PAkT 2: DESCRIPTION OF THE RESOURCE

SUBPART A: DESCRIPTION OF THE STOCKS

§2A1 The Species and The Fisheries

Three major groundfish species, the Atlantic cod, haddock, and yellowtail flounder, have traditionally been the species of highest value to the overall demersal finfish complex in New England waters. However, other important species within that complex have also attracted directed fishing effort or have been caught as by-catch. In addition, several species (such as whiting, scup, and summer flounder) are the focus of seasonal fisheries, particularly in Southern New England. Species taken in the demersal finfish fishery are typically found on (flounders) or near (cod, haddock) the bottom, while others may spend only a portion of the time near the bottom (redfish, butterfish, whiting). All of these species are available to the fishery on a seasonal/geographical basis and thus have interactions at the harvesting and marketing levels. Fishing gear used in the demersal finfish fishery is characteristically bottom-tending including fixed (e.g., gillnets) and mobile (e.g., otter trawls) units.

This section gives a description of the important biological characteristics of the various species comprising the resource base with a brief resume of the historical fishery. To introduce the historical fishery for the overall multi-species complex, Table 2A1 provides catch data for the recent period 1976-1983, and Table 2A2 and Figure 2A1 give a more detailed breakdown of catches (provisional) for 1983.

ATLANTIC COD

The Atlantic cod (*Gadus morhua*) is distributed in the Northwest Atlantic from the southern end of Baffin Island to Cape Hatteras and from near-shore areas to depths exceeding 200 fathoms. In New England waters they concentrate over hard bottoms at depths from 5 to 75 fathoms, ranging in areas of plentiful food supply. Cod feed principally upon fish (about 60% of total diet), but also prey upon crustaceans and molluscs. They typically do not exhibit significant migratory behavior in New England waters, although a southern group of fish migrate from summer grounds off southern New England to wintering grounds off the coast of New Jersey. Characteristically, cod in New England waters exhibit seasonal movements into shoal waters in the spring followed by a retreat to deeper water during the winter in response to the annual temperature cycle.

Four major groups of Atlantic cod are recognized in U.S. waters (Wise, 1962). One is found distributed between eastern Georges Bank and southwestern Nova Scotia. Another is endemic to the western Gulf of Maine. The third group occurs in Southern New England waters west of the Great South Channel, and a fourth apparently reproductively isolated group migrates between Southern New England and New Jersey as noted above. These cod populations have been managed as two stock-units, Gulf of Maine and Georges Bank and Southward.

Table 2A1

COMMERCIAL LANDINGS (metric tons) FROM U.S. WATERS, 1976-1983

SPECIES	1976 US	1976 FOREIGN	1977 US	1977 FOREIGN	1978 US	1978 FOREIGN	1979 US	1979 FOREIGN	1980 US	1980 FOREIGN	1981 US	1981 FOREIGN	1982 US	1982 FOREIGN	1983 US	1983 FOREIGN
Cod	25078	5036	33564	6335	39005	9288	44319	6390	53581	8255	46382	9107	52773	19231	50737	14923
Haddock	4769	1511	11230	2935	16698	10820	18901	5439	24782	10304	24989	6175	18356	6209	14292	5215
Redfish	10131	565	13012	211	13992	92	14722	33	10085	98	7899	19	6797	167	5215	113
Pollock	10241	3138	12722	3517	17535	4754	15412	3032	17905	5634	18019	4050	14623	5374	13445	4383
Whiting	23063	58734	21919	55049	23984	14487	16488	4897	16461	1678	16237	2382	16564	957	16840	284
Red Hake	3941	24244	2587	5243	3444	2151	6892	978	4988	149	4247	52	2225	34	2159	11
White Hake	3071	195	3943	508	3798	184	3055	255	3596	307	5707	454	6074	766	6168	811
Yellowtail	17154	10	16590	39	11487	59	16019	17	19385	81	15594	12	27126	18	33066	46
Am. Plaice	3509	27	7068	190	9503	108	11354	89	13549	48	12881	17	15197	27	13159	37
Witch Fl.	1853	22	2478	24	3520	24	3011	17	3374	19	3421	7	5143	9	5850	45
Winter Fl.	6739	12	10583	25	12344	66	12204	19	17384	44	17779	19	15348	19	15467	19
Summer Fl.	10757	15	8884	52	8454	12	12330	11	11536	57	7958	41	7904	5	11780	-
Windowpane	2242	-	1880	-	2035	-	1587	-	966	-	1286	-	1098	-	1252	-
Scup	7228	87	8468	28	9328	3	8722	-	8497	16	9766	1	7955	-	7814	-
Other GFS	12827	3164	12982	4677	13163	1019	13974	783	10282	1454	8877	2650	7945	2142	8164	1675
TOTAL GFS	142603	96760	167910	78833	188290	43067	198990	21960	216371	28144	201042	24986	205128	34958	205408	27562
Mackerel	2712	205956	1377	53664	1605	371	1990	72	2683	406	2942	5282	3250	6298	3805	1481
Butterfish	1528	10280	1448	3205	3676	1326	2831	840	5356	879	4851	681	8693	450	4915	212
Illex squid	229	24707	1024	23859	361	17207	1593	15748	335	17529	619	7503	11451	3283	9789	968
Loligo squid	3602	21682	856	15902	725	9369	3896	13424	3744	19750	2091	9114	4540	4613	13839	5131

Source: ICNAF Statistical Bulletin, 1975-78.
NAFO Provisional Nominal Catches in the Northwest Atlantic, 1979. NAFO SCS Doc. 80/IX/27.
" " " " " " " " , 1980. NAFO SCS Doc. 81/VI/15 (Rev. 6 July 1981).
" " " " " " " " , 1981. NAFO SCS Doc. 82/VI/7.
" " " " " " " " , 1982. NAFO SCS Doc. 83/IX/22.
" " " " " " " " , 1983. NAFO SCS Doc. 84/VI/22.

Table 2A2

PROVISIONAL 1983 COMMERCIAL LANDINGS (metric tons)
FROM THE NORTHWEST ATLANTIC

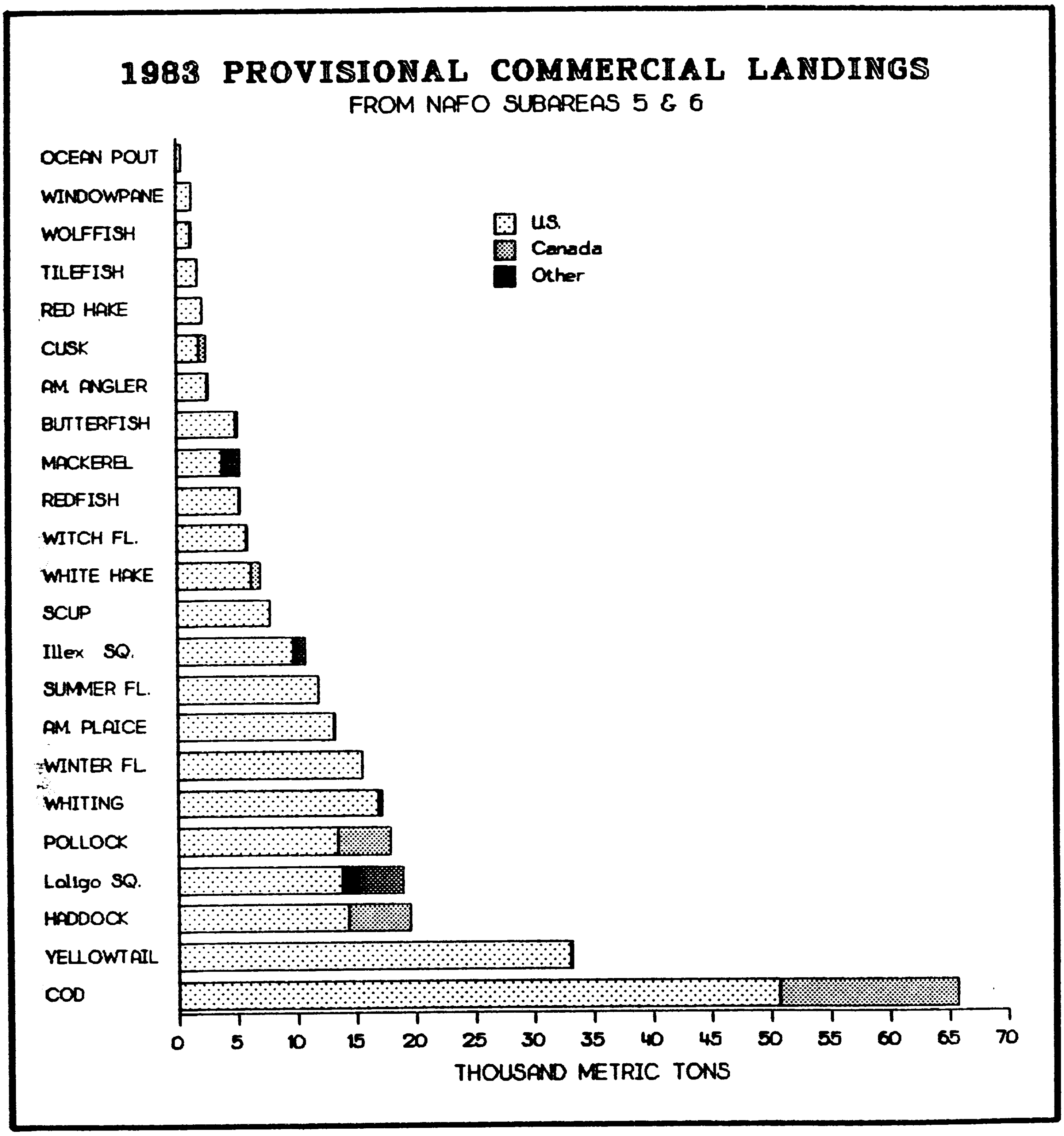
STATISTICAL AREA

	5Y			5Ze			5Zw			6			TOTAL 1/		
SPECIES	US	Canada	Other	US	Canada	Other	US	Canada	Other	US	Canada	Other	US	Canada	Other
Cod	13,867	2,752	-	34,149	12,171	-	1,778	-	-	376	-	-	50,737	14,923	-
Haddock	5,593	2,003	-	8,669	3,212	-	14	-	-	7	-	-	14,292	5,215	-
Redfish	3,889	91	-	1,325	22	-	1	-			-	-	5,215	113	-
Pollock	7,377	1,079	-	5,912	3,304	-	20	-	-	7	-	-	13,445	4,383	-
Whiting	4,800	-	-	1,149	-	73	5,415	-	59	5,473	-	152	16,840	-	284
Red Hake	818	-	-	78	-	5	546	-	5	716	-	1	2,159	-	11
White Hake	5,051	441	-	1,086	369	-	25	-	1	2	-	-	6,168	810	1
Yellowtail	1,314	3	-	19,389	43	-	10,343	-	-	2,000	-	-	33,066	46	-
Am. Plaice	9,137	7	-	3,955	30	-	40	-	-	4	-	-	13,159	37	-
Witch Fl.	4,468	11	-	1,214	34	-	107	-	-	43	-	-	5,850	45	-
Winter Fl.	2,095	5	-	8,013	14	-	3,569	-	-	1,643	-	-	15,467	19	-
Summer Fl.	61	-	-	1,112	-	-	1,887	-	-	8,708	-	-	11,780	-	-
Windowpane Fl.	53	-	-	696	-	-	479	-	-	24	-	-	1,252	-	-
Scup	3	-	-	23	-	-	3,021	-	-	4,702	-	-	7,814	-	-
Other Gfs.	3,530	172	-	1,903	1,086	40	1,557	-	50	1,361	-	110	8,381	1,258	200
TOTAL GFS	62,056	6,564	-	88,673	20,285	118	28,802	-	115	25,066	-	263	205,625	26,849	496
Mackerel	605	-	-	17	-	2	988	-	34	2,183	-	1,445	3,805	-	1,481
Butterfish	33	-	-	68	-	8	3,473	-	100	1,334	-	104	4,915	-	212
Illex squid	17	-	-	-	-	149	1	-	162	9,771	-	657	9,789	-	968
Loligo squid	25	-	-	56	-	851	6,627	-	820	7,131	-	3,460	13,839	-	5,131

1/ Totals include all landings which the data do not attribute to a specific statistical area.

Source: NAFO Provisional Nominal Catches in the Northwest Atlantic, 1983. NAFO SCS Doc. 84/VI/22.

Figure 2A1



8/30/85

The Historic Fishery

The cod has had a long history of exploitation in New England waters beginning in colonial times with a predominately trap fishery. However, the modern fishery may be separated into three periods: 1) an early period from 1893-1910 when record high landings in 1895 and 1907 were followed by much reduced catches, 2) a middle period from 1910-1950 during which landings remained relatively stable, and 3) the latest period since 1950 when landings rose to near record high levels with the introduction of the otter trawl and improved marine engines and navigation equipment.

During the period 1932-1960, annual U.S. commercial catches of cod from the Georges Bank and South stock complex fluctuated between 8,100 and 32,300 mt. With increased Canadian effort and the advent of the distant water fleets in the 1960's, total landings rose sharply to reach 52,000 mt in 1966. This increased effort and resultant catch followed an apparent modest increase in the size of the Georges Bank and South cod stock. The stock subsequently declined with landings stabilizing at around 26,000 mt during 1970-1975 as the fishery became more dependent upon current recruitment. Moreover, cod became less abundant in more southerly areas during the winter than formerly. Following reductions in fishing effort by the distant water fleets with the advent of the MFCMA and entry of significant recruiting year classes, total commercial landings from Georges Bank and South have risen to average more than 56,000 mt since 1977.

Commercial cod landings from the Gulf of Maine fishery have generally fluctuated between 2,700 and 14,500 mt since 1932 with the great bulk taken by U.S. fishermen. Since 1976, landings have consistently exceeded 10,000 mt and have averaged more than 13,000 mt since 1977.

Current Conditions and Future Prospects

Gulf of Maine. The total 1983 commercial cod landings from the Gulf of Maine (provisional) were 16,619 mt. U.S. commercial landings were 13,867 mt. The balance of 2,752 mt was taken by Canadian fishermen. The 1983 U.S. recreational cod catch in the Gulf of Maine is not known although party boat captains have reported a steady decline in landings over the past 5 years.

The 1982 NMFS research vessel autumn bottom trawl survey abundance and biomass indices were among the highest observed indicating continued high stock levels despite 7 continuous years (since 1976) of total annual catches which exceed the estimated MSY (8,000 mt). The above average strength of 4 year classes, 1977 through 1980, comprising over 80% of the autumn 1982 Gulf of Maine cod population (by number), give the expectation of a continued strong spawning stock and continued, good recruitment, given favorable environmental conditions and moderate catch levels. The 1981 and 1982 year classes appear to be average and below average in strength, respectively. (Serchuk et al, 1982)

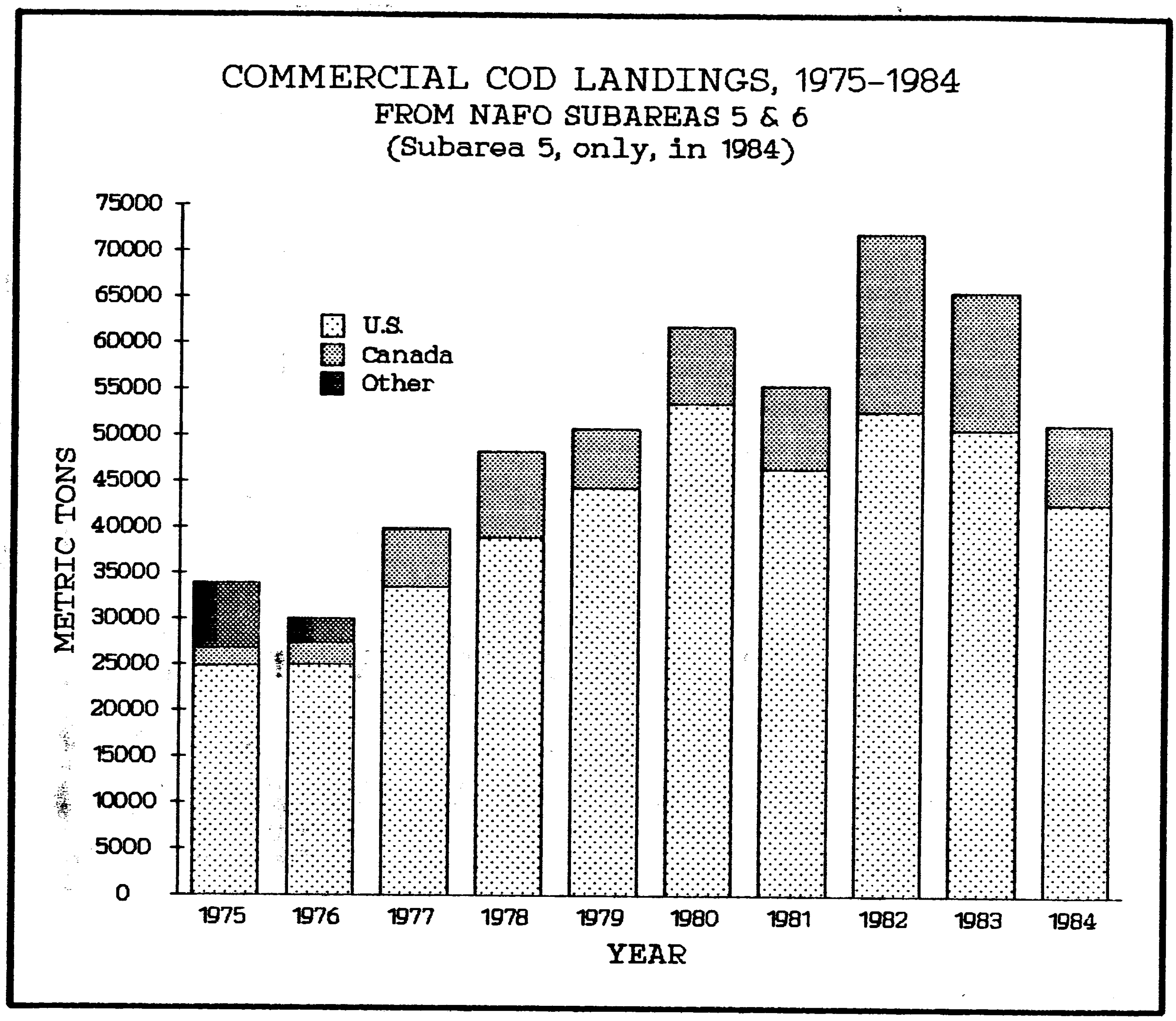
Recent fishing mortality rates in the Gulf of Maine cod fishery appear to have remained relatively stable although slightly exceeding the F-max level. Given current resource conditions, catch levels of about 12,000 mt appear to be consistent with maintenance of a strong spawning stock. Long-term prospects for good recruitment and continued, high yield from the fishery will be enhanced with a fishing mortality rate at the F-max level and with an age at first capture which approximates the mean age at maturity.

