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Status of the Icelandic scallop, Chlamys islandica in the northeastern Gulf of St Lawrence, 1985.

by

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ABSTRACT

The assessment of the northeastern Gulf of St. Lawrence Icelandic scallop stock was based on experimental survey and commercial fishing data. The results indicated an increase of effort in 1985 and a decrease in catch per boat-day. The yield per recruit analysis suggested that the present yield was at its optimal value. However, the analysis is disputable in terms of reliability of the data available. In spite of an increase in landings and some indication of a good recruitment (percentage of prerecruits in experimental catches), it is suggested that some actions be taken to restrict the development of the fleet in order to avoid overfishing. Management options and guidelines for further research are presented.

RESUME

L'évaluation de la population de pétoncles d'Islande dans le nord-est du Golfe du St-Laurent a été effectuée en utilisant les données d'une campagne d'exploration et des données de la pêche commerciale. Les résultats de 1985 mettent en évidence une augmentation de l'effort et une diminution des captures par jour de pêche. L'analyse des rendements par recrue suggére une situation de rendement optimal. L'analyse est cependant discutable en raison des incertitudes sur les paramètres disponibles. Malgré l'augmentation des débarquements et des indices de bon recrutement (pourcentage de prérecrues dans les captures expérimentales), les auteurs suggèrent de prendre des dispositions pour stopper le développement de la flotille afin d'éviter la surpêche. Des options de gestion et des lignes de conduite pour les recherches futures sont présentées.

INTRODUCTION

The Icelandic scallop fishery located in the Strait of Belle Isle, in the northeastern Gulf of St. Lawrence (Fig. 1A), is very different from the southern Gulf sea scallop fishery both in its structures and strategies. The first studies on the population dynamics of Chlamys islandica commenced in 1973 and an extensive survey and review of available data was initiated in 1980/81 (Naidu et al, 1982). The present study is the first since the transfer of the mandate in 1982 from Newfoundland to the Gulf Region.

HISTORIC AND PRESENT SITUATION

Commercial scallop fishing for Icelandic scallops in the northeastern Gulf of St. Lawrence began in the late 60's (Table 1). In 1969, landings reached 224 MT (live weight). It was the start of a first pulse which reached a peak in 1972 with 2343 MT landed. A combination of several factors (ice conditions, success on other

species, low price for scallop meat) resulted in poor fishing performances in 1974 (Naidu and al. 1982); as a consequence, no active fishing took place between 1975 and 1978 inclusive.

The fishery resumed in 1979 when a second phase was initiated. After high landings in 1981 (1381 MT), a sharp decrease in landings (315 MT) and effort was observed in 1982 (despite a steady increase in price).

Since scallop fishermen hold other fishing licenses, the effort each fisherman applies to scalloping is highly variable. Hence, overall effort from one year to the other shows considerable variation. As mentioned in Naidu et al (1982), very little is known of the fleet behavior during the 1969-1973 period. This makes it difficult to explain the first pulse. However, the sharp increase in landings between 1971 and 1972 coincides with a major change in the basic design of the Digby drag whose rings were changed from 76 mm to 64 mm diameter (3 in. to 2.5 in.).

In 1984, a majority of fishermen changed their dredge to one similar to the offshore drag used for sea scallops on Georges Bank. The changeover resulted in a sharp increase in landings (1270 MT). The fishing areas have also changed since 1969. Up to 1981, almost all the fishing effort was concentrated in the area between Anchor Point/Point Charles/Ferolle Point (Figure 1B). In 1982, the Labrador coast was actively fished between Point Charles and Red Bay. The northeast movement seemed to continue in 1984 as boats were fishing up to York Point and Southwest of Belle Isle.

MATERIALS AND METHODS

Resource survey

A survey was conducted in the Strait of Belle Isle (Fig. 1), Newfoundland from August 10 to 21, 1985. The survey site was chosen following discussions with fishermen and local personnel of the Department of Fisheries and Oceans. It was decided to sample a large area in order to cover most of the commercial fishing grounds, as a first approach to resource mapping.

The stations were chosen and accordingly spaced along transects to cover the entire Strait of Belle Isle. This sampling protocole was adopted to minimize the problem accounted in positionning the stations using the LORAN C. A total of 75 tows were performed using a single bucket drag, commonly utilized by local fishermen (Fig. 2). A shrimp net lining (2 cm stretched courlene mesh) inside the drag was used for 19 of these tows in order to capture small scallops.

The scallops caught were all measured to the nearest millimeter (distance between hinge and distal margin of the valve) unless the catch was too abundant, in which case about half of the individuals

were measured and the remainder of the catch was counted. Size frequency distributions (size classes of 3 mm) were drawn from the data obtained (Fig. 3).

Shell heights (L) were transformed into meat weights (MW) using Naidu et al (1982) relationship:

$$MW = 0.000036\ L^{2.85}$$

The data were used, with the towing time and the distance covered, to calculate the bottom densities (gram of muscle/m^2).

Logbooks and interviews

Logbooks were distributed to 37 fishermen with temporary permits. They provided daily information on estimates of catch, fishing locations and effort. The data were used to calculate catch per unit of effort (CPUE, in kg of meat/m/h) in different regions of the Strait. The logbook information was complemented by a questionnaire distributed by local Fisheries personnel. The questionnaire mainly covered effort location during the season and cost of operation.

Landing statistics

Landing statistics were used to calculate effort as the number of days fished during the season. The transformation of landings in live weight (LW) to meat weight (MW) or vice versa was performed using conversion factors (I) calculated by Naidu (pers. comm., Table 2).

