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Biological Characteristics of Atlantic Cod (*Gadus morhua*) from Three Inshore Areas of Northeastern Newfoundland

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Abstract

During December 1995, aggregations of cod (*Gadus morhua*) were found at several locations in shallow (30–100 m) waters in Smith Sound and Northwest Arm, but not in Southwest Arm in western Trinity Bay. Over 2 000 fish caught with jiggers and feathered hooks were tagged and released and another 204 were sampled for length, sex, maturity and otoliths. Cod were mostly between 40 and 80 cm with mean lengths typically around 56 cm. Ages of cod ranged from 3 to 8 years, but more than 50% were 5 year olds. Mean weights-at-age were higher than those reported for commercial samples of cod from NAFO Div. 3L during recent (1990–95) years. Cod were generally in good condition, with mean values of Fulton's *K* (based on round weight) in the range 0.85 to 0.94. Most cod sampled were adults, and examination of the gonads of females suggested they would spawn in the coming spring. In April 1996, as part of a hydroacoustic survey to estimate the biomass of cod in these areas, further biological sampling was conducted. Aggregations of cod were located in all three areas, particularly in Smith Sound and Southwest Arm. A total of 1 542 cod were caught with otter trawl, jiggers and feathered hooks, and gill nets. Cod in all three areas were generally large and of comparable size range and condition to those seen in December 1995. Comparison of the maturities of females revealed a dense aggregation of spawning fish in deep water (>200 m) in the outer reaches of Smith Sound. In contrast, the cod in all other regions, including the inner reaches of Smith Sound, were mostly mature but not spawning and appeared destined to spawn later in the spring. The prevalence of the parasitic copepod *Lernaeocera branchialis*, particularly among larger fish and all sizes caught in Southwest Arm, was much higher than that of comparable sized fish sampled offshore over the past 13 years. Since transmission of the parasite occurs only during autumn and mainly in the inshore, the high prevalences suggest that these fish had resided inshore throughout the autumn and winter months.

Key words: age, cod (*Gadus morhua*), condition, inshore spawning, length, maturity, *Lernaeocera branchialis*, parasitic copepod

Introduction

During April 1995, a dense school of adult cod (*Gadus morhua*) with a biomass estimated using hydroacoustics to be about 17 000 metric tons was located in Smith Sound, Trinity Bay, Newfoundland (Rose, MS 1996). The discovery of these fish was of considerable interest because this region is outside the area traditionally surveyed by research vessels, and the autumn 1994 and autumn 1995 stratified random trawl surveys did not locate any major concentrations of cod in other (offshore) areas of NAFO Divisions 2J and 3KL. Reports of aggregations of adult cod in other inshore areas off the northeast coast of Newfoundland have also been received. A recent tagging study revealed that adult cod were present in Smith Sound and Northwest Arm in December 1995. From an assessment perspective these observations raise two issues: (1) what is the biomass of cod in these inshore waters that are outside the areas traditionally surveyed, and (2) what are the origins and biological characteristics of these cod.

Recent inshore studies have been directed toward addressing these issues. Since much of the inshore is untrawlable, a further hydroacoustic survey of cod in Smith Sound and adjacent areas (Fig. 1) was conducted (15–26 April 1996) to obtain further biomass estimates. Results are presently being analyzed. Tagging studies, including the December 1995 study, and previous ones employing sonic and conventional tags, have also been conducted to investigate the migration patterns and stock structure of these fish (Wroblewski *et al.*, 1994; Taggart *et al.*, 1995; Taggart, 1996). However, minimal fishing activity due to the moratorium has resulted in few tag returns

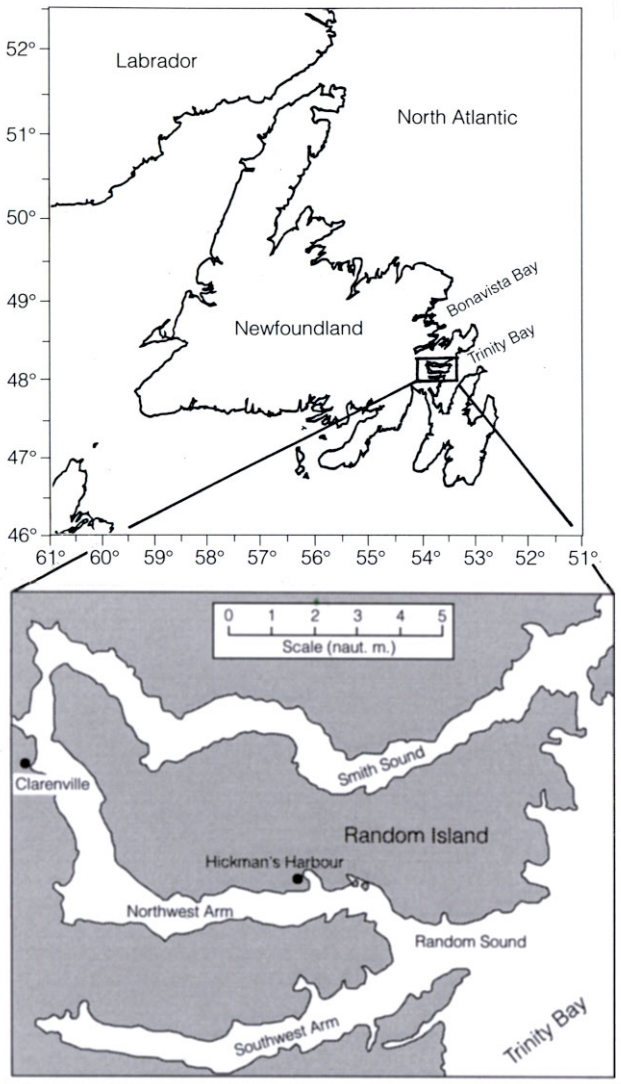

Fig. 1. Location of the study area in Western Trinity Bay, Newfoundland.

in recent years. Samples for genetic analysis have also been collected from inshore aggregations and results of these investigations are presented elsewhere (Ruzzante *et al.*, 1996; Taggart *et al.*, 1996).

The present paper summarizes information on the distribution, catch rates, length frequencies, maturity stages, and parasite (*Lernaeocera branchialis*) infestation of cod collected from these inshore areas during the December 1995 and April 1996 studies. An age-length key is given for samples collected during December 1995. Findings are also compared with recent data from cod collected during the regular autumn surveys in Div. 2J and 3KL (Shelton *et al.*, MS 1996). Information on the bathymetry and environmental conditions (temperature and salinity) within the sampled areas is also presented.

