Scallop Fishing Grounds on the Scotian Shelf

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ABSTRACT

Lately, the exploitation of fishing grounds on the Scotian Shelf has been an alternative to the more traditional scallop beds of Georges Bank for the deep-sea fleet and to the Digby grounds for the Bay of Fundy fleet. The production of some areas of the Lurcher Shoals have approached levels usually found on Georges Bank. Catch, effort, and catch-rate values for the different fishing areas have reached their maximum and the most recent data indicate a downhill trend. Stock survey indices show mixed age-classes on the Scotian Shelf, but in a diversity of areas. Recruitment is sporadic. Yield per recruit could be slightly improved for most areas. Inadequacies exist in the management of the exploitation strategies of the two fleets.

RÉSUMÉ

Récemment, l'exploitation de bancs de pêche sur le plateau néo-écossais a pris de l'importance par rapport aux régions exploitées traditionnellement sur le banc Georges pour la flottille hauturière et près de Digby pour la flottille de la Baie de Fundy. La production de certains endroits de Lurcher Shoals se rapproche de niveaux normalement associés au banc Georges. Les prises, l'effort et les taux de capture pour les différentes régions de pêche ont atteint leur maximum et les données les plus récentes révèlent un déclin. Les indices d'inventaires de stock montrent des classes d'âge variées sur le plateau néo-écossais, mais dans une diversité d'endroits. Le recrutement est sporadique. Le rendement par recrue pourrait être légèrement amélioré pour la plupart des bancs de pêche. La gestion de pêche pour les deux flottilles en cause souffre d'inégalités.

INTRODUCTION

During the early 1950's extensive explorations for commercially producing scallop grounds were conducted on the Scotian Shelf and St. Pierre Bank (Bourne, 1964). Deep-sea scallops were found on Middle Grounds, near Sable Island, on Western Bank, and on Browns Bank. Misaine and LaHave Banks were devoid of scallops and no fishing has taken place there to this day. Lately, the exploitation of fishing grounds on the Scotian Shelf has been an alternative to the more important scallop beds on Georges Bank. Landings from the Scotian Shelf and St. Pierre Bank have become increasingly significant as the Georges Bank scallop production was steadily declining (Fig. 1). Scallop beds to the southwest of Nova Scotia on Browns Bank contributed significantly to offshore landings in 1976. Since 1980 they have been revisited along with Middle Grounds and the Sable Island area on the Scotian Shelf and St. Pierre Bank further east. There is a strong seasonal trend to the exploitation pattern of these grounds.

Stock surveys were initiated in 1979 on Browns and German Banks as reported by Jamieson et al. (1981).

This document presents the recent (1979 onward) profile of the scallop fishery on the Scotian Shelf including stock surveys which took place in 1983 and 1984. The Scotian Shelf described here includes from east to west, (Fig. 2) Banquereau, Middle Grounds (Bank), Sable Island Bank, Western Bank, Browns Bank (south side) (north side: Tusket), German Bank, Lurcher Shoals and outer reaches of the Bay of Fundy, and Southwest Bank to the southwest of Grand Manan Island. Very little biological data on growth, meat yield, reproduction periods, etc. and specific distribution of scallop beds were available prior to recent times. Data used here are still less precise than desirable but, are considered adequate for the present purposes.

METHODS

Fishery Information

There are two sources of information to estimate the respective contributions of scallop fishing grounds on the Scotian Shelf. The Statistics Division, Department of Fisheries and Oceans, Halifax, compiles, on a yearly basis, landings by vessel size and by NAFO Sub-subareas. Log information as to the origin of the catch provided by vessels is the other source. There are at times discrepancies between statistical and logged catches as NAFO Sub-subareas are not tailored to the physical location of particular scallop beds and may cut a major scallop bed in two. This problem was previously presented by Robert et al. (1984).

All vessels (over 25.5 G.T.) fishing the Scotian Shelf are required to keep logbooks in which daily fishing activities are recorded. Daily log records supply information on the catch and its location and fishing effort such as hours spent fishing, width of the gear, and number of crew. Catch-rate estimates may be computed when complete effort data are provided with respect to the catch (Class 1 data). Total effort may be estimated according to the effort that generated the catch for which all information (location, hours fished, gear, etc.) is available. The productivity of a

specific ground may also be established assuming that the catch with known location is representative of the total catch from the ground.

Scallop Fleets

Two components of the Canadian offshore fleet may drag for scallops on the Scotian Shelf. The deep-sea fleet, L.O.A. over 19.8 m. is excluded from a 12 nautical miles zone near-shore and the Bay of Fundy. The Bay of Fundy fleet, L.O.A. between 14 and 19.8 m mostly (Bay of Fundy-licensed vessels), may fish scallop beds in the Bay of Fundy and other areas of NAFO Subarea 4X.

Despite the different size of vessels, both fleets used an offshore-type scallop drag which width may vary from 2.4 to 4.9 m (8-16 feet). The Bay of Fundy fleet fishes only one drag at a time while the deep-sea fleet fishes two drags simultaneously, one on each side; these are slightly wider than the ones used by the Bay of Fundy fleet.

Catch Sampling

Catch sampling information is available for the deep-sea fleet only. Port coverage varies greatly so that fishing areas like German/Lurcher off southwest Nova Scotia have not been given good coverage. Yarmouth and Saulnierville-based vessels are the main users of those grounds. Since the exploitation of scallop grounds on the Scotian Shelf is somewhat irregular and does not necessarily take place year after year, sampling of the catch is sporadic.

Survey Procedures on the Scotian Shelf

The catch distribution derived from log records for each particular fishing ground is used to randomly stratify survey stations. Catches from the deep-sea fleet over the year prior to the survey are considered; in the Brier Island area, catches from the Bay of Fundy fleet are also included. Annual surveys are carried out during May (Scotian Shelf) or Sept.-Oct. (Brier Island) on a Government research vessel.

A 2.44 m wide New Bedford offshore dredge (75-mm ring size) lined with 38-mm stretch mesh polypropylene netting was the survey gear on Middle Grounds, Sable Island and Western Banks, and Browns Bank. Due to extremely rough bottoms, the lining was removed for fishing German/Lurcher. During the course of the fall Grand Manan survey, Brier Island scallop beds were studied using a four-gang Digby drags (3.06 m wide) with 75-mm rings, of which two buckets were lined as above.

Tows were of ten minutes duration; distance towed was determined either from Loran C bearings, start-end of tow, or from continuous recording via a desk-top computer. Catches were later standardised to a tow length of 800 m. For each tow, the following data were recorded: 1) shell heights in 5-mm intervals for all live scallops and cluckers; 2) tow location with Loran C bearings; 3) depth (m); 4) compass bearing for direction of tow; 5) duration of tow in minutes; 6) substrate type; 7) count of the number of vertical rings covered by the catch; and 8) total scallop catch as a round weight.

Biological Information Supporting the Fishery Analysis

Only essential information such as growth-rate and meat yield for a given shell height are discussed here. For most fishing areas, the number of samples examined is limited. Data presented here are an integral part of a study in progress; they are used here for lack of better results presently available. Table 1 presents variables of von Bertalanffy growth curves and the number of scallop shells that have been ring-read for each area. It also gives the parameters for estimating meat yield as a function of shell height and the number of animals examined. In an attempt to reduce seasonal effects in yield conditions, samples collected at all times of the year have been included in the analysis to approximate a 'year round' value.

Figure 3 shows shell height at age for different areas derived from von Bertalanffy growth curves. Of the areas looked at, Middle Grounds and the Sable Island area have the fastest growth-rates while Browns Bank has the slowest. Even though German Bank and Lurcher Shoals are geographically adjacent to each other, the growth-rate of scallop beds above latitude 43°50'N, i.e. Lurcher Shoals and the outer reaches of the Bay of Fundy is significantly ($P < 0.01$ level) better than on German Bank, below latitude 43°50'N.

RESULTS

Scallop Fleets

Over 110 vessels exploit the Scotian Shelf scallop fishing grounds, on an annual basis (Table 2); this contingent varies slightly from year to year.

As shown in Figure 1 for the deep-sea fleet the exploitation of the Scotian Shelf is not a feature as permanent as the exploitation of Georges Bank. The Bay of Fundy fleet has also supplemented catches from the traditional grounds off Digby by fishing near Brier Island, at the mouth of the Bay of Fundy, German/Lurcher, and Browns Bank when weather conditions are the most favorable. A license stipulation does not allow the Bay of Fundy fleet in NAFO SA 4W, Middle Grounds, Sable Island and Western Banks.

Vessels from the deep-sea fleet based in Saulnierville and Yarmouth usually expend most fishing effort on German/Lurcher during spring and fall of the year. Lunenburg and Riverport-based vessels tend to sail east to St. Pierre Bank, fishing in NAFO SA 4W on the way, mostly in the fall at the time when the effects of a low fishable biomass on Georges Bank are accentuated.

Regulations

Besides stipulations associated with categories of scallop fishing licenses, there are regulations governing scallop fishing on the Scotian Shelf. At times, it is a contentious issue as the two fleets are not operating under the same set of rules. All rules applying to the fishing of Georges Bank (meat count, trip duration, trip limit, trip quota, etc.) apply

as is to the deep-sea fleet fishing the Scotian Shelf. However, a Bay of Fundy-licensed vessel fishing the same waters does not have to abide by any of those measures.

To give methodical coverage to all fishing areas (Fig. 2) (from east to west), each area will be looked at with respect to: a fishery profile, an estimate of its productivity in terms of distribution of scallop beds and production, catch sampling, a yield per recruit analysis, and survey results.

Middle Grounds

Middle Grounds is the shallowest fishing area of the Scotian Shelf with an average depth of 45 m. It is located in NAFO SA 4W north of latitude 44°N and west of longitude 60°W. According to logged fishing locations, commercial densities of scallops would occur in an area of 500 nautical miles^2. Its fishery characteristics are found in Table 3. With a sporadic production, maximum of 105 t in 1983, it does not appear that good catch-rates may be maintained. Figures 4, 5, and 6 illustrate the gradual intensification of exploited grounds from 1980 to 1983, catches coming from a greater number of ten-minute squares (TMS), and catches increasing from a particular TMS. As Table 4 indicates, the catch was sampled somewhat adequately in 1983-1984; the average scallop meat weight was 20.82 g in 1983 and 13.96 g in 1984 representing fairly large (110-115 mm) mature scallops. However, a yield per recruit analysis (Thompson and Bell) (Fig. 7) suggests that for fishing mortalities greater than 0.6 yields could be slightly improved from this exploitation pattern.

Tables 5, 6, and 7 report stock survey findings. A relatively slight pulse of age five scallops observed in 1983 (Table 6) was rapidly depleted as 1984 results indicate. Even though the gear was lined, there was no sign of prerecruits presence.

Sable Island - Western Bank

Commercial quantities of scallops were lately fished in a small area (60 nautical miles^2) of Western Bank and at the edge of the continental shelf, southwest of Sable Island, along a distance of 80 nautical miles. Higher catches (Table 3) than for Middle Grounds were reported here, but catch-rates were always lower (0.2 kg/crhm). Extension of areas exploited in SA 4W since 1980 (Figs 4-6) is pronounced here. A relatively good portion of the catch was examined (Table 4); the average meat weight was 11.4 g (approximate shell height: 105 mm). At most fishing mortalities, yield may be increased by an additional 25% (Figure 8). Repetitive bad weather prevented the 1983 survey from taking place. 1984 results (Tables 5-7) indicate relatively good representation of all age-classes, both recruits and prerecruits.

Browns Bank - Tusket

Scallop aggregations are commercially important along the southern edge of Browns Bank (NAFO Sub-subarea 4XP) around the 100-m isobath and on the northern side of Browns Bank (Tusket, NAFO Sub-subarea 4XO) but in much deeper waters.

