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Discrimination of the cod stock complex in Division 2J+3KL based on tagging

by

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INTRODUCTION

At present the cod off southern Labrador and east Newfoundland are managed as a stock complex (Pinhorn, 1976). There is a cline from north to south in biological parameters such as growth, vertebral numbers, age and size at maturity of these cod. At the same time, however, tagging studies have confirmed that there is clear indication of localization of tag returns from the Labrador and Newfoundland coasts from cod tagged at specific inshore and offshore locations.

May (MS 1966) hypothesized that the "stock complex" was composed of at least three major groups which overlapped in their summer distribution but tend to separate in winter. These are as follows:

- "Labrador-Newfoundland" cod stock which spawns mainly on Hamilton Bank though possibly to a small extent on the northeast Newfoundland Shelf and is distributed in summer on the coasts of Labrador and northeast Newfoundland.
- 2. "Northeast Newfoundland" cod stock which spawns mainly on Hamilton Inlet Bank but also on the northeast Newfoundland shelf. In summer its distribution extends only to northeast and eastern Newfoundland. Alternately these may be two stocks, one spawning on Hamilton Inlet Bank, the other on the northeast Newfoundland shelf.
- 3. "East Newfoundland" cod stock which spawns on the northern Grand Bank and is distributed in summer mainly in eastern Newfoundland, though extending to northeast Newfoundland as well.

It has been suggested by May (MS 1966) and Templeman (1962, 1966, 1974, 1979, and 1981) that there is some evidence of smaller local stocks associated with the coastal shelf areas such as those off Baccalieu, Bonavista, Fogo, Lascie, and St. Anthony to the Grey Islands. Templeman (1981), based upon summer-autumn taggings inshore at many localities from northern Labrador to the Avalon Peninsula, found that in summer-autumn of years after tagging, there was considerable homing of local populations of cod to and near the original tagging locations. Either the fish remained in the same coastal area throughout the year or they really homed" back to the areas to which they drifted as larvae and in which they spent their first few years of life. The purpose of this paper is to present new data based on tag recaptures of adult cod tagged during 1978-81 from the winter-spring spawning concentrations from Hamilton Bank to the northern Grand Bank, summer-autumn taggings of adult cod during 1979-81 from coastal Newfoundland and Labrador and from summer taggings of juvenile cod during 1978-79 from eastern Newfoundland. The foregoing hypotheses will be discussed based upon the results of these tag recaptures plus the analysis of a small amount of meristic data (vertebrae, dorsal, and anal fin rays) collected from the spawning or pre spawning concentrations during spring of 1982.

MATERIALS AND METHODS

During February-March, 1978-81, about 25,000 adult cod (45 cm and larger) were tagged, using a variety of tag types (Table 1) from the pre-spawning concentrations on Hamilton Inlet Bank, Belle Isle Bank, Funk Island Bank, and the north cape of the Grand Bank. During October-November 1979 and October 1980, 437 and 766 adult cod respectively were tagged in Conception Bay in southeastern

STOCK DISCRIMINATION SYMPOSIUM

Newfoundland with similar tag combinations. During 1979-81, juvenile cod have been tagged around Conception and Trinity bays and the eastern Avalon with yellow and orange streamer tags. The results of taggings at Harbour Grace, Conception Bay during October, 1978, Dildo, Trinity Bay, during October, 1978 and Seal Cove, Conception Bay, during June, 1979, are presented to describe the distribution of juvenile cod in the years succeeding their tagging.

The cod tagged during February-March, 1978-81 in 2J3KL were obtained by an Engel High Rise otter trawl. The net was not lined with a fine mesh liner except during the 1978 tagging. The sets were generally short (10-20 minute duration) but in 1981 frequently were of 30 minute duration. The duration of the set depended upon the concentration of cod as indicated from the echo sounder. Since the concentrations of cod were in deep water (230-350 m) and in generally ice covered areas, particular demands were placed on the tagging operations. In the first instance the net had to be taken back very slowly (8-10 m/minute) to allow the cod to acclimate to the changing pressure and to prevent drowning from crowding in the codend. In the second instance the codend had to be hauled back in open water to prevent death of the cod from supercooling and eventual freezing, if after being pulled through water temperatures of about -1.5 to -1.7°C they were hauled through water filled with ice crystals. Similarly, the tagged cod had to be released in polynas or open water to prevent death from freezing in the cold water laden with ice crystals.

Only fish classed in excellent condition were tagged. Any fish showing signs of bruising, scale loss, injuries to fins or gills, bleeding, and "pop eye" condition were routinely culled out during the tagging procedures. Any fish with distended swim bladders were culled out rather than attempt to squeeze the gas out of the swim bladder. The cod were held in holding tanks, which were filled with running sea water. The cod to be tagged were dipped out with dip nets. They were measured, examined for Lernaeocera branchialis, and tagged. The cod were then placed in recovery tanks filled with running sea water until they fully recovered and actively swam in the tank and were then released through the rock hatch at the level of the water line of the ship. Thus the cod were placed, not dropped, into the sea. The recaptures are grouped arbitrarily by seasonal periods corresponding to the offshore fishery season (January-April) and the inshore fishery season (May - December). The results from the year of tagging are treated separately from subsequent years to compare for annual changes in migration pattern. The tag recaptures are grouped by rectangles where possible. There were a few instances where tag recaptures offshore could be assigned only to NAFO Division and had to be omitted from the charts. Generally, however, it was possible to utilize ship's logs and observer data to obtain a best estimate of where the tag was caught and minimize omissions of this type.