Yield per recruit

Yield per recruit was calculated for different instantaneous fishing (F) and natural (M) mortality rates using the Thompson and Bell method (Ricker, 1975). The parameters needed for the calculations were taken from Naidu et al's (1982) growth curve ($L_t = L_\infty [1 - e^{-K(t-to)}]$ and the meat weight (MW)/shell height (L) relationship ($MW = aL^b$) previously presented. The growth parameters for C. islandica in the Strait of Belle Isle are as follow:

$K = 0.149$	(Brody growth coefficient)
$L^\infty = 107.30$	(asymptotic height)
$W^\infty = 22.245$	(asymptotic meat weight)
$t_o = 0.89$	(hypothetical age at zero height)
$t_c = 8$	(mean age at capture, 50% retention in fishing gear use by Naidu et al, 1982).
$t^\infty = 20.553$	(hypothetical age at assymptotic height)
$a = 0.000036$ $b = 2.85$	(parameters of the meat weight/shell height relationship)

RESULTS

Survey

A total of 5753 scallops were fished, 261 (4.5%) of which were cluckers (dead scallops with valves still attached). Size frequency distributions for the tows made with an unlined drag and tows made with a lined drag are represented in Figure 3A and 3B respectively.

Scallop height varied from 32 mm to 121 mm ($\bar{L}$ = 85.5 mm, s = 8.43) in the unlined drag and 12 mm to 121 mm ($\bar{L}$ = 83.0 mm, s = 13.25) in the lined drag. The major modes were at 87 mm and 90 mm respectively (Fig. 3). An average bottom density of 0.33 g of meat/m^2 (s = 0.292) was calculated from the tows made with the unlined drag. The percentage of prerecruits (< 70 mm shell height) of 19% was estimated from the 19 tows made with the lined drag.

Logbooks

Logbooks returned by 13 fishermen represented 430 daily reports (logsheets). The CPUE in 40 different squares was calculated from the logbook information (Fig. 4, Table 3). The CPUE varied from 1.93 kg of meat/m/h to 9.08 kg of meat/m/h. Some squares were not represented because the information was believed to be inaccurate or non representative (i.e. represented by only one logsheet). The zones best represented were off the Labrador coast, between Point Charles and Red Bay and north of Newfoundland between Four Mile Head and Cape Norman (Figure 1).

The questionnaire was answered by 65 fishermen fishing in the study area. Figure 5a shows the fishermen's homeport locations and their contribution as a percentage of questionnaires answered. A distribution of effort, expressed as a percentage of fishing days in the different zones, was derived from the questionnaire (Figure 5b). It shows that the fishing effort is now distributed all over the Strait of Belle Isle with some areas sustaining a high percentage of the effort (along Labrador coast from Point Charles to Red Bay). The majority of the fishermen who answered the questionnaire are from that area or on the opposite side of the strait (along Newfoundland coast). Therefore the distance from the fishing grounds does not seem to be an important factor in determining the fishing strategy. The logbooks and the questionnaire indicated low fishing effort in the northeastern limits of the Strait. The fishermen in the nearby homeports (Cape Norman, Cape Bauld) preferred to travel to beds inside the Strait, possibly because of unfit bottoms or low catches in the northeastern area. It was calculated that 79% of the fishermen fished in the same areas as in 1984.

Statistics

The landings from 1969 to 1985 are presented in Table 1. The catch per boat-day was stable in 1974 and 1979 (Table 4). It increased to over 1000 kg of live weight/boat day in 1980 and 1981 but fell below 800 kg/boat day in 1982 and 1983. As effort increased in 1984, catch per boat day increased (999 kg/boat day). In 1985, the number of fishing days attained its highest level since 1974 but the catch per boat day dropped 27% from 1984 value.

Yield per recruit

Yields per recruit (Y/R, in grams of meat) were calculated using different instantaneous rates of natural mortality (M) and fishing mortality (F). The resulting Y/R are presented as a function of F in Figure 6 and as Y/R isoplethes in Figure 7. To avoid any overlaps of the curves in Figure 6, each representation was divided into two sections. The lower part shows the increase of Y/R as t_c increases. The upper part shows the decrease of Y/R as t_c increases. In order to make use of these figures it is necessary to know the actual values of M, F, and tc. According to Naidu et al (1982), 70 mm is the size at 50% retention by the gear (64 mm ring size), a size which corresponds to an age tc of 8 years. They calculated the value of M to vary between 0.0881 and 0.4075 from 8 to 15 year old scallops. The intantaneous rate of natural mortality was also calculated using the present survey data (unlined drag) and Dickie's equation (Dickie, 1955):

$$A = 1 - e^{-M} = 1 - e^{-\frac{C}{t} \times \frac{1}{N} (365)}$$

where A = annual mortality
C = number of cluckers
N = number of live scallops
t = 210.8 days which correspond to the time of disarticulation (Mercer, 1974).

The calculation did not consider each age group separately because of the low number of cluckers in the catches. The value of M = 0.0657 calculated was lower than the ones calculated by Naidu et al(1982). An in-depth analysis to evaluate M was not possible with the data, an approximation of the mean value calculated by Naidu et al (1982) was considered (M = 0.15) to be the best possible M value for 1985.

An F value for 1985 cannot be easily calculated because of the lack of reliable data, as there was no commercial samplings or experimental surveys between 1981 and 1985. Naidu et al (1982) estimated the F value in 1980-81 to vary from 0.338 to 1.431 (F = 0.590) depending on the age (9 to 14 years). As the effort in 1985 was greater than the one in 1980-81, it is likely that F value

will also be greater. Using a cautious approach, yield per recruits (Figures 6 and 7) were calculated using a constant F = 0.5, and a knife-edge recruitment at age 8 (t_c).