These scallop beds are exploited by both fleets, the deep-sea fleet landing more than the Bay of Fundy fleet (Table 8). These grounds are travelled over on the way to Georges Bank for vessels based on the south shore of Nova Scotia. Trips may be directed solely to those grounds or some tows are performed on the way out and/or in from Georges Bank. Despite discrepancies between statistical landings and logged catches, the scallop production from the Browns Bank area has erratically decreased after 1979-1980. This is also observed in the performance of catch-rates for both fleets (Table 8). Figures 9-13 map the productivity of the Browns Bank area on a TMS basis. Except for 1981 when a meat count relaxation on Georges Bank (where high catch-rates could be obtained) precluded the exploitation of Scotian Shelf grounds to any great extent; it can be seen that production is gradually declining as noticed by the number of TMS with up to 100 t per year. The meat weight distribution in the catch (Table 9) varies greatly on an annual basis but the percentage of catch examined/landed is too small to generate useable data. According to available data yield (optimum) is very low (Fig. 14), slightly over 5 g for a shell height of 100 mm. These are the lowest yield per recruit values encountered throughout the Scotian Shelf.

Survey characteristics are given in Tables 10-12. Except for the strong show of age two scallops in 1983 (they are not caught very effectively by the survey gear), there does not appear to be other age-classes present in any quantities. This pulse was not necessarily followed through in 1984 when a new year-class shows up but not as strong. However, survey station locations are not replicated year after year; concentrations of juvenile scallops but few in numbers and/or small in terms of patch diameter may be missed.

German Bank - Lurcher Shoals and Outer Reaches of the Bay of Fundy

These three fishing areas are lumped together for convenience; it is far from ideal. NAFO Sub-subarea 4XQ includes German Bank and the lower half of the Lurcher Shoals (up to latitude 44°N) but the upper half of the Lurcher Shoals is part of Sub-subarea 4XR which makes for a somewhat distorted picture. Statistical landings and logged catches for both fleets (Tables 13 and 14) outline the problem by their divergence. However, it appears that biological differences exist between these different scallop beds to the extent that German Bank is looked at, in the biological sense, separately from Lurcher Shoals and the outer reaches of the Bay of Fundy which seem to have more in common than geographical contiguity.

Despite their inadequacies in representing catches accurately, general trends of declining fishable stocks show in Tables 13 and 14. Catch-rates have also steadily decreased to low values (0.2 kg/crhm) for both fleets. Some TMS on Lurcher have been, during a few years, as productive as the same size area on Georges Bank (Figs. 9-13). The area exploited seems to have reached its full potential in terms of physical grounds explored. Sampling of the catch may not represent true values as it has been insufficient four years out of six. It appears that the size of meats shucked would usually range from 11 g to 16 g (shell height over 95 mm for Lurcher; over 100 mm for German) (Table 15). At that size yield could be slightly improved from German Bank (Fig. 15) but significantly improved (Fig.16) from the Lurcher Shoals.

This area, while offering a wide range of fishable depths, is very rocky, boulder-type, and extremely hard on the gear. The research gear was not lined during these surveys, hence does not provide a reliable indicator for prerecruits. Tables 16-19 tabulate relevant information for fall surveys 1982-1983 in the Brier Island area and spring surveys 1983-1984 on German/Lurcher. 'Old' scallops are found on German/Lurcher where age-classes seven and eight are most important (Table 17). A fair number of even older scallops (age 10+) characterises the Brier Island area (Table 18); in some instances, meats are stringy and of poor quality in these large scallops. There is a noticeable reduction in extra large scallops (age 11+) between areas and between years (Table 19).

Banquereau Bank

At the extreme east of the Scotian Shelf, east of longitude 60°W, there are a few patches of scallops (Figs. 4-6) that the deep-sea fleet has sporadically visited. Annual catches have not amounted to more than 3 t.

Southwest Bank

Southwest Bank and deeper waters of NAFO Sub-subarea 5YB have been visited lately by some vessels of the deep-sea fleet and inshore vessels from nearby Grand Manan Island. Catches from the larger vessels have been small (15-20 t) and catch-rates moderate (0.4 kg/crhm). However, fishing by smaller vessels in this area has been important, over 100 t in 1983; little fishery information is available as this size vessel rarely provides fish logs. It is discussed summarily by Robert et al. (1985).

DISCUSSION

Status and Outlooks

For the 110 vessels or so fishing Scotian Shelf scallop grounds when the production from their traditional fishing areas declines or when an opportunity arises, the past five years especially in NAFO SA 4X, have had an important contribution to both fleets' landings. The production of some TMS on Lurcher have approached levels usually found on the reliably productive Georges Bank. Unfortunately, catch, effort, and catch-rate values for the different fishing areas have reached their maximum; and data from the most recent years indicate a downhill trend.

Historically, the deep-sea fleet as well as the Bay of Fundy fleet have been most resourceful in exploring for new scallop beds and exploiting areas with commercial densities. It is doubtful that scientific-type surveys in what is perceived as scallop habitat on the Scotian Shelf would discover worthwhile quantities.

According to stock survey indices, mixed age-classes are found on the Scotian Shelf, but in a diversity of areas. Recruitment is sporadic. Large old scallops predominate on German/Lurcher. The Browns Bank area has revealed a tremendous number of prerecruits; but with a characteristically slow growth-rate, these year-classes will not likely be fished for a number of years. Middle Grounds, because of its limited physical dimensions,

appears to have been fished out; prerecruits were not observed. The Sable Island area has been surveyed only once; however, the average number of scallops per tow is comparable to the one established for German/Lurcher. Moreover, there is a good representation by all age-classes with a possible slight recruiting pulse of age two.

Yield Improvement

According to the biological data available at present and the somewhat limited catch-at-age distribution data, yield per recruit could be slightly improved for most areas, up to a maximum of 25%. Scotian Shelf scallop grounds have diversified yield patterns and it would be a serious disadvantage to, say, use one set of values for the whole Shelf. While Middle Grounds' yield pattern is similar to the one found for the traditional Digby grounds in the Bay of Fundy (Robert et al. 1984), Browns Bank is characterised by a yield per recruit value almost half the value found for the other Shelf areas.

In any event, the optimal range of yield per recruit values encountered on the Shelf is by no means similar to the yield per recruit profile for Georges Bank. But, for the deep-sea fleet at least, the meat count used as a management tool is identical. In the pursuit of an optimal meat count for Georges Bank (which would be lower than the same for areas on the Shelf) the exploitation of Shelf areas could be jeopardised by a 'uniform measure' throughout (as is presently the case). During this time, the Bay of Fundy fleet may fish side by side with the deep-sea fleet and subjects the scallop resource to underutilisation and overexploitation as no meat count nor other effort restrictive measures apply.

REFERENCES

Bourne, N. 1964. Scallops and the offshore fishery of the Maritimes. Fish. Res. Board Can. Bull. 145: 61 p.

Jamieson, G.S., G. Kerr, and M.J. Lundy. 1981. Assessment of scallop stocks on Browns and German Banks - 1979. Can. Tech. Rep. Fish. Aquat. Sci. 1014: 17 p.

Robert, G., M.J. Lundy, and M.A.E. Butler-Connolly. 1984. Recent events in the scallop fishery of the Bay of Fundy and its approaches. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 84/71: 41 p.

Robert, G. and M.J. Lundy. 1985. The scallop fishery of the Grand Manan area, 1984. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 85/29.

Table 1.- Biological data on growth-rate and meat yield for scallop fishing grounds on the Scotian Shelf. N = number of scallops examined.

	Growth	Yield
Middle Grounds	N = 177 L_{inf} = 160.279mm t_0 = 1.276 k = 0.185	N = 169 intercept= -10.450 slope = 2.840
Sable, Western Bank	N = 189 L_{inf} = 155.95mm t_0 = 1.346 k = 0.200	N = 507 intercept= -10.632 slope = 2.800
Browns Bank	N = 280 L_{inf} = 113.45mm t_0 = 1.312 k = 0.268	N = 360 intercept= -16.655 slope = 4.093
German Bank	N = 270 L_{inf} = 130.58mm t_0 = 1.387 k = 0.234	N = 420 intercept= -13.395 slope = 3.404
Lurcher Shoals	N = 267 L_{inf} = 156.041mm t_0 = 1.281 k = 0.185	N = 327 intercept= -8.688 slope = 2.416

Table 2.- Number of vessels by fleet involved in fishing scallop grounds on the Scotian Shelf as per log information.

Fleet	1979	1980	1981	1982	1983	1984
Bay of Fundy	38	37	44	45	27	29
Deep-sea	75	75	76	75	73	50
Total	113	112	120	120	100	79

Table 3.- Fishery characteristics for the Middle Grounds area (NAFO 4WE) for the deep-sea fleet. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries & Oceans, Halifax. Effort pertaining to Class 1 catch only.

Year	Landings	Logged catches	Class 1 catch	Effort(crhm)	CPUE(kg/crhm)
1979	-	-	-	-	-
1980	3.65	0.96	0.96	3,233	0.298
1981	-	-	-	-	-
1982	72.39	60.20	59.24	115,613	0.512
1983	105.16	104.92	100.59	309,055	0.325
1984	11.90	9.94	8.34	47,585	0.175

Fishery characteristics for Sable Island and Western Bank (NAFO 4WJ)

1979	-	-	-	-	-
1980	60.99	31.16	31.16	142,655	0.218
1981	0.56	0.00	0.00	0	-
1982	64.10	59.69	59.69	237,538	0.251
1983	185.15	165.88	163.86	882,760	0.186
1984	71.30	63.11	62.04	362,924	0.171

Table 4.- Nature of the catch from NAFO SA 4W determined by the analysis of scallop meat weights.

	% catch examined / catch landed	meat weight (g)			
		mean	min	max	s.d.
Middle Grounds					
1983	0.0234	20.82	3.04	69.99	0.12
1984	0.0486	13.96	3.38	58.00	0.13
Sable Island/Western Bank					
1979	-	-	-	-	-
1980	0.0132	9.40	2.21	34.21	0.05
1981	-	-	-	-	-
1982	-	-	-	-	-
1983	0.0313	13.81	2.25	72.43	0.04
1984	0.0153	11.09	2.65	42.48	0.07

Table 5.- Number of survey stations in NAFO SA 4W by year and by stratum types.

Middle Grounds		1983		1984	
low catch	<5%	4	<7%	8	
medium	5-15%	4		-	
high	>15%	12	≥7%	12	
		20	stations	20	stations

Sable Island, Western Bank	1983		1984	
low catch	N/A	<4%	14	
medium	N/A	4-8%	13	
high	N/A	>8%	13	
			40	stations

Table 6.- Average number of scallop at age caught in a lined 2.44m New Bedford offshore dredge, Middle Grounds, Sable Island-Western Bank area.

Middle Grounds	Age (years)										Mean	s.d.
	1	2	3	4	5	6	7	8	9	10+		
1983 stock survey												
low	0	0	0	0	1	0	0	0	0	0	2	2
medium	0	0	0	2	13	8	1	0	0	2	26	15
high	0	0	0	3	31	9	0	0	0	1	55	67
1984 stock survey												
low	0	0	0	0	2	1	2	1	0	0	8	10
high	0	0	0	0	2	6	4	2	1	2	17	16
Sable Island area												
1984 stock survey												
low	0	4	2	4	5	3	3	1	1	5	28	39
medium	1	22	6	3	8	6	4	1	1	4	60	63
high	0	5	5	6	10	9	3	3	2	3	46	39

Table 7.- Summary of average number of scallops at age caught for prerecruits, shell height under 75mm or age less than 5 years, and recruits, shell height over 75mm by catch stratum.

	Age(years)		
	1-4	5-10	11+
Middle Grounds 1983			
low	0	1	0
medium	2	23	1
high	3	40	1
Middle Grounds 1984			
low	0	6	0
high	0	16	1
Sable Island/Western Bank 1984			
low	10	14	4
medium	32	21	3
high	16	28	2

Table 8.- Fishery characteristics for the Browns Bank-Tusket area (NAFO 4XP and 4XO) for the two fleets. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries & Oceans, Halifax. Effort pertaining to Class 1 catch only.

