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Status of the Cod Stock in Division 3M[1]

by

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Nominal catches

Catches were generally low during 1953-59. In the periods 1960-64, 1965-69 and 1970-74, the average catches were 26,000, 43,000 and 33,000 tons respectively. Catch regulation was introduced in 1974.

	1974	1975	1976	1977	1978	1979
TAC 000 tons	40	40	40	25	40	40
Catch 000 tons	25	22	22	25	33	

Age compositions of commercial catches in 1976-78

The age compositions for 1976-78 are shown in Table 1. Age compositions for 1977 and 1978 were derived from commercial sampling on file at ICNAF. The 1976 age composition was derived from Portuguese length frequencies observed in August, September and October 1976, and from an age length key from a Canadian research vessel survey in January - February 1977 (Table 2). These age compositions, together with the corresponding length frequencies, are shown in Fig. 1. Also shown is the length frequency of catches by Portuguese otter trawlers in the fall of 1975. The data are consistent with the progression of the dominant 1973 year-class through the fishery over this period.

Estimation of F in the 1970's

Table 3 shows the per mille age frequencies for 1977 and 1978. Regression parameters for a variety of age groups in the descending limb of the combined per mille catch curves for 1977 and 1978 are also shown in Table 3. It would appear that F has been increasing in the most recent years to the level of about 1.6.

Partial recruitment pattern

The percentage retention of cod by length for a 5 inch mesh is given in Hodder (1964). The average length at age derived from the current commercial sampling was applied to this retention curve to derive the percentage retention at age. See Table 4.

Yield per recruit

A yield per recruit curve based on the data of Table 5 is shown in Fig. 2. F max is estimated to be about 0.27.

Assuming an F in 1978 of 0.8, the partial recruitment of Table 4 and the 1978 age composition were used to estimate the stock biomasses at the beginning of 1978 and 1979. Table 6 would indicate that these values would approximate 64,000 and 51,000 tons respectively. A stock biomass in 1979 of 51,000 tons would imply an F in 1979 of about 0.9 if the catch were about 25,000 tons.

[1] The Appendix to this paper was added after discussion at the April 1979 Meeting of the Assessments Subcommittee.

Conclusions

1. The 1973 year-class has been dominant in the commercial catches in the period 1976-78.

2. The fishing mortality in 1978 was not estimated precisely but was probably higher than 0.8 and perhaps in the order of 1.6

3. The fishing mortality in 1979 implied by a catch of 25,000 tons is at least 0.9.

Acknowledgement

C. A. Bishop assisted in the construction of the 1977 and 1978 commercial age compositions.

REFERENCES

Hodder, V. M. 1964. Assessments of the effects of fishing and of increases in the mesh size trawls on the major commercial fisheries of the Newfoundland Area (ICNAF Subarea 3). Fish. Res. Bd. Canada Manu. Rept. Ser. (Biol.) No. 801, 116 pp.

Table 1. Age composition of cod in Div. 3M, 1976-78.

AGE:	1976	1977	1978
1	131		
2	1761		
3	28370	89	134
4	1845	15509	1724
5	111	5318	17749
6	22	227	2367
7	1	137	160
8	23	22	92
9	4	74	56
10	4	44	49
11		15	
12		7	21
13		7	21
14			
15			21
>15			43
Total (000)	32272	21449	22437
Av.Wt. (kg)	0.69	1.18	1.56
Landing (t)	22266	25273	35000

Table 2. Age length key for cod on the Flemish Cap, January - February, 1979.