A Y/R of 6.4 g of meat/recruit was estimated, corresponding closely the optimal value (Y/R) for F = 0.5 (Fmax). Augmenting the effort would not increase the Y/R as the curves were essentially flat-topped (Fig. 6)

DISCUSSION

Many changes of the Icelandic scallop fishery have been unclearly reported throughout the years. The fishery has experienced two major pulses of exploitation starting in 1969 and 1979. The substantial increase in landings and effort (number of boat-days) in 1984 and 1985 suggests the beginning of a third one, which was caused in part by the changeover to a supposedly more efficient gear and to some extent, by the use of larger vessels (20 m). Conversely, the average daily catch per boat day in 1985 has decreased from the 1984 value. This situation is similar to the one experienced during the second exploitation pulse, when the Digby drag was still in use. The many changes which occurred in this fishery over the last 5 years (movement of the fleet, modification of gear, fluctuation of effort) make it difficult to elaborate on the results.

Size frequency distributions in the 1985 survey have similar size ranges to those presented by Naidu et al (1982) in 1980 and 1981. However, the main modes in 1980 and 1981 (77 and 74 mm respectively) were lower compared to the 1985 mode (87 mm). The discrepancy cannot be considered as a pertinent changeover in the stock because two different gears were used for sampling and the areas explored were much different. The percentage of prerecruits in 1985 (13.3%) was slightly higher that the percentage calculated in 1980 and 1981 (10.1% and 10.2% respectively) by Naidu et al (1982). These results may indicate stable levels of recruitment.

The distribution of the fishing squares reported in the log-books and the results of the questionnaire suggest that the entire Strait of Belle Isle has been explored and that the locations of the scallop beds are well known to the fishermen. Distance from home port to the fishing ground does not seem to be a major factor as the exploited scallop beds are all located inside the narrow section of the Strait of Belle Isle. This supports the conclusion that the fishery is no longer in its development stage or expanding. Most of the short term fleet movements are made within the Strait, to grounds already known, in order to maintain catches at high levels. The 162% increase of effort from 1983 to 1984 followed by an 130% increase from 1984 to 1985 could result in overfishing. Although part of the additional fishing pressure was applied on new beds, the downward trend of the average daily catch per boat-day between 1984

and 1985 might be the result of effort increasing faster than the availability of the resource.

The yield per recruit analysis, assuming F = 0.5, M = 0.15 and tc = 8, suggests a fishery operating near an optimal yield of 6.4 g of meat per recruit. Naidu et al (1982) had similar results in 1980/81 with a yield of 6.7 g of meat per recruit using the Thompson and Bell (1934) method and almost identical initial parameters (F = 0.52, M = 0.156, tc = 8). These results and the stable percentage of prerecruits in 1980, 1981 and 1985 suggest that the increase of effort (and likely of F) from 1983 to 1985 did not significantly affect the Y/R yet as it stays almost leveled at 6.4 g of meat per recruit.

CONCLUSION

The northeastern Gulf of St Lawrence Icelandic scallop fishery is experiencing large fluctuations of fishing effort and landings. It has also gone through major changes (many unreported) in gear and fishing grounds over the last 10 years. The fishery can be considered as a secondary fishery controlled by socio-economical factors and by fluctuations of the main fishery (i.e. cod).

The yield per recruit calculations presented in this paper were made assuming constant instantaneous natural and fishing mortality rates for recruited or partially recruited age groups. These assumptions are considered as approximations of the parameters needed for the yield per recruit model. The edge-knife selectivity curve at S_{50} = 8 years (Naidu, 1982) does not consider partial recruitment. Furthermore, the results of Naidu's selectivity study may not apply as the fishing gear studied was very different than the one used in the present study. As the fishing gear and fleet have undergone major changes, studies should be initiated to gather more relevant data on the selectivity and the efficiency of the new gear. The changes and expansion of the fishing grounds may also have result in geographical variations in growth and lenght/weight relationship which still have to be verified. Any further use of the yield per recruit results for assessment would need more reliable calculation parameters and a quantitative estimation of the recruitment level.

At the present time, the combination of increasing effort (number of fishing boats) and decreasing catch per boat-day can not be seen as a biological problem. Any further increase of effort will likely result in further decreases in catch per boat-day (as the production is harvested by more fishermen), which may eventually result in lower landings. The immediate management strategy would be to limit the effort by not permitting any new entries into the fishery until more reliable data are available for the assessment.

Measures will have to be taken to evaluate the effort level in respect to the maximum yield and the available biomass. The conservation and the rational utilisation of the resource can only be achieved through proper scientific studies and management actions:

1- Future surveys have to be planned to acquire more relevant data for population dynamic studies.

2- Logbooks should be filled by all fishermen. It is the only way to precisely locate the effort and gather relevant information on the fishery.

3- The gathering of statistical data should be improved. Landings classified as "roe" are automatically added to the total meat landing without even considering that the muscle and the gonad are commonly sold attached. A simple conversion factor could solve the problem.

4- A unit of effort should be standardized by regulating scallop drag ring diameter and other gear specifications (i.e. size, material used in the construction).

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Table 1. Total landings (live weight in MT) in the Northeastern Gulf of St. Lawrence from 1969 to 1985.

Year	Total (MT)
1969	224.3
1970	173.6
1971	151.3
1972	2343.4
1973	1976.8
1974	220.3
.	.
.	.
.	.
.	.
1979	406.1
1980	1022.7
1981	1381.2
1982	314.8
1983	335.7
1984	1270.3
* 1985	2111.7

* Conversion factors (see Table 2) calculated by Naidu (pers. comm.) were used to transform meat weight into live weight. A factor of 8.3 was used for the previous years.

Table 2. Conversion factors (I) used to convert live weight (LW) into meat weight (MW = LW/I).

Month	I*
April	11.35
May	10.49
June	9.60
July	9.45
August	9.78
September	9.35
October	9.27
November	9.34

(*) Monthly conversion factors provided by K.S. Naidu (pers. comm.)