Material and Methods

RV *Shamook* Trip 250 (4–14 December 1995)

The primary purpose of this trip was to obtain live cod for tagging. All cod from Smith Sound and Northwest Arm were obtained using a Norwegian jigger and feathered hooks; cod in Southwest Arm were collected using a Yankee 36 otter trawl equipped with a 3/4-inch mesh liner in the cod-end (mechanical problems prevented use of the trawl in other areas). Information on the number of persons jigging and the duration of fishing was recorded so that catch rates could be standardized. Live cod were placed in holding tanks until recovered and those in excellent condition were tagged with yellow t-bar spaghetti tags just below the first dorsal fin. The length (nearest cm), round weight (nearest gm), numbers of the parasitic copepod *Lernaeocera branchialis*, and tag number were recorded before each fish was released. An additional 204 cod, including those damaged during capture, were killed and sampled as above, except that sex, maturity (following the scheme of Templeman *et al.*, 1978), and otoliths were also collected. Blood samples for DNA analysis were collected from approximately 100 cod. Temperature and salinity profiles at each fishing station and elsewhere in the study area were recorded using a SeaBird vertical cast CTD.

RV *Shamook* Trip 251 (15–26 April 1996)

The primary purpose of this trip was to conduct a hydroacoustic survey of cod in Smith Sound, Northwest Arm, and Southwest Arm. Biological sampling was conducted with three gear types; the Yankee 36 otter trawl equipped with a 3/4-inch mesh liner, jiggers and feathered hooks, and single (i.e. 50 fathom) 5.25 inch mesh gill nets. Fish were examined as per the December survey. Otoliths were collected from approximately 700 fish but ages were not yet available. Samples from Smith Sound were divided into two groups for analysis of maturity and parasite data; inner Smith Sound refers to samples collected in the shallower (<160 m) western portion of the area (set nos. 1, 2, 6, 7, 8) and outer Smith Sound refers to samples from the deeper (>200 m) eastern portion of the area (set nos. 3, 4, and 5). Samples were collected to verify the identity, size range, and density of targets observed on the hydroacoustic apparatus, as well as provide biological information on cod in the study area. Oceanographic date were collected as per the previous trip.

Bathymetry and topography

The study area consisted of three adjacent fjords, ranging from approximately 20–30 nm long and 0.5– 1.0 nm wide (Fig. 2). Smith Sound and Southwest Arm are extremely steep sided with deep

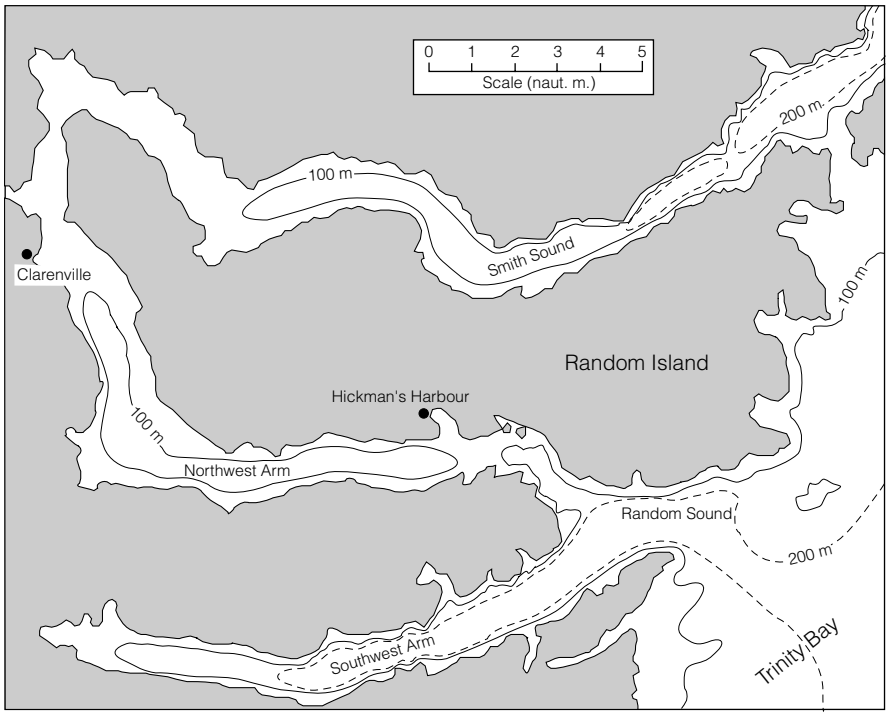

Fig. 2. Bathymetry of the study area.

(>200 m) central channels that converge with deep water in Trinity Bay which extends outward onto the continental shelf. In contrast, the central channel of Northwest Arm is not as deep (160 m) and has a relatively shallow (70 m) sill near the entrance. Within Northwest Arm the rough bottom and numerous submerged cables make trawling almost impossible in all except one small area, thereby limiting the range of sampling gears. Smith Sound and Southwest Arm had some trawlable areas in the deep central channel interspersed with areas of rough bottom. Jigging was possible throughout the shallower portions of inner Smith Sound and Northwest Arm, and at the extreme western end of Southwest Arm.

Results and Discussion

Temperature and salinity

During December 1995, water temperatures (not shown) in all three areas were generally between 2 and 3.6°C at the surface down to a depth of about 80 m, but decreased to a minimum of -1.2°C in areas where depth extended down to 200 m. Temperatures increased somewhat at depths below 200 m to 0.0°C at 290 m in the deepest areas near the mouth of Southwest Arm.

In April 1996, water temperatures were generally between 0 and 2.5°C at the surface in all areas (Fig. 3). Smith Sound and Southwest Arm showed similar temperature and salinity profiles, with a cold (-1.2°C) intermediate layer at depths of 60–200 m, and a relatively warm (0.5°C) deep layer below 200 m. In Northwest Arm, water temperatures were relatively uniform with increasing depth at about -0.5°C from 50 m down to the bottom. Salinity in Smith Sound and Southwest Arm increased with depth from 32.0 psu at the surface to about 33.6 psu at the bottom. Salinity in Northwest Arm was lower and more uniform, increasing with depth from 31.5 psu at the surface to about 32.5 psu at 50 m, but thereafter remained constant down to the bottom.

