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Possible effect of a closure of Div.1B to Trawling  
judged by tagging experiments and other relevant data

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## I. Introduction.

At the 1965 Annual Meeting of ICNAF Denmark proposed that Division 1B be closed to trawling in order to protect the great quantities of small cod present on the grounds in Div. 1B. Panel 1 considered this proposal and recommended that the Committee on Research and Statistics be requested to examine the desirability of further protection for small cod at Greenland and in particular in this connection the effects of a closure of Store Hellefiske Bank.

A Greenland Cod Working Group (hereinafter called the group) has been established to consider the matter. This group met in Rome in September 1965 and in Copenhagen in February 1966. At these meetings great progress was made in tabulating basic data required for the assessment. The group also had some discussion of the various problems. However time did not permit the group to finish the work. In preparation for the meeting in Madrid 1966 the group asked Mr. Gulland to prepare a paper containing assessment of mesh size regulation and of closure of 1B based on data as size composition of catches, discard rate etc. and the present author to prepare a paper on the likely effect of closure of 1B based on the Danish tagging experiments in West Greenland waters. The present paper deals with these tagging experiments, but it is emphasized that a great part of other data used here is based on material compiled and discussed by the group during the Copenhagen meeting and partly given in the report of that meeting (Res.Doc. 66-18).

It is also emphasized that the present paper together with the paper to be prepared by Mr. Gulland should be fully discussed by the group in Madrid previous to the 1966 Annual Meeting of ICNAF. The present paper is thus prepared more as a working paper for the group than as a document with final conclusions on the question of protecting small cod at West Greenland.

## II. Data necessary for the calculations.

Some basic data and assumptions are needed for the calculations in this paper. Such basic data are:

- 1) Natural mortality and mortality due to tagging.
- 2) Growth rate of cod and length-weight relation.
- 3) Fishing effort and fishing intensity in all divisions of Subarea 1.
- 4) Discard rate by gears.
- 5) Proportion between liners' and trawlers' effort in 1B. Proportion between trawlers' effort in 1B and total effort in other parts of Subarea 1.
- 6) Age and size at recruitment in 1B together with gear selection.
- 7) Factors to convert number of tags reported to real number of recaptures.

### 1) Natural mortality and mortality due to tagging.

Estimates of total mortality rate ( $Z$ ) and of its two components ( $F$  and  $M$ ) are given in previous report from the Assessment Subcommittee (Beverton

and Hodder, eds., 1962). These estimates were based mainly from series of age composition data. For the period 1952-57  $F$  was estimated to equal  $M$ , both being about 0.18. For the Labrador cod which may have a  $M$  similar to that of Greenland cod the Assessment Subcommittee found  $M$  to be between 0.15 and 0.35 and May (1966) proposes the true value to be within the lower half of that range. The group at the meeting in Copenhagen estimated  $M$  for Subarea 1 cod to be 0.15 to 0.20.

In the present paper therefore  $M$  has been taken as 0.20 for all sizes of cod regarded although it is possible that  $M$  is somewhat larger for the smaller cod. For tagged cod it is quite clear that some will die due to tagging or lose their tags. It has not been tried to calculate this extra mortality but very roughly  $M$  has been estimated to be 0.35 in the calendar year of tagging. As all tagging experiments dealt with here are from mid year months this value of  $M$  runs for half a year. Thereafter  $M$  is taken as 0.20 ( $t=1$  year).

## 2) Growth rate of cod and length-weight relation.

The growth rate of cod in Subarea 1 has been subject to changes from time to time (Hansen and Hermann, 1965). The Danish samples from 1A-1D offshore, quarter of July, 1953-1965 clearly show that concerning growth rate this period falls into two, viz. 1953-59 and 1960-65, the growth rate in the last period being higher than in the former (Table 2, Fig.1). This corresponds with recent German studies (Meyer, 1966). Applying German figures for gutted weight to these growth curves and looking on 10 cm groups of cod (the -5 cm regarded as mean of the group) this means that e.g. a cod of 30-39 cm length with the present growth rate will more than double its weight in one year and that the weight after two years is more than four times the original weight (Table 1). At the same time there is most likely also a considerable increase in value per unit weight.

## 3) Fishing effort and intensity.

Due to the great variation between fishing vessels, between gears and between catchability and distribution of cod at various seasons it is extremely difficult to get reliable single figures for fishing effort and intensity. The author has tried to estimate the effort on the base of Portuguese Dory Hours (Horsted, 1965 a). Garrod (Table 2 in the report of the Copenhagen meeting of the group, Doc. 66-18) gives some estimates of total fishing effort based on other fleets. The two sets of figures correspond extremely well with each other. In this paper the figures estimated by the author (l.c.) have been used.

## 4) Discarded and industrial fish.

Discarded cod and cod processed to fish meal are hereinafter called discards.

It is most essential to know the rate of discarding for each size group of cod, but unfortunately very few data exist. Some figures of total discards are

given by Meyer (l.c.) for the German trawl fishery in Subarea 1 in 1965.

The group has tried to estimate discards for each size of fish by comparing commercial landings with catch of research vessels but points out that this may give an overestimate of discards as the trawlers may prefer to fish on those parts of the grounds where big cod are relatively most abundant.

For the purpose of this paper it has only been necessary to estimate the discards in 1B.

Assuming that the difference between commercial landings and research catches (Doc.66-18, Fig.5) expresses the discards the rate of discarding in per cent of numbers caught would for 1B be as given in Table 3. Applying these figures to the average catch of trawlers in 1B as estimated by the group (Doc. 66-18, Table 4) gives about 54% discards of total numbers caught by trawlers in 1B. This may as pointed out be an overestimate.

For the purpose of this paper also a completely hypothetical but I hope underestimated discard rate in 1B has been used (discard A) besides the discard rate given in details in Table 3 (discard B), viz.:

Discard A			Discard B	
<u>trawlers:</u>		length group		
no catch, no discard		32 cm	100%	discarded
90% discarded		33-41 cm	100%	"
70% "		42-50 cm	84%	"
none "		51-59 cm	43%	"
none "		60 cm	none	"
<u>liners:</u>	none "	all	none	"

Applying the rate A to the average trawl catch in 1B as done above for rate B gives about 21% discards by numbers of trawlers' catch (rate B = 54%).

5) Proportion between liners' and trawlers' effort in Div. 1B. Proportion between trawlers' effort in Div. 1B and total effort in other parts of Subarea 1.

Table 4 partly taken from Horsted (1965 a) gives for various former periods the new effort in 1B and in 1C-1F if the effort of trawlers' fishing in 1B had been diverted to the more southern divisions of Subarea 1. The effort for the year 1964 has here been estimated purely from catch data assuming that catch per effort in 1964 was as in 1963.

The total effort in 1B has in Table 4 been splitted up in liners' and trawlers' effort according to the landings from these two fleets. As trawlers are presumed to have more discards than liners this estimate for the two fleets may be biassed, the effort of the trawlers tending to be too low, that of the liners too high.

When dealing with fishing mortality of different length groups of cod the effort ought to be splitted up also according to length groups. This has partly been done when calculating the long-term change by a closure. Using the two rates of discarding (A and B) together with the Tables 4 and 5 of the

group's Copenhagen report (l.c.) it is found that of the total effort in 1B in 1961-64 the following percentages were due to liners and trawlers respectively:

length group	A		B	
	liners	trawlers	liners	trawlers
32-39	75	25	22	78
40-49	40	60	22	78
50-59	48	52	34	66

These figures are used for all periods when calculating the long-term change and referring to the growth rate (Section II, 2) cod of length group 32-39 cm could next year well be regarded as the 40-49 cm group and this again next year as the 50-59 cm group. For cod outside 1B and for all cod bigger than 60 cm the figures given in Table 4 are used.