Table 3. Number of logsheets returned for each fishing square and estimated value of CPUE (kg/m/h).

Number of square	Number of logsheets	CPUE (meat weight)	Number of square	Number of logsheets	CPUE (meat weight)
38	1	1.93	123	3	5.03
84	24	3.99	124	21	5.21
90	1	9.08	125	12	4.58
91	1	2.08	128	4	7.04
92	5	4.27	129	23	4.96
93	9	5.21	130	30	4.60
96	9	8.18	138	1	8.63
98	3	2.60	141	4	5.68
99	11	3.79	142	58	5.74
100	16	4.12	143	1	4.76
101	34	5.48	144	6	6.30
102	16	7.71	146	26	4.75
104	4	7.31	147	33	5.36
106	1	4.02	148	20	4.94
109	12	6.15	149	1	7.29
115	10	5.88	154	3	5.88
117	2	4.39	157	2	2.28
120	3	5.86	158	2	2.31
121	2	5.74	159	4	4.85

Table 4. Effort (boat days) and capture/boat day in kg (live weight) in the C. islandica fishery in the northeastern Gulf of St. Lawrence.

Year	Number of boats actively fishing	Effort (boat days)	Capture/boat days (live weight) Kg
1974	24	269	820
.			
.			
.			
.			
1979	16	459	885
1980	14	774	1321
1981	24	1262	1094
1982	24	413	762
1983	23	485	692
1984	46	1272	999
1985	107	2887	732

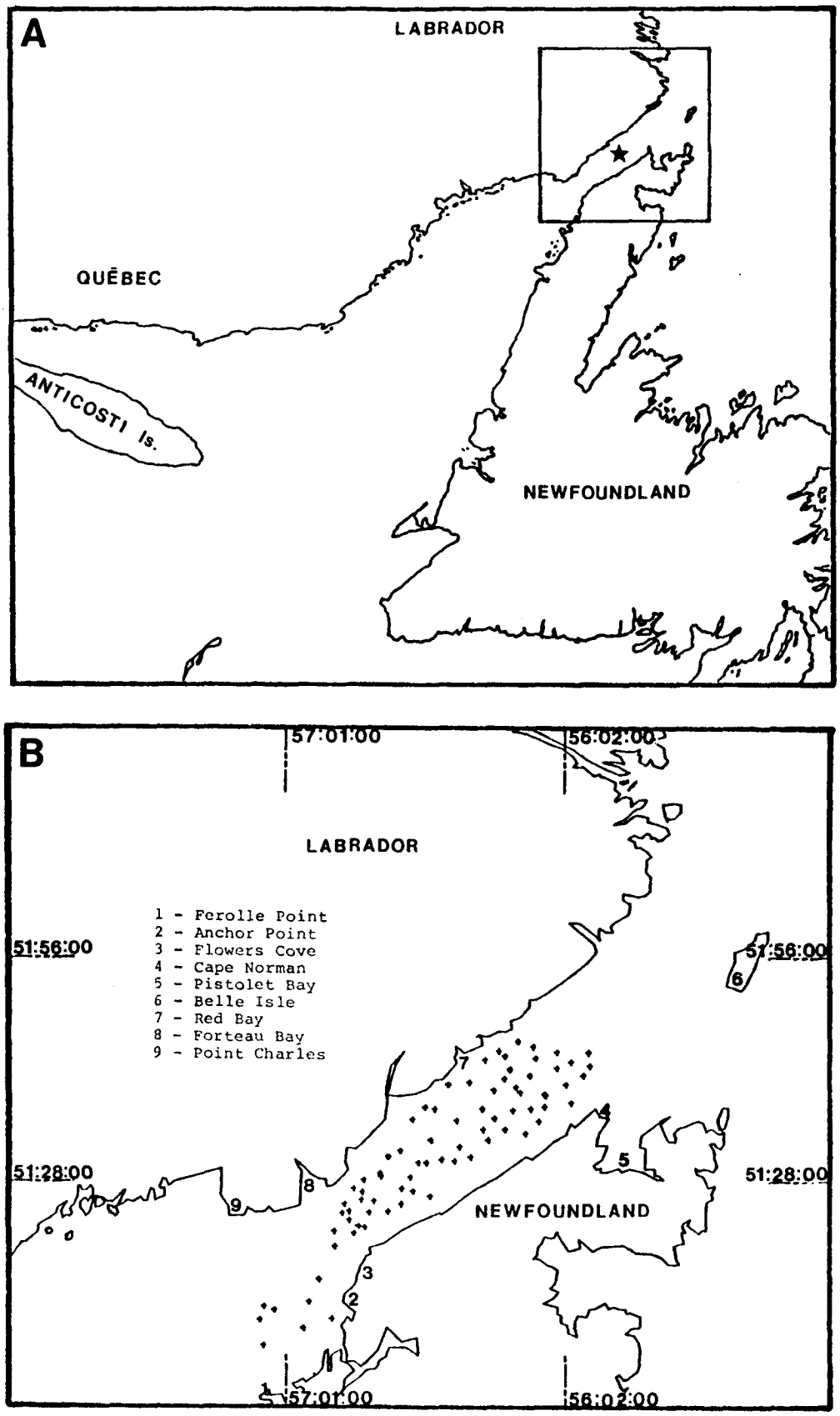


Figure 1. A - Location of the 1985 survey in the northeastern Gulf of St. Lawrence (★ - Strait of Belle Isle). B - Position of tows in the Strait of Belle Isle, Newfoundland.