Catches of cod

During the *Shamook* Trip 250 of December 1995, cod were found to be abundant in shoal water (<90 m) in Smith Sound, and high catch rates using jiggers and feathered hooks (34.8–59.9 kg per person hr) were achieved at three sites in the inner reaches (see Table 1 and Fig. 4) giving a total catch of over 1 100 fish. There was no evidence from the echosounder of a dense aggregation of cod in the deeper central channel in the outer section of Smith Sound. Cod were, however, widely distributed on the shallower slopes and shoals along the sides of the sound, particularly on the north side. Similarly, a survey of Northwest Arm with the echosounder revealed that fish, subsequently identified as cod, were abundant in shoal water at four sites, one near the mouth and three inside Northwest Arm. Catch

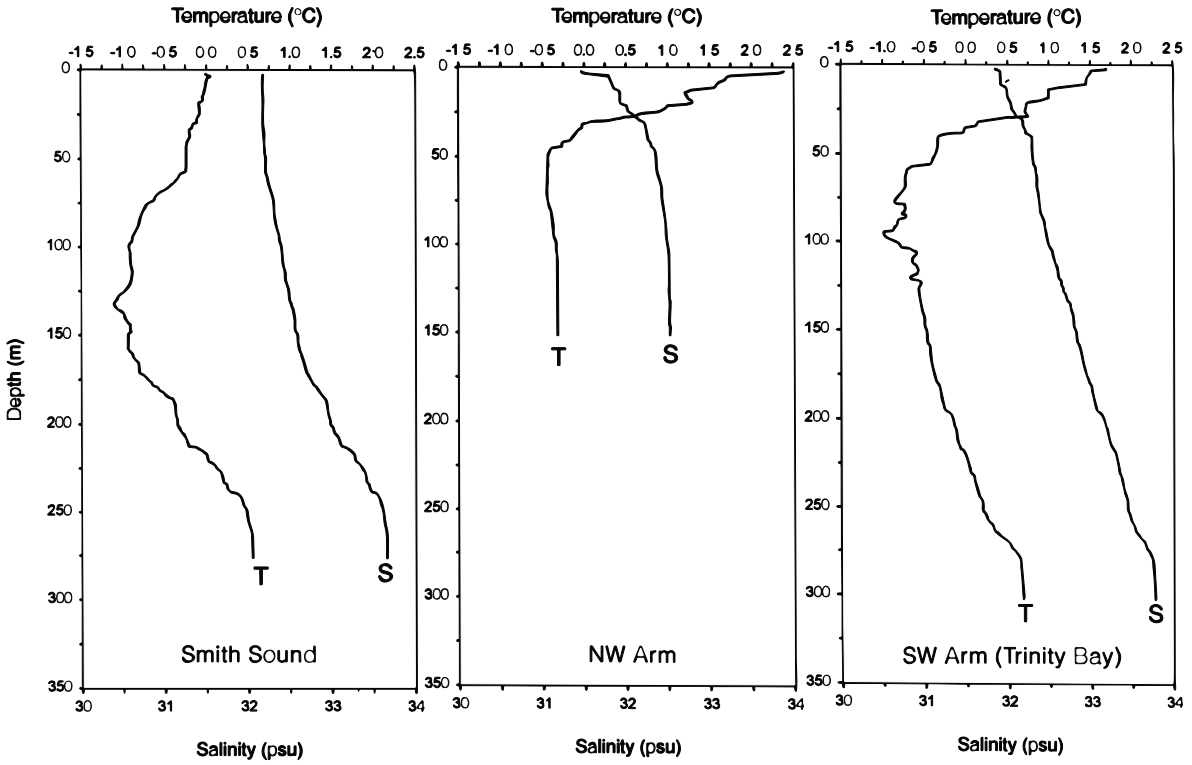

Fig. 3. Temperature (T) and salinity (S) profiles from deeper regions taken during mid-April 1996.

TABLE 1. Catch details for *Shamook* Trip 250, December 1995. Inshore Trinity Bay. See Fig. 4 for set locations.

Area	Date	Set Number	Gear	Depth fished (m)	Number of cod	Catch weight (kg)	Catch rates[1] (kg/hr)	Catch rates[1] (fish/person/hr)
Smith Sound	13 Dec 95	10	Jigger	49	424	810.3	34.8	18.2
	14 Dec 95	11	Jigger	58	318	561.4	45.5	25.8
	14 Dec 95	12	Jigger	51	425	857.2	59.9	29.7
				Total	1 167	2 228.9		
NW Arm	04 Dec 95	1	Jigger	31	313	554.9	46.2	26.1
	05 Dec 95	2	Jigger	30	443	706.4	38.5	24.2
	07 Dec 95	3	Jigger	79	6	14.7	7.4	3.0
	08 Dec 95	8	Jigger	59	217	312.9	13.4	9.3
	11 Dec 95	9	Jigger	49	254	428.0	20.1	14.9
				Total	1 233	2 016.9		
SW Arm	07 Dec 95	4	Trawl	155	34	11.0	33.0	
	07 Dec 95	5	Trawl	128	24	3.3	1.4	
	07 Dec 95	6	Trawl	205	2	3	0.1	
	07 Dec 95	7	Trawl	270	0	0.0	0.0	
				Total	60	14.6		
				Overall Total	2 460	4 260.4		

[1] Catch rates are given as kg per hour for trawl, and kg per person per hour and number of fish per person per hour for jigger plus four feathered hooks.