Georges Bank and South. The total 1983 commercial landings of cod from Georges Bank and South (provisional) was 48,474 mt (US landings were 36,303 mt), the second highest since 1975. Canadian landings of 12,171 mt accounted for the balance. The 1983 U.S. recreational landings are currently unavailable. A nominal catch level of 2,000-3,000 mt is probably not unreasonable.

Recent NMFS research vessel bottom trawl survey data indicate somewhat conflicting abundance indices. The autumn 1981 and spring 1982 survey results were above average, but the autumn 1982 survey indices were near the lowest observed. This inconsistency may have been due to reduced availability to the survey gear although actual declines in the cod populations are possible. The Georges Bank and South cod stocks are currently dominated by 3 above average or strong year classes, 1978-1980. The 1981 and 1982 year classes are believed to be strong and average, respectively. These results suggest the opportunity for maintaining a broadly based spawning stock (in terms of age classes) which has the potential for continued strong recruitment, but probably not at the continued 1983 catch level (which exceeded the estimated MSY of 35,000 mt by 38%).

Recent fishing mortality rates in the Georges Bank and South cod fishery have substantially exceeded F-max, but the succession of above average or strong year classes (including the 1981 and 1982) may support, in the short run, significant catch levels. The current fishing mortality rate has been estimated to range from F=0.6 to F=0.8. Thus, the 1982 and 1983 catch levels were apparently accompanied by substantial increases in F. If the resulting stock sizes register persistent declines, this may jeopardize not only the expectation of continued high catch levels but may also affect future recruitment. The combination of very high F's and the (possibly anomalous) low autumn 1982 survey index suggests the need for responsive remedial action to reduce fishing mortality to the level of F-max.

Figure 2A2



8/30/85

HADDOCK

The haddock (Melanogrammus aeglefinus) is distributed in the Northwest Atlantic from West Greenland to Cape Hatteras and, in U.S. waters, is most common in the western Gulf of Maine and Georges Bank at water depths of 25-75 fathoms. Haddock are less widely distributed than cod and are more closely associated with the bottom as reflected in a diet which is dominated by crustacea and polychaetes. Georges Bank haddock appear to be relatively sedentary, undergoing seasonal adjustments of depth distribution in response to spawning and feeding conditions. The generally less abundant haddock populations which inhabit wintering grounds in the southwestern Gulf of Maine migrate to summer grounds along the coast of Maine east of Mt. Desert.

There are thought to be three haddock groups in New England waters. The largest group is distributed generally on eastern Georges Bank and the northern edge, but is considered to be reproductively isolated from haddock east of the Fundian Channel. A smaller group inhabits the area from Nantucket Shoals to the western Georges Bank. The last group is distributed in the Gulf of Maine as indicated. These haddock groups have been managed as two stock-units, Georges Bank and the Gulf of Maine.

The Historic Fishery

The haddock stock on Georges Bank has been a classic for fishery management. During the period from 1930 to the early 1960's, with total commercial landings averaging near 50,000 mt, all of the available information indicated that the populations remained very stable despite fluctuations in the strength of recruiting year classes. The large number of year classes in the population has been considered to be the major factor for providing that stability. The stock collapsed in the 1960's as a result of a succession of poor recruiting year classes which occurred just prior to the extremely heavy removals by distant water fleets which reduced the spawning stock to only 10% of former levels. Throughout the late 1960's and early 1970's, the spawning stock remained at very low levels and recruiting year classes remained very poor (and occasionally not detectable). Moreover, the variability between year-class strengths increased at least ten-fold. With recruitment of the extremely strong 1975 year class, the population size increased substantially. Total landings which averaged 6,100 mt over the period 1972-1976 and fell to 5,100 mt in 1974, doubled to 14,200 mt in 1977 and doubled again to 27,500 mt in 1978 as the 1975 year class recruited to the commercial fishery. With recruitment of the strong 1978 year class, average total landings during 1980-1981 increased to 33,100 mt but have subsequently declined to a total of 24,565 mt in 1982. The 1975 year class was extremely strong, ranking with the larger ones which occurred prior to 1964. The fact that such good year classes have been so infrequent since then as compared to previously supports the overall importance of maintaining a strong spawning stock, particularly one with several age classes. It should be noted that the strong 1978 year class, which compares in strength with those seen in 1930-1960, was the first to be spawned by the 1975 year class.

Current Conditions and Future Prospects

Gulf of Maine. The total commercial catch of haddock from the Gulf of Maine (provisional) in 1983 was 7,596 mt, 5,593 mt by U.S. fishermen and the balance of 2,003 mt by Canadians. The nominal catches of haddock by recreational fishermen between 1980-1983 in the Gulf of Maine have been estimated to range 500-600 mt. The most recent recreational survey information (1979) indicated a catch of 406 mt, nearly all of which was taken in the western Gulf of Maine.

The 1983 NMFS survey indices continue a trend of declines in haddock abundance in the Gulf of Maine which has been in evidence since 1978. (Overholtz et al, 1983) Since the early to mid-1970's, when the survey index was at an all time low, only one reasonably strong year class (1975) has recruited to the fishery, although the 1979 and 1980 year classes were at least moderate in strength. Commercial landings of haddock from the Gulf of Maine, supported principally through recruitment from the 1975 year class (and more recently the 1978, 1979, and 1980 cohorts), have reached levels since 1980 which are the highest seen since 1960. These recent trends in commercial landings are the result of increased levels of fishing mortality, currently about F=0.6, which are significantly higher than F-max.

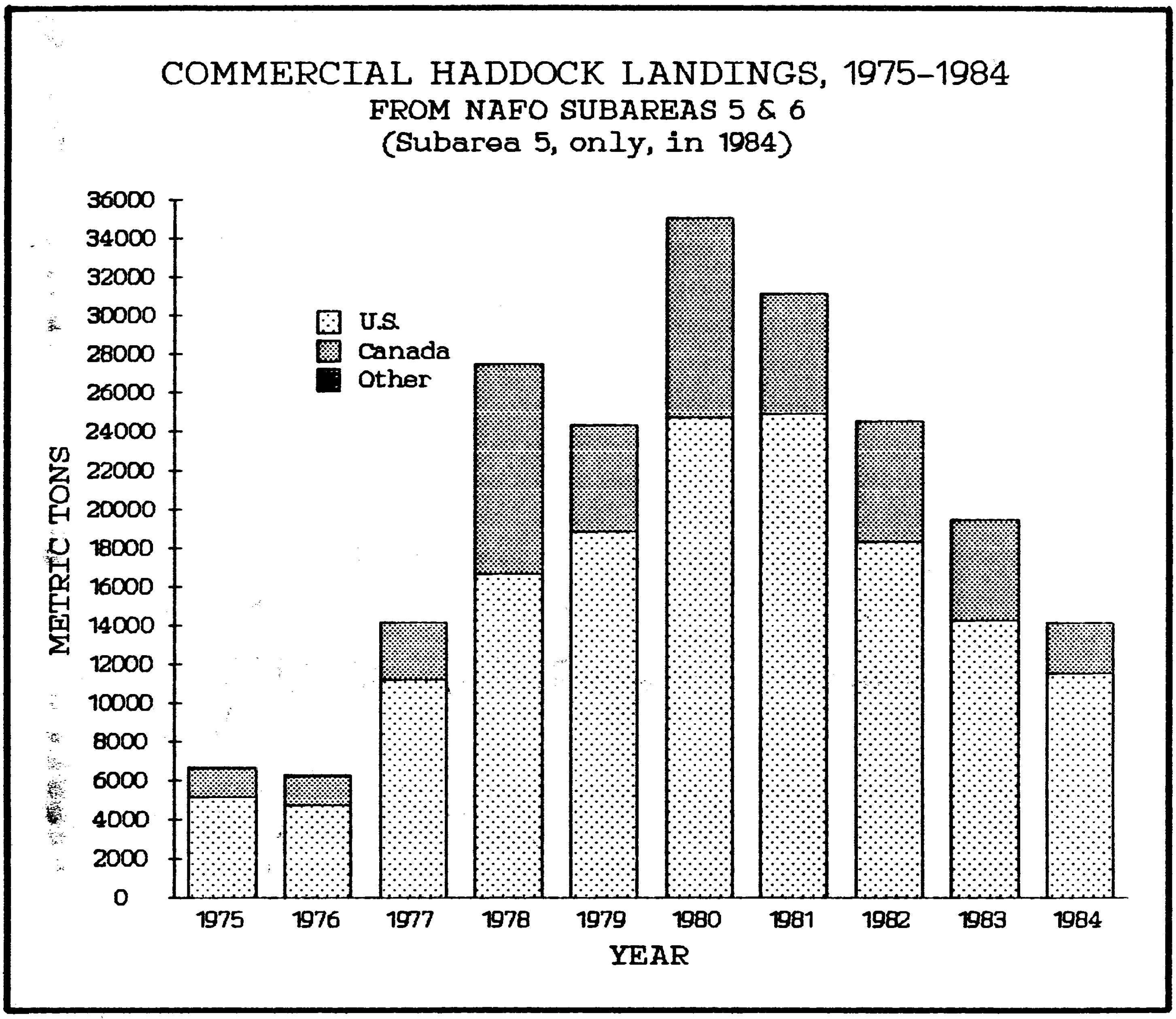
The 1981 year class appears to be very weak, continuing the trend since the 1977 year class. The 1979, 1980, and 1982 year classes appear to be at least moderately strong. Therefore, resource conditions suggest some degree of stability through 1984, although abundances may be expected to register further declines without reductions in fishing mortalities. The current presence of three moderately strong year classes suggests the opportunity for obtaining some degree of stability in spawning stock size, optimizing prospects for consistently good recruitment in the near future, provided that fishing mortalities are moderated.

Georges Bank. The total commercial catch (provisional) of haddock from Georges Bank in 1983 was 11,900 mt. Of this total, the U.S. catch was 8,688 mt with the balance of 3,212 mt taken by Canadian fishermen. Recreational catches from the Georges Bank haddock stock have traditionally been negligible.

NMFS bottom trawl survey indices for 1983 indicate that stock sizes have declined to levels seen in the 1970s when stocks were minimal. Survey catch per tow in weight rose sharply in the series of NMFS spring surveys from 1974 to 1979 and in the 1975 to 1980 autumn surveys reflecting significant recruitment and growth of the 1975 and 1978 year classes. These two year classes have been the primary support for the Georges Bank haddock fishery since they began to recruit in 1977. With the exception of the below average 1980 year class, all other year classes since 1978 have been very weak.

The NMFS survey data indicate that fishing mortality rates since 1977 (when the 1975 year class began to recruit) among recruiting year classes of haddock at age 2 have been substantially higher than F-max. Estimates of the 1983 Georges Bank haddock stock are only about 10% of the average size of the age 2 and older stock seen in the period 1935-1960 and are comparable to the stock sizes seen in the mid-1970s. The immediate prospects through at least 1986 are for a continuation of the very poor conditions seen in the mid-1970s.

Figure 2A3



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REDFISH

Several species of the redfish group, Sebastes spp., are distributed on both sides of the North Atlantic. In New England, Sebastes fasciatus, also known as ocean perch and rosefish, is most common in deep waters of the Gulf of Maine to depths exceeding 150 fathoms in the temperature range 3-8°C. Redfish are a slow growing, long-lived species which may be found in large, discrete aggregations extending over rather broad geographic areas. Moreover, redfish are apparently segregated by fish size and depth. Large, older individuals are virtually the only redfish found at depths exceeding 200 fathoms. Redfish live in excess of 50 years and reach maximum sizes of 18-20 inches, attaining sexual maturity in 8-9 years at an average length of 8-9 inches. With a rather narrow range of preferred water temperatures, movements of redfish are not extensive. Diurnal vertical migrations occur, probably in response to similar movements by their crustacean prey, especially the shrimp-like euphausids. In addition, the viviparous female redfish undergo season vertical migrations during the spring and summer to liberate their young in the upper part of the water column.

Areas of principal concentrations of redfish in U.S. waters have historically included Jeffreys Ledge, Cashes Ledge, the northern approach to the Great South Channel, the deep basins in the Gulf of Maine, and along the southern margin of Georges Bank. All of these aggregations are collectively recognized as the NAFO Subarea 5 redfish stock.

The Historic Fishery

The fishery for redfish arose out of virtual non-existence in the early 1930's following the development of quick-freeze processing and the discovery that redfish yielded a small, white fillet similar in taste to fresh water perch. Frozen fillets of redfish, sold under the name "ocean perch", found ready acceptance in a large market in the Midwest and South. Total landings of redfish in New England from all areas rapidly increased from an average of about 100 mt in the early 1930's to a peak of over 117,000 mt in 1951 and then steadily declined. The fishery began in the Gulf of Maine and then expanded to the Nova Scotia banks, the Gulf of St. Lawrence, and the Grand Banks of Newfoundland as the more accessible aggregations of fish became depleted. By 1960, most areas of redfish production within reasonable steaming time from New England ports showed the effects of heavy fishing.

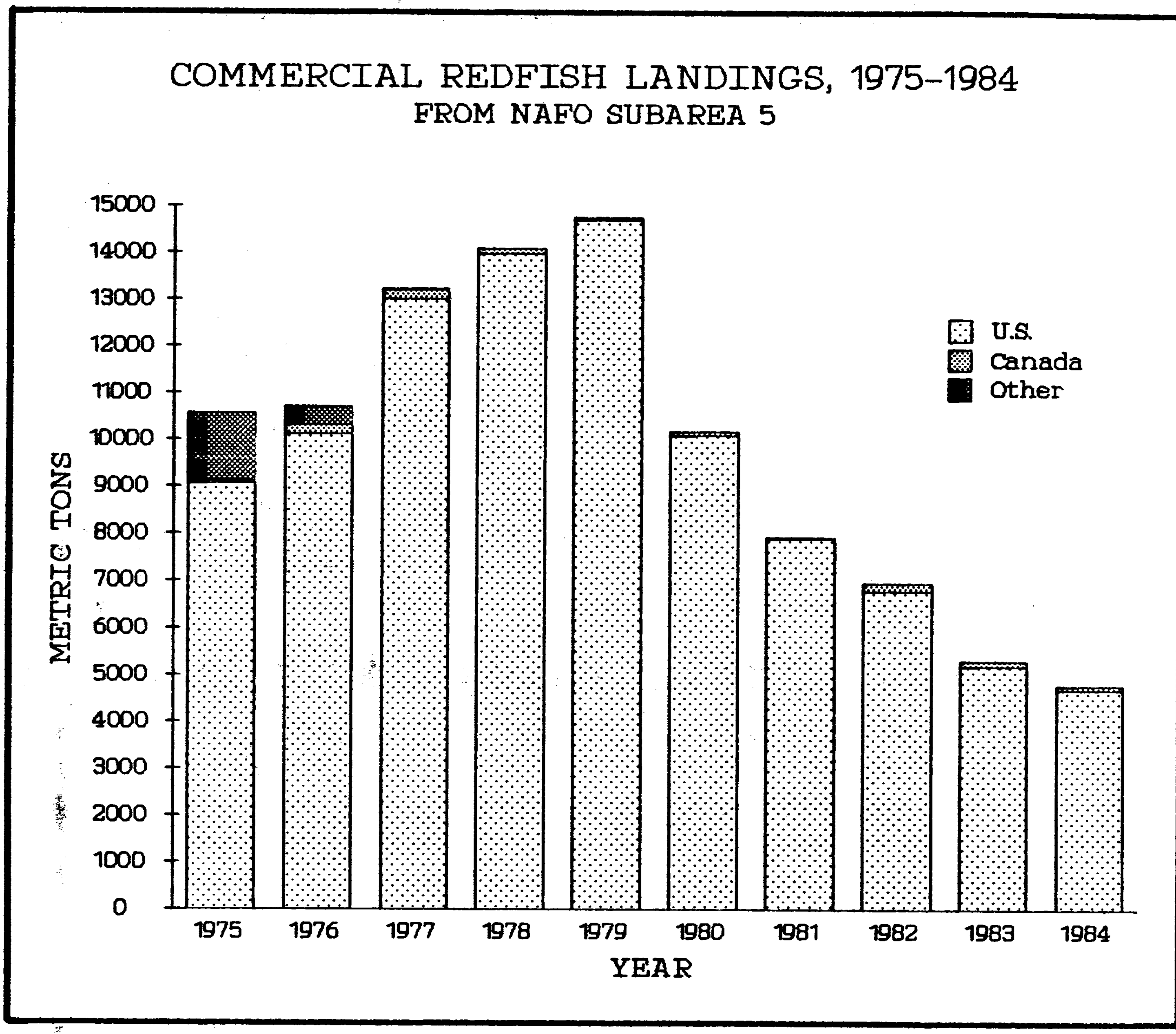
In the Gulf of Maine-Georges Bank region, total catches, taken entirely by U.S. fishermen, peaked at nearly 56,000 mt in 1942 (4 times the estimated MSY level of 14,000 mt) as accumulated biomass was removed from an essentially virgin stock. Subsequent catches then steadily declined until the relatively stable period 1954-1963 when an average of 14,100 mt were taken annually. With a nearly 70% reduction in total effort over the period 1964-1968, total catches declined to only about 8,500 mt, but the stocks underwent partial rebuilding as the strong 1963 year class entered the population. By 1971 as the 1963 year class recruited to the fishery, effort was resumed at near the level seen in the 1950's resulting in catches which, again, approximated MSY (14,000 mt) until falling below 10,000 mt since 1980. Prior to 1971 the redfish fishery in Subarea 5 was virtually an exclusively U.S. enterprise. By 1972, over 31% of SA5 redfish catches were taken by foreign vessels, principally Canada and the USSR. Since 1979, redfish catches in SA5 have once again been taken almost exclusively by U.S. vessels.

