

Contribution to the Biology of the Spotted Wolffish (*Anarhichas minor*) in the Northwest Atlantic

Wilfred Templeman

Science Branch, Department of Fisheries and Oceans
Northwest Atlantic Fisheries Centre, P. C. Box 5667
St. John's, Newfoundland, Canada A1C 5X1

Abstract

Data on the biology of the spotted wolffish in the Northwest Atlantic were obtained in 1946-67 during research fishing with otter trawls and longlines. Length frequencies of males and females showed no consistent differences. The longest male was 118 cm and the longest female was 121 cm. Egg diameters and ovarian weights of mature fish indicated that spawning of most spotted wolffish occurred during or soon after July-August. Sexual maturity of females over most of the area began at sizes of 75-80 cm or larger, but there were indications that maturity may have begun at smaller sizes off West Greenland and on Flemish Cap. Males weighed more than females at the larger sizes. Weights of the larger size-groups in July-September were lower than in other quarters of the year, in agreement with the probable spawning period. The mean vertebral number of 684 spotted wolffish was 77.64, with the range being 74-80. There were no significant differences in vertebral means throughout the area, although West Greenland and Flemish Cap data showed possibilities of being lower. The dorsal fin-ray mean for 45 specimens was 75.90, with the range being 74-77. The correlation between dorsal fin-ray and vertebral numbers was highly significant. Invertebrates and fish composed 77 and 23% by volume respectively of the stomach contents. Echinoderms, which constituted 52% of the volume, were the most important prey group.

Introduction

The spotted wolffish (*Anarhichas minor*) is rare in the Gulf of Maine (NAFO Subarea 5) (Bigelow and Schroeder, 1953) and scarce on the Scotian Shelf (Subarea 4) (Scott, 1982). It is more plentiful in the northern areas off Newfoundland and Labrador (Subareas 3 and 2) (Templeman and Fleming, 1956; Albi-kovskaya, 1982) and off West Greenland (Subarea 1) (Hansen, 1958; Beese and Kändler, 1969). Little is known of the biology of spotted wolffish in the Northwest Atlantic.

In 1946-67, as opportunity permitted during research vessel cruises that were directed towards investigations of other species, especially cod, haddock and redfish, information was gathered on various biological characteristics of spotted wolffish, including length frequencies, sexual maturity, length-weight relationship, vertebral numbers, dorsal fin-ray numbers and food. Such biological information is useful for comparisons with studies of spotted wolffish from the North Central and Northeast Atlantic by Barsukov (1959), Østvedt (1963), Beese and Kändler (1969), and the studies of wolffish food in the Northwest Atlantic by Albikovskaya (1983) and Templeman (1985). There was the possibility, also, of finding distinctions between areas, which would aid in stock discrimination.

Materials and Methods

Data on the biology of spotted wolffish in the Northwest Atlantic were gathered usually from samples of catches by research vessels fishing with bottom

otter trawls. Data on length, sex, and vertebral numbers were also obtained from bottom catches by research longliners. The distribution of the spotted wolffish samples is shown in Fig. 1. Most were taken between 100 and 200 fathoms (183-366 m). For the analysis of vertebral numbers, Div. 2J was divided into 2Jn and 2Js at 53° 10' N. This division allowed data from 2Js to be included with data from the Northeast Newfoundland Shelf (Div. 3K) of which it (2Js) forms a natural part.

Females with ovaries containing yellowish or orange-yellow developing eggs greater than 1.4 mm in diameter were classed as maturing or mature. Females were also classed as mature when the spent ovaries had a tough, wrinkled appearance and when large residual eggs remained in the ovaries from a previous spawning. Sexual maturities were not determined for males because their relatively small testes made field observations of maturity uncertain.

Total length was measured from the most anterior part of the head, with the mouth closed, to the posterior end of the caudal fin. The gonads of the gutted and gilled fish were removed before weighing. Fish to be weighed on shore were kept in good condition in ice. Shore weights were taken to the nearest 50 g, except for those over 13.6 kg which were to the nearest 450 g. Weights at sea were usually taken to the nearest 100 or 200 g, but those over 13.6 kg were taken to the nearest 450 g. Only four fish less than 30 cm were weighed, and these were not included in the comparisons.