The landings of cod by Newfoundland fishermen from designated fishing areas (Fig. 1) were obtained for 1978-81 using comparable seasonal groupings as those used to group tag recaptures (Table 2). Although the unit areas for which catches are reported are different in area and shape than those for which the recaptured tags are grouped, they give a reasonable picture of distribution of catches for comparison purposes especially for the east coast of Newfoundland, the Strait of Belle Isle, and Labrador.

RESULTS

RECAPTURES FROM TAGGING ON OFFSHORE OVERWINTERING CONCENTRATIONS

Belle Isle Bank (1978)

From the tagging of 2,728 adult cod during February 26-March 12, 1978, returns during May-December, 1978 were mainly north of Cape Freels (Fig. 2) (95% north of Cape Freels). The distribution of returns during May-December, 1979-81 was remarkably similar (94% of inshore recaptures north of Cape Freels). This pattern persisted during these years with few tags reported south of Cape Freels, yet the May-December catches from Cape Freels to Smokey during 1978 and 1979-81 were 58% and 66% of the total catches from Cape Race to Smokey (including the Strait of Belle Isle (unit area 401). There appears to exist a particular tendency for cod of the Belle Isle Bank to home to the southern part of Labrador, the northeast Newfoundland coast and to enter the Strait of Belle Isle during the May-December period. In the year following tagging, (1979) the winter (January-April) distribution of tags was either in the tagging areas or in the adjacent areas. The degree of homing is not so clearly distinguished here possibly because the commercial trawlers were fishing more on Funk Island Bank (Areas 204 and 347) than in the areas in which the cod were tagged (Area 203). Winter returns during 1980-82 were mainly from the tagging areas although there was an indication of northward movement of cod to Hamilton Bank. In these years there is more evidence of homing to the general areas in which the cod were tagged and could possibly be termed their specific spawning area.

Northern Slope of Funk Island Bank (1978)

During February 27-March 10, 1978, 1725 adult cod were tagged on the northern slope of Funk Island Bank, adjacent to the tagging areas on Belle Isle Bank (Fig. 3). The distributions of tags during May-December, 1978, and 1979-81, were similar to each other and were also similar to the returns from Belle Isle Bank (i.e. mainly north of Cape Freels, southern Labrador coast and at the entrance to the Strait of Belle Isle) although there was more of a southward tendency than those recaptured from the Belle Isle Bank tagging (84% and 83% north of Cape Freels during 1978 and 1979-81 respectively). The recaptures during winter of 1980-82, the returns were more northerly distributed although there were returns from tagging areas and adjacent areas.

Northeast Slope of Funk Island Bank (1979)

Of the 3119 cod tagged during February 27-March 2, 1979 on the northeast slope of Funk Island Bank, the inshore recaptures during May December, 1979 were distributed from Cape Harrison to Cape Race with only 3 recaptures inside the Strait of Belle Isle (Fig. 4). Most of the recaptures, however, were south of Cape St. John (65%) with 40% south of Cape Freels. During May-December, 1980-81 the pattern of distribution was different with lower percentages south of Cape St. John (45%) and Cape Freels (12%). In the offshore area during May-December the tags were distributed from Makkovik Bank to the Virgin Rocks and the southwest slope of the Grand Bank but mainly from the Belle Isle Bank and Funk Island Bank. The recaptures from the Virgin Rocks were mainly during June-August. The winter recaptures during 1980 were mainly from Funk Island Bank and the neighboring Belle Isle Bank although there were 12 recaptures from the area in which they had been tagged the previous year. During January-April, 1981-82, the returns were mainly from the surrounding area but there were 8 from the southeast slope of Hamilton Bank during 1982 when there was a major concentration of effort during February-March 1982.

Eastern edge of Funk Island Bank (1979)

The inshore returns during May-December, 1979 from a total of 1801 cod tagged on the eastern slope of Funk Island Bank during February 23-March 2, 1979 were distributed mainly south of Cape St. John (88%) with a strong distribution (58%) south of Cape Freels in Bonavista, Trinity, and Conception Bays and the eastern Avalon (Fig. 5). There were a few returns from the northern Grand Bank and the Virgin Rocks. A somewhat similar pattern of distribution was evident during May-December, 1980-81 (80% south of Cape St. John and 37% south of Cape Freels) but with a reduced proportion in the southern area. There were also returns from the Virgin Rocks, the northern Grand Bank, and Belle Isle Bank.

The winter distributions of tags during the 1980 and 1981-82 periods were mainly from the slope area between Belle Isle Bank and Funk Island Bank with some from the slope between Belle Isle Bank and Hamilton Inlet Bank.

Southern Funk Island Bank (1979)

Most of the May-December returns from the tagging of 251 cod during March 9-19, 1979, on the southern Funk Island Bank (mainly the southwestern slope) were from White Bay to Baccalieu (Fig. 6A). There were only two returns during January-April, 1980-82, one from the tagging area and one from Belle Isle Bank.

North Cape of the Grand Bank (1979)

The inshore recaptures during May-December, 1979-81 from the 293 cod tagged during March 11-12, 1979 on the north cape of the Grand Bank were all from areas south of Cape Freels and were mainly from the Avalon Peninsula as far west as Cape St. Mary's (Fig. 6B).

The returns during January-April, 1980-82 were mainly distributed around the slopes of Funk Island Bank. There was one return from the Virgin Rocks during April, 1981.

Northeastern Funk Island Bank (1980)

The inshore returns for May-December 1980-81 from northeastern Funk Island Bank tagging of 560 cod during March 15-20, 1980 were mainly distributed from White Bay to the eastern Avalon with most returns in the area from Cape Freels to Conception Bay (Fig. 7). There were three returns during the summer from the Virgin Rocks. The three winter returns during 1981-82 were from the slope areas surrounding Belle Isle Bank. This pattern is similar to that from the 1979 tagging on the eastern edge of Funk Island Bank (Fig. 5).