6) Age and size at recruitment. Gear selection.

Danish tagging experiments in inshore waters of Div. 1B (Tables 5, a-c) have shown that many cod of length group 20-29 cm by tagging are recaptured on Store Hellefiske Bank in the second year after tagging, while many of those of length 30-39 cm by tagging are caught on Store Hellefiske Bank in the first year after tagging.

Trawling with covered cod end by German research vessels in 1965 (Meyer, l.c.) has shown that considerable numbers of year class 1962 (3 years old cod) were present on Store Hellefiske Bank in November, this year class predominating the samples. Also the year class 1963 (2 years old cod) which is normally regarded to be a rather poor one was fairly <sup>well</sup> represented.

Judging by this it is reasonable to believe that cod in 1B are fully recruited by a total length of 40 cm.

In the group's Copenhagen report (l.c.) a selection factor of 3.7 and a selection range of 10 cm has been used. Recent German investigations (Bohl, 1966) suggest that this factor is too high. A factor of 3.38 was found by Bohl, selection range being 8.7 to 10.3 cm. Applying these last data to a 110 mm mesh size means that selection starts by a total length of cod about 32 cm. For the convenience of the assessment it has therefore been assumed that also cod of length group 30-39 cm (or at least 32-39 cm) are fully recruited. To judge by the age composition of the samples mentioned above this may not be <sup>an</sup> unrealistic assumption.

7) Conversion of number of tags reported to actual number of recaptures.

Concerning Danish tagging experiments in Greenland waters the problem of fishermen's non-returning of tags has been dealt with before by Poulsen (1957) and Horsted (1963 and 1965 b). The factors given by Horsted (1965 b, p.3) have been used for tags released before 1961. The great majority of tags used before 1961 are Petersen tags fixed to the gill cover of the cod.

Various papers presented to the North Atlantic Fish Marking Symposium,

Woods Hole, 1961 (ICNAF Spec.Publ. 4) suggested, however, that fixing the Petersen tag dorsally was better than fixing in the gill cover and that also Spaghetti tags fixed dorsally gave relatively many returns. In 1961 and 1962 Danish cod tagging in Subarea 1 was accordingly made partly with Petersen tags fixed dorsally and to the gill cover (1961) and partly with Spaghetti tags and Petersen tags fixed dorsally (1962). The result were, however, very disencouraging. It would complicate this paper too much to go into details. It was found, however, that by small cod (less than 50 cm) Petersen tag fixed to gill cover was clearly much better (5-10 times better) than the same tag fixed dorsally, while by big cod (70 cm or more) the dorsal position was slightly better than the gill cover position. Results varied very much for the medium sized cod. Spaghetti tag seems to be somewhat better than dorsally fixed Petersen tag but unfortunately the printed number on some of the Spaghetti tags is washed out.

As a whole the comparison mentioned is very complicated as the experiments gave most confusing results and although some conversion factors have been used the author is not too happy of these factors. Further experiments and analyses will have to be made before such factors should be published.

Complicating the 1961-62 tagging experiments too is the relatively poor Portuguese return of tags in 1962 proposed by Horsted (1965 b) and later on confirmed and explained by Capt. de Almeida and R. Monteiro (personal comm.) All this make any judging by the 1961-62 experiments most uncertain, also as some returns may still be expected from these experiments.

### III. Various assumptions.

Having data as given in Section II it is still necessary for the assessment also to introduce some basic assumptions besides those already mentioned in Section II.

The proposal for closure of 1B to trawling were based on the general theory .....

- 1) that the relative amount of small cod is greater on Store Hellefiske Bank than on any other West Greenland fishing bank. This is generally confirmed by the various samples (Copenhagen report of the group, Tables 4 and 5, Fig.5).
- 2) that these small cod are more heavily fished by trawl than by line. Discussed in Section II, 4.
- 3) that small cod when reaching a bigger size begin to emigrate from Div.1B (analysed in Sections IV and VII, Tables 5, 8 and 11).
- 4) that the migration of medium sized and big cod from other divisions to Div. 1B is rather small or, if such migration takes place, a great part of these cod will again move out of 1B (analysed in Section VII, Tables 7, 8 and 10).

In the calculations it has further been assumed .....

- 5) that migration of cod and distribution of cod after a closure of 1B will still be as shown by the tagging experiments before the closure, including here the basic assumption that tagged cod is evenly distributed in the stock and behave as non-tagged cod.
- 6) that migration of cod from 1B offshore areas to 1B inshore waters is rather small and not likely to change very much after a closure (analysed in Section IV, 1 and 2, Table 6).
- 7) that the migration which takes place in a certain year as shown by tagging experiments has been completed at the beginning of that year's fishing season.
- 8) that trawlers formerly fishing in 1B will fish in other Greenland waters after a closure of 1B.
- 9) that distribution of liners in Subarea 1 will not change after a closure of 1B to trawling. This assumption may not hold as 1B after a closure may attract liners partly because at any rate they believe the conservation effect in 1B to be very great and partly because they avoid having their lines spoiled by trawlers. This question needs perhaps further study by the group in Madrid.
- 10) that as the majority of tagged fish recaptured are caught in the first and second year after tagging it is proper to assume, that the effort, which has caught the recaptures from a period's tagging experiments is the effort from the period: 1 year after first experiment started to two years after last experiment started, i.e. cod from tagging experiments 1955-57 are assumed to have been recaptured by the effort in the years 1956-59.

Some smaller assumptions are introduced in the calculations because of

- 11) Recaptures from year NK (not known) have been regarded as belonging to first year after tagging. Recaptures from Div. 1 NK have been allocated to known divisions according to known recaptures. Recaptures from areas outside Subarea 1 (mainly East Greenland - Iceland) and recaptures from Subarea NK have been regarded as caught in Div. 1C-1F. Catch, effort and recaptures from Div. 1A have been included in 1B. All this transferring of figures may sound rather drastic, but has little or no effect on the calculations as only very few recaptures are involved in the transferring.

#### IV. Migration of cod towards and within Div. 1B.

As mentioned in the previous section some study of the migration of cod towards and within 1B is necessary before further assessments of the effect of a closure of 1B can be made.

##### 1) Migration from inshore waters of 1B to offshore waters.

Cod have frequently been tagged in inshore waters of Div. 1B, mainly in the harbour of Christianshåb (Disko Bay), in the coastal waters close to Holsteinsborg and in the fjords Amerdloq and Ikertoq just south of Holsteinsborg. The

results of tagging experiments from these localities in the period 1955-62 are given in Tables 5a - 5c, giving actual number of returns as well as estimated number of recaptures in per cent of numbers tagged. Although a full study of migration needs to deal with recaptures per effort instead of just numbers of recaptures the Tables 5a-c nevertheless demonstrate very clearly that there is a considerable migration of cod from inshore of 1B to offshore waters, especially when it is taken into account that all returns from area not known have been taken by nations other than Greenland. In fact, in all experiments and for all sizes of fish very few tags are returned by Greenland fishermen 3 or more years after tagging while there are still considerable numbers returned by other nations fishermen, this suggesting that nearly all cod original present in inshore waters of Div 1B will migrate to offshore area, and when they have arrived here most likely behave as other cod present in the offshore area.

