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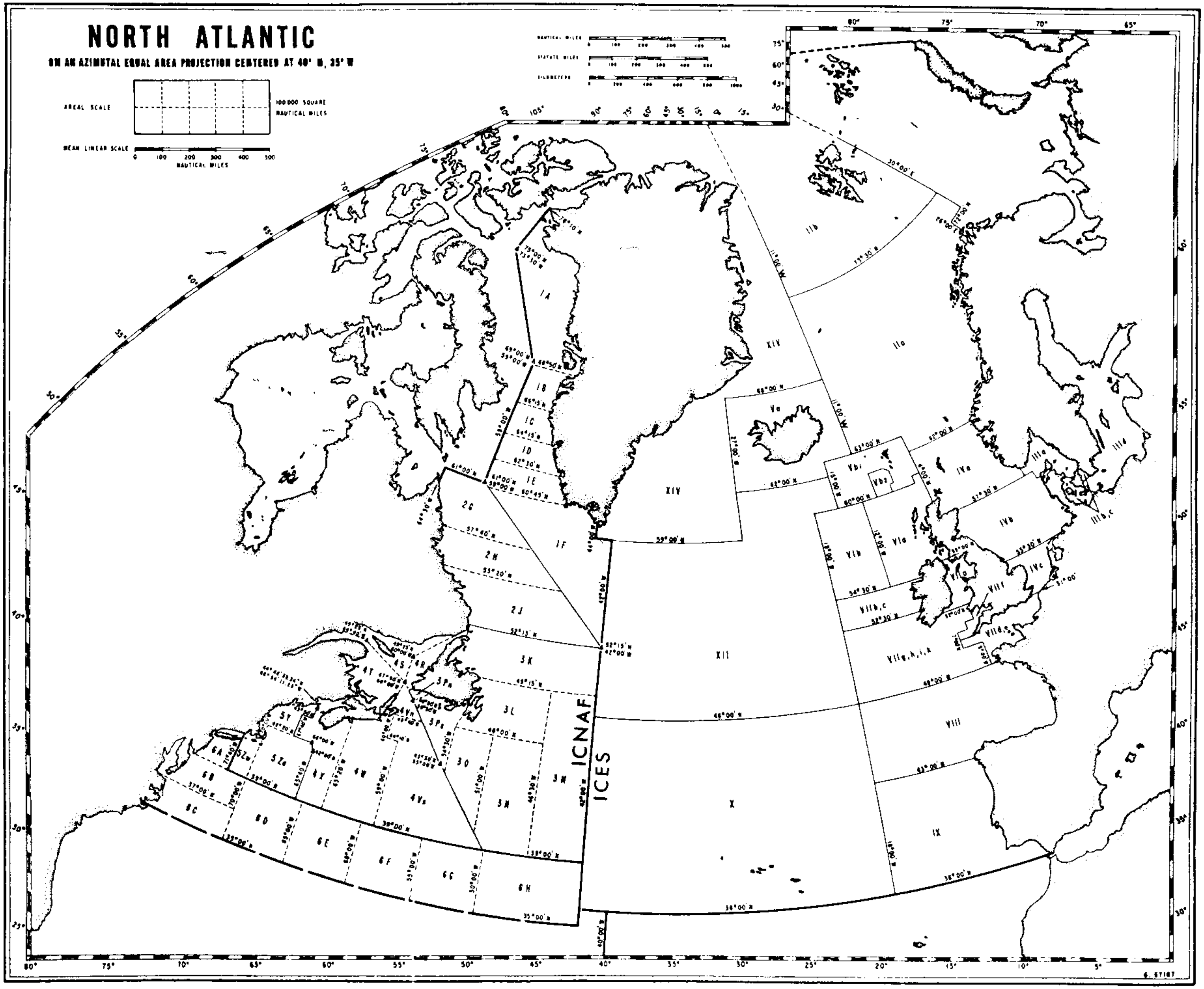

NORTH ATLANTIC
ON AN AZIMUTHAL EQUAL AREA PROJECTION CENTERED AT 40° N, 35° W
AREAL SCALE
100 000 SQUARE NAUTICAL MILES
MEAN LINEAR SCALE
NAUTICAL MILES
NAUTICAL MILES
STATUTE MILES
KILOMETERS
ICNAF
ICES
1A
1B
1C
1D
1E
1F
2G
2H
2J
3K
3L
3M
3N
3O
3Pn
3Ps
4R
4S
4T
4Vn
4Vs
4W
4X
5Y
5Ze
5Zw
6A
6B
6C
6D
6E
6F
6G
6H
IIa
IIb
IIIa
IIId
IIIb,c
IVa
IVb
IVc
Va
Vb1
Vb2
VIa
VIb
VIIa
VIIb,c
VIIf
VIIg,h,i,k
VIId,e
VIII
IX
X
XII
XIV
11°00' W
30°00' E
59°00' N
42°00' W
48°00' N
36°00' N
35°00' N
39°00' N
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Variation in the Incidence of Larval Nematodes in Herring from Canadian Atlantic Waters

By L. S. Parsons[1] and V. M. Hodder[1,2]

Abstract

The incidence and intensity of infestation of herring from Canadian Atlantic waters with larval *Anisakis* varied with locality. Incidence was higher in herring from southwestern and northeastern Nova Scotia (73% and 64%) and the Banquereau-Sable Island area (66%) than in herring from southwestern Newfoundland (30%) and the southern Gulf of St. Lawrence (29%). *Anisakis* incidence increased northwards along western Newfoundland to 61% in the Strait of Belle Isle. There was a southward decrease to 8% in Notre Dame Bay and thence an increase to 48% in herring from eastern Avalon Peninsula. Both the incidence and intensity of infestation increased with fish age (size). The geographic variation in incidence indicates that larval *Anisakis* in herring are useful as biological indicators of stock heterogeneity. The remarkable similarity in *Anisakis* incidence in herring which are fished along Southwest Newfoundland in winter, near Magdalen Islands in autumn and spring and near Gaspé in summer supports the view that these various fisheries occur on the same stock complex of herring. The high but similar nematode incidence values for northeastern Nova Scotia and Banquereau-Sable Island areas suggest a possible inshore-offshore migratory pattern on the Scotian Shelf and that these herring probably do not intermingle to any great extent with the more northerly Gulf of St. Lawrence-Southwest Newfoundland stocks.

Introduction

Geographical variation in abundance of parasites of marine fish have proven useful in the study of fish populations and migrations. The value of certain parasites as natural biological "tags" in identifying fish from different areas has been demonstrated for several fish species (Templeman, Squires and Fleming, 1957; Sindermann, 1961*a*; Templeman and Squires, 1960; Kabata, 1963; Margolis, 1963; Templeman and Fleming, 1963).

Both Pacific and Atlantic herring are often infested with larval nematodes or roundworms, generally 20-30 mm long and usually found coiled in cysts in the abdominal cavity; sometimes, however, they occur in the musculature. The two types known to occur in herring are *Anisakis*, Dujardin 1845, and *Contracaecum*, Raillet and Henry 1912. In the Northeast Atlantic Khalil (1969) found that *Anisakis* larvae were more prevalent in adult herring and *Contracaecum* in juveniles. Bishop and Margolis (1955) reported that British Columbia herring, *Clupea pallasi*, were frequently infested with *Anisakis* larvae and that the level of infestation varied with area. Sindermann (1957, 1959) utilized larval nematodes as well as other parasites to determine the degree of intermingling of certain Northwest Atlantic herring stocks, with particular emphasis on the Gulf of Maine and Nova Scotian stocks. Khalil (1969) investigated the incidence of *Anisakis* larvae in herring from British coastal waters and reported that the degree of infestation varied with locality.

In the autumn of 1968 a survey of the incidence and intensity of infestation of herring, *Clupea harengus* L., in Canadian Atlantic waters with larval nematodes was initiated to assess the usefulness of such observations in determining the degree of heterogeneity of Canadian Atlantic herring stocks. During the course of the study the nematodes from many herring samples were examined by Mr J. H. C. Pippy (personal communication) and practically all identified as *Anisakis* sp.; consequently all nematodes found were recorded as *Anisakis* larvae although a few may have been *Contracaecum*. This paper presents the results of that study, with emphasis on herring stocks in the Newfoundland-Labrador area.

Materials and Methods

From November 1968 to September 1970 about 11,000 herring, 8,500 sexually mature adults and 2,500 juveniles, were examined for larval nematodes. Herring samples, usually of 50 fish each, were obtained from catches of purse seines, midwater trawls, gillnets, codtraps, and weirs. Most of the samples were thawed and examined after being kept in frozen storage for several weeks, but a few were examined in the fresh condition immediately after capture.

At the start of the study, slicing and candling fillets of about 500 herring, some fresh and some after frozen storage, revealed that less than 1% of the specimens had nematodes in the musculature. Subsequently the examination for larval nematodes was

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restricted to the body cavity and viscera. The length, sex, stage of maturity, and weight of the fish were also recorded and otoliths taken for subsequent age determination. The length used is the greatest total length measured from the tip of the lower jaw to the end of the longest lobe of the caudal fin with the lobe extending posteriorly in line with the body. Length measurement data, recorded to the nearest millimetre, were grouped into 1-cm intervals of the 0.5 cm below (i.e. all lengths ranging from 310 to 319 mm were grouped into the 31-cm interval). The stage of maturity was determined by gross examination of gonads using the various stages of gonadal development as adopted by ICNAF (1964). The ageing techniques are described in Hodder and Parsons (1971).

Results

Nearly all of the nematodes were found encapsulated on the mesenteries, coiled in flat spirals against the intestine, the posterior extension of the stomach and the pyloric caecae, or free in the abdominal cavity (Fig. 1). Practically all of the nematodes measured were in the 20-30 mm size range.

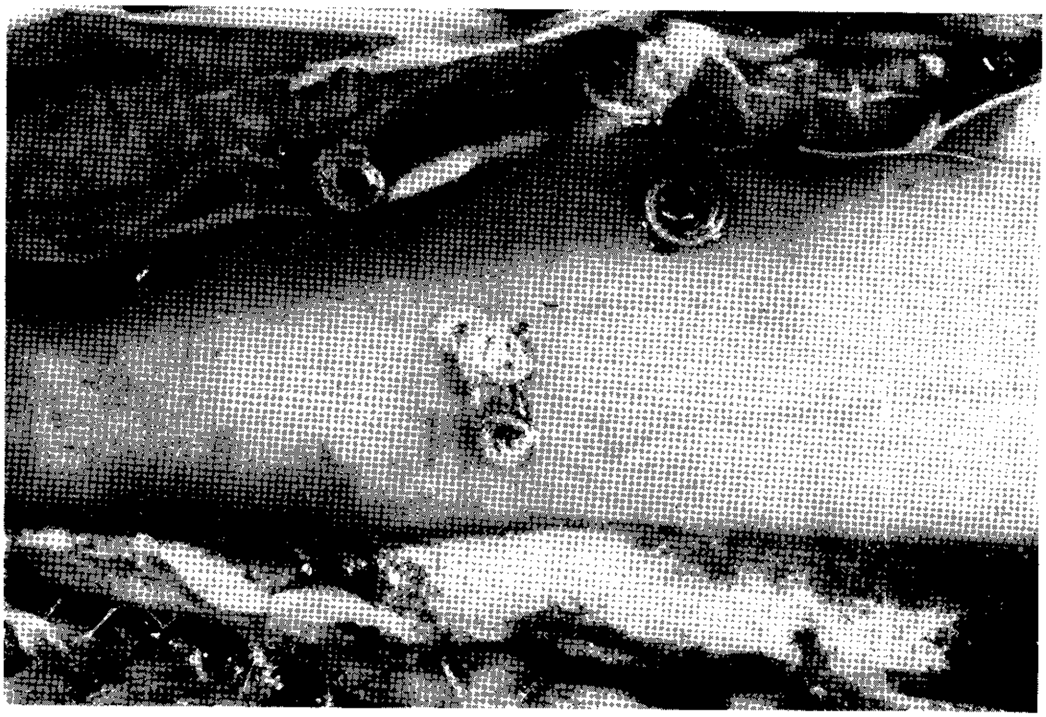

Fig. 1. Larval nematodes encysted in the abdominal cavity of a split herring (× 2.5).

Size of herring and infestation

Both the incidence (percentage of fish infested) and the intensity (average number of nematodes per fish) increase with fish size (Fig. 2). No nematodes were found in herring less than 20 cm long and the degree of infestation was less than 20% for the 20- to 30-cm length groups. Herring of these sizes are either immature or maturing for first spawning. The increase in degree of infestation with increasing size is very pronounced for herring over 30 cm in length, which are generally sexually mature.

Within areas there is considerable fluctuation in the relation between fish size and both the percentage incidence of infestation and the average number of nematodes per fish; for some areas the relationship is much more evident than for others (Table 1). Generally though, immature herring (< 30 cm long) are less heavily infested than sexually mature adults. Juveniles from Fortune, Placentia and St. Mary's Bays, Newfoundland, had a much lower nematode incidence than adult herring (10, 12, and 11% compared with 43, 32, and 33% respectively). Similarly juveniles from northeastern Nova Scotia had a lower incidence than adults (27% compared with 64%).

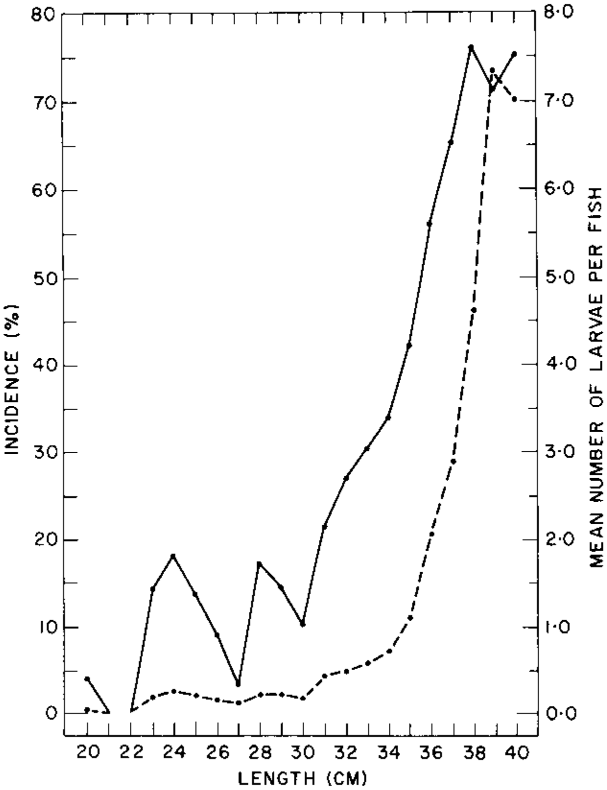

Fig. 2. Relation between the incidence of infestation (solid line), mean number of *Anisakis* larvae (broken line) and length of herring for all areas combined.

Age and infestation

Both the incidence and the intensity of infestation of herring with larval nematodes increase with age (Fig. 3). Herring less than age III have a very low level of infestation in all areas from which specimens were examined. From age III onwards there is a gradual increase in incidence and intensity of infestation with age. The sharp increase from age IX to age X+ occurs because the X+ category includes all specimens of age X and older.

Although the increase in degree of infestation with age is clearly evident for certain areas (e.g. northeastern Nova Scotia and Hawke's Bay), it is less prominent in others (e.g. Placentia and Notre Dame Bays) (Table 2).

Geographic variation in incidence

Considerable geographic variation in the level of infestation of sexually mature herring by larval nematodes is evident (Fig. 4 and Table 3).

There is remarkable similarity in both nematode incidence and intensity for herring which are fished near Magdalen Islands in the autumn just prior to the start of the Newfoundland fishery, herring which overwinter along southwestern Newfoundland, and herring which are fished between Cape Breton and Magdalen Islands in the spring after the cessation of the Newfoundland fishery. The nematode incidence in herring from Chaleur Bay during summer (based on 44 specimens only) is similar, although slightly lower.

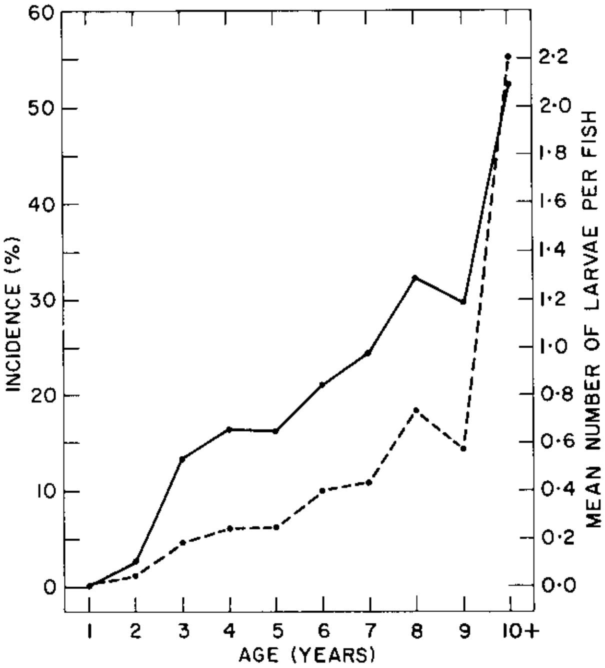

Fig. 3. Relation between the incidence of infestation (solid line), mean number of *Anisakis* larvae (broken line) and age of herring for all areas combined.

Herring from northeastern Nova Scotia (Gabarus Bay) and the offshore area (Banquereau and Sable Island banks) have a similar level of infestation, the incidence being more than twice that for the southern Gulf of St. Lawrence and Southwest Newfoundland and the intensity being four times as large. Adult herring from southwestern Nova Scotia (St. Mary's Bay) are similar in both incidence and intensity to those from northeastern Nova Scotia and the Sable Island-Banquereau area.

Nematode incidence and intensity increase from Bonne Bay northwards along western Newfoundland to the Strait of Belle Isle and southern Labrador. However, the herring samples from the latter areas, taken mostly during the summer, contained larger and older herring than those from Bonne Bay and Hawke's Bay, taken in late autumn.

There is a southward decrease in incidence and intensity from Labrador to Notre Dame Bay where the level of infestation is very low for even the largest and oldest herring (Tables 1 and 2). Southward from Notre

TABLE 1. Percentage incidence (left) and average number of nematodes per fish (right) in relation to size of herring for the various areas sampled (numbers of fish examined in parentheses).

Area code	Locality	Percentage incidence by 2-cm length groups <20	20-21	22-23	24-25	26-27	28-29	30-31	32-33	34-35	36-37	38-39	>39
1	St. Mary's Bay, N.S.					50.0 (8)	73.5 (34)	70.6 (34)	78.9 (19)	75.0 (4)		100.0 (1)	
2	N.E. Nova Scotia (Gabarus Bay)		0.0 (5)	14.3 (21)	23.9 (71)	27.7 (47)	39.6 (53)	52.9 (70)	76.6 (47)	67.8 (28)	66.7 (6)	100.0 (1)	100.0 (1)
3	Banquereau-Sable Island Bank						66.7 (9)	55.6 (9)	56.5 (23)	70.0 (50)	83.3 (6)	100.0 (1)	
5	Magdalen Islands					0.0 (3)	9.1 (22)	15.3 (72)	27.1 (210)	38.6 (179)	50.0 (14)		
7	S.W. Newfoundland					0.0 (6)	15.8 (38)	17.2 (302)	29.4 (779)	32.8 (139)	45.5 (33)		
9	Hawke's Bay, Nfld.				0.0 (6)	5.4 (37)	30.7 (88)	17.2 (93)	45.2 (93)	65.5 (84)	92.1 (38)	100.0 (6)	
10	Strait of Belle Isle						0.0 (2)	0.0 (2)	30.0 (10)	60.0 (15)	68.8 (96)	84.1 (44)	100.0 (1)
11	Southern Labrador							0.0 (1)	42.9 (7)	31.1 (45)	53.9 (65)	71.8 (39)	66.7 (3)
12	Quirpon, Nfld.						20.0 (10)	17.4 (23)	22.8 (57)	24.3 (74)	62.5 (48)	71.4 (7)	
13	Conche, Nfld.					0.0 (4)	8.4 (24)	3.3 (30)	9.5 (42)	12.5 (24)	38.5 (39)	45.4 (11)	
14	Notre Dame Bay, Nfld.					0.0 (5)	1.9 (104)	3.2 (225)	4.9 (121)	11.7 (85)	37.5 (8)		
15	Bonavista Bay, Nfld.	0.0 (1)		0.0 (1)	0.0 (2)	0.0 (8)	1.2 (48)	9.0 (134)	11.8 (93)	34.4 (61)	44.7 (47)	66.7 (6)	
16	Trinity and Conception Bays, Nfld.						0.0 (31)	15.1 (172)	23.8 (151)	39.2 (79)	62.0 (100)	80.6 (60)	
17	Eastern Avalon Peninsula, Nfld.						0.0 (2)	32.2 (31)	53.4 (30)	50.0 (6)	80.0 (5)		
18	St. Mary's Bay, Nfld.	0.0 (30)	2.1 (19)	0.0 (4)		0.0 (2)	13.7 (51)	12.3 (101)	25.2 (139)	36.0 (125)	66.3 (80)	58.3 (12)	100.0 (1)
18	Placentia Bay, Nfld.			0.0 (1)	0.0 (2)	5.0 (101)	20.0 (10)	26.1 (68)	29.5 (95)	26.0 (104)	51.4 (71)	62.5 (16)	66.7 (3)
19	Fortune Bay, Nfld.	0.0 (11)	3.9 (26)	0.0 (13)	8.9 (79)	9.8 (41)	20.6 (34)	37.0 (73)	45.3 (86)	60.9 (23)	100.0 (7)	75.0 (4)	

Area code	Locality	Intensity by 2-cm length groups <20	20-21	22-23	24-25	26-27	28-29	30-31	32-33	34-35	36-37	38-39	>39
1	St. Mary's Bay, N.S.					0.88	1.53	2.50	2.79	3.10		10.00	
2	N.E. Nova Scotia (Gabarus Bay)		0.00	0.19	0.37	0.51	0.64	1.20	2.62	1.97	3.33	16.00	2.00
3	Banquereau-Sable Island Bank						1.22	2.11	1.96	2.78	6.83	2.00	
5	Magdalen Islands					0.00	0.09	0.20	0.42	0.71	1.43		
7	S.W. Newfoundland					0.00	0.24	0.29	0.46	0.57	1.30		
9	Hawke's Bay, Nfld.				0.00	0.08	0.40	0.29	0.85	2.17	8.03	17.00	
10	Strait of Belle Isle						0.00	0.00	0.80	1.60	2.57	6.61	2.00
11	Southern Labrador							0.00	1.14	0.74	1.19	4.51	20.33
12	Quirpon, Nfld.						0.30	0.22	0.42	0.67	2.35	6.29	
13	Conche, Nfld.					0.00	0.12	0.03	0.52	0.17	0.92	2.73	
14	Notre Dame Bay, Nfld.					0.00	0.03	0.06	0.07	0.17	1.63		
15	Bonavista Bay, Nfld.	0.00		0.00	0.00	0.00	0.04	0.16	0.21	0.81	1.53	1.33	
16	Trinity and Conception Bays, Nfld.						0.00	0.27	0.38	0.93	2.82	5.13	
17	Eastern Avalon Peninsula, Nfld.						0.00	0.49	0.87	0.67	1.66		
18	St. Mary's Bay, Nfld.	0.00	0.02	0.00		0.00	0.18	0.17	0.57	0.82	1.91	1.83	6.00
18	Placentia Bay, Nfld.			0.00	0.00	0.06	0.20	0.11	0.53	0.52	2.03	5.31	2.33
19	Fortune Bay, Nfld.	0.00	0.04	0.00	0.13	0.09	0.32	0.99	0.89	1.61	2.14	14.00	

TABLE 2. Percentage incidence (left) and average number of nematodes per fish (right) in relation to age of herring for the various areas sampled (numbers of fish examined in parentheses).

Area Code	Locality	Percentage incidence by age (years)										Intensity by age (years)									
		1	2	3	4	5	6	7	8	9	10+	1	2	3	4	5	6	7	8	9	10+
2	N. E. Nova Scotia (Gabarus Bay)		6.7 (15)	22.2 (117)	32.4 (34)	33.3 (9)	52.7 (74)	63.6 (33)	81.8 (22)	64.7 (17)	75.0 (28)		0.13	0.32	0.62	0.44	0.95	1.48	3.59	2.71	2.68
3	Sable Island Bank						66.7 (3)	50.0 (4)	71.4 (7)	75.0 (12)	95.5 (22)						3.67	2.00	3.43	2.67	3.95
5	Magdalen Islands			0.0 (7)	9.1 (22)	10.8 (37)	28.8 (80)	25.9 (81)	30.6 (111)	25.5 (55)	44.9 (107)			0.00	0.14	0.11	0.38	0.43	0.51	0.49	0.93
7	S.W. Newfoundland		0.0 (1)	0.0 (2)	0.0 (7)	13.0 (23)	27.3 (77)	16.5 (71)	34.7 (121)	37.8 (74)	35.1 (74)		0.00	0.00	0.00	0.30	0.43	0.62	0.51	0.50	0.61
9	Hawke's Bay, Nfld.		6.3 (16)	22.2 (72)	16.7 (96)	35.9 (39)	35.9 (39)	54.6 (22)	45.5 (33)	63.9 (36)	78.9 (90)		0.13	0.29	0.22	0.51	0.56	0.86	1.15	1.56	5.87
10	Strait of Belle Isle					0.0 (2)		40.0 (15)	63.6 (11)	30.0 (10)	73.5 (162)					0.00		0.93	1.18	0.90	3.60
11	Southern Labrador						33.3 (3)	100.0 (4)	22.2 (9)	23.1 (13)	55.0 (131)						0.33	2.8	0.78	0.69	2.65
12	Quirpon, Nfld.				28.6 (7)	16.7 (6)	24.0 (50)	28.6 (11)	26.1 (23)	6.7 (30)	51.1 (90)				0.29	0.33	0.44	0.64	0.78	0.10	2.06
13	Conche, Nfld.			11.1 (9)	16.7 (6)	8.3 (12)	2.7 (37)	15.4 (13)	3.2 (31)	0.0 (8)	39.7 (58)			0.22	0.17	0.08	0.11	0.23	0.48	0.00	1.21
14	Notre Dame Bay, Nfld.				0.0 (8)	0.0 (6)	5.5 (73)	2.3 (263)	5.9 (17)	3.4 (59)	12.5 (120)				0.00	0.00	0.14	0.02	0.06	0.03	0.27
15	Bonavista Bay, Nfld.	0.0 (1)	0.0 (3)	0.0 (7)	0.0 (4)	0.0 (23)	11.3 (150)	11.5 (52)	8.3 (48)	20.8 (24)	43.0 (93)	0.00	0.00	0.00	0.00	0.00	0.25	0.12	0.17	0.38	1.26
16	Trinity and Conception Bays, Nfld.			0.0 (1)	0.0 (18)	7.1 (14)	12.0 (225)	31.7 (82)	13.3 (30)	33.3 (30)	64.8 (193)			0.00	0.00	0.14	0.22	0.54	0.83	0.67	3.27
17	Eastern Avalon Peninsula, Nfld.				40.0 (5)		0.0 (1)	38.8 (49)	50.0 (8)	100.0 (1)	70.0 (10)				0.60		0.00	0.59	0.88	2.00	1.20
18	St. Mary's Bay, Nfld.		1.2 (84)	0.0 (1)	18.5 (54)	0.0 (5)	20.1 (162)	21.2 (52)	33.3 (21)	25.0 (40)	50.6 (178)		0.01	0.00	0.24	0.00	0.35	0.56	0.76	0.48	1.44
18	Placentia Bay, Nfld.		0.0 (1)	5.7 (106)	0.0 (9)	40.0 (5)	26.3 (118)	27.3 (22)	16.7 (12)	23.1 (26)	44.6 (175)		0.00	0.07	0.00	0.40	0.42	0.50	0.17	0.38	1.72
19	Fortune Bay, Nfld.	0.0 (6)	2.6 (39)	8.1 (123)	22.2 (36)	100.0 (1)	36.2 (127)	58.6 (29)	50.0 (4)	80.0 (5)	74.1 (27)	0.00	0.03	0.11	0.36	2.00	0.89	1.14	0.50	1.60	3.63

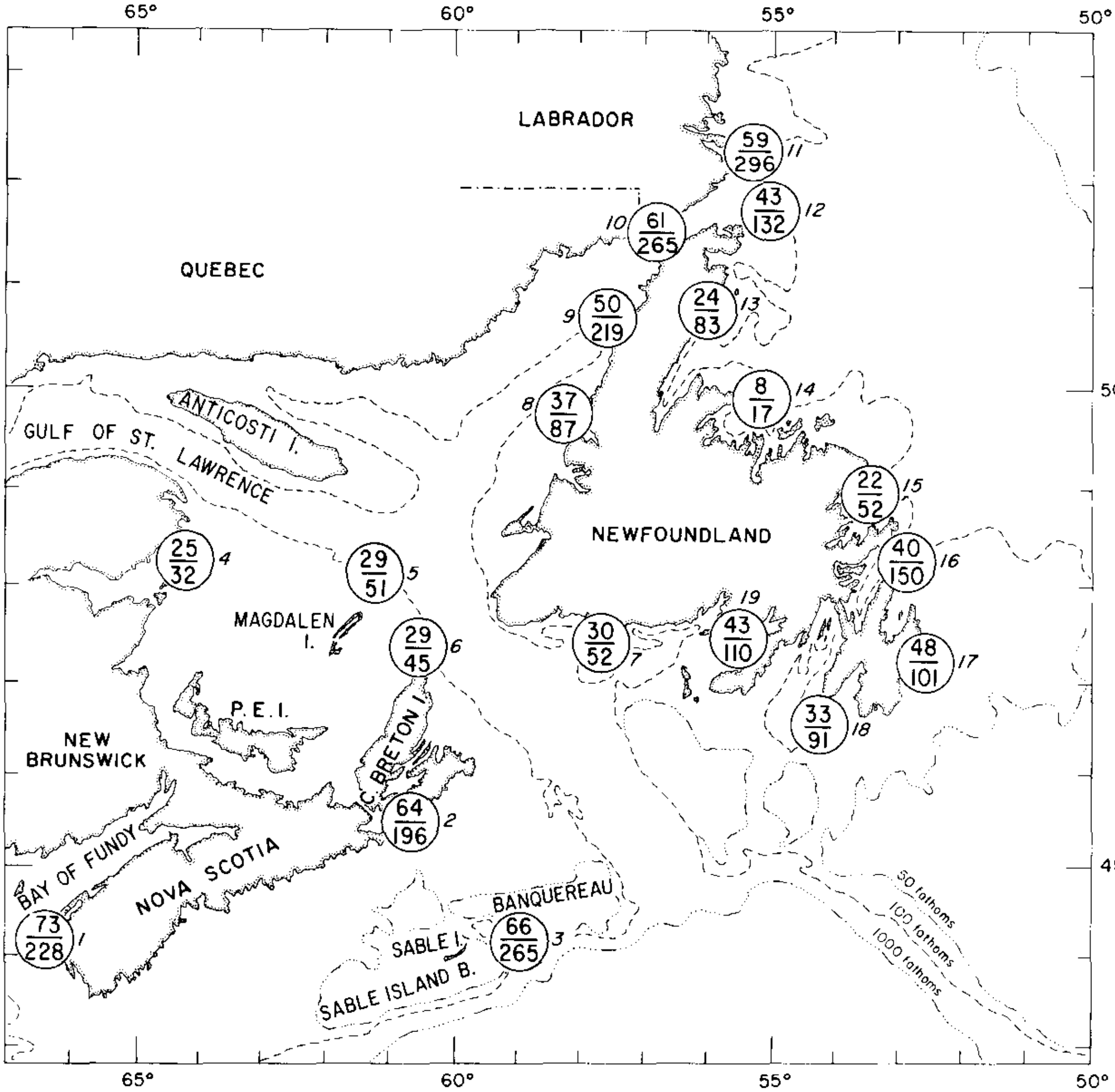

Fig. 4. Geographic variation in the incidence of larval nematodes in adult herring (≥30 cm) from Canadian Atlantic waters, 1968-70. (Within each circle the upper value represents the percentage incidence of infestation and the lower value represents the number of nematodes per 100 herring. The numbers adjacent to the circles correspond with place names in Tables 1-3.)

Dame Bay to the eastern Avalon Peninsula there is a sixfold increase in both incidence and intensity. However, the intensity in Trinity-Conception Bay samples is considerably higher than in samples from the adjacent areas.

Adult herring from Placentia and St. Mary's Bays were virtually identical in both incidence and intensity of infestation and the data for these bays were combined for comparison with other areas. Although the incidence is similar to that for southwestern Newfoundland, the intensity is considerably higher. Fortune Bay herring have only a slightly higher incidence of infestation than herring from southwest Newfoundland, but the intensity is twice as high.

Seasonal and annual variation in infestation

Because of the seasonal nature of the herring fishery in most areas, samples could not be obtained on a year-round basis from a single area to elucidate seasonal trends in nematode abundance. However, a major herring fishery, which occurs along southwestern Newfoundland from November to April (Hodder, 1969,

TABLE 3. Geographic variation in the incidence of larval nematodes in adult herring (⩾ 30 cm) from Canadian Atlantic waters, 1968-70.

Area code	Locality		No. of adult herring examined	Percentage of herring infected	No. of nematodes per 100 herring
1	St. Mary's Bay, N.S.		100	73	228
2	N.E. Nova Scotia		153	64	196
3	Banquereau-Sable Island Bank		98	66	265
4	Chaleur Bay-Gaspé		44	25	32
5	Magdalen Islands		500	29	51
6	North of Cape Breton Island		500	29	45
7	Southwest Newfoundland	1968-69	1939	27	51
		1969-70	1660	33	54
		1968-70	3599	30	53
8	Bonne Bay, Nfld.		150	37	87
9	Hawke's Bay, Nfld.		313	50	219
10	Strait of Belle Isle		250	61	265
11	Southern Labrador		110	59	296
12	Quirpon, Nfld.		306	43	132
13	Conche, Nfld.		108	24	83
14	Notre Dame Bay, Nfld.		549	8	17
15	Bonavista Bay, Nfld.		530	22	52
16	Trinity and Conception Bays, Nfld.		513	40	150
17	Eastern Avalon Peninsula, Nfld.		267	48	101
18	St. Mary's and Placentia Bays, Nfld.		983	33	91
19	Fortune Bay, Nfld.		470	43	110

1970), was intensively sampled for larval nematodes during the 1968-69 and 1969-70 seasons (Fig. 5). Except for December 1968 there was no significant variation in nematode incidence in herring during the overwintering period. The higher-than-average incidence value for December 1968 cannot be attributed to more larger and older herring in the samples for that month, since the average size remained relatively constant throughout the entire season. Sindermann (1957), in a study of seasonal parasitization of herring in the Bay of Fundy, found that the nematode incidence rose sharply in early winter and then stabilized at a somewhat lower level during spring and summer. Bishop and Margolis (1955) reported that the level of infestation in British Columbia herring remained constant throughout the winter for any particular fish age and area.

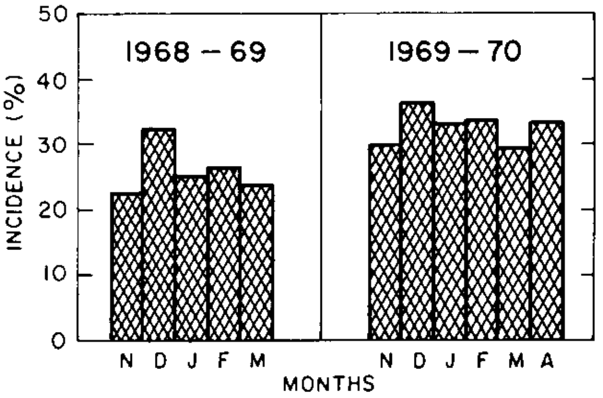

Fig. 5. Incidence of larval nematodes in herring from southwestern Newfoundland by month during the winters of 1968-69 and 1969-70.

In the present study the incidence of infestation of herring with nematodes was on the average slightly higher during the 1969-70 season (33%) than during the 1968-69 season (27%) (Fig. 5 and Table 3). This is probably due to the fact, as reported by Hodder (1970), that the average size (age) of Southwest Newfoundland herring was slightly larger in 1969-70 than in 1968-69 (33.2 cm compared with 33.0 cm).

Discussion

The distinct geographic variation in the incidence and intensity of infestation of adult herring from Canadian Atlantic waters with larval *Anisakis* indicates that this parasite is valuable as a biological indicator of stock heterogeneity. Hodder and Parsons (MS, 1970, 1971) compared certain biological characteristics of herring taken at Magdalen Islands in the southern Gulf of St. Lawrence just prior to the start of the Newfoundland fishery in the autumn of 1969 and in the coastal waters of southwestern Newfoundland shortly thereafter. The authors concluded that the samples from Magdalen Islands and along southwestern Newfoundland were derived from the same stock complex and that the winter fishery along southwestern Newfoundland is largely dependent on herring concentrations which migrate eastward out of the southern part of the Gulf of St. Lawrence in the autumn. Subsequent to that study herring were tagged in the inshore waters of southwestern Newfoundland in early March 1970 and, after the termination of the Newfoundland fishery about mid-April, recaptures were made at Magdalen Islands (Hodder and Winters, MS, 1970) and as far west as the Gaspé Peninsula (Winters, 1970), thus confirming the westward movement of the herring schools after they leave the Newfoundland coast in the spring. The similarity in incidence and intensity of *Anisakis* infestation of herring fished near Magdalen Islands in the autumn, herring from southwestern Newfoundland in winter, herring fished between Cape Breton and Magdalen Islands in the spring, and near Chaleur Bay-Gaspé during the summer provides further evidence of a seasonal migration of herring eastward from the southern Gulf of St. Lawrence in the autumn to overwintering areas along southwestern Newfoundland and westward again into the Gulf in the spring.

The similarity of nematode abundance in herring from northeastern Nova Scotia (Gabarus Bay) and from the Banquereau-Sable Island area suggests the possibility of an inshore-offshore migration of herring on the Nova Scotian shelf. However, the data indicate that herring from these areas probably do not intermingle to any great extent with the southwestern Newfoundland-southern Gulf of St. Lawrence stock complex, since intermixing should produce greater homogeneity in

Anisakis incidence than has been found in this investigation. Iles and Tibbo (MS, 1970) suggested that there is an influx of herring through the southern entrance of the Gulf in April which may involve Chedabucto Bay fish and/or herring recorded as caught in quantity in the early months of the year on Banquereau moving towards Cape Breton in the spring. In view of the present results which conflict with this hypothesis, intensive sampling of herring along the southern edge of the Laurentian Channel for *Anisakis* larvae is suggested to shed further light on the stock interrelationships in this area. Sindermann (1957, 1959) reported that larval nematodes were more abundant along the Nova Scotian coast than in either the Gulf of St. Lawrence or the Gulf of Maine, being more than twice as abundant in Nova Scotian fish as in Georges Bank fish. He also found that larval cestodes, which were common in herring from the southern Gulf of Maine, were less abundant in Nova Scotian fish and completely absent in the Gulf of St. Lawrence. Sindermann (1961*b*) reported an average incidence of 76% and 64% for adult herring from the outer Nova Scotia coast and the Nova Scotia Fundy coast respectively for 1955-58. These values are similar to those obtained during the present study – 64% for northeastern Nova Scotia herring and 73% for herring from St. Mary's Bay which borders on the Bay of Fundy. The average incidence in the southern Gulf of St. Lawrence during Sindermann's investigation (1955-58) was 22%, ranging from 19% in Chaleur Bay and along the north Gaspé coast to 31% in Northumberland Strait. There appears to have been a slight increase in incidence between 1955-58 and 1969-70.

From nematode abundance it appears that herring along the northwest coast of Newfoundland are relatively distinct from the southwestern Newfoundland-southern Gulf stock complex. Herring which occur during the summer in the Strait of Belle Isle may represent an older portion of the same stock which occurs in Hawke's Bay. The average nematode incidence in Bonne Bay (37%) is not much higher than that along southwestern Newfoundland. Sindermann (1957) reported an incidence of 24% in a sample of herring obtained from Bay of Islands in 1955. Herring from the southern portion of the Newfoundland west coast may contribute to the winter fishery along southwestern Newfoundland.

The low abundance of larval nematodes at all ages in spring spawning herring from Notre Dame Bay suggests that this herring stock is relatively discrete, although it probably intermingles to a certain extent with herring to the north and south in White Bay and Bonavista Bay. The higher nematode abundance in Fortune Bay herring compared with herring from southwestern Newfoundland indicates that Fortune Bay herring, which are almost exclusively spring spawners, do not intermingle to any great extent with the herring stock complex which overwinters along southwestern Newfoundland. Sindermann (1957) found an incidence of 94% in a sample of herring from Fortune Bay in 1956. It is possible that his sample consisted of very large old fish. Tibbo (1957) reported a high proportion of very old herring in Fortune Bay from 1946 to 1948. At that time the average size was 35.6 cm and the average age was 11 years. The average size and age of the adult specimens examined in our study was much less (Tables 1 and 2).

The similarity of incidence and intensity of infestation of herring from Placentia and St. Mary's Bays with *Anisakis* larvae suggests that the samples from these two adjacent bays were derived from the same stock. This was previously indicated by the migration of "red" herring, which had been exposed to phosphorus poisoning in Placentia Bay, into St. Mary's Bay in the spring of 1969 (Unpublished data, St. John's Biological Station).

Relatively little is known of the life cycle of *Anisakis* nematodes which occur in herring. Marine mammals are the definitive hosts of adult *Anisakis* (Baylis, 1920; Baylis and Daubney, 1926; Khalil, 1969). Templeman, Squires and Fleming (1957) list the following final hosts: the common porpoise, *Phocoena phocoena* L.; the common dolphin, *Delphinus delphis* L.; the white-beaked dolpin, *Lagenorhynchus albirostris* Gray; the narwhal, *Monodon monoceros* L.; the bottle-nosed whale, *Hyperoodon ampullatus* (Forster); the little piked or minke whale, *Balaenoptera acutorostrata* Lacépède; the fin whale, *Balaenoptera physalus* (L.); the sei whale, *Balaenoptera borealis* Lesson; the false killer whale, *Pseudorca crassidens* (Owen); the blue whale, *Balaenoptera musculus* (L.); the white whale *Delphinopterus leveas* (Pallas); the walrus, *Odobaenus rosmarus*. A more extensive list of cetacean hosts is given by Baylis (1932). Sergeant (1962) reported the occurrence of adult *Anisakis simplex* in the stomachs of pilot or pothead whales, *Globicephala melaena* (Traill), in Newfoundland waters. Scott and Fisher (1958) found adult *Anisakis* in the harbour seal, *Phoca vitulina;* the harp seal, *Phoca groenlandica;* and the grey seal, *Halichoerus grypus;* in the Canadian area of the western North Atlantic. Van Thiel (1966) also found *Anisakis* in grey seals on the east coast of Scotland.