Southeastern Slope of Funk Island Bank (1980)

The inshore returns during May-December 1980 from 2259 cod tagged during March 17-23, 1980 were mainly (94%) south of Cape St. John and as far west of Cape St. Marys (Fig. 8). The offshore returns were mainly from the Virgin Rocks where they were caught mainly during June-July. The inshore returns during May-December 1981 had a pattern very similar to that of the 1980 returns. The January-April returns during 1981-82 were from the slope areas around Funk Island and Belle Isle banks although there was one return from the southern part of Green Bank and one from deep water in Placentia Bay.

Southwestern Funk Island Bank (1980)

The recaptures during May-December 1980 from 2158 cod tagged during March 24-27, 1980 on southwestern Funk Island Bank were mainly distributed from the Strait of Belle Isle to Cape Race (Fig. 9) but most of the recaptured tags were in the area from White Bay to the eastern Avalon Peninsula. The returns during May-December 1981 showed a somewhat similar distribution but were concentrated mainly in the Notre Dame Bay area. The winter distributions of tag returns during January-April, 1981-82 were mainly from the slope areas of Funk Island Bank, the eastern slopes of Belle Isle Bank, and the north cape of the Grand Bank.

North Cape of the Grand Bank (1980)

The inshore returns during May-December, 1980 from the March 1980 tagging on the north cape of the Grand Bank were mainly south of Cape Bonavista and as far west as St. Mary's Bay (Fig. 10). Most of the returns however were from the northern half of the Grand Bank especially around the Virgin Rocks with some from the eastern edge of the Grand Bank.

The returns during May-December 1981 showed a somewhat similar pattern although there were no returns from the eastern edge of the Grand Bank. In both years there were several recaptures from the southern Grand Bank and St. Pierre Bank. The winter recaptures (January-April) during 1981-82 were predominantly from the tagging area and the northwestern slope of the Grand Bank although there were five returns from the slopes of Funk Island Bank and Belle Isle Bank.

Southwestern Funk Island Bank (1981)

The recaptures from the March 1981 tagging of 1195 cod on the southwestern slopes of Funk Island Bank were mainly south of Cape St. John and north of Conception Bay and were similar to the recaptures during 1980 and 1981 from the 1980 tagging in approximately the same area. The 1981 tagging was somewhat south of the 1980 tagging. There were no recaptures from Labrador and only two from the Strait of Belle Isle (Fig. 11). There were only 3 recaptures reported during January-April, 1982, one from the tagging area, one from the north cape of the Grand Bank, and one from the north slope of Belle Isle Bank.

Northeastern Hamilton Inlet Bank (1981)

The inshore returns during May-December, 1981 from the March 1981 tagging of 3305 cod on northeastern Hamilton Inlet Bank were mainly from Labrador and northeastern Newfoundland although there were three returns from the southeast Avalon Peninsula (Fig. 12). There were some offshore recaptures during this period from the inner slopes of Belle Isle and Funk Island banks and the northern slopes of the Grand Bank but none on the top of Grand Bank as opposed to the results from the taggings on the eastern Funk Island Bank and the northern part of the Grand Bank.

The winter returns (January-April, 1982) were mainly from the southeastern slope of Hamilton Inlet Bank, where most of the commercial effort was concentrated during the winter offshore fishery in 1982. There were some returns from the northern slopes of Hamilton Inlet Bank mainly during January, 1982.

Southeastern Funk Island Bank (1981)

From a small tagging experiment (372 cod tagged) during March, 1981 on the southeastern edge of Hamilton Inlet Bank, there were returns mostly from northeastern Newfoundland as far south as Trinity Bay and from Labrador, mainly around Domino (Fig. 13). There were single returns from the eastern Avalon, northern Gulf of St. Lawrence, and one from as far north as Makkovik. The winter (January-April) returns during 1982 were mainly from the tagging area or areas adjacent to the tagging area.

Northern Slopes of Funk Island Bank (1981)

During March 25-27, 1981, 3139 cod were tagged on the northern slopes of Funk Island Bank in the same area as tagging was conducted during February 27-March 10, 1978. The returns during May-December, 1981 from the 1981 tagging (Fig. 14) displayed a remarkably similar distribution to the recaptures during May-December, 1978 and May-December 1979-81 from the 1978 tagging (Fig. 3). This indicates a relatively constant summer distribution pattern of cod which overwinters in this shelf area. From each of the taggings there are recaptures into the Strait of Belle Isle as far south as Port aux Choix the apparent southern limit of northern cod in the northern Gulf of St. Lawrence.

The winter recaptures during January-April, 1982 were mainly from the slope area between southeastern Hamilton Inlet Bank and the northern and eastern slopes of Belle Isle Bank, an area of very intensive fishing during the winter of 1982.

RECAPTURES FROM ADULT COD TAGGED DURING SUMMER-AUTUMN IN INSHORE AREAS

Conception Bay (1979, 1980)

During October 19-November 5, 1979 and October 9-19, 1980, 437, and 766 adult cod respectively were tagged in Conception Bay in southeastern Newfoundland.

The returns during May-December, 1980 from the 1979 tagging were mainly from the tagging area or in adjacent unit areas (Fig. 15). The inshore returns were localized in southeastern Newfoundland from Cape Freels south to Cape St. Mary's. There were four offshore recaptures, two from the northern Grand Bank, one from the eastern Grand Bank and one from the western Grand Bank. The returns during summer 1981, although reduced in numbers, were mainly from the tagging area, indicative of homing to the same summer feeding area or overwintering in the bay. The two winter recaptures from Conception Bay indicate some overwintering in the bay while the offshore recaptures indicate that these cod migrate north to the north cape of the Grand Bank and the slope areas of Funk Island Bank during the winter.