Current Conditions and Future Prospects

The total 1983 commercial catch of redfish from the Gulf of Maine-Georges Bank area (provisional) was 5,328 mt, with 5,215 mt taken by U.S. fishermen and the balance of 113 mt by Canadians. The 1983 catch level continues a declining trend seen since a peak of 14,755 mt was reached in 1979. Preliminary information indicates a further decline in 1984 (see Figure 2A4). There is no recreational fishery for redfish.

Available evidence indicates that the Gulf of Maine redfish population is currently dominated by the 1971 year class, the only significant recruiting year class since the 1963. However, the NMFS bottom trawl survey indices indicate that redfish abundances have been declining since 1979 suggesting that growth and recruitment of the 1971 year class are no longer compensating for total mortality (Mayo et al, 1983). The estimated fishing mortality rate being exerted upon the 1971 year class is about 0.3-0.4 (2 to 3 times F-max=0.14) which, in consideration of the current condition of the stock, may be too high. Bottom trawl survey results indicate that the only significant recruitment since the 1971 year class were the 1978 and 1979 cohorts. However, these year classes are only about one tenth the size of the 1971 cohort, thus further declines in redfish biomass are expected to continue in the near future.

Figure 2A4



8/30/85

POLLOCK

Pollock (Pollachius virens) is a member of the cod family which inhabits cool temperate and boreal waters on both sides of the North Atlantic. Pollock off North America are distributed from Newfoundland to Cape Hatteras but are most abundant in the Gulf of Maine and on the Scotian shelf, usually in water depths of 20 to 100 fathoms (depending upon the availability of food). Pollock feed principally upon crustacea (about 70% of total diet) with fish as their secondary prey. Pollock is a schooling species which exhibits substantial shifts in abundance by area through movements and migrations associated with their search for food and for purposes of spawning. The major identified spawning grounds, to which fish from the Gulf of Maine and the Scotian shelf migrate during the autumn and winter, appears to be in the southwestern Gulf of Maine. Larval pollock use the sublittoral zone as a nursery area, and continue to reinvade shoal waters in large schools during the summer through age 2, but gradually tend to remain offshore at depth as they become older.

Although three stocks of pollock were once thought to be endemic to the Gulf of Maine and the Scotian shelf, the mix of fish which appear on the spawning grounds in the southwestern Gulf of Maine suggest that these are all a single stock. Accordingly, pollock from Cape Breton Island southward have been assessed and managed as a unit, the Gulf of Maine-Scotian Shelf stock.

The Historic Fishery

Traditionally, pollock have been taken primarily as by-catch in directed fisheries for other groundfish, but in recent years more effort has been directed towards this species. Transfers of fishing effort, back and forth, when past events affected fisheries for cod and haddock have influenced landings of pollock. Thus, historic patterns of pollock landings may not necessarily reflect real changes in abundance.

U.S. landings of pollock from the Gulf of Maine and Georges Bank remained relatively stable over the period 1940-1960, averaging 12,500 mt. Landings from the same area by U.S. fishermen declined sharply to an average of only 4,900 mt in the decade 1963-1973, but then increased to about 16,300 mt during 1977-1981.

Total commercial landings of pollock by all nations from the Scotian shelf, Gulf of Maine, and Georges Bank averaged 38,600 mt from 1960-1966, declined sharply to an average of 23,800 mt from 1968-1970, and then increased to 43,200 mt in 1973. Landings remained relatively stable at about 38,200 mt during 1974-1977, then sharply increased to average 55,200 mt in 1980-1981.

The fishery has historically been dominated by the U.S. and Canada. Nominal catches by distant water fleets have declined from 9,900 mt in 1973 to an average of 900 mt during 1977-1981, almost all of which was taken by the USSR on the Scotian shelf. Most of the Canadian landings have been taken on the western Scotian shelf while U.S. catches have been predominantly from the western Gulf of Maine.

Current Conditions and Future Prospects

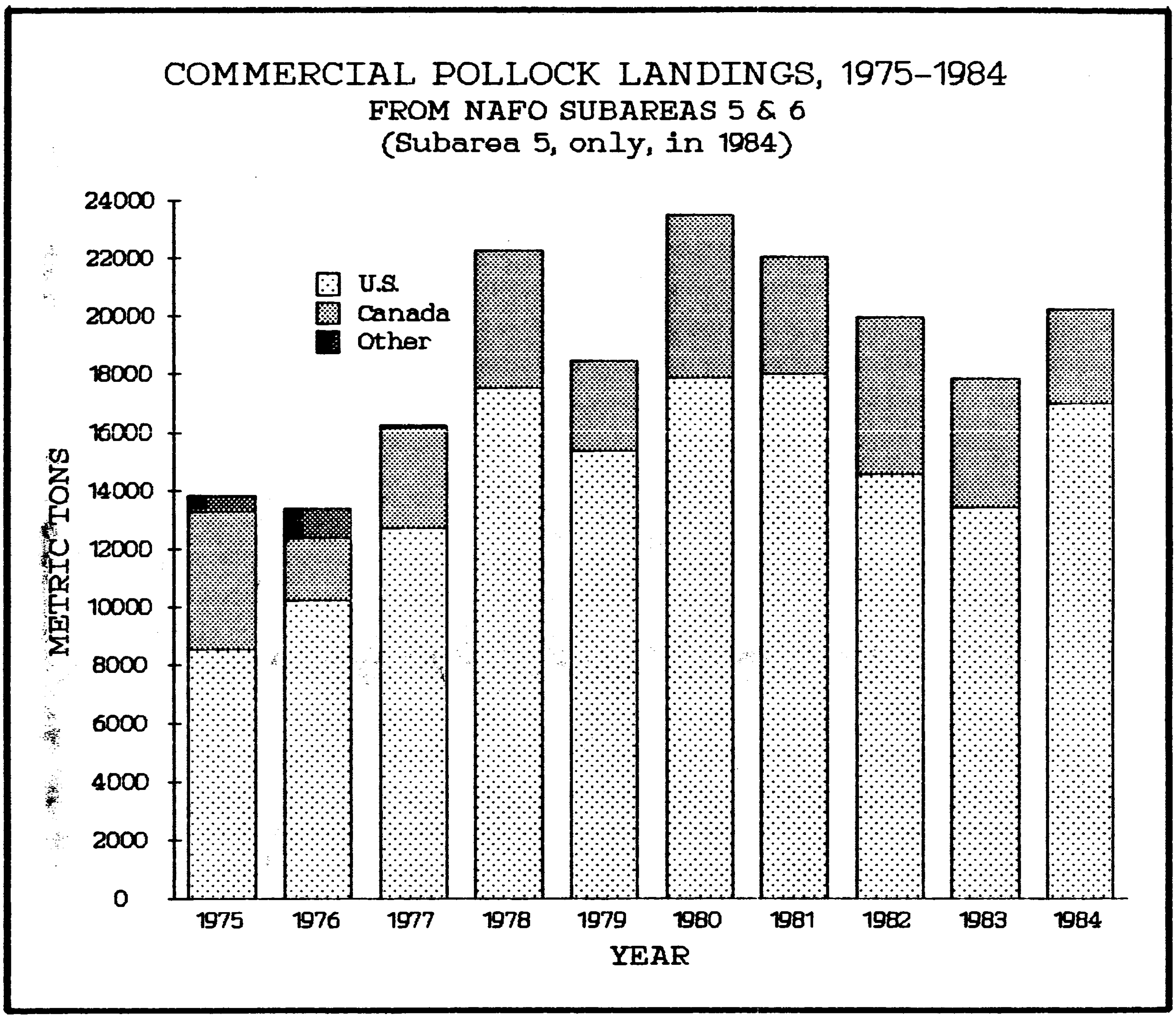
The total 1983 commercial catch of pollock from the Gulf of Maine and Georges Bank (provisional) was 17,828 mt, 13,445 mt was landed by U.S. fishermen and the balance by Canadians. This represents a decline from a total nominal catch of 23,500 mt reported in 1980, but the latter may have been biased upwards by misreporting of other species (e.g., haddock). The U.S. recreational pollock catch for 1983 is unknown but may approximate that estimated for 1979 (1,600 mt). The Canadian recreational pollock harvest appears to be of minor importance.

The total nominal catch of pollock (including recreational) from the FCZ plus the Scotian shelf increased from an average of 26,100 mt in 1968-1970 to 47,600 mt during 1978-1979. In 1980, total landings increased further to 57,400 mt while provisional statistics for 1981 indicate a total catch of 56,700 mt. Again, however, the accuracy of the reported data for recent years is not known.

The total size of the Gulf of Maine-Scotian shelf stock of pollock appears to be relatively high at present although the exact nature of current trends are somewhat obscured by conflicting evidence. Canadian commercial catch per unit of effort (CPUE) information, consistent with the Canadian summer survey index, indicated substantial increases in stock sizes in 1980. U.S. commercial CPUE indices, however, have not increased since 1979. The U.S. spring trawl survey results are lacking in any consistent trends, although the summer survey abundance indices for the period 1977-1980 are substantially higher than were seen in the 1960's. The U.S. autumn survey data have shown a definite decline in abundance (numbers of fish), however, in 1981 and 1982. It has been suggested that some of these inconsistencies may be explainable on the basis of fish distribution and availability to gear.

Virtual population analysis of commercial catch at age data indicate a decline in total numbers of fish in the Gulf of Maine-Scotian shelf stock of pollock from 1978 to 1982. However, biomass increased through 1981 due to growth of fish in the strong 1971, 1975, 1976, and 1979 year classes. Fishing mortality rates in 1982-1983 were about F = 0.26 (approximately at the F-0.1 level). With a continuation of the same level of effort in 1984, stocks should exhibit modest increases to about 321,000 mt while yielding about 50,000 mt. At equilibrium, fishing at the F-0.1 level would yield 56,500 mt from a stock of 338,300 mt; fishing at F-max would provide an equilibrium yield of 60,700 mt from a stock of 224,800 mt. Thus, recent catches of about 57,000 mt from a stock size at about 88% of the F-0.1 equilibrium level were probably at fishing mortalities approximating F-max.

Figure 2A5


COMMERCIAL POLLOCK LANDINGS, 1975-1984
FROM NAFO SUBAREAS 5 & 6
(Subarea 5, only, in 1984)
U.S.
Canada
Other
METRIC TONS
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
YEAR

WHITING

The silver hake (*Merluccius bilinearis*), known commercially as whiting, is a widely distributed, slender, swiftly swimming fish which ranges from Newfoundland to South Carolina, but is most abundant off the New England coast. Whiting are largely bottom dwellers inhabiting continental shelf waters from the shore to depths of about 50 fathoms during the summer. As winter approaches, fish move to more offshore waters to depths of 100 fathoms or more. Thus, although temperature affects the distribution of whiting, the availability of food is also important. Whiting are voracious predators, nearly 80% of their diet consists of prerecruit finfish, but they also feed on euphausids and other crustacea. As one of the more numerous species of finfish in the Northwest Atlantic, whiting predation on other fish may exceed the total harvest of the commercially exploited species. Thus, the impact of whiting on the overall biota is potentially very great.

The preponderance of evidence seems to indicate that there are two major groups of whiting along the U.S. Atlantic coast. On the basis of morphometric characteristics, a group inhabiting the waters off Southern New England and the Mid-Atlantic may be distinguished from two northerly groups found in the Gulf of Maine and on Georges Bank (but the latter groups are not demonstrably separable on the same basis). Biochemical studies indicate genetic differences between a northern group (Gulf of Maine and northern Georges Bank) and a southern group (southern Georges Bank and southern New England - Middle Atlantic). In consideration of these various lines of investigation, it is expected that future stock assessments will be based on a two-stock approach. The currently available assessments follow the three-stock system established under ICNAF which was based principally on the existence of three major identified spawning areas. These include the coastal Gulf of Maine from Cape Cod to Grand Manan, southern and southeastern Georges Bank, and the Southern New England waters south of Martha's Vineyard. (Almeida and Anderson, 1980)

The Historic Fishery

Prior to the 1920's, whiting were generally considered a nuisance by fishermen with landings amounting to only about 3,000 mt. With the development of quick-freezing and mechanization in the processing sector which allowed the marketing of a higher quality product, the fishery gradually expanded with landings increasing from 4,901 mt in 1931 to 65,840 mt in 1955. Beginning in the 1960's, distant water fleets (principally the USSR) began to heavily exploit the whiting stocks of Georges Bank and Southern New England-Middle Atlantic. Total reported catches rose dramatically to almost 400,000 mt in 1965 and thereafter declined to average about 116,000 mt between 1973 and 1976. With the more recent substantial reductions in fishing effort, the Georges Bank stock appears to be stabilizing at a level about twice the size seen in the 1950's. The Southern New England-Middle Atlantic stock is rebuilding as the result of good recruitment and may be almost as large as it was prior to the massive foreign effort.

In the Gulf of Maine, the whiting fishery has remained almost exclusively a U.S. enterprise. But the stock size declined steadily throughout the 1960's as a result of poor recruiting year classes and very high fishing mortality rates. A contributing factor may have been the mortality exerted on prerecruit fish by the small mesh nets used in the northern shrimp fishery. With the recent decline of the shrimp fishery, the spawning stock of whiting gradually recovered to about one-third the level seen at its peak.

Current Conditions and Future Prospects

Total provisional 1983 landings of whiting from the U.S. Fishery Conservation Zone were 17,124 mt. U.S. vessels caught a total of 16,840 mt with the remaining 284 mt taken by distant water fleets (DWF). No Canadian catches were recorded. The 1983 recreational catch may approximate that estimated for 1982 (3,000 mt), the bulk of which was probably taken from the Southern New England-Middle Atlantic stock.

Gulf of Maine. The total provisional 1983 landings of whiting from the Gulf of Maine, 4,800 mt taken entirely by U.S. vessels, representing a slight increase over the 1982 level, interrupted a trend of gradually reduced catches observed since 1976. No recreational catches of whiting were estimated or were known to occur in the Gulf of Maine.

The recent series of spring and autumn NMFS bottom trawl survey results reflect the commercial catch per effort data which indicated a continuously increasing stock biomass from 1971 through 1976 followed by declines in 1977 and 1978 with a resurgence through 1980. This pattern in overall abundance was due to strong 1972, 1973, and 1974 year classes followed by the relatively weak 1975, 1976, and 1979 year classes. The stronger 1977 and 1978 year classes contributed to the increases in biomass seen in 1980, but apparently were not sufficient in preventing declines seen in the 1981 and 1982 survey abundance indices. The 1980 and 1981 year classes appear to be at least average in strength with the 1980 year class being potentially quite strong. Spawning stock biomass (age 2+) maintained a high level of about 157,000 mt during the decade, 1955-1966, supporting an average catch level of 28,500 mt at fishing mortalities at or below F-0.1. Since falling to less than 16,000 mt in 1971, the spawning stock has generally been continuously rebuilding and is projected to have reached about 44,000 mt in 1982, but it is still at a level which is less than 30% of that seen formerly.

Fishing mortality rates in the Gulf of Maine whiting fishery since 1976 have been less than F-0.1 ($F_{0.1} = 0.55$), reversing the trend seen in the late 1960's culminating in the very high F's of about 1.0 seen in 1970-1971. With the more recent declining catch levels, fishing mortalities over the period 1979-1981 have been estimated at F = 0.14. With a continuation of low catches and assuming only average strength for the 1980 and 1981 year classes, stock biomass should remain at current levels. If the 1980 year class proves to be of exceptional strength, then somewhat higher catch levels would still be consistent with maintenance of a stable stock biomass.

Georges Bank. The total provisional 1983 commercial catch of whiting from Georges Bank was only 1,222 mt, all but 73 mt (taken by DWF trawlers) being landed by U.S. fishermen, reflecting a continuing trend of extremely low catches seen since 1979. Recreational catches were nil.