Bay of Fundy Fleet Year	Landings	Logged catches	Class 1 catch	Effort(hm)	CPUE(kg/hm)
1979	213.50	228.19	168.39	5,375	31.33
1980	48.39	38.83	5.79	3,181	1.82
1981	19.05	19.18	3.84	639	6.01
1982	1.25	6.98	3.92	1,294	3.03
1983	-	-	-	-	-
1984	0.47	-	-	-	-

Deep-sea Fleet Year	Landings	Logged catches	Class 1 catch	Effort(crhm)	CPUE(kg/crhm)
4XP					
1979	73.05	66.60	65.51	129,229	0.507
1980	258.23	187.28	180.24	422,127	0.427
1981	24.98	12.76	12.65	19,910	0.636
1982	114.07	83.40	82.84	217,580	0.381
1983	63.32	34.83	33.46	135,526	0.247
1984	16.60	4.95	4.95	26,565	0.186
4XO					
1979	0.00	12.43	12.43	18,671	0.666
1980	13.17	37.61	30.23	55,552	0.544
1981	0.36	1.40	1.40	2,219	0.632
1982	47.55	70.87	65.76	86,204	0.763
1983	42.70	53.11	44.96	78,613	0.572
1984	10.57	13.24	13.24	45,619	0.290

Table 9.- Nature of the catch from Browns Bank/Tusket area determined by the analysis of scallop meat weights.

	% catch examined / catch landed	meat weight (g)			
		mean	min	max	s.d.
1979	0.0027	15.33	4.01	58.66	0.16
1980	0.0200	11.14	1.37	74.87	0.04
1981	0.0040	42.25	31.73	55.33	0.27
1982	0.0053	15.84	2.90	58.75	0.10
1983	0.0033	16.15	5.86	40.74	0.18
1984	0.0063	21.98	6.46	68.63	0.51

Table 10.- Number of survey stations on both sides of Browns Bank NAFO 4XP on the south, NAFO 4XO on the north by year and by stratum types.

		1983		1984	
low catch	<5%	16	<4%	2	
medium		-	4-10%	7	
high	≥5%	18	>10%	10	
		34	stations	19	stations

Table 11.- Average number of scallop at age caught in a lined 2.44m New Bedford offshore dredge, Browns Bank-Tusket area.

	Age (years)										Mean	s.d.
	1	2½	3	4	5	6	7	8	9	10+		
1983 stock survey												
low	46	368	2	0	1	1	1	1	1	2	676	1068
high	59	248	1	0	0	0	1	2	3	10	416	969
1984 stock survey												
low	0	0	0	0	0	0	0	0	0	0	0	-
medium	3	94	53	6	3	0	0	2	3	14	209	280
high	3	58	0	0	0	6	12	9	4	4	118	184

Table 12.- Summary of average number of scallops at age caught for prerecruits, shell height under 75mm or age less than 5 years, and recruits, shell height over 75mm by catch stratum.

	Age(years)		
	1-4	5-10	11+
Browns Bank/Tusket 1983			
low	416	6	1
high	308	9	7
Browns Bank/Tusket 1984			
low	0	0	0
medium	156	11	11
high	61	34	1

Table 13.- Fishery characteristics for the German/Lurcher area (NAFO 4XQ) for both fleets. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries & Oceans, Halifax. Effort pertaining to Class 1 catch only. (In parenthesis, catches supported by sales slips only.)

Bay of Fundy Fleet

Year	Landings	Logged catches	Class 1 catch	Effort(hm)	CPUE(kg/hm)
1979	293.82	258.25	182.37	7,112	25.64
1980	113.72	89.91	65.96	6,485	10.17
1981	194.73	185.51 (46)	125.57	14,352	8.75
1982	99.06	119.11 (16)	78.11	12,348	6.33
1983	43.68	32.30 (6)	16.76	5,949	2.82
1984	11.07	32.90	25.29	7,660	3.30

Deep-sea Fleet

Year	Landings	Logged Catches	Class 1 catch	Effort(crhm)	CPUE(kg/crhm)
1979	102.32	141.22	138.80	152,574	0.910
1980	1269.71	969.01	871.22	1,396,896	0.624
1981	379.69	190.74	172.61	282,922	0.610
1982	659.74	535.84	403.51	954,628	0.423
1983	587.76	465.88	420.45	1,092,569	0.385
1984	207.13	175.83	156.45	581,969	0.269

Table 14.- Fishery characteristics for the outer reaches of the Bay of Fundy (NAFO 4XR) for both fleets. It is not possible to estimate landings from the Bay of Fundy fleet from this area; 4XR statistical landings also include the traditional fishing grounds off Digby. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries & Oceans, Halifax. Effort pertaining to Class 1 catch only.

Bay of Fundy Fleet

Year	Logged catches	Class 1 catch	Effort(hm)	CPUE(kg/hm)
1979	0.05	0.05	11	4.72
1980	135.31	119.05	9,881	12.05
1981	179.23	174.71	16,416	10.64
1982	161.25	155.06	20,626	7.52
1983	35.24	30.86	6,011	5.13
1984	24.90	23.96	7,674	3.12

Deep-sea Fleet

Year	Landings	Logged catches	Class 1 catch	Effort(crhm)	CPUE(kg/crhm)
1979	-	-	-	-	-
1980	16.86	63.22	59.17	118,471	0.499
1981	2.53	45.92	42.70	109,294	0.391
1982	0.03	86.68	57.90	152,872	0.379
1983	13.02	83.76	70.27	205,023	0.343
1984	4.55	24.35	20.11	98,465	0.204

Table 15.- Nature of the catch from German Bank/Lurcher Shoals area determined by the analysis of scallop meat weights.

	% catch examined / catch landed	meat weight (g)			
		mean	min	max	s.d.
1979	0.0017	11.47	4.74	34.15	0.08
1980	0.0144	11.89	2.13	85.82	0.02
1981	0.0074	12.14	2.34	75.27	0.04
1982	0.0186	15.97	3.69	76.92	0.03
1983	0.0003	13.75	3.35	35.92	0.24
1984	0.0009	22.69	3.88	53.52	0.42

Table 16.- Number of survey stations in NAFO 4XQ, German/Lurcher by year and by stratum types.

		1983		1984	
low catch	<4%	15	<4%	8	
medium	4-10%	19	4-10%	35	
high	>10%	37	>10%	36	
		71	stations	79	stations

Number of survey stations in the Brier Island area, north of latitude 44°N. (NAFO 4XR) by year and by stratum types (fall surveys).

		1982		1983	
low catch	<4%	15	<10%	5	
medium	4-10%	12	10-50%	12	
high	>10%	15	>50%	13	
		42	stations	30	stations

Table 17.- Average number of scallop at age caught in an unlined 2.44m New Bedford offshore dredge, German/Lurcher.

	Age(years)										Mean	s.d.
	1	2	3	4	5	6	7	8	9	10+		
1983 stock survey												
low	0	0	0	0	0	3	5	2	2	11	34	31
medium	0	0	0	0	0	3	11	12	7	12	58	53
high	0	0	0	0	0	5	9	8	8	13	50	45
1984 stock survey												
low	0	0	0	0	0	1	6	6	2	3	35	50
medium	0	0	0	0	0	5	10	6	5	8	41	83
high	0	0	0	0	0	2	11	13	8	10	48	64

Table 18.- Average number of scallops at age caught in a four-gang Digby drag projected from an end, unlined bucket for recruits and from a centre, lined bucket for prerecruits. (u): unlined, (l): lined Brier Island area.

	Age(years)										Mean	s.d.
	1	2	3	4	5	6	7	8	9	10+		
1982 stock survey												
low (u)	0	0	0	0	0	3	11	10	4	6	44	37
low (l)	0	7	3	0	0	2	7	11	3	4	50	52
medium (u)	0	0	0	0	0	0	4	11	7	21	48	26
medium (l)	0	2	2	0	0	1	2	8	8	16	46	22
high (u)	0	0	0	0	0	0	4	8	6	15	36	24
high (l)	0	1	0	0	0	0	2	6	5	12	36	14
1983 stock survey												
low (u)	0	0	0	0	0	0	0	0	1	5	17	12
low (l)	0	0	0	0	0	0	0	2	5	17	30	34
medium (u)	0	0	0	0	2	8	3	0	2	24	42	39
medium (l)	0	0	1	0	0	7	3	1	2	14	37	35
high (u)	0	1	0	0	0	0	1	1	2	23	31	23
high (l)	0	0	0	0	0	0	0	1	2	19	32	25

Table 19.- Summary of average number of scallops at age caught for prerecruits, shell height under 75mm or age less than 5 years, and recruits, shell height over 75mm by catch stratum.

	Age(years)		
	1-4	5-10	11+
Brier Island area 1982			
low	10	28	6
medium	4	22	21
high	1	18	15
Brier Island area 1983			
low	0	1	5
medium	1	15	24
high	0	4	23
German Bank/Lurcher Shoals 1983			
low	0	15	8
medium	0	36	9
high	0	35	8
German Bank/Lurcher Shoals 1984			
low	0	15	3
medium	0	29	5
high	0	38	6

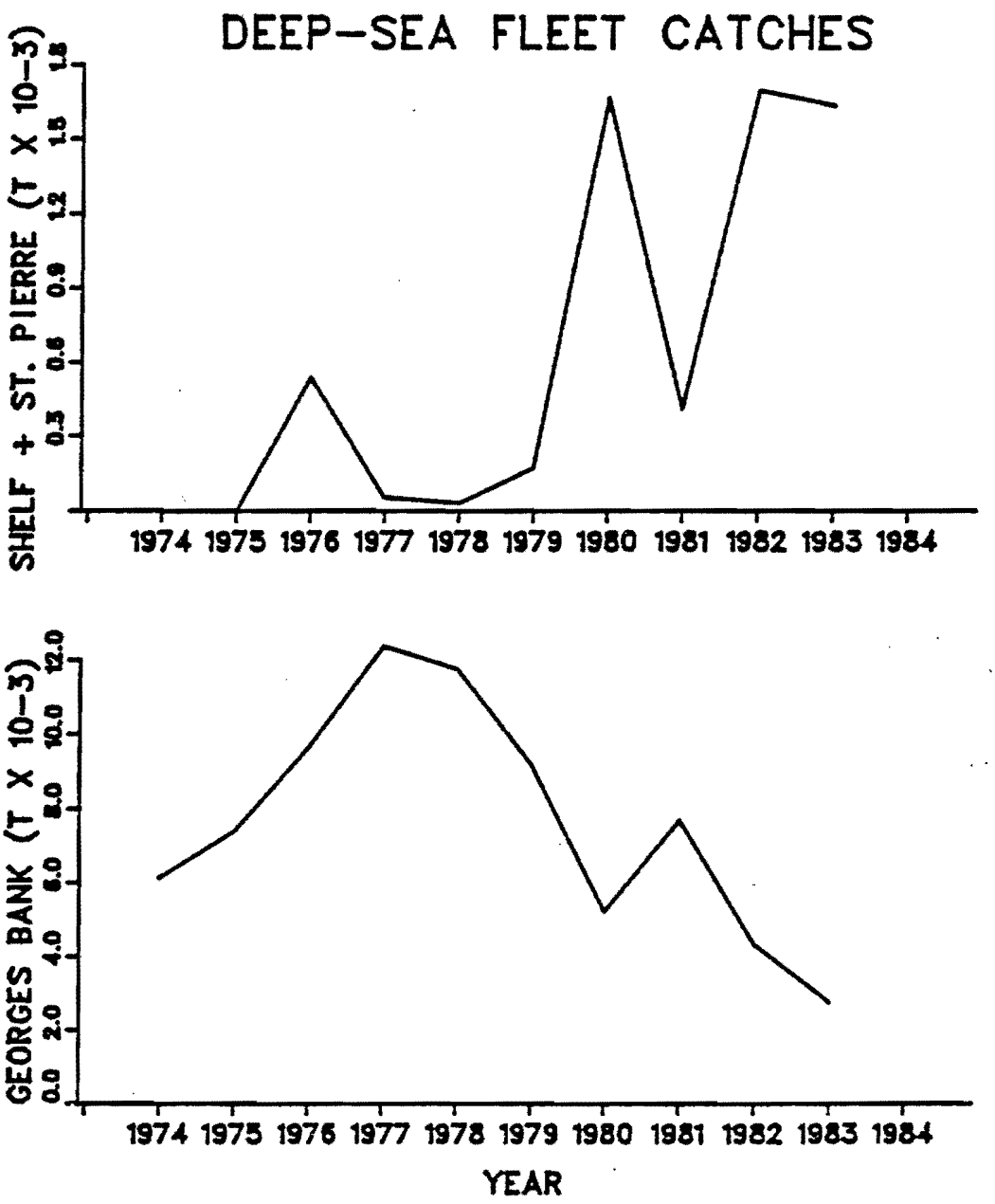

Figure 1.- Deep-sea fleet catches (t of meats) on the Scotian Shelf and Georges Bank. Source: Statistics Division, Fisheries & Oceans, Halifax.