2) Migration from offshore to inshore waters of 1B.

Table 6 summarizes return and estimated recaptures from Div 1A + B of cod tagged in 1B offshore waters in various periods. Comparing Greenlander's per cent of returns with Greenlander's per cent of total cod landings in 1A + B it is quite clear, that cod tagged in offshore waters do not mix very much with the stock in inshore waters.

Following this conclusion and the former conclusion it is therefore assumed that a closure of Div. 1B to hawling will have only minor effect (but this effect is gain) to the inshore cod fishery, and in the assessments migration from offshore to inshore area have been neglected (see also Section III,6.)

3) Migration from more southern divisions into Div. 1B.

Proposing the closure of 1B it was assumed that the migration of cod from southern areas into Div 1B was relatively small, or if such a migration existed the cod moving into Div 1B would behave as other cod present in 1B, which means that a great part of the inmoving cod would again move out of 1B. Table 7 summarizing tagging experiments for the years 1955-60 in Divisions 1B, 1C and 1D offshore area shows that from tagging experiments in 1C 5-15% of the recaptures are taken in 1B, while from tagging experiments in 1D 3-6% of the recaptures are taken in 1B. Although also these recaptures ought to be weighted according to effort in the various regions these figures by themselves say, that the migration from more southern divisions into 1B is rather small. It must also be remembered that cod having moved into 1B are part of the stock in 1B and hence that some of them - and as Table 7 and later assessment show a good deal



of them - again will migrate out of Div. 1B. It is therefore not likely that a closure of Div. 1B to trawling means that any great proportion of the stock found in more southern divisions will avoid been caught by migrating to Div.1B.

V. Different ways of expressing gain and loss due to closure of Div.1B to trawling.

The effect of a closure of 1B to trawling may be expressed in various ways. By introducing a larger mesh size than hitherto used the term "immediate loss" is used, but speaking about closure of a certain area one must distinguish between two sorts of loss. viz.

- a) the loss (or gain) which the banished fleet suffers expressed as the difference between the catch which the vessels would have obtained by staying in the closed area and the catch which they get in the areas to which they move.
- b) the loss in output of the stock which was present in the closed area when closing this.

The immediate effect which the banished trawlers feel is the type a) loss, and this loss depends on the possibility of finding another area where catch per effort is as good or very nearly as good as in the closed area. As shown in the groups report such areas exist throughout the year in the more southern part of Subarea 1. It is very difficult to say anything exact about this loss. The trawlers did perhaps choose 1B because catch per effort here was better or thought to be better than in other divisions. On the other hand some trawlers did at the same time fish outside 1B and these presumably thought fishing here to be better than in 1B. In some cases, therefore, the trawlers leaving 1B may find fishing outside 1B to be better than in 1B and therefore get an immediate gain instead of loss. It is, however, essential to remember that the cod in Subarea 1 must be regarded as being so heavily exploited (Assessment Subcommittee reports 1964,1965) that any increase in effort in any division is supposed not to give any increase in total catch but rather a steady or slightly decreasing total catch, and it is hence most reasonable to think that trawlers moving from 1B will not in the first short time after moving get their former catch in 1B fully compensated, and that entering a new division they will also have some influence on the catch of the fleet originally present here. This sort of loss has not been estimated in this paper. The "short time effect" is here taken as the type b) loss, viz. the loss in output of the stock present in 1B at the time of closure. This loss will of course be greatest in the first

year after closure, but gradually cod will move out from 1B and some of them be caught outside, so that the loss after some years is diminished or even changed to a gain due to the increased weight of the single fish. This short time effect has been calculated for each 10 cm group of cod present in Div.1B. The total short time loss should be weighted according to the size composition (in 10 cm groups) in 1B.

After some years the cod originally present in Div.1B at time of closure do not exist any more. From that time only cod recruited after closure are exploited, and the "long - term effect" is here given on a "per recruit base", the recruits being regarded as the cod in the 40-49 cm group. The long-term effect is here given by the difference in output of 1B<sup>in</sup> in 40-49 cm group without a closure and the output which would have been obtained in the same period with a closure, while the "short time effect" is given by the corresponding difference found for cod bigger than 50 cm present in 1B at time of closure.

The netto gain or loss for the total fishery in Subarea 1 is then the defined "long-term effect" minus a possible loss in total catch in divisions outside 1B due to the increased effort in these divisions by redistribution of trawlers from 1B.

VI. Model used to calculate "long-term effect" and "short time effect" from tagging experiments.

With reference to the various basic data and assumptions mentioned in Sections II and III the "long-term effect" and "short time effect" as defined in Section V is for each length group of fish present in 1B calculated in the following way:

Let  $N_0$  be initial number of fish tagged and  $n_0$  number of total recaptures in the calendar year (year 0) of tagging. Following Beverton and Holt (1957) the total fishing mortality coefficient  $F$  in this year is found from the equation

$$\frac{n_0}{N_0} = \frac{F_0}{F_0 + M_0} (1 - e^{-(F_0 + M_0) t_0}) \dots\dots\dots (1)$$

where  $M = 0.35$  and  $t = 0.5$  (Section II.1).

The number of fish present at the beginning of next calendar year (year 1) is then given by

$$N_1 = N_0 e^{-(F_0 + M_0) t_0} \dots\dots\dots (2)$$

and continuing with equations (1) and (2) (M in the next years = 0.20 and t = 1) the F in each year and the number of tags present at the beginning of each year, N, is calculated.

This F, however, is an overall F, but F may vary between divisions. Knowing the distribution of tagged fish and the returns from each division it is, however, possible to calculate the separate F in each area. This is done by splitting up n in three groups, viz. those caught by lines in 1B, those caught by trawlers in 1B and those caught by all gears outside 1B. Assuming further that the distribution of tags, which takes place during a calendar year, is finished at the beginning of that year (or at the beginning of the fishing season) N can be splitted up between divisions according to proportions given by

$$\frac{n_B}{f_B} / \frac{n_C}{f_C} \text{ etc., when}$$

n is number of recaptures in each division and f the chance of the tagged fish to be caught in each division as given by Horsted (1965a). In this way N is splitted up in a part staying inside 1B,  $N_B$ , and another  $N_C$ , having migrated to areas outside 1B. Following equation (1) F can be estimated for these two parts separately,  $F_B$  and  $F_C$ .

Assuming that a closure took place in the period dealt with  $F_B$  would be reduced in the same proportion as the effort in 1B (given in Table 4) while  $F_C$  would be increased. The two new coefficients are called  $F'_B$  and  $F'_C$ .

The new effort in the two areas would instead of a catch of  $n_B$  and  $n_C$  give a new catch  $n'_B$  and  $n'_C$  also calculated from equation (1). The total numbers surviving in a year, r, after closure is now given by

$${}_{r+1}N' = N'_B e^{-rF'_B} + N'_C e^{-rF'_C} \dots\dots\dots(3)$$

This number of survivors again can be splitted up into two parts. F and F' can again be calculated, and new catch and survivors for next year again estimated.

The gain or loss for each length group in each year is in terms of numbers given by the difference between n and n', but the gain and loss has in the calculation been splitted up so that the gain of remaining lines in 1B and the gain or loss for the total fleet outside 1B (including

the trawlers moving from Div.1B) are given separately.