LENGTH	AGE IN YEARS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	SUM
10	1																			1
13																				0
16		19																		19
19		24																		24
22		2	24																	26
25		2	30																	32
28		1	23	1																25
31			11	14																25
34			2	24																26
37			1	24																25
40				25																25
43				25																25
46				24	1															25
49				22	3															25
52				17	8															25
55				14	11															25
58				6	19															25
61				2	23															25
64					24	1														25
67					15	1														16
70					4	4														8
73						10														10
76						13	3													16
79						11	3													14
82						2	1			1	1									5
85					2	8	1	1	2											14
88						3	4		2											9
91									3											3
94									3											3
97																				0
100									2											2
103										1										1
106																				0
109																				0
112																				0
115										1										1
118													1							1
121													1						1	2
	1	48	91	198	110	53	12	1	12	3	1	0	2	0	0	0	0	0	1	533

Table 3. Per mille age compositions of cod in the commercial fishery in 1977 and 1978 on Flemish Cap.

Age	1977	1978	1977 and 1978
3	4	6	10
4	724	77	801
5	248	791	1039
6	11	105	116
7	6	7	13
8	1	4	5
9	3	3	6
10	2	2	4
11	1	-	1
12		1	1
13		1	1
14			
15		1	1
NK		2	2
Total	1000	1000	2000

regressions on ln combined age frequency against age

age groups	slope	r	t	df	F
5-11	-1.0	.93	5.6	5	.8
5-8	-1.8	.99	8.5	2	1.6
6-11	-.77	.92	4.6	4	.57

Table 4. Percentage retention of cod by 5" mesh (derived from Hodder, 1964)

AGE:	AV. LENGTH:	% RETAINED:
3	32.84	7
4	41.43	37
5	53.30	90
6	64.64	100
7	82.90	100
8	89.26	100
9	88.86	100
10	93.94	100
11	103.00	100
12	106.33	100
13	104.85	100
14	103.00	100
15	124.00	100

Table 5. Yield per recruit for cod in Div. 3M (see Fig. 2).

Age:	Selection Pattern:%	Av. Wt.
3	.07	0.31
4	.37	0.62
5	.90	1.34
6	1.00	2.42
7	1.00	5.17
8	1.00	6.48
9	1.00	6.39
10	1.00	7.57
11	1.00	10.02
12	1.00	11.04
13	1.00	10.58
14	1.00	10.02
15	1.00	17.65

Natural mortaltiy = 0.2

Maximum yield per recruit = 0.877 at F = 0.27 (based on 1,000,000 recruits at age 1).

Table 6. Projected stock size in 1979 and catch in 1979 at F = 0.87.

AGE	1978 Catch	1978 F	1978 Stock	1979 Stock	1979 F	1979 Catch
3	117	.06	2200	(10,000)	.061	500
4	1501	.30	6400	1700	.320	400
5	15499	.72	32800	3900	.624	1900
6	2060	.80	4100	13100	.866	7000
7	139	.80	300	1500	.866	800
8	80	.80	200	100	.866	100
9	49	.80	100	100	.866	
10	43	.80			.866	
11		.80			.866	
12	18	.80			.866	100
13		.80	100	100	.866	
14	18	.80			.866	
15	18	.80			.866	
>15	37	.80			.866	
TOTAL(000)	19529		46,200	30,500		10,800
WEIGHT(tons)	30477		64,000	50,700		25,000