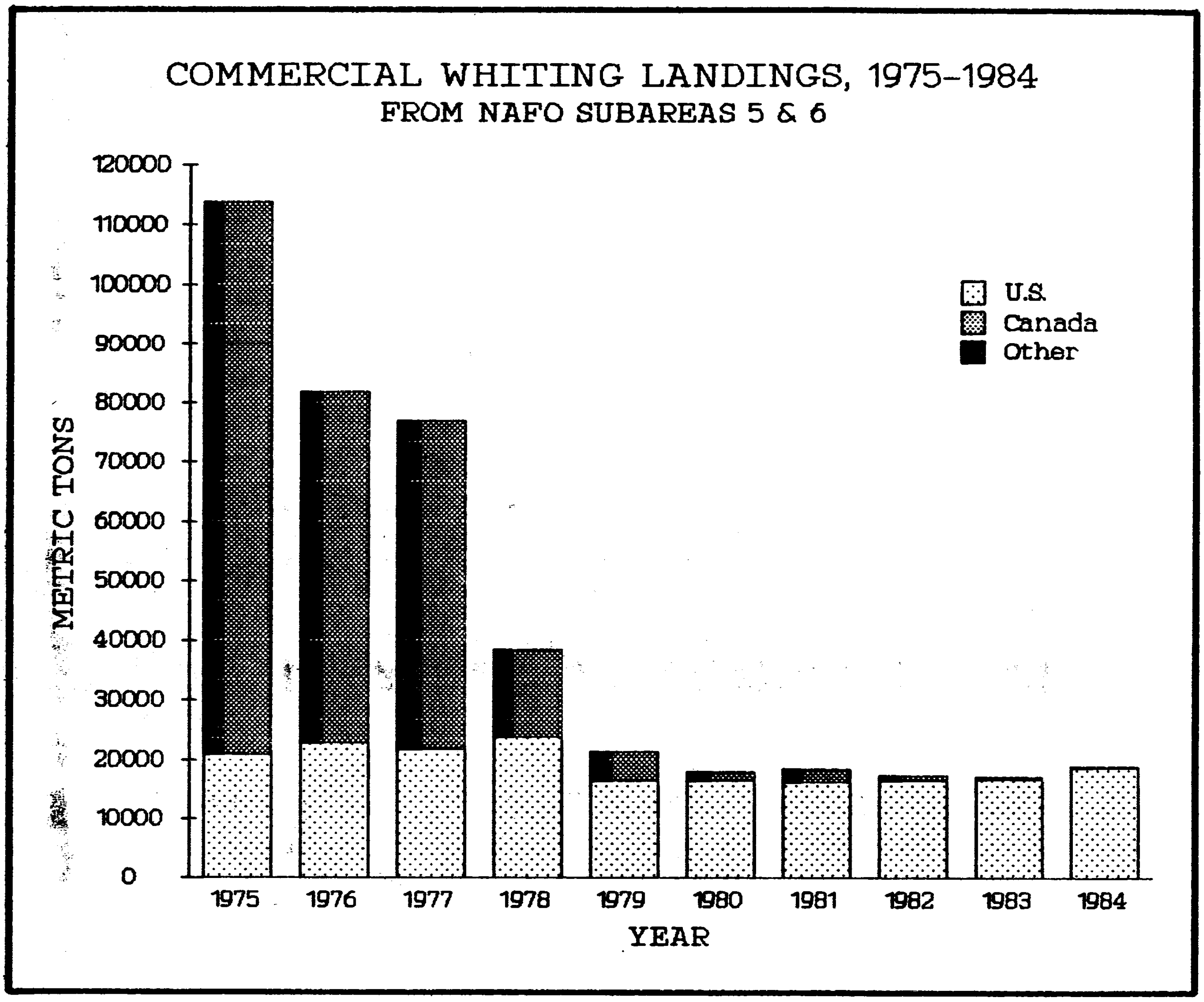
NMFS bottom trawl survey data indicate that the 1973 and 1974 year classes were quite strong, dominating catches through 1978, but that since 1975 no year classes of any substantial strength have appeared. Spawning stock biomass (age 2+), which reached nearly 600,000 mt just prior to massive removals by the DWF (principally the USSR), appeared to stabilize at about 167,000 mt over the period 1966-1976, but then sharply declined to only about 20,000 mt in 1978 due to a combination of high fishing mortality rates and relatively poor recruitment. Despite currently low recruitment levels (less than 30% of the 1955-1982 median), continuation of the recent low catches may be expected to result in gradual increases in stock sizes.

Southern New England-Middle Atlantic. The 1983 commercial catch of whiting in the Southern New England-Middle Atlantic area was 11,099 mt (provisional). The U.S. share of this total was 10,888 mt with the remaining 211 mt taken by foreign nationals other than Canada. The recreational catch of whiting from the Southern New England-Middle Atlantic stock may approximate 3,000 mt. Hence, total landings approximating 14,000 mt were at about the same level as were taken during the period 1955-1962 just prior to the sharp increases in stock size which attracted massive foreign effort during 1963-1969.

NMFS bottom trawl survey data indicate, as with the Gulf of Maine and Georges Bank stocks, that the 1973 and 1974 year classes were of superior strength as compared to more recent years. Since the 1974 year class, the 1976 and 1978 year classes appear to be the strongest. The 1980 and 1981 year classes are apparently average in strength. Total stock biomass (age 1+) at the beginning of 1982, estimated to be 79,100 mt, was substantially less than the peak value of about 450,000 mt which was reached in 1965, but was identical to the 1955-1960 average of 79,000 mt estimated from VPA. The spawning stock biomass (age 2+) at the beginning of 1982 was estimated to be 64,100 mt, slightly higher than the 1955-1960 average of 60,000 mt.

The most recent available estimate of fishing mortality (1981), F = 0.47 for the fully recruited age classes, continues a trend seen since 1976 of Fs less than F-0.1. The provisional 1983 catch of some 14,000 mt probably generated a fishing mortality rate less than F-0.1 in 1983. Thus, spawning stock sizes at the beginning of 1984 probably registered further increases over the 1983 level. For the forseeable future, maintenance of the current stock size is attainable with total removals of about 18,000 mt or less.

Figure 2A6


COMMERCIAL WHITING LANDINGS, 1975-1984
FROM NAFO SUBAREAS 5 & 6
METRIC TONS
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
U.S.
Canada
Other
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
YEAR

RED HAKE

The red hake (Urophycis chuss), variously known as the squirrel hake or ling, is a member of the true hakes (as opposed to the silver hake or whiting) and a close relative of the haddock, pollock, and Atlantic cod. The red hake is not at all cod-like in appearence, being a relatively slender, soft-bodied fish tapering from the shoulders to a small weak tail. Juvenile red hake are very similar in appearance to their white hake siblings, a fact which has led to some confusion with regard to some of the existing catch-at-age information. The early life history of the two species, however, differ appreciably. Red hake migrate to the bottom abandoning a postlarval existence in the plankton on reaching a total length of about 30 mm (1-3/16 inches). On reaching the bottom, postlarval red hake instinctively enter the mantle cavity of the sea scallop (Placopecten magellanicus) where they live inquilinistically until they are literally too large to enter the host animal (110-140 mm total length). By contrast, white hake remain in the surface waters until reaching a total length of about 80 mm and establish no similar relationship with sea scallops or any other animal upon descent to the bottom.

The red hake is a temperate species ranging from south of the Gulf of St. Lawrence to North Carolina. During the summer months they migrate shoreward to shoal, warm waters to spawn. Major spawning areas include the southwest part of Georges Bank, and off Southern New England south of Montauk Point. Overwintering areas include the deep waters of the Gulf of Maine and along the outer continental shelf and slope south and southwest of Georges Bank. On the basis of the two, rather distinct, spawning grounds, distribution studies, and trends in abundance, the red hake in U.S. waters are considered to be comprised of two stocks, the Georges Bank stock and the Southern New England-Middle Atlantic stock.

The Historic Fishery

There was no directed fishery for red hake on Georges Bank until the advent of substantial foreign effort, principally by the USSR, in 1963. Total commercial catches then reached a peak of 53,202 mt on Georges Bank in 1965 and 61,153 mt in 1966 from the Southern New England-Middle Atlantic region. The U.S. commercial fishery for red hake derived its major impetus from the industrial fishery in the Southern New England-Middle Atlantic area, with hake becoming an important component by the 1950's. Since 1966, however, with the expanding Peruvian anchovy fishery dominating the industrial fishery products market, total U.S. landings of red hake were sharply reduced to current levels fluctuating between 2,000 and 7,000 mt.

Current Conditions and Future Prospects

The total 1983 commercial landings of red hake (provisional) from the U.S. Fishery Conservation Zone were 2,170 mt, all but 11 mt of by-catch by DWF trawlers were taken by U.S. vessels. Recreational catches of red hake in 1982 were estimated to be about 500 mt, all of which was taken in the Mid-Atlantic Bight. The 1983 recreational catch is unknown but may approximate the 1982 level.

Georges Bank. The provisional 1983 commercial landings of red hake from the Georges Bank stock was 901 mt, most of which was taken in areas of the southern and western Gulf of Maine. The catch from Georges Bank (5Ze) was only 83 mt, reflecting the low abundance indices based upon the NMFS bottom trawl surveys. The spring trawl survey catch per tow index increased steadily during 1978-1981 but dropped sharply in 1982 to the lowest level seen in the 1968-1982 time series. Survey data indicate that the 1973 and 1974 year classes were quite strong as compared to other years while the 1975 and 1976 year classes were weak. Year classes produced since the 1977 appear to be average in strength although the 1980 year class shows indications of being quite strong.

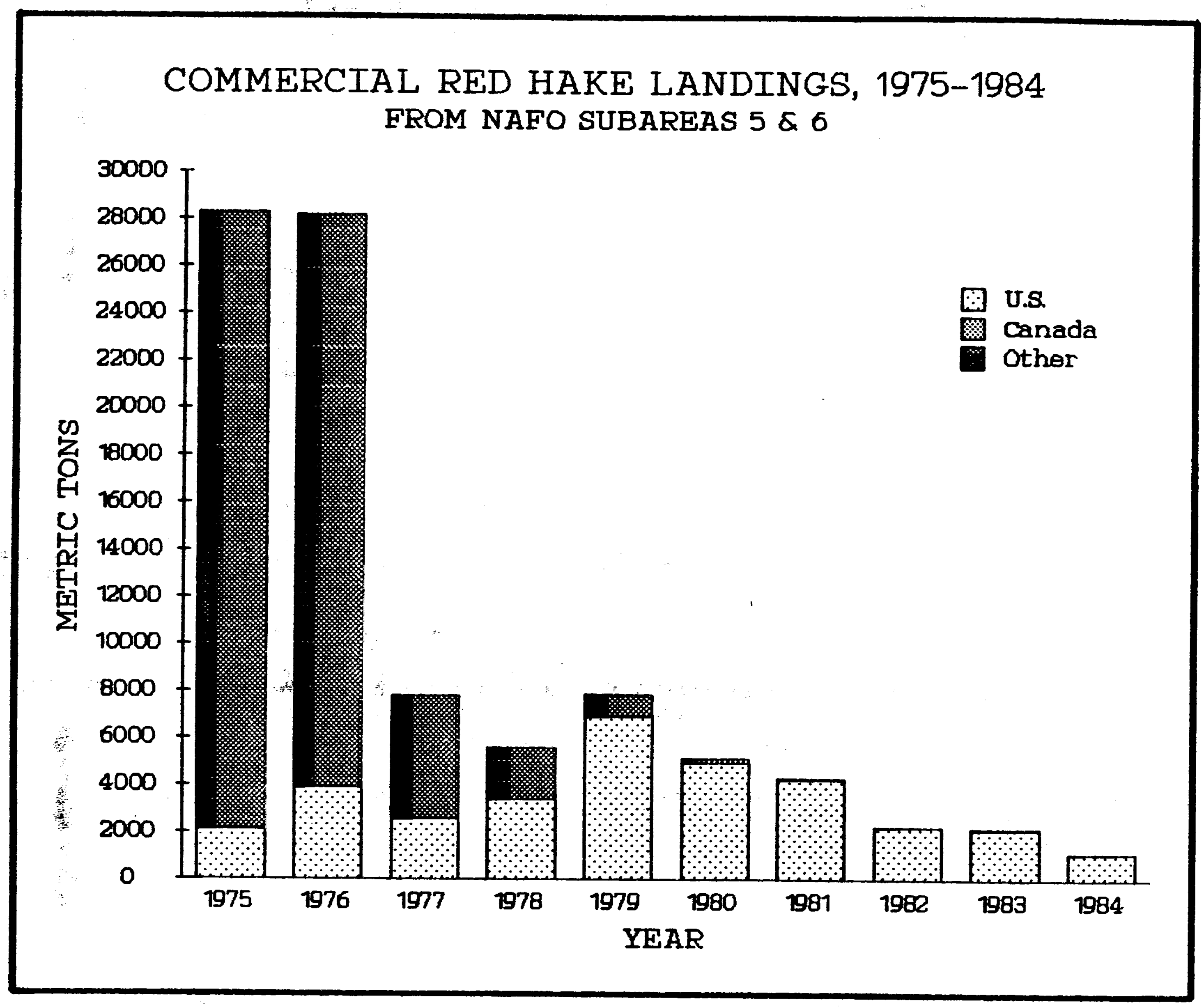
Fishing mortality rates for fully recruited age classes have shown two distinct peaks in recent years, exceeding F=1.0 in 1972-1973 and in 1976. The former was due to heavy removals principally by the USSR, the latter was probably due to a combination of poor recruitment and significant catch levels. Since 1979, F's have probably been only about F=0.1, substantially less than the F-0.1 level. Spawning stock (age 2+) biomass fell sharply from a peak of about 160,000 mt during 1965-1968 with very high catches in 1965 and 1966, recovered to nearly 87,000 mt in 1971, but declined steadily to less than 12,000 mt in 1977 with the heavy catches in 1972, 1973, and 1976. Since 1977, the spawning stock has slowly been rebuilding.

Southern New England-Middle Atlantic. The total 1983 commercial landings of red hake in the Southern New England-Middle Atlantic area was 1,268 mt (provisional). The total recreational catch of red hake from all areas (assumed to be 500 mt) was probably taken in the Mid-Atlantic Bight.

The NMFS spring bottom trawl abundance indices increased steadily during 1979-1981 but declined somewhat in 1982 to levels approximating their long-term average. Autumn trawl survey data show a similar pattern. Information regarding the strength of recruitment has shown that every fifth year since 1969 has produced a relatively strong year class, 1969, 1974, and 1979. The remaining year classes, including the 1980 and 1981, were average in strength.

Fishing mortality rates for fully recruited fish averaged about F=0.8 (significantly higher than F-0.1) during 1972-1976, but fell sharply to an average of F = 0.23 during 1977-1980 with the substantially reduced catch rates during those years, and has since been only about F = 0.1 with further reductions in catch. Spawning stock (age 2+) biomass has exhibited a pattern over time which is similar to that for the Georges Bank stock. Spawning stock biomass has gradually increased from a low of about 30,000 mt reached in 1977 to a projected 43,000 mt estimated for 1985 with a 1984 catch of 1,200 mt.

Figure 2A7


COMMERCIAL RED HAKE LANDINGS, 1975-1984
FROM NAFO SUBAREAS 5 & 6
METRIC TONS
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
YEAR
U.S.
Canada
Other

WHITE HAKE

The white hake (Urophycis tenuis), also known as the mud hake, Boston hake, and ling, is one of the true hakes and a relative of the Atlantic cod, haddock, and American pollock. Smaller individuals of the white hake are similar in appearance to the red hake, giving rise to an indeterminable bias in some of the reported catch at age information. White hake, however, grow to a significantly larger size such that all hake larger than 55 cm (22 inches) which appear in landed catches are probably white hake. Whereas red hake is basically a temperate species with a center of distribution in the New England-Middle Atlantic area, white hake is a boreal species which is most abundant in the Gulf of St. Lawrence and off Newfoundland. In U.S. waters, white hake are found most commonly in the deep waters of the Gulf of Maine over muddy bottom and along the edge of the continental shelf and slope. Although smaller individuals may be found in shoal water, adult white hake are most common at depths from 50 fathoms to over 500 fathoms or where cool water temperatures prevail. White hake of the Scotian Shelf, Gulf of Maine, and Georges Bank are considered to be a single stock.

The Historic Fishery

White hake have long been an important element in the overall mix of groundfish, particularly in the eastern Gulf of Maine. The larger catches of white hake from the American stock of fish have been by Canadian fishermen on the Scotian Shelf. However, the great majority of landings from the Gulf of Maine-Georges Bank area have been by U.S. vessels with a significant proportion of those landings being larger fish taken by gillnets. Since 1971, commercial landings have generally ranged from 3,000 to 4,000 mt with a gradual upward trend. Total catches averaged 3,630 mt over the period 1975-1980, then rose sharply to 6,160 mt in 1981. Recreational catches of white hake are generally considered to be insignificant.

