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Has the Catchability Coefficient (q) Really Changed in Div. 2J+3KL Cod Fishery ?

by

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INTRODUCTION

One of the controversial items of discussion at the June, 1982 meeting of STACFIS was whether the catchability coefficient (q) had changed significantly in the NAFO Divisions 2J3KL cod fishery, thus explaining the apparently anomalous data points for 1974-77 in the regression shown in Fig. 1. Data and arguments presented in this paper attempt to refute the claim that the catchability coefficient has changed and to present an alternate explanation for these anomalous points.

MATERIALS AND METHODS

Fig. 1 is plotted with total effort and total fishing mortality. However, in the present analyses the fishing mortalities applicable to the offshore fishery only were calculated from the following equation:

$$\frac{FO_{a,t}\,(1-e^{-(FO_{a,t}+\frac{M}{2})})}{FO_{a,t}+\frac{M}{2}} = \frac{CO_{a,t}}{N_{a,t}}$$

Where $FO_{a,t}$ = Instantaneous fishing mortality rate at age a in the offshore fishery in year t

M = Instantaneous natural mortality rate assumed to be constant for all ages and years and estimated to be about 0.2 (Pinhorn, 1975).

$CO_{a,t}$ = Catch in numbers at age a in the offshore fishery in year t (Wells, pres. comm.).

$N_{a,t}$ = Numbers of cod at age a in the population at the beginning of year t (i.e. beginning of offshore fishery) (Wells, 1981).

$\frac{M}{2}$ is used in the equation because it is assumed that the entire offshore fishery took place in the period January 1-June 30 of each year. The assumption is violated to the extent that during the 1970's an average of about 80% of the offshore catch was taken during the January-June period but this violation is not considered serious for the purposes of this analysis. These offshore fishing mortalities are shown in Table 1. The catchability coefficient for each year in the offshore fishery was then calculated by dividing the mean offshore fishing mortality, age 5+, weighted by the population numbers at each age, by the standardized offshore effort, derived by dividing the standardized catch rate for the offshore fishery into the catch by the offshore fleet (Table 1). In fact, catchability coefficients calculated in this manner are similar to those calculated from the F and effort in the total fishery.

RESULTS AND CONCLUSIONS

The plot of catchability coefficient in the offshore fishery (as calculated above-Table 1) over time is shown in Fig. 2. It is obvious that q as calculated from the effort standard increased dramatically in 1974-76 and as dramatically decreased in 1977. It is recognized that catchability coefficients in the 1977-80 period are a function of the F input (F_T) in the cohort model in 1980;

if F were as high as 0.25, the catchability coefficients for those years would remain at about 3.00 but the following argument and data presented at this meeting (Wells and Bishop, 1982) indicate that F_T was lower in 1980, more likely the range of 0.12.

Catchability coefficient can change abruptly with time because of a change in environmental factors causing more dense concentrations of fish but this should result in corresponding changes in catch rates; in this case a sudden increase in 1974-76 and a precipitous decline in 1977. As can be seen from Fig. 2 the standard catch rate showed a steady decline from 1968 to 1973 (except for a slight increase in 1974), after which it has steadily increased to about the 1970 level by 1980.

It has been demonstrated for some fisheries, mainly pelagic, that catchability coefficient can change inversely with population size (Ulltang, 1978); i.e. as population size gradually decreases from fishing pressure catchability coefficient gradually increases. Fig. 3 indicates that catchability coefficient remained relatively unchanged from 1961-73 at a level of about 1.35×10^{-6} while stock size changed from 2.3 billion fish, age 4+ to 1.0 billion fish, age 4+. Catchability coefficient then increased sharply to 2.2×10^{-6} in 1974, while population size only decreased to 0.73 billion fish, to 3.1×10^{-6} while population size decreased to 0.5 billion fish and to 4.0×10^{-6} while population size remained about 0.5 billion fish. Catchability coefficient then dropped sharply to close to the original level in 1977 while population size increased to only 0.65 billion fish. It remained at this level during 1978-80 while population size changed to about 1.0 billion fish. The change was so abrupt that it constitutes no evidence for a change in catchability coefficient related to a change in population size. Catchability coefficient can also change over time related to technological changes but this is normally gradual and sustained whereas the change here is sudden and lasts only three years, 1974-76.

Thus, from the above it is concluded that no real change occurred in the catchability coefficient in the 1961-80 for 2J3KL cod.