Vertebral counts were made on oven-dried specimens from which the flesh had been removed by steam cooking and cleaning with a water-pressure hose. Dor-

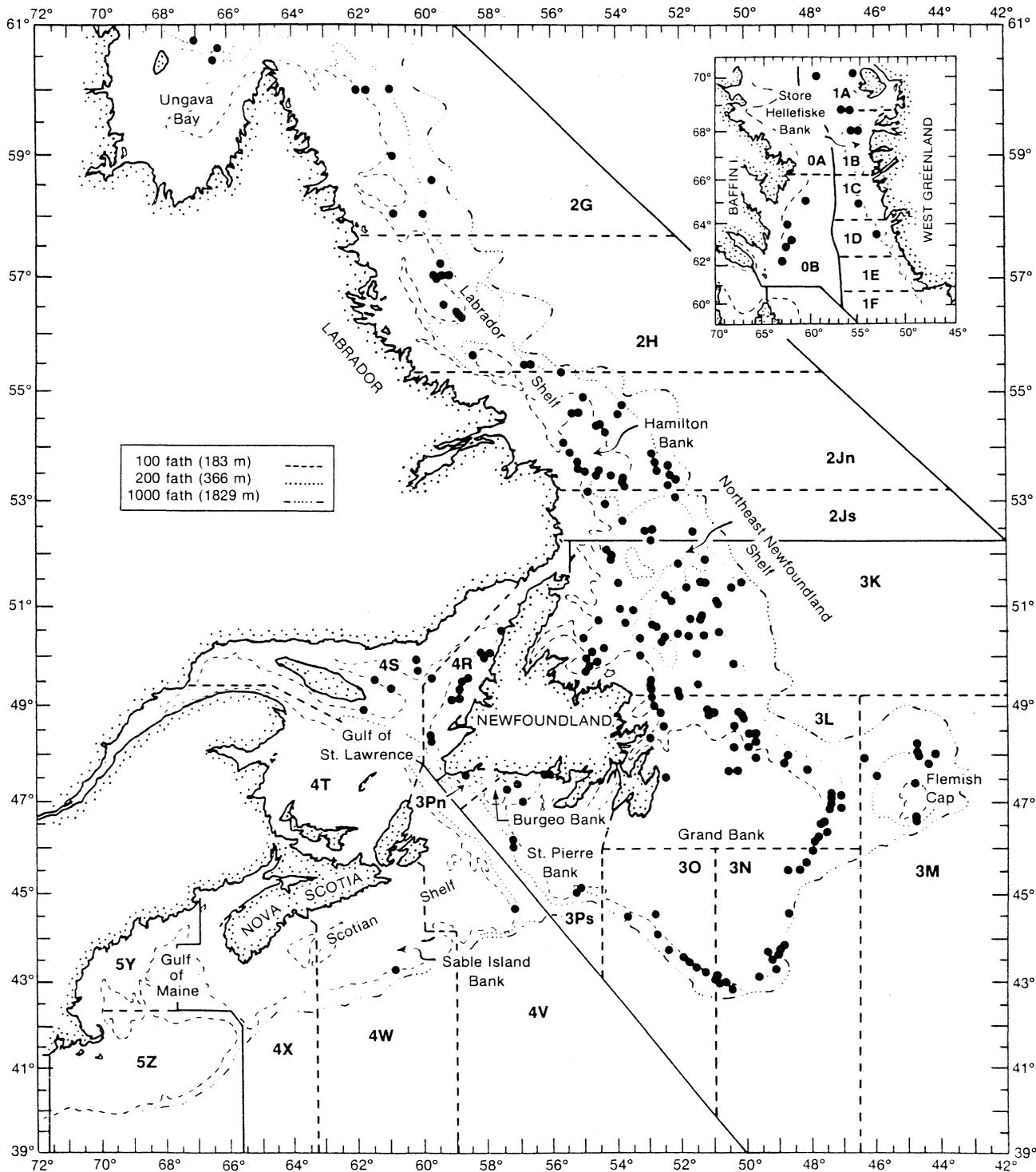


Fig. 1. Place names, NAFO divisions and locations of spotted wolffish samples in the Northwest Atlantic.

sal fin-ray counts were made directly from the fish with the skin peeled from one side of the fin. Vertebral columns with fused vertebrae were not used, and the urostyle half vertebra was included in the count as a vertebra. All wolffish used for dorsal fin-ray and verte-

bral counts were 20 cm or more in total length and were taken during 1950-67.

Stomach contents of the wolffish in field studies were recorded as occurrence or volume (ml) by spe-

cies, genus or higher taxonomic group.