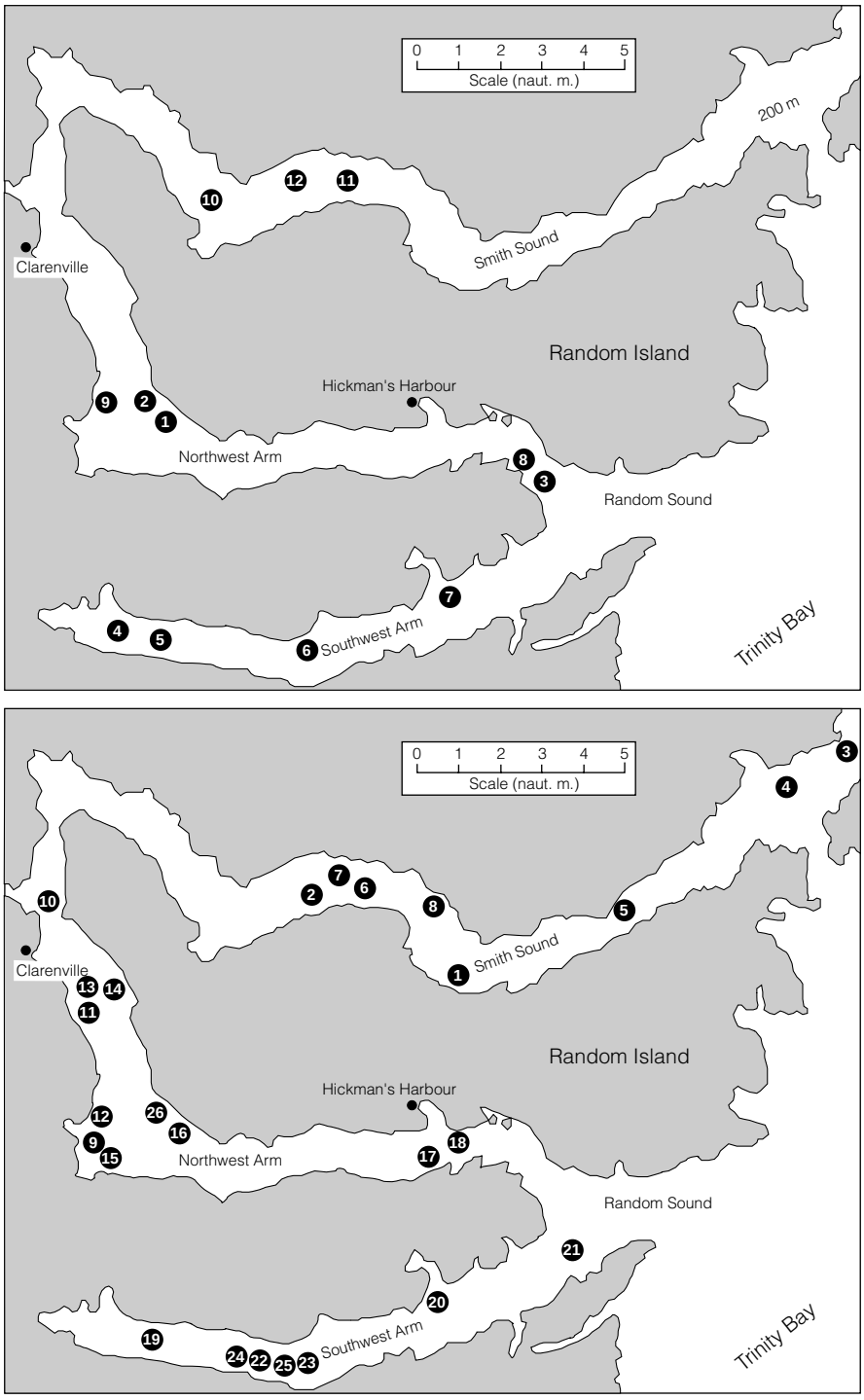

Fig. 4. Sampling (set) locations for the studies conducted during December 1995 (upper chart) and April 1996 (lower chart). See Tables 1 and 2 for further details.

rates were high but more variable (7.4–46.2 kg per person hr) than those in Smith Sound and a total of over 1 200 fish were caught. Cod appeared to be scarce through the deep central channel of Southwest Arm and four sets with the trawl caught only 60 fish; cod may have been present in the

shallow water in the extreme western end of Southwest Arm but this area was not surveyed during the study.

During the *Shamook* Trip 251 of April 1996, the hydroacoustic survey revealed a dense school of cod in deep (>200 m) water in the outer reaches of Smith Sound. Catches with the trawl were extremely high at two sites where the dense school was located (sets 4 and 5, Table 2 and Fig. 4). A smaller less dense school was also located further inside Smith Sound (set 7, Table 2). Jigging also revealed that cod were abundant on the shallower shoals at the sides of Smith Sound, although catch rates with jiggers (14.0–21.8 kg per person hr) were approximately half those recorded during December 1995 (Table 1).

Cod were widely distributed but not abundant in Northwest Arm (Table 2, Fig 4). Jigging gave generally lower catch rates (1.7–18.3 kg per person hr) than those reported during December 1995. Gill nets gave very poor catches and were often covered in slub, even after only 12 hr in the water. Fish caught in gillnets also showed extensive skin and fin erosion, probably due to predation by scavenging amphipods. A single trawl set in the middle of Northwest Arm caught only 9 cod.

TABLE 2. Catch details for *Shamook* Trip 251, April 1996. Inshore Trinity Bay. See Fig. 4 for set locations.

Area	Date	Set	Gear	Depth fished (m)	Number of cod	Catch weight (kg)	Catch rates[1] (kg/hr)	Catch rates[1] (fish/person/hr)
Smith Sound	16 Apr 96	1	Jigger	30	54	54.6	21.8	21.6
	16 Apr 96	2 [2]	Trawl	105	7	15.8	–	–
	17 Apr 96	3 [2]	Trawl	260	3	2.3	–	–
	17 Apr 96	4	Trawl	278	442	826.6	2 156.3	–
	18 Apr 96	5	Trawl	215	131	206.4	2 054.0	–
	18 Apr 96	6	Trawl	148	0	0	–	–
	18 Apr 96	7	Trawl	158	293	483.8	1 319.4	–
	20 Apr 96	8	Jigger	33	113	140.3	14.0	11.3
				Total	1 043	1 728.8		
NW Arm	20 Apr 96	9	Jigger	51	4	6.8	1.8	1.1
	21 Apr 96	10	Jigger	30	70	15.3	13.6	6.2
	21 Apr 96	11	Gillnet	60	4	9.1	–	–
	21 Apr 96	12	Gillnet	56	1	2.4	–	–
	21 Apr 96	13	Gillnet	61	3	10.6	–	–
	21 Apr 96	14	Trawl	105	9	6.5	48.8	–
	21 Apr 96	15	Jigger	25	2	4.2	1.7	10.0
	21 Apr 96	16	Jigger	31	128	228.5	18.3	10.2
	22 Apr 96	17	Gillnet	55	1	2.5	–	–
	22 Apr 96	18	Gillnet	70	2	5.5	–	–
	25 Apr 96	26	Jigger	25	29	38.4	12.8	6.7
				Total	253	467.5		
SW Arm	23 Apr 96	19	Trawl	173	69	111	444.0	–
	23 Apr 96	20	Trawl	268	78	133.4	444.7	–
	23 Apr 96	21	Trawl	290	0	–	–	–
	24 Apr 96	22 [3]	Trawl	162	0	–	–	–
	24 Apr 96	23 [3]	Trawl	214	16	26.9	–	–
	24 Apr 96	24	Trawl	168	23	34.5	155.4	–
	24 Apr 96	25	Trawl	215	60	103.7	259.3	–
				Total	246	409.5		
				Overall Total	1 542	2 605.8		

[1] Catch rates are given as kg per hour, for trawl and kg per person per hour and number of fish per person per hour for jigger plus four feathered hooks.
[2] Gear damaged.
[3] Gear fouled.