What then is the explanation for the anomalous points in Fig. 1? These can be caused by F being overestimated or fishing effort being underestimated. Given the catches during the 1974-76 period and given the F values that can be calculated from FRG survey results (average 0.8, age 5+) (Mestorff and Wells, pers. comm. at the 1979 ICNAF Meeting), it is very unlikely that F was lower than this in these years. Thus, the calculated fishing effort is likely to have underestimated the true effort. This may be because total catch is underestimated or the catch/unit effort is overestimated. Total catch would have to be underestimated by about one half (i.e. reported catch would have to be doubled) to account for the anomaly. This would result in F-values from the cohort which are extremely high and unlikely to be realistic. Thus, the standardized catch rate is likely to be overestimated. There is some evidence for this in the standardized catch rate series (Fig. 2) when the declining trend in catch rate is interrupted in 1974-76. This is also evident in the catch rate series by country for some countries (Gavaris. this meeting). The most likely conclusion is that the quota restrictions introduced in 1974 on all groundfish stocks resulted in unreliable catch and effort statistics used as a basis for Gavaris' model, resulting in the anomalous points in Fig. 1. It is interesting to note that the points for 1977-80 are much closer to the regression, these being the years during which Canada as a coastal state not only controlled catches taken from the stock but also the number of fishing days allocated.

In conclusion, therefore, the author sees no convincing evidence for a change in catchability coefficient in this stock and attributes the anomalous points in the F versus effort regression for 1974-77 to bias in the catch-effort series for these years. Therefore, the catch-effort data for these years should not be used in the assessment of the stock and regressions of F versus effort used to estimate current fishing mortalities should not include the values for these years. In fact, regressions of F on effort, ommiting the values for 1974-76, have been used in NAFO for the past few assessments of this stock.

REFERENCES

Gavaris, S. 1981. Surplus production Analyses for the cod stock in NAFO Divisions 2J+3KL. NAFO SCR Doc. 81/VI/65. 4 p.

Ulltang, O. 1978. Factors affecting the reaction of pelagic fish stocks to exploitation and requiring a new approach to assessment and management. In - The Assessment and Management of Pelagic Fish Stocks. ICES Rapports et Proces-Verbaux Des Reunions. Vol. 177. p. 489-504. 1980.

Wells, R. 1981. Status in 1980 of the cod stocks in Divisions 2J3KL. NAFO SCR Doc. 81/VI/66, 13 p.

Table 1. Offshore fishing mortality (FO) estimates at each age for 2J3KL cod, 1961-80, together with average fishing mortality for age 5 and older weighted by population numbers at age ($\overline{FO}$ (age 5+)), offshore standardized effort, catchability coefficient (q), standardized catch per hour and age 4+ population numbers.

Age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
4	0.027	0.037	0.038	0.034	0.029	0.069	0.079	0.122	0.049	0.089
5	0.065	0.070	0.118	0.102	0.099	0.171	0.163	0.315	0.185	0.169
6	0.175	0.152	0.210	0.196	0.206	0.222	0.295	0.426	0.497	0.349
7	0.261	0.240	0.214	0.353	0.391	0.331	0.363	0.504	0.683	0.595
8	0.289	0.261	0.217	0.361	0.493	0.369	0.401	0.518	0.751	0.435
9	0.326	0.270	0.207	0.278	0.513	0.369	0.400	0.524	0.561	0.368
10	0.364	0.280	0.238	0.303	0.413	0.244	0.526	0.345	0.651	0.187
11	0.252	0.222	0.196	0.342	0.324	0.208	0.293	0.437	0.523	0.178
12	0.338	0.287	0.127	0.243	0.258	0.141	0.303	0.306	(1.014)	0.170
13	0.457	0.200	0.192	0.250	0.261	0.194	0.266	0.333	0.548	0.261
$\overline{FO}$ (Age 5+)	0.191	0.153	0.184	0.230	0.266	0.236	0.263	0.392	0.434	0.316
Offshore effort ('000 hours)	148	136	128	176	196	167	200	276	299	229
$\bar{q}$ (X 10^6)	1.29	1.13	1.44	1.31	1.36	1.41	1.32	1.42	1.45	1.38
Standardized catch per hour	2.55	2.67	2.78	2.69	2.28	2.47	2.54	2.56	2.18	1.92
Population numbers (X 10^{-5})	21,850	21,579	20,511	18,801	19,064	20,711	22,956	21,723	18,168	15,879