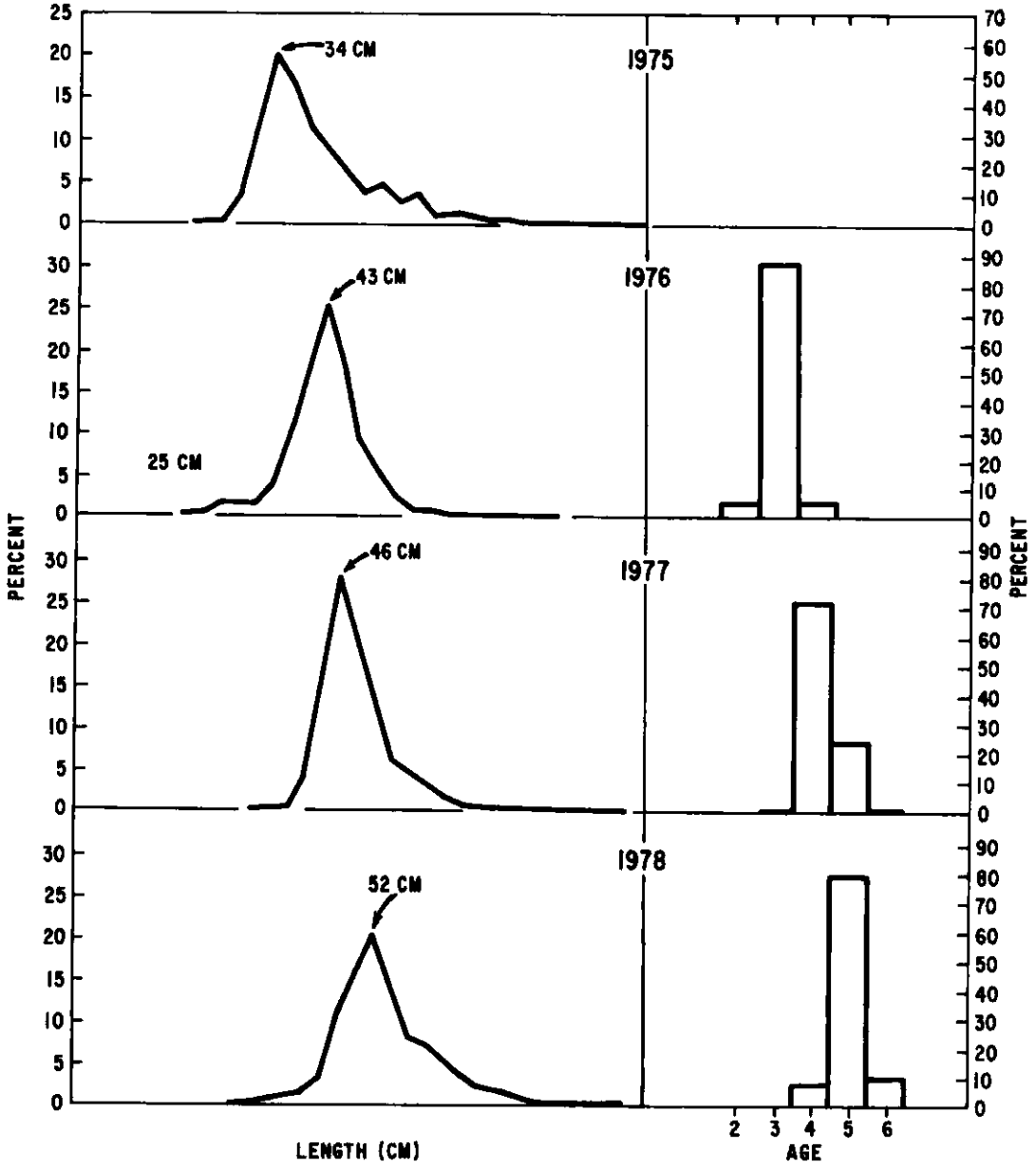

Fig. 1. Length and age distribution, Div. 3M cod fishery, 1975-78.