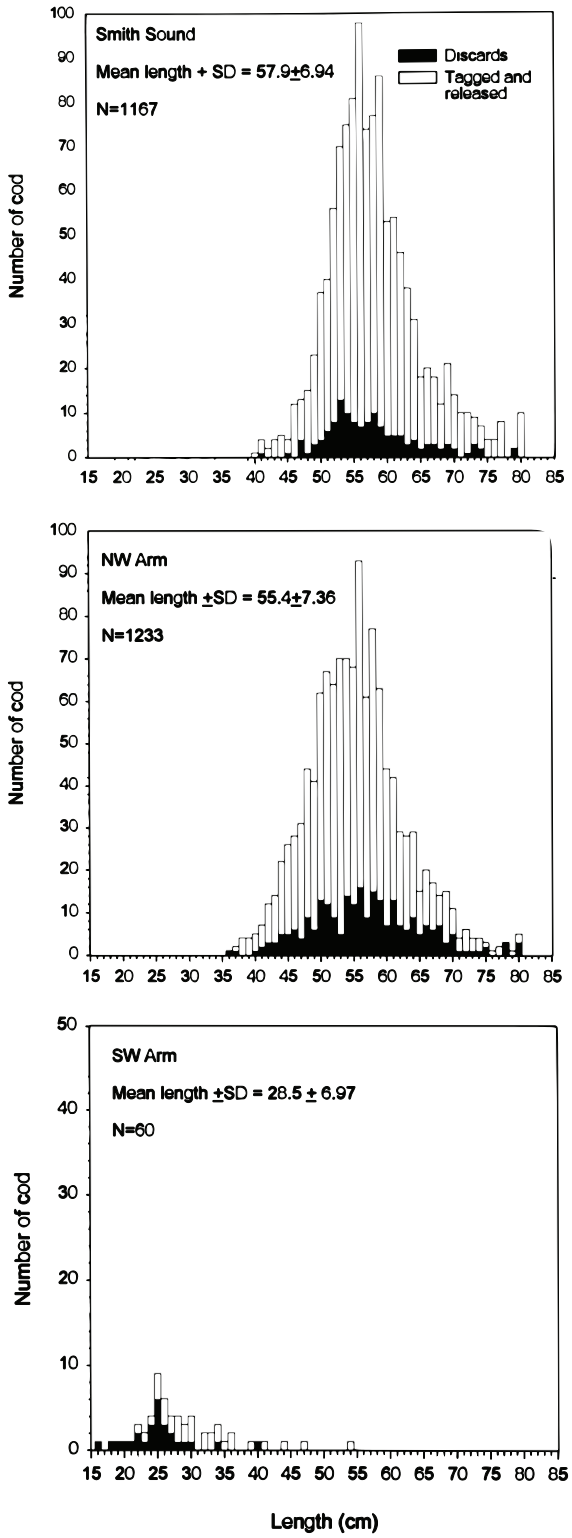

Fig. 5. Length frequencies of cod caught in three inshore areas of Trinity Bay during December 1995 (Smith Sound and NW Arm samples were caught with jigger and feathered hooks, SW Arm samples with Yankee 36 otter trawl).

Cod were abundant in Southwest Arm and a large school approximately 8 km long, 1 km wide and 100 m deep was observed in the central part of the channel. The school was much less dense than that observed in Smith Sound. Trawling gave modest catch rates (259.3–444.7 kg/hr) throughout the central channel of Southwest Arm. Jigging in the shallower western end of Southwest Arm failed to catch any cod.

Length frequency of cod

In December 1995, length measurements were obtained from over 1 000 cod caught with jiggers in each of Smith Sound and Northwest Arm. The cod were generally large (mean lengths 57.9 and 55.4 cm, Fig. 5) and of comparable size range within each area, with few fish under 40 cm. In contrast, in Southwest Arm where the trawl was used, cod were scarce and generally of much smaller size (<40 cm).

The size frequency of the total catch from these three inshore areas was also compared with that of the entire catch from the autumn 1995 survey of Div. 2J and 3KL (Fig. 6), with the latter based on a stratified random design incorporating approximately 400 sets of about 15 min duration using the Campelen trawl. Although different gears were used in these studies, the contrast in size frequency was striking, with many large cod (>50 cm) in the inshore

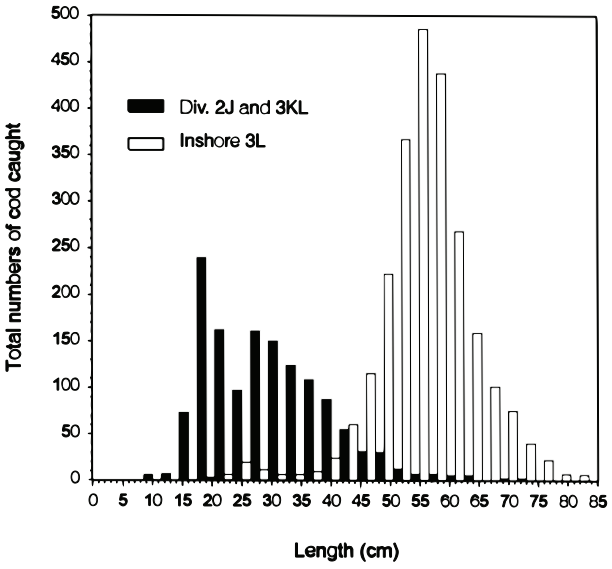

Fig. 6. Length frequency of cod (3 cm groups) from the 1995 autumn trawl survey in Div. 2J and 3KL compared with the catches (using jiggers and feathered hooks) from three inshore areas within Trinity Bay during December 1995.

catches, but very few large cod in the more offshore portions of Div. 2J and 3KL.

In April 1996, cod caught in Smith Sound, Northwest Arm, and Southwest Arm were of comparable size range (mean lengths 55.1, 56.2, and 54.7 cm; Fig. 7) to those caught in all except the latter area four months previously. Large cod apparently moved into Southwest Arm some time during the preceding four months as fish of this size were not observed in Southwest Arm during December 1995 (see Fig. 5).

Age distribution

Ages were obtained from 204 of the cod sampled during December 1995. An age-length key was constructed from these samples and applied to the length-frequency of the entire catch to give an indication of the overall age composition (Table 3). Ages ranged from 3–8 years, although over 50% of the fish caught were 5 year olds (1990 year-class).

Average weight-at-age (obtained by applying the standard cod length-weight regression parameters slope = 3.0879 and intercept = -5.2106) were generally somewhat higher than those reported in recent years for the Div. 2J and 3KL stock. Since our samples were collected within 3 week of the end of the year, we added 1 year to the ages given in Table 3 for comparison with beginning of the year (i.e. 1 January) mean weights at age from commercial catches from recent years (see Shelton *et al*., MS 1996). After incrementing ages by one year, the average weights at age for 4, 5 and 6 year olds from the present study were 0.74, 1.12 and 1.56 kg, respectively. The range of corresponding weights-at-age from the commercial samples for the years 1990–1995 were 0.45–0.62 for 4 year olds, 0.70–1.01 for 5 year olds, and 1.0–1.38 for 6 year olds. Weights-at-age were clearly higher for the present samples, suggesting good growth rates for inshore cod sampled during the present study. The values reported here are comparable to those given in Shelton *et al*. (MS 1996) for commercial catches for 1996 which are based largely on samples from the Sentinel Survey.