Age	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
4	0.116	0.153	0.186	0.064	0.053	0.215	0.104	0.037	0.014	0.008
5	0.247	0.303	0.326	0.257	0.254	0.298	0.196	0.073	0.056	0.050
6	0.387	0.369	0.284	0.541	0.534	0.521	0.174	0.140	0.093	0.075
7	0.423	0.444	0.333	0.568	0.685	0.671	0.158	0.154	0.091	0.061
8	0.388	0.452	0.453	0.739	0.881	0.689	0.239	0.148	0.068	0.044
9	0.336	0.364	0.450	0.735	0.761	0.956	0.286	0.126	0.073	0.038
10	0.270	0.354	0.474	0.864	0.864	0.811	0.431	0.129	0.096	0.107
11	0.198	0.337	0.408	0.972	0.554	0.652	0.279	0.098	0.069	0.126
12	0.215	0.252	0.506	0.775	0.680	0.307	0.178	0.071	0.050	0.045
13	0.548	(0.033)	(0.064)	(0.004)	0.633	0.483	0.178	0.056	0.060	0.029
$\overline{FO}$ (Age 5+)	0.332	0.357	0.337	0.536	0.582	0.511	0.198	0.095	0.071	0.060
Offshore effort ('000 hours)	230	270	248	240	188	127	131	84	62	43
$\bar{q}$ (X 10^6)	1.44	1.32	1.36	2.24	3.10	4.02	1.51	1.13	1.15	1.40
Standardized catch per hour	1.61	1.47	1.26	1.41	1.31	1.21	0.77	0.69	1.31	1.79
Population numbers (X 10^{-5})	15,721	14,416	10,410	7,190	4,883	5,064	6,554	8,749	10,530	10,242