In terms of weight each group of fish must for each year be multiplied by the weight factors given in Tables 1 and 2, and to judge the full gain these again ought to be multiplied by a value factor, which may vary from country to country.

#### VII. Effect of closure in former periods.

The basic material of the tagging experiments on which the calculation are based is given in Tables 8a - c, while an example of the detailed calculation as given in Section VI appears in Table 9. From the other experiments only the final figures for loss and gain are given.

The "short time effect" (defined in Section V) by a closure of 1B to trawling is given in Table 10 a-c as per cent change in catch of each length group by numbers and gutted weight (head on). The actual catch without a closure is within each length group the catch per 1000 fish present in 1B at time of closure or when tagging experiment stated.

Some of the figures, especially for year 1. may look very unreliable, but this is to some degree explained by the fact that all returns from year NK have been allocated to year 1 (Section III,11).

The "short time effect" for liners in 1B is as expected an immediate raise in catch and an increase in mean size of fish caught, gain in terms of numbers being less than gain in weight.

For the other fleet in Subarea 1, including trawlers formerly fishing in 1B the total "short time effect" is a decrease in catch but an increase in mean weight of fish, decrease in numbers being less than decrease in weight. This total loss, however, consists of two components, viz. a great loss in the first years after closure and later on a gain, but this gain smaller than the loss in the first years. The gain generally seems to begin in the 3rd year after closure. To estimate "short time effect" for the stock as a whole it is necessary to weight the effect in each length group with a factor which is the proportion that this length group has in the whole stock. As Table 10 deals with imaginary closure this has, however, not been found to be worth while.

Estimating the "short time effect" it must be<sup>be</sup>ared in mind that the "long-term effect" as defined in Section V begins within the period of the "short time effect", and as the "long-term effect" is an increase in catch this will make the total short time loss less than shown in Table 10.

The greatest interest, however, has the "long-term effect" of the closure.

The calculation of the "long-term effect" per recruit is based on

the 40-49 cm cod. There is, however, a fishery also on the 30-39 cm group, but due to gear selection (trawl as well as line) and possible not full recruitment of these smaller fish, fishing mortality must be less than for the bigger cod. It is impossible to say how big  $F$  is for these small cod, but it is supposed not to exceed 0.10.  $F$  for the 30-39 cm group has therefore been estimated to 0.00 at the discard rate A (Section II,4) and to 0.10 for discard rate B, the last estimate to consist of  $F = 0.02$  for liners and 0.08 for trawlers. The true value of discard rate and of  $F$  for small fish is supposed to be somewhere between the A and the B theory. Table II shows the "long-term effect" (% change in catch per fish recruited in 1B) if a closure had been effective in earlier years and if total fishing effort had remained as in those years.

Clearly the liners remaining in 1B would have a gain, immediate as well as long-term. The other fleets would with a fishery as on the 1955-57 tagged cod have had a loss (numbers as well as weight), but with a fishery as on cod tagged in 1958-60 and 1961-62 (these other fleets would have had a minor loss in terms of numbers but a gain in terms of weight of 1-4% in the discard rate A and 8-13% in the discard rate B.

As shown in Table 8 the material on which these calculations are based is unfortunately rather poor (119,76 and 175 cod tagged in the three periods respectively), but regarding also the "short time effect" (Table 10) when medium sized cod tend to give a gain after 2-3 years after closure it is reasonable to believe, that although the figures for "long-term effect" may be rather uncertain, there is no doubt about the fact, that cod recruited in 1B will be best exploited by a closure of 1B to trawling.

#### VIII. Possible effect of a future closure.

When calculation are based on tagging experiments it is quite clear, that the calculations must refer to former situations of fishery and their interest therefore be academic. In previous part of this paper it has only been possible to deal with situations as before 1962.

Great change in the efficiency and effort of the trawlers is, however, known to have taken place since 1962. In the Copenhagen report of the group ( l.c.) it is estimated that  $E \left( = \frac{F}{F + M} \right)$  is close to 0.70. The author has therefore tried to calculate the "long-term effect" which may occur by a future closure of 1B to trawling supposing that an overall  $F$  in Subarea 1 is 0.40 ( $E = 0.67$ ) and that effort outside 1B would raise by 20% if trawlers were banished from 1B to IC-IF. Inside 1B the effort

of liners is taken as mentioned in Section II,5. It is furthermore supposed that growth rate in future remains as in 1960-65 (Fig.1., Tables 1-2). The migration of cod from 1B southwards has been taken as a medium migration of that which the tagging experiments have shown for cod of length groups 40-49 and 50-59 cm.

This assumed migration used here is ( in terms of per cent of regarded fish found outside 1B)

Year	% found outside 1B
0	0
1	30
2	60
3 or more	80

Referring to Section II, 2 and II, 6 recruits are taken as 40 cm cod which will have a growth of

Year	0	1	2	3	4
cm	40	50	60	69	75
kg (guttet, head on)	0.530	1.020	1.735	2.490	3.165

The calculations are then made after the model given in Section VI and for the two discard theories A and B (Section II,4).

The results are given in Table 12. It is found that the "long-term effect" by a future closure will be that the exploitation of cod recruited on St. Hellefiske Bank will be much better than now. Liners remaining in 1B will increase their catch of the regarded cod in terms of numbers (25-55%) as well as weight (37-73%) and other fleets in Subarea 1 will also increase their catch of 1B recruits in terms of weight (8-22%) although not in numbers (loss of 28-31%). The long-term gain is thus due to the increase in mean size at which the recruits are caught. The total effect for the fishery of Subarea 1 as a whole depends on the proportion which 1B recruits constitute of the total landings from Subarea 1. Assuming that they constitute at least about 33% of the landings from 1B - 1D and nearly nothing of the landings from 1E - 1F and assuming that total catch in divisions 1C - 1F remains constant after redistribution of trawlers after a closure, this means that the long-term gain for the fishery in Subarea 1 as a whole (based on 1960-63 landings) will be at least between 6% and 12% for discard rate A and B respectively.

The main part of the gain is as mentioned due to increased size of the 1B recruits when these are caught. This increased mean size may mean that also the value of the fish has increased whatever this is in the

price paid to fishermen or the price on the different stages of production. This value per weight is therefore different from country to country but if a value factor can be worked out for each size group this factor could readily be used on the Tables 11 and 12.

The Royal Greenland Trade Department (Frølich and Svendsgaard, personal comm.) has tried to work out some factors for their frozen products using the formula

$$\text{Value factor} = \text{final market price} - \frac{\text{money paid fishermen and factory workers}}{\text{output by filleting}}$$

and found the following factors for cod of weight (gutted, head on)

600-700 g	= 1.65	per unit weight
13-1500 g	= 2.03	(= 123% of the 600-700 g)
21-2300 g	= 2.15	(= 130% .....

Applying such factors to Table 12 the "long-term effect" for liners in 1B is increased to 40% and 70% and for other fleets to 13% and 28% for discard rate A and B respectively. For the fishing of Subarea 1 as a whole (with the assumptions mentioned) the gain would increase to 7-13%, but the value factors given will most surely vary between countries and may well be more progressive than those given above, so that the gain for the fishery as a whole may be better than estimated above.