The relative importance of these marine mammals as final hosts for the *Anisakis* larvae which occur in herring is uncertain. Although pilot whales which are the most abundant cetacean in Newfoundland waters in summer harbour adult *Anisakis simplex*, they feed almost exclusively on the short-finned squid, *Illex illecebrosus* (LeSueur), and there is little evidence to indicate that herring form an important constituent in their diet (Sergeant, 1962). The common dolphin, *Delphinus delphis*, is abundant off eastern Nova Scotia in the region of "slope water" at temperatures between 13 and 17 C during the late summer and autumn (Sergeant and Fisher, 1957). The common porpoise, *Phocoena phocoena*, is abundant in the Passamaquoddy Bay region of the Bay of Fundy each summer, at which time herring is the principal item of diet. The porpoise is well-known elsewhere in the Maritimes and is frequently taken in cod traps in June and July in Newfoundland waters (Sergeant and Fisher, 1957). Another host of adult *Anisakis*, the minke whale, *Balaenoptera acutorostrata*, supports a shore-based fishery off eastern Nova Scotia and eastern Newfoundland, generally from late May to late July in the latter region, during its northward migration. Herring are of minor importance in its diet (Sergeant, 1963). A large population of white whales, *Delphinopterus leveas*, occurs in the St. Lawrence estuary and has been described by Vladykov (1944). Offshoots of this population sometimes occur in the Bay of Fundy but only rarely along Newfoundland and Labrador.

Templeman *et al.* (1957) and Scott and Fisher (1958) have described the distribution of harbour, grey and harp seals in the Canadian area of the western North Atlantic. Herring comprise a large portion of the diet of harbour seals in Newfoundland-Labrador waters (Templeman *et al.*, 1957). However, adult *Anisakis* occur only rarely in these seals (Scott and Fisher, 1958).

The geographic variation in the incidence and intensity of infestation of adult herring with *Anisakis* larvae is dependent not only upon the distribution and migrations of the final hosts but also upon the distribution of the first intermediate host, current patterns, herring migrations and particularly the location of herring feeding grounds. Herring may become infested by ingesting the eggs after they are discharged into the sea from a marine mammal. However, most investigators have assumed that infestation occurs as a result of herring feeding upon infested plankton which thus act as the first intermediate host. *Anisakis* larvae have been reported to occur in the euphausiid *Thysanoessa* (Polyanskii, 1955). The life span of the larvae in herring is unknown. The increase in incidence and intensity of infestation with increasing age and size of the fish indicates that the larval nematodes accumulate from year to year. Invertebrate organisms such as copepods and euphausiids are the chief food of herring. It is not known which of these invertebrates act as hosts for the larval *Anisakis* which occur in herring. Consequently, it is difficult to offer an adequate explanation for the specific geographic variation of *Anisakis* in herring as shown in the present study. Further research into the life cycle of this parasitic nematode may elucidate the reasons for its observed distribution in herring of the western North Atlantic.

Nematode larvae, such as those occurring in herring, can be harmful to man. The first case of so-called "herring-worm disease", later termed "anisakiasis", was observed in Holland in 1955. From 1955 through 1967, 149 proven cases were reported in the Netherlands. During 1967 there were 92 cases of "anisakiasis" in Japan. European scientists found that *Anisakis* larvae could be transmitted to man through eating infested herring either raw or inadequately treated. Following the introduction by the Netherlands government of new regulations for the treatment of herring for human consumption, the number of cases declined dramatically to only five proven cases in 1968 (Ruitenberg, MS, 1970). Khalil (1969) and Ruitenberg (MS, 1970) have described the effects of salt and temperature on the survival of *Anisakis* larvae in herring.

The intensity of infestation of adult herring in the Northwest Atlantic with *Anisakis* larvae varies with locality, ranging from 0.17 nematodes per fish in Notre Dame Bay to 2.96 nematodes per fish along southern Labrador, but is generally much lower than in herring from British coastal waters (33.1 larvae per fish with 30-50 larvae per herring being frequent) as reported by Khalil (1969). Herring from the west of Scotland and the northwest of Ireland (3.2 and 1.6 nematodes per fish respectively) were considered to have a low level of infestation. The intensity of infestation in herring from southwestern Newfoundland and the southern Gulf of St. Lawrence, where two of the major Canadian herring fisheries are presently concentrated, is very low in comparison with nematode abundance in eastern North Atlantic herring, particularly those from the North Sea. Even the highest intensities in the Canadian area (2.96, 2.65, 2.28, 2.19, and 2.01 nematodes per fish) are comparable to the intensities in herring from Scotland and Ireland, which have been termed low by European investigators. Thus, it appears that the relatively low intensity of *Anisakis* larvae in herring from the Canadian area of the western North Atlantic poses a negligible problem in the utilization of herring for human consumption particularly if the herring are properly treated.

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References

BAYLIS, H. A. 1920. On the classification of the Ascaridae. I. The systematic value of certain characters of the alimentary canal. *Parasitology*, **12**: 253-264.

1932. A list of worms parasitic in Cetacea. *Discovery Rep.*, **6**: 395-418.

BAYLIS, H. A., and R. DAUBNEY. 1926. A synopsis of the families and genera of Nematoda. 277 p. London: The British Museum.

BISHOP, Y. M. M., and L. MARGOLIS. 1955. A statistical examination of *Anisakis* larvae (Nematoda) in herring (*Clupea pallasi*) of the British Columbia coast. *J. Fish. Res. Bd. Canada*, **12**: 571-592.

HODDER, V. M. 1969. Herring landings and distribution of catches in Newfoundland, 1967-68. *Fish. Canada*, **22**: 3-6.

1970. Recent developments in the Newfoundland herring fishery. *Fish. Res. Bd. Canada, Biol. Sta., St. John's, Nfld.*, Circ. 18: 1-19.

HODDER, V. M., and L. S. PARSONS. MS, 1970. A comparative study of herring taken at Magdalen Islands and along southwestern Newfoundland during the 1969 autumn fishery. *Annu. Meet. int. Comm. Northw. Atlant. Fish., 1970.* Res. Doc. No. 77, Serial No. 2425 (mimeographed).

1971. Comparison of certain biological characteristics of herring from Magdalen Islands and southwestern Newfoundland. *Res. Bull. int. Comm. Northw. Atlant. Fish.*, this volume, p. 59-65.

HODDER, V. M., and G. H. WINTERS. MS, 1970. Preliminary results of herring tagging in southwestern Newfoundland, March 1970. Annu. Meet. int. Comm. Northw. Atlant. Fish., 1970, Res. Doc. No. 89, Serial No. 2440 (mimeographed).

ICNAF. 1964. Report of Standing Committee on Research and Statistics. App. I. Report of ad hoc group on herring and other pelagic fish. *Int. Comm. Northw. Atlant. Fish., Redbook* 1964, Part I: 23-30.

ILES, T. D., and S. N. TIBBO. MS, 1970. Recent events in Canadian Atlantic herring fisheries. *Annu. Meet. int. Comm. Northw. Atlant. Fish.*, 1970, Res. Doc. No. 78, Serial No. 2426 (mimeographed).

KABATA, Z. 1963. Parasites as biological tags. *Spec. Publ. int. Comm. Northw. Atlant. Fish.*, No. 4, p. 31-37.

KHALIL, L. F. 1969. Larval nematodes in the herring (*Clupea harengus*) from British coastal waters and adjacent territories. *J. Mar. Biol. Assoc. U.K.*, **49**: 641-659.

MARGOLIS, L. 1963. Parasites as indicators of the geographic origin of sockeye salmon, *Oncorhynchus nerka* (Walbaum), occurring in the North Pacific Ocean and adjacent seas. *Bull. int. N. Pacif. Fish. Comm.*, No. 11: 101-156.

POLYANSKII, Y. I. 1955. Materialy po parazitologii ryb severnykh morei SSSR. Parazity ryb Barentsova morya. *Trudy zool. Inst. Akad. Nauk SSSR*, **19**: 5-170. (Transl. from Russian by Israel Program for Scientific Translations No. 1655, 1966.)

RUITENBERG, E. J. MS, 1970. Anisakiasis-Pathogenesis, serodiagnosis, and prevention. Ph.D. Thesis, University of Utrecht, Netherlands, 138 p.

SCOTT, D. M., and H. D. FISHER. 1958. Incidence of the *Ascarid Porrocaecum decipiens* in the stomachs of three species of seals along the southern Canadian Atlantic mainland. *J. Fish. Res. Bd. Canada*, **15**: 495-516.

SERGEANT, D. E. 1962. The biology of the pilot or pothead whale *Globicephala melaena* (Traill) in Newfoundland waters. *Bull. Fish. Res. Bd. Canada*, No. 132, 84 p.

1963. Minke whales, *Balaenoptera acutorostrata* Lacépède, of the western North Atlantic. *J. Fish. Res. Bd. Canada*, **20**: 1489-1504.

SERGEANT, D. E., and H. D. FISHER. 1957. The smaller cetacea of eastern Canadian waters. *J. Fish. Res. Bd. Canada*, **14**: 83-115.

SINDERMANN, C. J. 1957. Diseases of fishes of the western North Atlantic. V. Parasites as indicators of herring movements. *Res. Bull. Dep. Sea Fish. Me.*, No. 27, 30 p.

MS, 1959. Population studies of herring using parasitological and serological methods. Fisheries Investigations, International Passamaquoddy Fisheries Board, Report to International Joint Commission, Appendix III (United States Biology), 16 p.

1961*a*. Parasitological tags for redfish of the western North Atlantic. *Spec. Publ. int. Comm. Northw. Atlant. Fish.*, No. 3, p. 111-117.

1961*b*. Parasite tags for marine fish. *J. Wildlife Mgmt*, **25**: 41-47.

TEMPLEMAN, W., and A. M. FLEMING. 1963. Distribution of *Lernaeocera branchialis* L. on cod as an indicator of cod movements in the Newfoundland area. *Spec. Publ. int. Comm. Northw. Atlant. Fish.*, No. 4, p. 318-322.

TEMPLEMAN, W., and H. J. SQUIRES. 1960. Incidence and distribution of infestation by *Sphyrion lumpi* (Krøyer) on the redfish, *Sebastes marinus* (L.), of the western North Atlantic. *J. Fish. Res. Bd. Canada*, **17**: 9-31.

TEMPLEMAN, W., H. J. SQUIRES, and A. M. FLEMING. 1957. Nematodes in the fillets of cod and other fishes in Newfoundland and neighbouring areas. *J. Fish. Res. Bd. Canada*, **14**: 831-897.

THIEL, P. H. van. 1966. The final hosts of the herring worm *Anisakis marina*. *Trop. Geogr. Med.*, **18**: 310-327.

TIBBO, S. N. 1957. Herring populations on the south and west coasts of Newfoundland. *Bull. Fish. Res. Bd. Canada*, No. 111, p. 153-164.

VLADYKOV, V. D. 1944. Études sur les mammifères aquatiques. III. Chasse, biologie et valeur économique du marsouin blanc ou béluga (*Delphinopterus leveas*) du fleuve et du golfe Saint-Laurent. *Dept. Pêch. Québec*, 194 p.

WINTERS, G. H. 1970. Preliminary results of herring tagging in southwest Newfoundland coastal waters, 1970. *Fish. Res. Bd. Canada, Biol, Sta., St. John's, Nfld.*, Circ. **18**: 20-24.

Fishing Mortality and Stock Size in the West Greenland Cod

By Albrecht Schumacher[1]

Abstract

The "virtual population" method is used to estimate fishing mortality per age-group in West Greenland (Subarea 1) cod for the years 1956-69. A good correlation is obtained between estimated total fishing intensity and mean fishing mortality. Stock size at the beginning of the years 1960-69 and the possible yield in 1971 at different levels of fishing mortality are estimated.

Fishing Mortality

Improvements in fishing techniques over the last 10 years have led to increased efficiency of the different fishing fleets in the North Atlantic. In addition some of the fleets exploiting the cod in West Greenland (ICNAF Subarea 1) have changed to a more seasonal fishery for economic reasons. Therefore, catch-per-unit effort data on the West Greenland cod fishery are not comparable over a long period of time and cannot be used as an index of stock abundance in estimating fishing mortality (F) in West Greenland cod.

To overcome these difficulties the virtual population method developed by Fry (1949, 1957) and modified by Gulland (1965) and Jones (1961, 1967) which is independent of effort data, has been used to estimate F. The basic data required to use this method are the total annual catch from the West Greenland cod stock in numbers per age-group for a series of years. Age composition data were taken from the ICNAF Sampling Yearbook for 1956-66 and the catch data from the ICNAF Statistical Bulletin for 1956-66. Using these data, it was possible to estimate the total number of cod per age-group taken from the West Greenland fishery in the years 1956-66 (Table 1). A good estimate of natural mortality (M) is also necessary and is given in Horsted (1968) from tagging experiments in 1935-39. Data on recaptures during the 1939-45 period gave an estimate of total mortality (Z) of 0.28. In view of the small amount of fishing carried out by the Greenland boats in the period, a value of M = 0.20 is not too inaccurate. Table 2 shows estimated fishing mortality for the years 1956-64 and fishing mortality extrapolated for the years 1965-69 by using the catch for the years 1965-69 and recruitment figures supplied by Mr Sv. Aa. Horsted, Greenland Fisheries Investigation Laboratory, Charlottenlund, Denmark. It is clear that in all age-groups, fishing mortality values for 1962-64 were more than twice corresponding values for the 1956-61 period. In the fully recruited age-groups, a level of F = 0.8 was reached in 1964 with no marked decrease through 1969. These fishing mortality values show reasonable agreement with those presented by Horsted (1969).

Mortality and Fishing Intensity

As pointed out previously a good estimate of effort is not available for the more recent years in the West Greenland cod fishery. However, a reliable estimate of fishing intensity for the years 1956-63 has been published by Horsted (1965) and is shown in the bottom line of Table 2 of this paper. There is a good correlation between this estimated fishing intensity and the mean fishing mortality for age-groups 3-13 in the years 1956-63. Figure 1 shows that the regression line almost goes through the origin; there is only a small intercept of 0.012. This confirms the validity of estimated natural mortality used in this and in previous assessments.

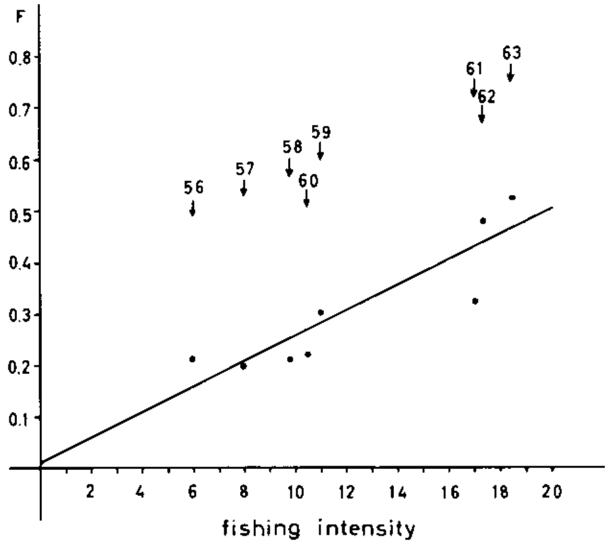

Fig. 1. Relationship of mean fishing mortality and fishing intensity in West Greenland cod during 1956 to 1963. ($y = 0.0124 + 0.243\,x$; $s_b = 0.005$).

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TABLE 1. Numbers of cod caught per year and age-group ($\times 10^{-3}$) at West Greenland (ICNAF Subarea 1) from 1956 to 1966.

Age (years)	Year 1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
2		544	488			24		296	8	2752	88
3	209	1177	348	578	435	2946	869	7612	8655	14718	1294
4	1758	19353	1772	2866	6186	22958	11423	6589	27181	58619	7738
5	4996[a]	12493	15136	5464	5168	19756	70311	19301	11407	53331	59987
6	17901	9362[a]	6751	27411	4652	8055	29344	48418	18624	8994	40726
7	6622	17367	7501[a]	6622	20250	6980	7816	22517	30864	9152	5791
8	6400	3967	17177	3881[a]	4492	23126	5050	3973	11355	15125	4403
9	24418	4061	3181	5996	2743[a]	4359	13772	1708	2543	2595	6667
10	2345	8893	3652	1124	5363	2333[a]	2433	6768	1027	539	1166
11	4106	1271	12981	1477	805	4724	1709[a]	1104	4138	472	276
12	1014	1899	1691	4327	1438	528	2599	1156[a]	591	1864	122
13	1363	485	2168	999	5195	1138	720	2325	321[a]	73	981
14	2893	436	725	836	741	5052	1219	189	933	34[a]	137
14+	1194	1383	3271	960	1859	2383	2897	3718	747	265	234[a]

[a]1951 year-class.

TABLE 2. Fishing mortalities (F) for West Greenland cod for the years 1956 to 1969. (Estimated catch in 1969 = 205,000 tons).

Age (years)	Estimated fishing mortality for the years 1956	1957	1958	1959	1960	1961	1962	1963	1964	Fishing mortality values for the years 1965	1966	1967	1968	1969[a]	Change of F with age in % of F in fully recruited age-groups
3	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	3
4	0.02	0.04	0.04	0.05	0.04	0.08	0.11	0.11	0.09	0.10	0.10	0.10	0.10	0.07	13
5	0.09	0.23	0.08	0.15	0.13	0.18	0.35	0.28	0.27	0.28	0.20	0.28	0.31	0.22	40
6	0.16	0.23	0.19	0.21	0.18	0.30	0.43	0.44	0.47	0.42	0.36	0.42	0.46	0.33	60
7	0.30	0.22	0.29	0.28	0.23	0.45	0.55	0.70	0.55	0.56	0.48	0.56	0.62	0.44	80
8	0.22	0.30	0.36	0.24	0.31	0.44	0.70	0.61	0.96	0.70	0.60	0.70	0.77	0.55	100
9	0.29	0.21	0.42	0.20	0.27	0.55	0.52	0.55	1.03	0.70	0.60	0.70	0.77	0.55	100
10	0.24	0.16	0.29	0.26	0.27	0.39	0.69	0.52	0.76	0.70	0.60	0.70	0.77	0.55	100
11	0.40	0.20	0.37	0.18	0.30	0.40	0.56	0.79	0.70	0.70	0.60	0.70	0.77	0.55	100
12	0.34	0.33	0.43	0.20	0.27	0.33	0.40	0.97	1.04	0.70	0.60	0.70	0.77	0.55	100
13		0.27	0.78	0.48	0.38	0.35	1.00	0.75		0.70	0.60	0.70	0.77	0.55	100
Mean F	0.21	0.20	0.30	0.21	0.22	0.32	0.48	0.52	0.59	0.51	0.43	0.51	0.51	0.33	
	Fishing Intensity (Horsted, 1965)														
	5.94	7.99	11.01	9.79	10.50	16.95	17.31	18.04							

[a]Estimated catch in 1969 = 205,000 tons.

Stock Size

To show the state of the West Greenland cod stock in the years from 1960 to 1969, the number of cod per age-group present in the stock at the beginning of the year has been estimated using catch and mortality. The results are presented in Table 3 and Fig. 2 which show a remarkable decline in the number of cod during the last 5 years.

Catch in 1971

The 1971 cod catch at West Greenland will be heavily dependent on the results of the fishing in 1969 and 1970. The year-classes recruiting in 1970 and 1971 are of minor importance and will not constitute much to the yield in 1971 because of the low fishing mortality in the 2 years after first recruitment. Figure 3 shows the possible yield in 1971 at different levels of F in fully recruited age-groups and with different catch in 1969 and 1970. It is clear that, assuming a moderate fishery of about 50% of the 1968 catch in 1969 and also in 1970, the catch in 1971 will not exceed a level of 220,000 metric tons with F = 0.7–0.8 (1968 level) in 1971. If the 1970 catch is greater, the 1971 catch will be considerably below the above level.

TABLE 3. Numbers of cod ($\times 10^{-6}$) of age-groups 3–14 + in the West Greenland stock at the beginning of the years 1960-69.

	Year									
Age (years)	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
3	404	164	97	423	481	171	72	70	150	100
4	172	328	120	69	348	386	137	58	56	120
5	47	132	261	87	54	261	286	104	43	42
6	31	34	92	149	53	34	161	184	64	26
7	108	21	20	49	80	27	18	92	99	33
8	18	71	11	10	20	38	13	9	43	44
9	13	11	37	4	4	6	15	6	4	16
10	25	8	5	18	2	1	3	7	2	1
11	3	16	4	2	9	1	0.5	1	3	1
12	7	2	9	2	1	4	0.3	0.2	0.5	1
13	18	4	1	5	0.6	0.2	1	0.1	0.1	0.2
14	2	10	2	0.3	2	0.2	0.1	0.7	0.1	0.1
14+	4	5	6	7	1	1	0.6	0.3	0.4	0.2
$\sum_{3}^{14+}$	852	806	665	825	1056	930	708	532	465	384
$\sum_{4}^{14+}$	448	642	568	402	575	759	636	462	315	284
$\sum_{5}^{14+}$	276	314	448	333	227	373	499	404	259	165

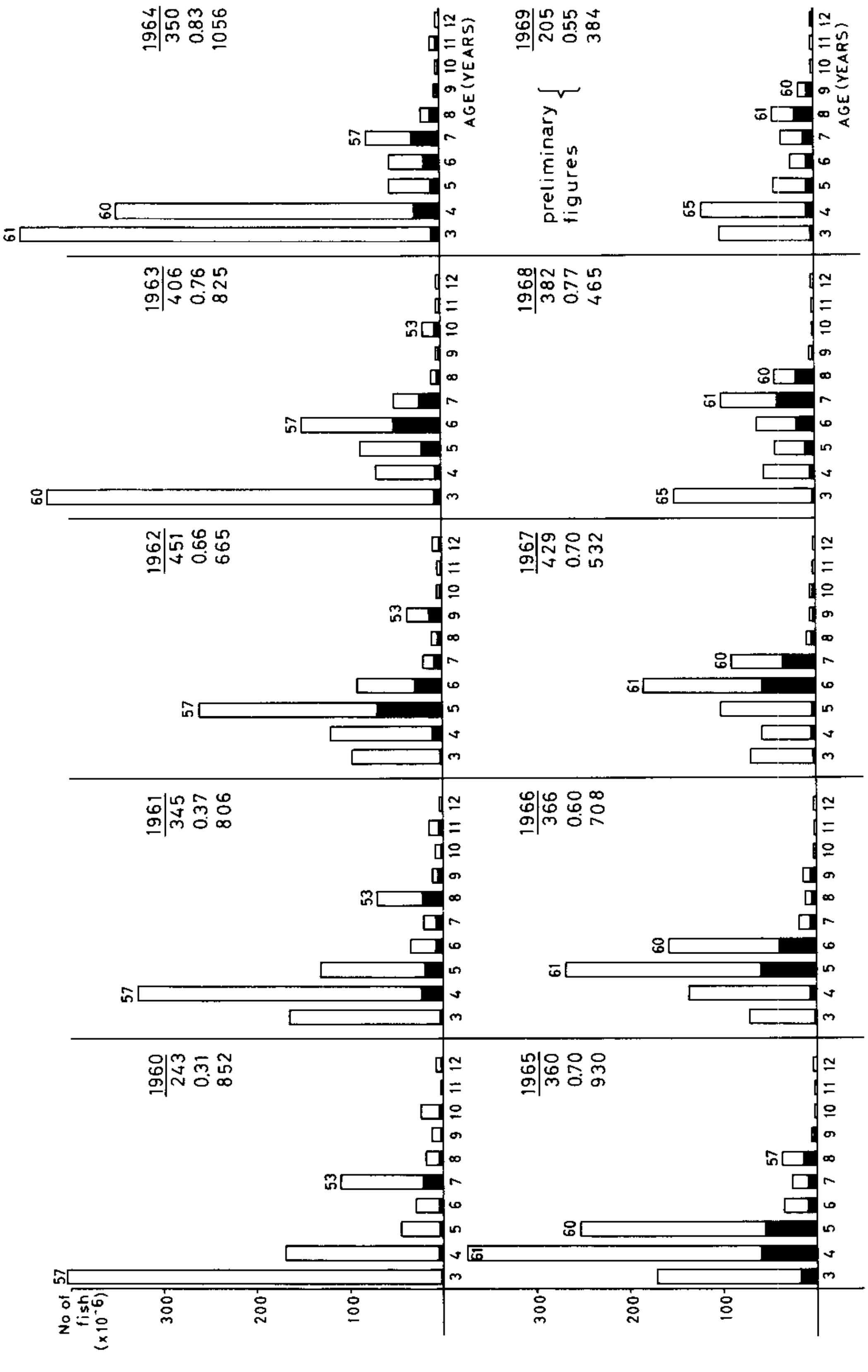

Fig. 2. Number of cod ($\times 10^{-6}$) per age-group in the West Greenland stock at the beginning of the year from 1960 to 1961.

1960 = year;

243 - catch in 1,000 tons;

0.31 - F (7+);

852 = total number of fish in age groups 3-14+.

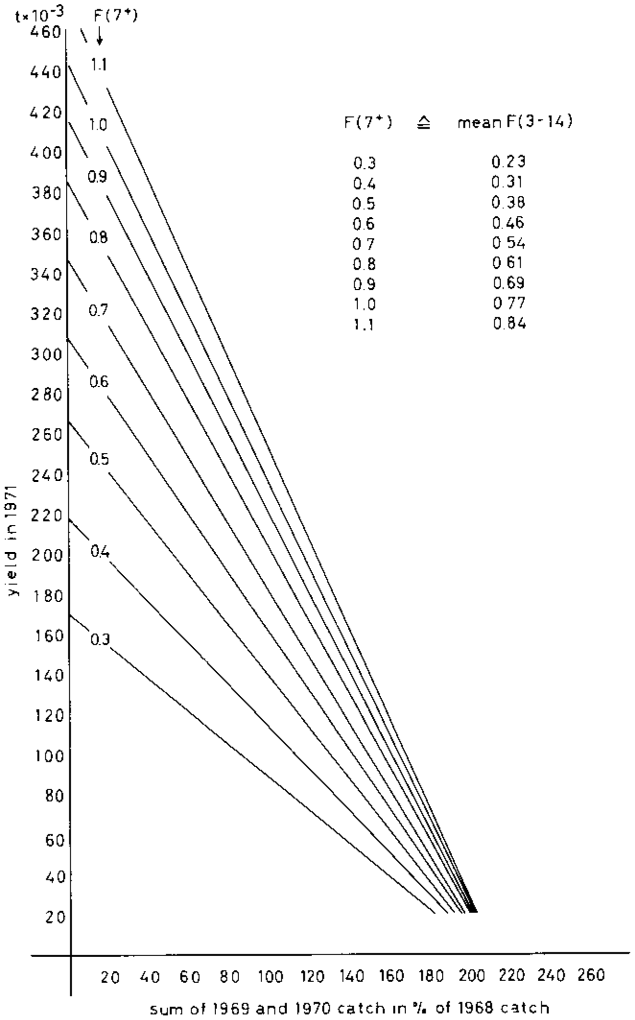

Fig. 3. Yield of West Greenland cod in 1971 ($t \times 10^{-3}$) at different levels of fishing mortality (F) in fully recruited age-groups with different catch in 1969 and 1970.

References

FRY, F. E. J. 1949. Statistics of a lake trout fishery. *Biometrics*, 5 (1) 27-67.

1957. Assessments of mortalit by use of virtual populations. Proceedings of the Joint Scientific Meeting ICNAF, ICES and FAO on Fishing Effort, the Effects of Fishing on Resources, and the Selectivity of Fishing Gear. Contribution No. P15 (mimeographed).

GULLAND, J. A. 1965. Estimation of mortality rates. Annex to Arctic Fisheries Working Group Report. *ICES, C.M.* 1965, Doc. No. 3 (mimeographed).

HORSTED, S. A. 1965. Fishing Activity, Effort and Intensity in Subarea 1, 1952-1963. *Annu. Meet. int. Comm. Northw. Atlant. Fish.* 1965, Res. Doc. No. 67 (mimeographed).

1968. Cod in Subarea 1. Review and Revision of Parameters. Reassessment. *Ibid*, 1968, Res. Doc. No. 57 (mimeographed).

1969. On the possibility of assessing stock size and catch quota for Subarea 1 cod. *Ibid*, 1969, Res. Doc. No. 74 (mimeographed).

ICNAF. 1958-1968. *Sampl. Yearb. int. Comm. Northw. Atlant. Fish.*, Vol. 1-11 for the years 1956-66.

1958-1968. *Stat. Bull. int. Comm. Northw. Atlant. Fish.*, Vol. 6-16 for the years 1956-66.

JONES, R. 1961. The assessment of the long-term effects of changes in gear selectivity and fishing effort. *Mar. Res.*, No. 2, p. 1-19.

1964. Estimating Population Size from Commercial Statistics when Fishing Mortality Varies with Age. *Rapp. Cons. Explor. Mer.*, 155, (38): 210-214.

1968. Appendix to the Report of the Northwestern Working Group. *ICES, C.M.* 1968, Doc. No. 20 (mimeographed).

Tagging of White Hake, *Urophycis tenuis* Mitchill, in the Southern Gulf of St. Lawrence[1]

By A. C. Kohler[2]

Abstract

White hake (2,271), *Urophycis tenuis* Mitchill, were tagged with yellow Petersen disc tags in the southeastern Gulf of St. Lawrence in August 1967. This was the first recorded mass tagging of hake. A total of 603 returns had been received to the end of 1969. Previous attempts to tag hake had been foiled by mortalities caused by rapidly and greatly expanding air bladders. High mortalities were avoided in this experiment by choosing a relatively shoal water tagging area and by using a hypodermic needle to remove excess air bladder gas.

Returns from the tagging indicated that this hake population was resident in the southern Gulf of St. Lawrence the year round. Movements of the fish around Prince Edward Island and toward the western shore of Cape Breton were recorded.

Introduction

A study of the fishery for white hake, *Urophycis tenuis* Mitchill, in the southern Gulf of St. Lawrence was begun in 1965 as an M.Sc. project and has been reported in a McGill University thesis (Nepszy, 1968). The study was based on examination of samples of research and commercial catches at sea and commercial landings ashore. Objectives of the investigation were estimation of values for age, growth, length, weight and feeding, and statistics of landings and discards. To examine movements of the population studied, a tagging experiment was initiated in August 1967. The species has been traditionally hard to tag but a successful method was devised. A description of the method and results from the tagging to the end of 1969 follow.

Tagging Operations

White hake have not been tagged successfully in large numbers previously, because of the rapid expansion of the air bladder as they are brought from the bottom to the surface of the sea. In most Northwest Atlantic areas white hake are resident in fairly deep water, i.e. over 40 fathoms. However, a unique feature of the hake population in the southern Gulf of St. Lawrence (ICNAF Division 4T) is that, during the summer months, a large portion is resident in areas of the Gulf that are only 8-20 fathoms deep. This made it possible to capture the animals at minimum depth with relatively less resultant expansion of the air bladder.

The gear used for the capture of hake for the tagging experiment was a No. 41 polypropylene otter trawl with a $1\frac{1}{8}$ inch nylon codend liner, towed by the R/V *E. E. Prince*. In order to keep injuries to the fish to a minimum and yet catch enough for an efficient operation, tows were standardized at 15 min duration, except for a few half hour tows when hake were scarce. Two main areas in the southern Gulf of St. Lawrence were fished: one near Wood Island off the southeast part of Prince Edward Island and the other near East Point at the northeast corner of the island (Figs. 3A and 5A).

The size of catch and crowding in the codend of the net when it was brought on deck influenced the condition of the fish to be tagged. For the East Point area, in 56 tows, catches averaged 97 hake per 15-min tow together with a number of other species, the most abundant being herring and winter flounder. In the Wood Island area, in 19 tows, the average catch of hake was 20 per 15-min tow and there were less of the other species, although herring and winter flounder were still the most common incidental ones. Only 37% of the fish caught in the East Point area were suitable for tagging as compared with 88% in the Wood Island area. Even though a larger percentage per tow could be tagged in the Wood Island area, greater numbers per tow were available at East Point and this is the area in which most of the tagging was concentrated. Total numbers tagged were 1,948 hake at East Point and 323 hake at Wood Island.

After a haul the codend of the otter trawl was lowered gently to the deck and the fish were carefully released. The deck was kept well wetted-down to cool it since the air temperature ranged from 60° to 70°F in the shade and hotter in the sun. A maximum of 70 hake were immediately selected by members of the ship's crew and scientific party and divided between two circular 5 ft diam. holding tanks filled with sea water. Excess fish were discarded. Water in both tanks was aerated and the water itself was re-circulated through a cooling system which lowered the temperature about 1°C below ambient sea surface temperature.

Most of the fish put in the tanks were found swimming belly-up as soon as they stopped reacting

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[1]Issued as Canadian IBP Contribution No. 112.

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violently to handling. Dissection confirmed that there was an excess of gas in their air bladders, so this was removed immediately using a 3⅝ inch No. 15 gauge hypodermic needle. The needle was inserted through the lower part of the dorsal musculature near the position the tip of the pectoral fin takes when flattened against the side. The fish were then held under water and gentle pressure was applied to their sides until bubbles ceased to emerge from the outer end of the hypodermic needle.

The hake were tagged with two yellow Petersen disc tags, one on each side, held by a stainless steel wire, after they appeared to be swimming normally in the tanks. After preliminary tests, the tagging wires were inserted through the dorsal muscle, about 1 inch behind and below the second dorsal fin. This position was found to hold the tag wire more securely than the area below the division between the first and second dorsals that was first tried. As the tagged fish were returned to the sea, the tagger noted whether they appeared to be in good or doubtful condition, depending on the feel of the fish as it was put overboard and its appearance when swimming away from the ship. Any fish appearing or behaving abnormally in the holding tanks after puncture was not used.

Differences in surface and bottom temperatures apparently influenced the time which the fish could be kept on deck in good condition in the slightly-cooled holding tanks. Average surface and bottom temperatures at East Point were 19° and 2.8°C, and at Wood Island 16° and 3.6°C as shown by BT records. In general, while the skin and muscle of the hake remained firm and cold to the touch during tagging, as they were when on bottom, they seemed to return to the sea in good condition, but as they warmed up and the muscular parts became softer, they rapidly became too weak to swim properly. Forty to 60 fish, of approximately 70 held, were tagged from each tow. The number tagged was dependent on the speed at which the tagging crew could handle the fish, since they usually stayed in good condition in the tanks for only 15-20 min. Five live tagged hake recaptured during the trip indicated some survival of those tagged.

Results and Conclusions

The fishery for white hake is seasonal in the southern Gulf of St. Lawrence because of the presence of sea ice in the area in the winter, which inhibits the use of fishing vessels, and the use of the vessels in other fisheries. Most of the gillnet and longline fishermen trap lobsters up to the end of the legal season in June. The seasonal nature of the catches of hake is shown in Fig. 1, where landings from the southern Gulf have been plotted by months for the years 1967 and 1968. The fishery started in May, built to a peak in the July-September period and dropped off in October and

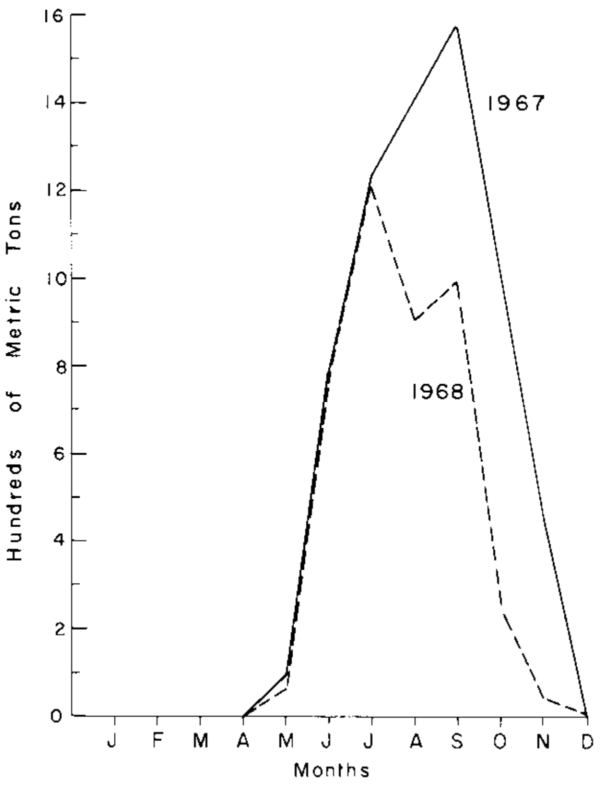


Fig. 1. Landings of white hake from the southern Gulf of St. Lawrence in 1967 and 1968.

November. Numbers of hake tags recovered have followed this seasonal pattern of the fishery.

Recoveries of those fish that were considered to be in doubtful condition on release were compared against those fish considered to be in good condition. Of 247 doubtful fish, 18.2% were recovered. Of 2,024 hake considered to be in good condition, 27% were recovered. These figures indicate there may have been some mortality due to the tagging process among fish that we had considered to be in doubtful condition when they were released.

No particular size seemed to be more vulnerable to tagging mortality. Sizes tagged are shown in Fig. 2 ranging between 40 and 94 cm with a peak at 64 cm. Percentage length distribution of fish tagged and of fish recovered shown in the figure indicate no essential difference between the two length compositions.

The return rates for tagged hake are not very high as compared with some others for gadoid taggings in the Canadian Atlantic (McCracken, 1956, 1959) and, if valid, would indicate a fairly low fishing mortality rate. As shown in the table below, in 1967, returns of tags totalled 390 with 2,271 tags out, a return of 17%. In 1968, there were still 1,881 tags out and 150 were returned for a total of 8%. In 1969, 1,731 tagged fish were still out and 63 or 4% were returned.

Year	Tags out	Tags recovered		% recovered
1967	2,271	390	361 East Point 29 Wood Island	17
1968	1,881	150	124 East Point 26 Wood Island	8
1969	1,731	63	53 East Point 10 Wood Island	4

For most recoveries the fork length of the fish and the area of capture were obtained. Recoveries were plotted in Figs. 3, 4, and 5 in the appropriate area, by type of gear and by month of recovery. The large numbers of recoveries in 1967 and 1968 from the East Point tagging were separated into five separate figures (3A-C, 4A, 4B) to facilitate examination.

The large number of tagged fish recaptured by gillnet has been noticed in other tag recovery programs and may be related to the type of gillnet material and the type of tag that was used. The Petersen disc tag was put on with a wire which was twisted into a loop at each end and these catch very easily on the fine filaments of nylon gillnet, making tagged fish very vulnerable to this gear. This could affect estimates of fishing mortality.

Figure 3A-C show recoveries of hake tagged in the East Point area in 1967 and recaptured in 1967. During this period many fish were recaptured close to the tagging area by otter trawl and by other gears. Recaptures away from the tagging area were mainly by gillnet and were spread around the coast of Prince Edward Island from Cape Bear to Savage Harbour. Gillnet recaptures were mainly in September, when the fish had spread out, with a few in August, October, and November. Most otter trawl recaptures were in August, September, and October. There were a few scattered recaptures by longline and Scottish seine. The only relatively far-ranging recaptures were one off North Point, Prince Edward Island, by gillnet in September, and two recaptures by Scottish and Danish seines off the northwestern part of Cape Breton in November and December.

Figure 4A-B show the recoveries of hake tagged in the East Point area in 1967 and recaptured in 1968. Recapture gear in this year was mainly gillnet and longline with some by otter trawl early in the season. Part of the reason for few otter trawl recaptures later in the season was likely the development of a fast expanding fishery for queen crab, *Chionoecetes opilio* (O. Fabricius), in the Gulf of St. Lawrence. Otter trawlers from Prince Edward Island were used extensively in this fishery and, as a result, otter trawling for hake fell to a relatively low level in this summer. Recaptures around Prince Edward Island were mainly in July, August, and September on the northeast or south sides of the island and reflect the position of inshore gears around the

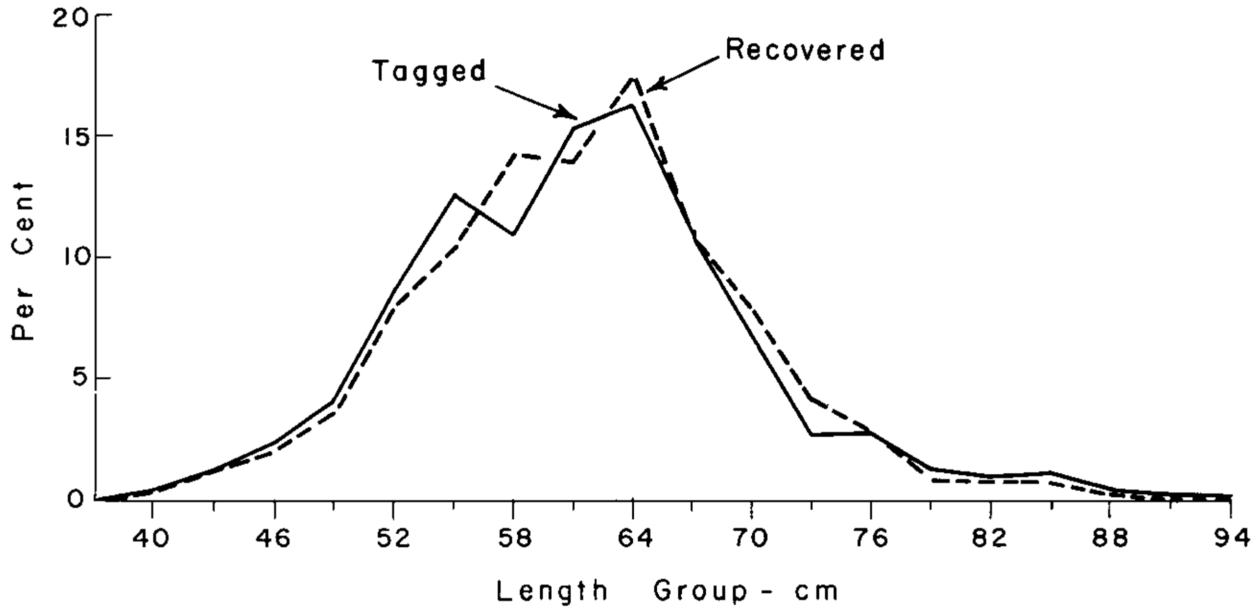


Fig. 2. Comparison of sizes of hake tagged and recovered.

island. Some fish were again recaptured off the northwest coast of Cape Breton Island and two distant migrants were found (not shown in figure), one on the northern edge of Banquereau in March and the other in the St. Margaret's Bay area near Halifax in August.