Results and Discussion

Length frequencies of catches

The spotted wolffish taken with longlines were from the slopes of the coastal shelves of Div. 2J, 3K and 3L in 1953-54 and show a bimodal distribution for each sex (Fig. 2). Ninety-one percent of the otter-trawl fish were from Div. 2GHJ and 3KLMNO, and the remainder from other divisions of Subareas 0-4. The otter-trawl frequencies were well distributed over a large part of the period of study, but, nonetheless, the length distribution of females was bimodal and very similar to that from the longline catches. The length frequencies of longline-caught fish showed a lack of females at the greatest lengths. From the otter-trawl catches, both sexes were similar in final size but males were more numerous at lengths above 78 cm. There were few longline fish below 60 cm and none below 42 cm, in contrast to the composition of otter-trawl catches. The largest male, from Div. 3O, was 118 cm in length and the largest female, from Div. 3Ps, was 121 cm.

McKenzie and Homans (1938) reported a 134-cm spotted wolffish from Sable Island Bank off Nova Scotia. Hansen's (1957) length frequencies of this species off West Greenland show sizes increasing from north to south with maximum lengths slightly over 130 cm. Barsukov (1959) reported that, in the northwestern part

of the Barents Sea, the maximum sizes of male and female spotted wolffish were 133 and 124 cm respectively, and, quoting from Knipowitsch (1902), he cited a maximum length of 135 cm for the Barents Sea. Østvedt (1963) reported, for Nordbank off northern Norway, maximum lengths of 133-139 cm for male and 138-143 cm for female spotted wolffish, but males predominated at the larger sizes and at the greatest ages off northern Norway and at Bear Island. Beese and Kändler (1969) found higher numbers of males than females at the largest sizes in their combined data for Greenland, Iceland and Barents Sea. In Lundbeck's (1937) market measurements of German catches, the greatest lengths of spotted wolffish were 111-120 cm from Iceland and 121-131 cm from the Barents Sea, but, in his length-weight records from these catches, Lundbeck (1952) recorded spotted wolffish of 123 cm from both Iceland and the Barents Sea.

Size at sexual maturity in females and fecundity

Length at sexual maturity. Female spotted wolffish began maturing in substantial proportions at lengths of 75-80 cm and higher, and almost all were mature or maturing at sizes greater than 92 cm (Table 1). The small numbers of specimens prevented close comparison of lengths at maturity in different areas but indicated the possibility that maturity began earlier off West Greenland (Div. 1ABCD) and on Flemish Cap (Div. 3M) than in other areas. However, it was in these areas that almost all of the smallest maturing and mature specimens at sizes of 80 cm or less were caught. Area differences in length at the beginning of sexual maturity were not so obviously present for *A. minor* of the Northwest Atlantic as they were for *A. lupus* (Templeman, 1986).

Beese and Kändler (1969) reported that sexually mature female spotted wolffish from the Northeast

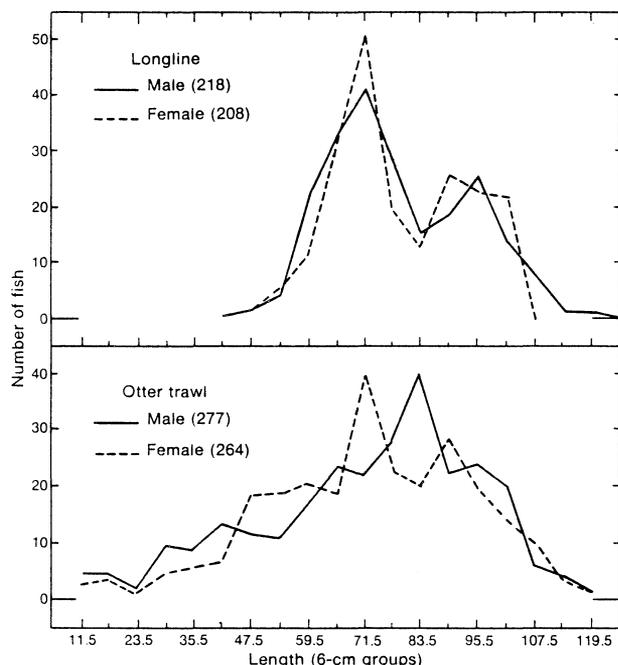


Fig. 2. Length frequencies of spotted wolffish samples caught by longline and otter trawl in the Northwest Atlantic, 1946-67.

TABLE 1. Percentage distribution of maturing and mature female spotted wolffish by length interval in combined samples from the Northwest Atlantic.