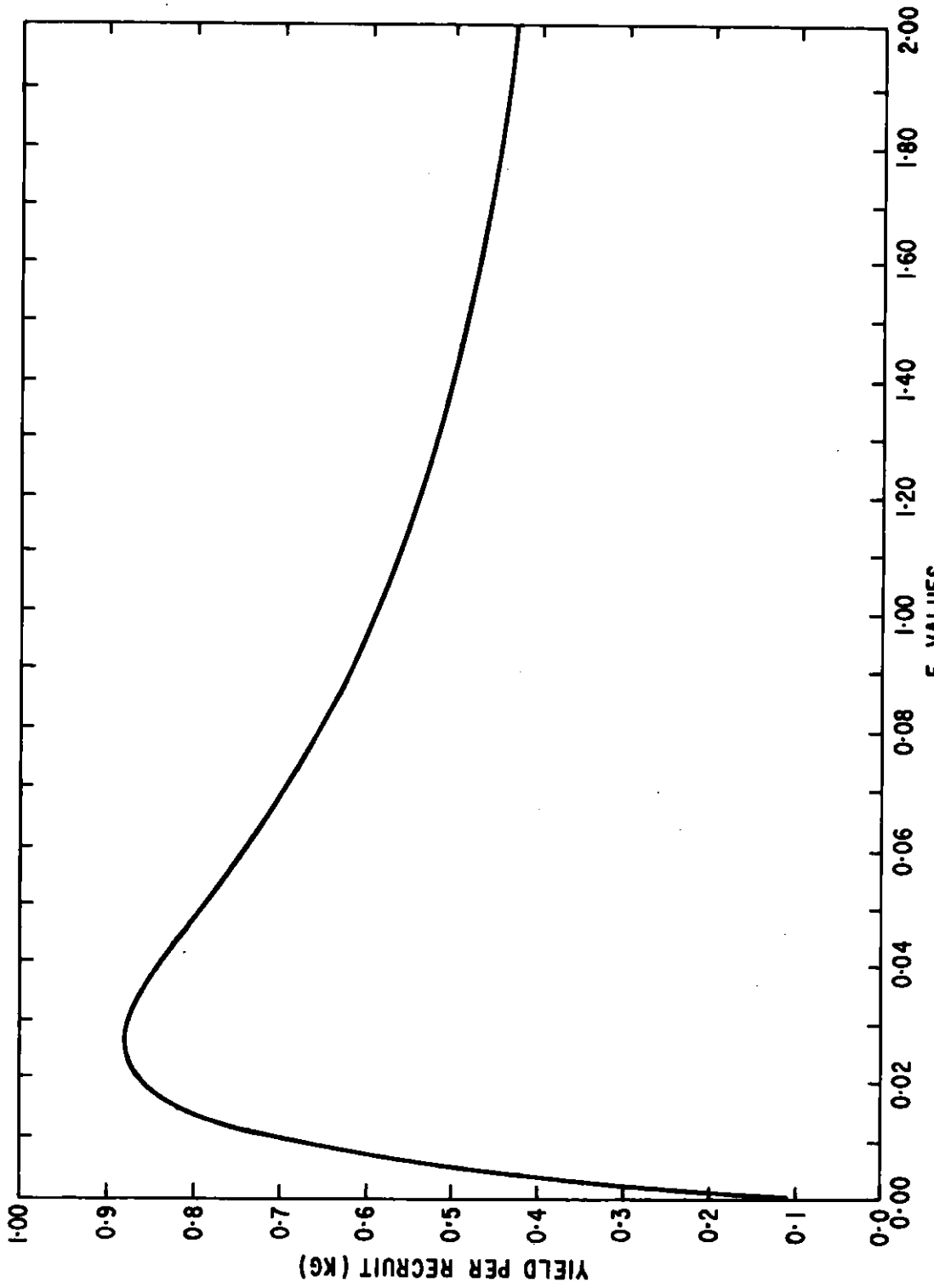

Fig. 2. Yield per recruit curve, Div. 3M cod.

APPENDIX

Status of the Cod Stock in Division 3M

As a result of calculations performed by the Assessment Subcommittee during the discussion of this stock, estimates for 1978 of F, partial recruitment, and stock size of the 1973 year-class and younger year-classes were revised.

Fishing mortality in 1978

An estimate of total mortality between 1977 and 1978 was derived from a comparison of the catch in numbers per hour fished of ages 5 and older in 1977 and the corresponding year-classes (ages 6 and older) in 1978 as follows:

	Catch Tons	Effort 000's Hours	Numbers Caught Per 1000 Hours Ages 5	Numbers Caught Per 1000 Hours Ages 6	e^{-Z}	Z
1977	25,273	38.50	151.97			
1978	30,477	56.44		43.62	.287	1.25

The effort estimates were taken from Gavaris (1979).