The recaptures during May-December, 1981 from the 1980 tagging indicate a similar homing tendency and a similar summer distribution to that obtained from the 1979 tagging (Fig. 16). There were only four inshore recaptures (5% of the total) north of Cape Freels. Thus it appears that the cod which migrate in summer to Conception Bay demonstrate a marked tendency to return in subsequent years to the same or adjacent areas.

The winter returns (January-April, 1981-82) were mainly from the northwestern and north cape of the Grand Bank with two from the slopes of Funk Island Bank.

Orton Island, Labrador (1981)

During August 20, 1981, 338 adult cod were tagged off Orton Island, near Nain in northern Labrador. These cod were obtained by Norwegian jiggers in shallow water (7-26 m) near Orton Island.

During November-December, 1981 there were three recaptures, two from Makkovik Bank and one from Harrison Bank (Fig. 17). During January 1982, there were five returns, one from the slopes of Makkovik Bank and four from the northern slopes of Hamilton Bank. During February, 1982 the recaptures were further south, eight from the northeastern slope of Hamilton Inlet Bank and three from the slope areas between Hamilton Inlet Bank and Belle Isle Bank. There were two recaptures during April both from the outer slopes of Belle Isle Bank. The southward movement may be partly a reflection of

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the fishing pattern yet it must be admitted that at least some of the cod which migrate during summer to the Nain area overwinter along the slopes of Hamilton Inlet Bank and as far south as Belle Isle Bank. Thus the cod which feed inshore in northern Labrador during summer-autumn are intermingled with the cod of NAFO Division 2J during the overwintering concentration and quite possibly also spawn in this area.

Recaptures from tagging of Juvenile cod, Harbour Grace, (1978)

During October, 1978, 1,000 juvenile cod were tagged at Harbour Grace, Conception Bay. These cod ranged in length from 15 to 40 cm but were mainly 18-30 cm (87% of the total). There were only two recaptures in the tagging year (1978), both from the tagging area. Recaptures during 1979 were mainly from the tagging area but there were three returns from the eastern Avalon, two from Cape St. Francis, seven from the northern shore of Conception Bay and six from Trinity Bay (Fig. 18). This indicates mainly northward movement of those fish which migrated out of the bay. Offshore during 1979 there was one return from the north cape of the Grand Bank from the spring fishery. During 1980 there were ten recaptures from within Conception Bay close to the tagging area. There were three returns from the southeast Avalon, two from the Baccalieu area and two from the eastern side of Trinity Bay. There was one recapture from Fogo, indicative of northward movement. During 1981 the returns from Trinity Bay, Bonavista Bay, Notre Dame Bay, and the north cape of the Grand Bank indicate northward migration. There was one recurn from the eastern Avalon. During 1982 there was one recapture from the spring fishery on the north cape of the Grand Bank. These results indicate that these cod migrate northward and eastward to offshore winter concentrations as they grow older and approach sexual maturity.

Dildo, Trinity Bay (1978)

During October, 1978, 249 juvenile cod were tagged at Dildo, Trinity Bay (Fig. 19). These ranged in length from 16 to 43 cm but were mainly 20-35 cm (85%). During the year of tagging there were no recaptures. During 1979 most of the recaptures were from the immediate tagging area but there was one from the southeast Avalon, 5 from the eastern shore of Trinity Bay, 1 from the west side of Trinity Bay, and two from Bonavista Bay. During 1980 there were three recaptures from the tagging area or in the approximate area of tagging, one from the southern Avalon, and 1 from the north cape of the Grand Bank. During 1981 there was a recapture from the winter fishery from the northern slope of Funk Island Bank. The tag returns in years subsequent to the tagging are indicative of northward movement with time.

Seal Cove, Conception Bay (1979)

During June, 1979, 1020 juvenile cod (20-30 cm) were tagged at Seal Cove, Conception Bay (Fig. 20). During the summer of 1979 most of the returns were from the immediate tagging area but there were six returns during July and August from the eastern end of Conception Bay and around Cape St. Francis indicative of movement of juvenile cod out of the bay along its eastern shore at this time. During 1980 most of the returns were from the immediate area of tagging indicative of overwintering in the bay or homing back to the tagging area. There were seven returns from the eastern shore of the Avalon Peninsula and one from St. Mary's Bay indicative of some southward movement and possibly intermingling of the Conception Bay juvenile cod with the Avalon-Burin stock. There was evidence of northward migration from the four recaptures from the northern end of Conception Bay and three from the eastern end of Trinity Bay. During 1981 there were two returns from the north cape of the Grand Bank and a northern recapture from Cape Bonavista. There was also one from Baccalieu area and there were two from the eastern Avalon.

During the winter fishery, 1982, there were 2 recaptures on the shelf and slope area east of Belle Isle Bank and north of Funk Island Bank, further evidence of northward migration of young cod with increasing age. There was also 1 recapture during spring, 1982 from deep water in a gillnet set in Notre Dame Bay, further evidence of northward migration. This cod could have possibly migrated into Notre Dame Bay from offshore.

MERISTIC CHARACTERISTICS

Six meristic characters were obtained from mature cod taken during 14-21 March, 1982 on the southeastern slope of Hamilton Inlet Bank, the northern slope of Funk Island Bank, and the northwestern slope of the Grand Bank east of Cape Bonavista (Fig. 21). During 8-12 May, 1982 samples were obtained from the north cape of the Grand Bank and the eastern edge of the Grand Bank.