Recoveries for 1969 from the East Point tagging in 1967 are shown in Fig. 4C. Here again the recaptures were scattered around Prince Edward Island mostly in the months of July, August, and September, and were mainly taken by gillnet. A few hake were recaptured by otter trawl and longline and the recapture gear again reflects distribution of effort in the hake fishery for the summer of 1969. Again one distant migrant was taken on Banquereau in April.

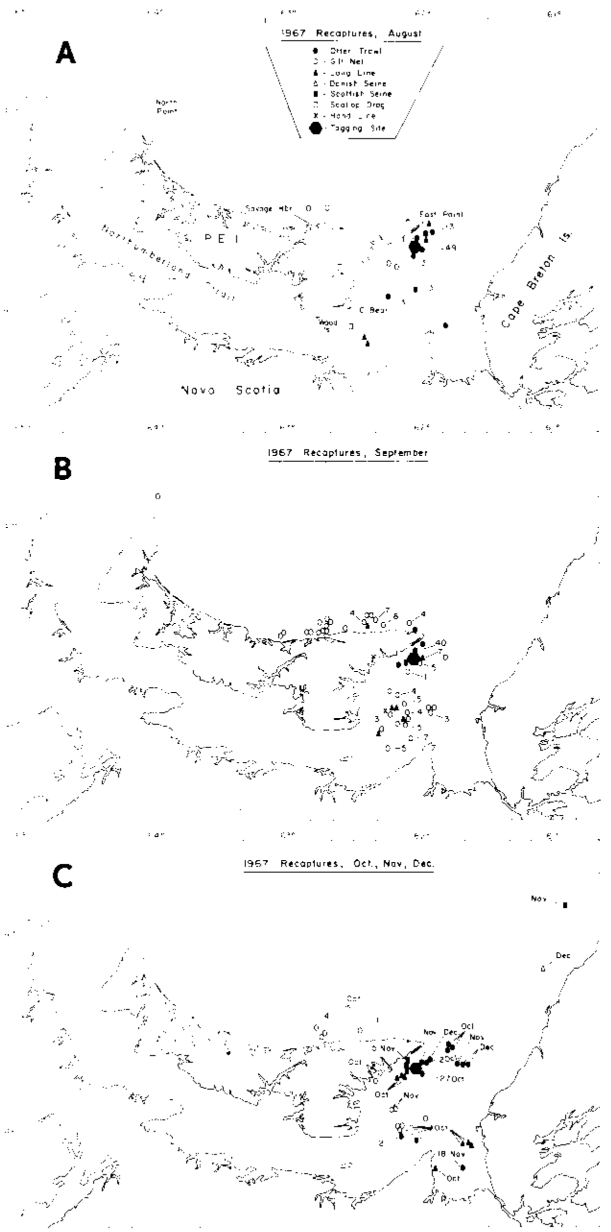
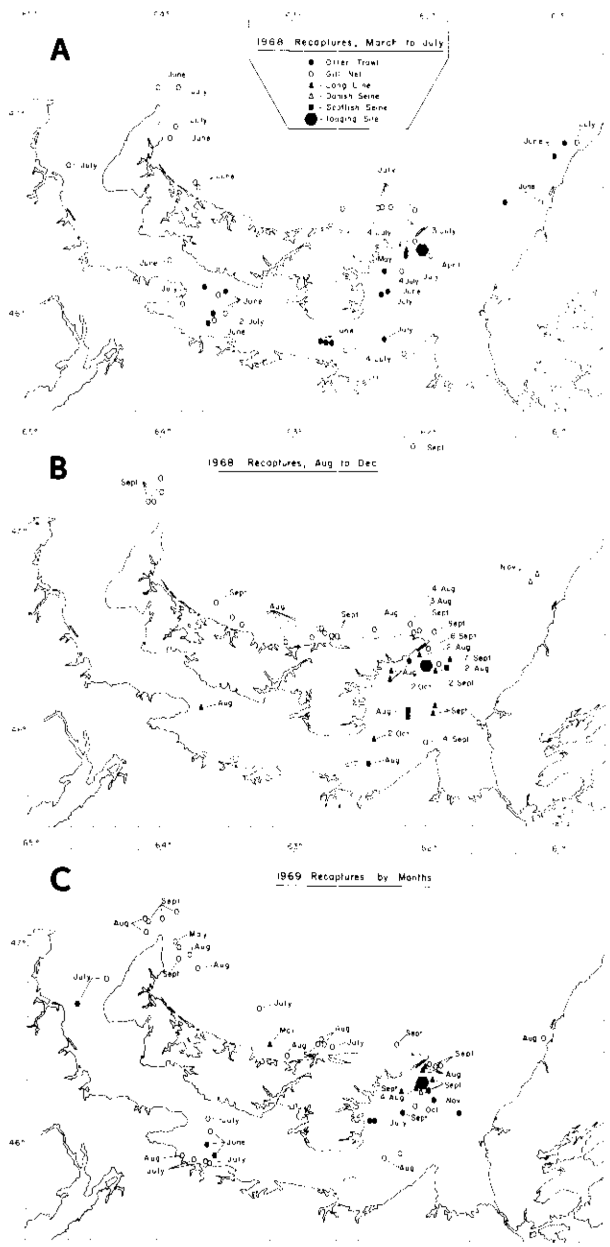


Fig. 3A-C. Recaptures of 1,948 hake tagged near East Point, Prince Edward Island in August 1967. Numbers indicate more than one recovery on a position.



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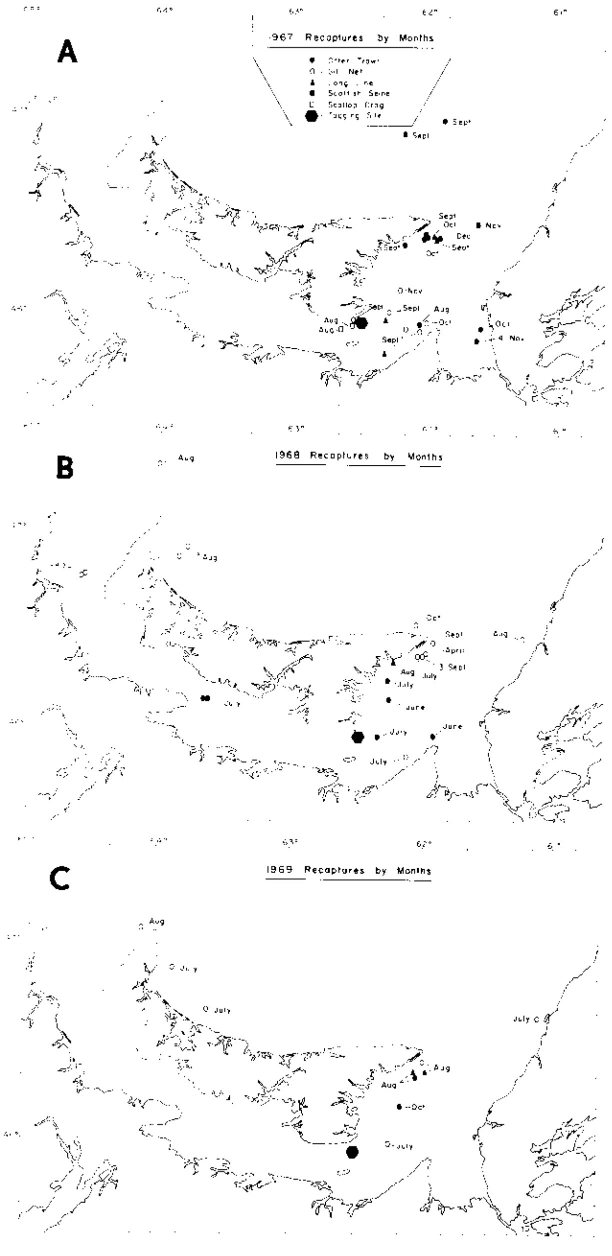

Fig. 5A-C. Recaptures of 323 hake tagged near Wood Island in August 1967. Numbers indicate more than one recovery on a position.

Recoveries from the tagging in the Wood Island area are shown in Fig. 5A-C by year of recapture. In 1967, (Fig. 5A) recaptures were taken by various gears in the months of August to November, and mainly in the area between the eastern end of Prince Edward Island and the western coasts of Cape Breton and Nova Scotia. Otter trawl, gillnet, and longline accounted for most of them. Two recaptures by otter trawl were taken about half way between East Point and the Magdalen Islands.

In Fig. 5B, 21 recoveries from the Wood Island tagging of 1967 are shown for 1968. The same pattern was evident with recaptures mainly by gillnets and otter trawls scattered around Prince Edward Island. Recaptures were in the July to October period, but one tag was taken in March of 1968 off La Poile Bay in Newfoundland (not shown on figure). In 1969 only 10 recaptures had been taken from this tagging. These are shown in Fig. 5C. They are scattered around Prince Edward Island with one recovery off Cape Breton in July.

The seasonal pattern of the fishery makes the movements of hake from the southern Gulf of St. Lawrence population difficult to trace in winter. McCracken (1956) found similar difficulties in interpreting movements of the haddock population off Lockeport in summer and winter, because of the seasonal pattern of the fishery. Cod tagging off northern New Brunswick in 1955 and 1956 indicated extensive migrations of cod in the winter from Chaleur Bay—Orphan Bank areas out to the Laurentian Channel area off Cape Breton (McCracken, 1959). Recaptures of hake off the west coast of Cape Breton in late autumn and in the spring indicate some movement of the population away from Prince Edward Island during the winter months. The extent of this movement may be obscured by the fact that there has been no extensive fishery specifically for hake in the Gulf of St. Lawrence during the winter. However, present information indicates that the main part of southern Gulf of St. Lawrence hake population remains in the Gulf with little inter-mixing with hake populations outside.

Acknowledgements

The cooperation of fishermen and fish processors who returned tags is gratefully acknowledged. Fisheries Research Board Technicians and Fishery Officers of the Department of Fisheries did an excellent job of collecting tags and information concerning recapture. Comments on the manuscript by Dr J. S. Scott were very useful.

References

McCRACKEN, F. D. 1956. Cod and haddock tagging off Lockeport, N.S. *Fish. Res. Bd. Canada, Atlantic Progr. Rept.*, **64**: 10-15.

1959. Cod tagging off northern New Brunswick in 1955 and 1956. *Ibid*, **72**: 8-19.

NEPSZY, S.N. 1968. On the biology of the hake (*Urophycis tenuis* Mitchill) in the southern Gulf of St. Lawrence. *M.Sc. Thesis*, Univ. McGill, Montreal, P.Q., 69 p.

Populations of *Sebastes* Larvae in the North Atlantic

By V. Bainbridge[1] and G. A. Cooper[1]

Abstract

Young *Sebastes*, principally *S. mentella* Travin, form the predominant group of fish larvae in the central and eastern regions of the North Atlantic sampled by the Continuous Plankton Recorder Survey at a depth of 10 m.

Four populations of larvae could be distinguished on the basis of geographical distributions, patterns of pigmentation and the month of first extrusion. These included a vast oceanic population centred in the Irminger Sea and three separate populations over the North American Shelf and Slope between Labrador and the Gulf of Maine.

The seasonal occurrence of the four populations of larvae can be linked to the periods when food organisms were most plentiful in the areas in which they live.

Introduction

The Continuous Plankton Recorder Survey, which covers a wide area of the North Atlantic throughout the year, offers a unique opportunity for studies on the distribution of fish larvae. When the survey was extended westwards from European waters in the late 1950's, large numbers of the larvae of the redfish (*Sebastes* spp.) were encountered in the central and western North Atlantic. Investigations of the seasonal and geographical distributions of *Sebastes* larvae formed the subject of a series of papers by Henderson (1961, 1965*a*, 1965*b*, and 1968). The further extension of sampling over the open ocean and North American Shelf waters in recent years together with the accumulation of data over a longer period have provided more detailed information on the biology of these larvae.

Redfish are viviparous but fecundity is relatively high, about 58,000 eggs per female having been reported for the population sampled at Weather Station Alfa in the Irminger Sea (Jones, 1969). The young are released after their external yolk reserves have been absorbed and range in length from 7 to 9 mm (or 5 to 7 mm after preservation in 5% formalin).

Materials and Methods

Details of the Continuous Plankton Recorder, the logistics of the Survey and the methods of analysis are provided by Glover (1967) *q.v.* for further references. Recorders are towed by selected merchant ships and ocean weather ships over a wide network of routes and at monthly intervals when practicable (Fig. 1). Plankton is sampled from a standard depth of 10 m and the results of analyses are expressed as the mean number of organisms per Recorder sample, (which represents 10 miles of tow or about $3m^3$ of water filtered).

The Fish Larvae of the Northwest Atlantic

The relative abundance and general composition of the young fish populations at 10 m depth in the North Atlantic and over the European and North American Shelves are illustrated in Fig. 2. The results were obtained by first calculating averages in each standard rectangle (1° lat by 2° long) for each month over all years, then the annual mean for each rectangle and finally average numbers within the area delimited in the figure. It should be noted that the averages refer to more than two decades of sampling in the Northeast Atlantic but only between 5 and 10 years off North American coasts.

Along the North American seaboard, fish larvae were more numerous over the Grand Banks than in the coastal waters to the north and south. Young Ammodytidae were particularly abundant over the Grand Banks and were also prominent in the Nova Scotia - Gulf of Maine area. In view of the study by Scott (1968) it seems likely that most of them were the larvae of the offshore sand launce, *Ammodytes dubius* Reinhardt, rather than the inshore launce, *A. hexapterus* Pallas. Gadidae, mostly *Gadus morhua* L., provided the outstanding group of larvae off the coast of Labrador with capelin, *Mallotus villosus* (Müller), second in abundance. Larvae of the Clupeidae, presumed to be entirely those of the Atlantic herring, *Clupea harengus* L., were common in the Nova Scotia - Gulf of Maine area as well as over the southern section of the Grand Banks.

Marked differences were also evident in the abundance and composition of young fish throughout the different regions of the open Atlantic shown in Fig. 2. Fish with luminescent organs tended to be most

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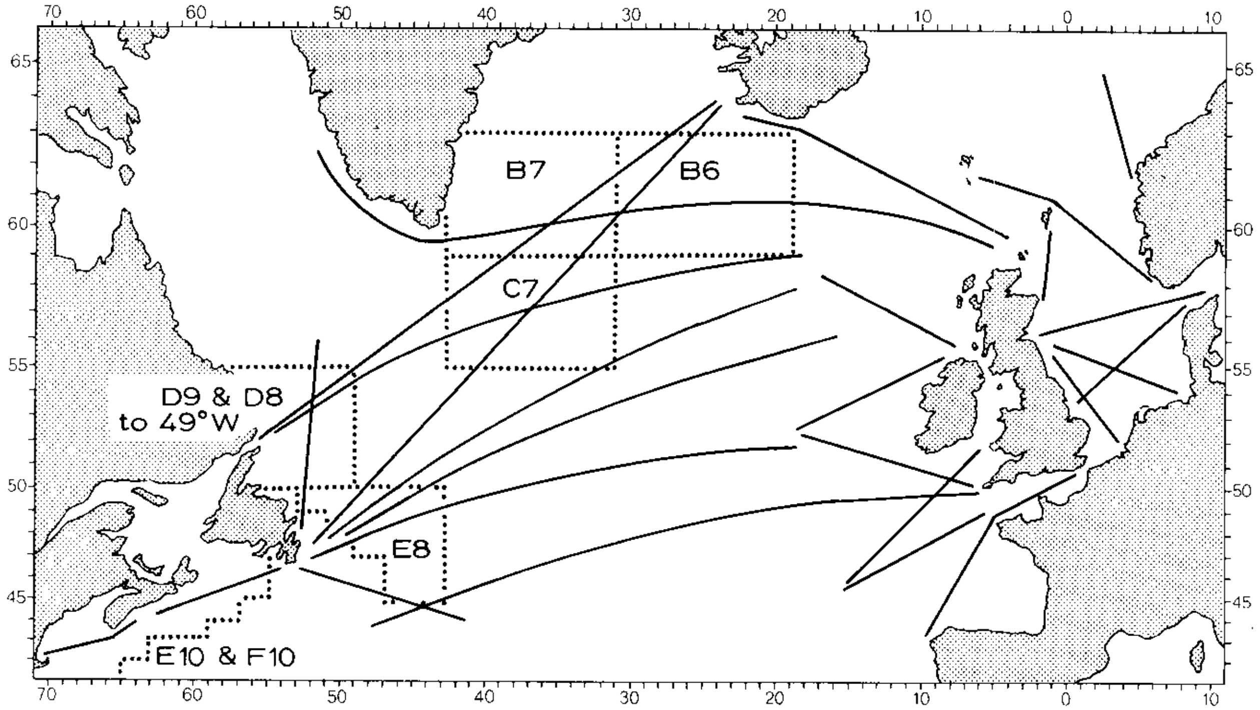

Fig. 1. Chart of the routes sampled by the Continuous Plankton Recorder in 1968 and some sub-divisions of the area surveyed.

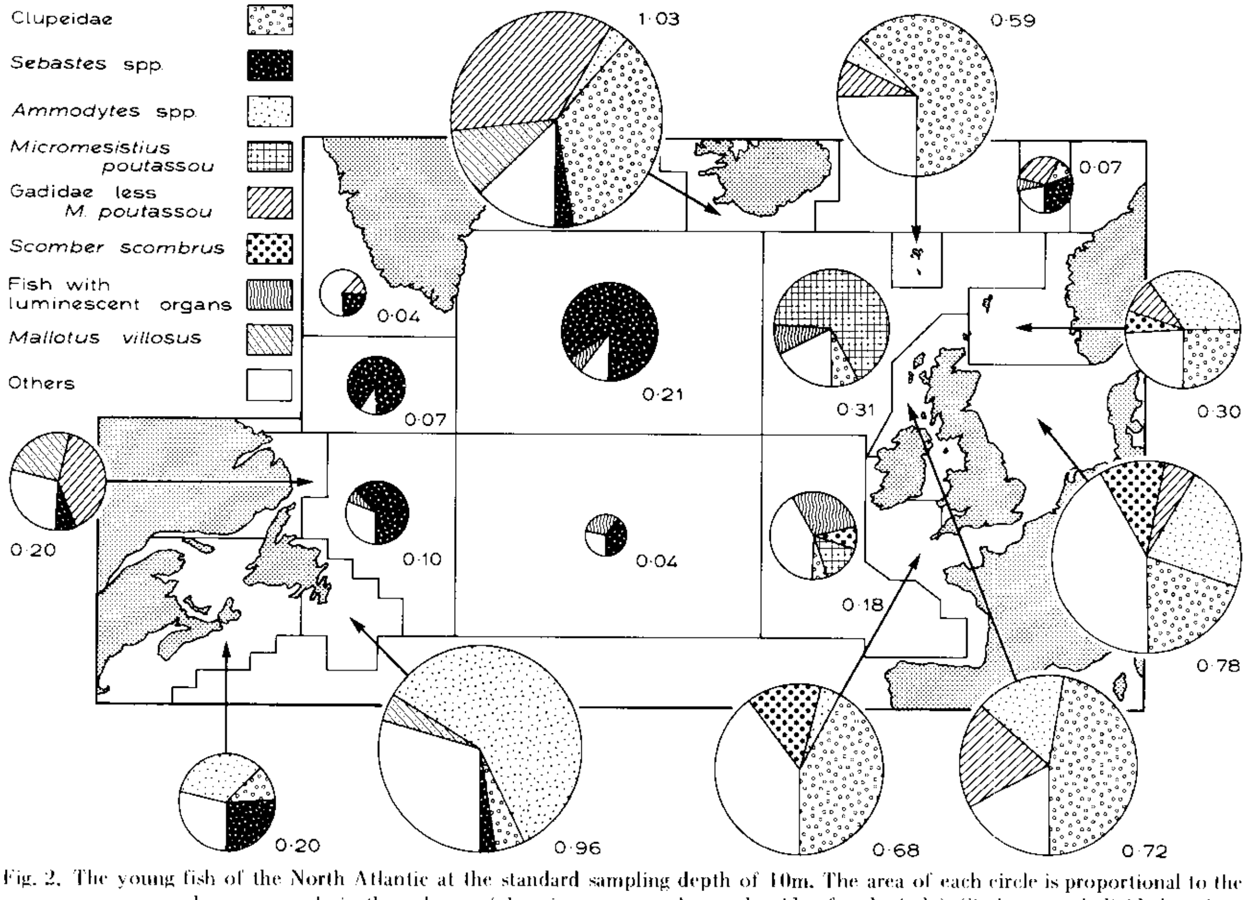

Fig. 2. The young fish of the North Atlantic at the standard sampling depth of 10m. The area of each circle is proportional to the average number per sample in the subareas (also given as a number at the side of each circle). Circles are sub-divided to show the relative average numbers of the major taxonomic groups. The sequence in the key is the rank order of the estimated total numbers of young fish in each taxon in the whole survey area.

frequent in the south. This group is a rather diverse assemblage of several families of small oceanic fishes including the Gonostomatidae (e.g. *Maurolicus* spp.), Stomiatidae (mainly *Stomias* spp.) and Myctophidae (e.g. *Myctophum* spp.). All three families were well represented in the southeastern region but elsewhere the Stomiatidae were scarce. In the northeastern region *Maurolicus* was the principal genus and in the south central area *Myctophum*, although many of the myctophids were metamorphosed specimens reaching up to 50 mm in length.

In the main northern oceanic regions of Fig. 2 the larvae of two fish were predominant — those of the blue whiting, *Micromesistius poutassou* Risso, in the northeast and of the redfish, *Sebastes* spp., in the north-central and northwestern regions. The young of *Sebastes* form a large part of the fauna of young fish in the North Atlantic, and, considering the entire area of the Recorder Survey, were only exceeded in abundance by the Clupeidae. In the Irminger and Labrador Seas *Sebastes* accounted for over 80% of all the fish larvae present. Their distribution also extended over the continental shelves off Iceland, Greenland, and North America where they constituted 25% of the young fish taken in the Nova Scotia - Gulf of Maine region. By contrast, throughout the eastern part of the survey area, young *Sebastes* were only to be found in the Norwegian Sea.

The Distribution of Young *Sebastes*

Figure 3 presents the widespread distribution of the young stages of *Sebastes* in greater detail. The centre of abundance of the oceanic population lies in the vicinity of the Reykjanes Ridge with numbers decreasing to the southwest leaving the populations of larvae over the North American Shelf and Slope well defined, although not separated, from the oceanic population. There appear to be three centres of larval concentrations over the shelf and slope; one off the northeast coast of Newfoundland another in the vicinity of Flemish Cap, and a third in the Nova Scotia - Gulf of Maine region.

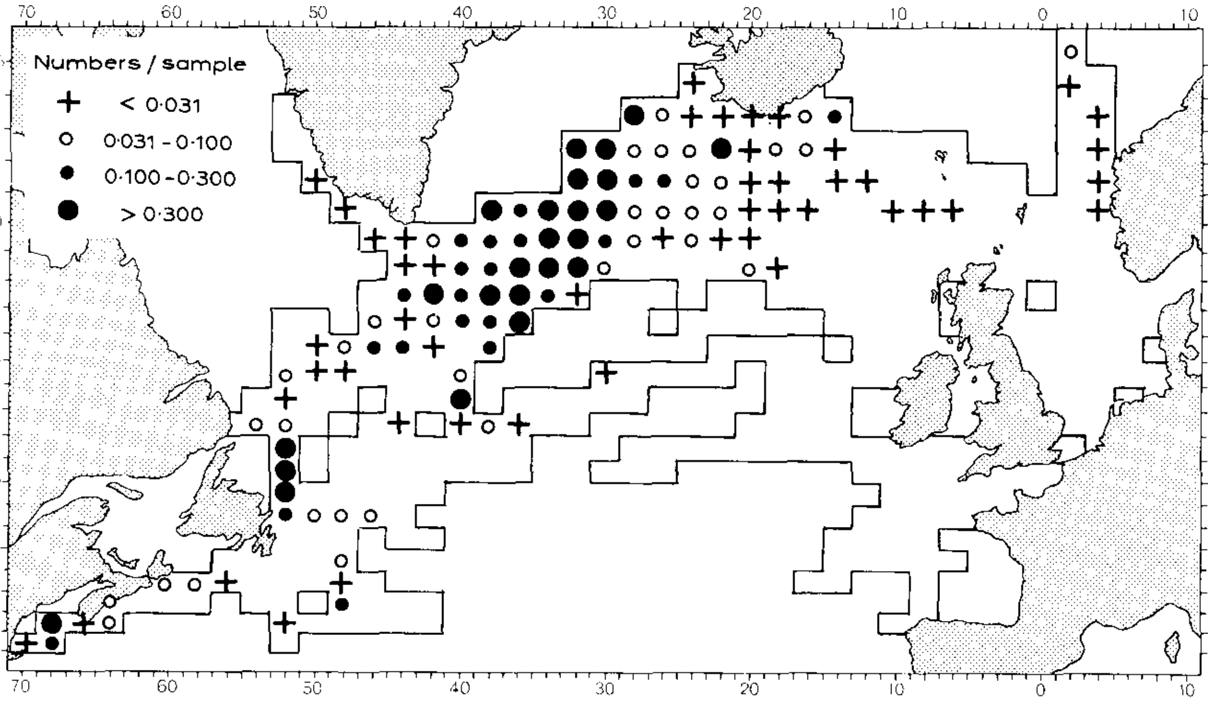

Fig. 3. Chart showing the distribution and abundance of young *Sebastes* at a depth of 10 m. Abundance was obtained by first calculating the average numbers in each statistical rectangle by calendar months over all years of sampling from 1948 to 1967 and averaging these monthly means to give an annual mean. Only rectangles sampled for at least 6 of the 12 months are included within the outlined sampled area.

Henderson (1965, 1968) has drawn attention to differences between the oceanic type of young *Sebastes*, found almost entirely over depths exceeding 1,000 fathoms, and the coastal type of the North American Shelf and Slope, found mainly over depths of less than 250 fathoms. Sub-caudal melanophores were absent from all specimens of the oceanic type (referred to by Henderson as "non-pigmented") while most specimens of the coastal type possessed from one to three, but mainly two melanophores (described by Henderson as "pigmented" young).

Some finer details of the distribution of the two forms are now available (Fig. 4). Several thousand larvae from the extensive oceanic population have been examined over a period of more than 10 years and none of these have possessed sub-caudal melanophores. Off Labrador and the north-eastern coast of Newfoundland between 81 and 90% of larvae were "pigmented" (that is, had sub-caudal melanophores). The patch of larvae in the vicinity of Flemish Cap consisted almost entirely of non-pigmented individuals; indeed, in this region larvae with sub-caudal pigmentation were found in only two rectangles where they constituted less than 10% of the total. The highest percentages of pigmented young, from 91 to 100%, were found in the Gulf of Maine and off the coast of Nova Scotia.

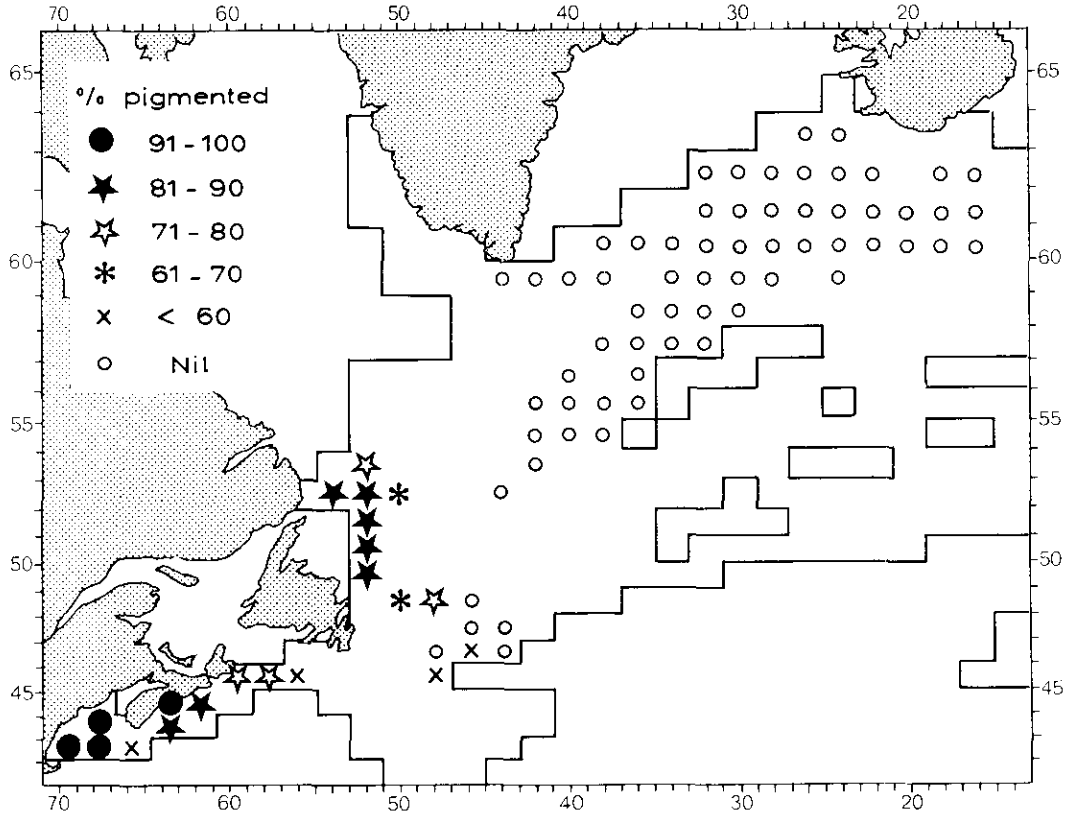

Fig. 4. Chart showing the percentage of young *Sebastes* with sub-caudal melanophores. All rectangles sampled three or more times in the period April to August, 1960-67, are included in the sampled area.

Differences in the month of first occurrence of newly extruded *Sebastes* larvae (i.e. from 5 to 7 mm in length) indicate a clear pattern of spawning (Fig. 5). At the centre of distribution of the oceanic population in the Irminger Sea, the extrusion of young was first evident in April and around the periphery of this area in May. Along the North American Shelf, the first larvae were extruded in April around Flemish Cap, in June off Labrador and the northeast coast of Newfoundland, and in July off Nova Scotia and the Gulf of Maine.

Figures 3, 4, and 5 are complementary and suggest that three distinct populations of larvae exist off the North American seaboard with the population near Flemish Cap morphologically identical with as well as "spawning" at the same time as the enormous oceanic population centred in the Irminger Sea. The distribution of the three populations of larvae in North American waters substantiate the concensus of opinion of other workers as given by Mead and Sindermann (1961) and quoted below:

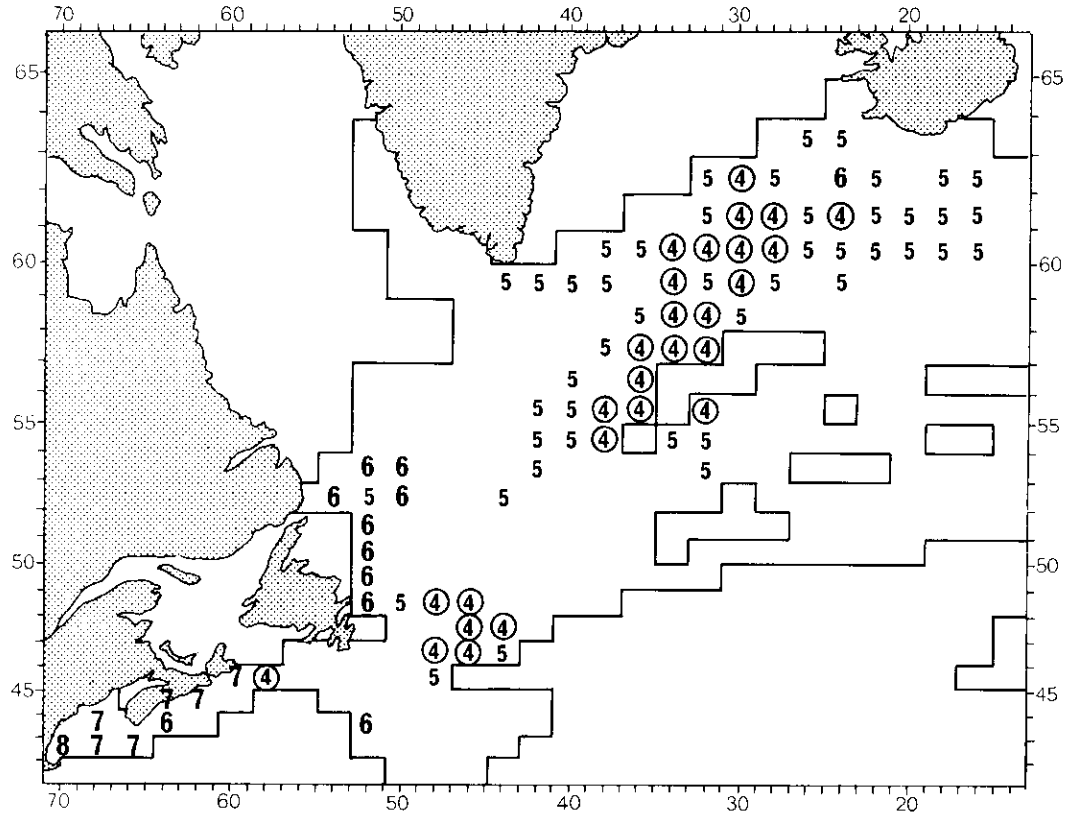

Fig. 5. Chart showing the month of first occurrence of newly extruded young *Sebastes* (5 to 7 mm in length) within each statistical rectangle. Months are numbered consecutively from 4 (April) to 8 (August). All rectangles sampled three or more times in the period April to August, 1960-67, are included in the sampled area.

"The commercial American fishery for redfish in the north-west Atlantic is based upon the *mentella*-type of redfish which may constitute three stocks for assessment purposes. The first of these lives in waters comprising ICNAF sub-areas 4 and 5, and Division 3 O and 3 P (the south-west Grand Banks and westward to the Gulf of Maine and including the Gulf of St. Lawrence). The second area is ICNAF Division 3 K, 3 L and Sub-area 2 (the northern Grand Banks, the Newfoundland Shelf and the coast of Labrador). These two groups intermingle in Division 3 N, the south-eastern Grand Banks, in which the situation is not yet clear. The third area is Division 3 M (Flemish Cap)".

There is some confusion over the taxonomic position of the various members of the genus so it is not surprising that doubts exist as to the specific determination of the larvae. The young stages of *Sebastes viviparus* Kr. are fairly easily distinguished and the larvae of this species were limited to the Norwegian Sea with a few specimens in Icelandic coastal waters. However, there appear to be no constant morphological differences between larvae of the other two species of *Sebastes* in the North Atlantic, *S. marinus* L and *S. mentella* Travin. Results of angling trials for adult redfish at Weather Station Alfa, given by Jones (1969), suggest that the parent stock of the oceanic larvae in the Irminger Sea consists entirely of *S. mentella*. All the larvae found in the ovaries and oviducts of the female *S. mentella* were like the free living young of the area in being entirely without any sub-caudal pigmentation (Henderson and Jones, 1964). This conflicted with the results of an investigation on the sub-caudal pigmentation of pre-extrusion redfish larvae from the Newfoundland area by Templeman and Sandeman (1959). They found sub-caudal pigmentation in 97.7% of the larvae of *S. mentella* (usually two melanophores) and in 23.9% of the larvae of *S. marinus* (usually single melanophores). Considering only the newly "extruded" larvae in the Recorder collections (i.e. those from 5 to 7 mm in

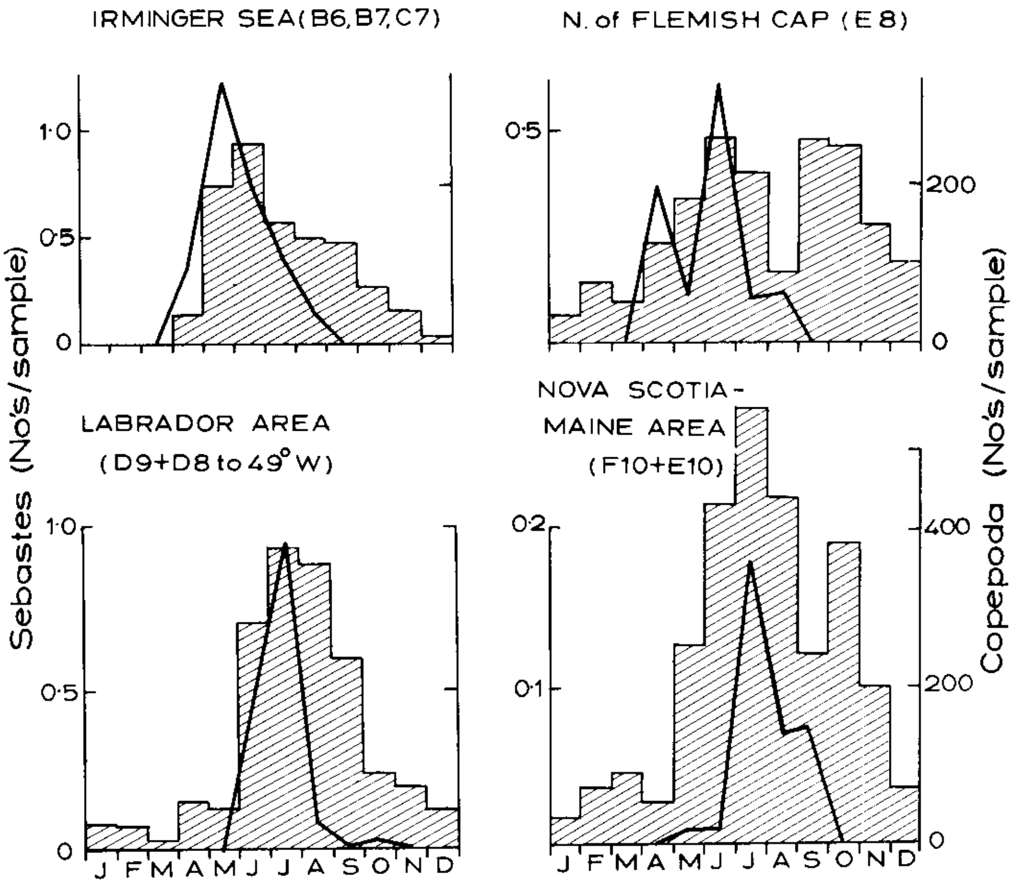

Fig. 6. Histograms representing the average numbers of Copepoda per Recorder sample in selected areas (right hand scale) with line graphs showing the average numbers of young *Sebastes* (left hand scale). Data are averages for the years 1957-68 in the Irminger Sea and for the years 1960-68 in the other three areas.

length) 87.5% of those off Labrador and the northeast coast of Newfoundland showed sub-caudal pigmentation and 90.5% of those from the Nova Scotia - Gulf of Maine region. Two sub-caudal melanophores were usually present in the larvae from both areas. Taking these results at their face value, the pigmentation of the larvae of *S. mentella* must vary in different parts of the Atlantic – a possibility suggested by Templeman and Sandeman (1959) – and the majority of the larvae taken by the Recorder off the North American coast as well as in the Irminger Sea may be ascribed to this species.

The Timing of Extrusion

There is a need for more detailed studies of the reproductive cycle of adult *Sebastes* but the indications are that larvae are released over a comparatively short period each year and that the timing of extrusion differs from region to region. Steele (1957), working on redfish from the Gulf of St. Lawrence, found that during 1954, the percentage of gravid mature females fell from 82% in late May to 41% in early June and only 6% remained by the end of the month. Contemporary plankton surveys confirmed that all but a very small proportion of the larvae were released during June and there was a sharp peak in the abundance of newly extruded larvae about the middle of the month. That liberation of young occurs earlier in the Irminger Sea is confirmed by studies of adults sampled at Station Alfa over a period of three years (Jones, 1970): all the mature females caught during March had ovaries full of larvae at an advanced stage of development while all those caught during May, June, and July were spent. These observations are consistent with the occurrence of newly extruded *Sebastes* larvae (length 5 to 7 mm) as shown by the results of the Recorder Survey. Thus, the peaks of abundance of larvae in the plankton samples appear to give valid and fairly precise indications of the periods of extrusion of larvae by the adults.

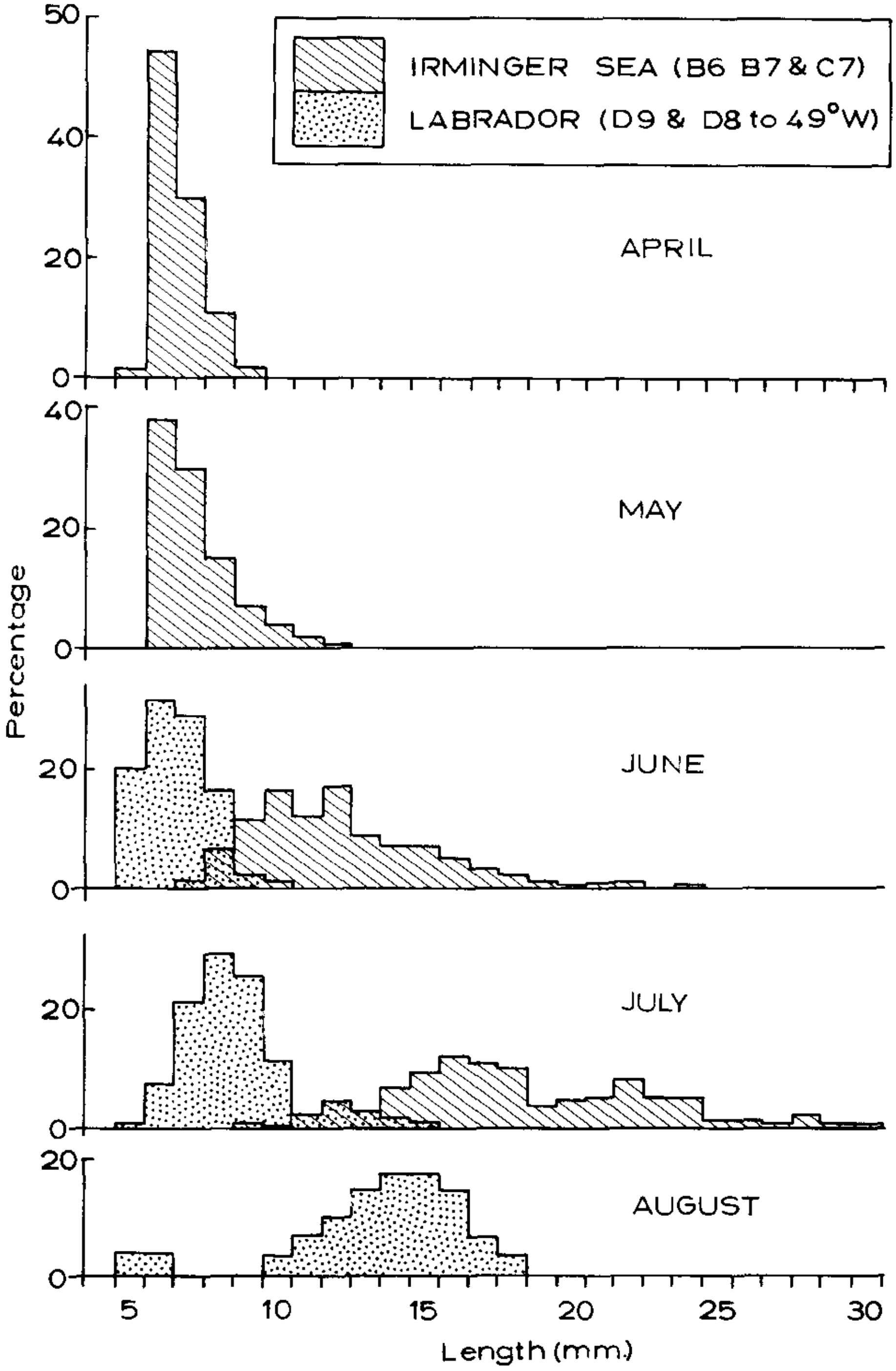

Fig. 7. Histograms showing the percentage size frequency composition of young *Sebastes* in the Irminger Sea area (hatched) and off Labrador (stippled). Percentages for each month refer to all larvae taken over the years 1960-68.