Length interval (cm)	Number of females	Maturing and mature females	
		Number	Percent
21-29	5	—	—
30-38	4	—	—
39-47	12	—	—
48-56	21	—	—
57-62	16	—	—
63-68	16	1	6
69-74	32	1	3
75-80	17	4	24
81-86	12	6	50
87-92	21	11	52
93-98	15	14	93
99-104	15	15	100
105-110	8	8	100
111-116	3	3	100

Atlantic overlapped the immatures at lengths between 48 and 62 cm. Their criteria for the maturing and mature stages appear to be fairly similar to those of the present paper. Østvedt's (1963) stage II (maturing) for spotted wolffish included fish with both large and small eggs. In this paper, fish with larger eggs were called maturing, and those with smaller eggs which may take a long time to develop were called immature. His stage III (mature or spawning) and stage IV (spent) females from Bear Island were 78–82 cm and greater in length. Barsukov (1959) recorded maturing female spotted wolffish of 85–120 cm in length.

Fecundity. The numbers of developing eggs for the next spawning were counted for three spotted wolffish: (a) 65 cm long, 5,080 eggs, maximum egg diameter 3.5 mm, captured at a depth of 311 m on Store Hellefiske Bank (Div. 1B) on 8 August 1965; (b) 82 cm long, 11,970 eggs, maximum egg diameter 3.2 mm, captured at 274 m on Flemish Cap (Div. 3M) on 22 March 1961; and (c) 91 cm long, 19,760 eggs, maximum egg diameter 2.5 mm, captured at 552 m on the southeast slope of Hamilton Bank (Div. 2J) on 4 April 1964. These egg counts were lower at 65 cm and higher at 82 and 91 cm than the fecundity results of 12 spotted wolffish specimens from the Northeast Atlantic (Beese and Kändler, 1969).

Spawning time

Ovarian egg sizes. Fish which were classed as immature, based on the criteria used, had maximum egg diameters in the range of 0.3–1.2 mm (Table 2). Some individuals, with ovaries containing residual eggs from the previous spawning and with obviously spent ovaries, had new eggs as small as 0.8–1.4 mm diameter. Fish with ripening eggs for the next spawning (defined as those greater than about 1.4 mm diameter) occurred in all bimonthly periods. The largest eggs (3.5–5.0 mm diameter) were from July–August samples, including a 103-cm fish from Div. 3L on 31 July with maximum egg diameter of 4.5 mm and a 94-cm fish from Div. 3K on 4 August with egg diameter of 5 mm. The latter specimen was ripe and running. There was, however, a female from Flemish Cap with 3.2-mm diameter eggs on 22 March. As many of the small whitish eggs developed and assumed the orange-yellow or yellowish appearance, some of the whitish eggs remained undeveloped at diameters of 0.6–1.1 mm (i.e. similar to those designated as immature).

Ovarian weight. The ovarian weight, as percentage of gutted and gilled weight of mature fish, exhibited an increase by March–April and was greater in July–August than in September–December (Table 3). There was, however, a female from Flemish Cap with an ovary which was 6.5% of the gutted and gilled weight in late March.

TABLE 2. Seasonal frequencies of largest non-residual eggs by egg size in ovaries of female spotted wolffish from the North-west Atlantic. (Numbers in parentheses are ovaries with residual eggs.)

Egg diameter (mm)	Frequency of observations					
	Jan–Feb	Mar–Apr	May–Jun	Jul–Aug	Sep–Oct	Nov–Dec
Immature						
0.3–0.5	—	4	2	4	—	1
0.6–0.9	—	3	6	6	7	3
1.0–1.2	—	4	14	8	12	3
Doubtful maturity						
0.9	—	—	—	1	—	—
1.0–1.4	—	3	2	6	10	10
Maturing and mature						
0.8–0.9	—	—	—	1(1)	—	—
1.0–1.4	1	4(2)	3	7(2)	2	8(8)
1.5–1.9	—	1	—	5	5(1)	10(3)
2.0–2.4	—	—	—	—	—	1(1)
2.5–2.9	1(1)	1	1(1)	—	—	1(1)
3.0–3.4	—	1	—	1	—	—
3.5–3.9	—	—	—	2	—	—
4.0–4.4	—	—	—	—	—	—
4.5–5.0	—	—	—	2	—	—

Variation in length-weight relationship relevant to spawning. Preliminary plotting of individual records of \log_{10} weight (kg) against \log_{10} length (cm), by sex and quarterly period, showed that the length-weight relationship of spotted wolffish could be represented adequately by log-log least squares straight lines. From the equations of these lines, weights at total lengths of 50, 75 and 100 cm were calculated (Table 4).