The cod were sampled at sea for length, sex, maturity, otoliths, and <u>Lernaeocera branchialis</u>. The fillets were removed from each cod and the three dorsal fins, two anal fins and the vertebral column were frozen and brought back to the laboratory. The vertebral columns and fin rays were x-rayed and the meristic counts were obtained from the radiograms.

Analysis of variance indicated that all 6 characters from the southeastern Hamilton Bank were significantly higher at the .01 level (except the first anal fin count at the .05 level) than the characters from the other 4 areas. Duncan's multiple range test (Kramer 1956) indicated no differences among the other 4 areas for the first dorsal fin ray, the second dorsal fin ray, the third dorsal fin ray, the first anal fin ray and the second anal fin ray averages. For the vertebral averages, Duncan's test indicated that the average from the southeastern Hamilton Inlet Bank was significantly higher than all the others, while that from the eastern edge of the Grand Bank was significantly lower than all the others. The averages from the north cape of the Grand Bank, eastern Grand Bank, and northern Funk Island Bank were not significantly different from each other for any of the six meristic characters analyzed.

DISCUSSION

MIGRATION AND DISTRIBUTION OF ADULT COD TAGGED FROM OVERWINTERING CONCENTRATIONS OFFSHORE

Hamilton Inlet Bank

The results from the tagging on the northeastern and southeastern Hamilton Inlet Bank confirm that the cod, which are on the outer slopes during March, migrate during the summer mainly to the southern Labrador coast and the northeast Newfoundland coast from Notre Dame Bay northwards, although this group of cod contribute to some degree to the fishery as far south as the eastern Avalon Peninsula. There is also a small proportion of these tags recaptured within the Strait of Belle Isle, suggesting that the Hamilton Inlet Bank cod intermingle with cod of the northern Gulf of St. Lawrence. The inshore distributions from the recent taggings are similar to the results obtained by Templeman (1979) for cod tagged during April 1966 and May 1964 on the northeast Hamilton Bank and southeast Hamilton Bank, respectively.

The offshore recaptures during January-April, 1982 from the recent Hamilton Inlet Bank taggings were mainly from the southeastern slope of Hamilton Inlet Bank. This indicates that the cod of the eastern slopes of Hamilton Inlet Bank intermingle during the winter and may concentrate anywhere along the slope, depending upon environmental factors such as temperature, current, and possible degree of ice cover in as much as it affects the levels of light intensity which may contribute to orientation along the slopes. Thus there is a high degree of homing back to the eastern slopes of Hamilton Inlet Bank during the winter.

Belle Isle Bank

The results from tag recaptures from cod tagged during February-March on Belle Isle Bank indicate very clearly that the group of cod which overwinters on the shelf and slopes in this area migrates during summer, mainly to southern Labrador, the entrance of the Strait of Belle Isle, and the northeast Newfoundland coast as far south as Notre Dame Bay. Only a few tags were recaptured south of Cape Freels. The patterns of return during the year of tagging and during the years subsequent to the tagging year were essentially very similar. These results are also similar to results obtained by Templeman (1979) from tagging during September 1962 on Belle Isle Bank. The winter distributions of tags during the 1979 and 1980-82 periods were similar in that most of the returns were from the tagging areas or adjacent rectangles, indicating a high degree of homing for four successive years to the shelf and slope areas where they were tagged.

Northern and Northeastern Slopes of Funk Island Bank

The distribution of tags during May-December from the 1978, 1979 and 1981 taggings on the northern slopes (Rectangles R19, S19) were mainly from southern Labrador and eastern Newfoundland, with a large contribution to the southeastern Newfoundland coast as far south as Conception Bay and the eastern shores of the Avalon Peninsula. There is a greater contribution of tags to the east and southeast coast of Newfoundland than from the taggings on Hamilton Inlet and Belle Isle banks. There were only a few from the Strait of Belle Isle. The winter distributions of tags were mainly from the shelf and slope areas around northern Funk Island Bank and the shelf and slope areas north of Funk Island Bank and east of Belle Isle Bank. During January-April 1982 there were some returns of the 1981 tagging from the shelf area Inlet Bank. The returns from the 1979 tagging on the northeastern slope of Funk Island Bank (R20, S20) were mainly distributed during summer in eastern and southeastern Newfoundland, mainly from Cape St. John to St. John's. There were also a few returns from southern Labrador and occasional returns from the Strait of Belle Isle. The winter recaptures during 1980 were from the tagging and adjacent areas as well as from Belle Isle Bank. During 1981-82 the winter recaptures were mainly from the slope area between Belle Isle Bank and Funk Island Bank. The summer recaptures during 1980-81 from the tagging on the northeastern slopes of Funk Island Bank (S19, S20) were mainly from eastern Newfoundland.

In most of the taggings from the northern Funk Island Bank there were a few recaptures during summer on the northern Grand Bank and around the Virgin Rocks.

Southeastern Slopes of Funk Island Bank

The tag recaptures during summer from tagging on the southeastern slopes of Funk Island Bank were mainly from the east coast of Newfoundland between Notre Dame Bay and St. Mary's Bay with only a total of three tags from Labrador. There were only a few tag recaptures during winter, possibly because of low fishing effort in the tagging area. The few winter returns were mainly from the shelves and slopes of Funk Island Bank.