Cushing (1967) has noted that the different spawning periods of various herring populations can be linked to the timing of production cycles in the vicinity of their spawning grounds and this may also be true for the populations of redfish. Figure 6 shows the seasonal cycle of young *Sebastes* and copepods in four selected areas. The earliest spring increase of copepods was found in the Irminger Sea where maximum numbers of *Sebastes* larvae occurred in May. In the Labrador and Nova Scotia - Gulf of Maine areas the increase of copepods was 2 to 3 months later and maximum numbers of *Sebastes* larvae were found in July. North of Flemish Cap, an area which includes two populations of young *Sebastes*, there was again coincidence between the occurrence of the larvae and the spring development of copepods which tended to be intermediate between those found in the shelf and oceanic regions.

Newly extruded *Sebastes* larvae are known to feed on the early stages of copepods, principally the eggs and nauplii of *Calanus* (Bainbridge and MacKay, 1968). The results therefore imply that the larvae of the different "spawning stocks", which appear at different times, are released during the period when suitable food organisms are usually plentiful in the area in which they live.

Figure 7 allows a comparison of the average percentage length distribution each month of young *Sebastes* from the Labrador area with that of the oceanic population in the Irminger Sea. The histograms confirm that the main period of extrusion is about 2 months later off Labrador, while the apparent growth rate - a compound effect of extrusion, mortality, dispersion and true growth is similar in the two areas. Insufficient data are available for comparisons with other regions.

Discussion

Data reviewed in the preceding section suggest the possibility that the different "spawning" seasons of *Sebastes* have evolved so that larvae are extruded at the period when food for them is usually most plentiful. The implication is that planktonic conditions, especially the timing of the production cycle in different areas, have been a major influence in the formation of separate "spawning" stocks.

Cushing (1969) has pointed out that fish can only link their times of spawning to production cycles in an indirect manner; that is, by spawning at a fixed season. In high latitudes the timing, amplitude and spread of the production cycle of the plankton is variable and, in the absence of any known mechanism for a fish to vary its time of spawning in anticipation of variations in the cycle it must, perforce, spawn at a fixed season. Although this is a "hit or miss" process, Cushing considered that it allows fish the best chance of profiting from the variability of the production cycle. If the spawning time varied randomly the link could not be sustained. He was able to demonstrate a marked regularity of the spawning seasons of Pacific sockeye salmon and stocks of herring, plaice, and cod in European coastal waters. The "spawning" of *Sebastes* also appears to be extremely regular since, within the Irminger Sea as a whole (areas B6, B7, and C7 combined), the highest numbers of newly extruded young have always been found in samples collected during the first half of May.

The productive season for phytoplankton in the Irminger Sea area is much shorter than it is over the continental shelf and slope off Europe and North America (Robinson, 1970) and there can be great variations of phytoplankton production in the area from year to year (Gillbricht, 1968). The development of copepods in these waters is likewise very restricted seasonally and is highly variable (Colebrook, 1965; Glover and Robinson, 1968). *Calanus* is by far the dominant member of the zooplankton and newly extruded *Sebastes* larvae have to rely on the eggs and nauplii of this species for food (Bainbridge, 1965). Taking all these observations into consideration, the Irminger Sea would indeed appear a precarious environment for fish larvae. Could the key to the dominant position and success of the *Sebastes* population in the Irminger Sea lie partly in longevity and iteroparity? Murphy (1968) has advanced the argument that evolutionary pressure for long life, late maturity, and many reproductions may be generated by an environment in which density independent factors cause wide variations in the survival of the early stages. He used computer simulation to test different models and drew examples from various plankton feeding fish to show that high variability of year-class strength is often associated with fish stocks which mature late and have a long reproductive life. Sandeman (1969) found female *Sebastes* from Hamilton Inlet Bank, Labrador, matured at 10-12 years of age and attained ages to 40 years. For the oceanic stock at Weather Station Alfa, Jones (1969) reported ages from 15 to 57 years with sexual maturity in females occurring at 15-25 years of age. It is possible that *Sebastes* may provide an extreme example of the necessity for multiple reproductions in a highly unpredictable environment for the planktonic larvae with the huge area occupied by the "spawning" stock in the Irminger Sea offering additional "biological insurance". As Murphy (1968) has theorized, a population of this type cannot withstand very great predation pressure - if this did develop both the population and the predators would be unobservable because of extinction. The Greenland shark and the sperm whale are known to include *Sebastes* in their diet (Roe, 1969) but we have no evidence of any common predators on the pelagic stock of *Sebastes* in the Irminger Sea and as yet no fishery exists.

Summary

Young *Sebastes*, principally *S. mentella* Travin, are the predominant fish larvae over a wide area of the North Atlantic.

Four populations of *Sebastes* larvae can be distinguished: an extensive oceanic stock centred in the Irminger Sea and three smaller populations over the North American Shelf and Slope. The oceanic group of larvae are the products of extrusion starting in April and have no sub-caudal melanophores. Off Labrador and northern Newfoundland, larvae are first extruded in June and normally 81 to 90% possess sub-caudal melanophores while those in the Nova Scotia - Gulf of Maine area are first extruded in July and over 90% have sub-caudal melanophores. Between these two populations, in the vicinity of Flemish Cap, lies a third group of larvae which is similar to the oceanic stock, both in respect of the timing of extrusion and in the absence of sub-caudal pigmentation.

The occurrence of the larvae of the different populations can be linked to the timing of the average seasonal cycle of Copepoda in the areas they occupy, the larval phase being associated with what is, on average, the period when food organisms are most plentiful. The very long life span of adult *Sebastes* could be advantageous in areas such as the Irminger Sea where the seasonal cycle of plankton development is relatively erratic in timing and amplitude. By spreading reproduction over many years more opportunities are available for one or more broods of larvae, produced during the life of a fish, to synchronize with favourable planktonic conditions.

Acknowledgements

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References

BAINBRIDGE, V. 1965. A preliminary study of *Sebastes* larvae in relation to the planktonic environment of the Irminger Sea. *Spec. Publ. int. Comm. Northw. Atlant. Fish.*, No. 6, p. 303-308.

BAINBRIDGE, V., and B. J. McKAY. 1968. The feeding of cod and redfish larvae. *Spec. Publ. int. Comm. Northw. Atlant. Fish.*, No. 7, p. 187-217.

COLEBROOK, J. M. 1965. On the analysis of variation in the plankton, the environment and the fisheries. *Spec. Publ. int. Comm. Northw. Atlant. Fish.*, No. 6, p. 291-302.

CUSHING, D. H. 1967. The grouping of herring populations. *J. mar. biol. Ass. U.K.*, **47**: 193-208.

1969. The regularity of the spawning season of some fishes. *J. Cons.*, **33**: 81-92.

GILLBRICHT, M. 1965. The phytoplankton during NORWESTLANT 1 – 3. *Spec. Publ. int. Comm. Northw. Atlant. Fish.*, No. 7, p. 73-84.

GLOVER, R. S. 1967. The Continuous Plankton Recorder Survey of the North Atlantic. *Symp. zool. Soc. Lond.*, No. 19, p. 189-210.

GLOVER, R. S., and G. A. ROBINSON. 1968. Continuous Plankton Records during the NORWESTLANT Surveys, 1963 – Zooplankton. *Spec. Publ. int. Comm. Northw. Atlant. Fish.*, No. 7, p. 123-126.

HENDERSON, G. T. D. 1961. Continuous Plankton Records: The distribution of young *Sebastes marinus* (L). *Bull. mar. Ecol.*, **5**: 173-193.

1965*a*. *Sebastes* in Continuous Plankton Records in 1963. *Ann. biol. Copenhague*, **20**: 85-87.

1965*b*. Redfish larvae in the North Atlantic. *Spec. Publ. int. Comm. Northw. Atlant. Fish.*, No. 6, p. 309-315.

1968. Continuous Plankton Records during the NORWESTLANT Surveys 1963 – Young redfish. *Spec. Publ. int. Comm. Northw. Atlant. Fish.*, No. 7, p. 157-161.

HENDERSON, G. T. D., and D. H. JONES. 1964. Adult redfish in the open ocean *Res. Bull. int. Comm. Northw. Atlant. Fish.*, No. 1, p. 107-109.

JONES, D. H. 1969. Some characteristics of the pelagic redfish (*Sebastes mentella* Travin) from Weather Station Alfa. *J. Cons.*, **32**: 395-412.

1970. Food, parasites and the reproductive cycle of pelagic redfish (*Sebastes mentella* Travin) from Weather Station Alfa in the North Atlantic. *Bull. mar. Ecol.*, **6**: 347-370.

MEAD, G. W., and C. J. SINDERMAN. 1961. Section 1, Systematics and natural marks, ICES/ICNAF Redfish Symposium. *Spec. Publ. int. Comm. Northw. Atlant. Fish.*, No. 3, p. 9-11.

MURPHY, G. I. 1968. Pattern in life history and the environment. *Amer. Nat.*, **102**: 391-403.

ROBINSON, G. A. 1970. Continuous Plankton Records: Variation in the seasonal cycle of phytoplankton in the North Atlantic. *Bull. mar. Ecol.*, **6**: 333-345.

ROE, H. S. J. 1969. The food and feeding habits of sperm whales (*Physeter catadon* L.) taken off the west coast of Iceland. *J. Cons*, **33**: 93-102.

SANDEMAN, E. J. 1969. Age determination and growth rate of redfish *Sebastes* sp., from selected areas around Newfoundland. *Res. Bull. int. Comm. Northw. Atlant. Fish.*, No. 6, p. 79-106.

SCOTT, J. S. 1968. Morphometrics, distribution, growth and maturity of offshore sand launce (*Ammodytes dubius*) on the Nova Scotia banks. *J. Fish. Res. Bd. Canada*, **25**: 1775-1785.

STEELE, D. H. 1957. The redfish (*Sebastes marinus* L.) in the Western Gulf of St. Lawrence. *J. Fish. Res. Bd. Canada*, **14**: 899-924.

TEMPLEMAN, W., and E. J. SANDEMAN. 1959. Variations in caudal pigmentation in late-stage pre-extrusion larvae from *marinus* – and *mentella* – type female redfish from the Newfoundland area. *J. Fish Res. Bd. Canada*, **16**: 763-789.

Assessments of the Effects of Increases in the Mesh Sizes of Trawls on the Cod Fisheries in Subareas 2 and 3

By A. T. Pinhorn[1] and R. Wells[1]

Abstract

Assessments were made of the effects of increases in the mesh sizes of trawls on the fisheries supported by the cod stocks in ICNAF Divisions 2J, 3KL, and 3Ps using combined data for the 1964-68 period. Results from a previous mesh assessment on 3NO cod for 1963-66 are also included. If M were 0.2 or less long-term gains to the fishery would have occurred with increases to 6-inch mesh in all areas. If M were as high as 0.3 small to moderate long-term gains with increases to 6-inch mesh would have occurred in all areas except in Division 2J for increases to both 5-inch and 6-inch mesh and in 3KL and 3Ps for increases to 6-inch mesh, where small long-term losses would have occurred. Immediate losses would have been small to moderate throughout the area. The implications of an increase to 5-inch mesh for the other important commercial species in Subareas 2 and 3 and the adequacy of samples are discussed.

Introduction

Results of assessments of the effects of increases in the mesh size of trawls on the fisheries in 3NO during 1959-62 and 1963-66 were presented at the 1969 ICNAF Annual Meeting (Pinhorn, 1969). It was suggested at this meeting that mesh assessments should be updated for the remaining major cod stocks in Subareas 2 and 3. New assessments have been made based on 1964-68 combined data for ICNAF Divisions 2J, 3KL, and 3Ps and the results are presented here.

Materials and Methods

The method used to compute the effects of increases in mesh size was identical to that outlined by Gulland (1961) and as applied by Beverton and Hodder, eds. (1962). Since it was impossible to separate Z into its natural and fishery components, the same range of values of M and E was used as in Beverton and Hodder, eds. (1962). Estimates of growth parameters (L_{∞}, k, t_o) and total mortality (Z) were taken from Wells and Pinhorn (1970).

Division 2J

From 1964 to 1968 there were approximately 600,000 length measurements of catches before discards and 8,000 measurements of landings after discards from the commercial cod fishery by otter trawl. In addition, there were 37,000 length measurements from the Newfoundland inshore fishery.

Since the measurements of landings after discards represented 2 years only, they were not used in the assessments. Length measurements before discards were adjusted to numbers caught, as determined from a knowledge of discard rates (ICNAF Discard Documents) and average weights, in the following manner: The per thousand length frequencies by each country reporting length measurements were adjusted by month to the numbers caught by the country in that month as reported in the ICNAF Sampling Yearbooks. Catch frequencies of the countries represented were then combined by quarters and the resulting frequencies adjusted to the numbers caught by all countries in each quarter. Catch frequencies for each quarter were combined to produce a representative catch frequency for each year. The frequencies for the 5 years were then averaged to produce an average catch frequency for 1964-68. Knife-edge discarding was assumed, on the basis of per cent discard by weight, to have taken place between 39-41 cm and 42-44 cm (Fig. 1).

Since the landings from the Newfoundland inshore fishery in 2J could not be separated by gear, the per thousand frequencies for each gear in each month were combined and averaged for the entire year, in the one case including only codtrap and jigger and in the other case including codtrap, jigger, and gillnet. These average per thousand frequencies were then adjusted to the total numbers landed in each year by the inshore gears and the frequencies for the 5 years averaged. This produced one average frequency for 1964-68 including gillnets giving a minimum estimate and one excluding gillnets giving a maximum estimate of the numbers landed (Fig. 1).

Divisions 3KL

The method of adjusting the monthly cod length measurements contained in the ICNAF Sampling Yearbooks for 1964-68 was the same as for Division 2J. Length measurements before discards amounted to

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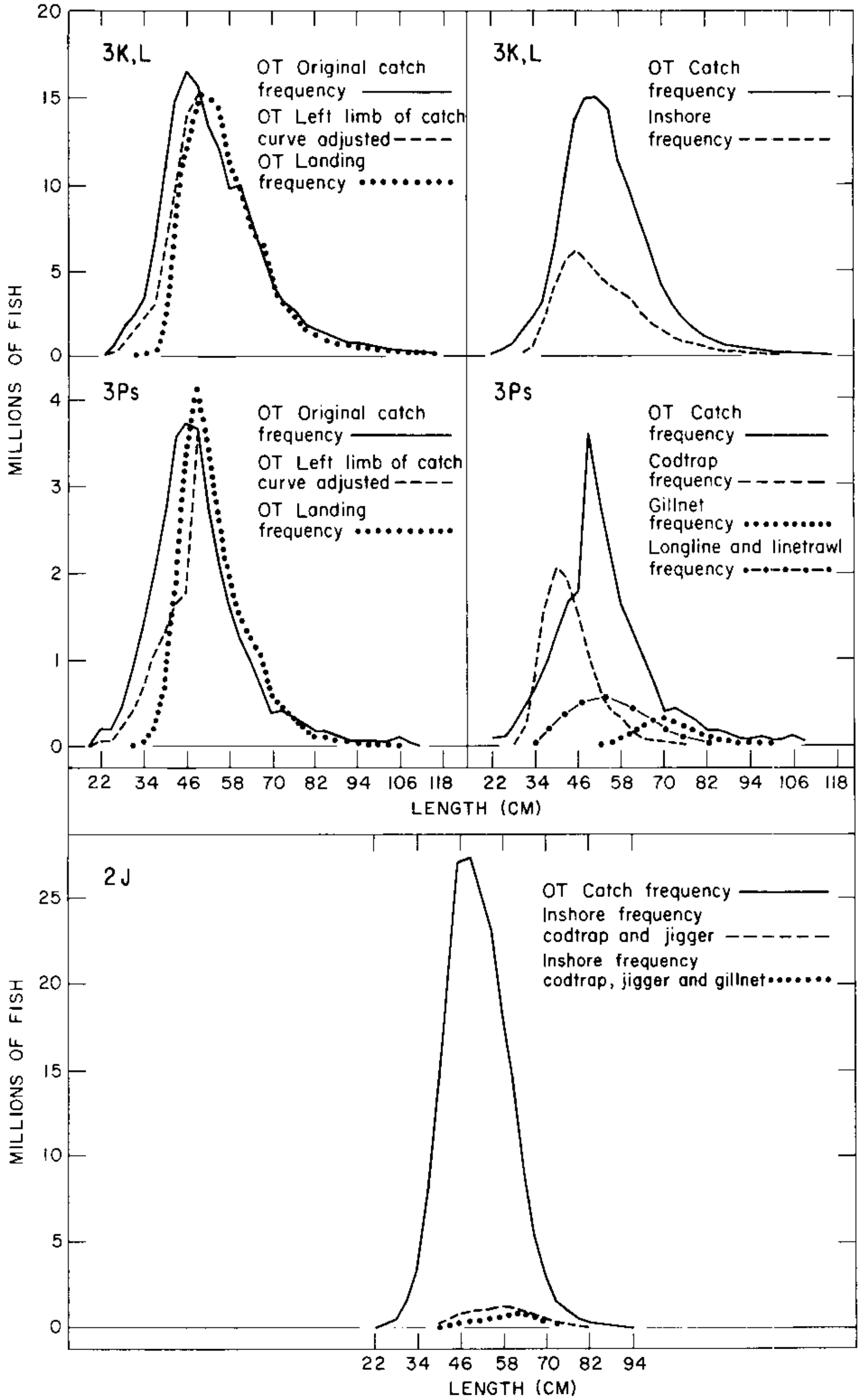

Fig. 1. Average annual catch and landing frequencies of the various gears used in mesh assessments for ICNAF Divisions 2J, 3KL, and 3Ps, 1964-68. The original and adjusted otter trawl catch frequencies for 3KL and 3Ps are shown for comparison.

about 70,000 and there were about 55,000 length measurements of landings after discards. Nearly 240,000 measurements were available from the Newfoundland inshore fishery.

The resultant average annual landing frequency was adjusted by a factor of .92 so that the weight derived from applying a length-weight key to the frequency would be the same as the average annual weight landed as derived from ICNAF Statistical Bulletins.

The apparent weight of discards as derived from the differences between the catch and landing curves was much greater than the amount calculated from the relevant ICNAF documents listed in the references. The catch curve was therefore adjusted to produce the amount of discards shown in these documents. The right limb of the curve was considered to coincide with the right limb of the landing curve at lengths of 52 cm and greater. The left limb was arbitrarily moved to the right by shifting the numbers at length up to the next length group, and a final adjustment made by multiplying the resulting left limb by a factor of .92. The weight of the average annual catch derived from this catch frequency and a length-weight curve was greater by a factor of .004 than the average annual weight caught as derived from the catch curve and ICNAF Discard Documents (Fig. 1).

The length frequencies for the inshore fishery were adjusted as for the otter trawl frequencies. Gillnet and longline frequencies were adjusted separately from the frequencies of the other inshore gears on a yearly basis. The total inshore frequency was obtained by combining these three groups of inshore gears (Fig. 1).

Data for the offshore line trawl fishery were scanty. The average annual landing for the period was considered to contain 6 million fish. It was assumed that this fishery would have received the full benefit of an increase in mesh size in otter trawls.

Division 3Ps

Since there were very few measurements of catches before discards for 1964-68, a representative catch curve was obtained by applying a 4½-inch selection curve to Canada (Newfoundland) research length frequencies in each year, adjusting these to the numbers caught in that year and averaging these frequencies for the 1964-68 period. Measurements of landings after discard totalled 10,000. The frequency for each country reporting length measurements in each month was adjusted to the numbers landed by that country in that month. These were then combined for each country for the entire year and adjusted to the numbers landed by that country in that year. Landing frequencies for these countries were then combined and the resulting frequency adjusted to the total numbers landed by all countries in each year. The frequencies for the 5 years were then averaged to produce an average landing frequency for 1964-68. Knife-edge discarding was assumed to have taken place between 39-41 cm and 42-44 cm.

On comparing the average annual catch and landing frequencies (Fig. 1), it was obvious that the small fish (< 49 cm) were overestimated in the research catches in relation to the proportion of discards as determined from the ICNAF Discard Documents. This was also evidenced by the fact that applying a length-weight key to the research catch frequency resulted in an apparent catch considerably greater than the true catch. From a comparison of this apparent catch with the true catch, it was calculated that the small fish in the research catch curve exceeded those in the true catch curve by a factor of 2.1. Consequently, the numbers of fish at each length below 49 cm were reduced by 2.1X and the resultant curve taken to represent the true catch curve (Fig. 1).

In arriving at representative landing frequencies for the various groups of inshore gears, codtrap, handline, and jigger were considered together since all three catch similar sizes of fish. Also longline and linetrawl were combined for the same reason. Gillnet, however, which catches different sizes than any of the other two groups, was considered alone (Fig. 1). A breakdown by type of gear was available for each year from a series of Manuscript Reports of the St. John's Biological Station. Therefore, the per thousand frequency for each month was adjusted to the numbers landed by the particular gear combination in each month, the resultant frequencies for the various months combined and this frequency adjusted to the numbers landed for the entire year by the gear in question. These were then averaged for the 1964-68 period to produce an average landing frequency for each gear combination for the entire period (Fig. 1).

Results

Tables 1-4 summarize the mesh assessments for ICNAF Divisions 2J, 3KL, and 3Ps during 1964-68, together with the previous assessment for 3NO for 1963-66. In the previous mesh assessment for 3NO cod (Pinhorn, 1969), it was assumed that the mesh size in use in the commercial fishery during 1963-66 was 4 inches. In the present assessments a 4½-inch mesh was assumed. Therefore, to facilitate comparisons between areas, the 3NO data were reassessed assuming a 4½-inch mesh and the results are presented in Table 3.

If M were 0.2 or less long-term gains to the landings by all gears and to the total fishery would have occurred with increases to 6-inch mesh in all areas. If M were as high as 0.3 small long-term losses to both trawl landings and total landings would have occurred with increases to 5-inch and 6-inch mesh for Division 2J, while small long-term losses to trawl landings only would have occurred at 6-inch mesh for Divisions 3KL and 3Ps. In all other cases small to moderate long-term gains with increases to 6-inch mesh would have resulted at this level of M. Immediate losses would have ranged from 2.8 to 7.5% at 5-inch mesh to 14.5 to 37.2% at 6-inch mesh for the various areas studied.

TABLE 1. Summary of assessments for 2J cod, 1964-68.

				Percentage change in 1964-68 landings				
					Long-term changes for			
Mesh size change (inches from 4½ to	l_c (cm) 39.2	t_c (yr) 4.3	Gear group	Immediate loss	0.57 0.40 0.30	0.71 0.50 0.20	0.86 0.60 0.10	E F M
5	42.9	4.9	Trawl	− 7.5	+1.6	+4.2	+7.0	
			Inshore	0	+4.9	+6.3	+7.8	
			Total	− 6.9	+1.9	+4.5	+7.2	
5½	48.3	6.0	Trawl	− 22.8	− 1.8	+5.8	+14.6	
			Inshore	0	+13.3	+18.2	+23.8	
			Total	− 21.0	− 0.5	+7.0	+15.6	
6	52.6	7.0	Trawl	− 37.2	− 8.9	+3.3	+18.4	
			Inshore	0	+22.0	+31.4	+43.2	
			Total	− 34.2	− 6.3	+5.8	+20.8	

TABLE 2. Summary of assessments for 3KL cod, 1964-68.

				Percentage change in 1964-68 landings				
					Long-term changes for			
Mesh size change (inches) from 4½ to	l_c (cm) 39.8	t_c (yr) 3.7	Gear group	Immediate loss	0.57 0.40 0.30	0.71 0.50 0.20	0.86 0.60 0.10	E F M
5	43.5	4.1	Trawl	− 4.2	+2.2	+4.0	+5.9	
			Inshore	0	+3.1	+4.0	+4.9	
			Offshore line	0	+6.7	+8.6	+10.5	
			Total	− 2.9	+2.7	+4.2	+5.8	
5½	48.6	4.8	Trawl	− 13.3	+1.8	+6.8	+12.3	
			Inshore	0	+7.9	+10.5	+13.3	
			Offshore line	0	+17.5	+23.2	+29.5	
			Total	− 9.1	+4.2	+8.5	+13.4	
6	52.7	5.5	Trawl	− 22.5	− 1.1	+6.8	+16.0	
			Inshore	0	+12.1	+16.6	+21.8	
			Offshore line	0	+27.7	+37.8	+49.7	
			Total	− 15.4	+3.8	+10.9	+19.1	

TABLE 3. Summary of assessments for 3NO cod, 1963-66.

Mesh size change (inches) from 4 to	l_c (cm) 33.21	t_c (yr) 3.08	Gear group	Percentage change in 1963-66 landings: Immediate loss	Long-term changes for E 0.33, F 0.15, M 0.30	Long-term changes for E 0.56, F 0.25, M 0.20	Long-term changes for E 0.78, F 0.35, M 0.10
			Assuming 4 inch mesh in use				
5	42.60	3.99	Trawl	– 6.1	+5.9	+14.9	+24.6
			Offshore line	0	+12.7	+22.3	+32.6
			Total	– 5.7	+6.4	+15.4	+25.1
5½	48.44	4.60	Trawl	– 13.3	+7.6	+24.4	+43.5
			Offshore line	0	+24.1	+43.4	+63.5
			Total	– 12.4	+8.7	+25.6	+44.9
6	52.73	5.07	Trawl	– 19.9	+7.8	+31.2	+59.1
			Offshore line	0	+34.6	+63.8	+98.6
			Total	– 18.6	+9.5	+33.3	+61.6

Assuming 4½ inch mesh in use

Mesh size change (inches) from 4½ to	l_c (cm) 38.01	t_c (yr) 3.54	Gear group	Percentage change in 1963-66 landings: Immediate loss	Long-term changes for E 0.33, F 0.15, M 0.30	Long-term changes for E 0.56, F 0.25, M 0.20	Long-term changes for E 0.78, F 0.35, M 0.10
5	42.60	3.99	Trawl	– 3.8	+2.5	+7.0	+11.7
			Offshore line	0	+6.6	+11.3	+16.1
			Total	– 3.6	+2.8	+7.3	+12.0
5½	48.44	4.60	Trawl	– 11.2	+4.1	+15.8	+28.6
			Offshore line	0	+17.2	+30.3	+44.8
			Total	– 10.4	+5.0	+16.7	+29.6
6	52.73	5.07	Trawl	– 18.0	+4.3	+22.1	+42.5
			Offshore line	0	+27.1	+48.8	+73.7
			Total	– 16.8	+5.8	+23.8	+44.5

TABLE 4. Summary of assessments for 3Ps cod, 1964-68 (CT = codtrap, J = Jigger, HL = Handline, GN = Gillnet, LL = Longline, LT = Linetrawl).

				Percentage change in 1964-68 landings				
					Long-term changes for			
Mesh size change	l_c	t_c			0.50	0.67	0.83	E
(inches) from	(cm)	(yr)		Immediate	0.30	0.40	0.50	F
4½ to	41.6	4.0	Gear group	loss	0.30	0.20	0.10	M
5	44.9	4.4	Trawl	– 4.6	+2.1	+4.5	+6.9	
			CT-J-HL	0	+2.6	+3.6	+4.6	
			GN	0	+3.5	+4.8	+6.0	
			LL-LT	0	+3.3	+4.5	+5.8	
			Total	– 2.8	+2.5	+4.4	+6.3	
5½	49.4	4.9	Trawl	– 14.4	+0.4	+6.3	+12.7	
			CT-J-HL	0	+5.6	+7.8	+10.2	
			GN	0	+8.6	+12.1	+15.8	
			LL-LT	0	+8.0	+11.2	+14.6	
			Total	– 8.8	+3.1	+7.8	+13.0	
6	53.1	5.4	Trawl	– 23.8	– 3.2	+5.7	+15.6	
			CT-J-HL	0	+7.8	+11.1	+14.8	
			GN	0	+13.5	+19.3	+25.8	
			LL-LT	0	+12.5	+17.9	+23.9	
			Total	– 14.5	+2.4	+9.7	+17.8	

Discussion

Mesh assessments presented in this paper indicate that small to moderate long-term gains in landings might be expected with an increase from the present minimum regulation mesh size of 4½ inches to 5 inches. The small long-term losses that were calculated in certain cases would have occurred only if M were as high as 0.3 and the best information available indicates that M is most likely less than 0.3 in this area. Thus, an increase at least to a 5-inch mesh in Subareas 2 and 3 would not adversely affect the future landings from those fisheries and would most likely result in long-term gains.

However, this assessment was only concerned with cod in Subareas 2 and 3. Redfish is also an important species in Subarea 2 and redfish, haddock, and flounder are important in Subarea 3. No detailed mesh assessment has been conducted for flounder in Subarea 3, but Hodder (1964) indicated that an increase in the mesh size of trawls to 6 inches would not have significantly affected the 1955-58 landings. Earlier assessments on 3NO haddock (Beverton and Hodder, eds., 1962) indicated that small long-term losses to the 1955-58 landings would have occurred with increases to 5-inch mesh only if M were as large as 0.35 whereas if M were 0.25 small long-term gains would probably have resulted. With the haddock stock at such a low level as at present, an increase to 5-inch mesh can only be expected to aid the recovery of the stock. No mesh assessment on redfish for Subarea 2 has been attempted but Beverton and Hodder, eds. (1962) indicated that for Subarea 3 redfish immediate losses to the 1955-58 landings would have been substantial for increases beyond 4½-inch mesh.

Considerable difficulty was encountered in carrying out these mesh assessments because of inadequacy of sampling data. Sampling data for Divisions 2J and 3KL were fair, but even in these areas some countries produced no data on lengths and ages at all in some years and the available data were at times concentrated in one or two quarters only. Sampling data for Divisions 3NO and 3Ps were so inadequate in the recent period that the authors were forced to use Canada (Newfoundland) research vessel data on lengths and ages to replace or supplement that from the ICNAF Sampling Yearbooks and these may not always produce parameters indicative of those in the commercial fishery. If future assessments are to be accurate enough to produce a basis for sound management of the various fish stocks, more emphasis must be placed on adequately sampling these stocks.

References

BEVERTON, R. J. H., and V. M. HODDER, eds. 1962. Report of Working Group of Scientists on Fishery Assessment in Relation to Regulation Problems. Supplement to *Annu. Proc. int. Comm. Northw. Atlant. Fish.*, 11: 1-81.

GULLAND, J. A. 1961. The estimation of the effect on catches of changes in gear selectivity. *J. Cons.*, 26(1): 204-214.

HODDER, V. M. 1964. Assessments of the effects of fishing and of increases in the mesh size of trawls on the major commercial fisheries of the Newfoundland area (ICNAF Subarea 3). *Fish. Res. Bd. Canada, MS Rep. Biol.* No. 801, 116 p.

ICNAF. 1966. Summary of discards (ICNAF Statistics Form 4), 1964. *Annu. Meet. int. Comm. Northw. Atlant. Fish.* 1966, Res. Doc. No. 10, Serial No. 1664 (mimeographed).

1967. Summary of statistics on discards (ICNAF Statistics Form 4), 1965. *Annu Meet. int. Comm. Northw. Atlant. Fish.* 1967, Res. Doc. No. 7, Serial No. 1786 (mimeographed).

1968. Summary of statistics on discards and industrial fish (ICNAF Statistics Form 4), 1966. *Annu. Meet. int. Comm. Northw. Atlant. Fish.* 1968, Res. Doc. No. 21, Serial No. 2003 (mimeographed).

1969. Summary of statistics on discards and industrial fish (ICNAF Statistics Form 4), 1967. *Annu. Meet. int. Comm. Northw. Atlant. Fish.* 1969, Res. Doc. No. 23, Serial No. 2183 (mimeographed).

1969. 1968 nominal catch from the ICNAF Convention and Statistical Areas and cod and haddock catches in the ICNAF area, 1958-68. *Annu. Meet. int. Comm. Northw. Atlant. Fish.* 1969, Res. Doc. No. 21, Serial No. 2234 (mimeographed).

1966-69. ICNAF Sampling Yearbooks for the years 1964-67. Vols. 9-12.

1966-69. ICNAF Statistical Bulletins for the years 1964-67. Vols. 14-17.

PINHORN, A. T. 1969. Assessments of the effects of increases in the mesh sizes of trawls on the cod fisheries in ICNAF Divisions 3N and 3O. *Res. Bull. int. Comm. Northw. Atlant. Fish.*, No. 7, p. 32-45.

PINHORN, A. T., A. W. MAY, and E. DUNNE. 1969. Breakdown of catch by type of gear in the Newfoundland inshore cod fishery in 1966. *Fish. Res. Bd. Canada, MS Rep. Biol.*, No. 1010, 6 p.

PINHORN, A. T., A. W. MAY, R. WELLS, and E. DUNNE. 1969. Breakdown of catch by type of gear in the Newfoundland inshore cod fishery in 1967. *Fish. Res. Bd. Canada, MS Rep. Biol.*, No. 1058, 5 p.

PINHORN, A. T., R. WELLS, and E. DUNNE. 1966. Breakdown of catch by type of gear in the Newfoundland inshore cod fishery in 1964. *Fish. Res. Bd. Canada, MS Rep. Biol.*, No. 879, 8 p.

1968. Breakdown of catch by type of gear in the Newfoundland inshore cod fishery in 1965. *Fish. Res. Bd. Canada, MS Rep. Biol.*, No. 987, 8 p.

WELLS, R. W., and A. T. PINHORN. 1970. Growth and mortality changes in cod from ICNAF Subareas 2 and 3. *Annu. Meet. int. Comm. Northw. Atlant. Fish.* 1970, Res. Doc. No. 88, Serial No. 2439 (mimeographed).

Size Selectivity of the Gulf III and Bongo Zooplankton Samplers

By Kenneth Sherman[1] and Kenneth A. Honey[1]

Abstract

Comparisons were made on the size selectivity in the catches of the Gulf III and bongo zooplankton samplers. Simultaneous tows were made with the samplers in winter and summer conditions. In both seasons the catches of the smaller zooplankters were significantly greater in the bongos than in the Gulf III. The evidence suggests that the differences in the catches of the two samplers are caused by the extrusion of the smaller zooplankton constituents through the meshes of the Gulf III, when towed at 6 knots (308 cm/sec).

Introduction

Previous comparisons of the catching efficiencies of the Gulf III (Gehringer, 1952) and paired bongo samplers (Posgay, Marak, and Hennemuth, MS, 1968) indicated that the abundance of the smaller zooplankters is underestimated in the Gulf III sampler (Sherman and Honey, 1968). The experiments described by us in 1968, were continued to examine the effects of seasonal changes in the size composition of the zooplankton on the catches of the two samplers by comparing catches made during winter and summer in 1968.

Methods

As in our previous trials, the samplers were hauled simultaneously in a step oblique tow of 30 min – 10 min each at 20 m, 10 m, and the surface during daylight. The nets were on the same wire; the bongo samplers were positioned about 25 cm above the Gulf III. Each of the samplers had a mouth diam of 20.3 cm. The amount of water strained was determined from a calibrated flow meter mounted in the mouth of one of the bongo nets, and in the tail section of the Gulf III. Each tow covered about 6.5 km and filtered approximately 165 m^3 of water. The towing speed was 308 cm/sec (6 knots). Volumes of the samples were measured in the laboratory by the mercury immersion method. Ctenophores, large coelenterate remains (>2 cm long) and all fish larvae were excluded. Zooplankton samples used for analysis ranged from the total sample to aliquots of $\frac{1}{256}$, depending on the mass of the samples. They were sorted into major taxonomic groups; copepods were identified to species, and numbers of copepods and other zooplankters per 100 m^3 of water strained were calculated.

Simultaneous tows were made in winter at 12 coastal locations between Cape Ann, Massachusetts, and Machias Bay, Maine. One of the bongos was fitted with 0.366 mm mesh. The other had fine mesh (0.158 mm) to sample the smaller zooplankters; because this net was torn repeatedly when towed at 308 cm/sec, however, the resulting data were not used in the comparisons. In summer, 10 tows were made in coastal waters in the vicinity of Boothbay Harbor; the mesh apertures in both bongos and in the Gulf III were 0.366 mm. In each season, 25 specimens of the copepod species and other taxa that were abundant were selected at random and measured for size in their widest dimension.

Composition of the Zooplankton

In winter, copepods were the predominant zooplankters. Two species, *Calanus finmarchicus* and *Pseudocalanus minutus*, constituted 97% of the copepods in the samples. In summer, 15 taxa were in the samples, and 10 (copepods, cladocerans, fish eggs, crustacean nauplii, gastropod eggs, decapod larvae, brachyuran larvae, pteropods, cirriped larvae, and appendicularians) constituted more than 1% of the total zooplankton. Copepods were predominant (63% of the total zooplankton); eight species (*C. finmarchicus*, *P. minutus*, *Centropages hamatus*, *Eurytemora herdmani*, *Temora longicornis*, *Acartia longiremis*, *A. clausi*, and *Tortanus discaudatus*) were in the samples.

Group and Species Size Comparisons

The differences in the catches of the major taxa and copepod species between the bongo and Gulf III samplers were tested for significance with the Mann-Whitney U test for winter observations, and with the Friedman two-way analysis of variance (Siegel, 1956) for the experiments in summer. In the summary of the results (Table 1) the zooplankters are listed by sizes.

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TABLE 1. Sizes of the major zooplankters and copepod species collected in the bongos and Gulf III samplers, winter and summer 1968[a].

Organisms	Median width (mm)	Median no./100m^3 Port	Starboard	Gulf III	χ_r^2	Probability value
Appendicularians	0.16	940	341	166	4.2	>0.10
A. longiremis	0.27	1,482	1,451	74	10.4	<0.01
A. clausi	0.31	584	534	55	9.6	<0.01
E. herdmani	0.31	2,008	1,358	606	12.6	<0.01
C. hamatus	0.35	2,129	2,212	634	15.0	<0.001
T. discaudatus	0.36	384	381	273	3.2	>0.20
P. minutus	0.36	3,026	1,858	297	10.4	<0.01
T. longicornis	0.38	1,013	1,209	839	5.4	>0.05
P. minutus (W)	0.38	–	687	19	4.0	<0.001
Cirriped larvae	0.40	89	142	250	2.5	>0.20
Decapod larvae	0.40	612	590	501	0.0	>0.99
C. finmarchicus	0.43	2,799	2,889	2,059	1.4	>0.30
Cladocerans	0.44	1,114	387	1,392	10.6	<0.01
Crustacean nauplii	0.45	641	715	701	2.2	>0.30
Pteropods	0.47	481	556	266	2.6	>0.20
Gastropod eggs	0.69	1,051	606	14	15.4	<0.001
C. finmarchicus (W)	0.79	–	2,670	2,756	66.0	>0.05
Fish eggs	0.85	1,001	1,083	892	1.6	>0.30
Brachyuran larvae	1.92	324	413	795	9.8	<0.01

[a] Only two of the organisms listed, *P. minutus* (W) and *C. finmarchicus* (W), were from winter collections; for these collections, no port sample was taken with the bongo net, and the values and probabilities given are for the Mann-Whitney U test. The Friedman two-way analysis of variance was used for the summer collections.

In winter the overwintering population of the large *C. finmarchicus* (median width 0.79 mm) was sampled equally well in the Gulf III and bongos. In contrast, the adult but smaller copepod, *P. minutus* (median width 0.38 mm), was undersampled in the Gulf III. In summer the five copepod species that were more numerous in the bongos (*A. longiremis*, *A. clausi*, *E. herdmani*, *C. hamatus*, and *P. minutus*) were also the smallest copepods in the samples ($\lessapprox$ 0.36 mm). *C. finmarchicus* were predominantly in the third and fourth copepodite stages; the other species were, with few exceptions, fifth copepodites and adults. The eight taxa that were collected equally well in the bongos and Gulf III (*T. discaudatus*, *T. longicornis*, *C. finmarchicus*, cirriped larvae, decapod larvae, crustacean nauplii, pteropods, and fish eggs) were all relatively large organizms, 0.36 mm or more in median width. Catches of appendicularians were also not significantly different in the bongos and Gulf III. The catches were, however, of tail remains only, and their median width (0.16 mm) is about 1/12 the full width of the outer gelatinous body of the organisms. The added mass of the outer body that was lost during the sampling may have accounted for the similarity in catches in the samplers. Three remaining taxa differentially retained in the samplers were the relatively large cladocerans, which were more numerous in the port bongo and Gulf III; brachyurans, more numerous in the Gulf III, and gastropod eggs, more numerous in the bongos (Table 1).

Sources of Variation Between Samplers

The possible influence in our experiments of the patchy microdistributions of zooplankters in the horizontal and vertical plane is considered inconsequential. The differences between the catches of the port and starboard bongos suggested that the patches of zooplankters were less than 40 cm distant on the horizontal plane. This effect, however, was not statistically significant ($P > 0.05$, Mann-Whitney U Test), over the series of replicate tows except for gastropod eggs and appendicularians which were more numerous in the port bongo. Within the water column in coastal waters of Maine we have found that zooplankters are more numerous at 10 m than at the surface. In the last 10 min of the step-oblique tow, the bongo nets were positioned just below the surface film, whereas the Gulf III was about 25 cm below them on the towing wire. Differences in catches caused by vertical patchiness would have resulted in increased numbers of zooplankters in the Gulf III rather than in the bongos. Catches of only 3 of the 17 taxa in the samples appear to be anomalous; the reasons for the significantly greater catches of the relatively large gastropod eggs in the bongos, cladocerans

TABLE 2. Friedman analysis of variance values (χr^2) for the pooled small (median width $\lessapprox$ 0.38 mm)[a] and large (median width $\gtrapprox$ 0.40 mm)[b] zooplankters collected in the bongo and Gulf III samplers, summer 1968.