In nine comparisons between sexes for the same quarterly period, method of weighing and location, males weighed more than females in four cases at 50 cm fish length, in seven cases at 75 cm, and in all nine comparisons at 100 cm. From covariance analysis (Snedecor and Cochran, 1980), F-values for three of these nine pairs of regression lines indicated significant differences (two for slope, and one for intercept). Males and females at the smaller immature lengths weighed about the same, but there was a tendency for males to weigh more than females at the greater maturing and mature lengths. Sexes were therefore compared separately in the quarterly comparisons.

At 100 cm, representing the mature fish, July–September weights were less than April–June weights in all four comparisons, and F-values of the length-weight regression lines for these quarters, compared by covariance analysis, were significantly different for the slopes in these comparisons. The July–September weights were less than the October–November weights in five of six comparisons, and F-values of the

TABLE 3. Seasonal trends in ovary weight, expressed as percentage of gutted and gilled weight, of female spotted wolffish (>30 cm in length) from the Northwest Atlantic.

Bimonthly period	Immature			Doubtful maturity			Maturing and mature		
	No. of fish	% ovary weight		No. of fish	% ovary weight		No. of fish	% ovary weight	
		Mean	Range		Mean	Range		Mean	Range
Mar-Apr	11	0.7	0.3-1.3	2	1.2	1.2-1.2	6	3.4	1.3-6.5
May-Jun	21	0.7	0.2-1.2	1	1.3	1.3-1.3	4	1.7	1.1-2.4
Jul-Aug	17	0.7	0.3-1.4	6	1.1	0.9-1.3	12	4.2	0.9-15.7
Sep-Oct	18	0.6	0.3-1.2	3	1.3	1.1-1.4	8	1.3	0.7-2.3
Nov-Dec	11	0.5	0.2-0.9	9	1.0	0.9-1.4	15	1.8	1.1-2.5

TABLE 4. Calculated weights from log-log (base 10) weight-length relationships by quarter and sex for spotted wolffish from the Northwest Atlantic, based on length and weight measurements taken on shore and at sea.

Sex	Quarter	No. of fish	Length range (cm)	Calculated weights (kg) for three wolffish lengths (cm)		
				50	75	100
Gutted and gilled weights on shore						
Male	Apr-Jun	13	57-103	0.84	3.50	9.65
	Jul-Sep	26	44-116	0.98	3.64	9.21
	Oct-Dec	34	39-110	1.34	3.85	8.13
Female	Apr-Jun	16	44-88	0.78	3.08	8.13
	Jul-Sep	21	45-109	1.09	3.44	7.79
	Oct-Dec	34	38-111	0.99	3.39	8.12
Round weights on shore						
Male	Apr-Jun	13	57-103	1.04	4.37	12.11
	Jul-Sep	24	57-116	1.32	4.65	11.34
Female	Apr-Jun	15	44-92	1.10	4.44	11.96
	Jul-Sep	19	45-109	1.41	4.28	9.41
Gutted and gilled weights at sea						
Male	Jul-Sep	24	32-100	0.90	3.34	8.44
	Oct-Dec	17	37-114	1.04	3.65	8.90
Female	Jan-Mar	14	39-116	0.98	3.36	8.08
	Jul-Sep	22	34-107	0.93	3.22	7.79
	Oct-Dec	21	50-111	0.98	3.39	8.17
Round weights at sea						
Male	Jul-Sep	40	32-102	1.22	4.27	10.41
	Oct-Dec	18	35-114	1.35	4.69	11.33
Female	Jan-Mar	15	35-116	1.18	4.14	10.07
	Jul-Sep	30	34-107	1.24	4.28	10.34
	Oct-Dec	22	38-111	1.18	4.30	10.73

length-weight regression lines for these quarters were highly significant for two of the five intercepts.

At 50 and 75 cm, representing immature and presumably mainly immature fish respectively, there was a progressive increase in weight from April-June to October-December. Weights in July-September were greater than in April-June in seven of eight comparisons, and weights in October-December were greater than in July-September in 10 of 12 comparisons.

It is common for the somatic weight of fish to reach an annual minimum associated with the spawning

period (Kohler, 1959). Thus, the observation that the lowest weights of the mature specimens of *A. minor* occur in July-September corresponds with the other evidence that this species spawns in the summer. For *A. lupus* of the North Atlantic, in agreement with its mainly autumn spawning, the weights at length were lowest in October-December and highest in July-September (Templeman, 1986).

Large catches during or near the spawning period.