Southwestern Slopes of Funk Island Bank

The returns from cod tagged on the southwestern slopes of Funk Island Bank indicate that this group of cod contribute mainly to the summer inshore fishery on the east coast of Newfoundland between Cape Bauld, the entrance to the Strait of Belle Isle and the eastern Avalon Peninsula. The areas of greatest concentration of tags from these taggings were Notre Dame Bay, Bonavista Bay and to a smaller degree, Trinity and Conception bays and the eastern part of the Avalon Peninsula. This cod group contributes relatively little to the Labrador inshore fishery. The winter recaptures were from the Funk Island Bank, the neighboring north cape of the Grand Bank and the shelf east of Belle Isle Bank.

North Cape of the Grand Bank

The distributions of tag recaptures from tagging during March on the north cape of the Grank Bank indicate that this group of cod moves mainly southwards over the top of the northern Grank Bank and its eastern slopes and to the areas of the Virgin Rocks during the summer. The inshore recaptures were mainly from Trinity and Conception bays and the eastern Avalon and St. Mary's Bay. This group of cod contributes very little to the inshore fishery north of Cape Bonavista. The recaptures during winter were mainly from the tagging area or areas adjacent to the tagging area, but there were occasional recaptures from Funk Island Bank and to a lesser extent, from Belle Isle Bank.

DISTRIBUTION OF ADULT COD TAGGED AT INSHORE LOCALITIES DURING SUMMER AND AUTUMN

Conception Bay

The distributions of tag returns during May-December of the years subsequent to the October-November tagging in Conception Bay indicate that there is a great degree of homing back to the tagging area, or neighboring areas. Most of the inshore returns were from Trinity and Conception bays, and the eastern Avalon, although there were some from St. Mary's Bay, Bonavista Bay and Notre Dame Bay. The winter recaptures were mainly from the northern Grand Bank and Funk Island Bank. There were two returns during April from Conception Bay, indicative of possible overwintering or of an early inshore migration into the bay. These two returns were close to the tagging area and in a similar depth of water (46 m) as that in which they were tagged (35-49 m).

Orton Island, Labrador

The distributions of tag recaptures from the August tagging of adult cod at Orton Island, near Nain, Labrador, indicate that during the autumn and early winter, there is a migration southwards along the Labrador shelf. The results of Postoloky (1966) indicate that the actual spawning areas of many of the recaptured cod from taggings off northern Labrador are farther north than they appear to be from their winter-spring recapture locations. Templeman (1979) summarizes the findings of Templeman (1964, 1965), Noskov and Zakharov (1964), Bogdanov <u>et al</u>. (1965), and Dias (1965, 1967),

and draws the conclusion that cod of Labrador (Subarea 2) spawn mainly in March-April in deep water on the continental slopes, with most of the remainder spawning in May. Based upon this conclusion, then it can be concluded that some of the cod which migrate during summer to the northern Labrador coast, specifically the Nain area, return to spawn along the slopes of Hamilton Inlet Bank and as far south as Belle Isle Bank during March and April.

DISTRIBUTION OF TAGGED JUVENILE ATLANTIC COD

The distributions of recaptures of juvenile cod tagged during 1978 and 1979 in Trinity and Conception bays indicate that in years subsequent to the tagging, there is a net northward movement of these cod as they grow older and attain sexual maturity. There were some recaptures along the eastern coast of the Avalon Peninsula, but these may have migrated offshore during the winter and returned during the summer. The offshore recaptures were taken during the winter and spring and were mainly from the northern Grand Bank, although there was evidence of migration as far north as southeastern Hamilton Bank. This lends support to the hypothesis that the juvenile cod of eastern Newfoundland are progeny of northern stocks of cod and upon maturing will migrate back to the areas in which they were spawned. The analyses of the vertebral averages of juvenile cod from the east coast of Newfoundland indicate that these cod are mainly of northern origin (Lear and Wells, this symposium).

MERISTIC CHARACTERS OF MATURE COD TAKEN FROM WINTER-SPRING CONCENTRATIONS

The significantly higher meristic counts of the fin rays and vertebrae of the mature cod of the southeastern Hamilton Bank than those from the Funk Island Bank suggest that the Hamilton Bank cod are different from those of the Funk Island Bank and the northeast Newfoundland Shelf. The tag returns from both areas also suggest different summer distributions, although overlapping, of the two major groupings.

The homogeneity of the meristic characters from Funk Island Bank, and the northern Grand Bank do not suggest any differences, but the difference in the summer distribution of cod tagged on Funk Island Bank and the north cape of the Grand Bank suggest that these groups are different in their summer migration pattern. The significantly lower vertebral averages of the cod of the eastern slope of the Grand Bank suggest that the mature cod in this area during the spring are somewhat different from the other groups.

CONCLUSIONS

- 1. The cod which overwinter on the eastern slopes of Hamilton Inlet Bank contribute mainly to the summer inshore fishery along the southern Labrador coast, the northeast Newfoundland coast mainly from Notre Dame Bay northwards. It contributes in a lesser degree to the inshore fishery as far south as the Avalon Peninsula. There is a high degree of homing back to the eastern slopes of Hamilton Inlet Bank during the winter where they presumably spawn.
- 2. The group of cod which overwinters on the slopes of Belle Isle Bank migrate during summer mainly to southern Labrador, the entrance to the Strait of Belle Isle and the northeast coast of Newfoundland as far south as Notre Dame Bay. It contributes very little to the inshore fishery south of Cape Freels.
- 3. The cod of the northern and northeastern slopes of Funk Island Bank migrate during summer to eastern and southeastern Newfoundland with smaller contributions to southern Labrador and the Strait of Belle Isle area than from the taggings on Belle Isle Bank.
- 4. The cod of the southeastern slopes of Funk Island Bank contribute to the inshore fishery mainly along the east coast of Newfoundland between Notre Dame Bay and St. Mary's Bay. There is a negligible contribution to the inshre fishery in Labrador from this group of cod.
- 5. The cod from the southwestern slope of Funk Island Bank contribute mainly to the summer inshore fishery on the east coast of Newfoundland between Cape Bauld, the entrance to the Strait of Belle Isle and the eastern Avalon Peninsula. The greatest contributions of this cod group are to Notre Dame Bay and Bonavista Bay and to a smaller degree Trinity and Conception bays and the eastern part of the Avalon Peninsula.
- 6. The cod which overwinter on the north Cape of the Grand Bank migrate southwards over the top of the Grand Bank and its eastern slopes and around the Virgin Rocks. This group of cod contributes