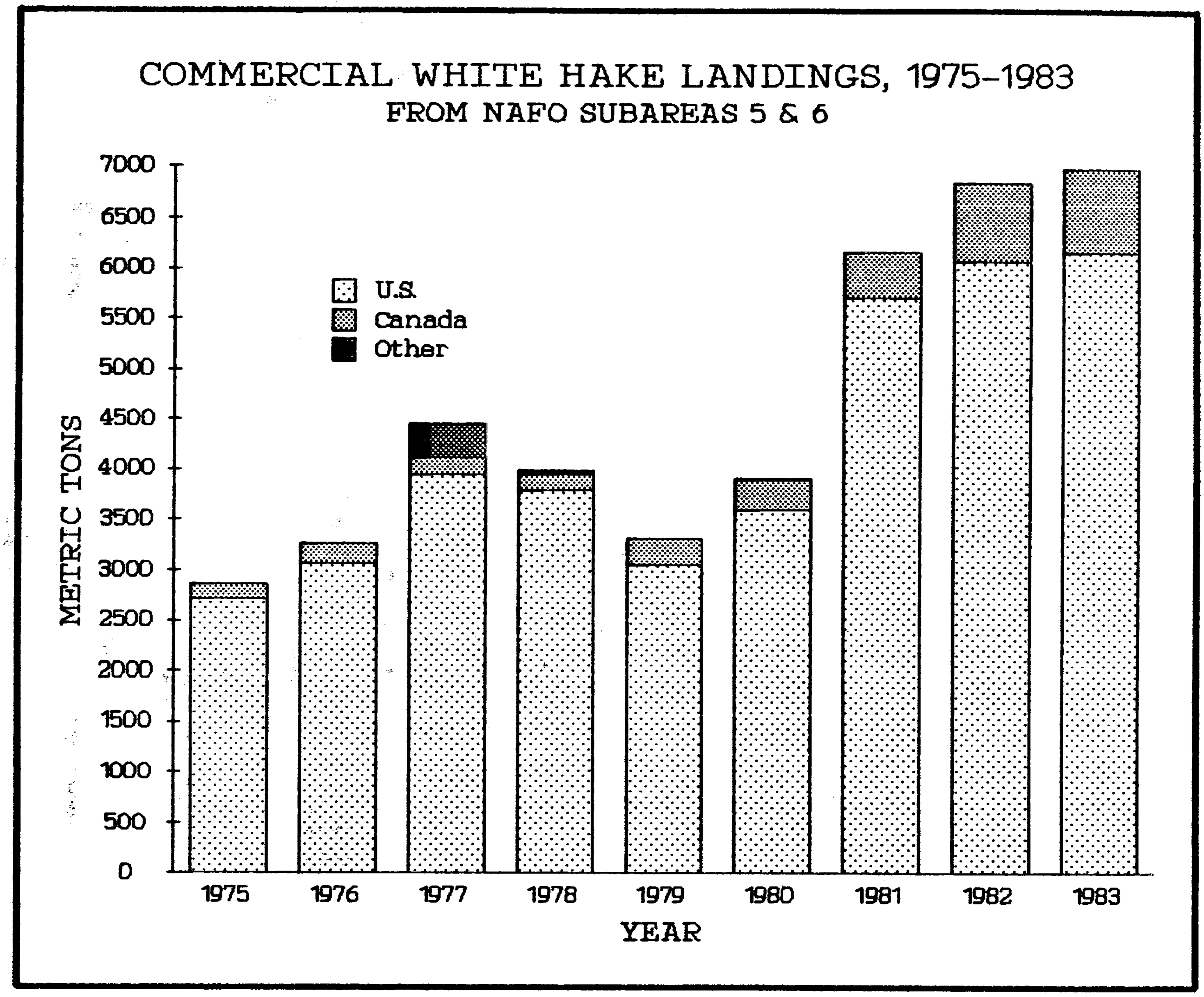
Current Conditions and Future Prospects

The total 1983 commercial catch of white hake from the Gulf of Maine - Georges Bank area (provisional) was 6,979 mt, of which 6,168 mt were by U.S. fishermen with virtually all of the balance of 811 mt by Canadians.

The NMFS spring trawl survey abundance index fluctuated about an average of 13.1 kilograms per tow over the period 1973-1977, registered a drop to 5.0 kilograms in 1979, sharply increased to 19.9 kilograms in 1981, but has since continuously declined to only 4.1 kilograms in 1984. The autumn survey index has fluctuated without definite trends since the late 1960s but has also shown significant declines in 1982 and 1984. US commercial catch per unit of effort (CPUE) information has remained relatively high since 1980, but such indices may have been biased upwards with the increasing share of the catch by larger (tonnage class 4) vessels, operating with relatively higher fishing power, at the expense of class 2 vessels (Burnett et al, 1984).

In the face of a declining biomass since the sharp peak in 1981, 1982 and 1983 catch levels have remained in the 6,000-7,000 mt range, strongly suggesting that fishing mortality rates have been increasing and may continue to increase with such levels of catch. Although more information is needed for proper evaluation of the white hake resource, it appears doubtful that continuation of recent recruitment will be able to sustain harvest levels in the 6-7,000 mt range (Burnett et al, 1984).

Figure 2A8


COMMERCIAL WHITE HAKE LANDINGS, 1975-1983
FROM NAFO SUBAREAS 5 & 6
U.S.
Canada
Other
METRIC TONS
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1975
1976
1977
1978
1979
1980
1981
1982
1983
YEAR

YELLOWTAIL FLOUNDER

The yellowtail flounder (Limanda ferruginea) is a medium sized, small mouthed, 'right handed' flounder which ranges from Newfoundland to Chesapeake Bay with major concentrations in U.S. waters on Georges Bank and in the Southern New England mid-shelf area at depths to about 40 fathoms. It may also be found along the outer edge of Cape Cod to Massachusetts Bay and to a lesser degree along the western periphery of the Gulf of Maine. Yellowtail is a relatively sedentary species which prefers sandy mud bottoms in rather distinct geographic areas. Although fish in the Georges Bank-Cape Cod-Southern New England assemblages exhibit insignificant seasonal movement patterns such that these areas represent rather distinct groupings, yellowtail found in the western Gulf of Maine may undergo seasonal north-south movements along the coast.

Since fish are concentrated in two major areas, western Georges Bank and Southern New England, which have attracted the bulk of effort in the historic commercial fishery, yellowtail have been managed on the basis of the same two areas delimited by the Great South Channel (69°W Long). Whereas this definition probably encompasses the two major spawning units of fish, it is somewhat ambiguous with regard to the Cape Cod and western Gulf of Maine assemblages. In particular, the former group may constitute a separate spawning stock. However, both the Cape Cod and western Gulf of Maine assemblages have arbitrarily been grouped with the Southern New England unit (West of 69°W) for management purposes.

The Historic Fishery

Yellowtail flounder were relatively unexploited prior to 1935. Concurrent with a decline in the abundance of winter flounder, the Southern New England yellowtail fishery rapidly developed, exhibiting two apparent cycles with peak landings reaching 36,000 mt to 38,000 mt in the 1940's and 1960's and falling to 2,000 mt or less during the 1950's and 1970's. Foreign catches, which were insignificant prior to 1965, peaked in 1969 with a nominal catch of 17,600 mt. The Georges Bank fishery developed more slowly, not reaching landings of 10,000 mt until 1962. Catches then peaked at about 21,000 mt in 1969-1970 but subsequently declined to reported landings of only 5,000 mt in 1978. Although some of the more recent reported landings may be biased to some unknown degree (missreported with respect to which side of the 69° meridian the catches were actually taken) when restrictive catch quotas were in effect under the Atlantic Groundfish FMP, the overall cyclical nature of reported yellowtail landings is probably a true reflection of actual catches. Landings of yellowtail from the Cape Cod grounds since 1935 have consistently averaged about 2,000 mt, although recent catches have been somewhat higher (reaching 5,700 mt in 1980) with increased levels of fishing effort. Catches in the western Gulf of Maine have been relatively insignificant, about 500 mt or less.

Current Conditions and Future Prospects

The total 1983 commercial landings of yellowtail flounder from the U.S. Fishery Conservation Zone were 33,112 mt (provisional), the highest level of landings since 1972. All but 46 mt, taken by Canadian fishermen principally on Georges Bank, were landed by U.S. vessels. There is no significant recreational fishery for yellowtail although some fish are apparently taken in the Mid-Atlantic area.

Georges Bank. The provisional 1983 commercial landings of yellowtail flounder from Georges Bank (area 5Ze) were 19,432 mt, including 43 mt by Canadians. This represents a 100% increase over the 1981 level of about 9,700 mt from the same area. Catch at age information from the 1982 and 1983 landings indicated that the increase in landings over the 1981 level largely resulted from recruitment of the 1980 year class with significant contributions from the 1979 and 1981 cohorts. Preliminary information indicates a 1984 catch level of only 5,765 mt from the area east of 69°W Long, a precipitous decline from the 1983 level.

Commercial catch per unit of effort information has remained stable since 1982 but NMFS spring and autumn trawl survey indices have significantly declined. Consistent with landings data, survey data reflect the strength of the 1979-1981 year classes, particularly the 1980 year class. The 1982 and 1983 year classes appear to be among the weakest observed in the history of the trawl surveys. Since 1982, the autumn trawl survey abundance index has declined to the lowest level seen in the history of the survey. These results indicate a rapid deterioration of resource condition in the past two years which is not likely to improve in the near future, given the poor indications from the 1982 and 1983 year classes.

Fishing mortality rates in the historic Georges Bank yellowtail flounder fishery have consistently exceeded F-max = 0.5, but have been nearly double that level in recent years. Assuming a natural mortality rate, M=0.2, for yellowtail, then estimated fishing mortalities, based on analysis of survey data, range from F=0.62 to F=1.12 (mean 0.84) for the period 1977-1983, and F=0.59-1.24 (mean 0.85) during 1980-1983. The total cost to the fishery from foregone potential yield associated with such excessive exploitation rates is very substantial.

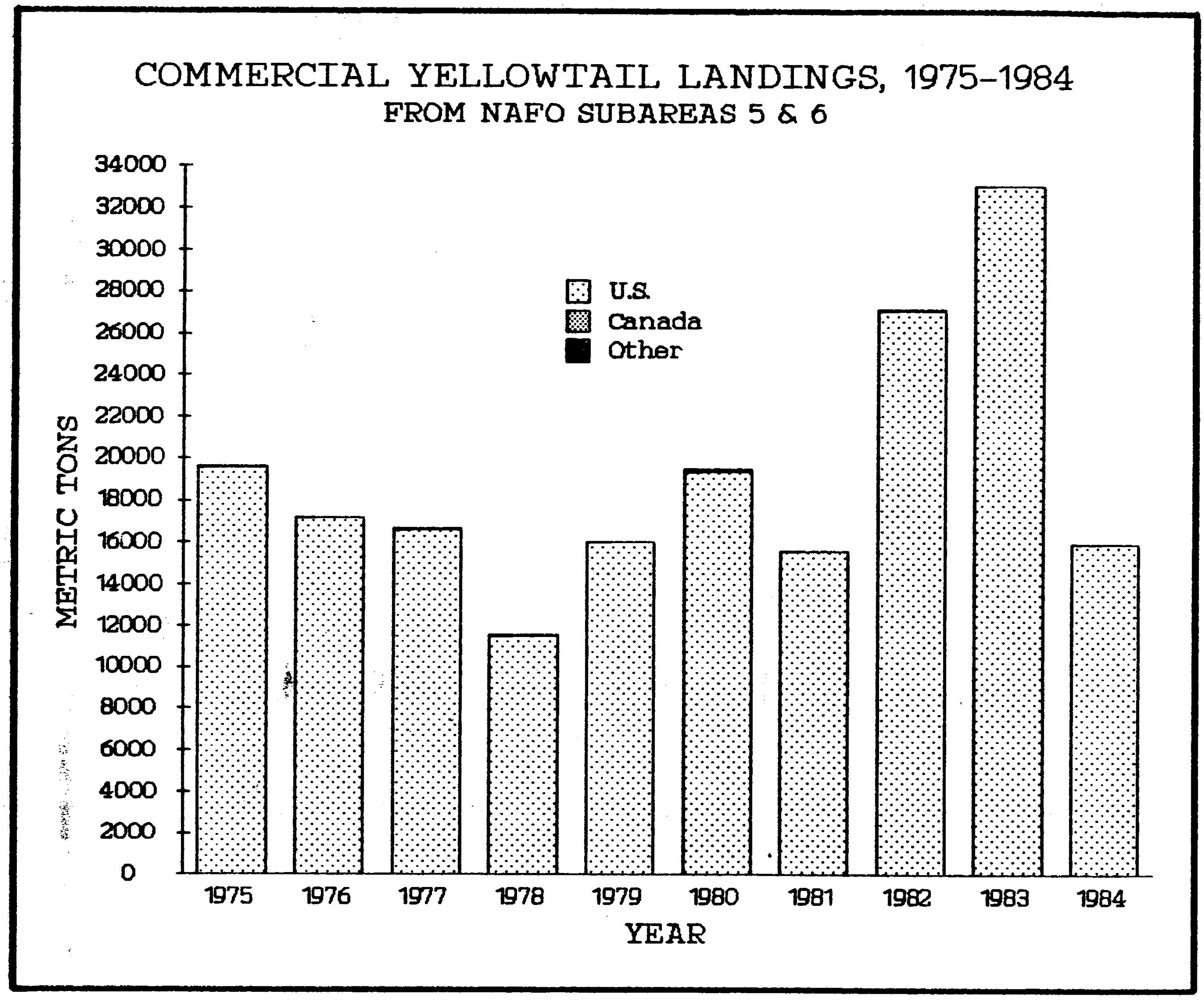
Southern New England-Middle Atlantic. The total 1983 commercial landings (provisional) of yellowtail flounder from area 5Zw-6 were 12,343 mt, all by U.S. fishermen. The 1981 catch level from the same fishing grounds was only about 3,750 mt. Catches more than doubled to about 7,850 mt in 1982 and registered a further increase of nearly 60% to the 1983 level. Recreational catches of yellowtail flounder are not well documented, but it is likely that all such catches occur in the Mid-Atlantic area and probably do not exceed 50 mt, annually.

NMFS bottom trawl surveys indicated a substantial increase in yellowtail abundance (by number) and biomass through 1982 for the Southern New England and Mid-Atlantic areas followed by a precipitous decline through 1984 to levels near the lowest seen in the historic time series. Age data indicate that the 1979, 1980, and 1981 year classes were the strongest since the mid-1970's with the 1980 year class being the stronger. With recruitment of these year classes in 1982 and 1983, intensified fishing effort rapidly dissipated stock biomass. With the weak appearance of the 1982 and 1983 year classes, the 1984 stock biomass reached the low levels last seen in the mid to late 1970s. The Cape Cod assemblage has not shown any consistent trend in recent years; indices are currently at near the long-term average.

Fishing mortality rates of yellowtail flounder in the southern New England-Middle Atlantic areas have historically exceeded F-max. Based upon analysis of survey data, estimates of F over the period 1980-1983 range F=0.8-1.33, capping a trend of high mortality rates seen over the past twenty years (Clark et al, 1984). So long as fishing mortality rates continue to exceed F-max, yield from the fishery will continue to be dependent upon the newly recruiting year classes. Moreover, with the appearance of strong recruiting year classes (e.g., 1980 year class) additional effort may be expected to enter the fishery, resulting in higher fishing mortality which is concentrated principally on the recruits with a concurrent increase in discards.

Despite the historic pattern of excessive fishing mortality rates in the yellowtail flounder fishery, there is little evidence that recruitment is in any serious jeopardy. It is probable, however, that the intensive exploitation of the species has contributed to the extreme variability seen in the strength of recruiting year classes and that a less intensive fishery would allow the creation of a more stable spawning population. It is certain that reductions in the levels of fishing mortality and discarding would have a dramatic impact on yield from the fishery.

Figure 2A9


COMMERCIAL YELLOWTAIL LANDINGS, 1975-1984
FROM NAFO SUBAREAS 5 & 6
METRIC TONS
34000
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
U.S.
Canada
Other
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
YEAR

AMERICAN PLAICE

The American plaice or dab (Hippoglossoides platessoides) is a large mouthed, 'right handed' flounder which occurs on both sides of the North Atlantic and is distributed in North America from southern Labrador to the waters off Rhode Island. The American plaice is an arctic-boreal species, preferring a temperature range of about 35° to 45°F, and is most commonly found on sandy mud bottoms in the Gulf of Maine and on Georges Bank at depths of 20 to 100 fathoms. Commercial concentrations in U.S. waters are generally in the depth range 50-100 fathoms. American plaice tend to remain within the same general locality once taking up a benthic existence after metamorphosis, exhibiting no significant seasonal or spawning migrations.

There are two recognized stock units of American plaice, Gulf of Maine and Georges Bank. Spawning appears to be a widespread phenomenon in the western Gulf of Maine and on the continental shelf south of Martha's Vineyard with the Massachusetts Bay region representing a major nursery area. American plaice is one of the few species of commercially important fish which exhibits spawning activity in the Bay of Fundy although there is no evidence that such activity is successful in producing viable larvae.

The Historic Fishery

Commercial interest in American plaice has principally been as an alternative to winter flounder and yellowtail flounder. Historic landings of American plaice from the 1940's through the 1960's were variable from less than 2,000 mt to over 5,000 mt (in 1951) as landings of the alternative, higher valued, flounders waxed and waned. Despite commercially significant abundance levels (in terms of numbers of fish), historic demand for American plaice failed to stimulate development of a significant directed fishery probably because of the slow growth rate of American plaice relative to other, commercially more attractive flounders. With a slow growth rate for American plaice, most of the fish taken may be too small to be marketable and are either discarded or are used as bait in other fisheries.

In recent years, landings of American plaice have increased as a reflection of greater demand as abundances of yellowtail flounder were in decline. Catches in the FCZ increased from 2,000-3,000 mt in the mid-1970's to average 12,646 mt over the period 1979-1981.