#### IX. Discussion.

The validity of the results given in the previous Section depends of course on the validity of the data and assumptions used in the calculations. The validity of the data and assumptions has to some extent been discussed in previous Sections where data and assumptions are introduced. Furthermore the paper is as pointed out thought as a working paper for the group in Madrid. The author has therefore not found it necessary to go into a detailed discussion on the validity here. It should, however, be pointed out, that in all the calculations based on tagging experiments there has in every case been less than 10% of the tagged fish left after 4 years and in no years more estimated recaptures than estimated tagged fish left. This seems to indicate that natural mortality and estimated number of recaptures are fairly close to the true values and fishing mortality found may accordingly be close to true value too.

The author has in this paper not tried to judge whether the same conservation of small cod could be obtained by an increased mesh size. This may to some extent be the case, but the author is most inclined to

believe that a closure of Div. 1B to trawling together with an increased mesh size in other divisions may be the best method of protecting small cod at West Greenland. This question must be discussed by the group in Madrid.

X. Summary.

The effect of closing Div. 1B to trawling is judged by tagging experiments introducing at the same time some assumptions, and to evaluate fully the results given in this paper it is necessary to read all sections of the paper.

It is found that a closure ten years ago would not have been of benefit, partly because of relatively low fishing intensity and partly because of rather slow growth rate of cod at that time. Within the last 7-8 years a closure would, however, have been of some benefit. A closure would at the present time mean a much better exploitation of cod recruited on St. Hellefiske Bank and for the fishery of Subarea 1 as a whole there would possibly be a gain in terms of weight about 6% by a low present discard rate and up to 12% at a high discard rate.

The economical effect would be somewhat higher as the main effect of a closure is a decrease of small cod and an increase of medium sized cod caught, and these medium sized cod presumably have a higher value per unit weight than small cod.

The possible effect of a closure of 1B to trawling together with mesh size regulation should be studied by The Greenland Cod Working Group in Madrid, 1966.



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Table 1. Mean weight (fresh gutted) of West Greenland cod of various length and - within each length - after various periods. Length based on figures from Table 2 and Fig. 1. Weight based on German figures kindly supplied by Dr. A. Meyer.

a = total length (cm below)  
 b = weight (gutted) in gram  
 c = weight in per cent of original weight (when r = 0)

Original length fish regarded	1953-59					1960-65						
	Length and weight of fish regarded after r years					Length and weight of fish regarded after r years						
	r=	0	1	2	3	4	r=	0	1	2	3	4
25 cm	a	25	36	45	54	62	25	38	49	59	68	
	b	135	385	735	1295	1885	135	455	950	1665	2395	
	c	100	285	544	959	1396	100	337	704	1233	1774	
35 cm	a	35	44	53	62	67	35	46	56	66	73	
	b	355	690	1225	1885	2300	355	780	1440	2205	2930	
	c	100	194	345	531	648	100	220	406	621	825	
45 cm	a	45	53	61	67	72	45	56	65	72	77	
	b	735	1225	1810	2300	2815	735	1440	2115	2815	3415	
	c	100	167	246	313	383	100	196	288	383	465	
55 cm	a	55	62	68	72	75	55	65	72	77	81	
	b	1370	1885	2395	2815	3165	1370	2115	2815	3415	3970	
	c	100	138	175	205	231	100	154	205	249	290	
65 cm	a	65	70	74	76	77	65	72	77	81	84	
	b	2115	2595	3045	3290	3415	2115	2815	3415	3970	4440	
	c	100	123	144	156	161	100	133	161	188	210	
75 cm	a	75	76	77	78	79	75	79	83	85	86	
	b	3165	3290	3415	3545	3675	3165	3675	4280	4600	4800	
	c	100	104	108	112	116	100	116	135	145	152	

Table 2. Mean total length of cod from Danish samples in Divisions 1A - 1D, offshore areas, quarter of July. Mean of lengths measured to cm below.

See also Fig.

Age	1953-59	1960-65
2	27.0	-
3	38.8	40.3
4	45.8	50.2
5	55.6	60.8
6	63.3	70.0
7	68.2	75.5
8	73.0	80.0
9	75.0	83.6
10	77.2	85.6

Table 3. Maximum discard rate by trawlers in Div.1B (per cent of numbers caught) taken from Fig.5 of the report of the Greenland cod. Working Group, Copenhagen Meeting.

cm group	landed	caught	discarded	per cent discarded	
33-35	-	17	17	100	} 100
36-38	-	34	34	100	
39-41	-	70	70	100	
42-44	5	115	110	96	} 84
45-47	20	170	150	88	
48-50	50	180	130	72	
51-53	80	175	95	54	} 43
54-56	80	150	70	47	
57-59	91	112	21	24	
60-62	100	120	20	17	

Table 4. Change of effort in Div.1B and Divs.1C-1F if trawlers effort are diverted from 1B to 1C-1F. Effort given in "Portuguese August trawling hours" (Horsted 1965 a).

Period	Effort Div.1B		Effort Div.1C-1F	New effort in per cent of former effort when trawlers are diverted from 1B to 1C - 1F.	
	trawl	line		1B	1C - 1F
1953-56	128646	117608	415900	47.8	130.9
1956-59	110721	156014	615549	58.5	118.0
1959-62	183833	206696	851025	52.9	121.6
1962-63	99335	115081	549455	53.7	118.1
1962-64	140417	157730	819728	52.9	117.1

Table: 5 a-c

Returns (corrected and uncorrected) of cod tagged in Division IB inshore waters in the years 1955 - 62. Length is total length to cm below. Year indicate calénder year after tagging. Fish caught more than 4 years after tagging are included in those caught 4 years after tagging. NK = area or year not known. All returns from area NK have been taken by other nations than Greenland.

Tagging locality	Length when tagged (cm)	Numbers tagged	Year of recapture	Total returns		Percent of returns uncorrected figures				Percent of returns corrected figures					
				uncorr.	corr.	Recaptured in		Recaptured in		Recaptured in		Recaptured in			
						IB by Greenland fishermen	IB by other nations	outside IB	NK	IB by Greenland fishermen	IB by other nations	outside IB	NK		
Disko Bay, harbour of Christianshåb	20 - 39	922	0	16	16	100.0	-	-	-	-	100.0	-	-	-	
			1	9	15	77.8	22.2	-	46.7	53.3	-	-	-	-	
			2	20	44	20.0	35.0	40.0	5.0	9.1	34.1	50.0	6.8	-	
			3	22	54	13.6	40.9	31.8	13.6	5.6	24.1	55.6	14.8	-	
			≥ 4	7	13	14.3	28.6	57.1	-	7.7	46.2	46.2	-	-	
			NK	2	10	-	50.0	-	50.0	-	50.0	50.0	-	-	-
			Total	76	152	40.8	27.6	25.0	6.6	20.4	30.9	41.4	7.2	-	-

C.