In August-early September 1972, some Newfoundland otter trawlers landed unusually large quantities of spotted wolffish which were caught on the northwest-

ern slope of the Grand Bank. The St. John's *Evening Telegram* on 1 September 1972 reported that otter trawlers from Burin and Marystown, Placentia Bay, Newfoundland, had discharged 410,000 kg of wolffish during the preceding 10 days, more than has ever been landed before in a similar period of time. As a rule, less than 1,000 kg of wolffish (Atlantic and spotted) are landed at these ports from a single trip of a vessel with 140,000 kg of groundfish. These large trawl catches in 1972, some of which are recorded in Table 5, were reported to be spotted wolffish by an experienced fisheries technician from the St. John's Biological Station. Records of large schools of spotted wolffish are unusual and these large catches are particularly noteworthy, because the time of capture was close to the probable spawning season and may have been related to schooling for spawning.

Conclusion. The evidence for mainly summer spawning of spotted wolffish in the Northwest Atlantic is thus from egg sizes, ovarian weights, quarterly length-weight relationships, and possibly from large catches near the spawning period. Although lack of extensive data results in the conclusions from each source separately being weak, the relative agreement from all sources makes it likely that most spawning occurs in summer. This is consistent with observations in other areas. Spotted wolffish off southern Iceland spawn in the late summer months (Lühmann, 1954). Østvedt (1963) reported that spotted wolffish near Bear

Island spawn in July and that the main spawning season for this species in the Barents Sea is July and probably also August.

Meristic variation

Vertebral numbers. Vertebral means of spotted wolffish from various divisions of the Northwest Atlantic ranged between 77.27 for Flemish Cap (Div. 3M) and 77.72 for southern Labrador (Div. 2Jn), but there were no significant differences among areas ($P > 0.05$) (Table 6). The means for West Greenland (Div. 1ABC) and for Flemish Cap (Div. 3M) indicated the possibility that they might be significantly lower than those for the other divisions if sample sizes had been larger for the two areas. Differences in vertebral numbers of spotted wolffish between areas in the Northwest Atlantic were not so evident as those demonstrated by Templeman (1984) for the Atlantic wolffish.

The overall vertebral frequency for the Northwest Atlantic was: 74(1), 75(3), 76(37), 77(241), 78(322), 79(77), 80(3), with mean and standard errors of 77.64 ± 0.03 . This compares with Lühmann's (1954) vertebral average (78.16) and range (77-79) for 45 spotted wolffish from southwestern Iceland. The mean of 75.2 with range of 74-78 for *A. minor* from the Barents Sea, stated by Barsukov (1959) to be from Lühmann (1954), are not from the latter author, but presumably are Barsukov's data on *A. lupus* from the Barents Sea, mis-

TABLE 5. Some catches of spotted wolffish (from captain's estimates in logbooks) on the northwestern slope of Grand Bank in August-early September 1972 by Newfoundland trawlers landing at Burin and Marystown, Placentia Bay.

Trip dates of trawlers	Fishing area		Depth (m)	Fishing days	Catch (kg)
	Lat.	Long.			
11-22 Aug	48°-50° N	51°-53° W	183	10	45,000
13-24 Aug	48°-50° N	49°-51° W	146-183	1	59,000
18-29 Aug	48°-50° N	51°-53° W	183	4	45,000
19-29 Aug	48°-50° N	51°-53° W	192	7	42,000
20-31 Aug	48°-50° N	51°-53° W	179-183	3	12,000
20-31 Aug	47°-48° N	51°-53° W	174-192	9	45,000
30 Aug-8 Sep	48°-50° N	51°-53° W	165-174	6	11,000

TABLE 6. Numbers of vertebrae in spotted wolffish from various areas of the Northwest Atlantic, 1950-67. (0B+2GH includes Ungava Bay; SE = standard error; 95% limits = 95% confidence interval.)

NAFO Div. (Fig. 1)	Years of sampling	No. of fish	Length range (cm)	Vertebral numbers			
				Mean	SE	95% limits	Range
1ABC	1965	12	21-100	77.33	0.28	76.71-77.96	76-79
0B+2GH	1959-64	32	30-107	77.69	0.13	77.42-77.95	77-79
2Jn	1950-64	127	30-106	77.72	0.08	77.57-77.87	76-80
2Js+3K	1950-64	193	35-110	77.66	0.05	77.56-77.77	75-79
3L	1950-54	195	29-114	77.63	0.06	77.52-77.74	75-79
3M	1955-64	22	25-81	77.27	0.15	76.96-77.59	76-79
3NOP	1950-67	88	27-120	77.65	0.09	77.47-77.83	74-80
4RSVW	1960-67	15	26-116	77.53	0.17	77.18-77.89	76-78
Overall	1950-67	684	21-120	77.64	0.03	77.58-77.70	74-80