Width : 3.7 meters
Ring size : 64 mm (bottom)
Mesh size : 100 mm streched mesh (top)

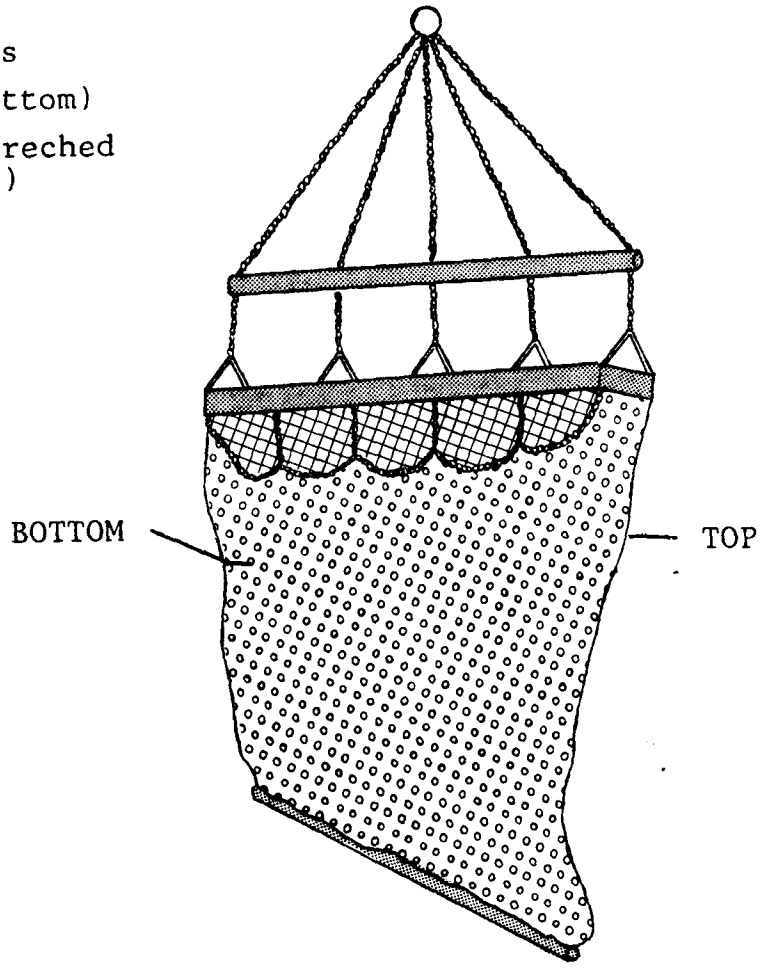
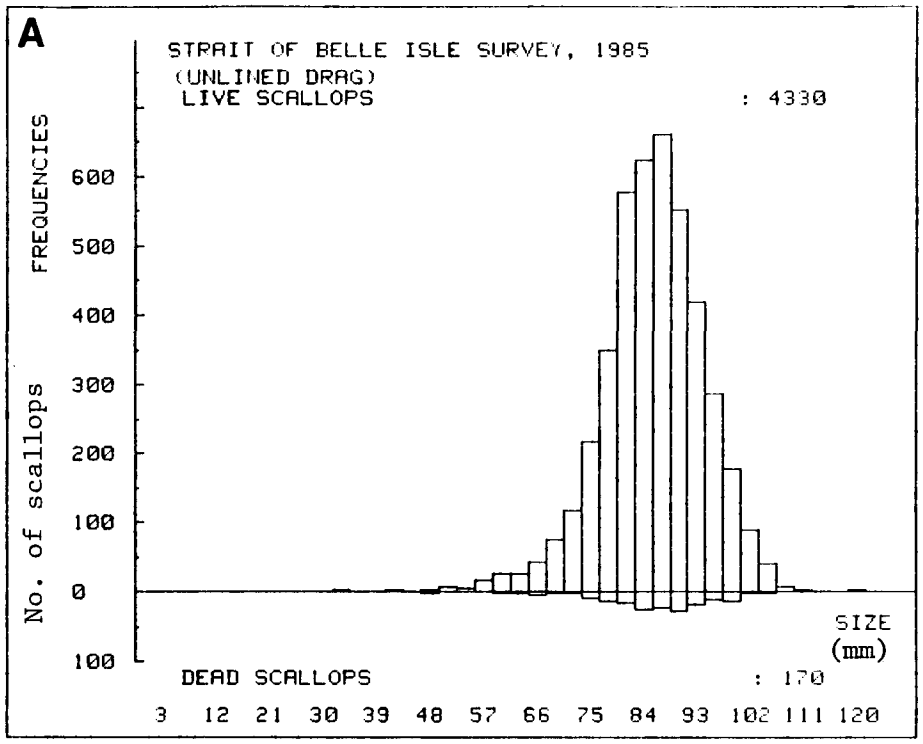


Figure 2. Drag used for the 1985 Islandic scallop survey.