	Small zooplankters (median no./100m^3)			Large zooplankters (median no./100m^3)		
Tows	Port	Starboard	Gulf III	Port	Starboard	Gulf III
1	4,362	4,551	1,377	7,084	5,995	5,242
2	6,755	13,829	2,574	7,420	5,670	6,680
3	5,987	5,270	2,180	7,530	8,498	7,810
4	12,223	9,246	2,788	10,718	9,140	4,991
5	10,896	7,038	2,489	10,012	7,568	8,873
6	3,169	2,703	2,800	3,950	3,773	9,883
7	18,121	9,327	4,693	11,648	12,691	12,189
8	16,132	33,007	2,718	13,948	12,178	6,044
9	16,450	19,742	4,435	10,895	12,505	8,226
10	16,651	17,296	7,067	13,579	9,576	16,276
		χr^2 12.2, P <0.01			χr^2 1.4, P >0.30	

[a] Includes: *Acartia clausi, Acartia longiremis, Centropages hamatus, Eurytemora herdmani, Pseudocalanus minutus, Temora longicornis,* and *Tortanus discaudatus.*

[b] Includes: brachyuran larvae, *Calanus finmarchicus,* cladocerans, cirriped larvae, crustacean nauplii, decapod larvae, fish eggs, gastropod eggs, and pteropods.

in the port bongo and Gulf III, and brachyurans in the Gulf III are not clear and will require additional investigation.

The median cephalothorax widths of three copepod species (*T. discaudatus* [0.36 mm], *T. longicornis* [0.38 mm] and *C. finmarchicus* [0.43 mm]) that were collected equally effectively in summer in both samplers were the same as or only slightly larger than the width of *P. minutus* (0.36 mm). Vanucci (1968) suggested that the escape of organisms larger than the meshes is aided by the compressibility of the organisms and flexibility of the net. Irregularities in the retention of zooplankters at the size range where the percentage retained and the percentage lost through the meshes is approximately the same has been observed by Saville (1958). The retention of *T. discaudatus* and the loss of *P. minutus* may have been caused by differences in compressibility of the cephalothorax; also the maxillipeds and antennae of *T. discaudatus* are longer and more rigid than those of *P. minutus.* It is also likely that some of the smaller copepods ($\lessapprox$0.36 mm median width) were lost through the 0.366 mm mesh apertures (0.517 diagonal measure) of both the bongos and Gulf III samplers.

Preliminary observations of the hydrodynamics of the Gulf III sampler indicate that when under tow mesh velocities are high because of the differential flow of water through the net, accentuated by the encasement; the resulting high-velocity produces high mesh velocities in the lower third of the net (personal communication, Paul Smith, Bureau of Commercial Fisheries, La Jolla, California). In contrast, the mesh velocity would be lower in an unenclosed net with a cylinder-cone configuration (Tranter and Smith, 1968). Also, it has been shown that an unenclosed Gulf III, when towed at 258 cm/sec (5 knots), catches more plankton than an enclosed Gulf III sampler (Nellen and Hempel, 1969). In our experiments, significantly more of the smaller zooplankters (<0.38 mm median width) were retained in the bongos, but differences were not significant among the samplers in the catches of the larger (>0.40 mm median width) organisms (Table 2). The differences between the catches of zooplankton in the Gulf III and bongo samplers, fitted with netting of 0.366 mm apertures, apparently result from the extrusion of the smaller copepods and other small zooplankters through the meshes of the Gulf III when towed at 308 cm/sec (6 knots).

The Gulf III sampler has been used routinely in a longterm study of the zooplankton in coastal waters of the Gulf of Maine (Sherman, 1968). Because the Gulf III undersamples the smaller zooplankton constituents, it has been replaced on our coastal surveys with the more efficient and lighter weight bongo samplers.

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References

GEHRINGER, J. W. 1952. An all-metal plankton sampler (Model Gulf III). *Spec. sci. Rep. U.S. Fish. Wildl. Serv. – Fish.*, No. 88, p. 7-12.

NELLEN, W., and G. HEMPEL, 1969. Vesuche zur fängigkeit des "Hai" und des modifizierten Gulf – V – Plankton Samplers "Nackthai". *Ber. dtsch. Komm. Meeresforsch.*, 20(2): 141-154.

POSGAY, J. A., R. R. MARAK, and R. C. HENNEMUTH. 1968. Development and test of new zooplankton samplers. *Annu. Meet. int. Comm. Northw. Atlant. Fish.* 1968, Res. Doc. 85 (mimeographed).

SAVILLE, A. 1958. Mesh selection in plankton nets. *J. Cons.* 23(2): 192-201.

SHERMAN, K. 1968. Seasonal and areal distribution of zooplankton in coastal waters of the Gulf of Maine, 1965 and 1966. *Spec. sci. Rep. U.S. Fish. Wildl. Serv. – Fish.*, No. 562, 11p.

SHERMAN, K., and K. A. HONEY. 1968. Observations on the catching efficiencies of two zooplankton samplers. *Int. Comm. Northw. Atlant. Fish. Redbook* 1968, Part III: 75-80.

SIEGEL, S. 1956. Non-parametric statistics. McGraw-Hill Co., New York, 312 p.

TRANTER, D. J., and P. E. SMITH. 1968. Filtration performance. Monographs on oceanographic methodology 2. Zooplankton Sampling [Tranter, D. J. editor] Unesco, Geneva, Switzerland, 174 p.

VANUCCI, M. 1968. Loss of organisms through the meshes. Monographs on oceanographic methodology 2. Zooplankton sampling [Tranter, D. J. editor] Unesco, Geneva, Switzerland, 174 p.

Recent Events in the Haddock Fishery of the Eastern Scotian Shelf

By R. G. Halliday[1]

Abstract

An assessment of the eastern Scotian Shelf haddock stock using the constant parameter yield per recruit model indicates that the traditional, mainly Canadian, fishery has been exploiting this population close to its maximum yield under present mesh regulations. It is deduced that the large Soviet fishery in 1965 was based almost entirely on haddock younger than those normally exploited by the traditional fishery. This probably resulted in a substantial loss in yield from the eastern Scotian Shelf haddock stock and was an important contributory factor to the present low adult stock abundance.

Introduction

The eastern Scotian Shelf (ICNAF Divisions 4V-W) has long supported an important haddock fishery. Distribution, tagging, and meristic studies have shown that the haddock of Divisions 4V-W and of 4T (southern Gulf of St. Lawrence) are closely interrelated and probably belong to a single major stock (Clark and Vladykov, 1960; McCracken, 1963, 1965). Traditionally, this fishery has been prosecuted mainly by Canada on the winter and spring concentrations of large fish found in the Emerald Bank-Western Bank region (western 4W).

In the 1958-68 period landings from this stock averaged 27,500 metric tons annually, reaching a maximum of 55,518 metric tons in 1965 and a minimum of 10,912 tons in 1967 (Table 1). (Haddock landings quoted are from ICNAF Statistical Bulletins, Vol. 8-17, and ICNAF Res. Doc. 69/21.) The 4T fishery, prosecuted almost entirely by Canadians, was insignificant during these years falling to less than 1,000 tons from 1964 onwards. Landings from 4V averaged almost 4,500 tons, taken mainly as by-catches in the predominantly cod and flatfish fisheries of Spain and Canada. Canadian landings from 4W reached a peak of 22,000 tons in 1961, then declined rapidly to about 7,500 tons in the 1965-68 period. Spain consistently landed around 2,000 tons each year incidentally to the 4W cod fishery. The USSR first landed small quantities of haddock from 4W in 1961 and continued to do so in subsequent years until 1965, mainly as a by-catch in the summer silver hake fishery. However, in 1965, particularly in July and August, the USSR prosecuted an intensive haddock fishery, landing almost 43,000 tons in that year. Soviet

TABLE 1. Haddock landings (metric tons round fresh) from the eastern Scotian Shelf stock, 1958-68.

Year	All Countries 4T	All Countries 4V	All Countries 4W	Total All Countries 4T-V-W combined	Divisions 4T-V-W Canada (M & Q)	Divisions 4T-V-W Spain	Divisions 4T-V-W USSR	Divisions 4T-V-W Other
1958	2,750	4,586	19,592	26,928	23,336	3,087	–	505
1959	3,061	8,259	26,600	37,920	29,153	3,643	–	5,124
1960	2,041	6,552	21,244	29,837	24,636	5,047	–	154
1961	1,572	3,483	23,908	28,963	25,184	3,287	151	341
1962	1,142	3,416	21,408	25,966	18,853	4,315	2,567	231
1963	1,065	5,369	20,138	26,572	14,157	7,853	3,301	1,261
1964	462	3,816	19,016	23,294	11,613	5,001	4,391	2,289
1965	438	3,593	51,487	55,518	8,799	3,362	42,876	481
1966	150	3,300	20,199	23,649	9,838	2,856	10,501	454
1967	121	2,101	8,690	10,912	8,156	1,920	554	282
1968	149	3,094	10,066	13,309	9,710	3,230	254	115

[1]Fisheries Research Board of Canada, Biological Station, St. Andrews, New Brunswick.

vessels took a further 10,000 tons from 4W in 1966, but their landings in 1967 and 1968 were negligible.

Previous assessments of this stock were based on 1949-58 Canadian data (Beverton and Hodder, 1962; Beverton, 1965). More recently, McCracken (1968) described size and age compositions of Canadian landings and discussed recruitment variations and total mortality rates over the period 1948-65. The present paper updates McCracken's work to 1968 and presents a preliminary stock assessment based on 1958-68 data. Data collection and processing methods are those of McCracken, unless otherwise stated.

Length and Age Composition of Canadian Landings

Canadian landings from 1958 to 1968 were composed mainly of haddock 4-7 years old, the greatest contribution in terms of numbers normally being made at age 5 and in terms of weight at ages 5 and 6 (Table 2). Fish 40-60 cm formed the bulk of the catch (McCracken, 1968). In the years 1966-68, a slightly higher proportion of fish under 40 cm were landed, forming 7-12% of the catch by numbers compared with less than 2.5% prior to 1966.

TABLE 2. Numbers at age by year-class of 4V-W haddock per 100 hours fished by Canadian side otter trawlers of 151-500 gross tons, and the percentage contribution to Canadian landings (by numbers and weight) of each age group, averaged for the 1958-68 period. (Age composition representative of 4V-W. Catch/effort for 4W taken as representative of whole area).

Year-class	Age														
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1944	–	–	–	–	–	–	–	–	–	–	–	–	47	–	3
1945	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–
1946	–	–	–	–	–	–	–	–	–	–	109	–	10	6	–
1947	–	–	–	–	–	–	–	–	–	330	23	89	11	5	–
1948	–	–	–	–	–	–	–	–	473	23	82	64	2	–	–
1949	–	–	–	–	–	–	–	1438	282	247	128	12	6	–	–
1950	–	–	–	–	–	–	1388	311	155	89	38	–	5	–	–
1951	–	–	–	–	–	2030	321	479	220	54	2	7	–	–	–
1952	–	–	–	–	13402	4928	2475	915	242	22	22	5	7	–	–
1953	–	–	–	3848	3183	3210	1284	370	55	87	16	16	–	–	–
1954	–	–	4953	7257	4050	1429	996	203	123	84	14	14	5	–	–
1955	–	3032	10931	11743	5927	2121	841	703	194	43	7	23	–	–	–
1956	81	5485	8760	11798	8101	3736	3011	852	264	116	86	–	–	–	–
1957	–	402	5408	9669	7419	5243	2162	822	349	117	–	–	–	–	–
1958	–	505	1535	3555	3562	1486	1079	433	232	–	–	–	–	–	–
1959	120	393	4338	8644	4961	3518	1201	681	–	–	–	–	–	–	–
1960	–	95	2055	2370	1937	961	609	–	–	–	–	–	–	–	–
1961	–	623	2746	5812	2360	1223	–	–	–	–	–	–	–	–	–
1962	–	647	8066	5772	3923	–	–	–	–	–	–	–	–	–	–
1963	–	876	4283	5117	–	–	–	–	–	–	–	–	–	–	–
1964	126	1380	2966	–	–	–	–	–	–	–	–	–	–	–	–
1965	215	597	–	–	–	–	–	–	–	–	–	–	–	–	–
Av. contribution by numbers (%)	0.2	5.4	21.4	28.8	22.4	11.4	5.9	2.7	1.0	0.5	0.3[a]				
Av. contribution by weight (%)	0.1	2.9	14.5	24.7	24.3	15.2	9.3	5.1	2.0	1.1	0.7[a]				
Av. length (cm)	35.7	40.6	43.7	47.1	50.9	54.4	57.4	60.9	62.4	64.4	66.5[a]				
Av. weight (kg)	0.46	0.68	0.87	1.08	1.37	1.69	2.00	2.39	2.58	2.84	3.14[a]				

[a] Age 12 and over.

Abundance

Most Canadian haddock landings from 4V-W are by side otter trawlers of 151-500 gross tons. Thus, the catch per unit effort of these vessels is taken as a measure of haddock availability in each month, and the annual average of these monthly values is taken as an index of average abundance for the year. The unit of measurement used is weight caught per hour that the gear is fishing i.e. is on the bottom. Too little data are available to calculate abundance indices for 4T. However, from 1958 to 1968 this fishery was insignificant and can reasonably be ignored in this and following sections.

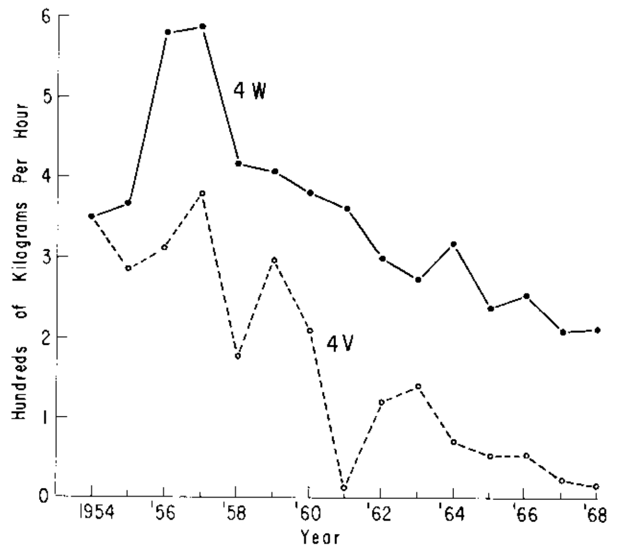

Fig. 1. Abundance indices of haddock in 4V and 4W, 1954-68. (Annual value, weighted by month, of kg/hr fished by Canadian side otter trawlers 151-500 gross tons.)

The 4V and 4W abundance indices follow similar trends (correlation = 0.78) (Fig. 1). However, these indices are not directly comparable, as haddock is seldom the species sought in fishing operations in 4V, while it frequently is in 4W. As 4V data are also scanty, a combined 4V-W index would possibly be less accurate an estimate of stock abundance than the 4W value alone. Thus, the 4W index is taken as representative of stock abundance in the whole area of distribution, the assumption being that relative stock distribution is the same in all years.

The abundance estimates for 4W haddock are not negatively correlated with those for 4W cod between 1954 and 1968, when both are calculated in the above manner (correlation = − 0.18). Therefore, this method of calculation removes, at least partly, the major objection of Dickie (1965) to the use of these data for abundance estimates.

Haddock abundance increased from 1954 to 1957 due to recruitment of the extremely abundant 1952 year-class (McCracken, 1968), and then declined with minor fluctuations, reaching the lowest values for the 15-year period in 1967 and 1968 (Fig. 1).

McCracken (1968) found that the average year-class strength (mean numbers per hour fished at ages 5 and 6), over the 18 year-classes 1942-59 was 95.5 fish. This index calculated for the 1952-63 year-classes and adjusted to be comparable to McCracken's, shows that all four of the 1960-63 year-classes were below the long-term average year-class strength at ages 5 and 6 (Fig. 2).

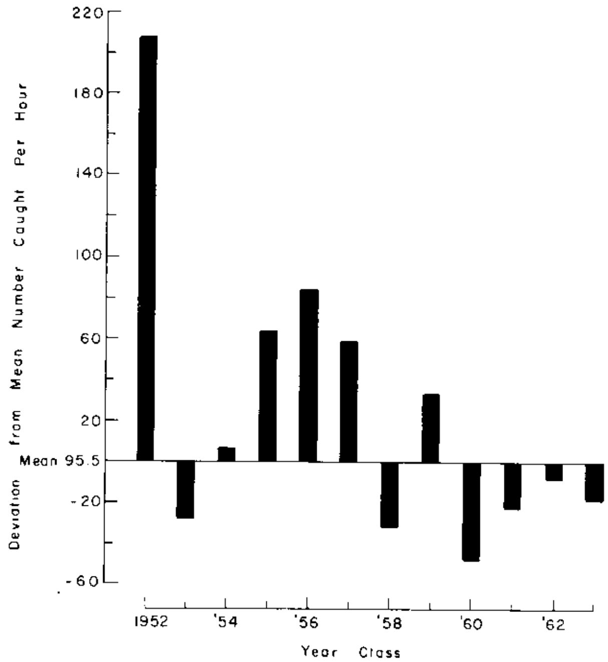

Fig. 2. Indices of haddock year-class strength, 1952-63. (Expressed as deviations from the long-term mean number caught per hour, 95.5 fish, at ages 5 and 6.)

Total Mortality

There are large variations in survival rates between calendar years (Table 3) calculated from abundance indices of each age group in each year (Table 2). They show, however, that the average instantaneous total mortality rate (Z), assumed constant with age, was approximately 0.70 in the 1958-68 period.

Estimates of Z calculated for individual year-classes from catch curves (Fig. 3) decline fairly regularly

TABLE 3. Total survival rate of 4V-W haddock.

Years	Age groups 2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	Σ 7–12/Σ 6–11
1958-59	67.72	3.61	1.47	0.83	0.37	0.16	0.22	0.20	0.05	0.07	0.31
1959-60	-	1.60	1.01	0.56	1.01	0.50	1.49	0.50	0.88	3.57	0.73
1960-61	–	13.45	1.35	0.50	0.35	0.40	0.37	0.46	0.57	0.52	0.38
1961-62	3.28	3.04	1.79	0.69	0.36	0.70	0.29	0.26	0.25	0.43	0.39
1962-63	–	11.04	2.32	0.77	0.46	0.40	0.20	0.15	0.09	0.04	0.41
1963-64	–	21.63	1.99	1.00	0.71	0.81	0.84	0.61	1.58	1.00	0.75
1964-65	–	4.41	1.15	0.57	0.42	0.41	0.28	0.28	0.68	0.18	0.38
1965-66	–	12.47	2.12	0.82	0.71	0.73	0.38	0.31	0.22	0.17	0.59
1966-67	10.95	4.89	0.72	0.41	0.50	0.34	0.40	0.42	0.44	0.16	0.40
1967-68	2.78	2.15	1.19	0.68	0.52	0.63	0.57	0.54	0.34	0.74	0.54
Average	21.18	7.83	1.51	0.68	0.54	0.51	0.50	0.37	0.51	0.69	0.49

Total instantaneous mortality = 0.71

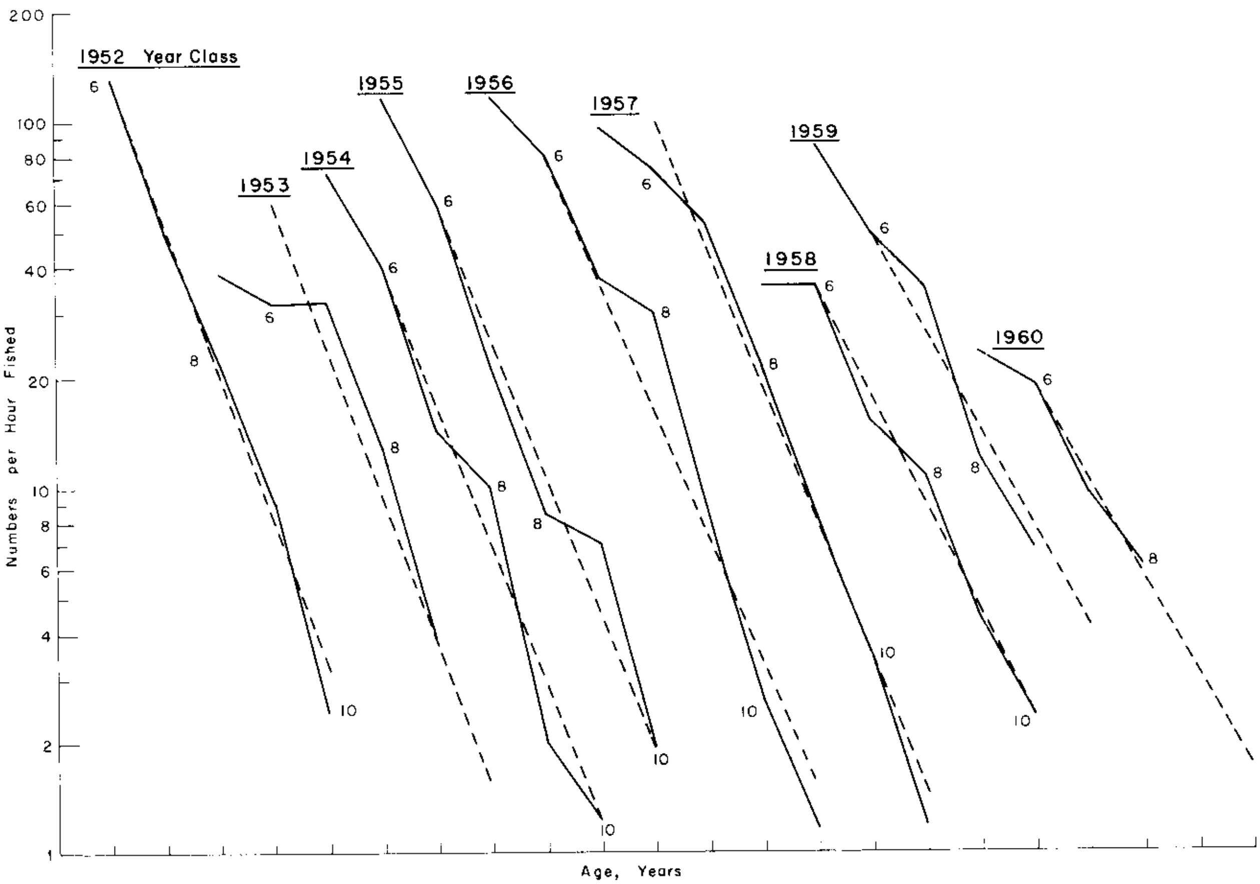

Fig. 3. Catch curves for 1952-60 haddock year-classes. (Broken lines represent author's interpretation of slopes, fitted from age 6 onwards.)

from 0.93 for the 1952 year-class to 0.61 for the 1960 year-class, as follows:

Year-class:	'52	'53	'54	'55	'56	'57	'58	'59	'60
Z:	.93	.92	.87	.86	.80	.85	.68	.61	.61

McCracken found that Z lay between .50 and .70 for the 1945-50 year-classes, increasing to .80 to 1.05 for those of 1951-55. Thus, total mortality was highest for the extremely abundant 1952 year-class and those year-classes associated with it in the fishery.

Natural Mortality

From the relationship between total mortality and fishing effort between 1949 and 1958, Beverton and Hodder (1962) estimated natural mortality (M) of this stock to be 0.20.

For the 1958-68 period Z values are calculated from age 6 onwards as catch curves indicate this to be the age at full recruitment to the Canadian fishery (Fig. 3). Thus, it is with the effective effort on fish age 6 and older that particular Z's are associated. Although Soviet and Spanish landings made up 35% of the total from 1958 to 1968, age compositions of their catches are not available. Spanish catches, being taken incidentally to the cod fishery, were probably similar in age composition to Canadian catches. Soviet catches, however, were partly incidental to the small-mesh silver hake fishery, and were taken mainly in 4W in summer. Haddock populations in 4W in summer normally consist almost entirely of fish smaller than 40 cm and younger than age 5 (McCracken, 1965). Thus, the age composition of the Soviet catch was probably very different from that of other countries, consisting mainly of young fish. Taking alternative hypotheses, firstly that the age composition of Soviet catches was identical to that of Canadian catches, secondly that no fish age 6 and over were contained in Soviet catches, Z for each year-class 1952-60 is plotted against the average estimated effective effort which effected this mortality (Fig. 4). A line is fitted to both data sets by the method of Paloheimo (1961).

When it is assumed that age compositions of Soviet and Canadian catches were the same, there is no significant correlation of Z and estimated effort (Fig. 4A). The estimate of M from Paloheimo's linear formula is 0.78, which is obviously erroneous. The alternative hypothesis that Soviet catches contained no haddock age 6 and over gives effort values which are correlated with Z (correlation coefficient = 0.88, significant at 1% level) and gives an estimate of M = 0.20 (95% confidence intervals ± 0.29) (Fig. 4B). This value of M is acceptable and identical to the value given by Beverton and Hodder (1962).

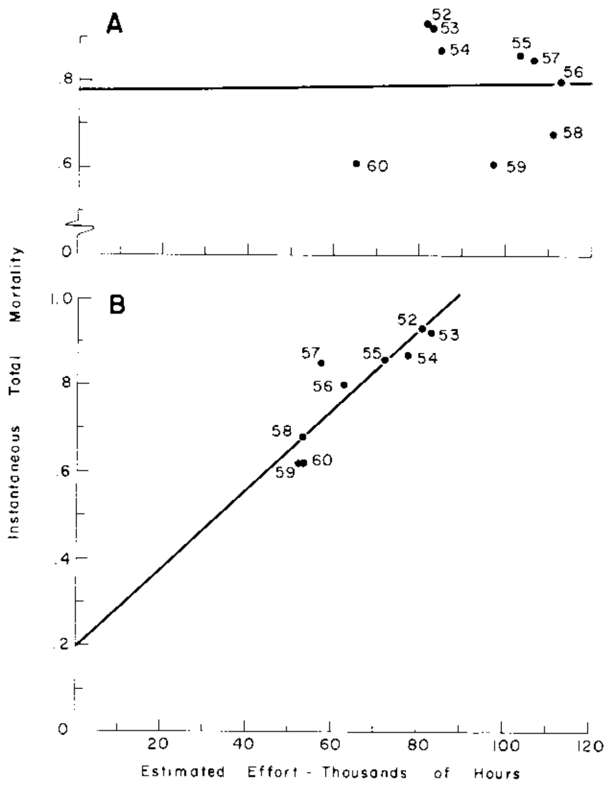

Fig. 4. Relationship of instantaneous total mortality (Z) to estimated effective effort on the 1952-60 haddock year-classes. A – assuming age composition of Soviet and Canadian catches identical, B – assuming Soviet catches contained no haddock age 6 and over.

It is shown below that Soviet catches probably contained small quantities of haddock older than age 5. This would cause effort estimates from the latter hypothesis to be biased downwards in the years of greatest Soviet haddock catches, i.e. 1965 and 1966. This would tend to bias M upwards (Fig. 4). Thus, the true value of M is possibly less than 0.20.

Growth

Fitting the von Bertalanffy growth equation to length and age data from Canadian first quarter commercial samples for each year 1958-68 by the method of Allen (1966) gives estimates of L_∞ varying between 66.7 cm and 99.3 cm, of K between 0.07 and 0.33, and t_o between −5.79 and +2.22. Means of the annual estimates of the parameters are:

L_∞ = 77.5 cm
K = 0.15
t_o = 0.84

These are close to the values of $L_\infty = 75$ cm and $K = 0.20$ used by Beverton (1965).

A value of $W_\infty = 5.03$ kg is obtained by substituting the value of L_∞ in a length-weight equation describing this relationship for 4W haddock in July 1969 (Kohler *et al.*, 1970).

Length and Age at Entry to the Exploited Phase

The majority of Canadian otter trawlers fishing haddock in Subarea 4 use polypropylene codends, but a substantial number use codends of polyethylene, polyester, and polyamide fibres (Canadian Department of Fisheries, unpublished data). Haddock selection factors for these different materials are recommended by the Joint ICES/ICNAF Working Group on Selectivity Analysis (MS, 1969). Haddock mean selection lengths are calculated for each material by multiplying the appropriate selection factor by the average mesh size for that material in the Canadian fleet in 1968 and 1969, measured by Fisheries Officers of the Canadian Department of Fisheries. A mean selection length for the fleet is calculated by taking the mean of the selection lengths for each material, weighted by the proportion of the fleet using that material. This gives a mean selection length for haddock of 38 cm. Substituting this value in the von Bertalanffy growth equation gives a mean selection age of 3.7 years.

Maximum Yield from the Traditional Fishery

The simple Beverton and Holt equation (Beverton and Holt, 1957) giving yield per recruit is calculated for the Canadian fishery for various levels of F (Fig. 5), using the values determined above for the other parameters:

M	$= 0.20$	
W_∞	$= 5.03$ kg	
K	$= 0.15$	
t_o	$= -0.84$	
t_ρ	$= 1.0$ year	(= age at recruitment to the fishing area)
$t_\rho{}^1$	$= 3.7$ years	(= age at recruitment to the exploited phase)
t_λ	$= 12$ years	(= maximum age of significant contribution to the fishery)

A long-term average value of $Z = 0.70$ is indicated from the results of both Beverton and Hodder (1962) for the 1947-58 period, and the present author for the

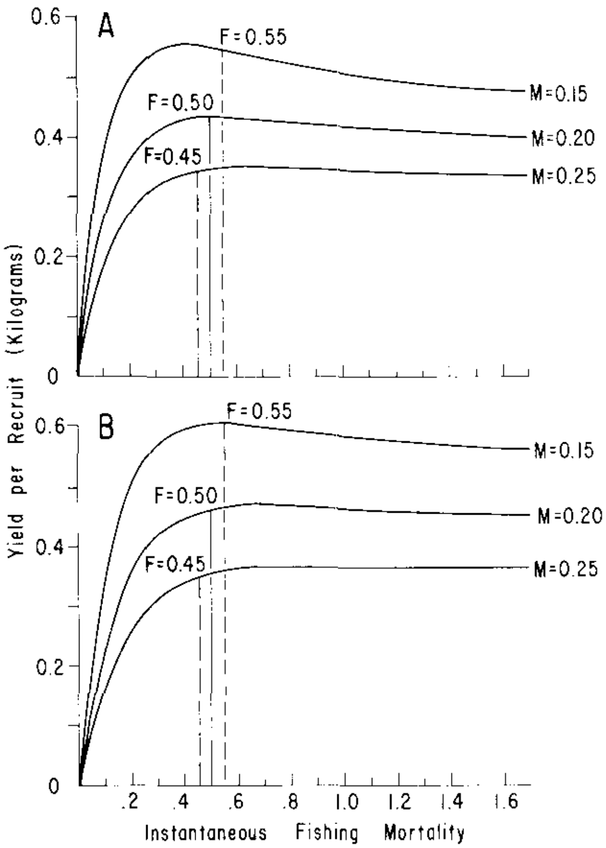

Fig. 5. Relationship of yield per recruit of haddock to instantaneous fishing mortality (F) at different levels of natural mortality (M), A – when age at entry to the exploited phase ($t_\rho{}^1$) is 3.7 years, B – when $t_\rho{}^1$ is 4.6 years.

1958-68 period. With M = 0.20, the average value of F would be 0.50, i.e. the value of fishing mortality giving maximum yield (Fig. 5A). If M = 0.15 (F = 0.55), yield would increase slightly with a decrease in effort of one-quarter. If M = 0.25 (F = 0.45) yield would increase only slightly with an increase in effort. Thus, in none of these circumstances would increased effort result in substantially increased yield.

It is possible that the value of $t_\rho{}^1$ used here is too low, perhaps due to the ability of the fleet to concentrate its activities on large fish. Beverton (1965) took a mean selection length of 43 cm equivalent to a $t_\rho{}^1 = 4.6$ years. It is unlikely, from examination of length and age compositions of Canadian catches, that $t_\rho{}^1$ is greater than this. Taking $t_\rho{}^1 = 4.6$ years does not greatly affect the conclusions drawn earlier on the state of the fishery (Fig. 5B). If M = 0.15, the average fishing intensity is close to the optimum, if M = 0.20, the yield would increase only slightly with increased effort, if M = 0.25, the yield is 93% of the maximum value.

Thus, the average fishing intensity is apparently close to that producing maximum yield. Only if M is considerably higher than indicated by the data presented here and by Beverton and Hodder (1962), could an increase in effort produce a substantial increase in yield.

Soviet Catches: Possible Age and Length Compositions, and Effect on the Traditional Fishery

In 1965, the USSR landed 42,876 tons of haddock from 4W, 30,675 tons of this taken in July and August (ICNAF Statistical Bulletin, Vol. 15). This raised haddock landings from the eastern Scotian shelf in 1965 to over twice the long-term average landings. Nevertheless, there was no marked increase in the mortality of haddock over age 6 resulting from this sharp increase in effort. Neither do Canadian statistics show any increase in abundance in that year of haddock aged 4-12 (the ages on which the Canadian fishery is based).

A Canadian research ship survey cruise in 4W between 29 July and 8 August, 1965, gives a good indication of what sizes of haddock were available to a commercial otter-trawl fishery in these months. Forty-three tows were made at depths of 35 to 375 m (19 to 205 fathoms) with a #41 otter trawl with 32 mm mesh liner in the codend and lengthening piece. Part of this

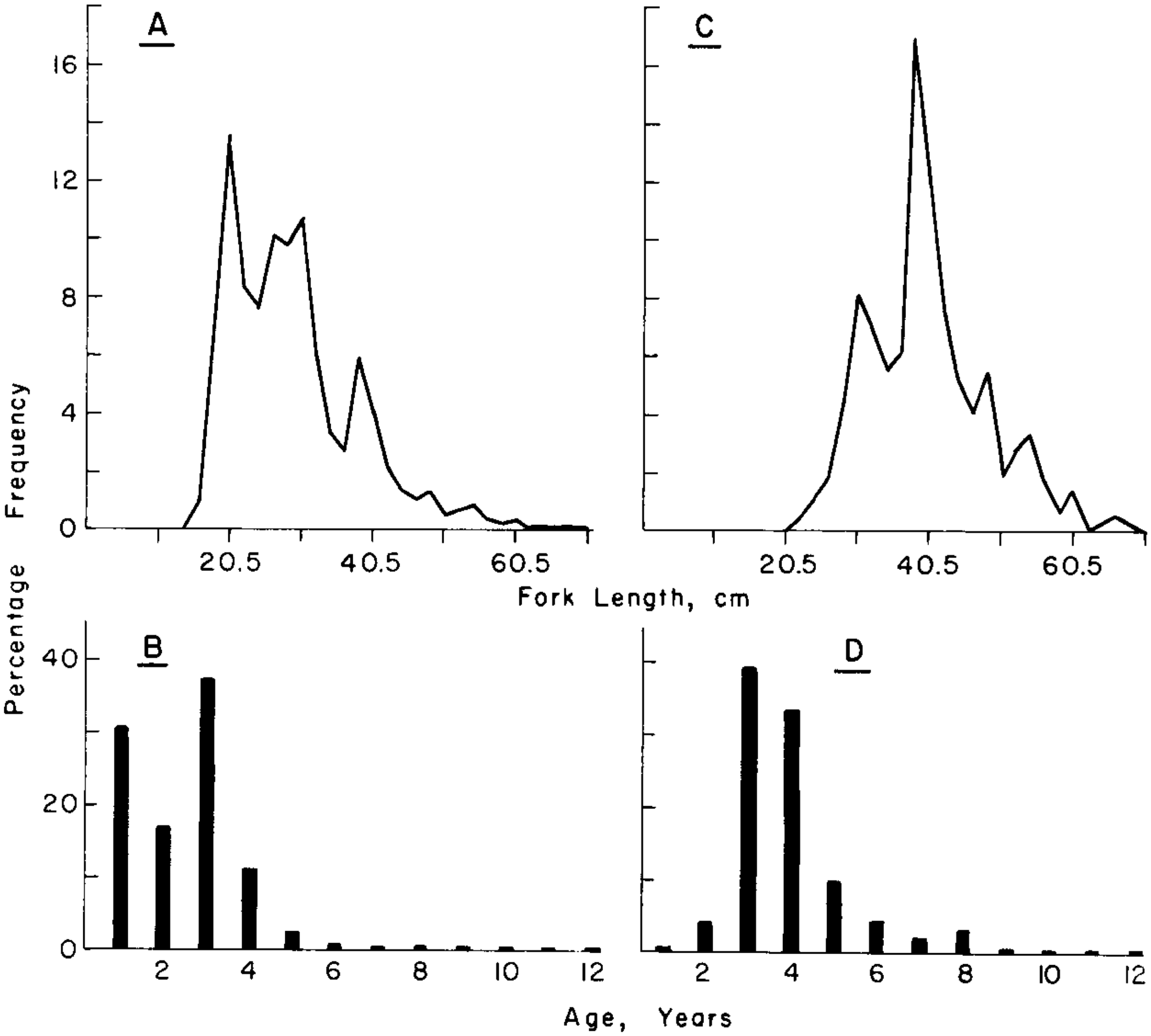

Fig. 6. Length (A) and estimated age composition (B) of Canadian research vessel haddock catches in 4W in July-August 1965, and estimated length (C) and age composition (D) of the catches of a vessel fishing this population, using a 114 mm codend mesh.

survey was undertaken in an area west of Sable Island being fished by an estimated 40 Soviet vessels. Haddock were abundant between 35 and 55 m (19 and 30 fathoms) around Sable Island and moderately abundant between 119 and 183 m (65 and 100 fathoms), at temperatures of 4.0° to 11.8°C, but very scarce in 73 to 101 m (40 to 55 fathoms) where temperatures were 1.4° to 3.4°C, and also scarce at depths greater than 183 m (100 fathoms). The length compositions of the shallow and deeper haddock concentrations were closely similar. Thus, the length frequencies of all tows are combined to give one length composition representative of the whole area (Fig. 6A). The length range was 15 to 73 cm, with 87% of the catch less than 40 cm.

Taking the Canadian research vessel catches as representative of the population, the catch of an otter trawler using regulation codend mesh is calculated, using a selection ogive for 114 mm double manila (Beverton and Hodder, 1962, Appendix II). Such a catch would be composed mainly of fish 25 to 50 cm (average = 40.1 cm), 52% being less than 40 cm (Fig. 6C).

The 4W haddock stock was sampled in August 1965 by a Polish research vessel also (ICNAF Sampling Yearbook, Vol. 10). These data give an independent estimate of the haddock length composition in the catch of a vessel using 114 mm codend mesh. Polish catches were mainly of fish 16 to 55 cm (average = 36.2 cm), 70% being less than 40 cm. (Polish data are converted to fork lengths from total lengths for direct comparison with Canadian data.)

Polish data also include an age-length key, whereas no aging material was collected on the Canadian research cruise. Unfortunately, Polish age readings are very different from those to be expected from Canadian experience of aging fish from this stock. Thus, apparently important differences in aging technique exist between the two countries. It is preferred, therefore, to estimate the age structure of Canadian 1965 catches using a Canadian age-length key for 4W haddock. A key based on data collected in July 1960 is used as there are no indications from commercial samples of appreciable changes in growth rate between 1960 and 1965. This method indicates that, with a 32 mm mesh codend, 84% of the catch was composed of age groups 1-3, only 3% being age 6 and over (Fig. 6B). The age composition of the estimated catch of a vessel using 114 mm mesh, would have been dominated by age groups 3 and 4, those age 6 and over composing 12% of the catch (Fig. 6D).

The Soviet silver hake fishery in Subarea 4 in 1965 was conducted with 40 mm mesh liners in the trawl codends (L. R. Day, personal communication). It is unlikely that gear rigged in this way has selection properties greatly different from those of the research vessel trawl with 32 mm mesh liner. Thus, any Soviet haddock catches made with this gear would have age and length compositions closely similar to those of research catches.

The Soviet silver hake fishery in 4W in 1965 was substantial, amounting to over 49,000 metric tons, and concentrated mainly in the same summer months as the haddock fishery. Large by-catches of haddock in this small-mesh fishery most likely occurred. Research vessel catches in the vicinity of the Soviet fleet in July and August took silver hake and small haddock in a ratio of approximately 4:1 by volume. Thus, it is a reasonable deduction that a considerable proportion of the Soviet haddock catch was taken with small-mesh liners in the codend. As this proportion cannot be ascertained at present, two extreme cases are considered, i.e. that all the haddock were trawled using 114 mm mesh codends, and alternatively, that all were trawled using small-mesh codend liners. The length and age compositions shown in Fig. 6, C and D, are taken as representative of the catch with a 114 mm mesh codend, those in Fig. 6, A and B, of that with small mesh liners. (Polish length-frequency data are not used because of the difficulties in converting from total length.)

If the entire Soviet haddock catch of 42,876 tons in 1965 was taken without liners, the average fish weight would have been 0.75 kg giving numbers caught as 57,000,000 fish. Contributions by numbers and weight of each age group are given in Table 4. Also given are the potential yields had they survived this fishery to be caught at ages 4 to 12 in the traditional fishery. Potential yields are calculated using the Beverton and

TABLE 4. Estimated contribution by numbers and weight of each age group to the 1965 Soviet haddock catch in 4W assuming that the fishery was conducted without codend liners, and the potential yield of those fish to the traditional fishery had they been allowed to survive.

Age	Numbers caught	Weight caught (metric tons)	Potential yield (metric tons)
1	300,000	30	100
2	2,000,000	500	1,400
3	22,000,000	9,400	16,000
4	19,000,000	13,400	17,500
5	6,000,000	6,000	6,300
6+	8,000,000	13,600	10,600
Total	57,000,000	42,900	51,900

Loss in yield = 9,000 metric tons

Holt yield equation with t_ρ = 1.5, 2.5, 3.5 years, etc. as appropriate, $t_\rho{}^1$ = 3.7 years, M = 0.20, F = 0.50, and other values as before.

If the entire Soviet catch was trawled using small-mesh liners, the average fish weight would have been 0.33 kg giving numbers caught as 131,000,000 fish. Contributions by numbers and weight of each age group and potential yields to the traditional fishery are shown in Table 5. The potential yields are calculated as before.