Current Conditions and Future Prospects

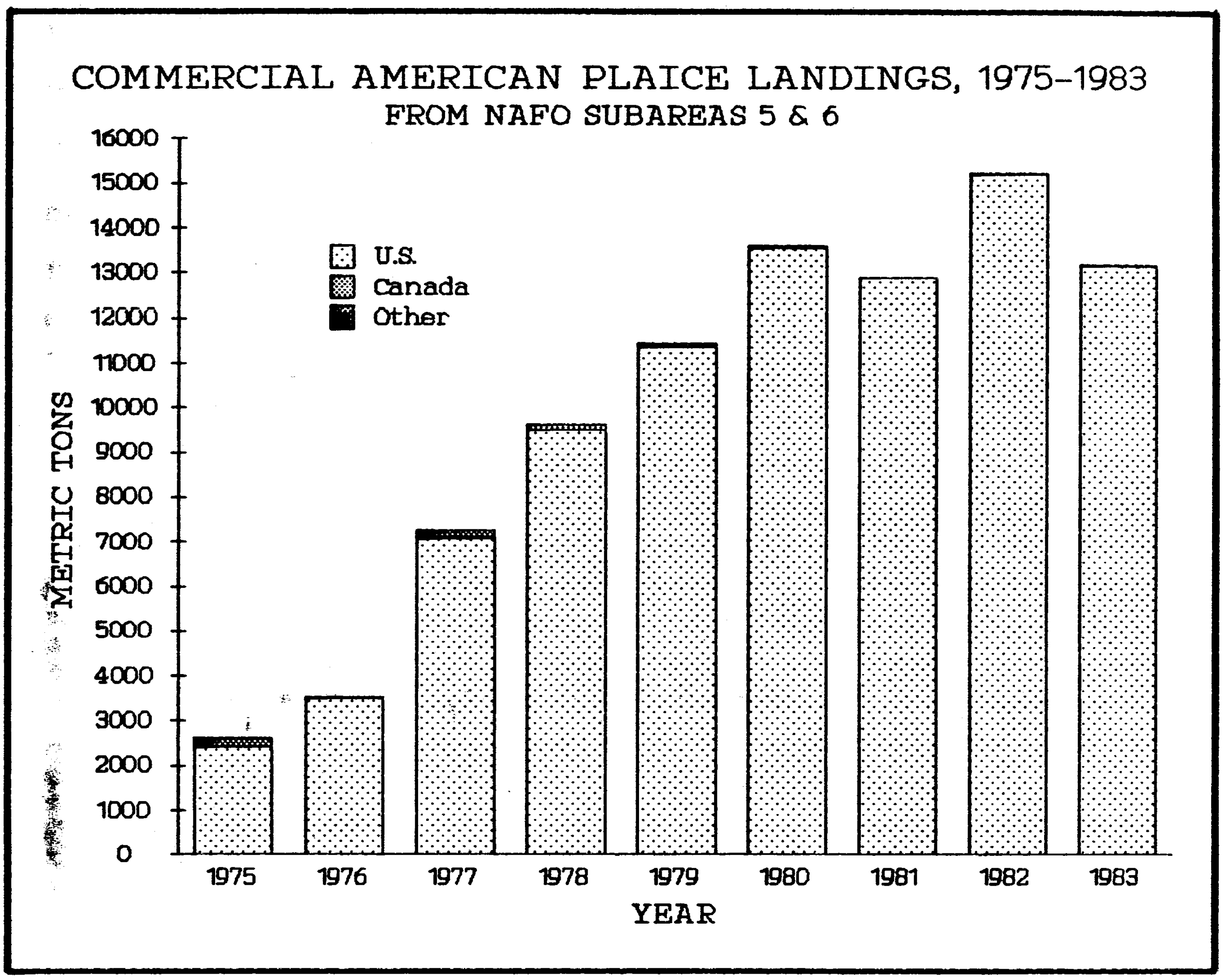
The total 1983 commercial landings of American plaice from the FCZ decreased 13% from the record 1982 landings to 13,196 mt (provisional). All but 37 mt, taken by Canadians principally from Georges Bank, were by U.S. fishermen. There is no recreational fishery for American plaice.

Gulf of Maine. The 1983 commercial landings of American plaice from the Gulf of Maine amounted to 9,144 mt (provisional), a 19% decline from the record 1982 level, and represented over 69% of the total commercial landings of American plaice from the FCZ. This continues a trend of dominance by Gulf of Maine catches seen since

1975. Historic catches, particularly since 1970, have generally paralleled NMFS autumn bottom trawl biomass indices which currently suggest that Gulf of Maine American plaice stock biomass is at near record-high levels. Current levels of fishing mortality rates are unknown. (U.S. DOC, 1982)

Georges Bank. The 1983 commercial landings of American plaice from Georges Bank and South were 3,985 mt (provisional) for a new record level of catch. All but 30 mt, taken by Canadians, were landed by U.S. vessels. American plaice landings from Georges Bank have been trending upwards since 1976, paralleling a similar trend in NMFS autumn bottom trawl biomass indices seen since 1974. The 1982 NMFS spring index was the highest in the time series. The survey data suggest continuing improvement in the population of American plaice on Georges Bank with current abundance and biomass approaching historically high levels. There are no current estimates of fishing mortality. (U.S. DOC, 1982)

Figure 2A10


COMMERCIAL AMERICAN PLAICE LANDINGS, 1975-1983
FROM NAFO SUBAREAS 5 & 6
U.S.
Canada
Other
METRIC TONS
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1975
1976
1977
1978
1979
1980
1981
1982
1983
YEAR

WITCH FLOUNDER

The witch flounder or gray sole (*Glyptocephalus cynoglossus*) is a medium sized, small mouthed, 'right handed' flounder which is common throughout the Gulf of Maine and also occurs in the deeper areas on and adjacent to Georges Bank and along the edge of the shelf as far south as Cape Hatteras. Witch flounder is a boreal species found on both sides of the North Atlantic and as far north as Newfoundland in North American waters. It is a fish of moderately deep water with the majority of catches being from 60 to 150 fathoms in bottom water temperatures of 2°-4°C in winter and 7°-9°C in summer. Witch flounder is apparently slow-growing since fish 24 inches in length taken on the Scotian Shelf have been found to be 18-20 years old.

Witch flounder exhibit no significant seasonal movements or spawning migrations, remaining in the same locality year round. Spawning occurs widespread throughout the Gulf of Maine and along the shelf edge of Georges Bank and South with peak activity occurring during July and August. The southwestern part of the Gulf of Maine may be an important nursery area. Research vessel survey data suggest that the Gulf of Maine population may be relatively discrete from fish in other areas.

The Historic Fishery

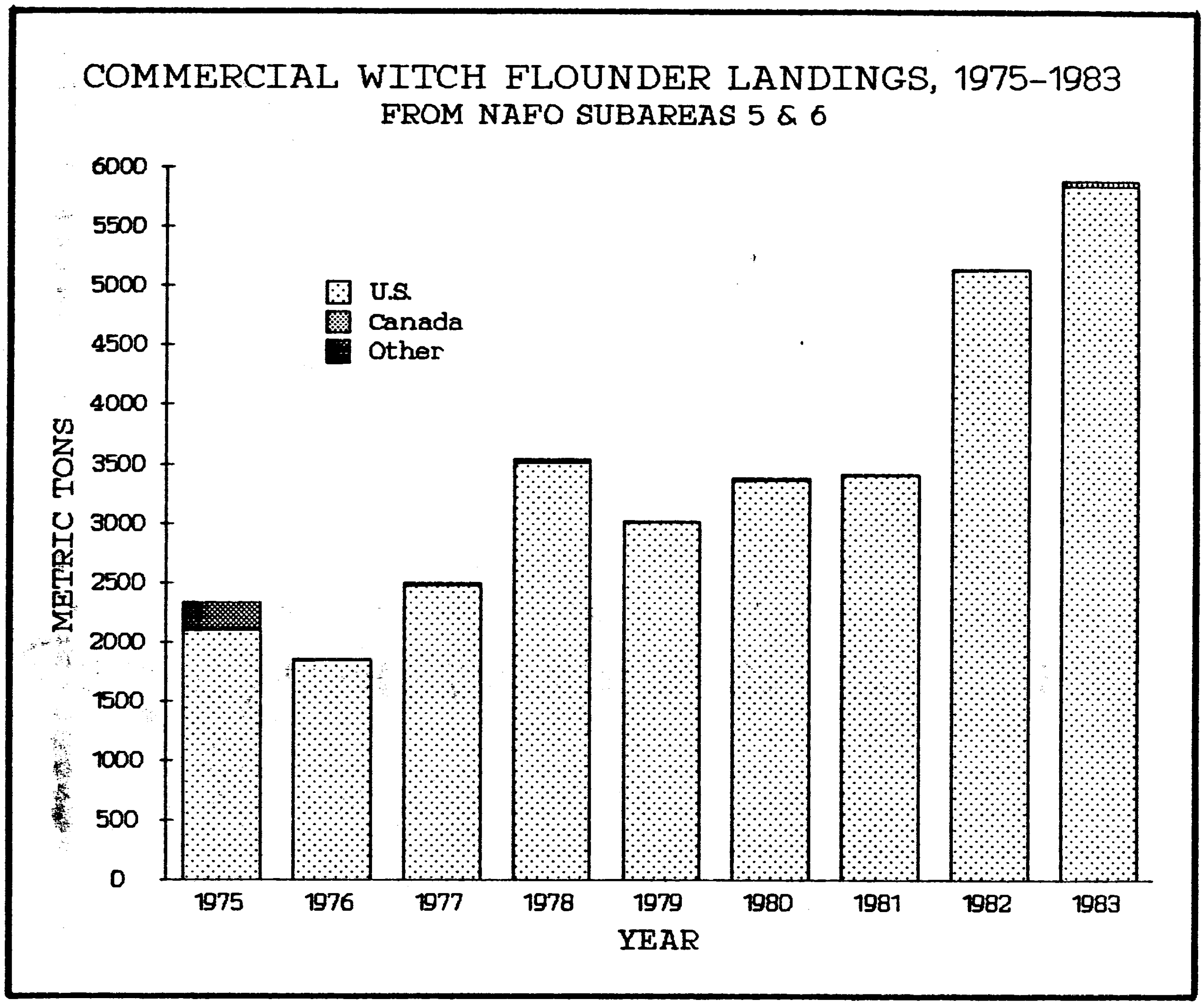
There is no significant directed U.S. fishery for witch flounder. However, a sporadic Canadian fishery exists on the Scotian Shelf. U.S. catches of witch flounder are usually taken as by-catch in directed fisheries for other species or as a component of mixed catches. Reported U.S. commercial landings of witch flounder over the period 1937-1977 have been variable, ranging 1,200-5,000 mt, exhibiting an historical pattern very similar to that for American plaice. Total reported commercial landings of witch flounder from the FCZ during 1965-1977 averaged 3,334 mt, with 78% (2,592 mt) by U.S. fishermen. Foreign catches (principally by the USSR) reached 2,600 mt in 1971-1972, then subsequently declined to insignificant levels by 1977. Recent U.S. catches from the FCZ have increased slightly to average 3,348 mt during 1978-1981, while Canadian catches have generally averaged less than 30 mt. There is no recreational fishery for witch flounder.

Current Conditions and Future Prospects

The total 1983 commercial catch of witch flounder from the U.S. Fishery Conservation Zone was 5,895 mt (provisional), all but 45 mt (Canada) by U.S. vessels. Continuing the trend seen in recent years, the bulk of the catch (76%) was taken in the Gulf of Maine.

The NMFS spring bottom trawl survey indices fail to exhibit a consistent trend over the time series, although the autumn survey data indicate a general decline since the late 1960's. The spring surveys indicate significant peaks in numbers and biomass in 1973 and 1981, the latter peak being reflected in the Massachusetts inshore spring survey. With the NMFS spring survey results being corroborated by the Massachusetts inshore survey, it is possible that the apparent declines traced by the NMFS autumn survey may be attributable to declining availability to the survey gear. However, in light of the apparent increased levels of exploitation in recent years, particularly by the larger vessel classes, and in light of the fact that witch flounder is a long-lived and slow-growing species less resilient to exploitation than other flatfish, further development of the fishery should proceed with caution. (Burnett and Clark, 1983)

Figure 2A11



8/30/85

WINTER FLOUNDER

The winter flounder (Pseudopleuronectes americanus), also known as the blackback and lemon sole, is a medium sized, small mouthed, 'right handed' flounder which is distributed in coastal waters and on offshore banks from southern Labrador to Georgia. Winter flounder generally exhibit only small scale movement patterns. In Mid-Atlantic waters, however, they undergo more extensive seasonal inshore-offshore migrations, inshore during the winter and offshore during the summer, in response to water temperatures.

Restricted movement patterns, and differences in meristic and morphometric characteristics suggest that relatively discrete local groups exist. Winter flounder tend to occupy the same spawning locations in consecutive years. Coastal populations of winter flounder move into estuaries, embayments and salt ponds during the winter to spawn and return to the adjacent coastal areas in the following spring. These inland waters then serve as nursery areas. Spawning also occurs offshore on Georges Bank, where ripe, partly spent, and wholly spent fish have been observed in research vessel catches coincident in time with inshore spawning activity. Together with data from tagging and meristic studies, the evidence indicates that the Georges Bank populations are self-sustaining. Nursery areas on Georges Bank are undefined but young fish, following a planktonic phase, probably seek shelter on hard, rocky bottom.

The Historic Fishery

Winter flounder were of little economic importance until about 1910. The small market demand was generally satisfied by catches with traps and beam trawls. Increased demand, leading to the introduction of the otter trawl around 1915, stimulated the development of a significant domestic commercial flounder fishery (principally winter flounder) with landings reaching 7,000 mt. Catches continued to rise to about 23,000 mt in 1930. Subsequent catches declined and have fluctuated between about 6,000 and 14,000 mt since 1937. Substantial foreign catches of winter flounder, taken by distant water fleets in the late 1960's and early 1970's, peaked at 6,900 mt in 1969 but have declined to insignificant levels since 1977.

U.S. commercial landings of winter flounder during 1972-1976 averaged only 7,961 mt (dropping to a low of 6,739 mt in 1976), repeating a period of reduced catches seen in the 1950's and early 1960's, but have since exceeded 10,000 mt annually, reaching 17,800 mt in 1981.

Recreational fishing for winter flounder is popular from Maine to Delaware Bay as it is one of the more accessible sport fish from shore and small boats during much of the year. Estimates of the recreational catch of winter flounder range from 7,500 to 15,800 mt, depending upon the recreational survey methodology.

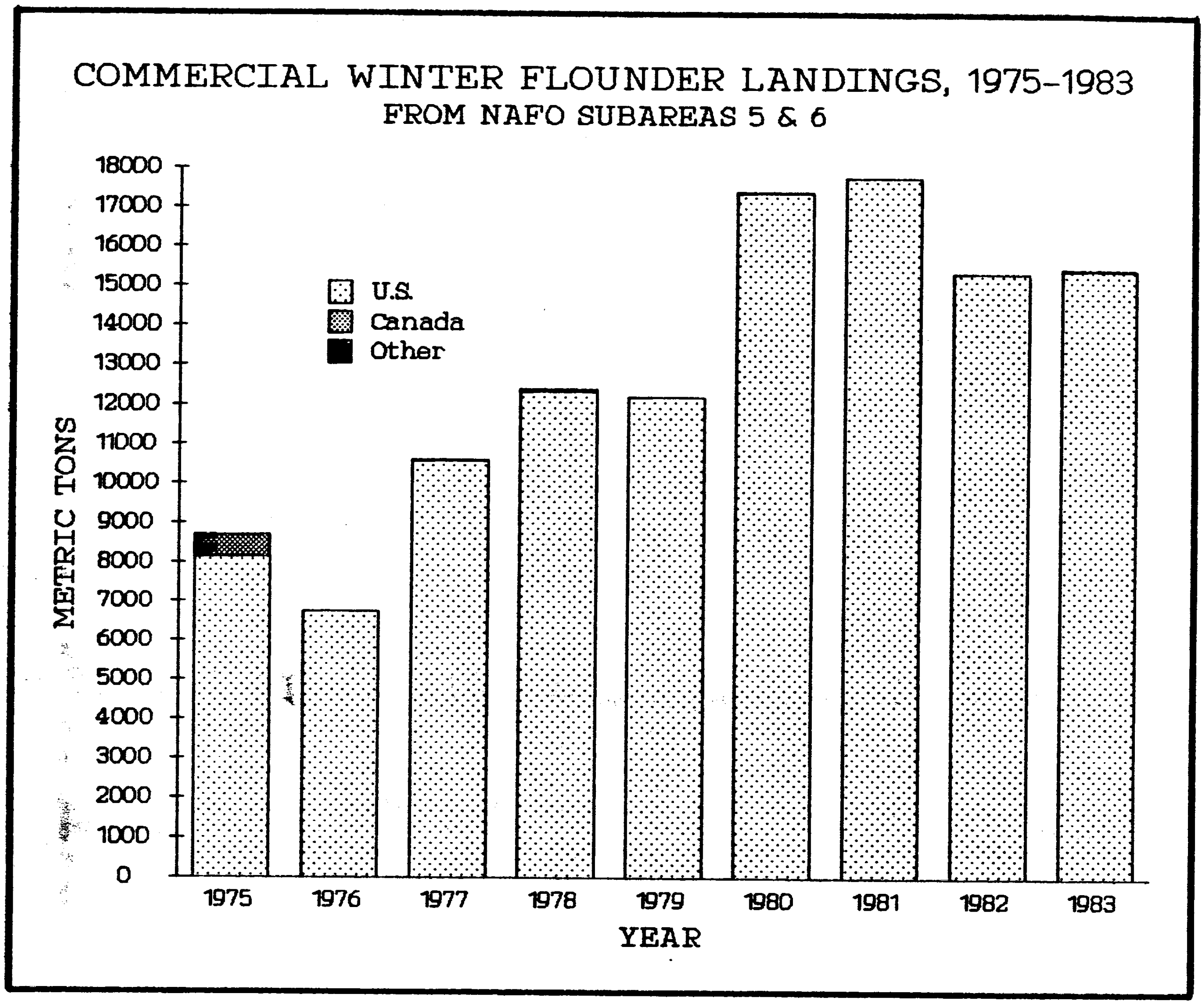
Current Conditions and Future Prospects

The total 1983 commercial landings of winter flounder from U.S. coastal waters and the FCZ were 15,486 mt (provisional). Annual Canadian landings over the last three years have amounted to only 19 mt, the balance being landed by U.S. fishermen. Over half (52%) of the 1983 landings were from

Georges Bank; Southern New England and Mid-Atlantic catches accounted for 34% of the total, and Gulf of Maine catches of 2,100 mt comprised 14% of the total 1983 landings.

