al. 1975, Morse 1981) in the Mid-Atlantic Bight.

The above locations and timing of spawning, deduced from egg collections, were corroborated by collections of larvae. Small larvae were most abundant in early fall in subarea II but occurred into early spring in the southern subareas (Table 3).

Larvae of all sizes were found over the continental shelf throughout the study area (Fig. 3). Thus, there appeared to be no pronounced movements by larvae out of the major spawning areas as might be predicted from the general southerly or southwesterly flow reported for much of the Mid-Atlantic Bight (Bumpus and Lauzier 1965, Norcross and Stanley 1967). The only apparent exception is subarea I where egg collections (Fig. 2, Table 2) indicated spawning occurred, yet few larvae were collected (Fig. 3). Stronger currents in the prevailing flow off the southern and western portions of Georges Bank into the northern Mid-Atlantic Bight (Colton and Temple 1961, Butman and Beardsley 1987) might explain this exception.

Estuarine recruitment and growth

The movement of larval, transforming, and possibly juvenile *P. dentatus* into estuaries occurs over an extended time period. The collection of *P. dentatus* in New Jersey inlets October–April is consistent with the prolonged spawning period in the adjacent waters of subareas II and III (Table 3). Also, the peak in spawning in these areas in October and November may be reflected in the relatively abundant catches of small individuals (<20 mm TL) in October–December (Fig. 4).

Most authors have assumed that transforming *P. dentatus* move into estuarine nursery areas (see Rogers and Van Den Avyle 1983 for review). From the available evidence, we conclude that at least a portion of the *P. dentatus* do this in New Jersey estuaries. It is clear that at sizes larger than approximately 11 mm SL, they become scarce in continental shelf plankton collections (Fig. 3) and that they can be collected in New Jersey inlets, usually at sizes of 11–14 mm TL. In addition, the larger juveniles have been collected, at least from power plant screens, with some regularity (Fig. 4). In some years larger YOY (240-300 mm) are clearly represented in recreational catches in New Jersey estuaries (Festa 1979). Despite this pattern, it is not always easy to collect small juvenile *P. dentatus* in New Jersey estuaries. As we pointed out earlier, the collections of small juveniles (30–50 mm, Fig. 4) occurred in a single year (1975) but not in subsequent years (1976-80). In addition, small juveniles are rarely encountered in the winter (January–April), following recruitment to the estuary (Fig. 4). Limited data might lead to the assumption that YOY *P. dentatus* could not survive winter temperatures in New Jersey inshore waters. Johns et al. (1981) indicate that larval *P. dentatus* fail to develop past yolksac absorption when reared at temperatures below 5°C. Estuarine temperatures in New Jersey regularly drop to several degrees below this level in winter (Rutgers Univ., Mar. Field Stn., Tuckerton, NJ 08067, unpublished data). Thus, if transforming individuals suffer the same mortality as the yolksac larvae, individuals that have moved into the estuaries may not survive winter. Also, several studies indicate that *P. dentatus* in Chesapeake Bay may succumb to infections of the hemoflagellate *Trypanoplasma bullocki* at low temperatures (Burreson and Zwerner 1982, 1984; Sypek and Burreson 1983). Effective immune response to the parasite was not noted in natural infections below 10°C (Sypek and Burreson 1983). This parasite occurs in New Jersey waters (G. Burreson, Va. Inst. Mar. Sci., Gloucester Pt., VA 23062, pers. commun. July 1987), but its effect on New Jersey populations of *P. dentatus* is unknown.