TABLE 5. Estimated contribution by numbers and weight of each age group to the 1965 Soviet haddock catch in 4W assuming that the fishery was conducted using small-mesh codend liners, and the potential yield of those fish to the traditional fishery had they been allowed to survive.

Age	Numbers caught	Weight caught (metric tons)	Potential yield (metric tons)
1	40,000,000	3,400	19,100
2	22,000,000	3,800	12,700
3	48,000,000	15,500	34,500
4	14,000,000	9,400	13,000
5	3,000,000	3,400	3,700
6+	4,000,000	7,400	5,800
Total	131,000,000	42,900	88,800

Loss in yield = 45,900 metric tons

The actual situation in 1965 most probably lay somewhere between these two extremes. The intensive fishery for young fish resulted in an overall loss in yield to the eastern Scotian Shelf haddock fishery of between 9,000 and 46,000 metric tons (Tables 4 and 5). This loss was almost entirely from the 1961-64 year-classes.

Discussion

On average, over the last 10 years, fishing mortality caused by the traditional fishery on large haddock has been close to that giving maximum yield under present mesh regulations. As indicated by McCracken (1968), the relative success of the fishery has been directly related to variation in year-class strength. Year-classes make their first significant contribution to the traditional fishery at age 4 and their largest contributions at ages 5 and 6. Many 4 year olds and most 5 year olds are mature (unpublished data). Thus, the traditional fishery is based mainly on adult fish. The recent decline in adult stock abundance, and yield, is apparently due to a recruitment failure, the 1959 year-class being the only moderately good one at ages 5 and 6 among those of 1958-63.

The large Soviet haddock catch of 1965 was undoubtedly an event of considerable importance in the history of this fishery. It is unfortunate that the lack of sampling data prevents the accurate determination of its effects. It seems certain that the Soviet fishery concentrated on juvenile haddock of the 1961-64 year-classes prior to any significant contribution by these year-classes to the traditional fishery. Effectively, this reduced the age at recruitment to the fishery, resulting in a loss in yield from the stock of possibly 9,000-46,000 metric tons. One or more of those year-classes must have been extremely abundant for these large removals to have been possible.

The declining adult stock abundance is thus due to a combination of recruitment of naturally poor year-classes, i.e. those of 1958, 1960, and possibly others, and of year-classes impoverished by large removals of juveniles.

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References

ALLEN, K. R. 1966. A method of fitting growth curves of the von Bertalanffy type to observed data. *J. Fish. Res. Bd. Canada*, **23**: 163-179.

BEVERTON, R. J. H. 1965. Catch/effort assessments in some ICNAF fisheries. *Res. Bull. int. Comm. Northw. Atlant. Fish.*, No. 2, p. 59-72.

BEVERTON, R. J. H., and V. M. HODDER, eds. 1962. Report of working group of scientists on fishery assessment in relation to regulation problems. Supplement to *Annu. Proc. int. Comm. Northw. Atlant. Fish.*, **11**: 1-81.

BEVERTON, R. J. H., and S. J. HOLT. 1957. On the dynamics of exploited fish populations. *Fish. Invest., Lond. (2)* **19**: 1-533.

CLARK, J. R., and V. D. VLADYKOV. 1960. Definition of haddock stocks of the northwestern Atlantic. *Fish. Bull., U.S.*, **60** (No. 169): 283-296.

DICKIE, L. M. 1965. Difficulties in interpreting trends in cod and haddock landings from the eastern Scotian Shelf. *Res. Bull. int. Comm. Northw. Atlant. Fish.* No. 2, p. 80-82.

ICES (MS) 1969. Report of the joint ICES/ICNAF working group on selectivity analysis. Comparative selectivity of bottom trawls made of different materials. ICES Gear and Behaviour Committee, Doc. C. M. 1969/B: 13, 65 p. (mimeographed).

KOHLER, A. C., D. N. FITZGERALD, R. G. HALLIDAY, J. S. SCOTT, and A. V. TYLER. 1970. Length-weight relationships of marine fishes of the Canadian Atlantic region. *Fish. Res. Bd. Canada, Tech. Rept.* No. 164, 11 p. + 1 figure and 199 tables.

McCRACKEN, F. D. 1963. Migrations of haddock between the Gulf of St. Lawrence and offshore Nova Scotian banks. *J. Fish. Res. Bd. Canada*, **20**: 855-857.

1965. Distribution of haddock off the eastern Canadian mainland in relation to season, depth, and bottom temperature. *Spec. Publ. int. Comm. Northw. Atlant. Fish.*, No. 6, P. 113-129.

1968. Size, age, and recruitment comparisons for haddock of the central Scotian Shelf. *Res. Bull. int. Comm. Northw. Atlant. Fish.*, No. 5, p. 99-109.

PALOHEIMO, J. E. 1961. Studies on estimation of mortalities. 1. Comparison of a method described by Beverton and Holt and a new linear formula. *J. Fish. Res. Bd. Canada*, **18**: 645-662.

Comparison of Certain Biological Characteristics of Herring from Magdalen Islands and Southwestern Newfoundland

By V. M. Hodder[1] and L. S. Parsons[1,2]

Abstract

In order to test the hypothesis that the herring schools, which inhabit the southern part of the Gulf of St. Lawrence, migrate eastward in the autumn and overwinter in the fjords of southwestern Newfoundland, herring samples taken in November 1969 at Magdalen Islands just prior to the beginning of the Newfoundland fishery and later along southwestern Newfoundland were compared using such biological characteristics as length, age, maturity condition, vertebral count, pectoral, dorsal and anal fin ray counts, and parasite incidence.

Although highly significant differences were found between spring and autumn spawners within areas, the between-area comparisons revealed no significant differences. It is concluded that samples taken at Magdalen Islands and along southwestern Newfoundland were derived from the same stock complex and that the winter fishery in southwestern Newfoundland is dependent on herring concentrations which migrate eastward out of the Gulf of St. Lawrence in the autumn.

Introduction

Since its beginning in the autumn and winter of 1964-65, herring landings from the purse seine fishery primarily along the western half of the south coast of Newfoundland increased rapidly from less than 10,000 metric tons in 1965 to about 170,000 metric tons in 1969. The herring concentrations, on which the fishery is based, appear in the coastal waters in late November and disappear in April. Hodder (1966, 1969) suggested that the herring, like the cod, probably exhibit a seasonal migration between the Gulf of St. Lawrence and the south coast of Newfoundland. Just prior to the beginning of the Newfoundland fishery a short but intense fishery occurs at Magdalen Islands in late October and November, and a similar fishery takes place there in late April and May after the termination of the fishery along the south coast of Newfoundland, followed by a summer fishery (July to September) in the southwestern part of the Gulf of St. Lawrence. These observations together with information on the temporal and spatial distribution of herring catches along the south coast of Newfoundland suggest the hypothesis that the herring fisheries at various times and places in the southern Gulf of St. Lawrence and southern Newfoundland areas occur on the same stock or group of stocks along a 400-mile migratory route. One may even further hypothesize that, as the stock complex which inhabits the southwestern Gulf of St. Lawrence in summer moves eastward in the autumn, most of the herring schools which move around the northern part of the Magdalen Islands ultimately overwinter in the fjords of southwestern Newfoundland while most of those which pass around the southern part of the islands move eastward past Cape Breton and southeastward along the southern side of the Laurential Channel to overwinter in deep water (Fig. 1).

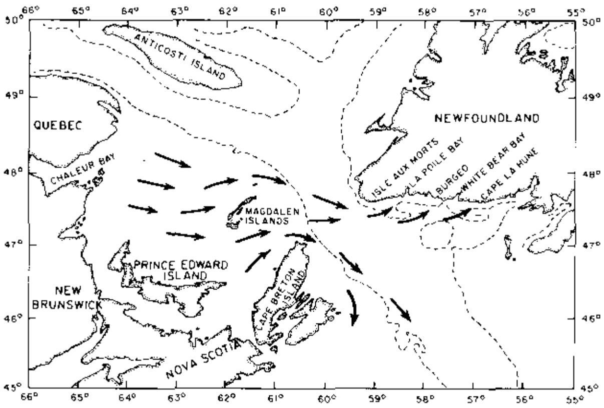

Fig. 1. Map of the southern Gulf of St. Lawrence and Newfoundland showing the hypothetical autumn migration of herring.

The rapid development of Canadian purse seine fisheries in the Gulf of St. Lawrence and southwestern Newfoundland and midwater trawl fisheries by some European countries off northeastern Nova Scotia has led to considerable concern regarding the size and extent of the herring resource and its capacity to withstand the rapidly increasing fishing pressure of recent years. This is all the more important if the various fisheries at different times and places occur on the same stock complex. In an attempt to resolve this problem three

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main lines of approach were considered for implementation beginning in the 1969-70 season: (1) herring tagging to be carried out in 1970 at three or more locations along the hypothetical migratory route; (2) herring samples to be collected at various locations for biochemical analyses; and (3) herring samples from various areas to be compared using such biological characteristics as age, length, sex, maturity, meristics, and parasite incidence. This paper presents the results of a study involving the third line of approach, namely a comparison of the biological characteristics of herring samples taken at Magdalen Islands just prior to the start of the Newfoundland fishery in the autumn of 1969 and samples taken in the coastal waters of southwestern Newfoundland shortly thereafter.

Materials and Methods

During 1-17 November, 1969, 10 samples of herring, each containing 50 specimens, were taken from the landings of purse seiners which obtained their catches in the vicinity of the Bird Rocks, just north of Magdalen Islands. Similarly, an additional 10 samples were randomly chosen for detailed examination from samples for age and growth studies collected routinely during the first 3 weeks after the commencement of the purse seine fishery along southwestern Newfoundland. All 20 samples used in this comparative study were collected at Isle aux Morts, Newfoundland, and shipped in a frozen condition to the St. John's Biological Station where the examinations were carried out 4-6 weeks later.

The specimens were measured from the tip of the lower jaw to the end of the longest lobe of the caudal fin with the lobe extending posteriorly in line with the body (greatest total length). Length measurement data, recorded to the nearest millimeter, were grouped into 1-cm intervals to the 0.5 cm below (e.g. all lengths ranging from 320 to 329 mm were grouped into the 32-cm interval).

Age determinations were made from whole otoliths premounted in small circular depressions of otolith trays made of black plexiglass. A description of the tray and technique of otolith mounting is given by Hourston (MS, 1968). The age was recorded as the number of actual summer (opaque) growth zones on the otolith. The authors initially read the otoliths independently with 60 to 80% agreement on a sample basis. Subsequently the initial disagreements were mutually resolved. The degree of uncertainty for specimens of age X and greater was such that these were grouped into a X+ category. Such grouping of old herring is not unusual, for Tibbo *et al.* (MS, 1969) used a similar grouping for Gulf of St. Lawrence herring, and Boyar (1968) grouped all herring greater than age VIII into an VIII + category.

The specimens have been assigned ages based on the number of summer zones, but they have not been assigned to year-classes because of the current difficulty in relating the time of spawning of adults, as determined from gonad development, to the time when these same individuals were hatched. Messich (1969) and Hourston and Parsons (MS, 1969) have questioned the validity of using otolith nucleus type as indicative of the time of hatching for Northwest Atlantic herring.

The sex and the stage of maturity were determined by gross examination of gonads using the various stages of gonadal development as adopted by ICES in 1962 and by ICNAF in 1964 (ICES, 1963; ICNAF, 1964). For the purpose of assigning individuals to spawning groups, maturity stages III and IV were classed as spring spawners and stage VIII as autumn spawners.

Four meristic characters were examined, namely the numbers of vertebrae, dorsal fin rays, anal fin rays, and pectoral fin rays. The vertebral and dorsal fin ray counts were determined from radiographs; the anal and left pectoral fin rays were counted with the use of a binocular microscope. The hypural is not included in the vertebral counts.

The specimens were examined to determine the incidence and intensity of infestation with larval nematodes of the genus *Anisakis*. Previous examination of the musculature of herring in the Newfoundland area by slicing and candling the fillets has revealed that less than 1% of the specimens have nematodes in the musculature (Unpublished data, St. John's Biological Station). Consequently for this study the examination for nematodes was restricted to the body cavity and viscera.

Sample details of capture, maturity condition, and size are given in Table 1. With the exception of samples 17 and 19, the size and maturity condition exhibit a high degree of similarity between samples and between areas. For analytical purposes the 10 samples from each area were combined.

Results

Spawning groups

Out of 500 specimens collected for this study from each of the two areas, only 20 from the Magdalen Islands and 4 from southwestern Newfoundland were classed as immature (stage II). The remainder were assigned to two categories on the basis of gonadal development. Those with well-developed gonads (stages III and IV) were designated as spring spawners, and those showing little if any gonad development following a recent spawning (stage VIII) were classed as autumn

TABLE 1. Date and locality of capture, maturity condition and average length of herring samples taken at Magdalen Islands (samples 1-10) and along southwest Newfoundland (11-20) in the autumn of 1969.

Sample No.	Date of capture	Locality	Maturity condition: Imm.	Spring spawners	Autumn spawners	Total	Average length (cm)	Length range (cm)
1	1 Nov.	Bird Rocks	–	11	39	50	33.2	29-36
2	2 "	" "	4	10	36	50	32.9	27-36
3	2 "	" "	6	11	33	50	32.0	27-37
4	8 "	" "	5	14	31	50	32.2	27-36
5	9 "	" "	–	14	36	50	33.2	30-36
6	17 "	" "	1	6	43	50	33.0	28-35
7	17 "	" "	3	14	33	50	32.6	29-37
8	17 "	" "	–	10	40	50	33.0	30-36
9	17 "	" "	1	10	39	50	32.7	29-37
10	17 "	" "	–	12	38	50	33.2	31-36
			20	112	368	500	32.8	27-37
11	22 "	Burgeo	–	10	40	50	33.3	31-36
12	25 "	"	1	11	38	50	33.0	27-35
13	25 "	White Bear Bay	–	13	37	50	32.7	29-36
14	29 "	Cape La Hune	–	9	41	50	33.4	31-37
15	30 "	Bay de Vieux	1	14	35	50	32.7	28-35
16	1 Dec.	White Bear Bay	–	14	36	50	33.5	31-36
17	1 "	Burgeo	–	25	25	50	32.5	29-34
18	4 "	Le Poile Bay	1	10	39	50	32.4	29-37
19	5 "	White Bear Bay	1	22	27	50	32.8	28-36
20	12 "	Burgeo	–	11	39	50	33.2	30-36
			4	139	357	500	32.9	27-37

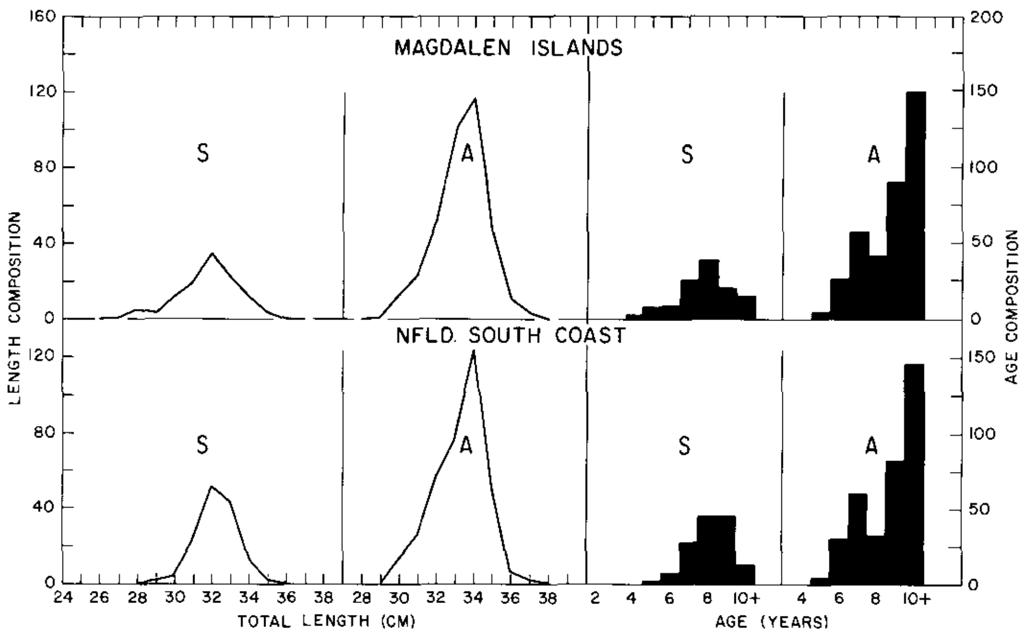

Fig. 2. Length and age composition of herring samples by spawning group and area (S = spring spawners, A = autumn spawners).

spawners. Although stage VIII passed into stage III during the gonad developmental cycle, no borderline cases were observed and the distinction between spring and autumn spawners was clearcut. The few immature specimens have not been included in the data analyses that follow.

Autumn spawners constituted 77 and 72% of the adults in the combined samples from Magdalen Islands and from southwestern Newfoundland respectively (see Table 1). A chi-square test for homogeneity showed no significant difference between areas (P = 0.10) insofar as the ratio of spring to autumn spawners is concerned.

Length and age

The relative length and age compositions by spawning groups are shown in Fig. 2. Although differences between spring (S) and autumn (A) spawners within areas are obvious, the frequency pattern is similar for the same spawning groups between areas.

The modal length group for spring spawners in both areas is 32 cm and for autumn spawners is 34 cm. The mean length for autumn spawners from both areas is 33.3 cm. Spring spawners at Magdalen Islands were slightly smaller (31.8 cm) than those from Newfoundland (32.3 cm). The difference (significant at P = 0.05 but not at P = 0.01) is due largely to the presence in the Magdalen Islands samples of more fish less than 30 cm in length (Fig. 2).

The age composition data (Fig. 2) show a mode at age VIII for the spring spawners and age IX (assuming that age X+ fish are distributed over several age-groups of age X and greater) for autumn spawners. The similarity of the age frequency data from both areas is striking, especially for autumn spawners in which the VIII group from each area is less abundant than the VII and IX age-groups.

Because of the grouping of ages greater than IX into an age X+ category statistical procedures based on the assumption of normality are not valid. A non-parametric test, considered suitable for comparing two frequency distributions, without the assumption of normality, is the Kolmogorov-Smirnov 2-sample test as described by Siegel (1956). This test is claimed to be more powerful in all cases than the chi-square test and to have a power-efficiency greater than 90% when compared with the *t*-test. While the difference between spring and autumn spawners was found to be highly significant (P < 0.01) for both areas, the difference between areas for the same spawning group was not significant (P > 0.05).

Meristics

Frequency distributions of the four meristic characters examined are shown in Fig. 3. Differences between means for spring and autumn spawners within each area and between areas for each spawning group were tested for statistical significance using the *t*-test at P = 0.05 (Table 2).

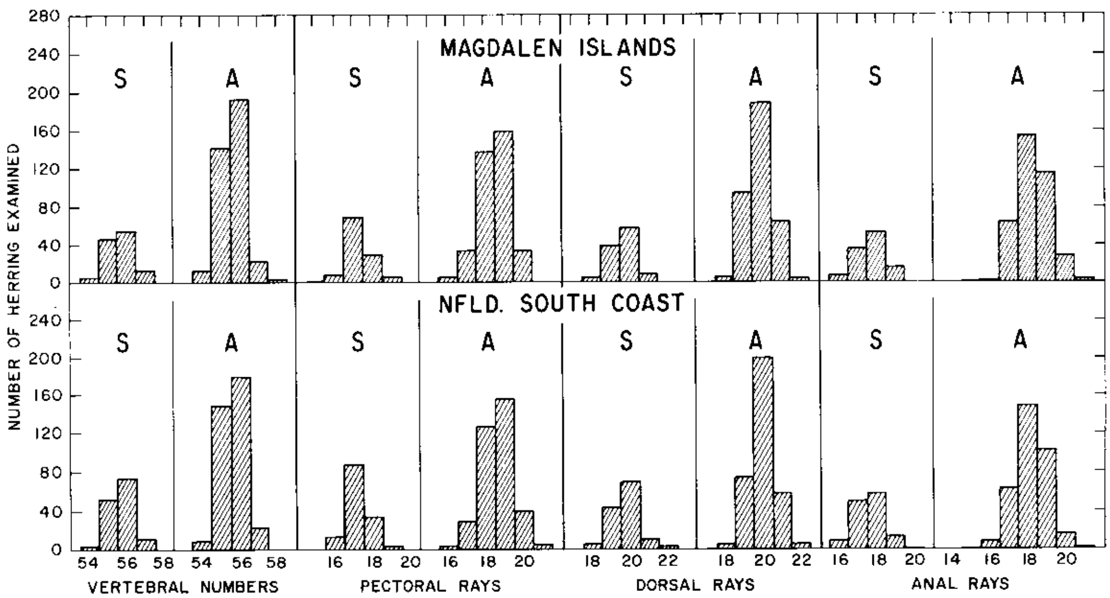

Fig. 3. Frequency distributions of vertebrae, pectoral rays, dorsal rays, and anal rays by spawning group and area.

TABLE 2. Summary of statistical analyses for herring samples taken at Magdalen Islands and southwestern Newfoundland during the 1969 autumn fishery. (MI = Magdalen Islands; SN = southwestern Newfoundland; P = probability of random occurrence.).

Biological character	Area	Spring spawners between areas Mean	Spring spawners between areas P	Autumn spawners between areas Mean	Autumn spawners between areas P	Between spawning groups within areas P
Length (cm)	MI	31.81	<0.05	33.31	>0.05	<0.01
	SN	32.27	>0.01	33.28		<0.01
Age (years)	MI	7.82 +	>0.05	8.73 +	>0.05	<0.01
	SN	8.17 +		8.67 +		<0.01
Vertebrae	MI	55.65	>0.05	55.62	>0.05	>0.05
	SN	55.64		55.61		>0.05
Pectoral rays	MI	17.28	>0.05	18.49	>0.05	<0.01
	SN	17.18		18.59		<0.01
Dorsal rays	MI	19.63	>0.05	19.89	>0.05	<0.01
	SN	19.70		19.95		<0.01
Anal rays	MI	17.69	>0.05	18.30	>0.05	<0.01
	SN	17.58		18.17		<0.01
Anisakis incidence	MI	30.8%	>0.05	32.8%	>0.05	–
	SN	42.3%		32.8%		–
Anisakis intensity	MI	0.41	>0.05	0.57	>0.05	–
	SN	0.59		0.48		–

Although several European workers (Einarsson, 1951; Wood, 1936; Johansen, 1924; and others) have found significant differences between the mean vertebral counts of spring and autumn spawners in the Northeast Atlantic, Tibbo (1957), Day (1957), and Jean (1956) concluded that spring and autumn spawners in the southern Gulf of St. Lawrence did not differ in mean vertebral count. Similarly our results show that mean vertebral counts do not differ between spring and autumn spawners sampled at the Magdalen Islands and along southwestern Newfoundland, nor was there any difference between areas.

Comparisons of fin ray counts for herring from the Newfoundland south coast and Magdalen Islands by spawning groups showed no significant differences between areas. However, within areas the mean pectoral, dorsal, and anal fin ray counts were significantly higher for autumn spawners than for spring spawners. The greatest difference (an average of 1.21 rays) was found in the pectoral fin ray counts, while the differences between autumn and spring spawners were 0.60 and 0.26 for the anal and dorsal counts respectively.

Parasites

Herring from both the Northwest and Northeast Atlantic Ocean and from the Northeast Pacific Ocean are infected with larval nematodes of the genus *Anisakis;* the incidence of infestation by this parasite has been used as a means of separating herring populations. Bishop and Margolis (1955) reported that British Columbia herring were frequently infected with *Anisakis* larvae and that the level of infection varied with area. Sindermann (1957) used larval nematodes as well as other parasites to distinguish populations of herring in the western

North Atlantic. Khalil (1969) investigated the occurrence of *Anisakis* larvae in herring from British coastal waters and found that infection increased with increase in fish length (age) and varied with locality.

Herring from Magdalen Islands and southwestern Newfoundland were examined to determine the incidence and intensity of infestation with *Anisakis* larvae. Practically all of the nematodes occurred free in the body cavity, encapsulated on the mesenteries, or were coiled in spirals against the intestine or the posterior extension of the stomach. Figure 4 shows the level of infection by age and the frequency distribution by spawning group for both areas. The Kolmogorov-Smirnov two-sample nonparametric test (Siegel, 1956) was used to determine whether the frequency distributions of infected fish and of nematodes by length and age differed between areas; no significant area differences were found ($P > 0.05$). Subsequent tests were performed without regard for length or age.

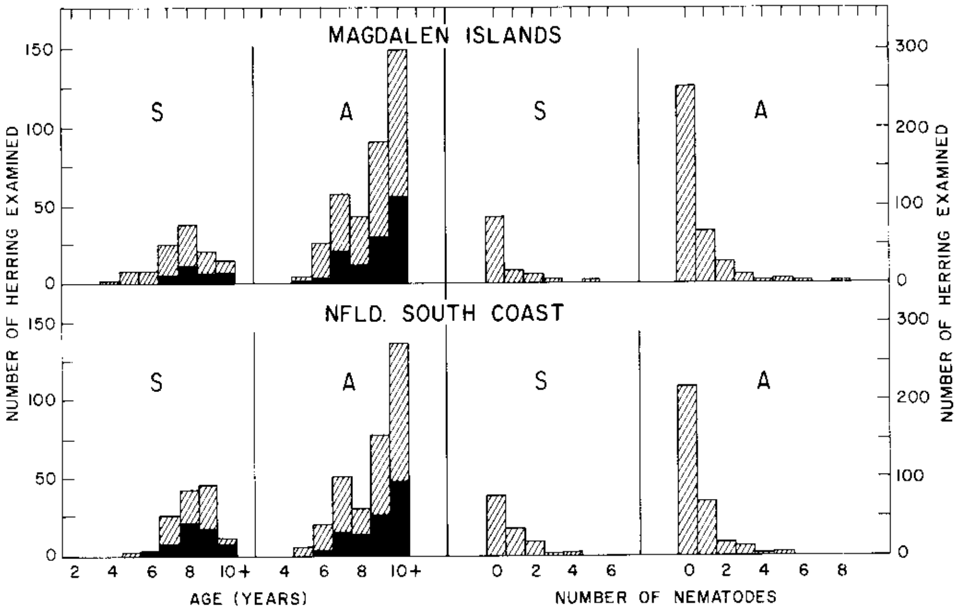

Fig. 4. Frequency distributions of infected herring by age-groups (left) and of the number of nematodes (right) by spawning group and area. (In the left half of the diagram the solid bars represent the numbers of infected fish and the cross-hatched portions the numbers of herring with no nematodes.)

In both areas none of the spring and autumn spawners less than 31 cm in total length were infected. Overall incidence in spring spawners was 30.8% for Magdalen Islands and 42.3% for southwestern Newfoundland. Autumn spawners from both areas had the same level of infection (32.8%). A chi-square test at $P = 0.05$ indicated that there were no significant area differences in the level of infection by spawning groups.

The intensity of infestation was generally low in both areas. In spring spawners the average number of nematodes per herring examined was 0.41 for Magdalen Islands and 0.59 for southwestern Newfoundland; for autumn spawners the corresponding values were 0.57 and 0.48. With spawning groups tested separately by chi-square, the frequency distributions of larval nematodes were not significantly different between areas ($P > 0.05$).

The intensity of infection was much lower in our samples than in herring from British coastal waters (33.1 larvae per fish with 30-50 larvae per herring being frequent) as reported by Khalil (1969). Herring from the west of Scotland and the northwest of Ireland (3.2 and 1.6 nematodes per fish respectively) were considered to have a low level of infection. Thus it appears that the very low intensity of *Anisakis* larvae in herring from southwestern Newfoundland and the Magdalen Islands poses a negligible problem in the utilization of herring for human consumption.

Conclusions

For all characters tested statistically, except vertebral counts, the differences between spring and autumn spawners within areas were highly significant (Table 2). With the spawning groups considered separately the between-area comparisons revealed no significant differences except for length of spring spawners, which was significantly different at P = 0.05 but not at P = 0.01. This difference is due largely to the presence of slightly more small herring in the Magdalen Islands samples than in the samples from southwestern Newfoundland (Fig. 2). On the basis of these analyses we conclude that the samples taken at Magdalen Islands and along southwestern Newfoundland were derived from the same stock complex and that the winter fishery along southwestern Newfoundland is largely dependent on herring concentrations which migrate eastward out of the southern part of the Gulf of St. Lawrence in the autumn.

Subsequent to this study herring were tagged in the inshore waters of southwestern Newfoundland in early March 1970, and, after the termination of the Newfoundland fishery about mid-April, recaptures were made at Magdalen Islands (Hodder and Winters, MS, 1970) and as far west as the Gaspe Peninsula, thus confirming the westward movement of the herring schools after they leave the Newfoundland coast in the spring.

References

BISHOP, Y. M. M., and L. MARGOLIS. 1955. A statistical examination of *Anisakis* larvae (Nematoda) in herring *(Clupea pallasi)* of the British Columbia coast. *J. Fish. Res. Bd. Canada*, **12**(4): 571-592.

BOYAR, H. C. 1968. Age, length, and gonadal stages of herring from Georges Bank and the Gulf of Maine. *Res. Bull. int. Comm. Northw. Atlant. Fish.*, No. 5, p. 49-61.

DAY, L. R. 1957. Populations of herring in the southern Gulf of St. Lawrence. *Bull. Fish. Res. Bd. Canada*, No. 111, p. 121-137.

EINARSSON, H. 1951. Racial analysis of Icelandic herring by means of otoliths. *Rapp. Cons. Explor. Mer*, **128**: 55-74.

HODDER, V. M. 1966. Recent herring investigations in Newfoundland waters. (Proceedings Canadian Atlantic Herring Fishery Conference, Fredericton, N.B., May 5-7, 1966.) *Canadian Fish. Rep.*, No. 8, p. 39-54.

1969. Herring Landings and distribution of catches in Newfoundland, 1967-68. *Fish. of Canada*, **22**(4): 3-6.

HODDER, V. M., and G. H. WINTERS. MS, 1970. Preliminary results of herring tagging in southwestern Newfoundland, March 1970. *Annu. Meet. int. Comm. Northw. Atlant. Fish.*, 1970, Res. Doc. No. 89, Serial No. 2440, 2 p.

HOURSTON, A. S. MS, 1968. Age determination of herring at the Biological Station, St. John's, Newfoundland. *Fish. Res. Bd. Canada, Tech. Rep.*, No. 49, 24 p.

HOURSTON, A. S., and L. S. PARSONS. MS, 1969. Opaque and hyaline otolith nuclei as indicators of spring and autumn spawning herring in Newfoundland waters. *Fish. Res. Bd. Canada, Tech. Rep.*, No. 138, 26 p.

ICES. 1963. Report of Herring Committee. App. I. Recommendations adopted by the Herring Committee concerning routine methods and the reporting of herring biological data in the ICES area. *Rapp. Cons. Explor. Mer*, 1962, p. 71-73.

ICNAF. 1964. Report of Standing Committee on Research and Statistics. App. I. Report of ad hoc group on herring and other pelagic fish. *Int. Comm. Northw. Atlant. Fish., Redbook 1964*, Part I: 23-30.

JEAN, YVES. 1956. A study of spring and fall spawning herring *(Clupea harengus L.)* at Grande-Rivière, Bay of Chaleur, Quebec. *Quebec Dept. Fish.*, Contr. No. 49, 76 p.

JOHANSEN, A. C. 1924. On the summer and autumn spawning herrings of the North Sea. *Medd. Komm. Havundersøg. Kbh., (Fisk.)*, 7(5): 1-119.

KHALIL, L. F. 1969. Larval nematodes in the herring *(Clupea harengus)* from British coastal waters and adjacent territories. *J. mar. biol. Ass. U.K.*, **49**: 641-659.

MESSIEH, S. N. 1969. Similarity of otolith nuclei in spring- and autumn-spawning Atlantic herring in the southern Gulf of St. Lawrence. *J. Fish. Res. Bd. Canada*, **26**(7): 1889-1898.

SIEGEL, SIDNEY. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Co. Inc., New York, 312 p.

SINDERMANN, C. J. 1957. Diseases of fishes of the western North Atlantic. V. Parasites as indicators of herring movements. *Res. Bull. Dep. Sea Fish. Me*, 27, 30 p.

TIBBO, S. N. 1957. Herring of the Chaleur Bay area. *Bull. Fish. Res. Bd. Canada*, No. 111, p. 85-102.

TIBBO, S. N., S. N. MESSIEH, and C. D. BURNETT. MS, 1969. Catch statistics, length and age composition Gulf of St. Lawrence herring. *Fish. Res. Bd. Canada, Tech. Rept.*, **139**: 81 p.

WOOD, H. 1936. Race investigations of the herring populations of Scottish waters. *Rep. Fish. Bd Scot. sci. Invest. 1936*, No. 3, 52 p.

Some Biological Features of Southwest Newfoundland and Northern Scotian Shelf Herring Stocks

By V. M. Hodder[1,2] and L. S. Parsons[1]

Abstract

In an attempt to clarify the relationship between southwest Newfoundland-southern Gulf of St. Lawrence herring stocks and those which frequent the northern part of the Scotian Shelf, herring samples taken during the 1971 winter purse-seine fishery along southwest Newfoundland and in April near St. Paul Island were compared with similar material obtained in February and March 1971 from Chedabucto Bay, Canso Bank, and Banquereau, using such biological characteristics as size and year-class composition, maturity condition, vertebral numbers, pectoral and anal fin-ray counts, gillraker numbers, and parasite incidence.

Considerable between-area variation is evident for such characters as the size and age composition and the ratio of spring- to autumn-type spawners. However, the analyses of data on the incidence and intensity of the larval nematode *Anisakis* in herring from the various areas, supported by differences in pectoral fin-ray and gillraker numbers, indicate that the southern Gulf of St. Lawrence stocks, which migrate seasonally from as far west as the Gaspé Peninsula to overwinter in the fjords along southwest Newfoundland, do not intermingle to any great extent with herring concentrations fished in winter by Canadian vessels in the Chedabucto Bay-Canso Bank area and by European vessels on Banquereau. It is also concluded that the herring samples taken on Canso Bank and on Banquereau were derived from the same stock.

Introduction

The study of Hodder and Parsons (1971), involving the analysis of data from herring samples taken at Bird Rocks, just north of the Magdalen Islands in the Gulf of St. Lawrence, and in the fjords of southwest Newfoundland, revealed no differences that could be construed as indicating that the samples were drawn from different populations. This together with data on the seasonal nature of the herring fishery (Hodder, 1969) suggested the hypothesis that a substantial portion of the stock complex of herring, which spawn and feed in the southern Gulf of St. Lawrence from spring to autumn, migrates eastward via the Magdalen Islands to overwinter in the fjords along southwest Newfoundland. Iles and Tibbo (1970) hypothesized that the spring influx of herring into the Gulf of St. Lawrence in April involves fish which in winter are exploited in Chedabucto Bay by Canadian vessels and also on Banquereau by European fleets, especially those of USSR, Poland, and the Federal Republic of Germany. However, recent data on the incidence and intensity of the larval nematode *Anisakis* in herring (Parsons and Hodder, 1971) suggest a relationship between Chedabucto Bay and Banquereau herring but that these may not be closely related to the southern Gulf of St. Lawrence-southwest Newfoundland stock complex.

The east-west seasonal migration of herring between the southern Gulf of St. Lawrence and southwest Newfoundland has recently been confirmed by tagging experiments undertaken during 1970 (Hodder and Winters, MS, 1970; Winters, 1970, MS, 1971; Beckett, MS, 1971). The absence of a Canadian offshore fishery for herring on the Scotian Shelf and the lack of facilities on board of European vessels, which fish there, to recover magnetic metal tags have thus far restricted our knowledge on herring migration routes, based on tag recaptures, to stocks exploited inshore by Canadian vessels.

In March 1971 herring samples were obtained from Canso Bank and Banquereau on the northern part of the Scotian Shelf. In this study biological data from these samples are compared with similar data from herring samples collected during the winter and spring of 1971 from Chedabucto Bay, St. Paul Island, and southwest Newfoundland.

Materials and Methods

The Canso Bank and Banquereau herring samples were taken during a cruise of the midwater trawler *J. B. Nickerson*, which was chartered by the Fisheries Research Board of Canada for the period 15-28 March 1971, to assess the distribution and abundance of herring on the Scotian Shelf. Five hundred specimens were randomly selected for detailed examination from the catches in each area. The southwest Newfoundland specimens, used for comparison, represent a random selection of ten 50-specimen samples from a much larger collection taken during the winter purse-seine fishery in the fjords along the western half of the south coast. The

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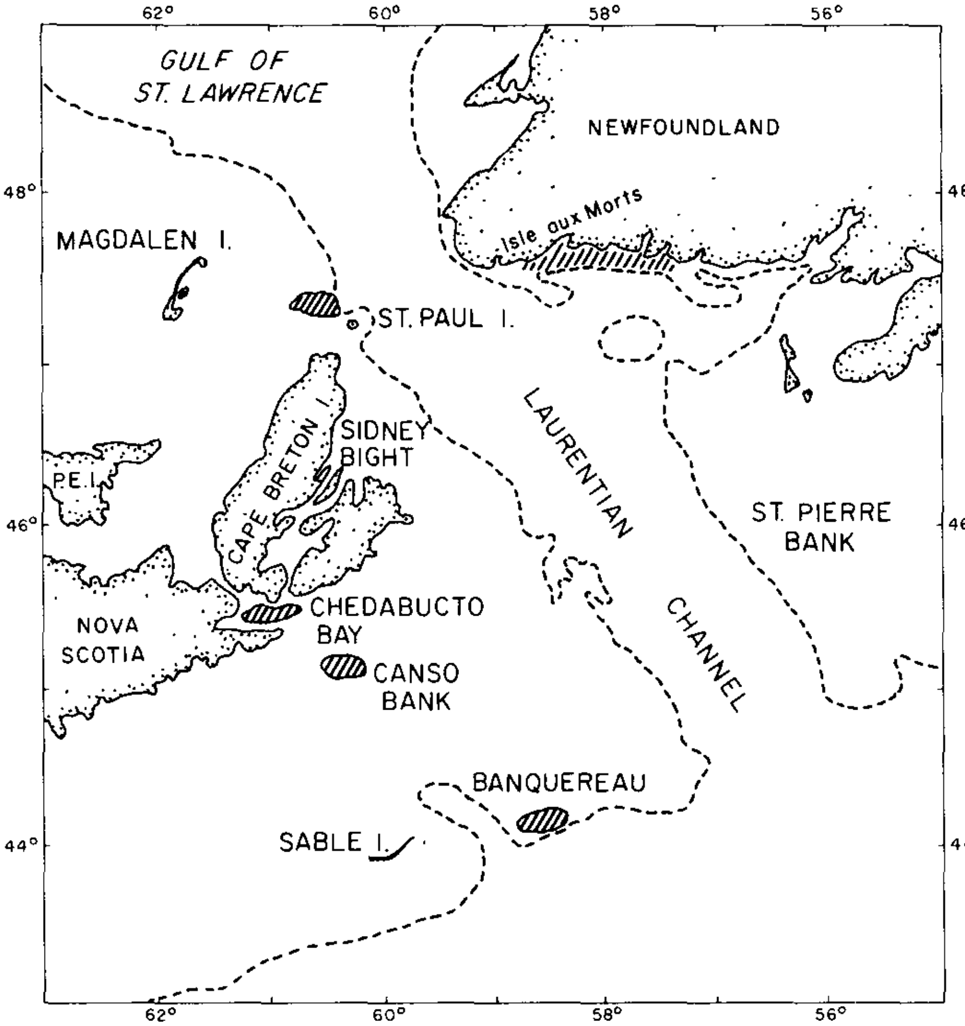

Fig. 1. Map of southwest Newfoundland and the northern part of the Scotian Shelf showing the areas from which herring samples used in this study were obtained.

St. Paul Island samples (250 specimens) were taken in April from purse-seine catches during the spring influx of herring into the Gulf of St. Lawrence. The latter two groups of samples were obtained from vessels landing their catches at Isle aux Morts, Newfoundland, as were also the samples of juvenile herring (200 specimens) taken in Chedabucto Bay. Areas of capture are shown in Fig. 1.

Length compositions are based on the grouping of total length measurements, initially recorded in millimeters, into 1-cm intervals to the 0.5 cm below, i.e. all herring in the size range 300-309 mm are grouped in the 30-cm length interval. Age compositions are based on otolith readings according to the standard procedure for many species of fish. Because of the unreliability of age determination in the old fish, specimens greater than 10 years old are grouped into a 10+ category.

The maturity condition of the gonads is based on the classification into the various maturity stages as adopted by ICNAF (1964). The absence of stages 5-7 in the samples facilitated the classification of the adults as spring or autumn spawners based on gonad development: those classed as stages 3 and 4 (mostly 4) were designated as possible spring spawners and stage 8 as autumn spawners. Immature herring (juveniles classed as stages 1 and 2) were assigned to spring or autumn spawning type by otolith characteristics (L. S. Parsons, unpublished data).

Meristic comparisons are based on fin-ray, gillraker, and vertebral numbers. The number of rays in the left pectoral and anal fins and the number of gillrakers on the lower branch (hypobranchial and ceratobranchial) of the first left gill arch were counted with the use of a binocular microscope. Vertebral counts, excluding the hypural plate, were determined from radiographs. All pectoral fin rays and all rakers on the lower limb of the first left gill arch, including rudimentary rakers and rakers in the bend of the arch were counted. In the anal fin the last split rays originating from the same base were counted as one.

The nematode incidence (percentage of the specimens containing nematodes) and the nematode intensity (average number of nematodes per fish examined) are based on the number of larval nematodes found on the viscera and in the body cavity. Previous examination of several hundred herring revealed that less than 1% of the nematodes occurred in the musculature, and consequently our nematode studies have been limited to the much less time-consuming examination of the body cavity and its contents.

Results

Size and age composition

Like the southwest Newfoundland herring, the Banquereau sample consisted almost entirely of adult herring mostly in the length range of 32-38 cm with a distinct mode at 36 cm compared with 35 cm for Newfoundland fish (Fig. 2). Autumn spawners constituted nearly 99% of the Banquereau specimens compared with 77% of those from southwest Newfoundland. The year-class compositions of both groups are remarkably similar with about 60% of the herring belonging to pre-1961 year-classes.

Most of the Canso Bank herring were in the length range of 26-35 cm with the majority of those below 31 cm classed as immature. Eighty-three percent of the specimens were classed as autumn spawners. The 1966 and 1963 year-classes are dominant and together constituted 50% of the sample. The same 2 year-classes, although not very prominent in the Banquereau sample as a whole, are the most abundant of those since 1963.