Tagging locality	Length when tagged (cm)	Numbers tagged	Year of recapture	Total returns		Percent of returns uncorrected figures				Percent of returns corrected figures					
				uncorr.	corr.	Recaptured in				Recaptured in					
						IB by Greenland fishermen	IB by other nations	outside IB	NK	IB by Greenland fishermen	IB by other nations	outside IB	NK		
*) Holsteinsborg District, Coastal area	20 - 39	783	0	3	3	100.0	-	-	-	-	100.0	-	-	-	
			1	16	25	75.0	12.5	12.5	-	-	48.0	24.0	28.0	-	
			2	18	51	33.3	16.7	27.8	22.2	-	11.8	19.6	33.3	35.3	
			3	7	16	14.3	28.6	42.9	14.3	-	6.3	37.5	37.5	18.8	
			≥ 4	12	30	8.3	8.3	75.0	8.3	-	3.3	3.3	63.3	10.0	
			NK	2	4	-	50.0	50.0	-	-	-	75.0	25.0	-	
			Total	58	129	39.6	15.5	34.5	10.3	-	17.8	20.2	43.4	18.6	
			0	-	-	-	-	-	-	-	-	-	-	-	-
			1	21	31	4.8	38.1	57.1	-	-	3.2	32.3	64.5	-	
			2	8	16	12.5	37.5	50.0	-	-	6.3	43.8	50.0	-	
3	5	13	-	40.0	60.0	-	-	-	15.4	84.6	-				
≥ 4	5	9	-	-	100.0	-	-	-	-	100.0	-				
NK	-	-	-	-	-	-	-	-	-	-	-				
Total	39	69	5.1	33.3	61.5	-	-	2.9	27.5	69.6	-				

\*) 7 cod of length 40 - 49 cm tagged; no returns.

cont/

Tagging locality	Length when tagged (cm)	Numbers tagged	Year of recapture	Total returns		Percent of returns uncorrected figures				Percent of returns corrected figures					
				uncorr.	corr.	Recaptured in				Recaptured in					
						LB by Greenland fishermen	LB by other nations	outside LB	NK	LB by Greenland fishermen	LB by other nations	outside LB	NK		
The fjords Amerdloq and Ikertoq near Holsteinsborg	20 - 39	461	0	13	13	100.0	-	-	-	-	100.0	-	-	-	
			1	8	16	50.0	37.5	-	12.5	25.0	43.8	-	-	31.3	
			2	11	19	27.3	36.4	18.2	18.2	15.8	21.1	31.6	31.6	31.6	
			3	6	16	16.7	50.0	16.7	16.7	6.3	43.8	18.8	31.3	31.3	
			≥ 4	5	11	-	60.0	20.0	20.0	-	27.3	27.3	45.5	45.5	
			NK	1	5	-	-	100.0	-	-	-	-	-	100.0	100.0
			Total	44	80	47.7	29.5	9.1	13.6	26.3	26.3	15.0	32.5	32.5	
			0	31	35	96.8	3.2	-	-	-	85.7	11.3	-	-	-
			1	16	20	18.8	62.5	12.5	6.3	15.0	50.0	10.0	25.0	25.0	
			2	13	22	7.7	69.2	23.1	-	4.5	45.5	50.0	-	-	
3	14	24	42.9	14.3	35.7	7.1	25.0	8.3	45.8	20.8	20.8				
≥ 4	1	1	-	100.0	-	-	-	100.0	-	-	-	-			
NK	2	6	-	-	50.0	50.0	-	-	16.7	83.3	83.3				
Total	77	108	51.9	29.9	14.3	3.9	37.0	25.9	23.1	13.9	13.9				
50 or more		79	0	14	14	100.0	-	-	100.0	-	-	-	-		
			1	5	5	20.0	80.0	-	-	20.0	80.0	-	-		
			2	2	6	-	50.0	50.0	-	-	83.3	16.7	-		
			3	1	1	-	-	100.0	-	-	-	100.0	-		
			≥ 4	1	1	-	-	100.0	-	-	-	100.0	-		
Total	23	27	55.2	21.7	13.0	-	55.6	33.3	11.1	-	-				

Table 6. Relation between total returns from Div.1B and Greenlanders returns from Div.1A of cod tagged in 1B offshore areas. Only cod bigger than 40cm total length when tagged are regarded. Figures in bracket give per cent of numbers tagged.

Period of tagging	Numbers tagged	Total returns from 1A + B		Greenlanders returns from 1A+B(no corr)	Greenlanders returns in per cent of total returns.		Greenlanders' cod landings in 1A+B in per cent of total cod landings from 1A+B
		uncorr.	corrected		uncorr.	corrected	
1952-54	1843	280 (15.2)	489 (26.5)	2 (0.1)	0.71	0.41	6.03
1955-57	1462	252 (17.2)	391 (26.7)	4 (0.3)	1.59	1.02	8.51
1958-60	1631	206 (12.6)	505 (31.0)	12 (0.7)	5.83	2.38	7.15
1961-62	1224	79 (6.5)	290 (23.7)	10 (0.8)	12.66	3.45	5.88

Table 7. Summary of returns and estimated recaptures from Danish cod tagging experiments in Divisions 1B, 1C and 1D offshore waters in the years 1955-60. NK = area not known or area outside Subarea 1.

Tagging in Div.	Length when tagged (cm)	Numbers tagged	Total returns and estimated recaptures		Returns in per cent of total returns			Estimated recaptures in per cent of total estimated recaptures		
					1A-B	1C-F	NK	1A-B	1C-F	NK
1B	30-39	5	0	0	-	-	-	-	-	-
	40-49	195	39	96	77	18	5	71	24	5
	50-59	738	165	379	71	25	4	64	31	5
	60-69	1105	239	528	60	36	4	53	42	5
	≥ 70	1055	245	477	69	29	2	64	33	3
1C	30-39	8	0	0	-	-	-	-	-	-
	40-49	92	19	43	11	74	16	5	65	30
	50-59	207	51	125	12	82	6	14	75	10
	60-69	548	107	213	8	83	8	10	75	15
	≥ 70	2122	436	903	5	90	5	5	85	10
1D	30-39	1	0	0	-	-	-	-	-	-
	40-49	39	6	14	0	100	0	0	100	0
	50-59	434	79	210	6	82	11	4	79	17
	60-69	1245	281	634	2	90	8	2	84	14
	≥ 70	2375	483	973	5	88	7	5	80	15

Table 8. Estimated recaptures (returns corrected) from Danish tagging experiments in Div. 1B offshore waters. Total is given for both estimated recaptures and in brackets actual returns each of them in number as well as in per cent of numbers tagged. Length is total length in cm by tagging. Year indicates calendar year after tagging. Those caught more than 4 years after tagging are included in the 4 years' recaptures. NK = division, area or year not known. In the calculations those from Division 1 NK have been allocated to division according to proportion between known recaptures, and those from other areas plus area NK have been regarded as taken outside Div. 1B. Those from year NK have been regarded as taken in year 1.

Table 8 a. Tagging in the years 1955-57.

Length	Numbers tagged	Year	Div. 1B	Div. 1C-1F	Div. 1NK	Other areas + NK
40-49	119	0	6	-	-	-
		1	18	-	-	-
		2	14	5	-	-
		3	3	5	-	-
		≥ 4	5	1	3	-
		NK	-	-	-	-
		Total		46-38.7% (20-16.8%)	11-9.2% (3-2.5%)	3-2.5% (1-0.8%)
50-59	264	0	24	-	-	-
		1	32	15	5	-
		2	30	6	-	1
		3	2	4	-	-
		≥ 4	6	10	3	-
		NK	-	-	-	-
		Total		94-35.6% (55-20.8%)	35-13.3% (16- 6.1%)	8-3.0% (2-0.7%)
60-69	521	0	48	1	1	-
		1	36	71	-	1
		2	21	14	-	-
		3	9	4	-	-
		≥ 4	4	12	-	-
		NK	-	-	-	-
		Total		118-22.6% (79-15.2%)	102-19.6% (40- 7.7%)	1-0.2% (1-0.2%)
≥ 70	558	0	35	-	1	-
		1	49	48	8	6
		2	26	11	-	1
		3	12	2	-	-
		≥ 4	6	6	-	-
		NK	-	5	-	-
		Total		128-22.9% (98-17.6%)	72-12.9% (36- 6.5%)	9-1.6% (3-0.5%)



Table 8b. See text in front of Table 8a.