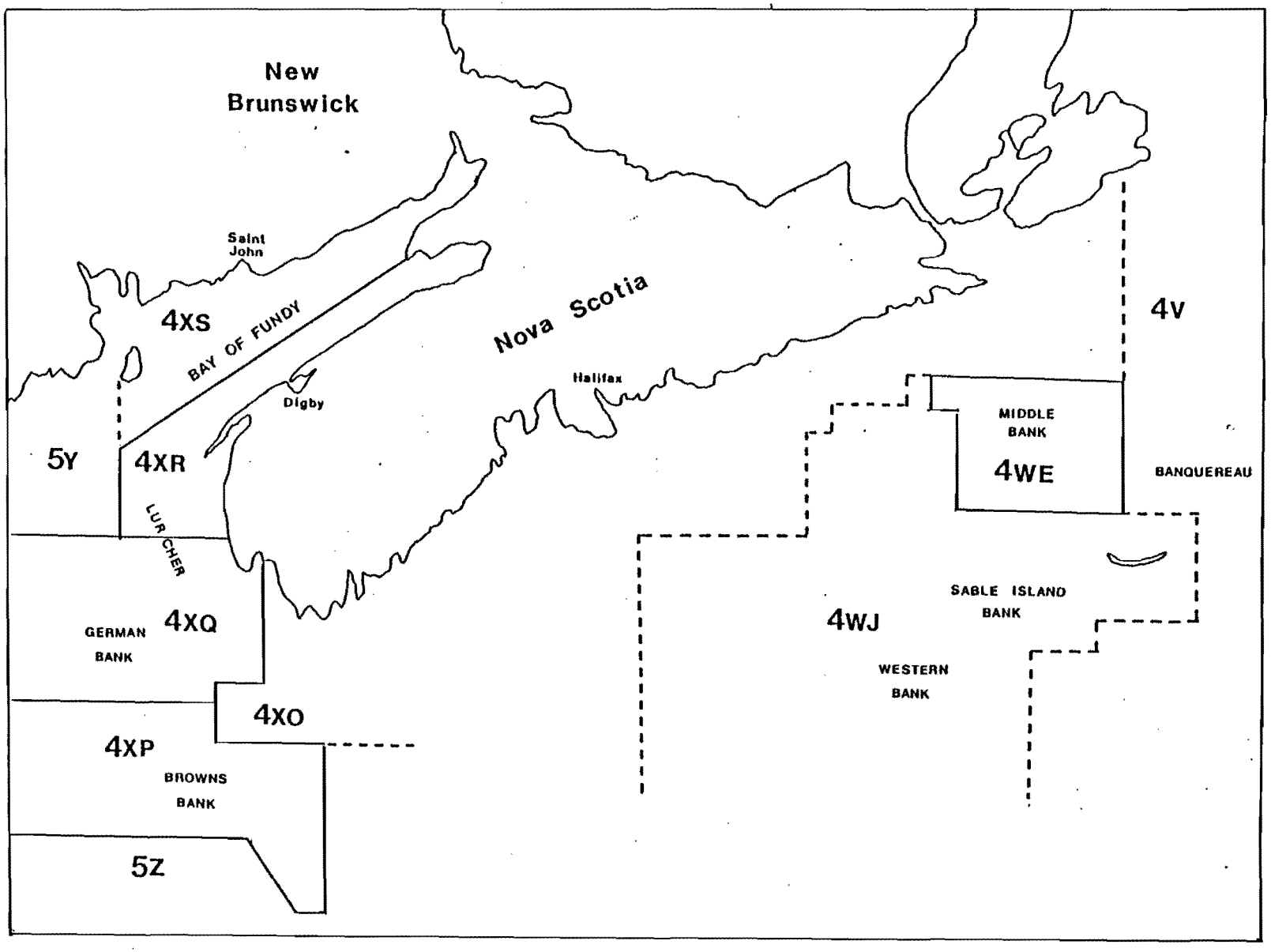

Figure 2.- Map of the Scotian Shelf and approximate location of scallop fishing grounds with corresponding NAFO sub-subareas or best approximation thereof.

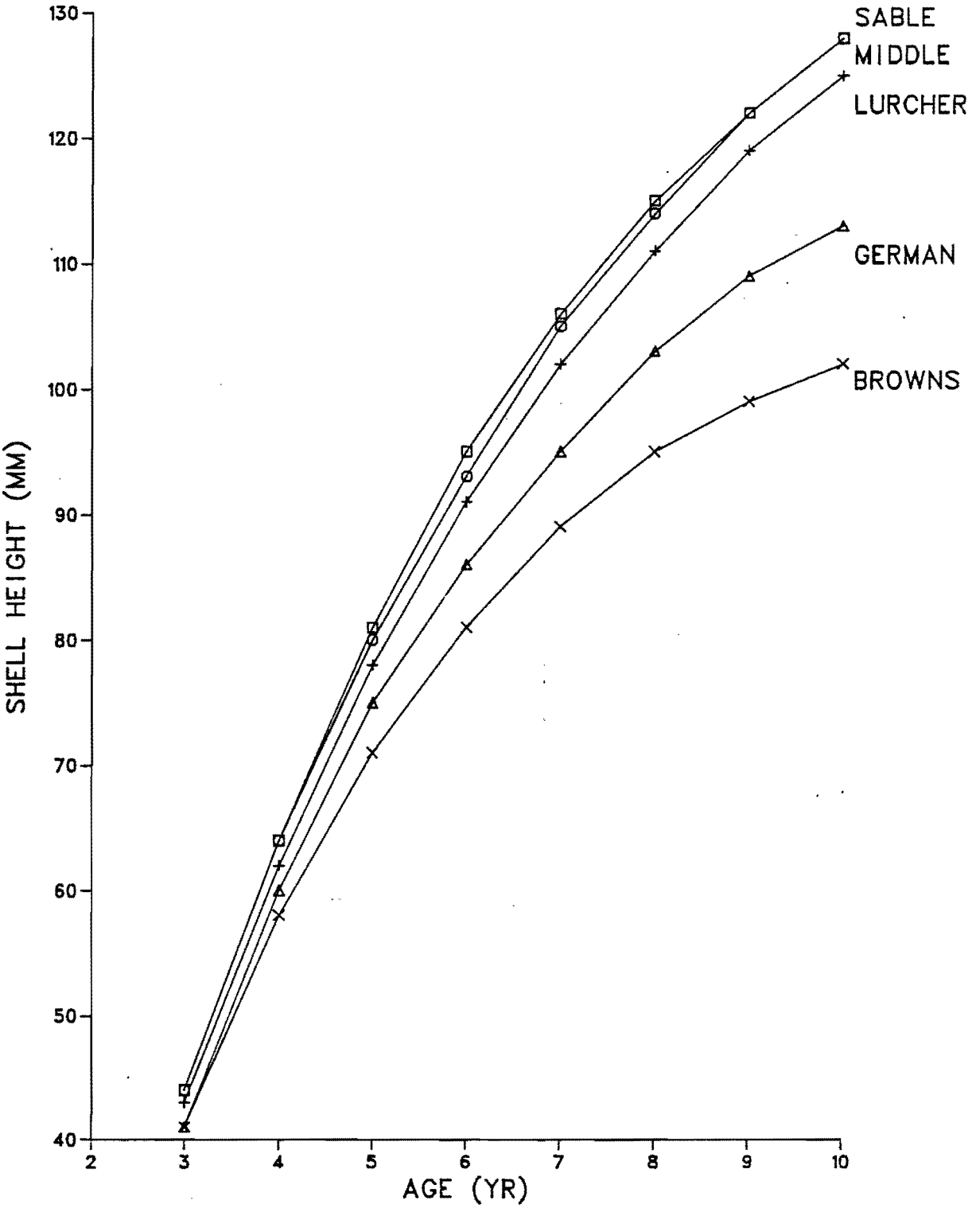

Figure 3.- Von Bertalanffy growth curves, age as a function of shell height, longest distance in a straight line between the umbo and the margin of the shell.

Figures 4, 5, 6.- Productivity of scallop fishing grounds in NAFO SA 4W on a ten-minute square (TMS) basis according to the convention established below.

Figures 9, 10, 11, 12, and 13.- Productivity of scallop fishing grounds in NAFO SA 4X on a TMS basis according to the following convention:

t of meats	
less than 0.1	
0.1 to 0.99	
1.0 to 9.99	
10.0 to 99.99	
more than 100.0	

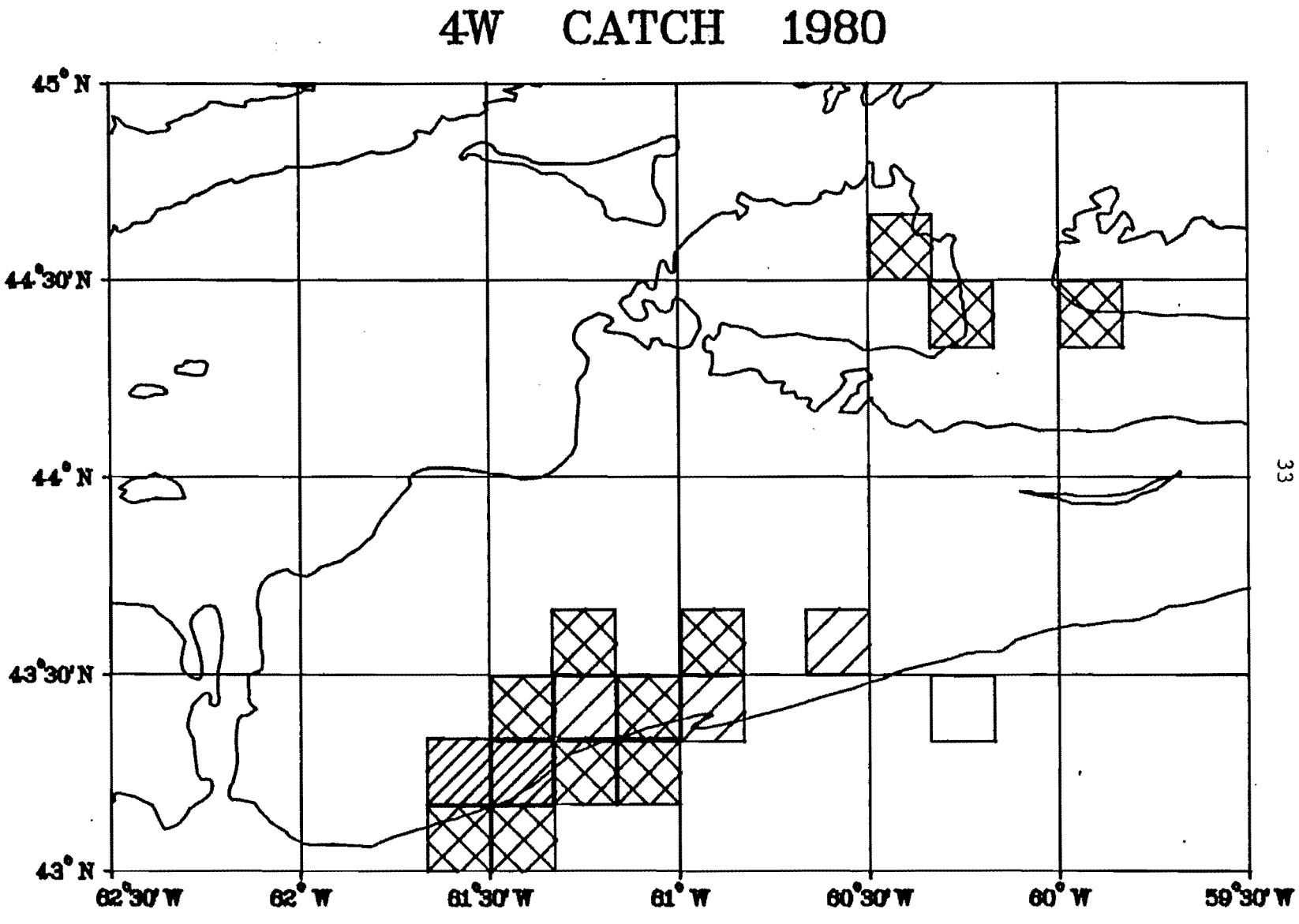
4W CATCH 1980
45° N
44°30'N
44° N
43°30'N
43° N
62°30'W
62° W
61°30'W
61° W
60°30'W
60° W
59°30'W