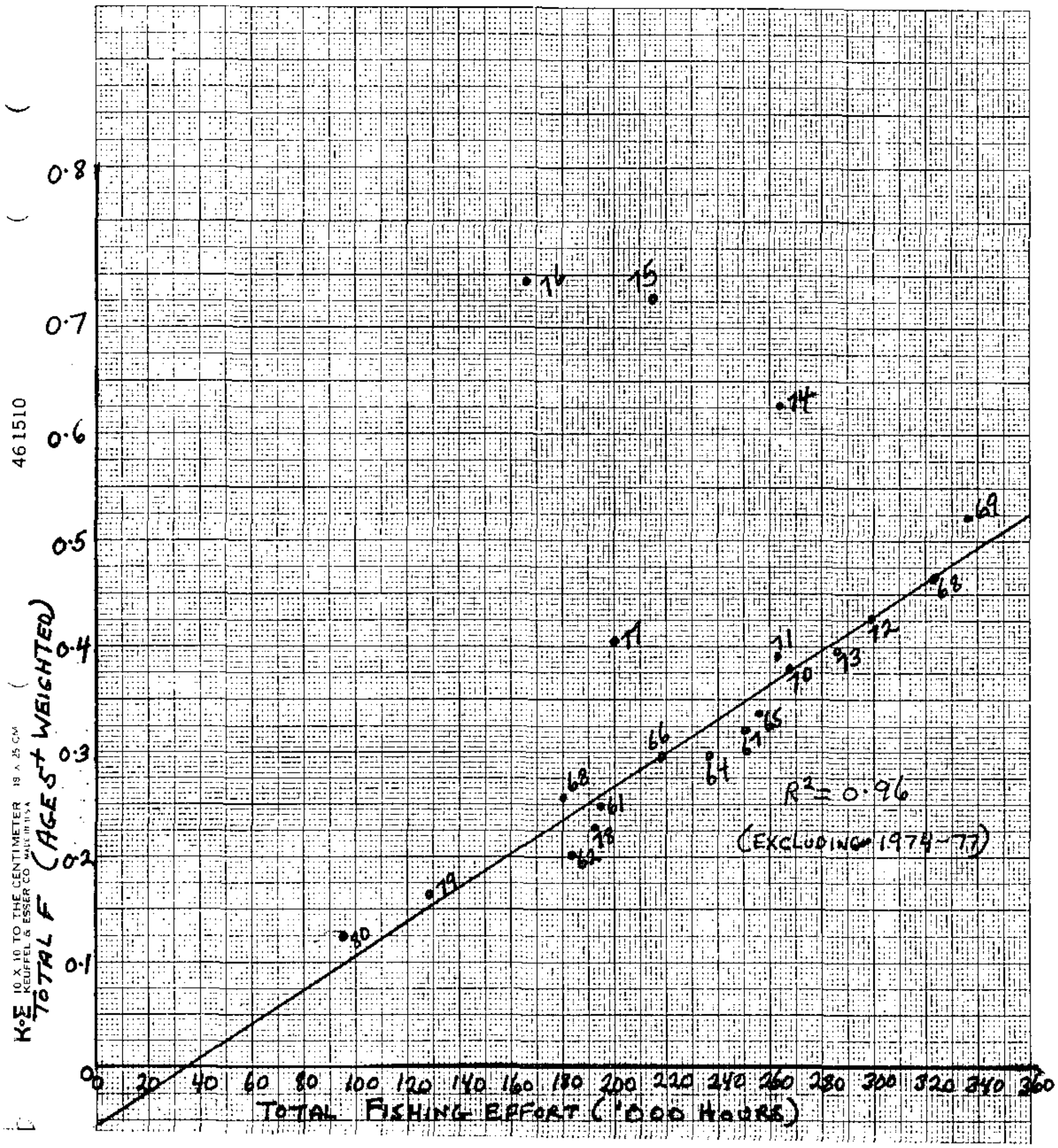

Fig. 1. Regression of fishing mortality and fishing effort in the total fishery for cod in Divisions 2J3KL. (Values for 1974-77 were not used in the regression.)

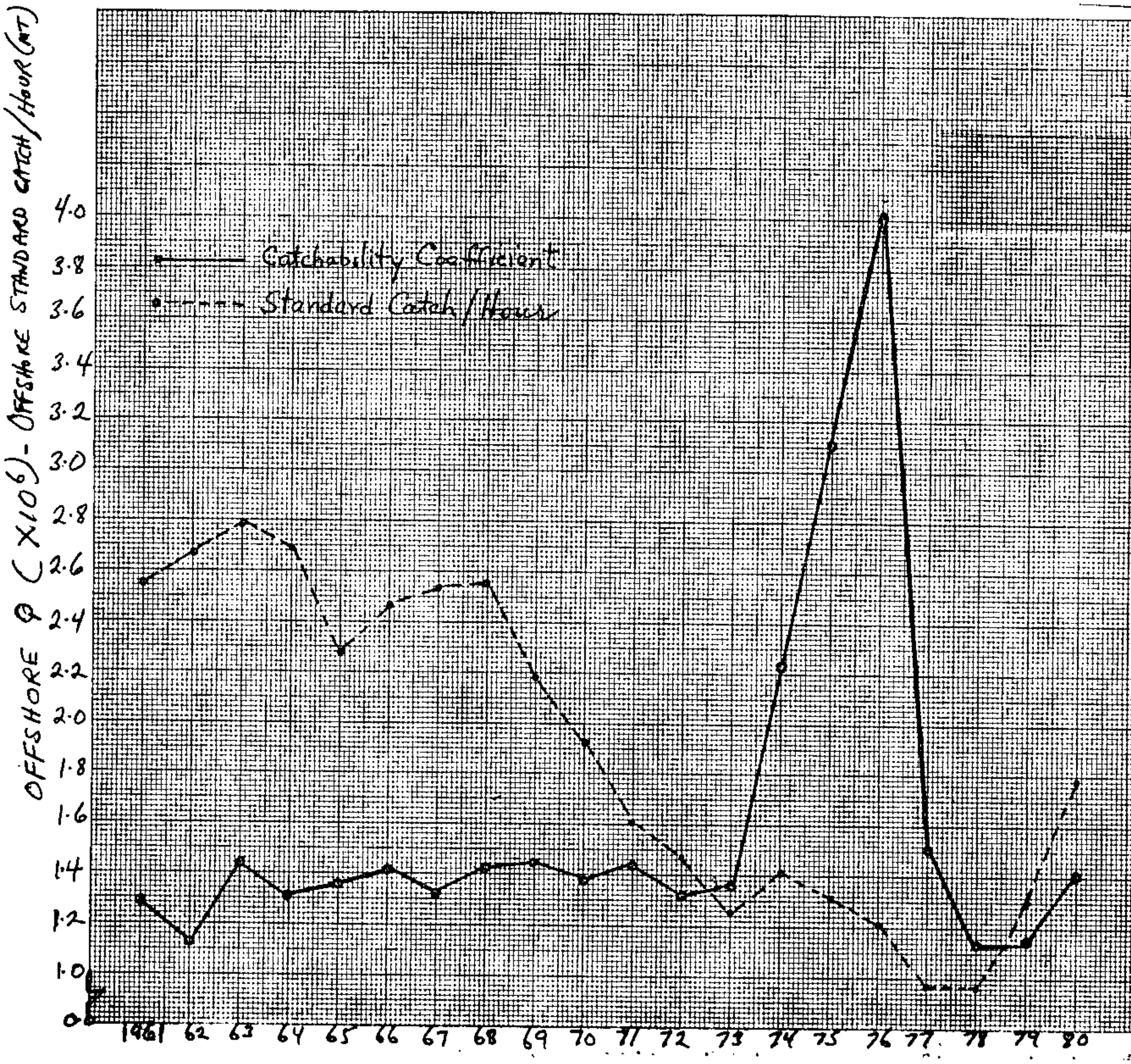

Fig. 2. Catchability coefficient (q) and standardized catch per hour in the offshore cod fishery in NAFO Divisions 2J3KL.