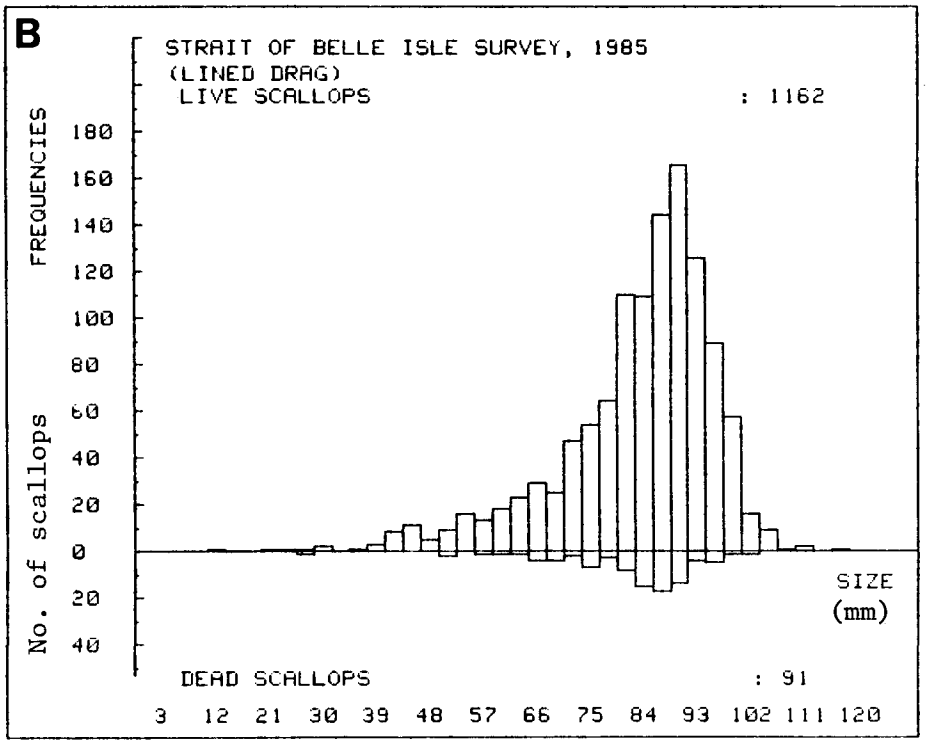


Figure 3. Size distributions of the survey catches (A - unlined drag, B - lined drag).

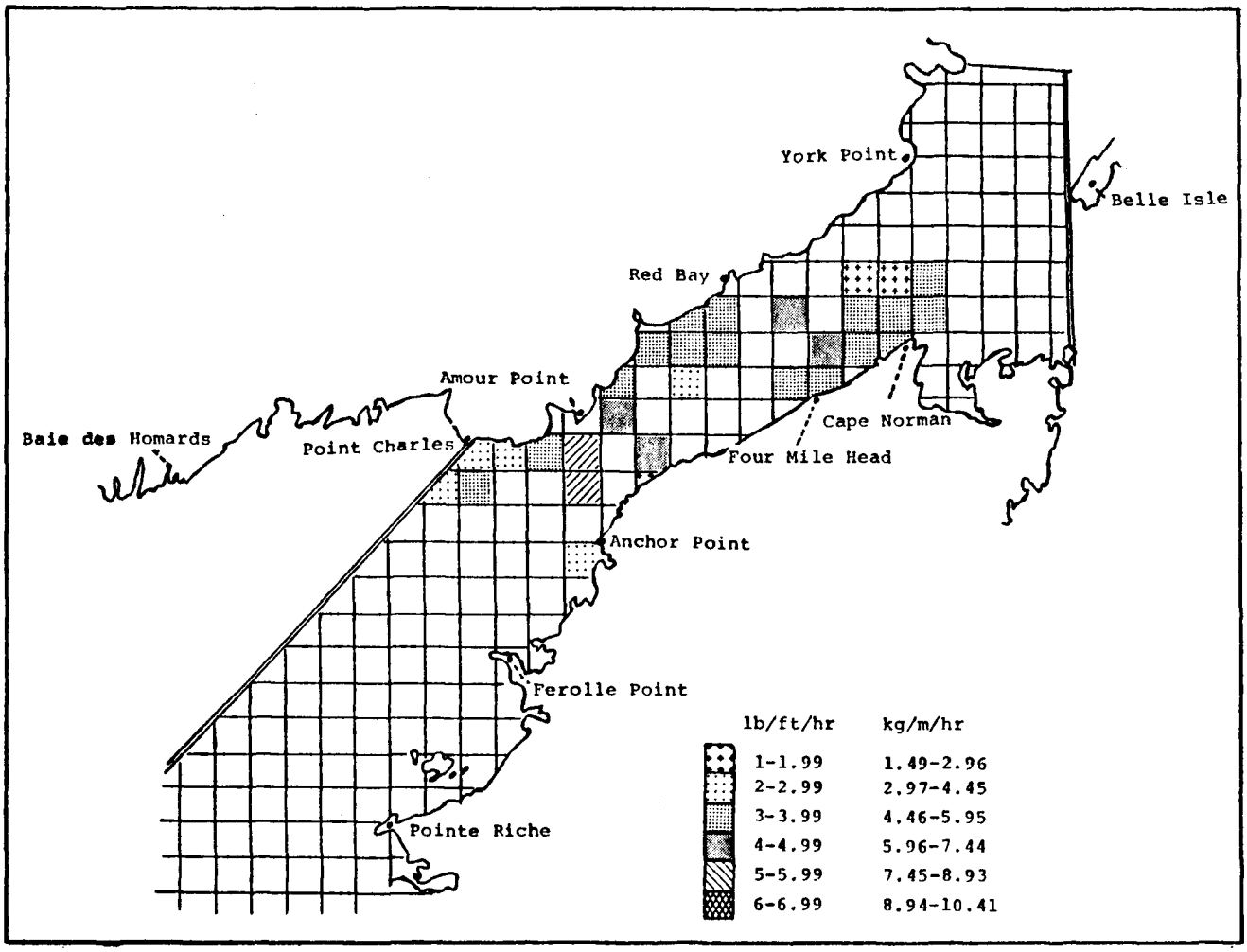


Figure 4. Mean CPUE's calculated from logbooks information for each fishing square in the Strait of Belle Isle.