Figure 4.-

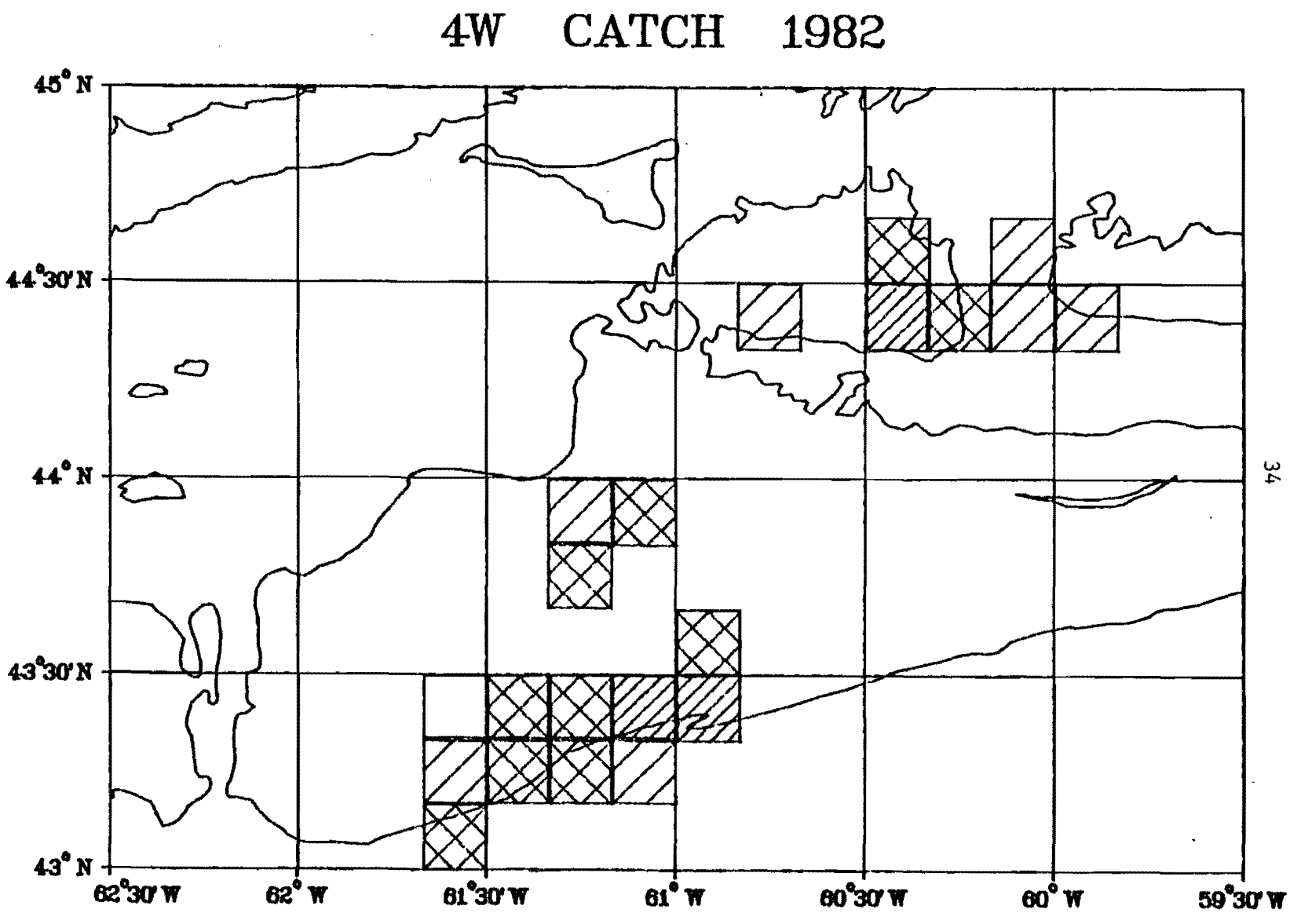
4W CATCH 1982
45° N
44°30'N
44° N
43°30'N
43° N
62°30' W
62° W
61°30' W
61° W
60°30' W
60° W
59°30' W

Figure 5.-

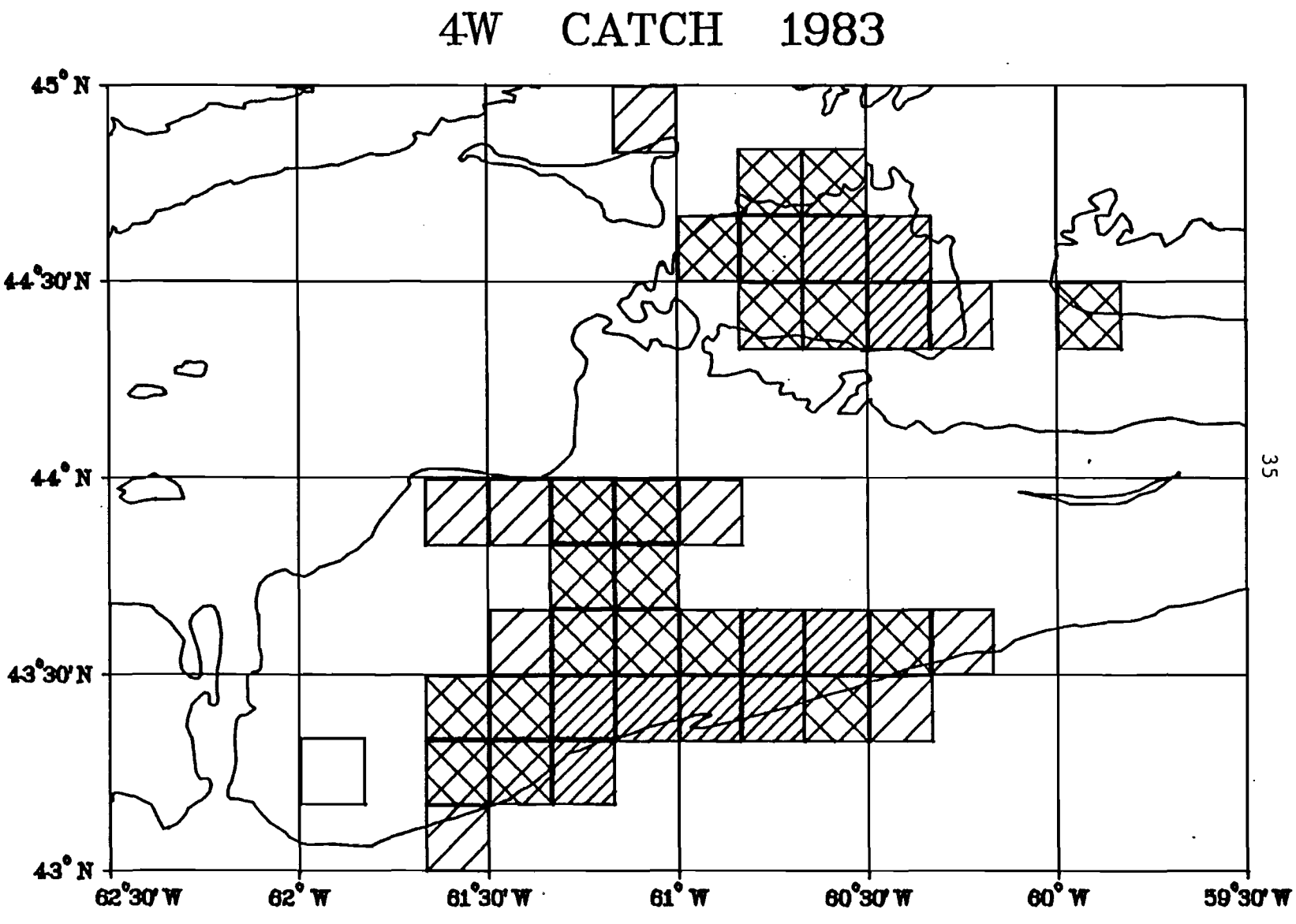
4W CATCH 1983
45° N
44°30' N
44° N
43°30' N
43° N
62°30' W
62° W
61°30' W
61° W
60°30' W
60° W
59°30' W

Figure 6.-

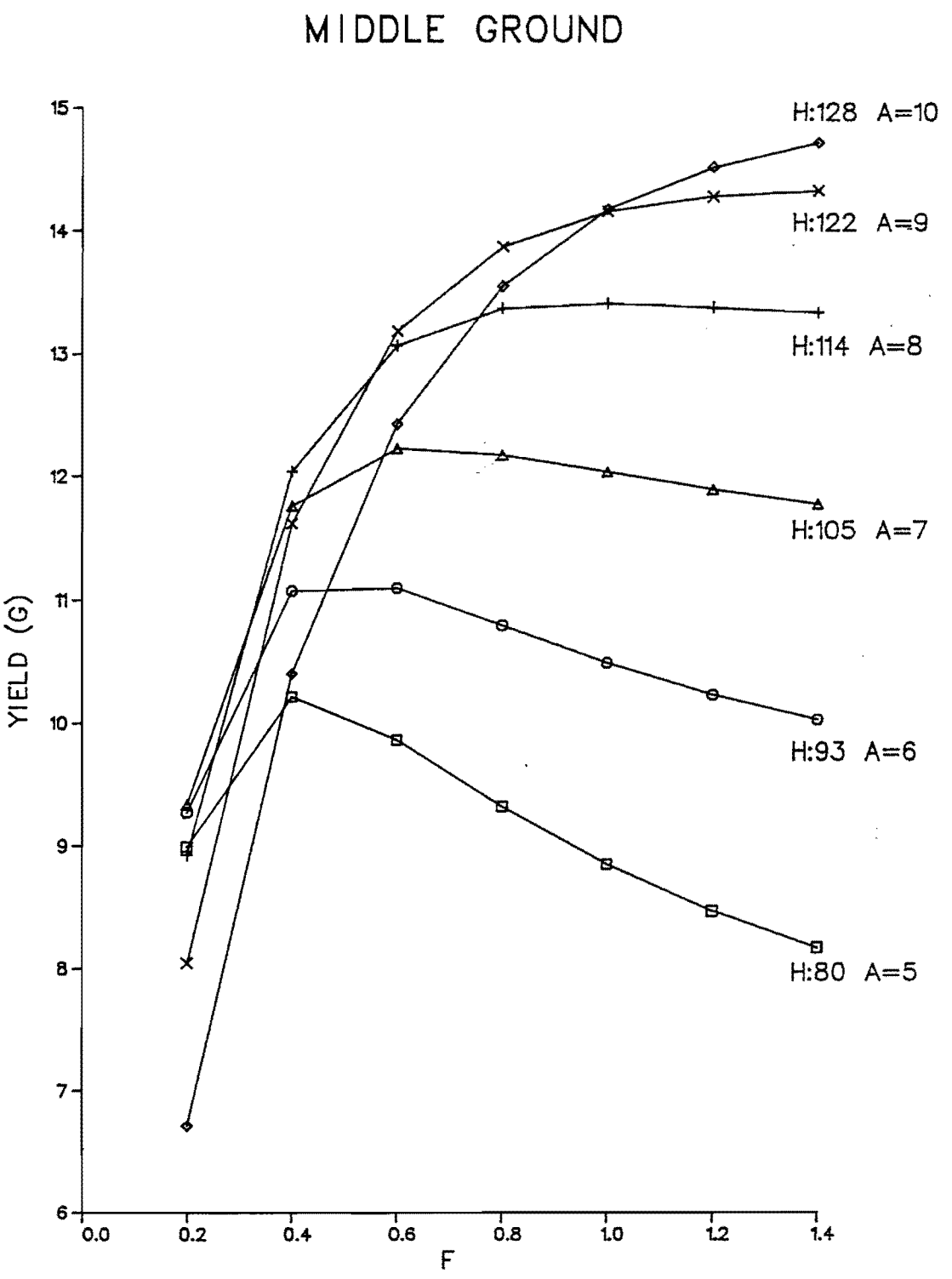

Figure 7.- Yield per recruit (Thompson and Bell) for shell height (H) and age (A) at different fishing mortality rates (F).