While the St. Paul Island herring fall within the same length range as the Canso Bank fish, unlike the latter they consisted largely of spring spawners (81%) and the dominant year-class is 1965.

The Chedabucto Bay samples consisted entirely of juveniles of the 1968 and 1969 year-classes, and, as far as could be judged from otolith patterns, all were classed as autumn-type spawners.

Meristic characters

There is insufficient between-area variation in mean vertebral numbers of both autumn and spring spawners to indicate that the herring stocks of the five areas are heterogeneous or even to suggest a relationship between two or more of the stocks (Fig. 3).

The mean pectoral and anal fin-ray and gillraker numbers are higher for autumn spawners than for spring spawners of the three areas in which the latter were adequately represented in the samples, with the pectoral fin-ray and gillraker numbers exhibiting the greatest degree of difference. The unusually low average gillraker number for Chedabucto Bay juveniles (autumn-type spawners) is attributable to the fact that the full complement of gillrakers is generally not acquired in Atlantic herring until they approach sexual maturity, after which the correlation between gillraker number and fish length is insignificant (Kreft, 1954, 1958).

For autumn spawners the between-area variation in fin-ray and gillraker numbers (except Chedabucto Bay) is not great, although St. Paul Island and southwest Newfoundland herring exhibit slightly lower mean gillraker numbers than Banquereau and Canso Bank fish. For spring spawners, on the other hand, Canso Bank herring have significantly higher pectoral fin-ray and gillraker numbers than St. Paul Island and southwest Newfoundland fish.

Nematode incidence and intensity

For Canso Bank herring the nematode incidence increases rapidly from about 15% for 27-cm fish to over 90% for herring larger than 33 cm in total length (Fig. 4B). Similarly for Banquereau fish the incidence is over 60% for 30-cm herring and increases to more than 90% for fish larger than 35 cm. In contrast, St. Paul Island and southwest Newfoundland herring exhibit a more gradual increase from about 15% at 30 cm to 60% for 36- and 37-cm fish.

The nematode intensity (Fig. 3A) likewise increases with fish size for both Canso Bank and Banquereau herring. The high value for Canso Bank herring at 35 cm is due to the influence of a single specimen with 44 nematodes, whereas most of the specimens contained less than 10 nematodes. The nematode intensity also increases rapidly for Banquereau herring, particularly for the larger sizes of fish. In contrast, the St. Paul Island and southwest Newfoundland herring have an average of less than one nematode per fish for all sizes up to 35 cm.

Nematodes were found in only 2 specimens of the 200 herring comprising the Chedabucto Bay samples of juveniles.

Discussion and Conclusions

Parsons and Hodder (1971) demonstrated the usefulness of the incidence of the larval nematode *Anisakis* in herring as a possible indicator of stock heterogeneity, particularly in regard to the southwest Newfoundland-southern Gulf of St. Lawrence stock complex, for which the nematode incidence ranged from

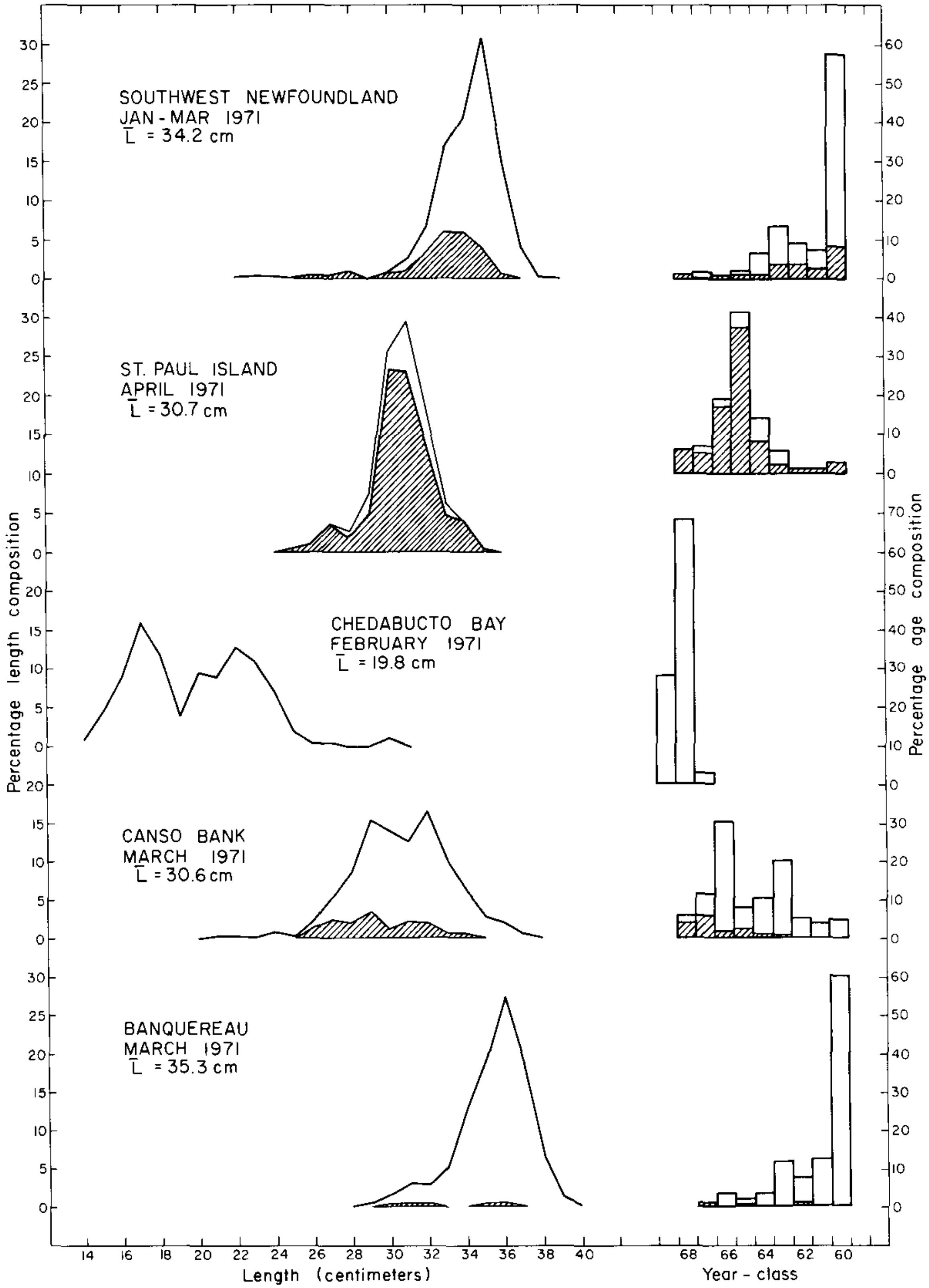

Fig. 2. Size and year-class composition of herring taken along southwest Newfoundland, near St. Paul Island and on the Scotian Shelf during the winter and spring of 1971. The shaded portions represent the distribution of spring spawners.

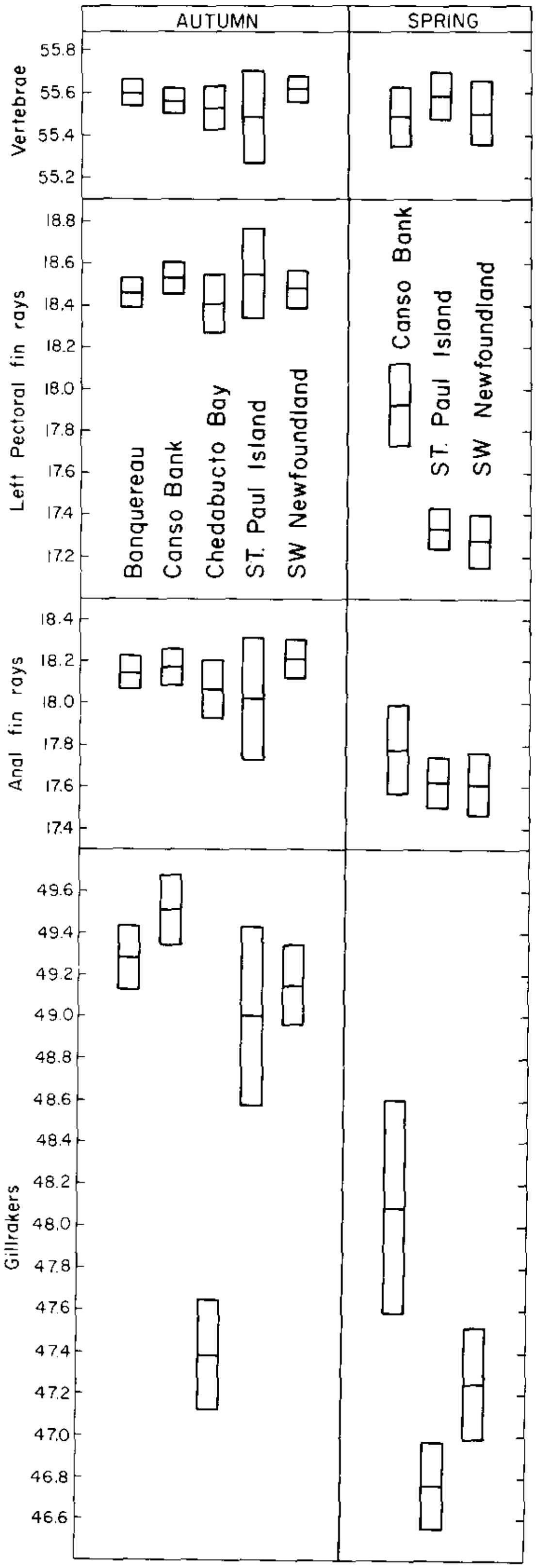

Fig. 3

25 to 30% for herring samples taken at various points along the migration route between southwest Newfoundland in winter and the Gaspé Peninsula in summer. They also suggested that Banquereau and Chedabucto Bay herring (64-66% incidence) were probably closely related, but the substantially higher nematode incidence in those areas, although based on only a few specimens, indicated little, if any, relationship with the more northerly stocks.

The analysis of data from recently acquired samples from southwest Newfoundland, St. Paul Island and the northern part of the Scotian Shelf tend to support the above-mentioned hypothesis in two ways: (1) The mean pectoral fin-ray and gillraker numbers in spring spawning herring from Canso Bank are significantly higher than those in herring from St. Paul Island and southwest Newfoundland; (2) More significant, however, is the similarity of the nematode incidence versus fish length curves for Canso Bank and Banquereau herring, and likewise for the nematode intensity curves, contrasted with the incidence and intensity curves for St. Paul Island and southwest Newfoundland.

Since the accumulation of larval nematodes in herring is obviously a function of the size (and hence age) of the fish (Parsons and Hodder, 1971), the usefulness of this biological character as a means to differentiate between stocks must be considered in relation to the size (or age) frequencies of the samples used for comparison. The overall percentage incidence values for Canso Bank and Banquereau herring (65 and 90%) must be considered in this light. For southwest Newfoundland herring the higher overall incidence (45%) in the samples used for this study than that (30%) in the samples examined during the 1969 and 1970 winter fisheries (Parsons and Hodder, 1971) is due to the fact that the average length of herring in the 1971 samples was 34.2 cm compared with 33.5 cm for the 1969 and 1970 data.

Although the length and age frequency distributions of the Chedabucto Bay, Canso Bank, and Banquereau herring samples are distinctly different, this does not preclude the possibility of the existence on the northern part of the Scotian Shelf of a stock of herring, most of the adults of which overwinter offshore on Banquereau and the younger herring closer to shore in the Canso Bank-Chedabucto Bay area, where a winter fishery on small herring has recently developed. To what

Fig. 3. Average numbers of vertebrae, pectoral fin rays, anal fin rays, and gillrakers in autumn and spring spawning herring taken during the winter and spring of 1971 from Banquereau, Canso Bank, Chedabucto Bay, St. Paul Island, and southwest Newfoundland. (Each vertical bar represents the mean plus and minus 2 standard errors.)

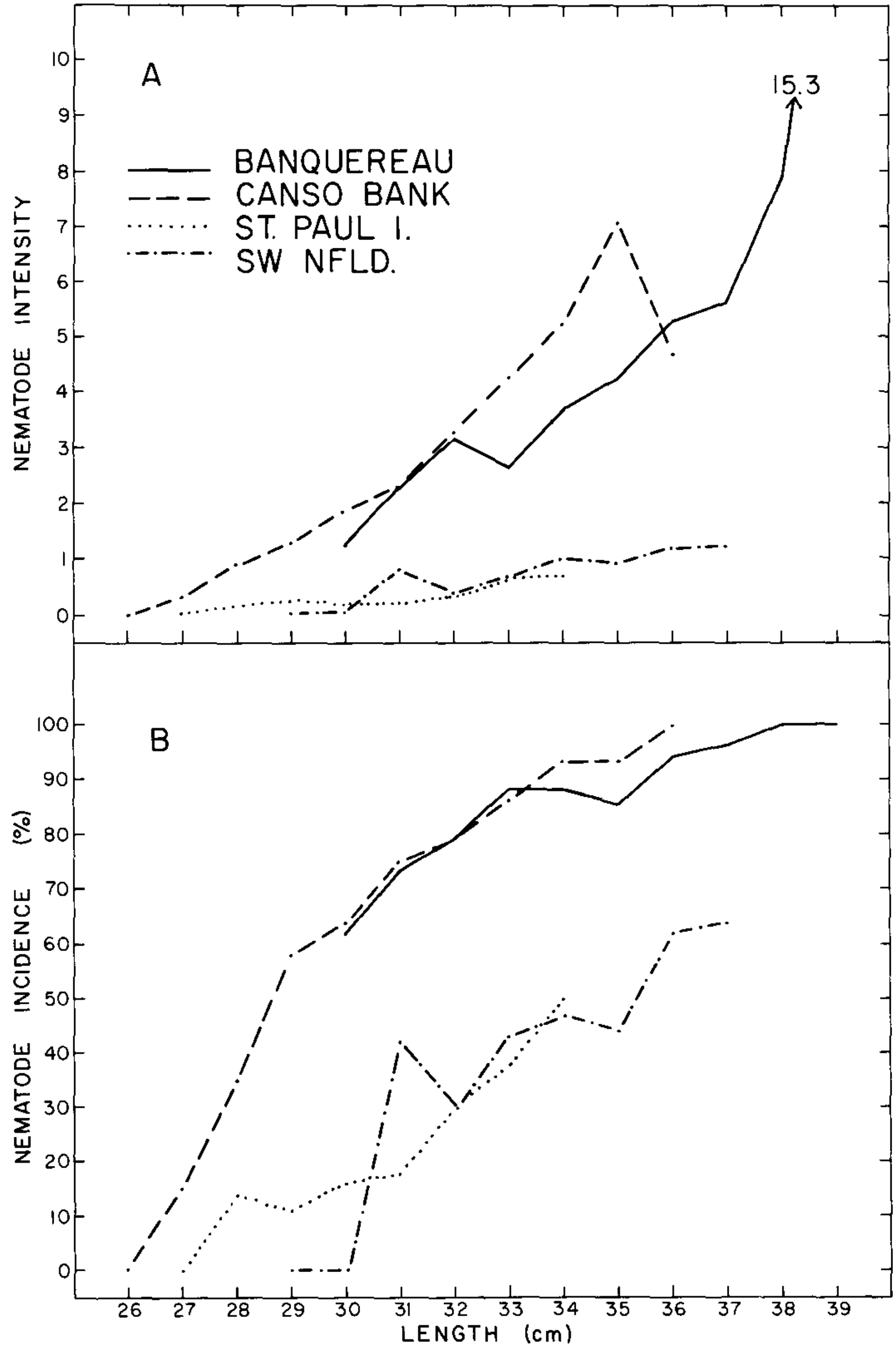

Fig. 4. Nematode intensity (A) and incidence (B) in herring taken on the Scotian Shelf, near St. Paul Island and along southwest Newfoundland during the winter and spring of 1971.

extent the adults migrate seasonally is presently unknown, but it is probable that the overwintering concentrations on Banquereau disperse to feed in the warm near-surface water layer during the summer and, since most are autumn-type spawners, spawn near the shore and on the shallow parts of the Scotian Shelf in early autumn. The coastal waters in the vicinity of Chedabucto Bay are probably the nursery grounds for the juveniles resulting from these autumn spawnings.

The extent of mixing of southern Gulf of St. Lawrence and southwest Newfoundland herring with those probably resident on the northern part of the Scotian Shelf is unknown, but the absence of tag recaptures in the 1971 winter fishery in and near Chedabucto Bay, despite the fact that more than 80,000 herring were tagged during March-August 1970 in southwest Newfoundland and the southern Gulf of St. Lawrence (Winters, MS, 1971; Beckett, MS, 1971), suggests that little, if any, mixing occurs. If, in addition to migrating to southwest Newfoundland in autumn, southern Gulf of St. Lawrence herring migrate eastward around the northern tip of Cape Breton, it is unlikely that they go much farther southward than the Sidney Bight area.

The spring influx of herring into the southern Gulf of St. Lawrence, as represented by the St. Paul Island samples taken in April 1971, probably indicates the movement of herring from the Sidney Bight area towards the Magdalen Islands, where substantial spring spawning occurs in late April and early May. These samples differ from the northern Scotian Shelf samples in age composition, proportion of spring-type spawners, mean fin-ray and gillraker numbers and nematode incidence. They are different from southwest Newfoundland herring only in age composition and proportion of spring spawners, both factors of which may vary according to the area and time of capture for the same stock complex. In the previous spring (1970) the April fishery near St. Paul Island yielded on the average considerably larger and older herring, and during a brief 2 week fishery there 51 tags were recovered from herring which 4-6 weeks earlier were tagged in the fjords of southwest Newfoundland (Winters, 1970).

Acknowledgements

We are indebted to officials at the Isle aux Morts herring plant who provided space for sampling and permitted the frequent sampling of purse-seiner landings. We thank the captain of the midwater trawler *J. B. Nickerson* without whose cooperation and enthusiam during the March 1971 herring cruise the acquisition of the Canso Bank and Banquereau herring samples would probably have not been achieved. We are also grateful to the technicians, assigned to the Pelagic Fish Division of the St. John's Biological Station, especially Messrs C. I. Barbour, R. Chaulk, and R. Sullivan, who assisted with the examination of the specimens, meristic counts, age determination and subsequent analysis of the data. Mr C. Monaghan of the St. Andrews Biological Station participated in the *J. B. Nickerson* cruise and assisted with the collection of the samples.

References

BECKETT, J. S. MS, 1971. Interim report of herring tagging in the Gulf of St. Lawrence, 1970. *Annu. Meet. int. Comm. Northw. Atlant. Fish. 1971,* Res. Doc. No 95, Serial No. 2565 (mimeographed).

HODDER, V. M. 1969. Herring landings and distribution of catches in Newfoundland, 1967-68. *Fish. of Canada,* 22(4): 3-6.

1971. Status of the southwest Newfoundland herring stocks, 1965-70. *Int. Comm. Northw. Atlant. Fish., Redbook 1971,* Part III (In press).

HODDER, V. M., and L. S. PARSONS. 1971. Comparison of certain Biological characteristics of herring from Magdalen Islands and southwest Newfoundland. *Res. Bull. int. Comm. Northw. Atlant. Fish.,* this volume, p. 59-65.

HODDER, V. M., and G. H. WINTERS. MS, 1970. Preliminary results of herring tagging in southwestern Newfoundland, March 1970. *Annu. Meet. int. Comm. Northw. Atlant. Fish. 1970,* Res. Doc. No. 89, Serial No. 2440 (mimeographed).

KREFT, G. 1954. Die Zahl der Kiemreusenfortsätze als Hilsmittel bei morphologischen Hering-suntersuchungen. *Ber. dtsch. Komm. Meeresforsch,* 13: 298-309.

1958. Counting of gillrakers as a method of morphological herring investigations. *Rapp. Cons. Explor. Mer,* 143:22-25.

ICNAF. 1964. Report of Standing Committee on Research and Statistics. App. I. Report of *ad hoc* group on herring and other pelagic fish. *Int. Comm. Northw. Atlant. Fish., Redbook 1964,* Part I, p. 23-30.

ILES, T. D., and S. N. TIBBO. 1970. Recent events in Canadian Atlantic herring fisheries. *Int. Comm. Northw. Atlant. Fish., Redbook 1970,* Part III: 134-147.

PARSONS, L. S., and V. M. HODDER. 1971. Variation in the incidence of larval nematodes in herring from Canadian Atlantic waters. *Res. Bull. int. Comm. Northw. Atlant. Fish.,* this volume, p. 5-14.

WINTERS, G. H. 1970. Preliminary results of herring tagging in southwest Newfoundland coastal waters. *Fish. Res. Bd. Canada, St. John's Biol. Sta.* Circ. No. 18, p. 20-24.

MS, 1971. Migrations of the southwest Newfoundland stock of herring as indicated by tag recaptures. *Annu. Meet. int. Comm. Northw. Atlant. Fish. 1971,* Res. Doc. No. 108, Serial No. 2591 (mimeographed).

Virtual Population Assessment of ICNAF Division 2J Cod

By A. T. Pinhorn[1]

Abstract

Fishing mortality estimates (F) for ICNAF Division 2J cod increased from 0.06 in 1959 to 0.36 in 1961 and 0.38 in 1962 and then decreased to a level of 0.28 to 0.38 during 1963-68, except for 1965 when F increased to 0.57 for 1 year only. Cod are fully recruited to the gear in the area at 8 years of age and 50% recruited at about 6 years of age with insignificant numbers of 2- and 3-year-old fish being taken.

The numbers of older fish in the stock (7+) have declined in recent years. However, the total stock seems to have increased in 1966-68 because of better recruitment from year-classes of the early 1960's. Yield per recruit calculations indicate the level of fishing in 1961-68 to have been within 92-98% of the maximum sustained yield.

Correlation of fishing mortality estimates and fishing effort indicated that the assumed value of natural mortality (M) was probably close to the true value.

Introduction

Because of increased concern for the state of the cod stocks in Subareas 2 and 3 as a result of increased fishing intensity in recent years, it was recommended at the 1970 ICNAF Annual Meeting that detailed assessments were necessary for these stocks of the type performed by the West Greenland Cod Working Group and presented by Schumacher (1970 *a*, *b*). As a result of this, assessments have been performed for cod in ICNAF Division 2J and are described in this report. This particular area was chosen first because the sampling data were more complete and it supports one of the most important cod fisheries in the ICNAF area.

Materials and Methods

The "virtual populations" method developed by Fry (1949, 1957) and modified by Gulland (1965) and Jones (1961, 1967) has been used to estimate F. The details of the method are described by Schumacher (1970 b). This method requires the total annual number in each age-group taken from a stock for a series of years. The period chosen for this study was 1959-69 and the basic data used were length frequencies, age-composition and age-length keys published in ICNAF Sampling Yearbooks for this period and the nominal catches published in ICNAF Statistical Bulletins for the same period. In addition age-length keys from Canada (Nfld.) research vessel cruises to the area during the period as well as those from the inshore fishery were also used to supplement or replace the Sampling Yearbook data.

Compilation of Length Composition of Otter Trawl Catches

The procedure used to obtain respresentative length compositions of the total catch by otter trawl in each year was identical to that used by Pinhorn and Wells (1970 *a*) for mesh assessment studies and is as follows: Total catches by country and quarter were obtained by applying appropriate discard rates to the landings of each country in each quarter for each year (Table 1). These discard rates were calculated from information supplied by member countries in Research Reports, Discard Documents, and various other documents throughout the period. In years where discard rates were unknown for a country they were estimated from known rates in other years for the same country or from rates for countries with related fishing practices or by using a rate of 5% which is close to the overall average for the period. From a knowledge of average weights of fish caught, total numbers caught could be calculated for each month, quarter, and year as needed for each country. Where these average weights were not supplied in the Sampling Yearbooks, they were calculated from average lengths by the length-weight relationship of May (1966 *a*). Per mille length frequencies for each country reporting frequencies for each month were then adjusted to numbers caught by that country in that month. These monthly frequencies were then combined by quarter for each country and the frequencies of all countries reporting then combined for the quarter. This frequency was then adjusted to the numbers caught by all countries in each quarter. Quarterly frequencies were combined to produce annual catch frequencies by all countries.

[1] Fisheries Research Board of Canada, Biological Station, St. John's, Newfoundland.

TABLE 1. Landings and catches by gear and country for ICNAF Division 2J, 1959-69. Discard rates in parentheses are assumed values based on best available data or an average of known values. In calculating discard rates it was assumed that Germany and Poland included industrial fish in nominal catches after 1965 and that USSR included industrial fish in all years. For other countries it was assumed that no industrial fish was produced in any year. Can (N) - Canada (Newfoundland); Non-m = Non-members of ICNAF.

	Otter trawl																
	UK	Germany	Iceland	USSR	Spain	France	Portugal	Can (N)	Poland	Non-m	Others	Total	No. mea-sure-ments	Countries with measure-ments	No. measured per 1,000 tons caught	Inshore gears Can(N)	Long-line
1959																17,533	
Landing	674	3,238	132	158	5,671	22,963	6,415			154		39,405		USSR			
% discard	(3)	(20)	(5)	0[a]	(1)	(2)	(1)	–	..	(5)		3.5	3,953	Spain	97		
Catch	695	4,048	138	158	5,729	23,431	6,480			162		40,841		Germany			
1960																15,418	
Landing	84	12,145		38,589	27,444	42,407	42,721	1		80	569	164,037		USSR			
% discard	(3)	(20)		0[a]	1	(2)	(1)	(5)		(5)	(5)	2.8	63,480	Spain	376		
Catch	87	15,182		38,589	27,717	43,272	43,153	1	–	84	599	168,684		Portugal			
1961																17,545	
Landing	1,264	10,184	4	108,883	40,826	35,504	46,149		358		1	243,173		USSR			
% discard	(3)	14.6	(5)	0[a]	1	2.1	1	–	(10)		(5)	1.4	24,259	Spain	98		
Catch	1,303	11,925	4	108,883	41,238	36,266	46,616	–	398		1	246,634		Portugal			
1962																23,424	
Landing	3,014	745		56,617	56,853	45,992	62,702	–	921			226,841		USSR			
% discard	(3)	19.5		0[a]	(1)	(2)	1.6	–	(10)			1.3	32,503	Spain	141		
Catch	3,104	926	–	56,617	57,427	46,931	63,721		1,023	–		229,749		Poland			
1963																23,767	
Landing	528	828	–	19,548	53,201	40,078	73,040	1	702			187,926		USSR			
% discard	(3)	20.2		0[a]	(1)	(2)	0.5	(5)	(10)	–	–	1.0	82,527	Portugal	434		
Catch	544	1,038	–	19,548	53,737	40,896	73,407	1	779			189,950		Poland			
1964																14,787	
Landing	1,609	3,207	91	56,548	42,705	35,919	38,095	13	2,058	8,642	300	189,187		USSR			
% discard	3	20.1	(5)	0[a]	1	3.3	1.2	(5)	(10)	(5)	(5)	1.9	115,945	Portugal, Poland	601		
Catch	1,658	4,014	96	56,548	43,136	37,144	38,558	14	2,287	9,097	316	192,868		Spain			
1965																25,117	
Landing	6,258	31,274	598	48,863	51,822	20,662	57,992		9,398	–	339	227,206		USSR			
% discard	(3)	18.5	(5)	0[a]	1	4	3		(10)		(5)	4.8	168,662	Portugal	706		
Catch	6,452	38,374	629	48,863	52,345	21,523	59,785	–	10,443		357	238,771					
1966																22,645	
Landing	7,021	36,395	208	26,005	13,839	25,395	36,530	39	17,866	27,745		221,043		USSR			
% discard	3	0.9	(5)	0[a]	1	3	2	(5)	3	(5)		2.0	84,842	Portugal	376		
Catch	7,238	36,725	219	26,005	14,281	26,180	37,275	41	18,419	29,205		225,588		France			
1967																26,359	2,367
Landing	7,280	21,047		14,366	36,178	23,616	46,845	1	28,592	34,403	22	212,350		USSR			
% discard	(3)	0.6		0[a]	1	3	1	(5)	0	(5)	(5)	1.7	184,031	Portugal, Spain	852		
Catch	7,504	21,175	.	14,366	36,543	24,347	47,317	1	28,592	36,213	23	216,080		Poland			
1968																12,804	8,016
Landing	9,826	47,868	–	83,478	32,852	38,587	51,485	4,166	51,301		186	320,049		USSR			
% discard	(3)	1		0[a]	0	3	2	2	0	–	(5)	1.0	47,929	Portugal, Spain	148		
Catch	10,130	48,352		83,178	32,852	39,780	52,536	4,557	51,301	–	196	323,182		Poland			
1969																4,328	
Landing	1,149	60,391		123,295	33,010	29,124	59,869	30	46,148		3,257	356,573		USSR			
% discard	(3)	1		0[a]	0	3	2	2	0		(10)	0.9	62,682	Portugal, Spain	174		
Catch	1,194	61,000	.	123,295	33,010	30,025	61,091	31	46,148		3,619	359,713		Poland, Germany			

[a]Dr A. S. Bogdanov, personal communication, VNIRO, Moscow, USSR.

Compilation of Numbers Caught at Each Age

Two methods were used to estimate numbers of cod caught at each age. The first of these was identical to that used by Wells and Pinhorn (1970) and is as follows: Per mille age compositions of otter trawl catches for each month and country reported in ICNAF Sampling Yearbooks were adjusted to numbers caught in that month by that country. These monthly age compositions were combined by quarters and adjusted to the numbers caught by all countries in each quarter. Quarterly age-compositions were then combined to produce the annual number caught per age-group. This method was used for the 1964-68 period. The second method was used for the entire 1959-69 period and consisted of applying the quarterly age-length keys of each country reported in Sampling Yearbooks to the quarterly length-composition of the otter trawl catches as derived above. In addition Canada (Nfld.) age-length keys from research vessel survey cruises and from samples from the inshore fishery by various gears were used where available. This method produced several estimates of the numbers caught at each age for some quarters and served as a means of validating the age-length keys from various sources. In quarters where no age-length keys were available other keys were used as follows: For the first quarter age-length keys from the second quarter were used if available; otherwise those from one of the adjacent years was used. For the fourth quarter keys from adjacent years were used. For the second and third quarters keys were available for all years except 1959 where 1960 keys had to be used for the third quarter. These quarterly age compositions of otter trawl catches were then compiled into annual compositions by combining minimum, maximum and average estimates of numbers caught at each age producing three sets of estimates of numbers caught at each age in each year. To these were then added the estimates of numbers caught by the Canada (Nfld.) inshore fishery as determined by applying age compositions averaged for all gears to the estimated number caught by this fishery in each year. The "virtual population" technique as modified by Jones (1967) was then applied to each of these estimates of numbers caught at each age to produce three series of estimates of F for the 1959-67 period.

Although no accurate value for M is available at present, age distributions in earlier years when fishing effort was low and calculations based on the change in effort from a low level to a high level (Silliman Method) indicate that M is probably in the vicinity of 0.2 (May, 1966*b*) and this figure was used in the present analysis. Based on this assumption a value of E of 0.7 and of E $(1\text{-}E^{-Z})$ of 0.342 for the oldest age-group was taken from Wells and Pinhorn (1970).

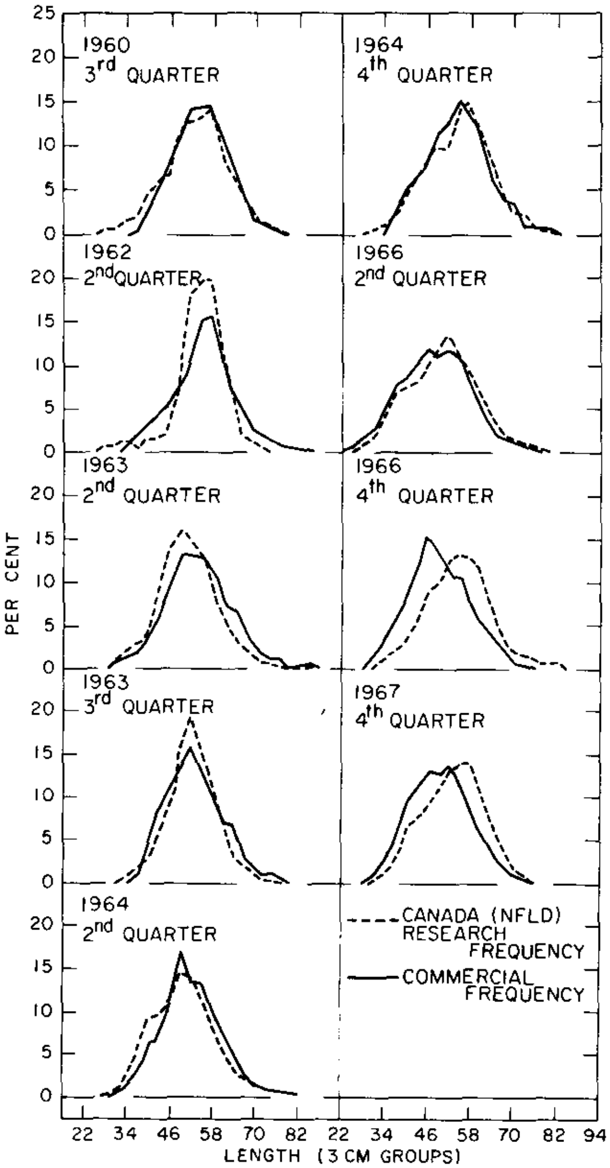

Fig. 1. Comparison of commercial catch frequencies with Canada (Nfld.) research frequencies adjusted to the minimum mesh size in force in each year, Division 2J.

Results

Accuracy of length compositions of the catches

To assess the accuracy of length compositions of the otter trawl catches, Canada (Nfld.) research length frequencies for quarters in which they were available were adjusted to the minimum regulation mesh size in force during the particular year and compared with the length compositions of the commercial catches. In this way compositions could be compared in nine quarterly periods and in seven of these the agreement between the two was considered quite satisfactory for assessment purposes (Fig. 1). However, in the 4th quarters of 1966 and 1967, the commercial length compositions contained more of the smaller fish than the research length compositions although the 1967 compositions are still fairly similar. Therefore the commercial length compositions represent what would be expected to be caught by vessels using an otter trawl of minimum regulation mesh size as determined from research vessel surveys in the same area and this indicates that they are probably representative of the actual catch by the otter trawler fishery.

Accuracy of age compositions of the catches

To provide some estimate of the accuracy of the age composition of the otter trawl catches, average ages of the actual compositions determined by applying age-length keys as described above were compared with those calculated from the average lengths of the length compositions using growth curves determined in 1959-62 from Canada (Nfld.) research age-length keys and in 1963-68 from commercial age-length keys published in the Sampling Yearbooks. Although the differences between the two average ages are quite variable from year to year, except for 1959 and 1960 the differences are all less than 1 year and in some cases the agreement is extremely close (Table 2). As a further means of examining the variations in age compositions derived from different age-length keys, the minimum and maximum estimates of the numbers caught at each age are plotted for each year in Fig. 2. Again the differences are not large except in 1964 and maybe 1968 and they indicate these age-compositions are probably accurate enough for our purposes. The average estimates of the number caught at each age for 1964-68 from applying age-length keys are practically identical to the estimates obtained by adjusting age distributions as described above (Fig. 3).

TABLE 2. Comparison of average ages calculated from length frequencies and age distribution, ICNAF Division 2J, 1959-69.

Year and quarter	Average ages: From length frequencies	Average ages: From age distributions	Year and quarter	Average ages: From Length frequencies	Average ages: From age distributions
1959			**1964**		
1st	7.9	7.7-8.4	1st	7.3	7.3-7.8
2nd	6.7	7.1	2nd	6.8	6.9-7.7
3rd	8.2	8.8-9.8	3rd	6.2	6.8-7.7
4th	6.3	6.7-8.0	4th	6.6	6.6-6.8
1960			1965		
1st	9.0	9.0	1st	7.8	8.1
2nd	7.4	8.8-8.9	2nd	7.6	7.6-8.0
3rd	7.5	8.2-8.9	3rd	6.9	6.6-6.8
4th	8.2	7.8-8.5	4th	7.5	6.8-7.0
1961			**1966**		
1st	9.2	9.0	1st	6.8	6.9
2nd	6.9	7.7	2nd	5.8	6.0-6.3
3rd	8.4	8.6	3rd	6.6	6.2-6.4
4th	7.8	7.6-8.3	4th	5.0	4.7-4.9
1962			**1967**		
1st	–	–	1st	5.6	5.8
2nd	8.0	8.8	2nd	6.4	6.4-6.7
3rd	7.4	7.0-8.4	3rd	6.0	5.5-6.1
4th	6.2	7.0	4th	4.9	5.3
1963			**1968**		
1st	6.4	6.0	1st	6.1	6.3-6.5
2nd	7.4	7.2-7.6	2nd	5.6	6.2
3rd	7.4	6.7-7.6	3rd	–	–
4th	6.3	6.4	4th	5.4	5.9
			1969		
			1st	6.3	6.9-7.1
			2nd	7.0	6.7

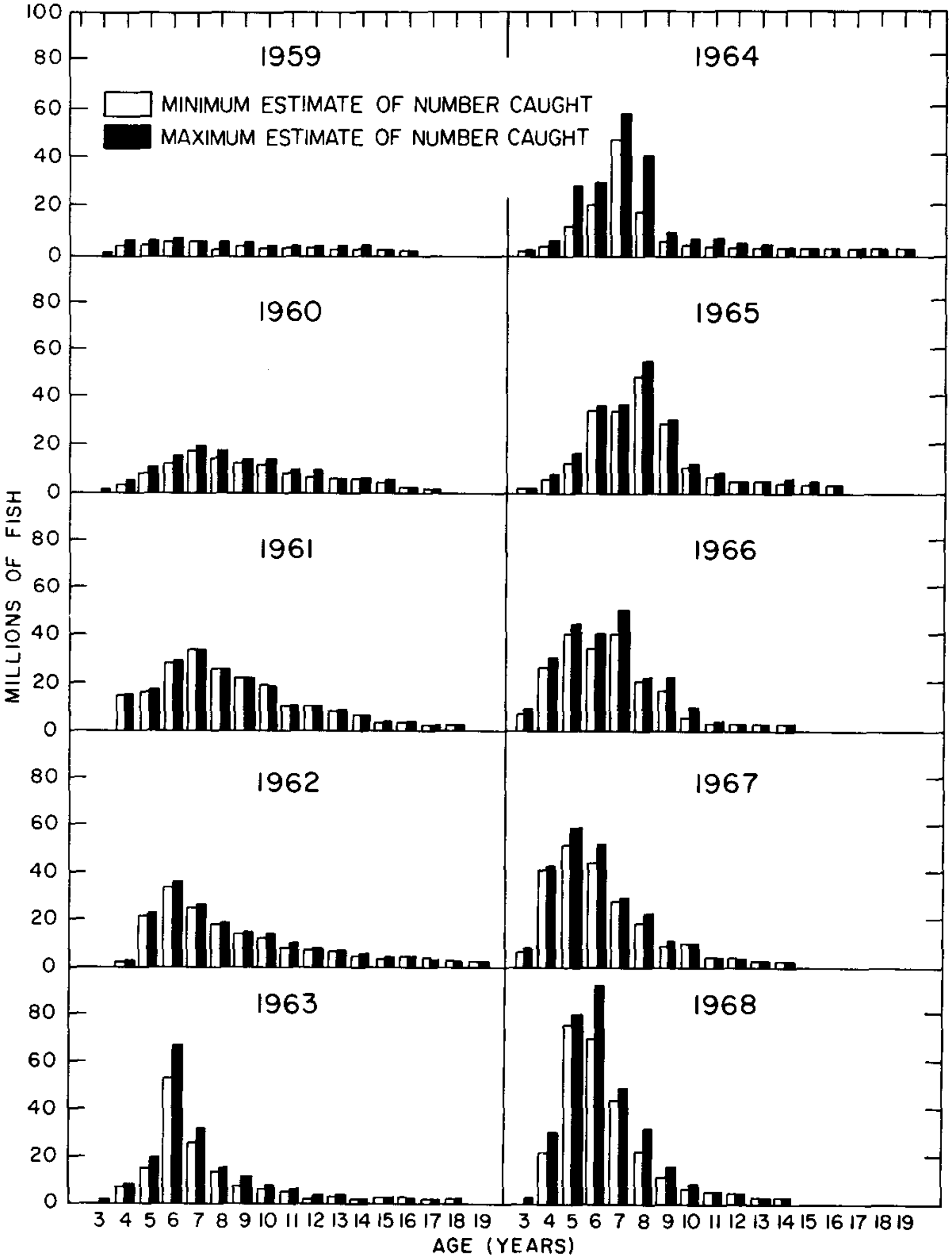

Fig. 2. Comparison of minimum and maximum estimates of numbers caught in each age-group, Division 2J, 1959-68.