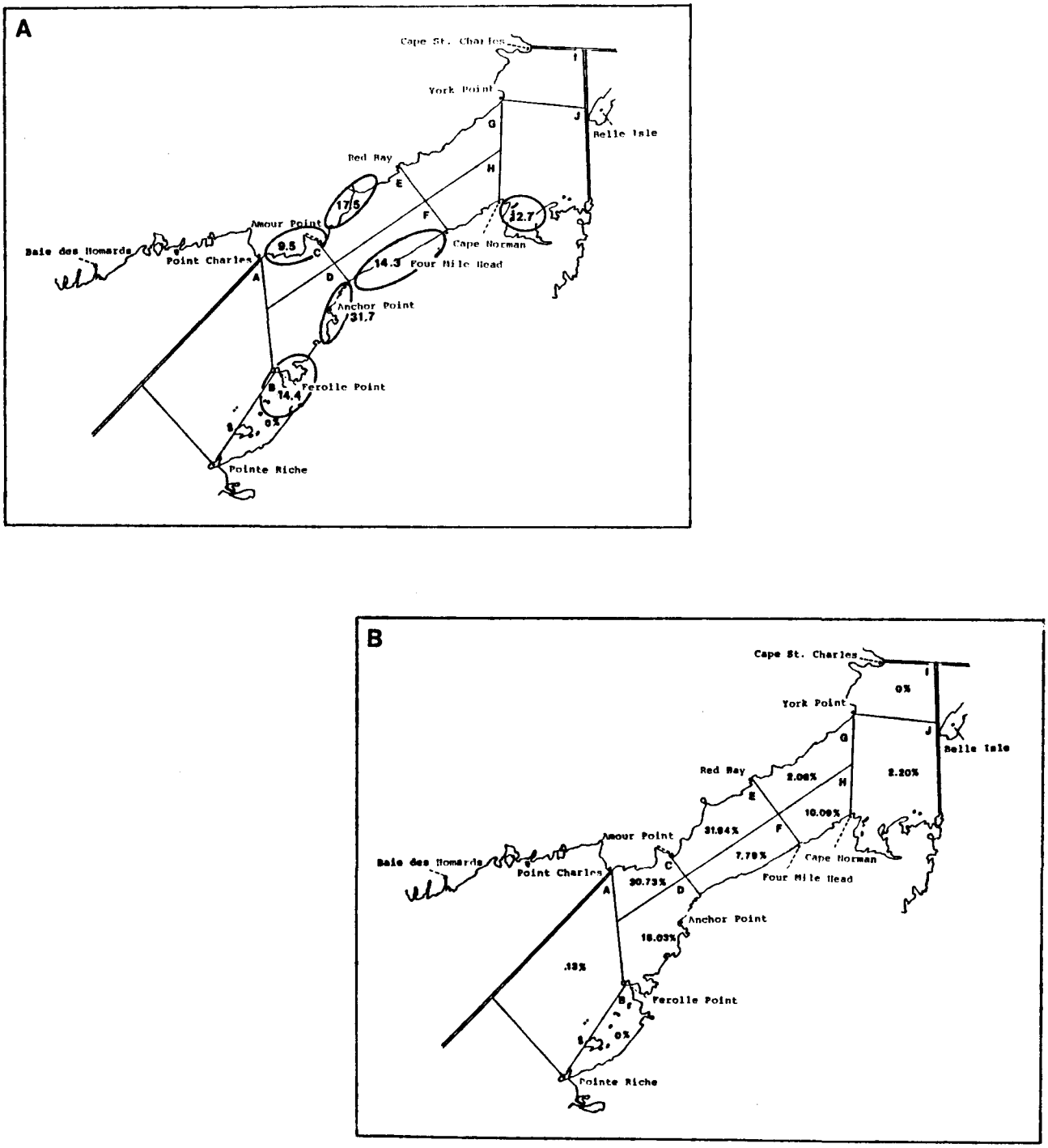


Figure 5. Results of the questionnaire. A - Percentage of fishermen per area who answered the questionnaire. B - Distribution of the fishing effort expressed as percentage of the total fishing days.