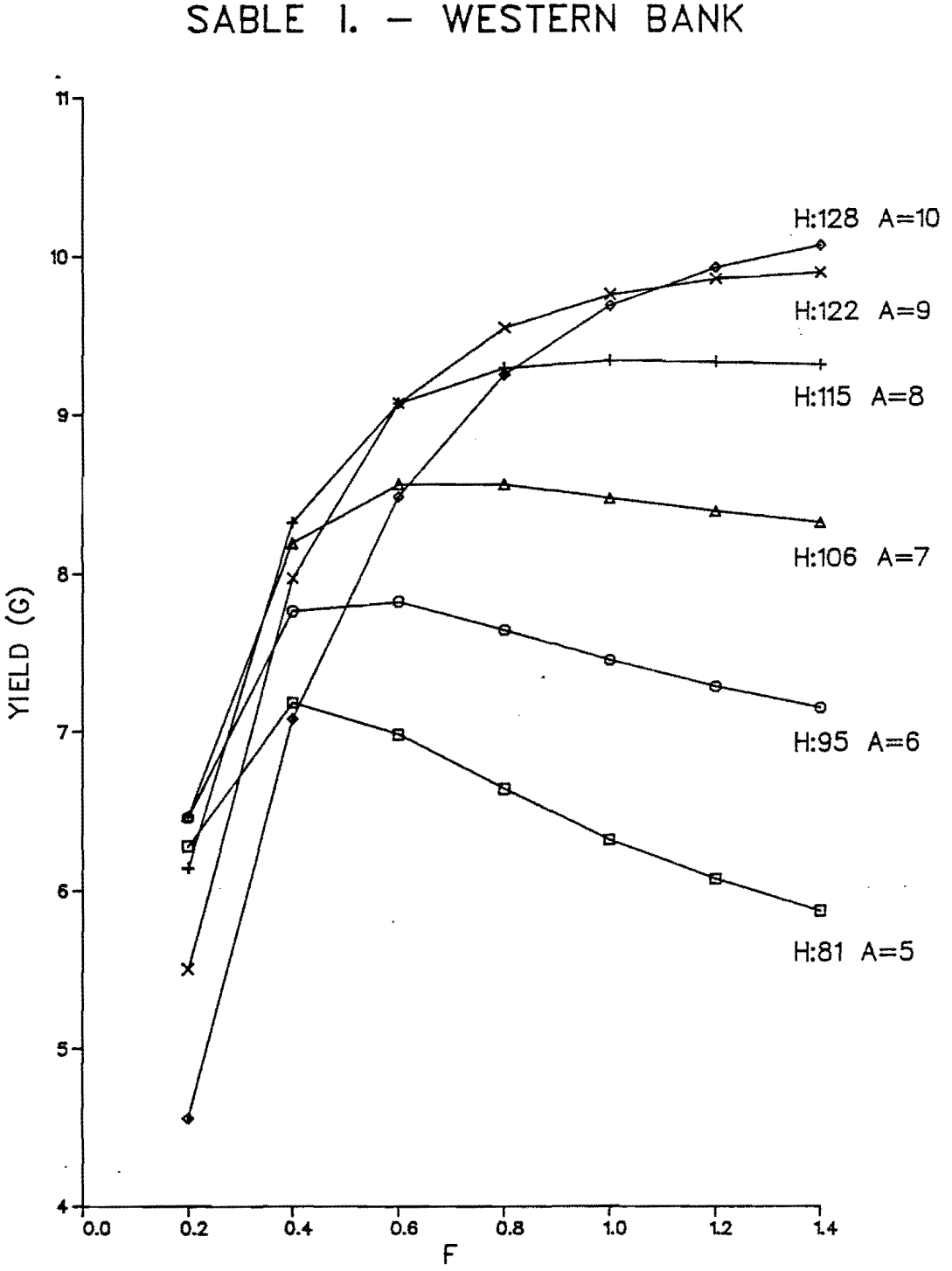

Figure 8.– Yield per recruit (Thompson and Bell) for shell height (H) and age (A) at different fishing mortality rates (F).