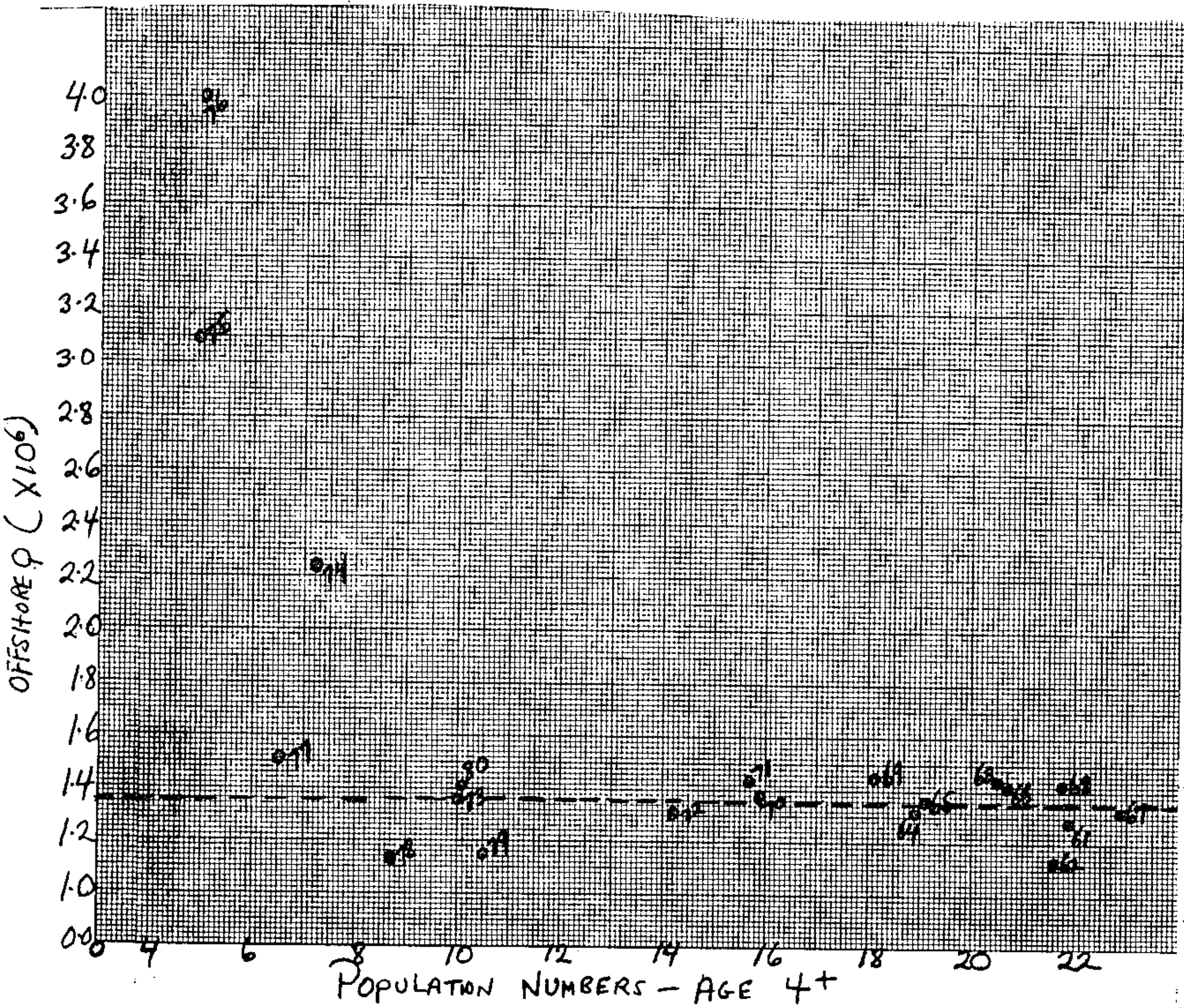

Fig. 3. Offshore catchability coefficient (q) versus age 4+ population numbers for 2J3KL cod, 1961-80. Dashed line is average q for 1961-73; 1977-80 with 1974-76 omitted.