The time series of NMFS bottom trawl survey data indicate that winter flounder stock sizes were significantly reduced during the early 1970's, probably as a result of heavy removals during years of substantial foreign participation in the offshore fishery. More recent trends in the survey indices suggest that stocks, particularly on Georges Bank, have regained former abundance levels seen in the early 1960's. Current levels of fishing mortalities are unknown. (U.S. DOC, 1982)

Figure 2A12



8/30/85

WINDOWPANE FLOUNDER

The windowpane flounder (Lophopsetta masculata), also known as the sand flounder or sand dab, is the closest North American relative to the European turbot. It is a relatively small, large mouthed, 'left handed' flounder which is distributed in coastal waters from the Gulf of St. Lawrence to South Carolina, occurring in greatest numbers south of Cape Cod and on Georges Bank. Windowpane are found on sandy bottoms from the shoreline out to about 25 fathoms off Southern New England and to about 40 fathoms on Georges Bank. Tagging studies in Southern New England indicate that it is a relatively sedentary species. But, research vessel survey catches of windowpane are made in somewhat deeper water during the winter than in summer indicating limited seasonal movements, probably in response to temperature.

Windowpane flounder spawn during April-June on Georges Bank and somewhat earlier in more southerly localities. Metamorphosis to the adult form is complete in late summer at a length of only 10 millimeters (0.4 inches) when juveniles take to the bottom. Nursery areas remain undefined but it is likely that rocky areas in coastal waters are of importance. Windowpane reach sexual maturity in 3-4 years at a length of 7-10 inches. Based upon analysis of U.S. commercial landings, females apparently grow faster and reach a larger size than males since few males grow to a marketable size.

The Historic Fishery

The commercial fishery for this small, thin-bodied flounder began during World War II in response to a demand created by food shortages. However, after 1945, the demand fell off and fish were no longer landed. The fishery for windowpane resumed in 1975 as landings of yellowtail flounder were in decline. Landings of windowpane averaged 2,035 mt during 1975-1978 with much of the catch taken on Georges Bank where the largest individuals of this species are found. Recently, landings have declined to average 1,280 mt during 1979-1981 coincidental to increasing catches of yellowtail. In addition to food landings, approximately 500 mt of windowpane flounder were landed annually in the industrial fishery in Southern New England during the 1940's and 1950's.

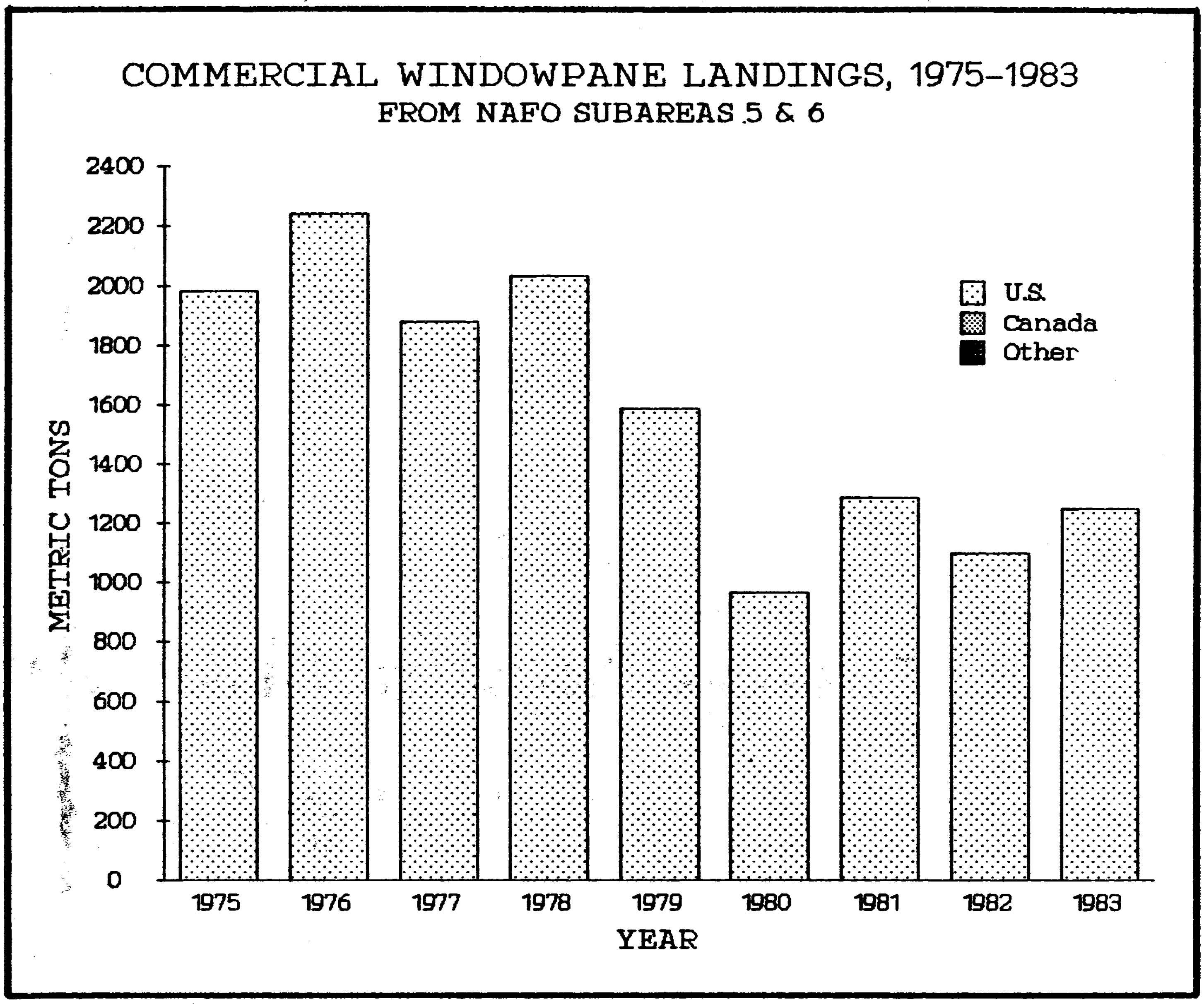
Current Conditions and Future Prospects

The 1983 commercial landings of windowpane flounder from the FCZ were 1,252 mt (provisional), all taken by U.S. fishermen. Ninety six percent (96%) of the overall catch was split between Georges Bank and Southern New England. The reported 1983 landings continue a trend of generally stable, low-level catches seen since 1981, following a period of declining catches, 1976-1980.

NMFS bottom trawl survey abundance indices (numbers of fish) of windowpane flounder on Georges Bank were substantially higher during the 1970's than during the 1960's. Relative abundances of windowpane in Southern New England have exhibited a modest recovery from reduced levels seen in the early 1970's. (U.S. DOC, 1982) Therefore, there does not appear to be any significant correlation between stock size and levels of catch, but such a conclusion may be premature since catch data are in existence only since 1975. It is likely that the major importance of windowpane flounder to the overall groundfish fishery is that it represents one of the possible alternative species during periods of decline of the higher valued yellowtail and winter flounders.

8/30/85

Figure 2A13


COMMERCIAL WINDOWPANE LANDINGS, 1975-1983
FROM NAFO SUBAREAS 5 & 6
METRIC TONS
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1975
1976
1977
1978
1979
1980
1981
1982
1983
YEAR
U.S.
Canada
Other

§2A2 Geographical Species Assemblages

The geographic distribution of groundfish species in the Northwest Atlantic over the years' time and the commercial and recreational fisheries which are dependent upon them is a complex mosaic whose wealth of detail is difficult to grapple with. To aid in reaching an understanding of the overall complex, a hierarchical approach was taken by fishery scientists at the Northeast Fisheries Center. Considering that the total mixed trawl groundfish fishery comprises the overall management unit, a subset of separable components was identified on the basis of the mix of fish species contained within each, while taking into account the operational characteristics of the various fisheries. Thus, the identified components of the overall management unit were based upon underlying ecological production areas on which commercial fishing enterprises act to give rise to the observed landings.

Hierarchical cluster analyses were applied to NMFS spring and autumn bottom trawl survey data to aid in defining the separable components of the overall management unit from the resource perspective. A second set of cluster analyses were applied to commercial landings data to provide operational dimensions to those definitions. (Murawski et al, 1981)

Resource Assemblages. The results of cluster analysis of the 1967-1981 series of spring and autumn bottom trawl survey data are depicted in Figures 2A14 and 2A15 (W. Gabriel, pers. communication). The strongest, most persistent transition zone occurs along the 100 fathom contour on the northern periphery of Georges Bank, separating the Bank from the deep water Gulf of Maine (shown as vertical hatching in Figures 2A14 and 2A15). This transition zone appears to extend northward from the South Channel to Cape Cod during the autumn. A second transition zone occurs inshore between Cape Cod and Cape Ann, possibly reflecting northern coastal declines in abundance of haddock, cod, and winter flounder.

The deep water Gulf of Maine species assemblage includes thorny skate, American plaice, witch flounder, redfish, white hake, and cusk. There are small scale variations in species composition which are probably due to local banks and swells. An inshore Gulf of Maine species assemblage, including cod, haddock, winter flounder, and mixed flounders, appears to be persistent.

The central Georges Bank species assemblage includes cod, haddock, winter flounder, yellowtail flounder, windowpane flounder, and pollock. This assemblage generally extends westward to the Southern New England area with a discontinuity at the South Channel which acts as a stock boundary for some species. The northeast peak of Georges Bank, strongly defined in the autumn but less evident during the spring, is characterized by cod and haddock.

A species assemblage, including red hake, whiting, cod, haddock, sea raven, American angler, and yellowtail flounder, is found along the southern periphery of Georges Bank to Southern New England inshore of the 100 fathom contour, and appears to seasonally move back and forth across the shelf, particularly in its southerly extension. The Southern New England offshore species assemblage, centered along the 100 fathom contour, includes red hake, Gulfstream flounder, fourspot flounder, and redfish.

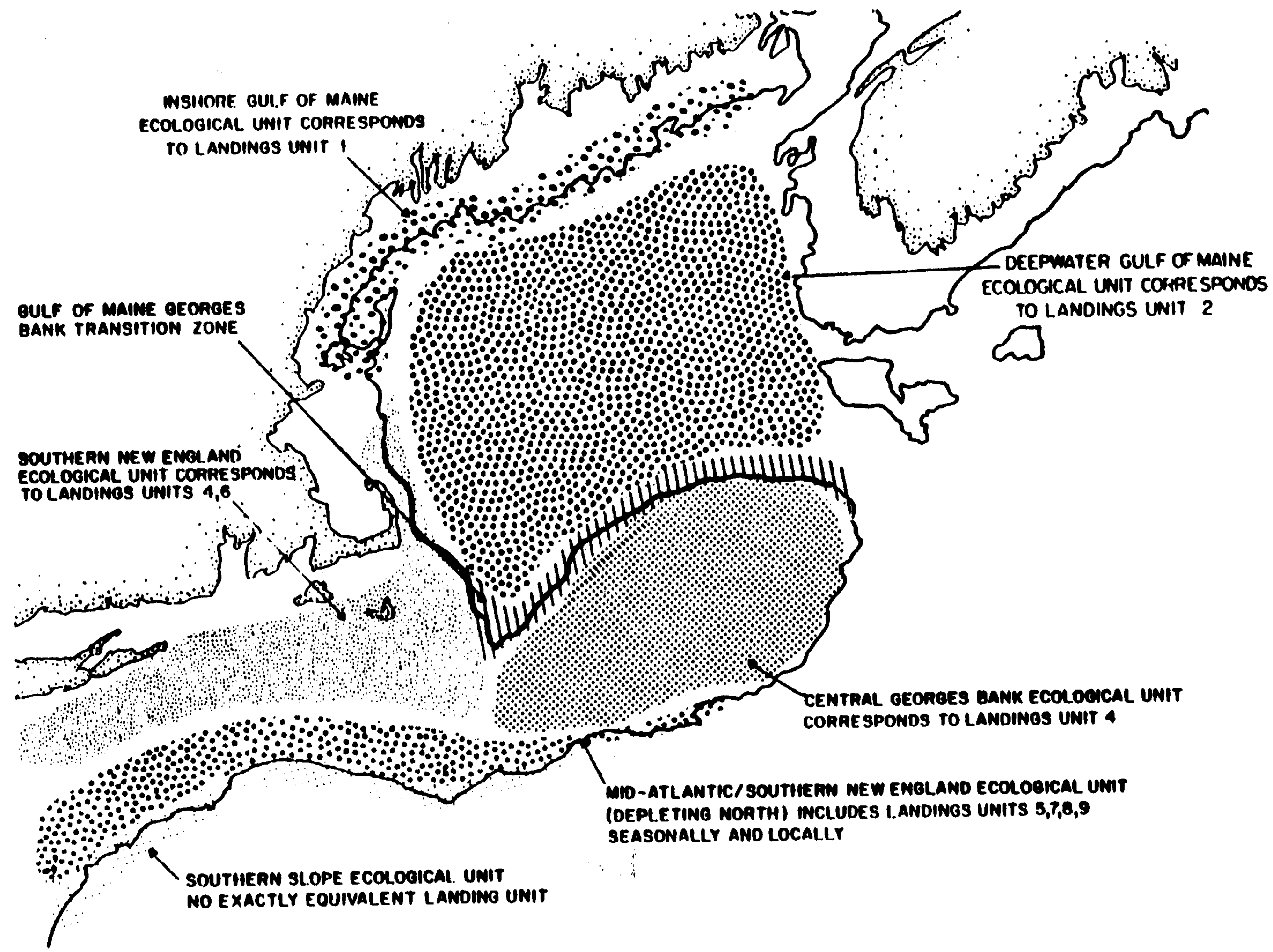


Figure 2A14: Assemblage Regions - Spring Trawl Data, 1967-1981.

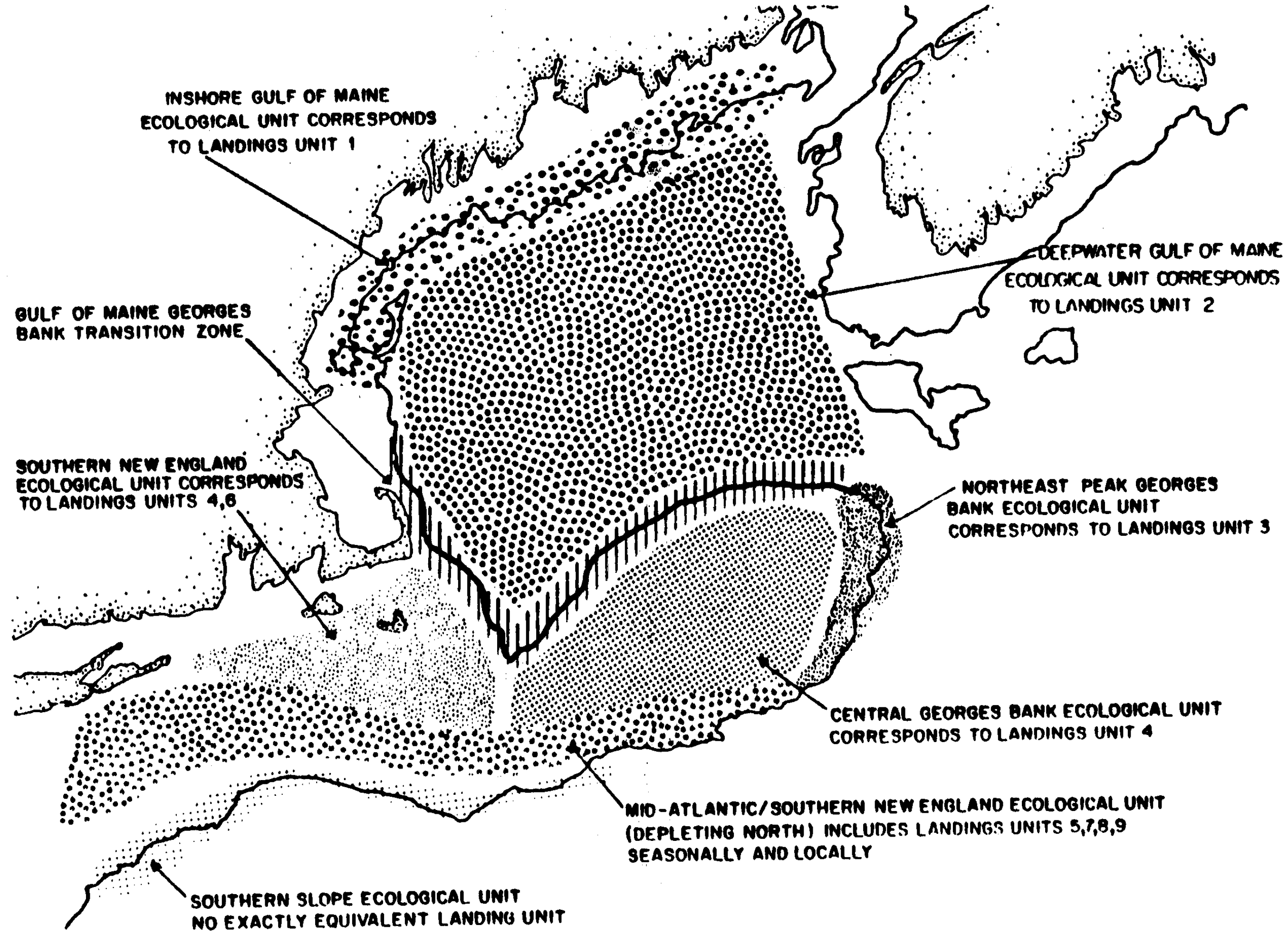


Figure 2A15: Assemblage Regions - Autumn Trawl Data, 1967-1981.