placed in table 7 of the translation. It is assumed also that the Barents Sea sample of *A. latifrons* (= *A. denticulatus*) in table 7 of the translation of Barsukov's (1959) paper is actually *A. minor*. This sample of 33 specimens had a vertebral average of 77.9 (range 76–79). Later in his text, in his description of *A. minor*, Barsukov gives the range of vertebral number for this species as 76–79. Beese and Kändler (1969), for 23 and 42 spotted wolffish from the Barents Sea and the Iceland-Greenland region, reported vertebral means and standard errors of 78.13 ± 0.13 and 77.42 ± 0.11 respectively and a vertebral range of 76–79 for the combined samples. Beese and Kändler's (1969) vertebral mean from the Barents Sea was significantly higher than their mean for the Iceland-Greenland region and the mean for the Northwest Atlantic in this paper. However, the mean of Lühmann's (1954) sample from southwestern Iceland was similar to that of Beese and Kändler from the Barents Sea. The difference between Beese and Kändler's mean for the Iceland-Greenland region and that for the Northwest Atlantic approaches significance, overlapping slightly at 95% confidence limits of 77.20–77.64 and 77.58–77.70 respectively, but the range of years during which the Northwest Atlantic data were collected weakens the comparison. Although Lühmann (1954) provided no detailed data for his vertebral mean of 78.16 for southwestern Iceland, his number and range indicate that the standard error should be close to that of Beese and Kändler (1969) for the Iceland-Greenland region (± 0.11). If so, the mean (78.16) differs significantly from that for the Northwest Atlantic.

Dorsal fin-ray numbers. The overall dorsal fin-ray frequency for 40 spotted wolffish from the Northwest Atlantic was 74(3), 75(7), 76(21), 77(9), with mean and standard error of 75.90 ± 0.13 . The mean and range of dorsal fin-ray numbers in 45 spotted wolffish from southwestern Iceland (Lühmann, 1954) were 75.58 and 74–78 respectively. Barsukov's (1959, table 7) sample of 31 specimens of *A. latifrons* (*A. denticulatus*), but presumably *A. minor* (note previous discussion of vertebral numbers), from the Barents Sea had a mean and standard error of 76.45 ± 0.14 dorsal fin-rays (range 75–78). The same sample of dorsal fin-rays is named *A. minor* in table 22 of the translation of Barsukov's (1959) paper. The dorsal fin-ray means and standard errors of 23 *A. minor* from the Barents Sea and 42 from the Iceland-Greenland region (Beese and Kändler, 1969) were 76.69 ± 0.13 and 75.85 ± 0.13 respectively, the combined range of both samples being 74–78.

The two Barents Sea means are not significantly different, but the remaining three means including that from the Northwest Atlantic are significantly lower (estimating that Lühmann's southwestern Iceland mean from its comparison of numbers and range with the Iceland-Greenland sample should have a standard

error of about ± 0.13). The Northwest Atlantic mean is not significantly different from the Iceland-Greenland and the southwestern Iceland means (assuming ± 0.13 for the standard error of the latter).

Correlation of dorsal fin-rays and vertebral numbers. The geometric mean functional regression equation (Ricker, 1973, 1975) best describes the joint variation of the small sample of dorsal fin-rays and vertebral numbers in the same fish. In a sample of 34 fish (21–100 cm in length) there was a highly significant correlation ($r = 0.65$) between dorsal fin-ray numbers and vertebral numbers (Fig. 3).

Stomach contents

Of 74 stomachs of spotted wolffish examined, 41 (55%) contained food. The observations included fish from West Greenland to the Scotian Shelf, but most of the stomachs with food (25) were from the Northeast Newfoundland Shelf and the Grand Bank, and only one was from south of the Laurentian Channel.