From the Soviet young fish surveys and from commercial and research sampling, it is clear that the strengths of year-classes of cod in this Div. vary considerably. An estimation of total mortality derived from the descending limb of the catch at age composition of a single year would therefore be subject to possible large bias. The relative year-class strengths of the 1968 year-class and year-classes 1971-75 were estimated by taking the geometric means of the numbers of each year-class as 1, 2 and 3 year-old fish caught per hour tow in the Soviet young fish survey.

The catch at age composition for 1978 was adjusted by dividing the appropriate geometric means for these year-classes into the per mille frequency (See Table 7). Natural logarithms of this adjusted age composition were then taken and the descending limb was composed as follows:

Year-Class	Age	In Abundance
1972	6	2.134
1971	7	-.944
1968	10	-2.996

These abundance figures could have been calculated simply by subtracting the geometric mean indices from the natural logarithms of the per mille age composition for 1978.

The regression of the relative abundance of the 72, 71 and 68 year-classes at ages 6, 7 and 10 in 1978 has a slope of 1.14, and the F, estimated at 0.94, applies to the 1970's period.

From a comparison of research vessel abundances estimates at age in 1978 and 1979, the F in 1978 for ages 5 and older was 1.72 (Res. Doc. 79/VI/63).

On the basis of the standardized effort in 1978 of 61,000 hours and a catchability coefficient of .0000186 from the general production model in Res. Doc. 79/VI/46, an F=1.14 was derived.

An average value of F=1.3 was used as the F on fully recruited age groups in the projection given below.

Stock sizes in 1978

An F of 1.17 was used as the fishing mortality applicable to the 1973 year-class at age 5 in 1978, and would imply a stock size of this year-class as 3 year-old fish in 1976 of 93.4 million, with F=0.41 in 1977 and 1976. Stock sizes of the 1974 and 1975 year-classes as 3 year-olds were derived from the geometric means given in Table 7 as follows:

Year-Class	Geometric Mean	Relative Abundance	Numbers in Stock at Age 3 (millions)
1973	391.51	1.000	93.418
1974	72.24	0.185	17.282
1975	11.36	0.029	2.709

The stock of the 1976 year-class was taken as 0.100 million fish at age 3 as catches of this year-class in the Soviet young fish as 1 and 2 year-old fish were very small. Since the catch of the 1977 year-class as 1 year-olds was 8 specimens as compared to a catch of 5 per hour specimens per hour towed of the 1975 year-class as 1 year-olds, the stock size of the 1977 year-class as 3 year-olds was estimated as 1 3/5 of the 1975 year-class, namely 4.300 million.

Partial recruitment in 1978

The fishing mortality acting upon the 1975 year-class in 1978, where the catch was .134 million and the stock size 2.7 million was 0.057. Since the F on the 1973 year-class was estimated from cohort analysis at 0.41 in 1977 and 1976 when this year-class was age 4 and 3, the F on the 1974 year-class as 3 year-olds in 1977 was assumed to be 0.41. This would lead to a reduction in the numbers of the 1974 year-class from 17.3 million in 1977 as 3 year-olds to 9.39 million in 1978 as 4 year-olds. The catch of 4 year-olds in 1978 was 1.724 million and therefore the F on this year-class was 0.225 in 1978.

From Table 4, the 5 year-olds in 1978 were 90% recruited for an F=0.90 X 1.3 =1.17. Ages 6 and older were considered fully recruited at F=1.3.

Projection of catches in 1980 at Fmax=0.27 under various assumptions of catch in 1979

In Table 8, the stock size at the beginning of 1979 is estimated to be less than 40,000 tons, the TAC set for 1979. It was assumed, therefore, that the TAC in 1979 would not be taken, and the effects on the catch in 1980 at catch levels of 10,000, 20,000 and 25,000 tons in 1979 are shown. The projected catches in 1980 with fishing at Fmax=0.27 are 7,000, 3,400 and 1,700 tons respectively. The corresponding projected spawning biomasses in 1980 are 31,000, 14,000, and 7,000 tons respectively.