Condition indices

Scatter plots of cod condition (measured as Fulton's *K* based on round weight) revealed that cod sampled in December 1995 were generally in good condition, with average *K* values of 0.94, 0.92 and 0.85 for Smith Sound, Northwest Arm, and Southwest Arm, respectively (Fig. 8). This index can vary widely among individual fish; it is not entirely independent of length and includes the weight of

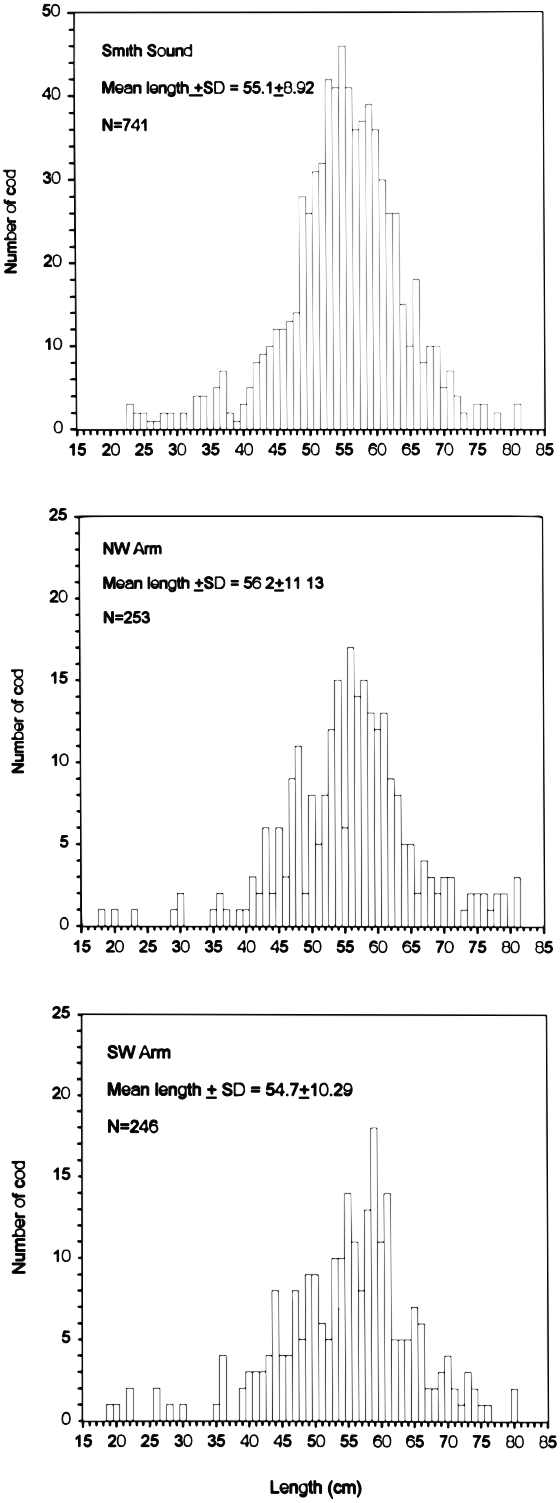

Fig. 7. Length frequencies of cod caught in three inshore areas of Trinity Bay during April 1996 (combined catches from Yankee 36 otter trawl, jigger and feathered hooks, and 5.25-inch gill nets).

TABLE 3. Age distribution of cod sampled from inshore areas of Trinity Bay during December 1995. Values were obtained by applying an age–length key from 204 aged samples to the length frequency of entire catch.

Length	0	1	2	3	4	5	6	7	8
40	–	–	–	24	–	–	–	–	–
43	–	–	–	20	–	40	–	–	–
46	–	–	–	46	35	23	12	–	–
49	–	–	–	9	139	65	9	–	–
52	–	–	–	–	98	257	12	–	–
55	–	–	–	–	47	345	94	–	–
58	–	–	–	–	–	345	80	–	13
61	–	–	–	–	–	169	99	–	–
64	–	–	–	–	–	56	94	–	9
67	–	–	–	–	–	40	34	27	–
70	–	–	–	–	–	25	25	17	8
73	–	–	–	–	–	–	13	27	–
79	–	–	–	–	–	2	2	–	2
82	–	–	–	–	–	–	3	–	3
85	–	–	–	–	–	–	–	4	–
Totals	–	–	–	99	318	1 368	476	74	36
Percent	–	–	–	4.18	13.41	57.70	20.08	3.12	1.52
Av. length (cm)	–	–	–	44.22	50.48	56.19	60.53	70.8	65.6
Av. weight (kg)	–	–	–	0.74	1.12	1.56	1.96	3.18	2.52

the gonads, liver, and stomach contents, all of which can vary considerably. Nonetheless, few fish had *K* values less than 0.7 which is a reasonable threshold below which fish can be considered in poor condition. Most *K* values were in the 0.8–1.1 range, suggesting that most cod sampled were generally in good condition. Lower values for Southwest Arm can probably be attributed to the smaller size of cod sampled, given that *K* tends to increase with length.

The condition of cod sampled in April 1996 was comparable to that observed four months previously, with overall mean *K* values of 0.86, 0.93, and 0.91 for Smith Sound, Northwest Arm, and Southwest Arm (Fig. 9). Again there were few fish with *K* values less than 0.7, suggesting that cod were generally in good condition. The slightly higher *K* values for cod in Northwest Arm and Southwest Arm were possibly due to the weight of the stomach contents; cod were feeding heavily on amphipods in these areas.

Maturities of female cod

Most of the cod sampled during December 1995 were adult fish. Among females, the percentage of immatures was higher in Northwest Arm (37.9%) than in inner Smith Sound (7.9%, Table 4) even though the average sizes were similar in each area. Most of the mature females had gonads at stage Mat AN (stages as in Templeman *et al.*, 1978) and would have spawned in the coming year.

Comparison of the maturities of females collected during April 1996 indicated two distinct groups of fish in the areas surveyed; female cod sampled in the outer reaches of Smith Sound had the largest average size (58.4 cm) and few (3.9%) were immature. In all other areas, the cod sampled were marginally smaller (average sizes 52.7 to 57.3) and the proportion immature was generally higher, ranging from 23.6% in Northwest Arm and to 54.4% in the inner reaches of Smith Sound. Most notable was the presence of spawning fish in the outer reaches of Smith Sound, with >70% of those sampled at stages Mat BP or Mat CP (i. e. with some clear eggs). In contrast, <3% of the females in any of the other areas appeared to be spawning, although most appeared destined to spawn some time later in the spring of 1996. A few spent fish were also observed in each area.