to the inshore fishery from Trinity Bay southwards to St. Mary's Bay and contributes very little to the inshore fishery north of Cape Bonavista.

7. The cod which were tagged during autumn in Conception Bay displayed a high degree of homing to the tagging area or neighbouring areas in subsequent years. During winter they migrated mainly to the northern Grand Bank and Funk Island Bank.

8. Some of the cod which are inshore in the Nain area during summer migrate southwards during autumn and winter along the outer continental slopes to Hamilton Inlet Bank and Belle Isle Bank where they presumably spawn.

9. There is a net northward movement of cod tagged as juveniles in Trinity and Conception bays. This lends support to the hypothesis that the juvenile cod of eastern Newfoundland are progeny of northern stocks and upon maturing will migrate back to the areas in which they spawned.

10. On the basis of six-meristic characters analyzed, it is concluded that the cod of Hamilton Bank are different from those of the Funk Island Bank and northern Grand Bank. The characters of the cod from the Funk Island Bank, northwestern Grand Bank and north Cape of the Grand Bank were not different from each other. The cod of the eastern slope of the Grand Bank had significantly lower vertebral averages than the other four areas.

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Table 1. Description of tag types applied to adult Atlantic cod during February- March, 1978-81 on Hamilton Inlet Bank, Funk Island Bank, Belle Isle Bank, and the north cape of the Grand, during October, 1979-80 in Conception Bay and near Nain, Labrador, during August, 1981.

Years applied	Description
1978-81	13 mm diameter yellow Petersen disc and blank attached posterior to first dorsal fin by .032 soft stainless steel wire, 3 mm space allowed on each side of fish.
1978	7 cm yellow spaghetti T-Bar tag attached through base of the first dorsal fin.
1979-81	8.25 cm yellow spaghetti T-bar tag attached through base of the first dorsal fin.
1979-81	8.25 cm orange spaghetti T-Bar attached through base of the first dorsal fin.
1979-81	Combination tag composed of 13 mm diameter yellow Petersen disc and blank with a yellow dangler tag (5 cm long by 13 mm wide) attached to trail along each side of fish. The attachment is by .032 soft stainless steel wire posterior to the first dorsal fin with a spacing of 3 mm allowed on each side of the fish.

Table 2. Cod landings (MT) by Newfoundland fishermen from designated fishing areas for 1978-81 by arbitrary fishing season. (+ indicates a catch 500 kg).

ICNAF 1978			1978		1979		1980		1981	
Area	Division	JanApr.	May-Dec.	Jan	Apr.	May-Dec.	JanApr.	May-Dec.	JanApr.	May-Dec.
201	2J	0	5655		0	6826	0	12,688	0	9.325
202	2J	0	6	. 1	Ö	5	0	0	147	0
203	2J	1,238	0		865	9	0	6.654	9,726	224
204	2J	2,520	0	. !	5,002	4	3,423	0	4,572	0
205	2J	0	0	1	0	4	309	0	0	0
206	2J	199	0		58	6	0	264	1,433	3
207	2J	0	4	.	0	521	0	15	0	2
208	2J	0	492	1	104	1301	0	3,044	0	2,904
209	2J -	0	486		0	813	0	634	. 0	986
210	2J	0	4		0	1,073	0	13	0	7
211	2J	0	+ , +	5.	. 77	9	. 0	17	0	0
212	2H	0	5		0	67	0	66	- 0	71
213	2H	0	16	1	0	14	0	0	0	3
214	2H	0	0		0	37	0	0	0	- 0
215	2H	0	14		0	8	0	. 34	0	9
216-	· · · · ·	a provincia de la composición de la com								
224	2GH	0	+		0	0	0	+	0	6

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Table 2. (Cont'd)