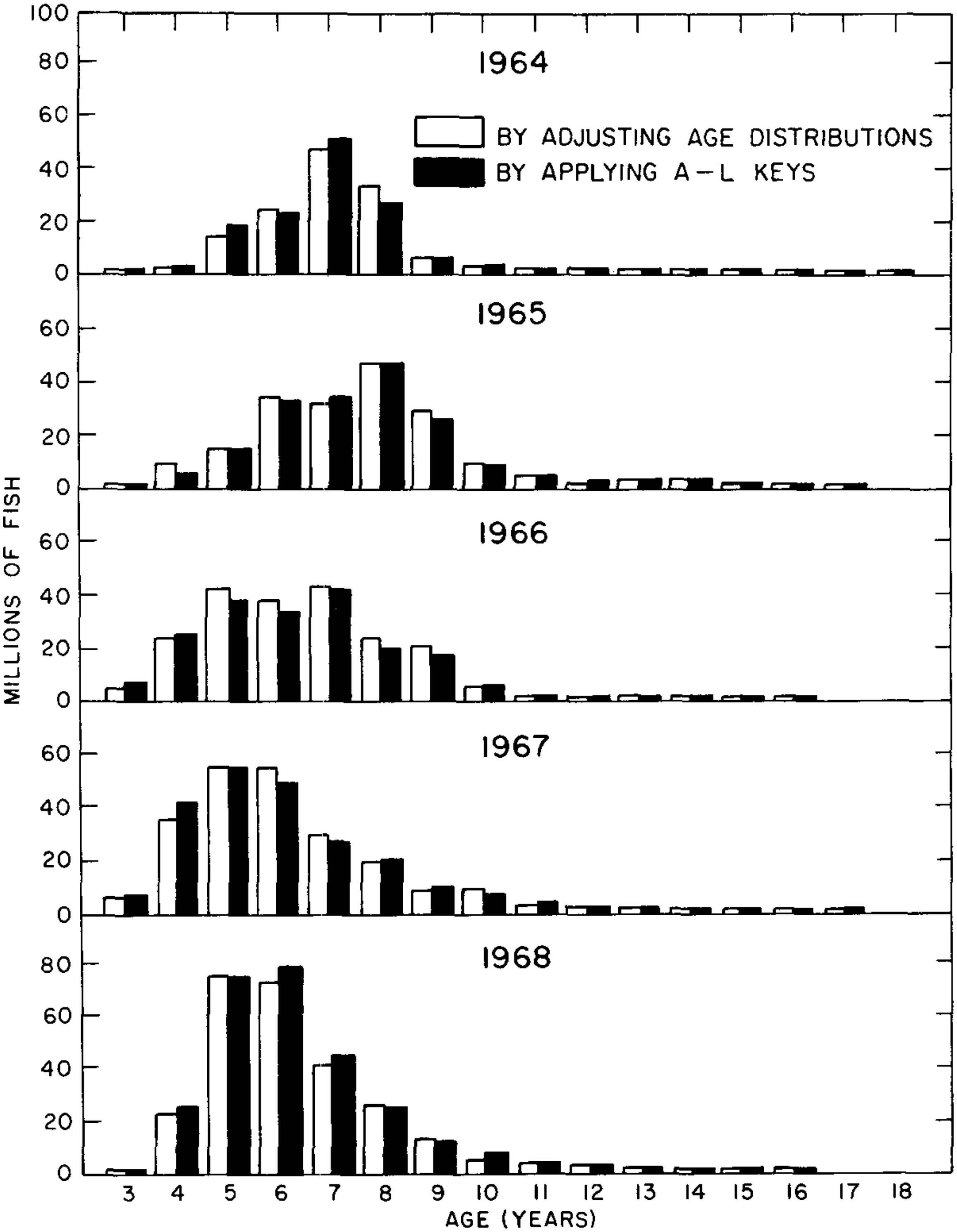

Fig. 3. Comparison of numbers in each age-group derived by applying age-length keys of various countries to the catch frequency and numbers derived by adjusting age compositions to numbers caught by each country, Division 2J, 1964-68.

TABLE 3. Number of cod caught per year and age-group, ICNAF Division 2J, 1959-69, using average estimates of numbers caught by applying age-length keys to length compositions ($\times 10^{-6}$).

Age	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
	Year										
2	–	40			76	–		336	71	–	–
3	132	932	92	326	1,541	707	414	7,048	6,289	1,737	699
4	4,253	4,099	14,399	2,061	7,958	3,943	6,285	26,866	40,958	24,888	9,291
5	4,864	9,779	15,935	22,024	17,666	20,286	13,262	40,253	54,160	76,758	29,710
6	5,260	14,052	28,604	34,910	60,262	24,133	34,267	36,332	47,873	80,238	87,890
7	4,675	18,512	33,790	25,140	28,495	52,063	34,670	42,915	27,252	46,135	65,617
8	3,117	16,307	24,738	17,661	13,680	27,678	49,916	20,114	18,787	26,434	32,270
9	4,380	12,730	21,728	13,559	8,808	6,524	27,488	18,169	7,872	12,828	13,537
10	2,282	12,251	17,722	12,694	6,621	4,039	9,901	5,769	6,845	3,900	7,733
11	2,770	7,938	9,091	8,228	5,267	3,724	5,045	2,031	2,916	3,870	4,010
12	2,720	7,042	9,060	6,907	2,129	2,158	2,591	1,147	1,014	1,440	3,072
13	2,193	5,028	7,317	6,562	2,588	1,984	2,413	926	986	601	1,844
14	1,567	5,439	5,197	4,536	1,637	1,241	2,779	515	346	596	745
15	505	3,691	2,390	3,398	2,055	918	1,951	219	129	310	194
15+	554	2,049	3,657	9,549	3,692	1,855	2,230	554	416	339	398
Total	39,272	119,889	193,720	167,555	162,475	151,253	193,212	203,194	215,914	280,134	257,010

TABLE 4. Fishing mortality estimates by year and age-group for cod in ICNAF Division 2J, 1959-68, using average estimates of numbers caught. (Min. = F-values using minimum estimates of numbers caught; Avg. = F-values using average estimates of numbers caught; Max. = F-values using maximum estimates of numbers caught.)

	Year											$\bar{F}$ 1959-67			Change in F with age as % of F in fully recruited age-groups, 1959-67		
Age	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968[a]	1969	Min.	Avg.	Max.	Min.	Avg.	Max.
3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	–		
4	0.021	0.016	0.031	0.009	0.028	0.013	0.013	0.031	0.021	0.021		0.02	0.02	0.02	5	5	5
5	0.029	0.060	0.066	0.065	0.10	0.092	0.053	0.10	0.075	0.050		0.07	0.07	0.07	16	17	18
6	0.041	0.11	0.25	0.20	0.25	0.20	0.22	0.20	0.17	0.16		0.19	0.18	0.18	43	44	47
7	0.044	0.20	0.41	0.37	0.25	0.35	0.49	0.46	0.22	0.25		0.34	0.31	0.29	77	76	76
8	0.039	0.21	0.44	0.39	0.35	0.40	0.68	0.59	0.37	0.34		0.40	0.39	0.37	100	100	100
9	0.071	0.22	0.49	0.47	0.35	0.28	0.91	0.56	0.48	0.46		0.45	0.43	0.43	100	100	100
10	0.049	0.29	0.53	0.59	0.44	0.27	0.89	0.48	0.43	0.44		0.48	0.44	0.40	100	100	100
11	0.076	0.24	0.36	0.50	0.52	0.47	0.63	0.45	0.48	0.49		0.46	0.41	0.37	100	100	100
12	0.094	0.28	0.46	0.52	0.23	0.41	0.71	0.28	0.42	0.50		0.43	0.38	0.33	100	100	100
13	0.096	0.25	0.52	0.74	0.38	0.35	1.13	0.60	0.41	0.40		0.59	0.50	0.39	100	100	100
Min. Ages 4-13	0.05	0.19	0.41	0.47	0.33	0.24	0.68	0.37	0.35								
Max. Ages 4-13	0.06	0.18	0.32	0.33	0.26	0.30	0.50	0.31	0.30								
Avg. Ages 4-13	0.06	0.19	0.36	0.38	0.29	0.28	0.57	0.38	0.31	0.31							
Avg. Ages 8-13	0.07	0.25	0.47	0.54	0.38	0.36	0.82	0.49	0.43	0.44							
Effort	42	92	151	110	91	107	119	109	106	140	?						
Landings 2J	57	179	261	250	212	204	252	244	241	341	361						

[a]Estimated from numbers present at beginning of 1968 and catch in 1968.

TABLE 5. Number of fish present in the stock at the beginning of the year ($\times 10^{-6}$), ICNAF Division 2J, 1959-68.

	Year									
Age	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
4	226	293	522	245	318	340	542	973	2179	(1324)
5	188	183	255	401	198	254	279	452	800	1747
6	145	149	142	212	300	146	191	220	341	628
7	120	113	110	90	142	192	98	127	149	233
8	91	95	75	60	50	92	111	49	67	100
9	71	71	62	40	33	29	50	46	23	38
10	53	54	47	31	20	19	18	17	22	12
11	42	41	33	23	14	11	12	6	9	11
12	33	32	26	19	11	7	6	5	3	4
13	26	25	20	14	9	7	4	2	3	2
14	19	23	15	10	5	5	4	1	1	2
15	6	16	12	7	6	3	3	1	–	1
4+	794	802	797	907	788	765	776	926	1418	2778
5+	606	619	542	506	590	511	497	474	618	1031
5-7	453	445	507	703	640	592	568	799	1290	2722
			2748					5971		
						+117%				
7+	341	357	290	204	148	173	208	127	128	170
			1340					806		
						- 40%				

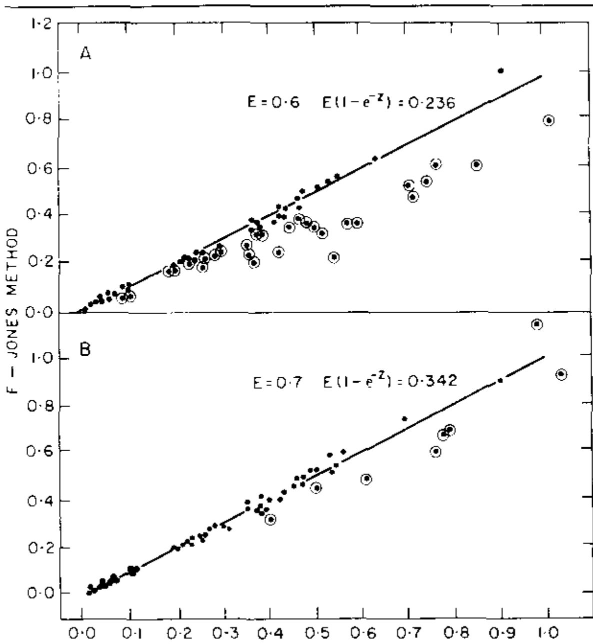

Fig. 4. Comparison of estimates of F for each age-group by Gulland and Jones Methods for two different assumed values of E of oldest age-group. Circled points indicate deviations of the Jones estimates from the Gulland estimates by more than 10%.

Fishing mortality

Table 3 shows average estimates of numbers of cod caught per year and age-group obtained by applying age-length keys to length compositions as described above. Table 4 shows fishing mortality estimates calculated from the figures in Table 3. Figure 4 illustrates the effect of the initial assumed value of E for the oldest age-groups on the final estimates of F.

Fishing mortality estimates (F) for ages 4-13 increased from 0.06 in 1959 to 0.36 in 1961 and 0.38 in 1962 and then decreased to a level of 0.28-0.38 during 1963-68 except for 1965 when the level increased to 0.57 for 1 year only (Table 4). This was caused by a high proportion of older fish in the catches in 1965. Cod are fully recruited to the gear in the area at 8 years of age and 50% recruited at about 6 years of age with insignificant numbers of 2- and 3-year-old fish being taken.

Stock size

Numbers present at the beginning of the year were calculated from fishing mortality estimates and numbers caught at each age for each year (Table 5 and Fig. 5). It is obvious that the numbers of older fish in the stock (7+) have declined in recent years. However, indications

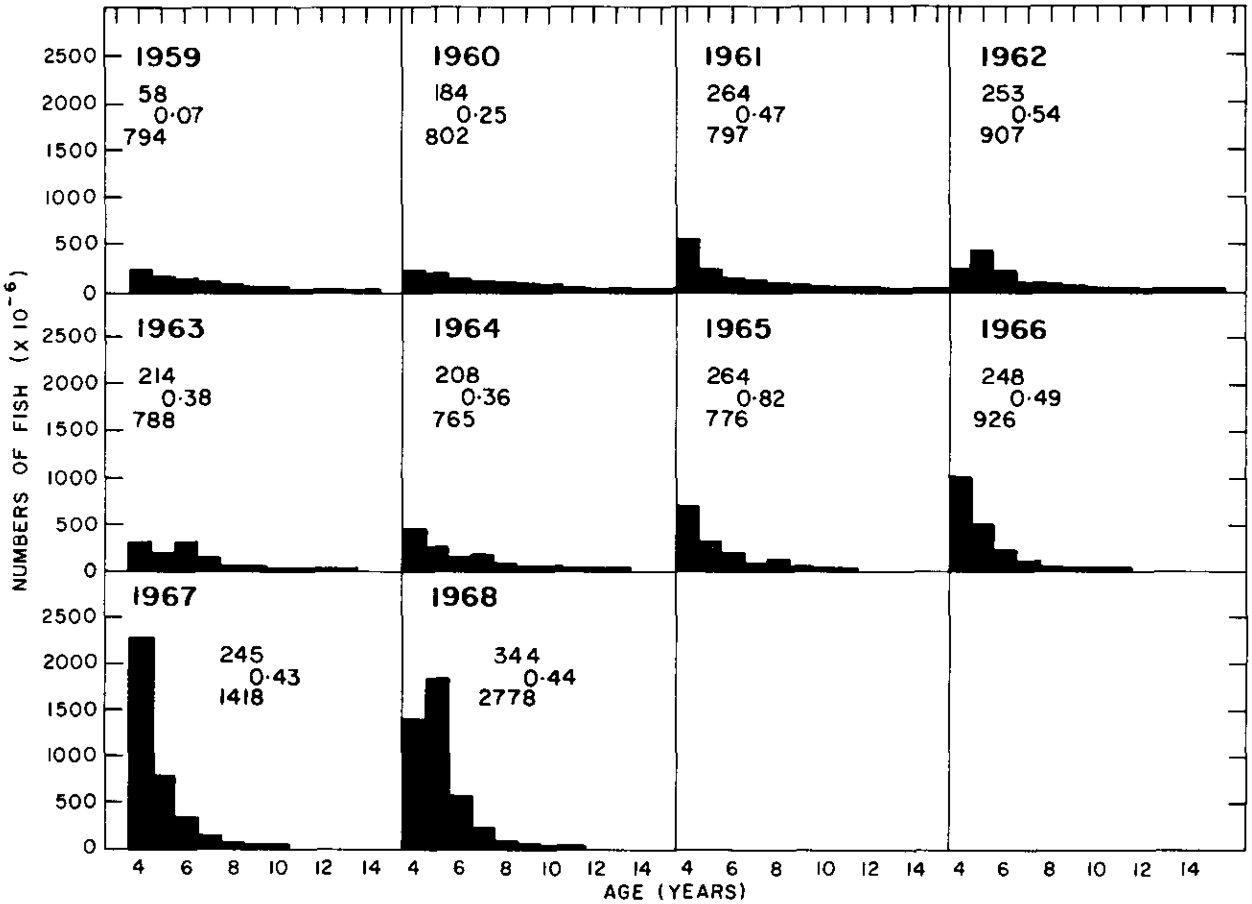

Fig. 5. Numbers of cod per age-group present in the stock at the beginning of the year, ICNAF Division 2J. Values below the date of the year: 1. Catch in 1000 tons; 2. F (8-13). 3. Total number of fish of ages 5-15.

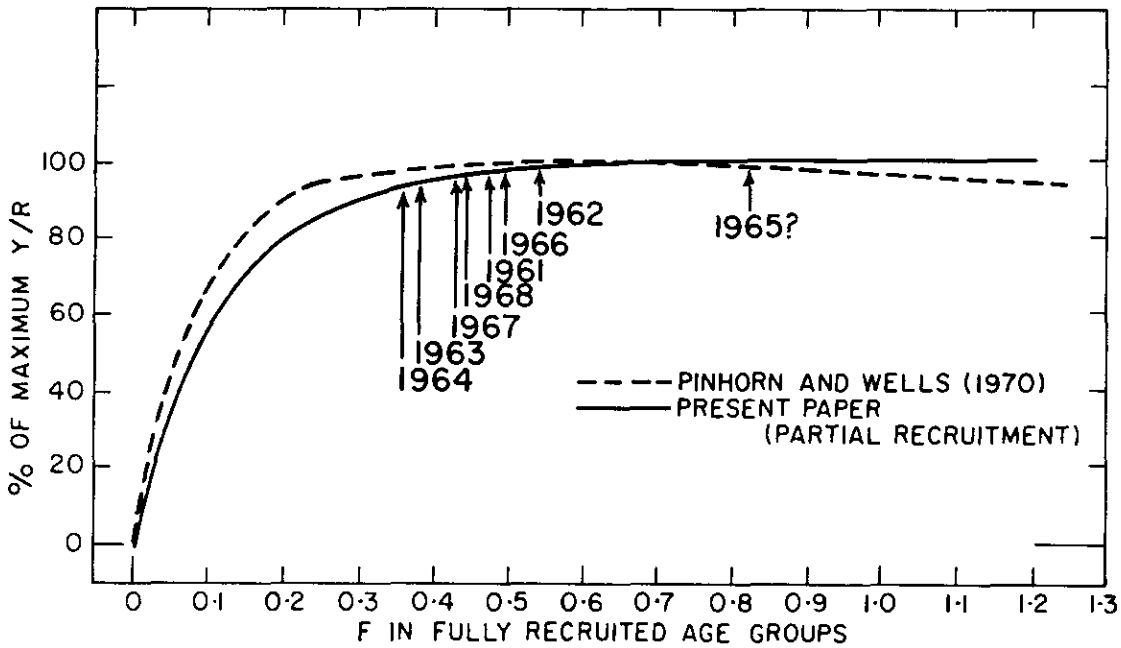

Fig. 6. Yield per recruit curves for ICNAF Division 2J cod incorporating partial recruitment estimates. Curve from previous catch/effort assessment is shown for comparison. Arrows indicate the level of F in various years.

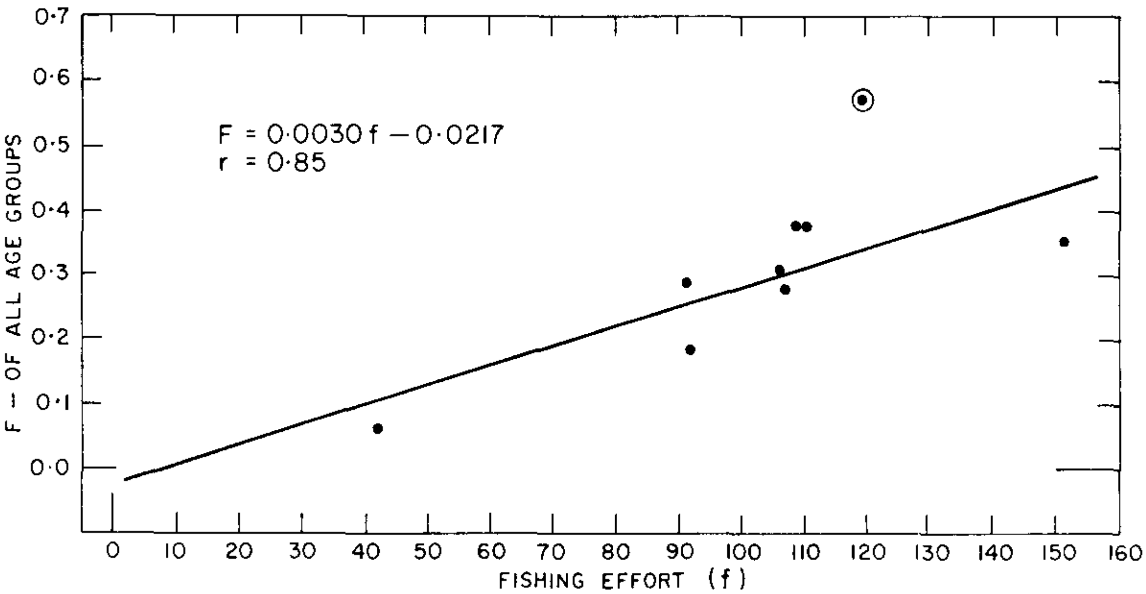

Fig. 7. Regression of estimates of F on fishing effort, ICNAF Division 2J, 1959-67. Circled estimate for 1965 not included in fitting straight line because of doubt as to its validity.

are that the total stock has not declined accordingly and in fact has increased in 1966-68 as a result of better recruitment in these years from year-classes in the early 1960's.

Yield per recruit

Yield per recruit calculations incorporating the partial recruitment estimates shown in Table 4 produced a curve somewhat similar to that presented by Pinhorn and Wells (1970) (Fig. 6). The level of fishing mortality in 1961-68 has been within 92-98% of the maximum sustained yield per recruit and may have been beyond this point in 1 year (1965), although the validity of this fishing mortality estimate may be questionable since the fishing effort did not increase accordingly in this year.

Fishing mortality and fishing effort

Fishing mortality values derived from average estimates of numbers caught are plotted against measures of fishing effort as determined by Pinhorn and Wells (1970 *b*) in Fig. 7. The correlation coefficient is 0.85 and the Y-intercept is -0.0217 indicating that the value used for M is probably close to the true value.

Discussion and Conclusions

The estimates of fishing mortality differ somewhat from those presented at the Mid-term Meeting of the Assessments Subcommittee, January 1971 for the following reasons:

a) The assumed values of E and E $(1\text{-}e^{-Z})$ for the oldest age-groups in the previous calculations were 0.6 and 0.236, respectively. On further analysis of the data it was obvious that these estimates were too low and resulted in estimates of fishing mortality (F) by the Jones Method which were also too low compared with estimates by the Gulland Method, especially in the later years (Fig. 4). Consequently, values of 0.7 and 0.343 were assumed in the present calculations and these produced estimates of F by the Jones Method which were almost all very close to the Gulland estimates (Fig. 4). Since the Gulland estimates were affected very little by the change from 0.6 to 0.7, the latter value (0.7) is probably closer to the true value.

b) In the previous calculations no account was taken of the obvious fact that when the oldest age of a year-class is less than the age of full recruitment, an adjustment in the assumed E of the oldest age is necessary since the exploitation rate for the younger age is obviously not as high as for the fully recruited age, where E was assumed to be 0.7.

c) The 1969 sampling data were included in the present calculations. The general conclusions from the data are, however, not altered.

The extent of the increased recruitment reflected in the stock table (Table 5) may be exaggerated especially in relation to estimates of stock size at age 4 since the fishing mortality estimates for this age in Table 4 are 0.02-0.03 and errors in these estimates lead to large errors in the estimate of stock size at this age. Also, there may have been a shift in the fishery from older spawning fish to the younger recruiting ages especially since recruitment was better in this period. This shift may have some effect on the F-values estimated for these ages. However, even disregarding the 4-year-old fish and considering the 5- and 6-year-old fish, where fishing mortality estimates were more reliable, the increase in recruitment is still apparent in 1966-68. The fishery has become increasingly dependent on these younger age-groups recruiting to the fishery and fluctuations in year-class strength, although not as great as in the southern stocks, will probably influence the success of the fishery more in the future.

The increase in fishing mortality, well beyond the point of maximum sustained yield in 1965, may have arisen from some inadequacy in the sampling data in that year but re-examination of the data failed to reveal it. These older cod may have been concentrated by hydrographic conditions in 1965 and may have been more susceptible to capture as a result of this. In any case these virtual population assessments have substantiated the conclusion drawn from the previous catch/effort assessments that further increases in fishing mortality will not give a long-term increase in yield, although short-term increases in catch in particular years may result from increased recruitment and/or from pecularities of cod distribution in relation to temperature variations. Increased catches would reduce the abundance of the stock.

References

FRY, F. E. J. 1949. Statistics of a lake trout fishery. *Biometrics*, 5(1): 27-67.

1957. Assessments of mortalities by use of virtual population. Joint sci. Meeting of ICNAF/ICES/FAO, Lisbon, 27 May-3 June 1957, Contribution No. P. 15 (mimeographed).

GULLAND, J. A. 1965. Estimation of fishing mortality rates. Annex to Arctic Fisheries Working Group Report. *ICES, C.M.* 1965, Doc. No. 3 (mimeographed).

JONES, R. 1961. The assessment of the long-term effects of changes in gear selectivity and fishing effort. *Mar. Res.*, No. 2, 1-19.

1967. Appendix to the Report of the North-Western Working Group. *ICES C.M.* 1968, Doc. No. 20 (Mimeographed).

MAY, A. W. 1966*a*. Length-weight relation in Labrador cod. *Annu. Meet. int. Comm. Northw. Atlant. Fish. 1966*, Res. Doc. No. 25, Serial No. 1633 (mimeographed).

1966*b*. Biology and fishery of Atlantic cod (*Gadus morhua* L) from Labrador. Ph.D. thesis. McGill University, Montreal, Quebec, 225 p.

PINHORN, A. T. and R. WELLS. 1970*a*. Assessments of the effects of increases in the mesh sizes of trawls on the cod fisheries in Subareas 2 and 3. *Res. Bull. int. Comm. Northw. Atlant. Fish.*, this volume, p. 37-43.

1970*b*. Catch/effort assessments for the major cod stocks in ICNAF Subareas 2 and 3. *Int. Comm. Northw. Atlant. Fish. Redbook 1970*, Part III: 65-74.

SCHUMACHER, A. 1970*a*. Fishing mortality and stock size in West-Greenland cod. *Res. Bull. int. Comm. Northw. Atlant. Fish.*, this volume, p. 15-19.

1970*b*. Bestimmung der fischereilichen Sterblichkeit beim Kabeljaubestand vor Westgrönland. *Ber. dtsch. Komm. Meeresforsch.*, 21(1-4): 248-259.

WELLS, R. and A. T. PINHORN. 1970. Growth and mortality changes in cod from ICNAF Subareas 2 and 3. *Annu. Meet. int. Comm. Northw. Atlant. Fish. 1970*, Res. Doc. No. 88, Serial No. 2439 (mimeographed).

NOTES

Notes on the Distinction of Northwest Atlantic Hakes, *Merluccius albidus* and *M. bilinearis*

By F. Mombeck[1]

At the end of January 1969, "silver hake" were caught by R/V *Walther Herwig* at the southern slope of Georges Bank (ICNAF Division 5Ze, southeast off Cape Cod) and sampled for length and age composition. When examining these materials more closely after the cruise at the laboratory, two types of otoliths – one "wide" and one "slender" form – were found. Because of a similar phenomenon observed in South African hake populations, where different types of otoliths could be attributed to two subspecies (see also Mombeck, 1970 *a* and *b*) (Fig. 1), it was suspected that this sample might consist of otoliths of silver hake, *Merluccius bilinearis*, as well as of offshore hake, *Merluccius albidus*, for both species could be expected to be abundant in this area according to distribution charts given by Lozano Cabo (1965). As external distinctive characteristics are not very marked between both species none had been recorded on board, and consequently, it was not possible to find out if in fact, both species had been caught, and if so, which otolith type belonged to which species.

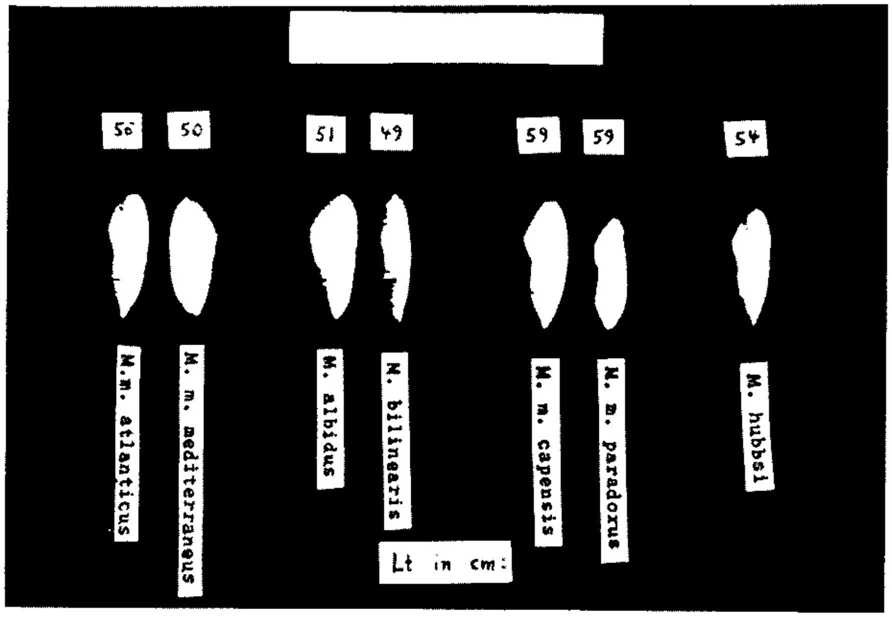

Fig. 1. Different types of otoliths of Atlantic hakes, which may occur in overlapping areas of distribution.

Due to this lack of information, special attention was given to the identification of both species on the next cruise of R/V *Walther Herwig* to ICNAF Subarea 4 and 5 in November 1969. Using the identification Key after Leim and Scott (1966), the following results have been obtained:

Near bottom midwater-trawl catches in Div. 4W on "Middle Ground" at 45m, as well as on the slope of La Have Bank at 200-400 m, contained of the species in question **only** silver hake, *M. bilinearis.*

In Div. 5Ze at the same positions as in January bottom trawl catches at 200-260 m contained *M. albidus* and *M. bilinearis* in almost equal numbers. Gill raker countings of the first gill arch varied between 9-11 and 15-19 respectively. Length frequency distributions for both divisions are given in Fig. 2

[1] Institute for Sea Fisheries, Bremerhaven, Federal Republic of Germany.

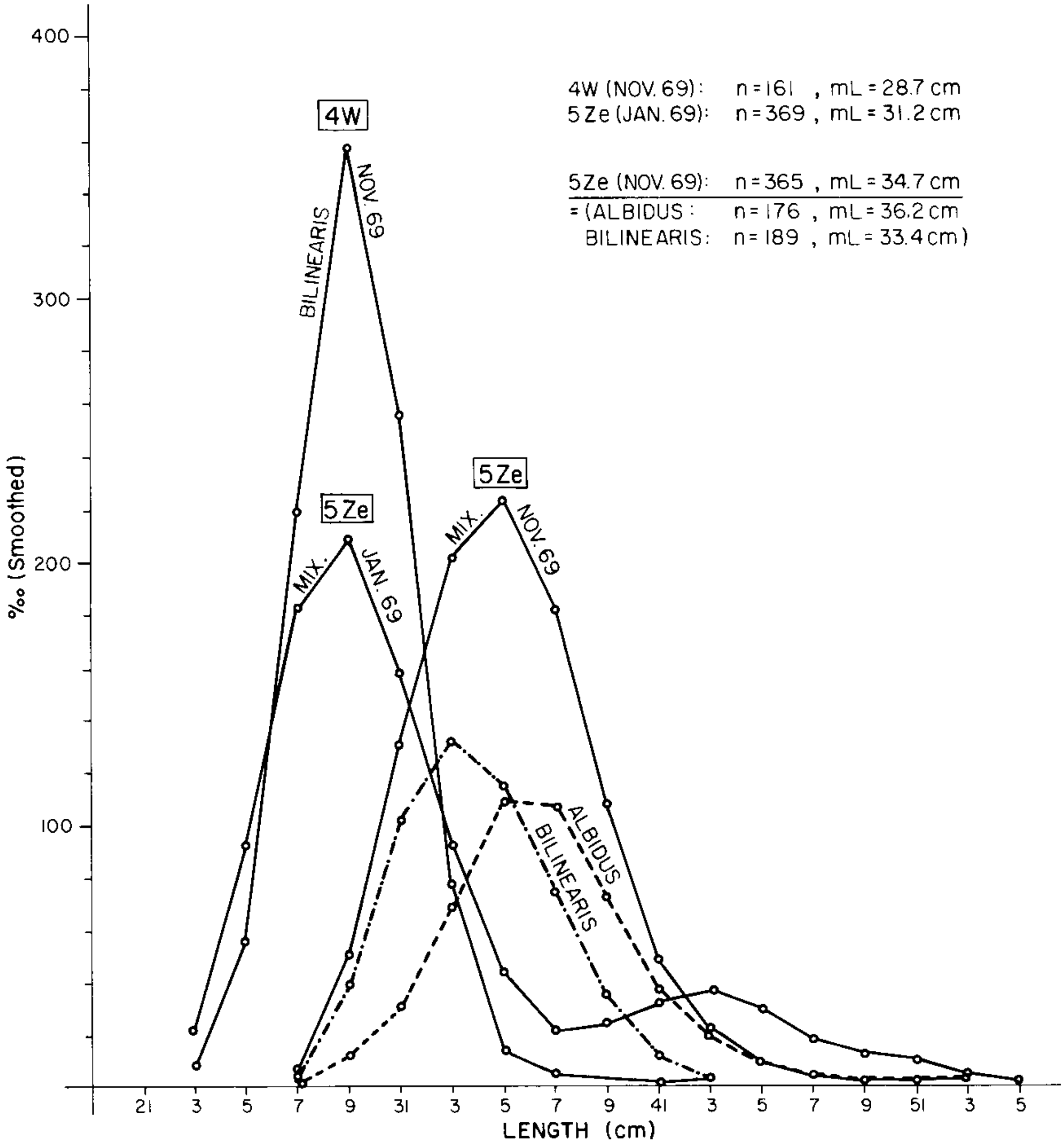

Fig. 2. Length frequency distribution of Northwest Atlantic hakes in research vessel collections in January and November 1969, ICNAF Division 4W – *M. bilinearis* (only species). Division 5Ze – mixed catches of *M. albidus* and *M. bilinearis*. The separation of both species in November 1969 shows a considerable overlapping of their length frequency distributions. Fish over 43 cm length were *M. albidus* only.

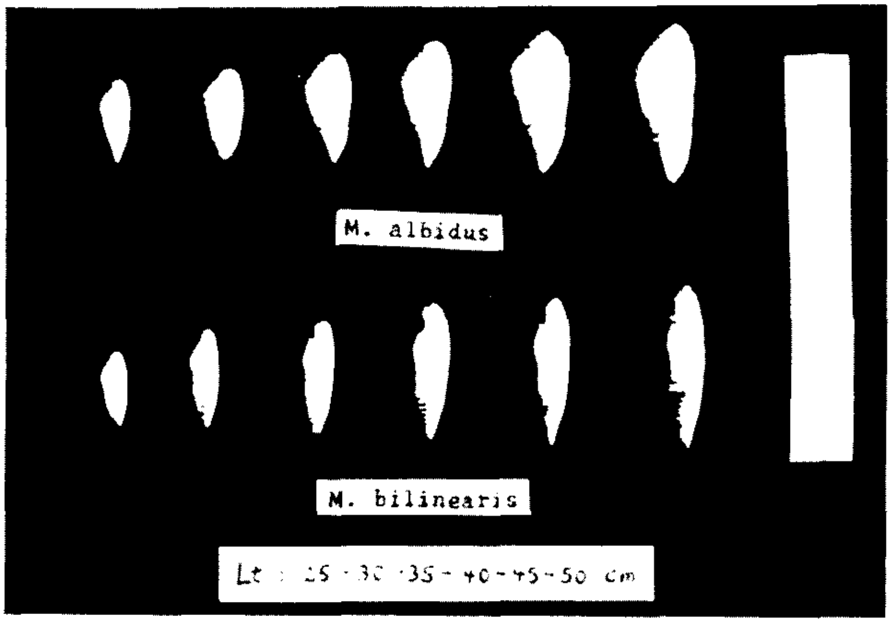

Fig. 3. Otolith shapes of *M. albidus* and *M. bilinearis* from ICNAF Division 5Ze at corresponding lengths of fish.

In the catches, 3-year-old fish of both species were predominant. From age studies it seems that the females grow faster than the males and also *M. albidus* faster than *M. bilinearis*.

By taking the otoliths it was found, that the "wide" type belonged to *M. albidus* and the "slender" type to *M. bilinearis* (Fig. 3).

The following further characteristics were recorded and supplied for this report by Dr J. Messtorff.

	M. albidus	*M. bilinearis*
Lateral line:	Black-grey lined, in the beginning slightly curved dorsally	Light, almost straight
Colour:		
dorsal	Grey-black	Grey-brownish
lateral	Silver grey	Silvery-golden
ventral	Whitish-light silver-grey	Silver white-golden iridescent
oral cavity	Far-reaching intense inkblue, including tongue	Whitish-reddish, only near throat bluish-blackish
peritoneum	Deep black	Dusky-reddish

Conclusion

Silver hake, *M. bilinearis*, and offshore hake, *M. albidus* are readily mistaken because of their similar external characteristics. Commercial catches of silver hake taken in overlapping areas of distribution of both species might therefore contain unknown quantities of unidentified offshore hake. Accordingly, special care should be taken to separate both species at least for sampling purposes before providing length frequencies and age compositions, and also to obtain information on the respective proportions in the catches. Reliable identification can easily be achieved by the different shapes of the otoliths and by the different number of gill rakers.

References

LEIM, A. H., and W. B. SCOTT. 1966. Fishes of the Atlantic coast of Canada. *Bull. Fish. Res. Bd. Canada*, No. 155, p. 205-208.

LOZANO CABO, F. 1965. Las Merluzas Atlanticas. *Direccion General de Pesca Maritima, Espanha*, Publ. No. 4, p. 11-31.

MOMBECK, F. 1970a. Vorläüfiger Bericht über Seehecht-Untersuchungen im SE-Atlantik. *Arch. Fisch Wiss.*, XXI (1): 45-61.

1970b. Weitere Mitteillungen über den Seehecht im Südafrikanischem Raum. *Ibid*, p. 62-66.

The Commission in Brief

Under the terms of a Convention signed in 1949, the International Commission for the Northwest Atlantic Fisheries (ICNAF) is responsible for promoting and co-ordinating scientific studies on the stocks of the species of fish which support international fisheries in the Northwest Atlantic. Based on these researches, the Commission recommends measures to keep these stocks at a level permitting the maximum sustained catch.

The governments sharing these conservation interests are Canada, Denmark, France, Federal Republic of Germany, Iceland, Italy, Japan, Norway, Poland, Portugal, Romania, Spain, Union of Soviet Socialist Republics, United Kingdom, and United States of America.

Research Bulletin of ICNAF

The International Commission for the Northwest Atlantic Fisheries invites contributions to its new serial publication, "The Research Bulletin of ICNAF".

There will be one or more issues each year depending on the number of papers received and accepted for publication.

Purpose. The main purpose of the Research Bulletin is to publish the results of research carried out in the ICNAF area. It is expected that most papers published in the Research Bulletin will be selected from papers presented at Annual Meetings of the Commission, but other papers, either concerning the ICNAF area or outside it, will be accepted if their contents are of importance to the work of the Commission.

Submission of Manuscripts. Manuscripts for publication should be submitted to the Commission's Secretariat on or before 1 October each year. This provides authors with sufficient time to revise or extend papers submitted or solicited at the previous Annual Meeting of the Commission which is held in early June each year. The arrangement also provides the possibility that the Bulletin can be issued before the next Annual Meeting of the Commission.

Editing. The Editor of the Research Bulletin will be the Executive Secretary of the Commission. He will be assisted on matters of editorial policy by the Chairman of the Commission's Standing Committee on Research and Statistics and the members of the Steering and Publications Subcommittee.

Refereeing. To maintain a high standard of publication each contribution will be submitted by the Editor to one or more referees from a panel of experts appointed for that purpose. On the advice of the referee(s), the Editor will request the author to make such amendments to his manuscript as will help to avoid error or misunderstanding and add strength to his presentation or will reject the manuscript. Referees will remain anonymous and will treat all manuscripts as confidential.

Preparation of Manuscripts. To achieve maximum conformity of presentation by authors and to minimize typing and other editorial work, the Commission's Secretariat has prepared the following aid.

Instructions to Authors for the Preparation of Manuscripts Intended for Publication in the Research Bulletin of ICNAF

Text

a) Manuscript should be type-written, *double-spaced*, and on one side only of good quality white bond quarto paper, size 8½ X 11 inches (220 X 280 mm).

b) Leave all margins 1 inch (25 mm) to 1½ inches (38 mm) for editorial marks and queries.

c) Prepare and submit the original and two carbon copies of the text and at least two sets of illustrations.

d) Number all pages of the manuscript consecutively with Arabic numerals in the centre of the top margin space.

e) Start a new page for each of the following sections with appropriate headings and sub-headings: (1) title, name and address of author, list of contents (if applicable); (2) abstract of the paper; (3) text; (4) references to literature; (5) tables; (6) legends for figures and (7) figures.

f) Please *double-space everything* – Text, quotations, footnotes, tables and table headings, legends, references to literature, and use even greater spacing where helpful (particularly around equations and formulae).

g) Wherever practical the text should be subheaded into Introduction, Materials and Methods, Results, and Discussion. Authors must provide a Summary which lists one by one the principal facts and conclusions of the paper. Acknowledgements should be placed immediately after the Summary.

h) All measurements, linear, weight, and time, should be given in numerals (not words) in the metric system. The Celsius scale should be used as a standard. When other units of measure are preferred, authors should include equivalents in metric units.

i) Footnotes should be avoided as far as possible, but if necessary they must be numbered consecutively in the text and typed under a horizontal line at the foot of the page concerned.

j) Only those words to be printed in italics should be underlined.

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Abstract

Each manuscript should have an abstract not to exceed 3% of the length of the text or 200 words whichever is the smaller. For position of the abstract in the manuscript see (e) above. The abstract should summarize the contents and conclusions of the paper, point to new information in the paper and indicate the relevance of the work.

Tables

a) Tables should be carefully constructed so that the data presented may be easily understood.

b) Tables should be set out on separate sheets following the references.

c) Position of the tables in the text should be indicated clearly.

d) Each table should be provided with a descriptive heading which, together with the column headings, makes the table intelligible without reference to the text.

e) Tables should be numbered consecutively with Arabic numerals, e.g. Table 1, 2, 3, etc.

Figures

a) All illustrations, whether black-and-white drawings, graphs, photographs, or tone drawings, are to be considered as figures.

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e) Figures should be set out on sheets preferably the same size as the text pages and in any case should not require a printer's reduction to less than one-third. Small figures can be arranged in groups on sheets the same size as the text pages.

f) For guidance in preparing figures, the size of the printed area of the *Research Bulletin* page is 21 X 17 cm. The *Bulletin* will have a two-column format, each column 8 cm wide.

g) Photographs presented as figures should be high contrast, glossy prints, about 5 X 7 inches (125 X 175 mm) in size and should be shipped flat protected by stout cardboard.

h) Each illustration should be identified by marking on the back lightly in soft pencil on the margin the figure number and the author's name.

Bibliographic Style

a) References to literature in the text should be by the author-date system, for example

It was reported that (Collins, 1960) the . . .;
In examining the situation, Rossini (1959) felt that . . .

Where more than one paper by the same author(s) have appeared in one year, reference should be given as follows:

Osborne and Mendel (1914*a*); Osborne and Mendel (1914*b*)
or Oxborne and Mendel (1914*a* and *b*); (Barnet and Robinson, 1942; King and Pierce 1943*a*, 1954)

Reference to material not yet submitted for publication should be written into the text e.g. "Harvey, in an unpublished manuscript, . . ." or "Harvey, in a letter, . . ."

b) All references cited by the author-name system in the text should be listed alphabetically by the surname of the first *author* at the end of the paper. *Year* of publication follows the authorship. Then give the full *title* of the paper. This should be followed by the abbreviated name of the *periodical* with the *volume* and *pages* in Arabic numbers (e.g. :2 : 120 - 136). For abbreviations of periodicals follow the "Word List of Scientific Periodicals". An issue, number, supplement or other part within a volume is shown in parentheses only when paged independently (e.g.: 2(4) :1 - 56; 34 (Suppl.2) :1 - 26). Any special Series (Ser 3, III, cr C) precedes the volume number. In *book citations* after the title, there appears the edition, the publisher's name, place of publication, and the number of pages if one volume, but the number of volumes if more. Reference to material submitted but not yet published should be referred to in the list of references as "in press" or "Submitted for publication" followed by the date of submission.

All CORRESPONDENCE should be addressed to:

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