Tagging in the years 1958 - 60.

Length	Numbers tagged	Year	Recaptured in			
			Div. 1B	Div. 1C - 1F	Div. 1NK	Other areas + NK
30 - 39	5	Total	-	-	-	-
40 - 49	76	0	7	-	-	-
		1	10	-	-	-
		2	5	-	-	-
		3	-	6	-	-
		≥ 4	-	6	-	2
		NK	-	-	-	-
		Total	22 - 28.9 % (10 - 13.2 %)	12 - 15.8 % (4 - 5.3 %)	-	2 - 2.6 % (1 - 1.3 %)
50 - 59	474	0	61	1	-	-
		1	63	20	-	2
		2	5	23	-	5
		3	3	19	-	-
		≥ 4	10	19	-	5
		NK	5	-	-	-
		Total	147 - 31.0 % (62 - 13.1 %)	82 - 17.3 % (26 - 5.5 %)	-	12 - 2.5 % (3 - 0.6 %)
60 - 69	584	0	57	1	-	-
		1	68	45	6	-
		2	32	43	3	8
		3	1	20	3	8
		≥ 4	2	10	-	5
		NK	-	-	-	-
		Total	160 - 27.4 % (64 - 11.0 %)	119 - 20.4 % (47 - 8.0 %)	12 - 2.1 % (4 - 0.7 %)	21 - 3.6 % (5 - 0.9 %)
≥ 70	497	0	80	5	-	-
		1	46	27	-	-
		2	32	25	-	-
		3	7	14	-	-
		≥ 4	6	14	-	-
		NK	5	-	-	-
		Total	176 - 35.4 % (70 - 14.1 %)	85 - 17.1 % (35 - 7.0 %)	-	-

Table 8c. See text in front of Table 8a.

Tagging in the years 1961 - 62.

Length	Numbers tagged	Year	Recaptured in			
			Div. 1B	Div. 1C - 1F	Div. 1NK	Other areas + NK
30 - 39	2	Total	-	-	-	-
40 - 49	175	0	10	-	-	-
		1	3	10	-	-
		2	3	14	3	-
		3	9	5	-	3
		≥ 4	-	-	-	-
		NK	1	10	-	-
		Total	26 - 14.9 % (8 - 4.6 %)	39 - 22.3 % (10 - 5.7 %)	3 - 1.7 % (1 - 0.6 %)	3 - 1.7 % (1 - 0.6 %)
50 - 59	511	0	57	17	10	23
		1	49	44	22	21
		2	15	36	-	-
		3	2	8	-	-
		≥ 4	-	-	-	-
		NK	1	5	-	-
		Total	124 - 24.3 % (26 - 5.1 %)	110 - 21.5 % (22 - 4.3 %)	32 - 6.3 % (4 - 0.8 %)	44 - 8.6 % (6 - 1.2 %)
60 - 69	370	0	31	16	5	5
		1	36	60	7	8
		2	11	32	-	3
		3	-	5	-	4
		≥ 4	-	-	-	-
		NK	-	-	-	-
		Total	78 - 21.1 % (23 - 6.2 %)	113 - 30.5 % (33 - 8.9 %)	12 - 3.2 % (3 - 0.8 %)	20 - 5.4 % (5 - 1.4 %)
≥ 70	168	0	39	-	-	-
		1	13	36	5	7
		2	10	3	-	-
		3	-	-	-	2
		≥ 4	-	3	-	-
		NK	-	-	-	5
		Total	62 - 36.9 % (22 - 13.1 %)	42 - 25.0 % (14 - 8.3 %)	5 - 3.0 % (1 - 0.6 %)	14 - 8.3 % (4 - 2.4 %)

Table 9. Calculation of a gain - loss by a closure of Div. 1B to trawling based on tagging experiments in Div. 1B 1958-60, length group 50-59 cm by tagging. Symbols see the text, Section VI. Year is calendar year after tagging.

Year	N	N'	n			n <sub>C</sub> outside 1B	F	N <sub>B</sub>	N <sub>C</sub>
			total	1B line	1B trawl				
0	474.0	474.0	62.0	32.3	28.7	1.0	.31	469.6	4.4
1	340.8	385.2	90.0	36.0	32.0	22.0	.34	244.9	95.9
2	198.6	250.0	33.0	2.6	2.4	28.0	.20	23.4	175.2
3	133.1	164.4	22.0	1.6	1.4	19.0	.20	11.4	121.7
4	89.2	107.4	34.0	5.3	4.7	24.0	.54	21.1	68.1
5	42.6	50.9	-	-	-	-	-	-	-

ont.

Year	N' <sub>B</sub>	N' <sub>C</sub>	F <sub>B</sub>	F <sub>C</sub>	F' <sub>B</sub>	F' <sub>C</sub>	n' <sub>B</sub>	n' <sub>C</sub>	n' <sub>B</sub> - n' <sub>B</sub> line	n' <sub>C</sub> - (n' <sub>C</sub> + n' <sub>B</sub> trawl)
0	469.6	4.4	.30	.57	.16	.69	33.1	1.2	0.8	-28.5
1	276.8	108.4	.36	.29	.19	.35	43.5	29.2	7.5	-24.8
2	29.4	220.6	.27	.19	.14	.23	3.5	41.2	0.9	10.8
3	14.1	150.3	.34	.19	.18	.23	2.1	28.1	0.5	7.7
4	25.4	82.0	.73	.49	.39	.60	7.5	33.9	2.2	5.2
5	-	-	-	-	-	-	-	-	-	-

Table: 10

"Short time effect" (defined in Section V) by a closure of Div. 1B to trawling given as per cent change in catch within each length group of fish. Actual figures for catch without a closure are in each length group based on 1000 fish present in 1B when tagging experiment started. Kg is gutted weight. Year is calendar year after closure or after tagging experiment started - Year 0 is only 6 months, tagging experiments starting in mid year months and closure hence also thought to start in mid year.

a if closure had started in the period 1955 - 57.

Year	Length group	Catch without a closure				% change in catch after closure			
		Liners 1B		Other Subarea 1		Liners 1B		Other Subarea 1	
		numbers	kg	numbers	kg	numbers	kg	numbers	kg
0	50-59	53	72.6	38	52.1	0.8		- 100.0	
1		78	147.0	119	224.3	14.1		- 22.7	
2		66	158.1	74	177.2	22.7		- 47.3	
3		5	14.1	18	50.7	20.0		38.9	
4		16	50.6	56	177.2	37.5		26.8	
Total		218	442.4	305	681.5	15.3	17.9	- 25.6	- 17.5
0	60-69	55	116.3	41	86.7	0.0		- 92.7	
1		40	103.8	167	433.4	10.0		16.8	
2		24	73.1	44	134.0	4.2		- 13.6	
3		10	32.9	15	49.4	10.0		- 26.7	
4		4	13.7	26	88.8	25.0		23.1	
Total		133	339.8	293	792.3	5.3	5.9	- 4.8	- 2.4
0	≥70	38	120.3	27	85.5	5.3		- 100.0	
1		56	184.2	152	500.1	5.4		2.0	
2		27	92.2	41	140.0	11.1		- 22.0	
3		13	46.1	13	46.1	7.7		- 61.5	
4		6	22.1	15	55.1	16.7		13.3	
Total		140	464.9	248	826.8	7.1	7.2	- 16.5	- 16.2