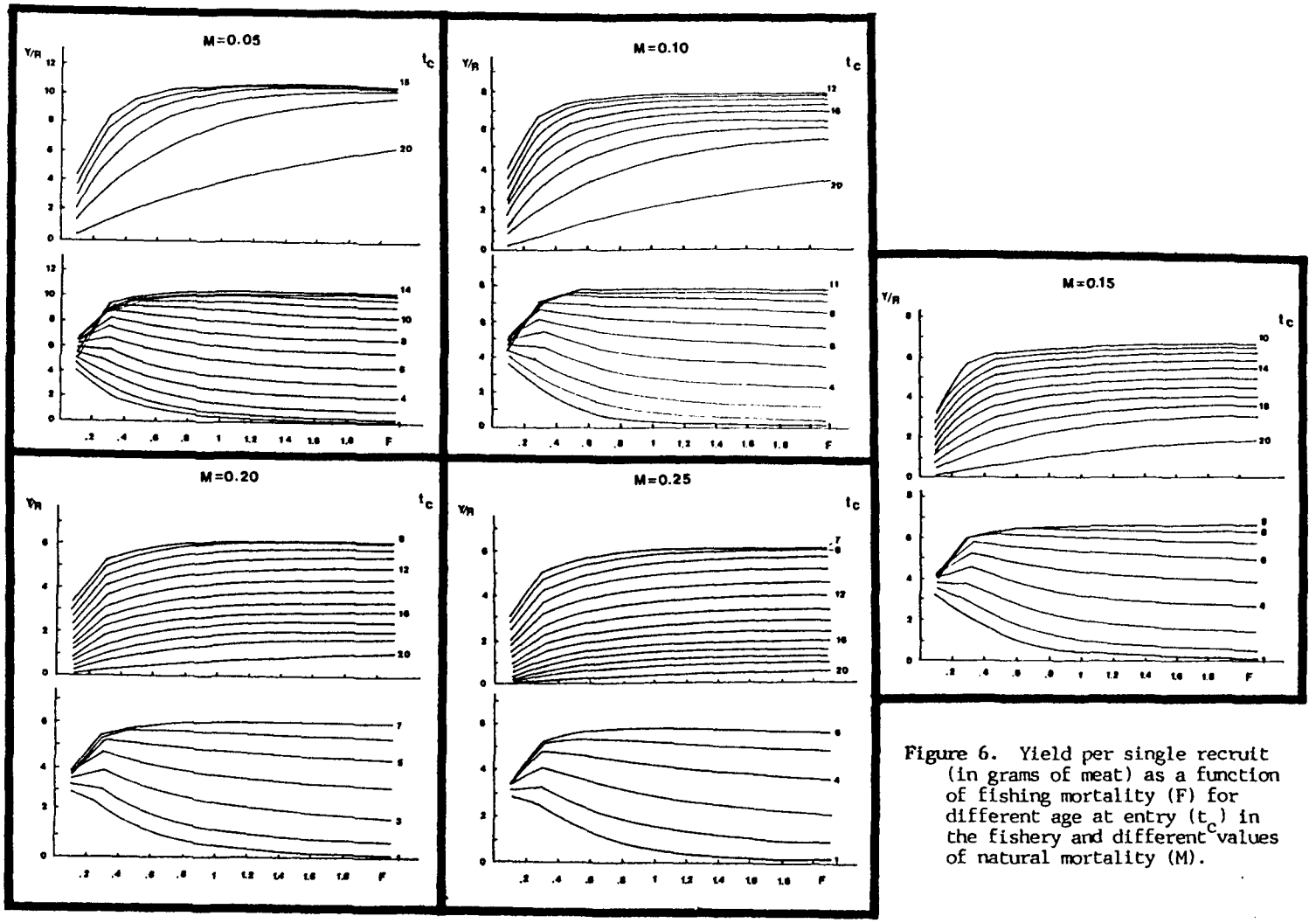


Figure 6. Yield per single recruit (in grams of meat) as a function of fishing mortality (F) for different age at entry (t_c) in the fishery and different values of natural mortality (M).

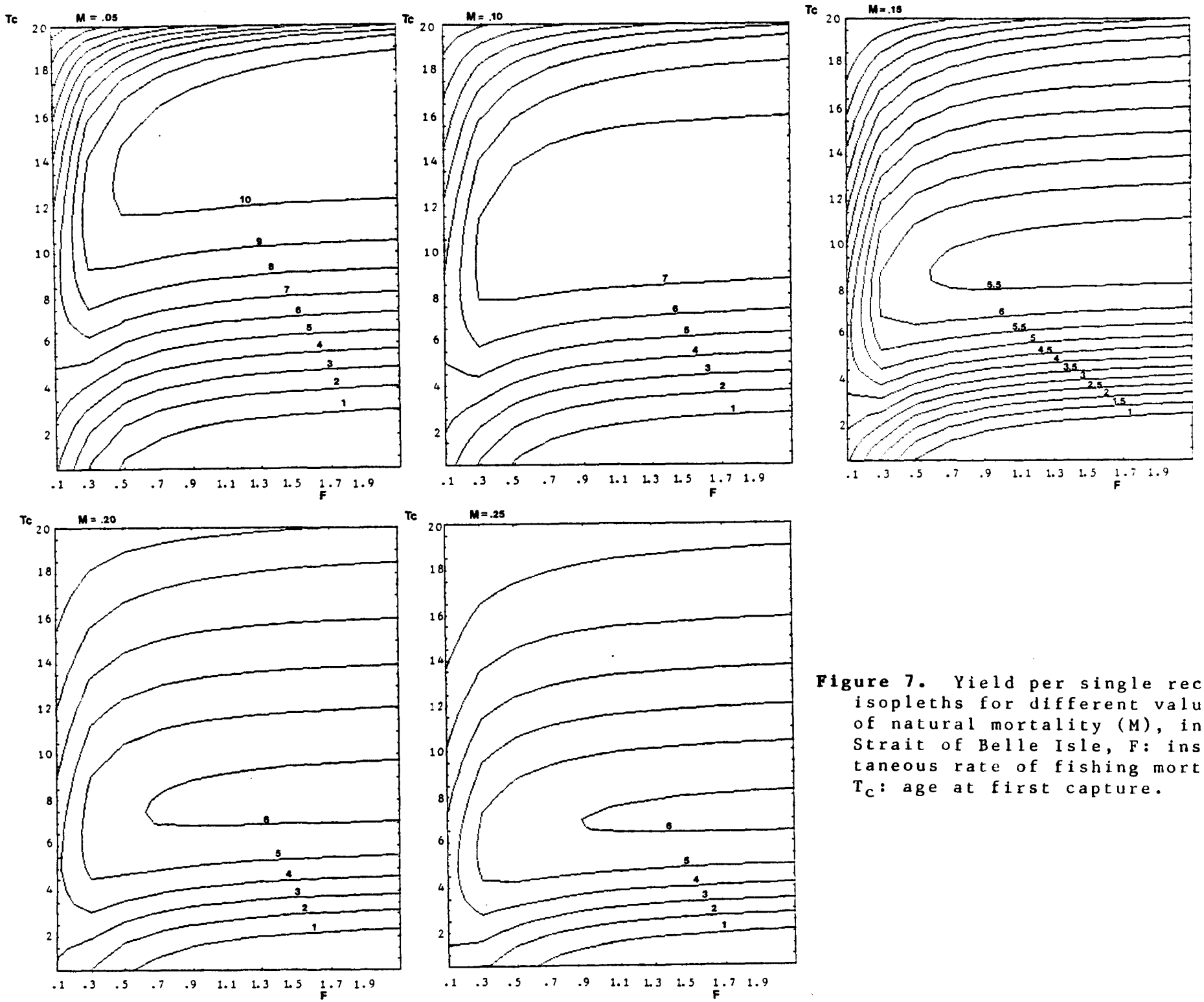


Figure 7. Yield per single recruit isopleths for different values of natural mortality (M), in the Strait of Belle Isle, F: instantaneous rate of fishing mortality T_c: age at first capture.