Area	ICNAF Division	JanApr.	1978 May-Dec.	19 JanApr.	79 May-Dec.	198 JanApr.	30 May-Dec.	JanApr.	1981 May-Dec.
301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320	3PN 3Ps 3PS 3PS 3PS 3PS 3PS 3PS 3PS 30 30 30 30 30 30 30 30 30 30 30 30 30	460 77 62 34 9 186 764 115 309 0 0 0 139 0 0 0 139 0 0 0 153 79 688 39	5,811 4,573 3,848 11,310 241 4 148 7 0 1,042 513 7 316 682 517 250 0 1 1 0	9,896 4,426 5,195 0 0 59 1,190 242 134 0 1,771 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	312 128 626 13,441 272 36 + 32 13 2,083 300 168 91 353 673 603 75 251 399 217	8,133 5,746 7,207 1,953 0 0 1,101 380 0 7 0 38 0 0 0 0 0 11 0 0 0 0 0 0 0 0 0 0 0 0 0	16 158 263 12,773 726 502 746 515 166 998 126 15 107 244 377 1,141 130 428 696 256	3,552 549 0 78 9 2 393 1,041 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	7,643 5,561 6,632 11,460 1,489 213 444 885 0 463 46 40 1,089 477 754 2,564 61 1 220 103
321- 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347	3M 3L 3L 3L 3L 3L 3L 3L 3L 3L 3L	$ \begin{array}{c} 1\\ 0\\ 0\\ 0\\ 0\\ 1,445\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 381\\ 0\\ 156\\ 0\\ 5\\ 62\\ 1,204\\ 1,208\\ 2,455\\ 321\\ 457\\ \end{array} $	$112 \\ 10 \\ 116 \\ 150 \\ 2,225 \\ 598 \\ 8 \\ 2,219 \\ 441 \\ 285 \\ 8,924 \\ 14,827 \\ 7,541 \\ 8,667 \\ 6,261 \\ 15,052 \\ 5,687 \\ 5,076 \\ 4,017 \\ + \\ 3 \\ 0 \\ 1 \\ 2$	$\begin{array}{c} 0\\ 1\\ 379\\ +\\ 0\\ 7\\ 5,434\\ 2,231\\ 0\\ 0\\ 7,092\\ 0\\ 1,310\\ 4,299\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\$	$\begin{array}{c} 1\\ 147\\ 74\\ 288\\ 2,034\\ 681\\ 256\\ 211\\ 2,118\\ 534\\ 2,442\\ 17,016\\ 6,018\\ 5,734\\ 7,366\\ 11,239\\ 8,015\\ 4,559\\ 3,533\\ 9\\ 23\\ 1,052\\ 10\\ 99\end{array}$	$\begin{array}{c} 0\\ 45\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\$	$\begin{array}{c} 0\\ 0\\ 239\\ 821\\ 851\\ 1,218\\ 10,532\\ 1,135\\ 2,194\\ 558\\ 5342\\ 12,950\\ 6,164\\ 5,960\\ 4,643\\ 14,986\\ 9,127\\ 7,503\\ 5,421\\ 2,825\\ 27\\ 53\\ 0\\ 8,128\end{array}$	$\begin{array}{c} 0\\ 21\\ 0\\ 0\\ 0\\ 0\\ 0\\ 632\\ 1,458\\ 0\\ 198\\ 0\\ 51\\ 0\\ 51\\ 0\\ 2\\ 3\\ 14\\ 0\\ 0\\ 0\\ 0\\ 787\\ 0\\ 1,080\\ 1,383\\ 10,805 \end{array}$	2 0 132 196 3,597 1,424 12,781 172 1,416 1,012 5,880 14,342 4,965 7,489 8,875 10,393 6,046 3,780 2,924 0 4,112 16 0 0
401 402 403 404 419	4R 4R 4R 4R 4R	0 696 4,275 4,930 0	16,454 5,521 2,442 1,058 0	0 5,087 2,048 1,517 0	18,930 3,728 2,564 3,222 0	297 3,380 2,499 11,018 0	30,285 3,540 869 470 0	0 419 + + 0	26,196 12,362 2,972 7,500 307

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Fig. 2. Location of returns in various monthly periods from adult cod tagged on Belle Isle Bank during Feb. 26-March 12, 1978.

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Fig. 3. Location of returns in various monthly periods from adult cod tagged on the northern slope of Funk Island Bank during Feb. 27 - March 10, 1978.



Fig. 4. Location of returns in various monthly periods from adult cod tagged on the northeast slope of Funk Island Bank during Feb. 27 - March 2, 1979.

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Fig. 5. Location of returns in various monthly periods from adult cod tagged on the eastern edge of Funk Island Bank during Feb. 27 - March 2, 1979.





Fig. 7. Location of returns in various monthly periods from adult cod tagged on the northeastern Funk Island Bank during March 15-20, 1980.

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Fig. 10. Location of returns in various monthly periods from adult cod tagged on the north cape of the Gand Bank during March 28-30, 1980.

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Fig. 11. Location of returns in various monthly periods from adult cod tagged on the southwestern Funk Island Bank during March 14-27, 1981.



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56° 52° 54° 58⁰ 12 55° 13 14 54° 15 8 16 100 fathoms (183m)---200 fathoms (366 m)--53° 17 18 52° 2 19 20 510 21 0 22 50° 23 24 21 EXPERIMENT 49° Number Tagged = 372 25 Tagging Area 26 MAY-DEC., 1981 48° 27 JAN-APRIL, 1982 28 47° Κ N R J L P

Location of returns in various monthly periods from adult cod tagged Fig. 13. on the southeastern Hamilton Injet Bank during March 24, 1981.

M

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- 25 -



Fig. 14. Location of returns in various monthly periods from adult cod tagged on the northern slopes of Funk Island Bank during March 25-27, 1981.

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Fig. 16. Location of returns in various monthly periods from adult cod tagged in Conception Bay during October 9-19, 1980.



Fig. 17. Location of returns in various monthly periods from adult cod tagged at Orton Island near Nain, Labrador during August 20, 1981.

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Fig. 18. Location of annual returns from juvenile cod tagged at Harbour Grace, Conception Bay during October 18-21, 1978.



Fig. 19. Location of annual returns from juvenile cod tagged at Dildo, Trinity Bay during October 26-29, 1978.

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Fig. 20. Location of annual returns from juvenile cod tagged at Seal Cove, Conception Bay during June 6-13, 1979.



Fig. 21. Averages and standard deviations of meristic characters of mature cod collected during March from Hamilton Inlet Bank, Funk Island Bank and off Cape Bonavista during March, 1982 and the north cape of the Grand Bank and the eastern slope of the Grand Bank during May, 1982. (D = dorsal fin; A = anal fin; V = vertebrae (including urostylar half-vertebra).

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