b if closure had started in the period 1958 - 60

0	50-59	68	93.2	63	86.3	2.9		- 95.2	
1		76	160.7	114	241.1	21.1		- 45.6	
2		5	14.1	64	180.2	40.0		35.9	
3		3	10.2	43	146.8	33.3		37.2	
4		11	43.7	61	242.2	45.5		18.0	
Total		163	321.9	345	896.6	16.0	20.3	- 18.0	- 3.2
0	60-69	52	110.0	48	101.5	7.7		- 95.8	
1		64	180.2	139	391.3	15.6		- 25.9	
2		29	99.0	113	385.9	27.6		3.5	
3		1	4.0	49	194.5	0.0		20.4	
4		2	8.9	27	119.9	0.0		11.1	
Total		148	402.1	376	1193.1	14.9	16.0	- 17.3	- 11.1
0	≥70	85	269.0	86	272.2	4.7		- 86.0	
1		54	198.5	103	378.5	20.4		- 33.0	
2		34	145.5	81	346.7	26.5		- 13.6	
3		7	32.2	35	161.0	42.9		20.0	
4		6	28.8	34	163.2	50.0		23.5	
Total		186	674.0	339	1321.6	16.1	17.8	- 30.7	- 25.4

cont/

Table 10 cont.

c if closure had started in the period 1961 - 62.  
(more returns expected to be received).

Year	Length group	Catch without a closure				% change in catch after closure			
		Liners lb		Other Subarea 1		Liners lb		Other Subarea 1	
		numbers	kg	numbers	kg	numbers	kg	numbers	kg
0	50-59	67	91.8	97	132.9	6.0		-	54.6
1		63	133.2	219	463.2	22.2		-	10.5
2		15	42.2	125	351.9	40.0			15.2
3		(2)	(6.8)	(17)	(58.1)	(0.0)			(17.6)
4		(-)	(-)	(-)	(-)	(-)			(-)
Total		147	274.0	458	1006.1	16.3	19.0	-	11.8
0	60-69	49	103.6	105	222.1	2.0		-	30.5
1		56	157.6	217	610.9	19.6			5.1
2		16	54.6	109	372.2	25.0			7.3
3		(-)	(-)	(24)	(95.3)	(-)			(29.2)
4		(-)	(-)	(-)	(-)	(-)			(-)
Total		121	315.8	455	1300.5	13.2	14.9	-	1.3
0	≥70	123	389.3	110	348.2	7.3		-	100.0
1		44	161.7	349	1282.6	109.0			10.9
2		32	137.0	46	196.9	12.5		-	56.5
3		(-)	(-)	(12)	(55.2)	(-)			(25.0)
4		(-)	(-)	(18)	(86.4)	(-)			(11.1)
Total		199	564.7	535	1969.3	30.7	61.1	-	17.4

Table 11  
 "Long-term effect" (defined in Section V) by a closure of Div. 1B to trawling based on tagging of 40-49cm cod and given for two rates of discarding (rate A and B, see Section II,4). Actual figures without a closure based on 1000 fish tagged. Kg is gutted weight. Year is calendar year after closure or after tagging experiment started. Year 0 is only 6 months, tagging experiments starting in mid year months and closure hence also thought to start in mid year.

1. Low rate of discarding.

Closed in the period	Year	Catch without a closure				% change in catch after closure				
		Liners 1B		Other Subarea 1		Liners 1B		Other Subarea 1		
		numbers	kg	numbers	kg	numbers	kg	numbers	kg	
1955-57	0	20	14.7	30	22.1	0.0		-	100.0	
	1	72	88.2	79	96.8	16.7		-	100.0	
	2	69	124.9	91	164.7	30.4		-	36.3	
	3	15	34.5	52	119.6	60.0			23.1	
	≥ 4	34	95.7	41	115.4	55.9		-	39.0	
	Total	210	358.0	293	518.6	29.0	35.4	-49.8	-37.8	
1958-60	0	37	27.2	55	40.4	2.7		-	100.0	
	1	63	90.7	68	97.9	11.1		-	100.0	
	2	34	71.9	32	67.7	26.5		-	100.0	
	3	0	0.0	79	222.4	-			49.3	
	≥ 4	0	0.0	105	358.6	-			36.2	
	Total	134	189.8	339	787.0	12.7	15.8	-23.0	4.3	
1961-62		23	16.9	34	25.0	0.0		-	100.0	
		11	15.8	126	181.4	9.1			7.1	
		12	25.4	102	215.7	16.7			6.9	
	Total up to year 2	46	58.1	262	422.1	6.5	9.8	-	6.9	0.7
	Estimated final total	55	83.4	292	506.6	5.5	6.8	-	5.8	1.1

2. High rate of discarding.

1955-57	0	11	8.1	39	28.7	9.1		-	100.0	
	1	51	62.5	100	122.5	23.5		-	100.0	
	2	69	124.9	91	164.7	46.3		-	28.6	
	3	15	34.5	52	119.6	73.3			36.5	
	≥ 4	34	95.7	41	115.4	73.5		-	31.7	
	Total	180	325.7	323	550.9	45.0	51.9	-49.2	-34.7	
1958-60	0	20	14.7	72	52.9	10.0		-	100.0	
	1	45	64.8	87	125.3	20.0		-	100.0	
	2	34	71.9	32	67.7	47.1		-	100.0	
	3	0	0.0	79	222.4	0.0			69.6	
	≥ 4	0	0.0	105	358.6	0.0			55.2	
	Total	99	151.4	375	826.9	27.3	31.9	-20.8	12.9	
1961-62	0	13	9.6	45	33.1	0.0		-	100.0	
	1	8	11.5	129	185.8	25.0			14.0	
	2	12	25.4	102	215.7	25.0			16.7	
	Total up to year 2	33	46.5	276	434.6	15.2	19.8	-	3.6	6.6
	Estimated final total	42	71.8	306	519.1	14.3	16.7	-	2.0	7.7

Table: 12

Possible effect by a future closure of Div. 1B to trawling based on assumptions as stated in Section VII, 3 of the text. Actual figures for catch without a closure are per 1000 fish recruited in 1B at a length of 40 cm. Year is calendar year after recruitment. Kg is gutted weight, head on.

Discard rate	Year	Catch without a closure				Change in catch after closure			
		Liners 1B		other Subarea 1		Liners 1B		other Subarea 1	
		Numbers	Kg	Numbers	Kg	Numbers	Kg	Numbers	Kg
A (low)	0	120	63.6	181	95.9	11.7		- 100.0	
	1	56	57.1	110	112.2	38.4		- 33.5	
	2	18	31.2	73	126.7	59.1		25.9	
	3	5	12.5	45	112.1	67.3		55.4	
	≥4	2	6.3	59	186.7	95.5		50.0	
	Total	201	170.7	468	633.6	+ 25.6	+ 36.8	- 30.9	+ 8.2
B (high)	0	66	35.0	235	124.6	27.8		- 100.0	
	1	39	39.8	126	128.5	71.2		- 32.7	
	2	18	31.2	73	126.7	92.3		51.9	
	3	5	12.5	45	112.1	102.0		87.5	
	≥4	2	6.3	59	186.7	145.5		80.8	
	Total	130	124.8	538	678.6	+ 54.6	+ 72.8	- 28.2	+ 21.5

Fig. 1

Growth of cod  
Divisions 1A-iD offshore  
Quarter of July