Another notable finding was the unusually high percentage of large fish (>60 cm) in Southwest Arm that had undeveloped gonads. Of 53 female cod >60 cm fork length collected in Southwest Arm, 34.0% had gonads that upon visual inspection appeared immature. Corresponding percentages, for Northwest Arm and Smith Sound (inner and outer areas combined) were 8.5% (n = 47) and 9.8% (n = 82). The reproductive status of these fish remained unclear. They possibly represented females that had spawned in previous years but would not spawn this year. Further analysis of maturity data are given in Morgan and Brattey (MS 1996).

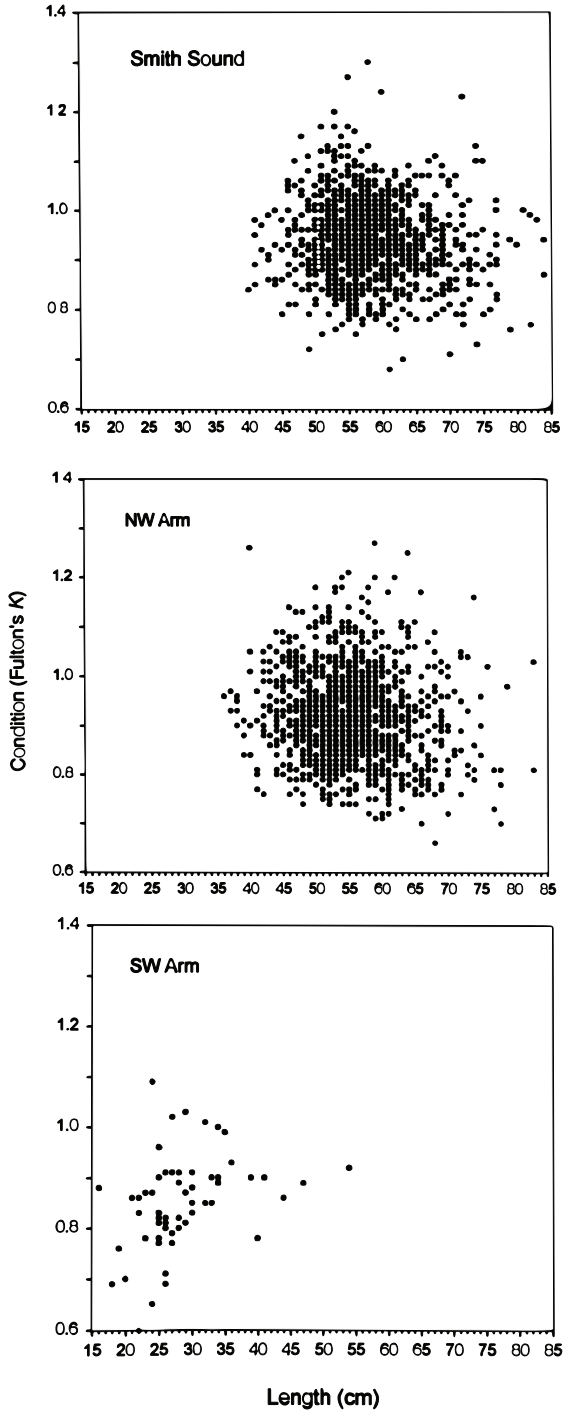

Fig. 8. Scatter plots of condition indices (Fulton's *K*, round weight 100×/Length^3) for cod sampled in three inshore areas of Trinity Bay during December 1995.

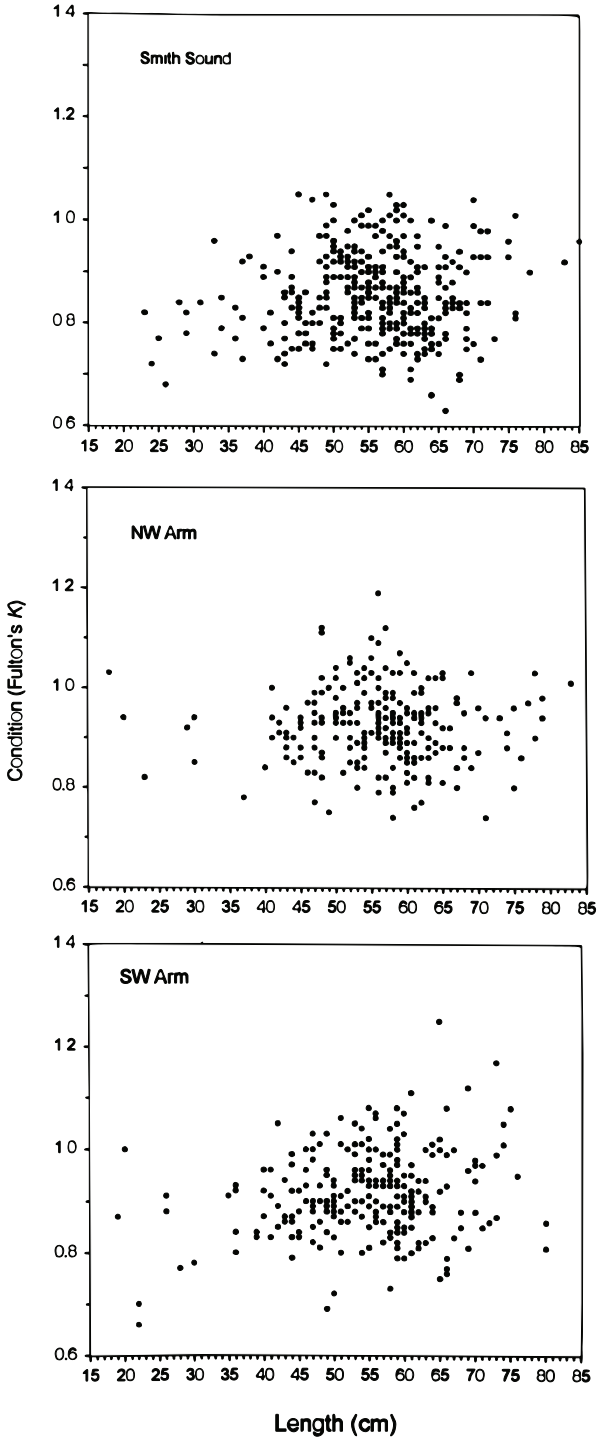

Fig. 9. Scatter plots of condition indices (Fulton's *K*, round weight 100×/Length^3) for cod sampled in three inshore areas of Trinity Bay during April 1996.