4X CATCH 1979

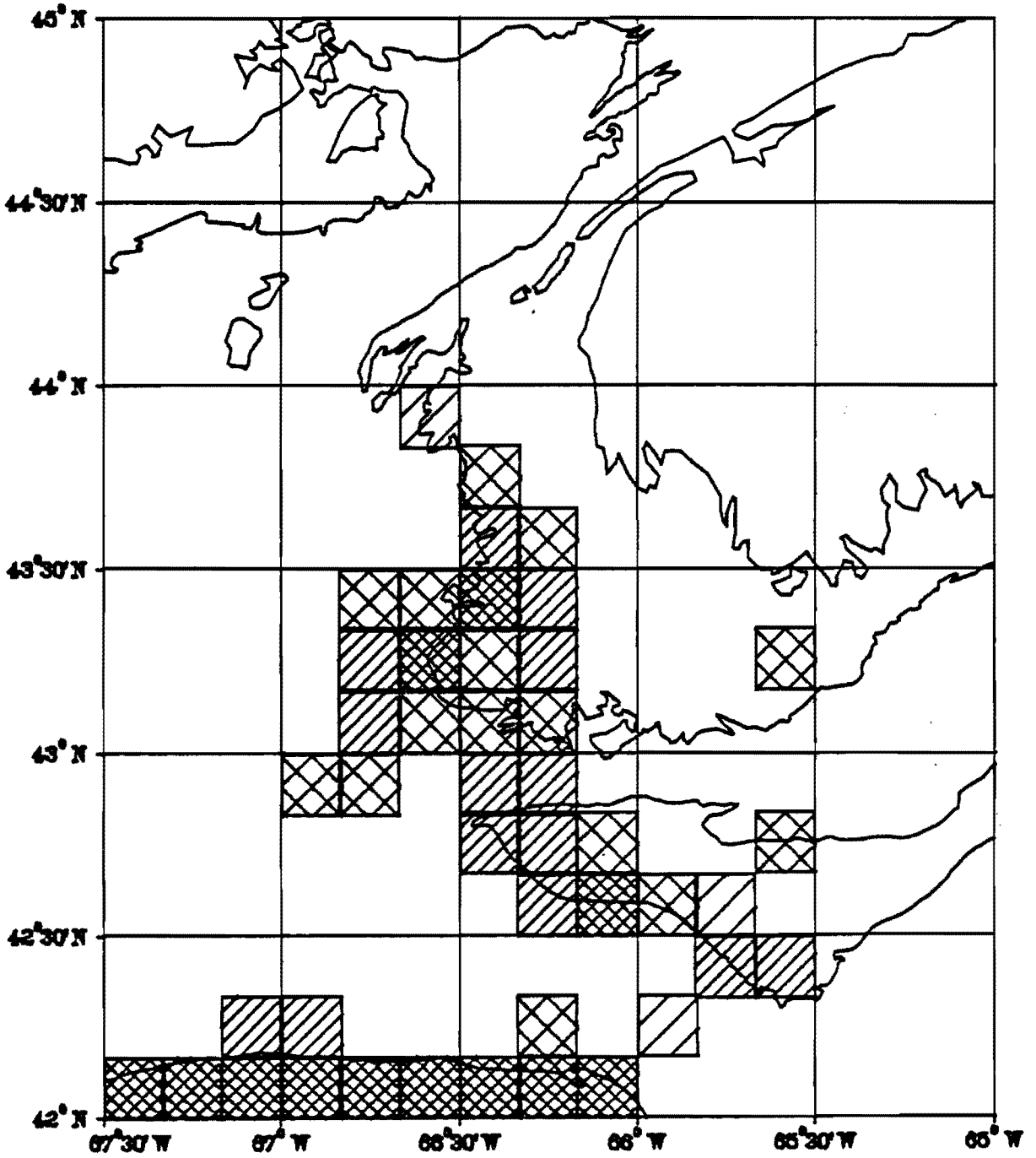

Figure 9.-

4X CATCH 1980

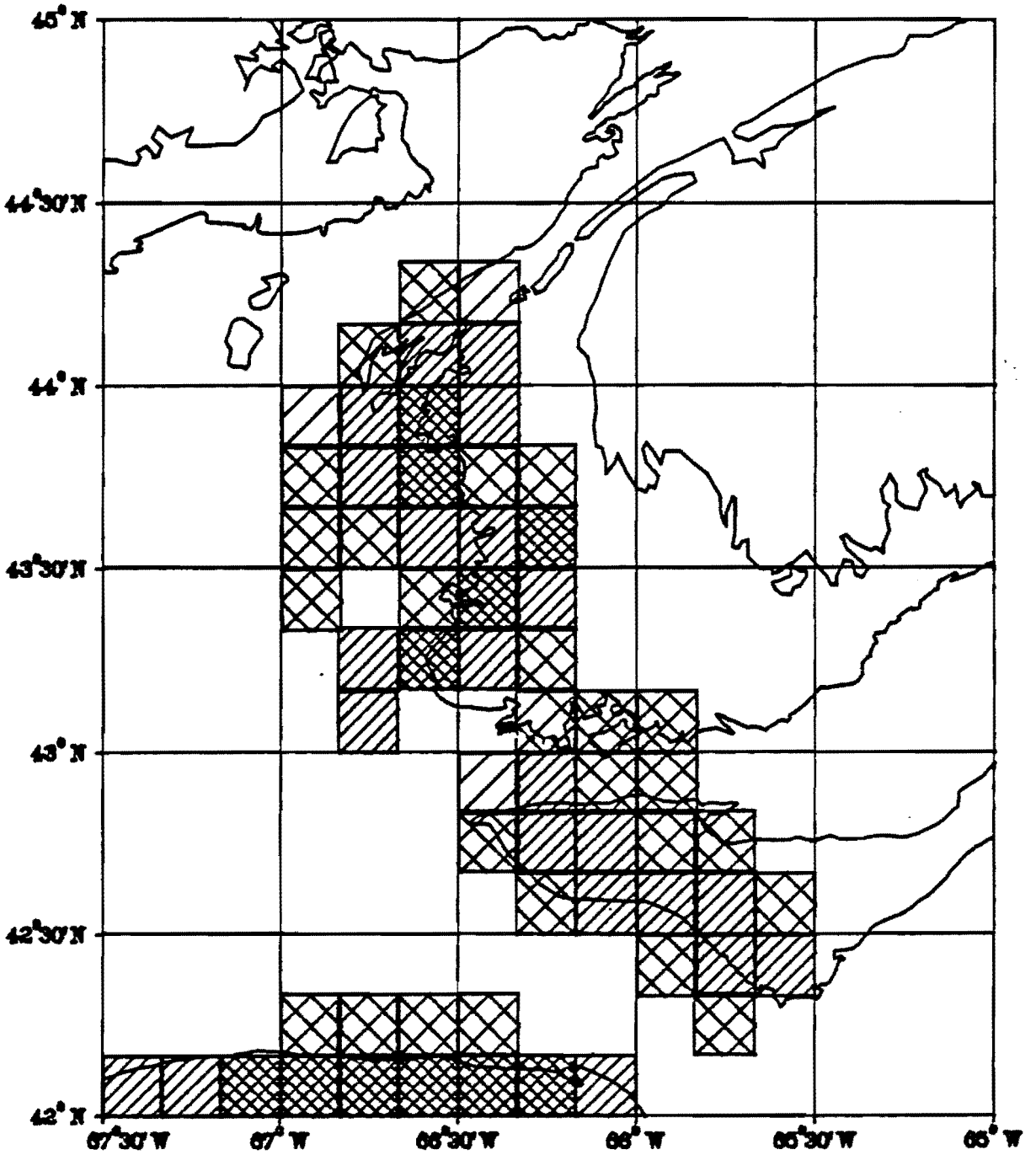

Figure 10.-

4X CATCH 1981

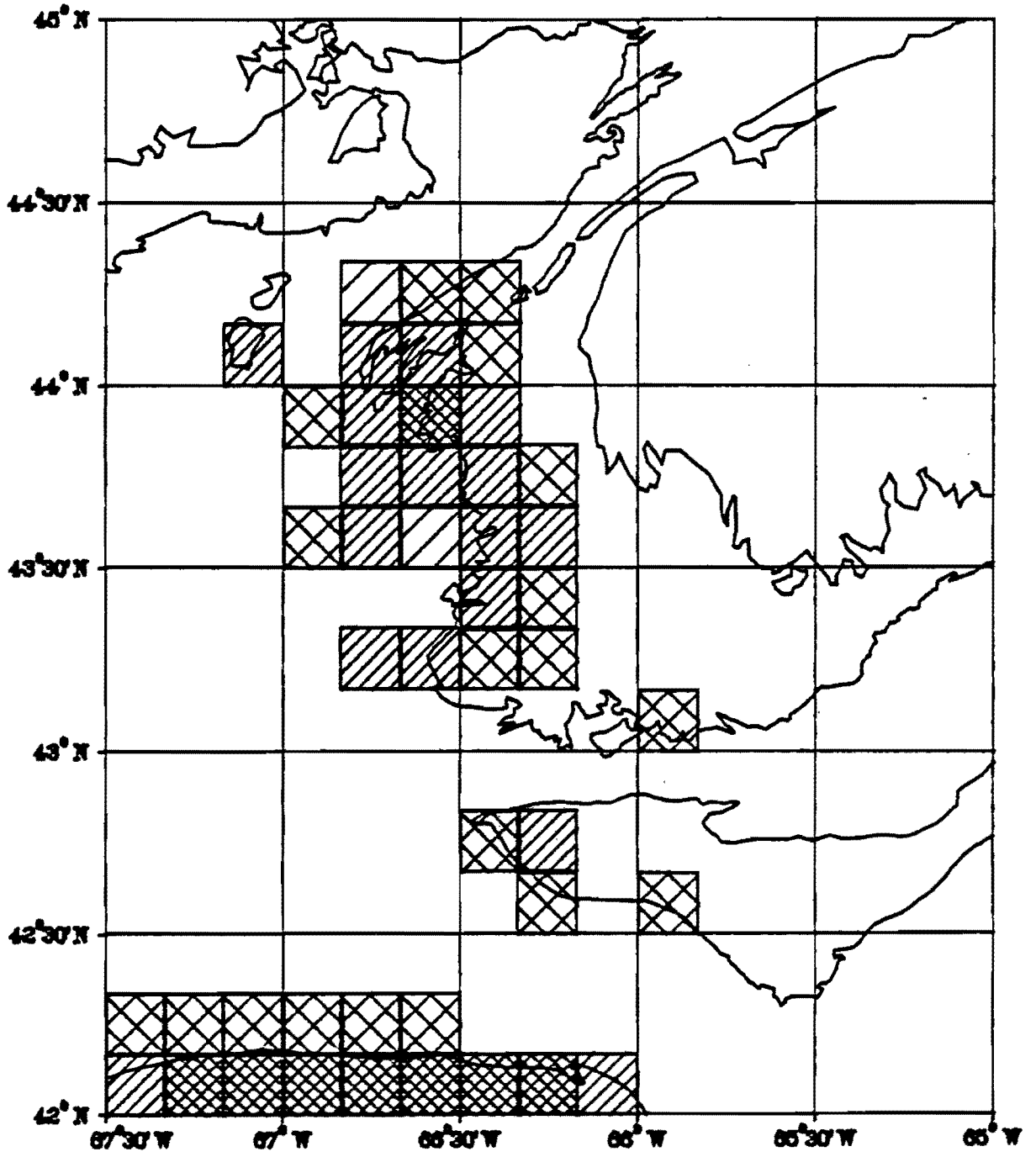

Figure 11.-

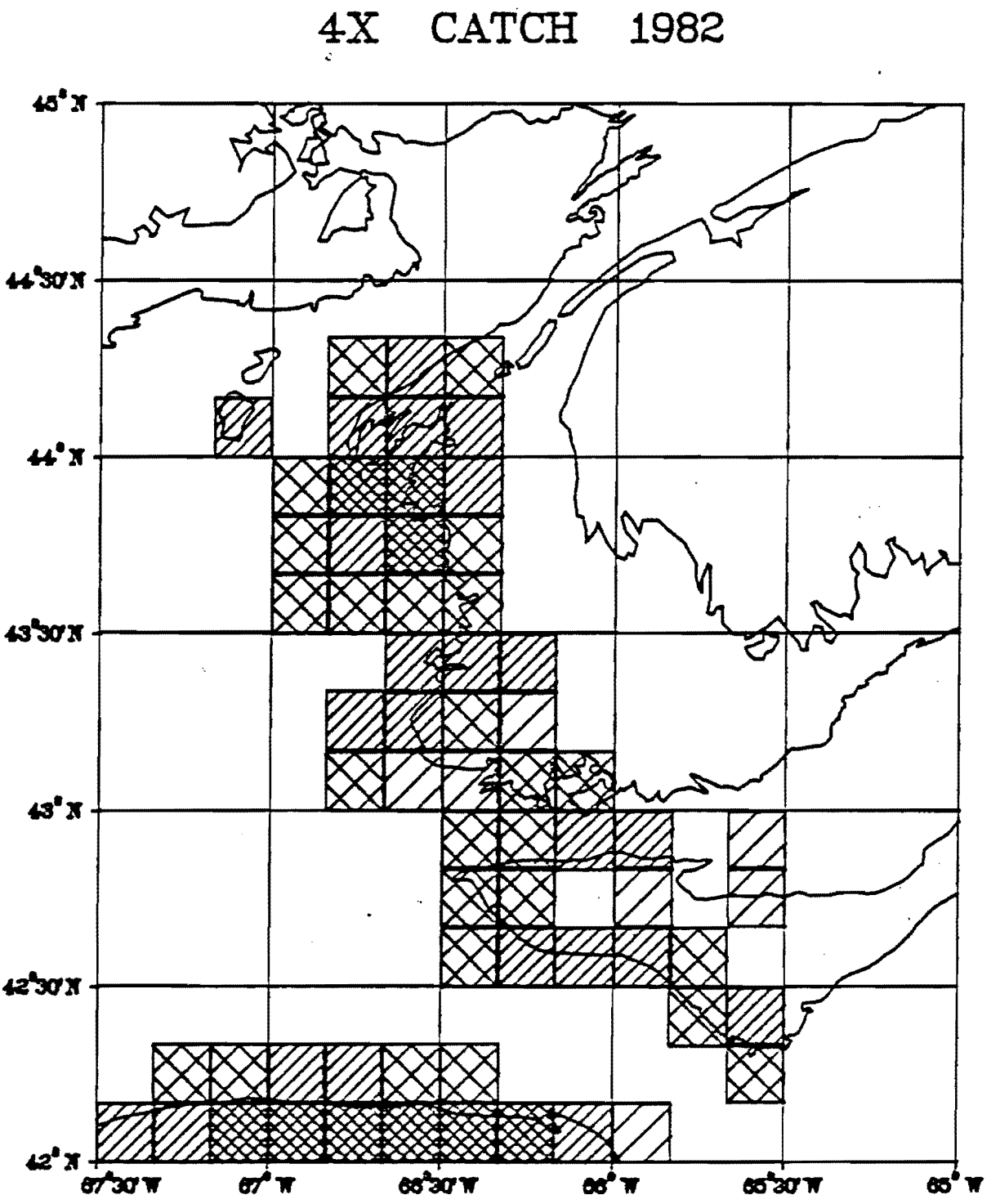
4X CATCH 1982
45° N
44°30' N
44° N
43°30' N
43° N
42°30' N
42° N
67°30' W
67° W
66°30' W
66° W
65°30' W
65° W