Conclusions

1. Fishing mortality in 1978 was in the order of 1.3.
2. The stock size at the beginning of 1979 is estimated at about 32,000 tons.
3. Projected catches in 1980 with fishing at Fmax=0.27 are 7,000 tons or less.
4. The spawning biomass in 1980 is projected to be at a low level.

Acknowledgements

G.H. WInters calculated the F values based on the catches at age per standard hour in 1977 and 1978.

W.G. Doubleday adjusted the 1978 age composition to allow for variation in year-class size in the calculation of Z from the descending limb of that age composition.

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Gavaris, S. 1979. Update of the Flemish Cap cod stock assessment. ICNAF Res. Doc. 79/VI/46.

Wells, R. 1979. Observations on the distribution, abundance, growth, mortality and sex and maturity of cod from the Flemish Cap. ICNAF Res. Doc. 79/VI/63.

Table 7. The estimation of the relative abundance of the 1968 year-class and the 1971-75 year-classes in the catches in 1978 when the effects of variation in year-class size have been discounted.

	SOVIET SURVEYS CATCH PER HOURS TOW					1978 AGE COMPOSITION		
YEAR-CLASS	AGE ONE YEAR	AGE TWO YEARS	AGE THREE YEARS	GEOMETRIC MEAN INDEX	GEOMETRIC MEAN	%	ADJUSTED	ln
1968	10	106	58	3.68	39.65	2	.050	-2.996
1971	22	87	3	2.89	17.99	7	.389	-.944
1972	3	29	22	2.52	12.43	105	8.447	2.134
1973	303	350	568	5.97	391.51	791	2.020	.703
1974	133	50	57	4.28	72.24	77	1.066	.064
1975	5	17	17	2.43	11.36	6	.528	-.639

The geometric mean index = $\frac{\ln (\text{age } 1) + \ln (\text{age } 2) + \ln (\text{age } 3)}{3}$

Table 8. Projection of catch in 1980 at F_{max} = 0.27 for varying levels of catch in 1979. (Numbers in 000^3, wt. in tons.)

Age	Catch 1978	Stock 1978	F 1978	Stock 1979	Catch 1979 At F=1.23	Stock 1980	Catch 1980 At F MAX=0.27
3	134	2700	.057	100	4	4300	46
4	1724	9390	.225	2087	367	77	3
5	17,749	27,862	1.17	6139	3813	1377	270
6	2367	3516	1.3	7079	4655	1638	354
7	160	238	1.3	784	515	1667	360
8	92	137	1.3	53	34	184	39
9	56	83	1.3	30	20	12	2
10	49	73	1.3	18	12	7	1
11				16	10	4	
12	21	31	1.3			3	
13	21	31	1.3	6	4	1	
14				6	4	1	
15	21	31	1.3				
15	43	31	1.3	12	4	1	
Total	22,413	44,123		16,337	9448	9277	1078
Wt.	33,963	57,468		31,849	20,000	17,265	3403

Table 8. (Cont'd).

Age	F=0.451 Catch 1979	Stock 1980	F=0.27 Catch 1980	F=2.04 Catch 1979	Stock 1980	F=0.27 Catch 1980
3	1	4300	46	7	4300	46
4	142	80	3	566	74	3
5	1868	1580	310	4814	1200	235
6	2345	3349	721	5762	800	172
7	259	3692	795	638	752	162
8	17	408	88	43	83	17
9	9	27	5	24	5	1
10	5	15	3	14	3	
11	5	9	2	3	1	
12		8	1		1	
13	1			4		
14	1	3		4		
15		3				
15	3			9	1	
Total	4664	13,485	1979	11,903	7225	640
Wt.	10,000	33,914	6984	25,000	9469	1728