Parasites

The parasitic copepod *Lernaeocera branchialis* was common on the gills of cod in all three areas (Table 5) with prevalences mostly in the 5–25% range. Infection level tended to vary with length, but not in any consistent pattern in all areas. There

TABLE 4. Maturity stages (according to the scheme of Templeman *et al*., 1978) and mean lengths of female cod sampled from inshore areas of Trinity Bay during December 1995 and April 1996.

	Inner Smith Sound	Outer Smith Sound	NW Arm	SW Arm
		4–14 December 1995		
No. cod	63	0	66	0
Mean length ± SD	58.1 ± 7.34	–	56.5 ± 7.86	–
% Mature	7.9	–	37.9	–
% Mat AN	82.5	–	62.1	–
% Mat AP	0.0	–	0.0	–
% Mat BP	0.0	–	0.0	–
% Mat CP	0.0	–	0.0	–
% Spent	9.5	–	0.0	–
% Other	–	–	–	–
		15–26 April 1996		
No. cod	57	153	140	164
Mean length ± SD	52.7 ± 14.17	58.4 ± 6.52	57.3 ± 12.18	55.6 ± 10.00
% Mature	54.4	3.9	23.6	43.9
% Mat AN	0.0	0.0	0.0	0.0
% Mat AP	38.6	23.5	74.3	52.4
% Mat BP	0.0	9.2	0.7	1.8
% Mat CP	1.8	62.1	0.7	0.6
% Spent	3.5	0.7	0.7	0.6
% Other	1.8	0.7	–	–

TABLE 5. Prevalence in percentage and numbers (n) of the parasitic copepod *Lernaeocera branchialis* on the gills of cod from inshore areas within Trinity Bay during December 1995 and April 1996 compared to the long–term (1982–95) prevalence observed during the spring and autumn trawl surveys of NAFO Div. 3L.

Cod length (cm)	Inner Smith Sound % (n)	Outer Smith Sound % (n)	NW Arm % (n)	SW Arm % (n)	Average 1982–95 % (n)
		4–14 December 1995			Div. 3L Autumn survey
20–29	–	–	–	27.0 (37)	4.0 (869)
30–39	–	–	–	33.3 (15)	6.5 (1 344)
40–49	4.8 (83)	–	9.1 (230)	–	6.5 (1 446)
50–59	9.2(694)	–	14.0 (695)	–	4.0 (1 411)
60–69	7.4(253)	–	11.9 (253)	–	2.4 (1 177)
≥70	16.7 (44)	–	11.4 (44)	–	1.1 (1 958)
		15–26 April 1996			Div. 3L Spring survey
20–29	–	–	–	–	8.9 (990)
30–39	–	–	–	–	9.4 (1 593)
40–49	5.7 (35)	6.9 (29)	13.3 (45)	21.6 (51)	6.8 (2 237)
50–59	25.0 (24)	12.1(140)	10.6 (113)	22.1 (104)	5.4 (2 297)
60–69	5.0 (20)	7.5 (93)	11.1 (63)	22.1 (60)	3.6 (1 576)
≥70	–	0.0 (12)	9.5 (21)	13.3 (60)	0.5 (3 052)

were no distinct differences in the prevalence of the parasite between inner and outer Smith Sound; although 50–59 cm cod from the inner portion appeared more heavily infected (25%) than those from the outer portion (12.1%), the difference was not significant (χ^2 test, $P>0.09$). Overall, the

percentage infection tended to increase from north to south and was particularly high in Southwest Arm.

Small cod (40–49 cm) from inner and outer Smith Sound showed prevalences (4.8–6.9%) comparable to the long-term averages for cod of comparable size sampled during the spring (6.5%) and autumn (6.8%) trawl survey conducted throughout offshore areas of Div. 3L. However, among other fish in Smith Sound and elsewhere inshore, prevalences were higher than the long-term average for comparable sized cod sampled during the spring and autumn trawl surveys of Div. 3L; the differences was particularly notable among the largest fish. The unusually high prevalences, particularly among the larger cod size-classes, support the notion that these cod have remained inshore throughout the autumn and winter months, as transmission of the parasite to cod appears to occur during autumn mainly in the inshore areas.

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References

MORGAN, M. J., and J. BRATTEY. MS 1996. Maturity of female cod in 2J3KL. *DFO Atl. Fish. Res. Doc.*, No. 64.

ROSE, G. MS 1996. Cross-shelf distributions of cod in NAFO Divisions 2J3KL in May and June 1995: some preliminary findings of a long-term study. *NAFO SCR Doc.*, No. 57, Serial No. 2733, 15 p.

RUZZANTE, D. E., C. T. TAGGART, D. COOK, and S. GODDARD. 1996. Genetic differentiation between inshore and offshore Atlantic cod (*Gadus morhua* L.) off Newfoundland: microsatellite DNA variation and antifreeze level. *Can. J. Fish. Aquat. Sci.*, **53**: 634–645.

SHELTON, P. A., D. E. STANSBURY, E. F. MURPHY, G. R. LILLY, and J. BRATTEY. MS 1996. Assessment of the cod stock in NAFO Division 2J–3KL. *DFO Atl. Fish. Res. Doc.*, No. 80.

TAGGART, C. T. MS 1996. Bank-scale migration patterns in northern cod. *NAFO SCR Doc.*, No. 42, Serial No. N2717, 9 p.

TAGGART, C. T., P. PENNEY, N. BARROWMAN, and C. GEORGE. 1995. The 1954–1993 Newfoundland cod-tagging data base: statistical summaries and spatio-temporal distributions. *Can. Tech. Rep. Fish. Aquat. Sci.*, **2042**: 441 p.

TAGGART, C. T., D. RUZZANTE, and D. COOK. MS 1996. Microsattelite polymorphism and population structure of Atlantic cod (*Gadus morhua*) in the Northwest Atlantic. *DFO Atl. Fish. Res. Doc.*, No. 44.

TEMPLEMAN, W., V. M. HODDER, and R. WELLS. 1978. Sexual maturity and spawning in haddock, *Melanogrammus aeglefinus*, of the southern Grand Bank. *ICNAF Res. Bull.*, **13**: 53–65.

WROBLEWSKI, J. S., W. L. BAILEY, and K. A. HOWSE. 1994. Observations of adult Atlantic cod (*Gadus morhua*) overwintering in nearshore waters of Trinity Bay, Newfoundland. *Can. J. Fish. Aquat. Sci.*, **51**: 142–150.