Some authors have assumed that because of the perceived paucity of YOY in New Jersey and other estuaries in the northeastern United States, the important nurseries for *P. dentatus* occur in Virginia and North Carolina (see Rogers and Van Den Avyle 1983 for review). We find the evidence to support this conclusion ambiguous and in some cases contradictory. First, the evidence for abundant juvenile *P. dentatus* is based primarily on studies in South Atlantic Bight estuaries that no doubt support *P. dentatus* nurseries (Tagatz and Dudley 1961, Miller and Jorgenson 1969, Burns 1974, Powell 1974, Cain and Dean 1976, Bozeman and Dean 1980). However, some of these data sources (Weinstein 1979, Weinstein et al. 1980) also include southern flounder *P. lethostigma* and gulf flounder *P. albigutta*, but the patterns observed are considered characteristic of *P. dentatus* (see Rogers and Van Den Avyle 1983). Second, there is evidence that estuaries in the northern Mid-Atlantic Bight do provide nurseries for juvenile *P. dentatus* (Grosslein and Azarovitz 1982). This has been substantiated for Connecticut (Pearcy and Richards 1962), Long Island (Poole 1961), New Jersey (Table 1 and this study), Delaware Bay (this study), and coastal Delaware (Pacheco and Grant 1973). That nurseries occur in these areas would certainly be consistent with the extensive spawning and larval development that occur in the northern Mid-Atlantic Bight (Smith 1973 and this study), especially considering the lack of evidence for larval transport or advection from this area. Third, the habitats utilized by small juvenile flounder may be difficult to sample. There is evidence that juvenile *P. dentatus* use eelgrass beds in North Carolina (Adams 1976), Chesapeake Bay (Orth and Heck 1980, Weinstein and Brooks 1983) and New Jersey (senior author's pers. observ.). Sampling flatfishes in these structurally complex habitats with conventional gears (trawls, seines) is inefficient and difficult.

To our knowledge, no one has presented data to confirm or deny the possibility that *P. dentatus* uses the continental shelf as a nursery area. Certainly spawning in the Mid-Atlantic Bight and on Georges Bank occurs great distances from estuaries (Fig. 2). Perhaps many of the larvae undergo transformation, descend to the bottom over the continental shelf, and then move into estuarine areas at a variety of sizes, beginning with early transforming individuals. This could help explain the relative scarcity of small juveniles and the large numbers of YOY (150–320 mm) that appear during summer (Fig. 4). These YOY occur in the recreational fishery in New Jersey in some years (Festa 1979). A continental shelf nursery area is more tenable in the northern Mid-Atlantic Bight, given the broad continental shelf (∼150 km) relative to the narrow shelf (∼50 km) off North Carolina. We know of no adequate continental-shelf sampling program, using appropriate collecting gear, to support or refute this possibility, but suggest it should be vigorously tested.

The growth of YOY *P. dentatus* in New Jersey estuaries appears to be very fast, with individuals reaching 160–320 mm 1 year after spawning (October, Fig. 4). An almost identical growth rate has been found in Long Island estuaries (Poole 1961), where length frequencies reported for July, August, and September are similar to those from New Jersey (Fig. 4). Additionally, the modal sizes of males (25.1 cm) and females (27.1 cm) of YOY reported from Long Island (Poole 1961) and those for both sexes from New Jersey (Fig. 4) are similar to the modes of YOY captured in fall over the continental shelf (Fig. 5). Assuming little or no growth during winter, these lengths would approximate those of individuals that are forming the first annulus during the winter. Similarly, a laboratory study of *P. dentatus* collected from North Carolina found a mean size of 232.8 mm TL at the end of 1 year under constant conditions, although most growth occurred June–November (Klein-MacPhee 1979).

Earlier attempts to review the age and growth of *P. dentatus* along the east coast of the United States (Smith et al. 1981) were not completely successful because of variation in size at first annulus formation. Our data support the estimates of size at first annulus formation proposed by Poole (1961), an interpretation that was not accepted by those at the age and growth workshop (Smith et al. 1981). The latter favored a slower growth estimate based on data from North Carolina estuaries (Powell 1974, 1982).

An alternate interpretation of the available *P. dentatus* growth data, and one that would resolve the above discrepancy, is that YOY *P. dentatus* from New Jersey grow at a faster rate than do those from North Carolina. This is consistent with the workshop interpretation that overall fish growth rate tended to increase from south to north (Smith et al. 1981) and with the presence of larger YOY individuals in more northern fall collections (Fig. 7). The possibility of geographical differences in growth patterns is also consistent with the view that northern Mid-Atlantic Bight populations of *P. dentatus* are distinct from those south of Cape Hatteras (Wilk et al. 1980, Delaney 1986).

Acknowledgments

Preparation of this manuscript was supported in part by grants from the New Jersey Fisheries Development Commission, New Jersey Fisheries and Aquaculture Technology Exchange Center, NOAA Sea Grant, New Jersey Marine Science Consortium, and the Center for Coastal and Environmental Studies, Rutgers University. P. Berrien provided information on egg distribution, G. Burreson discussed parasite/temperature effects on mortality, and S. Szedlmayer, J. Musick, and J. Defosse provided comments on an earlier draft. We are grateful to all of the above.

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