Figure 12.-

4X CATCH 1983

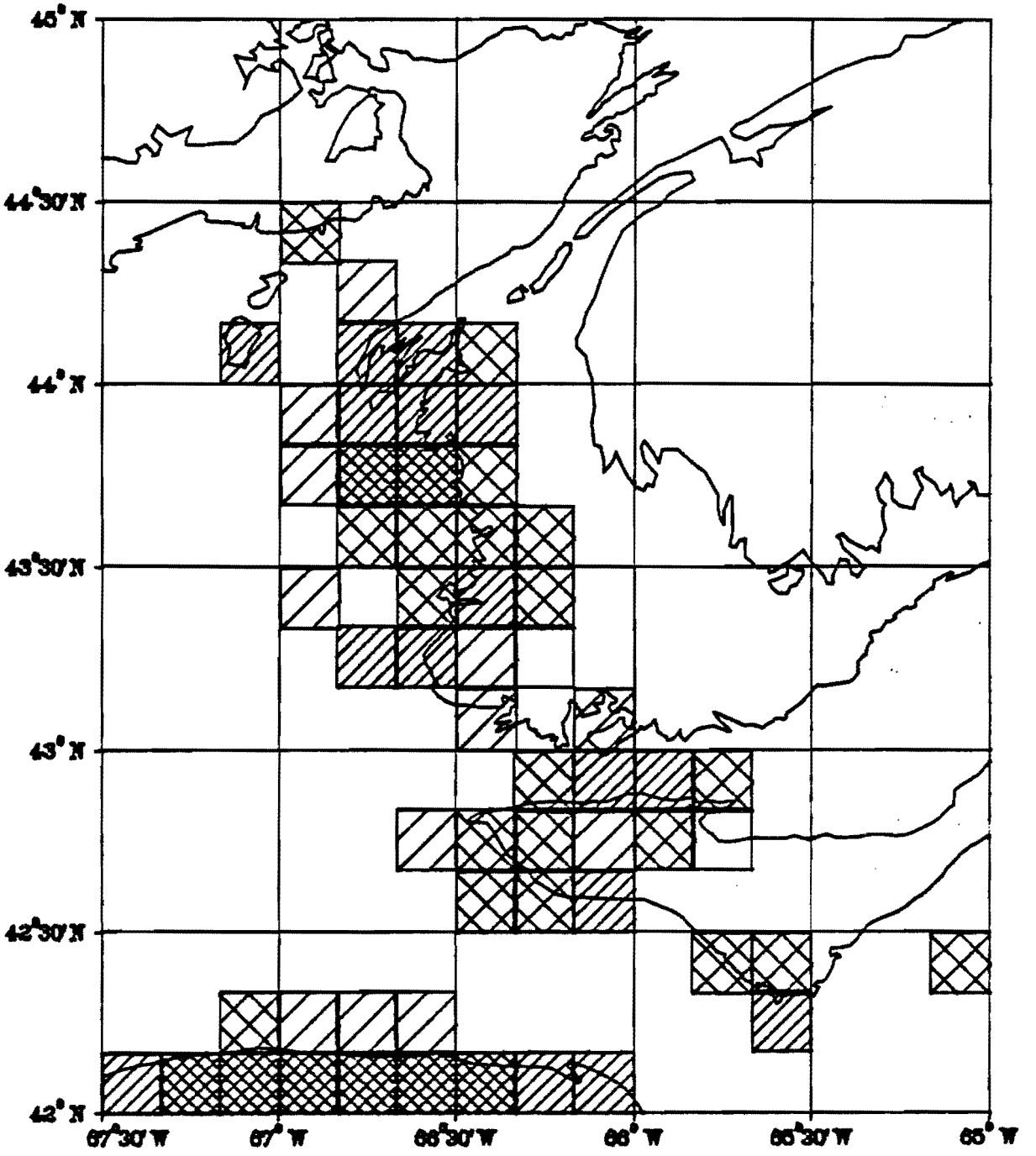

Figure 13.-

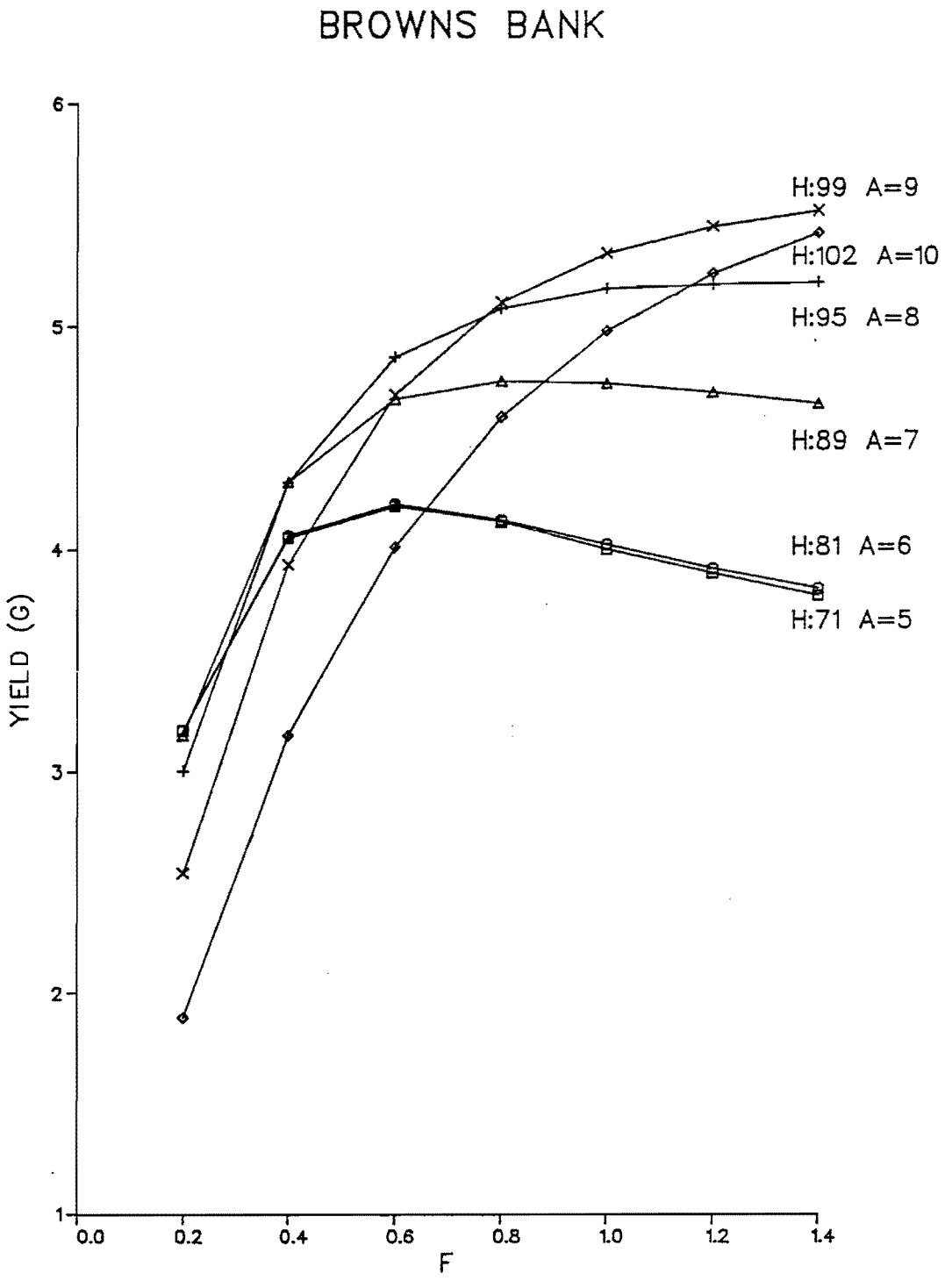

Figure 14.- Yield per recruit (Thompson and Bell) for shell height (H) and age (A) at different fishing mortality rates (F).

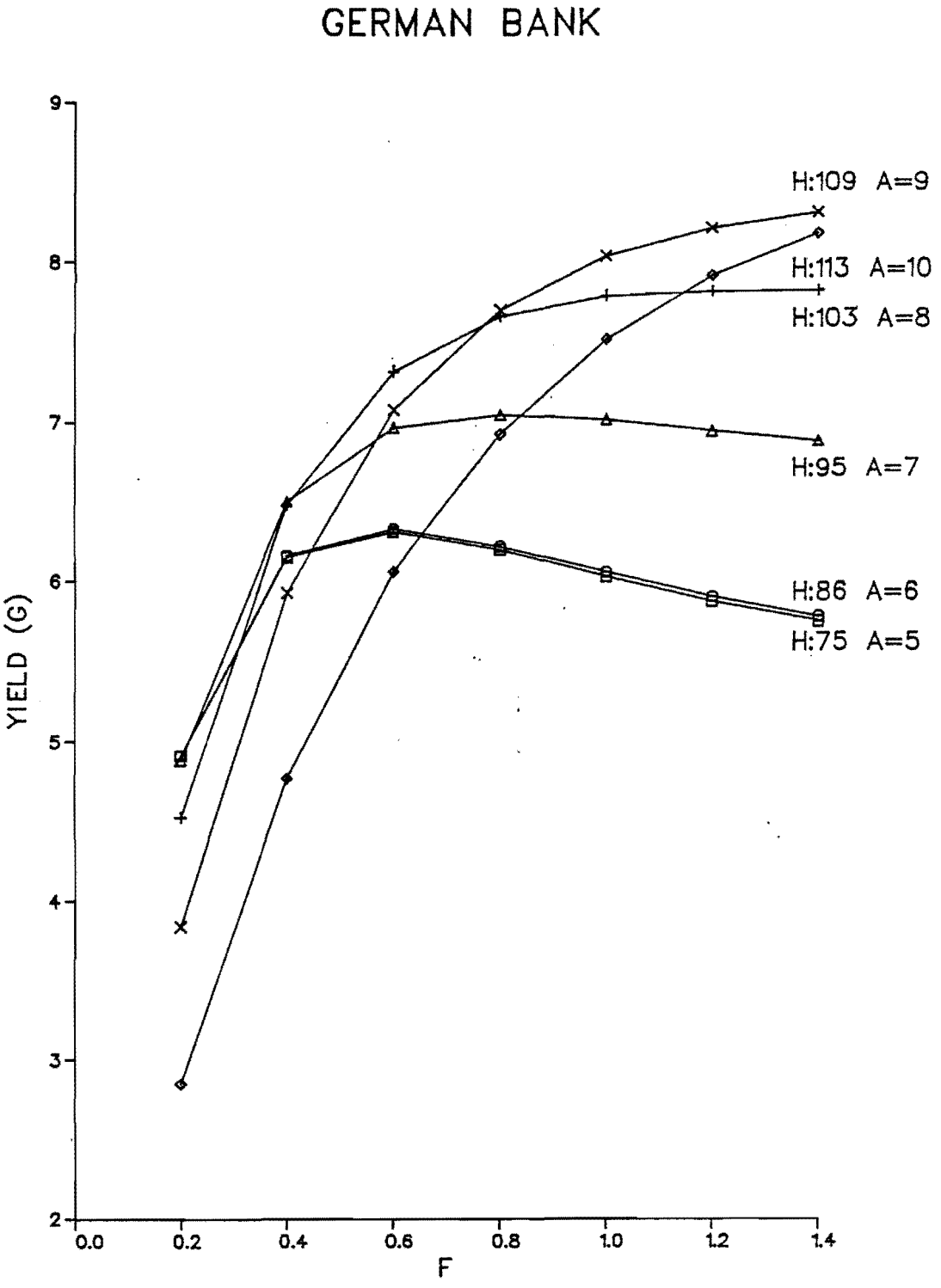

Figure 15.- Yield per recruit (Thompson and Bell) for shell height (H) and age (A) at different fishing mortality rates (F).

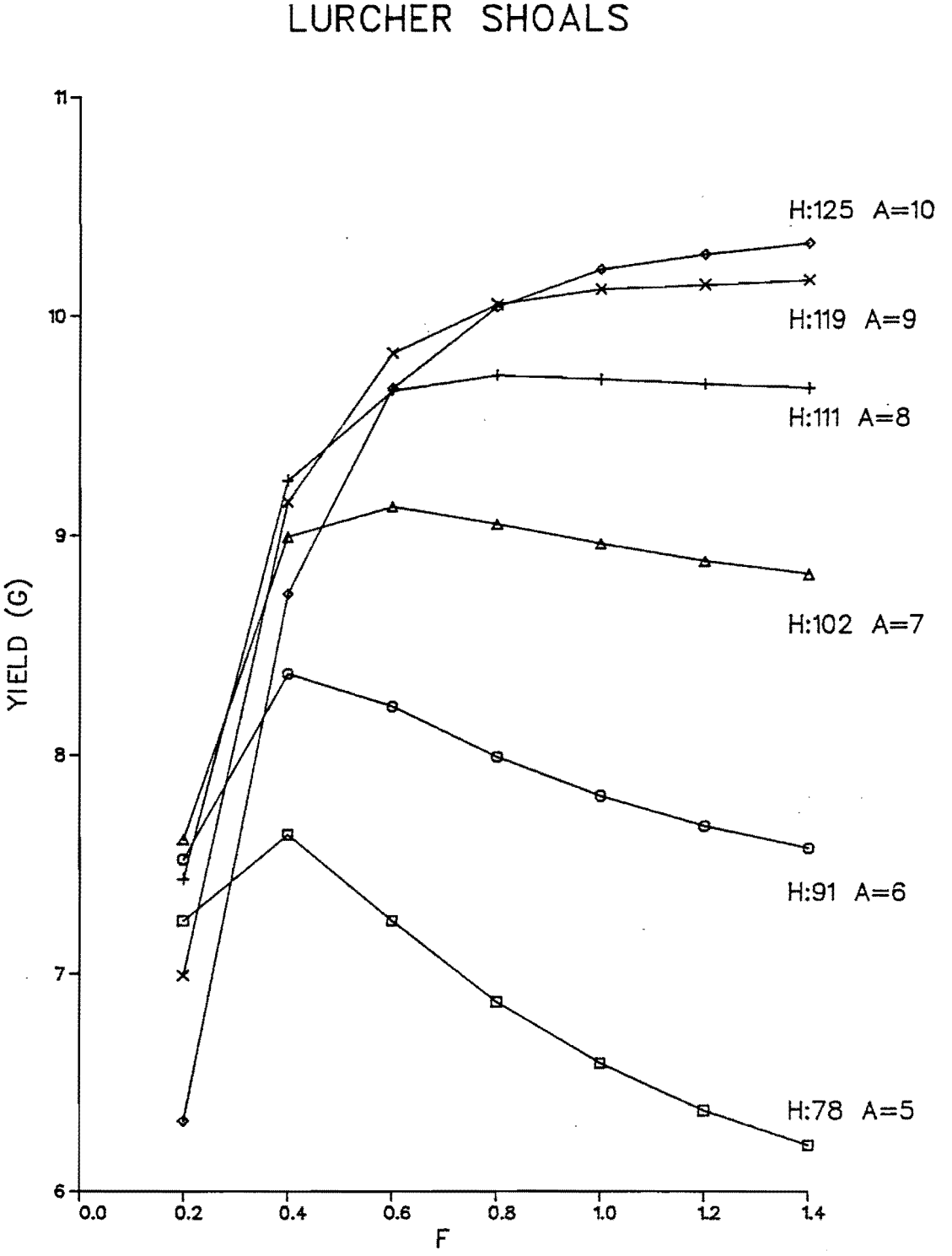

Figure 16.- Yield per recruit (Thompson and Bell) for shell height (H) and age (A) at different fishing mortality rates (F).