In the subset of stomachs for which food quantity was measured, echinoderms constituted the greatest volume (52%), followed by fish (23%) and crustaceans (16%) (Table 7). In terms of percentage occurrence of food types in all fish with food, echinoderms were again most important, followed by molluscs and decapod crustaceans. The wolffish ranged in size from 32 to 119 cm (8 at 32–59 cm, 12 at 60–89 cm, and 21 at 90–119 cm). There was no obvious difference in food type with fish size, except that the five specimens which had consumed fish were large (90–107 cm). One

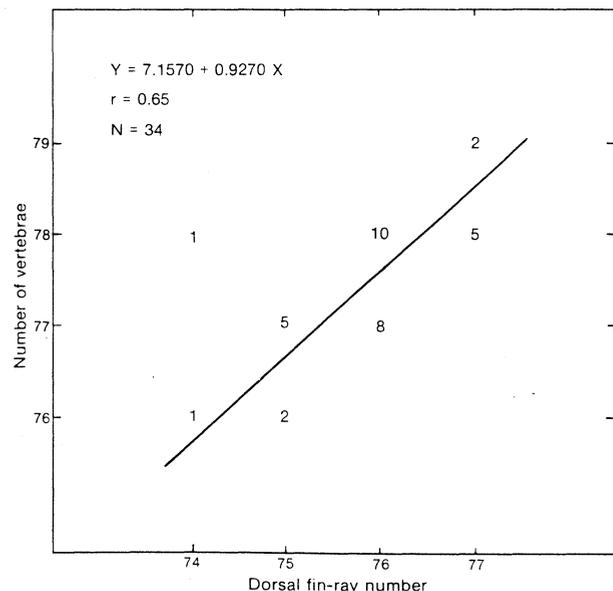


Fig. 3. Correlation of numbers of dorsal fin-rays and vertebrae in spotted wolffish from the Northwest Atlantic. (GM functional regression line is illustrated.)

TABLE 7. Occurrence and volume of various food items in stomachs of spotted wolffish from the Northwest Atlantic, expressed as percent occurrence and percent by volume of food in stomachs containing food. (Volume measurements pertain to a subset of stomachs with food; + indicates <0.1%.)

Phylum	Taxon	Species, type, etc.	Percent occurrence	Percent by volume	
—	Algae	—	2.4	+	
Cnidaria	Hydrozoa	Hydroid	2.4	+	
	Actiniaria	Sea anemone	2.4	0.2	
Bryozoa	—	—	9.8	+	
Mollusca	Polyplacophora	Chitons	2.4	—	
	Gastropoda	Whelks	17.1	3.4	
	Bivalvia	Clams	7.3	0.1	
			<i>Chlamys islandica</i>	9.8	5.2
			Unidentified mollusc remains	2.4	—
Annelida	Polychaeta	Tube worms	2.9	+	
Arthropoda (Crustacea) (Decapoda)	Macrura	Shrimp	2.4	—	
		<i>Pagurus</i> sp.	9.8	0.9	
	Brachyura	<i>Lithodes maia</i>	2.4	0.1	
		<i>Hyas coarctatus</i>	2.4	9.4	
		<i>Chionoecetes opilio</i>	2.4	4.4	
		Unidentified spider crabs	9.8	1.0	
Echinodermata	Echinoidea	Heart urchins	2.4	0.2	
		Unidentified sea urchins	31.7	21.3	
		Sand dollars	12.2	17.2	
	Asteroidea	Sea stars	17.1	1.0	
	Ophiuroidea	Brittle stars	24.4	12.2	
	Crinoidea	Crinoids	4.9	—	
	Chordata (Pisces)	Rajidae	<i>Raja radiata</i>	2.4	1.2
Gadidae		<i>Gadus morhua</i>	2.4	21.9	
		<i>Melanogrammus aeglefinus</i>	2.4	—	
Scorpaenidae		<i>Sebastes</i> sp.	2.4	—	
		Unidentified fish remains	2.4	—	
		Total number of stomachs containing food	41	25	
	Total volume of food in stomachs examined (ml)	—	3,200		
	Total number stomachs examined	74	...		

of these stomachs contained a 22-cm haddock and another contained a 35-cm redfish, confirming that fish is probably an important component of the diet of large spotted wolffish. However, the diet overall was largely composed of hard-shelled animals. Among the echinoderms, the most important forms were sea urchins, sand dollars and brittle stars. The sand dollars in the stomachs were broken into pieces (about 1 cm² in one instance and 2–4 cm² in another), and the sea urchins were also crushed.

Barsukov (1959) noted the relative numbers of food organisms in the intestines of spotted wolffish, presumably from the Barents Sea. Echinoderms were most numerous, followed by molluscs, crustaceans and fishes. Albikovskaya (1983) studied the stomach contents of spotted wolffish of the Labrador-Newfoundland region and found that echinoderms had both highest volume and frequency, with sand dollars, brittle stars and sea stars being most important. Gastropods and crabs were also important prey, and fish was an important component on Flemish Cap (Div. 3M). Thus, previously-published information and the present study indicate that echinoderms constitute the dominant food type in the diet of spotted wolffish.

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