The following tabulation summarizes the essential characteristics of the species assemblages previously described.

ASSEMBLAGE REGION

INSHORE G.of M.	DEEP G.of M.	CENTRAL G.B./SNE	NORTHEAST PEAK	SOUTHERN G.B./SNE OFFSHORE	DEEP SNE
Cod	Thorny skate	Cod	Cod	Red hake	Red hake
Haddock	Am. plaice	Haddock	Haddock	Whiting	Gulfstream fl.
Winter fl.	Witch fl.	Winter fl.		Cod	Fourspot fl.
	Redfish	Yellowtail		Haddock	Redfish
	White hake	Pollock		Sea raven	
	Cusk			Am. angler	
				Yellowtail	

The species assemblages which have been identified on the basis of survey data exhibit varying degrees of stability in terms of their species composition over time. The deep water Gulf of Maine and the deepest assemblage off Southern New England appear to be the most stable. Next in order is the central Georges Bank assemblage followed by its extension in the Southern New England area. In general, the deep water assemblages appear to be the most stable in terms of their species composition while the more shoal areas, particularly in Southern New England, appear to be the most variable from season to season and year to year. Autumn survey data were generally more variable than the spring data. This suggests that much of the apparent regional and seasonal variability may be traced to migratory behavior patterns of some of the species such as red hake, whiting, and spiny dogfish.

Fishery Assemblages. Cluster analyses of otter trawl landings data, for the period 1977-1979, from the commercial fishery were developed with the view of capturing, from the operational perspective, identifiable components of the overall groundfish fishery (Murawski et al., 1981). Based on the results of those analyses, nine major components (major fisheries) were identified as persistent subgroups within the overall complex. The following discussion provides a description of the identified major fisheries. Table 2A3 gives the relative species composition within each major fishery.

Major Fishery 1 - Inshore Gulf of Maine. Fishing activity occurs along the western periphery of the Gulf of Maine from Maine to Cape Cod in water depths to 60 fathoms. Fishing occurs throughout the year, but in 1977-1979 was concentrated during the months April-July (47.2%). Major species landed in 1977-1979 were cod (34.5%), pollock (14.4%), American plaice (12.1%), and haddock (10.5%). Other species having minor importance include whiting, yellowtail flounder, redfish, witch flounder, and winter flounder.

Table 2A3. Weighted average percent species composition of otter trawl landings from the nine major fisheries, 1977 - 1979

SPECIES	MAJOR FISHERY 1	2	3	4	5	6	7	8	9
Cod	34.5	13.4	44.9	37.3	0.2	0.3	4.0	1.7	0.4
Haddock	10.5	13.7	30.1	12.5	0.2	-	0.1	-	0.1
Redfish	3.9	33.7	1.7	0.6	19.3	-	0.1	-	1.4
Pollock	14.4	10.2	5.1	4.1	1.3	-	0.2	-	0.2
Whiting	5.2	13.7	0.6	0.8	20.3	0.6	17.9	4.4	3.1
Red Hake	1.4	0.3	-	0.1	1.4	-	1.3	0.1	-
White Hake	1.1	2.0	0.5	0.2	3.5	-	0.1	-	0.2
Yellowtail Flounder	4.4	1.3	5.4	21.1	-	0.1	7.0	6.6	0.9
American Plaice	12.1	4.7	2.7	1.6	0.1	-	0.1	0.1	0.3
Witch Flounder	3.2	1.9	0.9	0.6	0.6	-	0.1	0.2	0.2
Winter Flounder	2.7	0.9	6.3	13.9	-	11.9	6.4	10.1	0.3
Windowpane Flounder	0.3	-	0.3	2.9	-	5.2	1.1	0.3	0.3
Butterfish	-	-	-	0.1	0.2	0.4	8.9	11.3	4.3
Summer Flounder		-	-	1.0	-	3.9	4.0	10.4	66.4
Mackerel	-	-	-	-	-	-	0.3	0.9	0.1
Scup	-	-	-	0.1	-	25.4	1.5	34.2	0.4
Northern Shrimp	0.8	0.1	-	-	-	-		-	-
Loligo Squid	-	-	-	-	-	39.6	0.5	1.9	1.9
Illex Squid	0.2	0.3	-	-	1.6			-	-

Major Fishery 2 - Deep-Water Gulf of Maine. This fishery generally encompasses the waters of the offshore Gulf of Maine to the northern periphery of Georges Bank in the depth zone 61-150 fathoms (but including the offshore banks such as Cashes and Fippennies Ledges) and is conducted throughout the year. During 1977-1979, the primary species landed were redfish (33.7%), whiting (13.7%), haddock (13.7%), cod (13.4%), and pollock (10.2%), with small quantities of American plaice, white hake, and witch flounder.

Major Fishery 3 - Northeast Peak of Georges Bank. This is a fishery which is located along the northeastern periphery of Georges Bank at all depths to 150 fathoms and is prosecuted most predominately during the months of April-October when 77.7% of the annual landings were taken in 1977-1979. Landings over the three-year period were dominated by cod (44.9%), and haddock (30.1%), with lesser amounts of winter flounder (6.3%), yellowtail flounder (5.4%), and pollock (5.1%).

Major Fishery 4 - Central Georges Bank/Southern New England. A major fishery encompasses the shallow water areas of Georges Bank and extends seasonally into the western Gulf of Maine and Southern New England in water depths of 100 fathoms or less. Landings from this major fishery are evenly distributed throughout the year. During 1977-1979, the major species landed were cod (37.3%), yellowtail flounder (21.1%), winter flounder (13.9%), and haddock (12.5%), with pollock, windowpane flounder, and American plaice of lesser importance.

Major Fishery 5 - Southern Georges Bank Offshore Lobster Fishery. This fishery, which may be characterized as the offshore lobster trawl fishery, is located along the southern and eastern periphery of Georges Bank in water depths of 61 to greater than 300 fathoms primarily during the months of March, April and May. The primary species landed during 1977-1979 was American lobster (33%), but there were significant catches of whiting (20.3%) and redfish (19.3%) with small quantities of American angler and white hake.

Major Fishery 6 - Squid Fishery (Vineyard and Nantucket Sounds). As the name indicates, this fishery is prosecuted entirely within the shoal waters (30 fathoms and less) of Vineyard Sound and Nantucket Sound during May and June. Loligo squid accounted for 39.6% of the 1977-1979 landings, with significant catches of scup (25.4%), and winter flounder (11.9%), and lesser amounts of windowpane flounder and summer flounder (fluke).

Major Fishery 7 - Southern New England Industrial Fishery. This fishery may be characterized as the mixed species industrial/Southern New England small mesh fishery which is shifted seasonally between areas in Cape Cod Bay, Long Island Sound, and Southern New England inshore/offshore waters at all depths to 150 fathoms. During 1977-1979, industrial species of fish accounted for 36.8% of the total landings. The landings of important food fish included whiting (17.9%), butterfish (8.9%), yellowtail flounder (7.0%), and winter flounder (6.4%), with smaller amounts of sea herring, cod, and summer flounder (fluke).

Major Fishery 8 - Southern New England/Middle Atlantic Scup Fishery. This fishery is prosecuted in the Southern New England/Mid-Atlantic Bight in depths to 100 fathoms during the spring and autumn in response to seasonal inshore/offshore migrations of the major constituent species. In 1977-1979, those species included scup (34.2%), butterfish (11.3%), summer flounder (10.4%), and winter flounder (10.1%). Minor amounts of industrial species, yellowtail flounder, and whiting were also landed.

Major Fishery 9 - Middle Atlantic Fluke Fishery. This major fishery is primarily for summer flounder in deep offshore waters of Southern New England/Middle Atlantic during the winter and spring months. Landings between 1977-1979 were principally summer flounder (66.4%), but with significant quantities of tilefish (11%) and butterfish (4.3%).

If the 1977-1979 landings data are aggregated, by species, across the nine major fisheries, the relative magnitude of species landings by area is made clear. Table 2A4 provides that insight. Simplifying the data, major fisheries 1 and 2 were further aggregated to represent the overall Gulf of Maine, and major fisheries 3, 4, and 5 were aggregated as Georges Bank. Finally, major fisheries 6, 7, and 8 were aggregated as the Southern New England/Mid-Atlantic (SNE/MA) small mesh fishery (see Table 2A5). Major fishery 9 cannot be considered a small mesh fishery but, as seen in Table 2A4, the relative importance of all species except summer flounder is minimal.

The most striking feature of the data in Table 2A5 is the emergence of relatively clear-cut species assemblages by major fishing area. Thus, more than 50% of the total landings of haddock, redfish, pollock, whiting, red hake, American plaice, witch flounder, northern shrimp, and Illex squid were taken in the Gulf of Maine in 1977-1979. Using the same criteria, the Georges Bank assemblage includes cod, white hake, yellowtail flounder, winter flounder, and windowpane flounder. Caution is warranted in viewing these results, however, particularly in regard to the important, ubiquitous species, cod and haddock which are more evenly distributed than most. The SNE/MA small mesh fishery is dominated by the warm-water species including butterfish, summer flounder, mackerel, scup, and Loligo squid (discounting the industrial species), but important elements of the overall fishery include whiting, red hake, and winter flounder. Moreover, the relative importance of yellowtail flounder to Georges Bank versus Southern New England has undergone significant changes in the past and may be expected to exhibit similar shifts in the future.

From an operational point of view, as the data in Table 2A4 clearly show, management of the overall groundfish complex in the Gulf of Maine should take into account the small-mesh northern shrimp fishery in Major Fishery 1 as well as that for redfish and Illex squid in Major Fishery 2. On the other hand, it may be noted that management action directed towards cod and especially haddock on the northeast peak of Georges Bank (Major Fishery 3) may be expected to have minimal impact upon the overall fishery for other species.

Table 2A4. Percent of total species landings occurring in each of the nine major fisheries, 1977 - 1979

SPECIES	MAJOR FISHERY 1	2	3	4	5	6	7	8	9
Cod	14.9	20.9	8.2	53.0	0.1	0.1	2.1	1.0	0.1
Haddock	9.2	43.4	11.2	36.1	0.1	-	0.1	-	-
Redfish	3.3	94.6	0.6	1.5	0.1	-	0.1	-	0.1
Pollock	21.2	54.2	3.2	19.9	1.3	-	0.4	-	0.1
Whiting	6.1	58.1	0.3	3.1	0.2	0.1	25.0	7.0	0.2
Red Hake	31.1	24.1	-	7.3	0.3	-	34.3	3.0	-
White Hake	5.4	35.7	1.0	56.9	0.2	-	0.7	-	0.1
Yellowtail Flounder	4.5	4.8	2.3	70.8	-	0.1	8.5	9.1	0.1
American Plaice	33.9	47.5	3.2	14.7	0.1	-	0.3	0.4	0.1
Witch Flounder	25.0	53.5	3.0	15.4	0.1	-	0.9	2.1	0.1
Winter Flounder	3.5	4.2	3.5	59.3	-	2.1	9.8	17.6	0.1
Windowpane Flounder	2.4	-	1.0	76.9	-	5.8	10.5	3.3	0.1
Butterfish		-	-	1.3	0.1	0.2	40.1	57.7	0.7
Summer Flounder		-	-	12.9	-	2.1	18.6	54.8	11.6
Mackerel		-		-	-	-	22.7	77.0	0.3
Scup		-	-	0.6	-	6.8	3.4	89.0	0.1
Northern Shrimp	68.9	31.1						-	-
<u>Loligo</u> Squid		-		-	-	63.0	6.8	29.2	1.0
<u>Illex</u> Squid	15.4	83.5	-	-	1.1	-	-	-	-

Table 2A5. Percent of total species landings occurring by major geographic fishery, 1977 - 1979

SPECIES	GULF OF MAINE	GEORGES BANK	SNE/MA SMALL MESH
Cod	35.8	61.3	3.2
Haddock	52.6	47.4	0.1
Redfish	97.9	2.2	0.1
Pollock	75.4	24.4	0.4
Whiting	64.2	3.6	32.1
Red Hake	55.2	7.6	37.3
White Hake	41.1	58.1	0.7
Yellowtail Flounder	9.3	73.1	17.7
American Plaice	81.4	18.0	0.7
Witch Flounder	78.5	18.5	3.0
Winter Flounder	7.7	62.8	29.5
Windowpane Flounder	2.4	77.9	19.6
Butterfish	-	1.4	98.0
Summer Flounder	-	12.9	75.5
Mackerel		-	99.7
Scup	-	0.6	99.2
Northern Shrimp	100.0	-	-
Loligo Squid	-	-	99.0
Illex Squid	98.9	1.1	-

§2A3 Ecological Relationships

A fundamental problem in establishing a scientific basis for fishery management has been the separation of natural environmental effects from the impacts by man. The accumulated circumstantial evidence around the world indicates that, with the exception of a few anadromous species, it is the natural environment that plays the major role in controlling the abundance and distribution of marine fish. However, in some cases the effects of man's activities have been more evident.

The massive buildup of foreign fleets in the Northwest Atlantic in the 1960's and the associated heavy fishing pressure resulted in substantial reductions in the total finfish biomass. The level of exploitation probably exceeded the finfish productive capacity of the region. Although some species were much more affected than others (e.g., sea herring and haddock), an overall reduction of 65% in total finfish biomass was seen from 1963 to 1974.

With such notable exceptions, the distribution and abundance of fish species is predominately affected by ecological conditions but the understanding of the actual mechanisms involved is extremely limited. Variability in survival of fish larvae is generally believed to be the major factor in controlling the major fluctuations in population size. The important factors affecting the survival of fish larvae are thought to be food availability, predation, and larval transport within some satisfactory range of temperatures. There is little information, however, regarding the relative importance of these factors and how they interact.

The relationship between spawning stock size and the number of progeny is probably defined by the complex small-scale dynamics of plankton communities over the several months when the fate of a population of fish larvae is determined. Collectively, the various sources of larval mortality may be termed either density-dependent or density-independent. Density-independent mortality, that component of total mortality which is not affected by the size of the larval population, may be exerted principally by physical factors of the environment such as temperature, salinity, turbulence and water currents, storm winds, etc. Density-dependent mortality, which is affected by the size of the larval population, may be caused by certain types of predator-prey relationships such as cannibalism, or other factors such as competition for available habitat or for a limited food supply. Depending upon the intensity of those factors which contribute to density-independent mortality within the time span encompassed by any given reproductive cycle, very large year classes of fish can result despite the density-dependent effects. Thus, the likelihood of obtaining consistently good recruitment to a fishery is optimized by a consistently high level of spawning activity which implies the desirability of maintaining an adequate spawning stock.

Abiotic Factors

The interaction between the temporal and geographic distribution of fish species and environmental conditions is perhaps more apparent during the juvenile and adult phases of the economically important species by virtue of the information generated by the commercial and recreational fisheries.

Of all the physical attributes of the environment, temperature is perhaps the most extensively documented. Most fish species have temperature tolerances which are narrower than those seen in the normal seasonal temperature cycle. Thus, most fish are forced to migrate offshore in winter to reach water temperatures which do not fall below a preferred minimum. Species with a more southerly distribution in their range such as scup and summer flounder having higher minimum temperature tolerances not only move offshore during the winter but also move to more southern waters. The reverse migrations occur during the spring with the annual warming trend. Sea surface temperatures in inshore waters during the summer may actually reach levels which exceed the upper temperature tolerances of fish species. However, temperature stratification usually develops in the summer period to provide for cooler bottom water in areas relatively close to shore.

Most species of marine fish spawn within relatively narrow temperature ranges, thus time of spawning is usually closely linked to the seasonal temperature cycle. The time and place of spawning of endemic species exhibit a close linkage with the temporal and geographic progression of seasonal warming and cooling, progressing from south to north for spring spawners and north to south for autumn spawners.

A dominant feature of Southern New England continental shelf bottom waters is the so-called "cold cell" located in depths ranging from about 20 to 60 fathoms off Delaware Bay northeastward to the waters off Martha's Vineyard. Summer bottom temperatures typically range only 4°C to 10°C with warmer water both shoreward and seaward of the cell (see Figures 2A16 and 2A17, autumn bottom temperatures). Yellowtail flounder spawn chiefly in water temperatures from 4°C to 9°C corresponding to the range of temperatures frequently found in the cold cell. Since yellowtail occur on the same part of the shelf where the cold cell rests, it is possible that spawning success may be related to the extent and temperature of the cold cell.

The annual cycle in sea water temperatures are superimposed upon long-term temperature trends which appear to be characteristic of large areas of the world. The scale and nature of the temperature trends vary with the size and location of the region considered. For the whole northern hemisphere there was a gradual warming trend in air temperatures from the late 1800's until about 1940, followed by a cooling trend until the mid-1960's. Mean annual sea surface temperatures along the U.S. east coast reveal a pronounced warming trend beginning in the 1940's and peaking in the early 1950's, with the trend progressively stronger from south to north. Following peak temperatures in the early 1950's, the trend was reversed with temperatures declining until 1967 when another warming trend began as illustrated by sea surface temperatures at Boothbay Harbor, Maine (see Figure 2A18). Similar warming and cooling trends have occurred in the offshore New England area both at the surface and at depth. Since 1967, temperatures rose until about 1973-1974, but have since been declining. (Grosslein and Azarovitz, 1982)

On the basis of landings' statistics, a number of fish and invertebrates (notably, mackerel, lobster, menhaden, silver hake and yellowtail flounder) in the Gulf of Maine recorded a northward shift in their range during the warming trend of the 1940's. (Grosslein and Azarovitz, 1982)

Figure 2A16

Bottom temperatures, 1973 trawl surveys (spring-left, autumn-right)

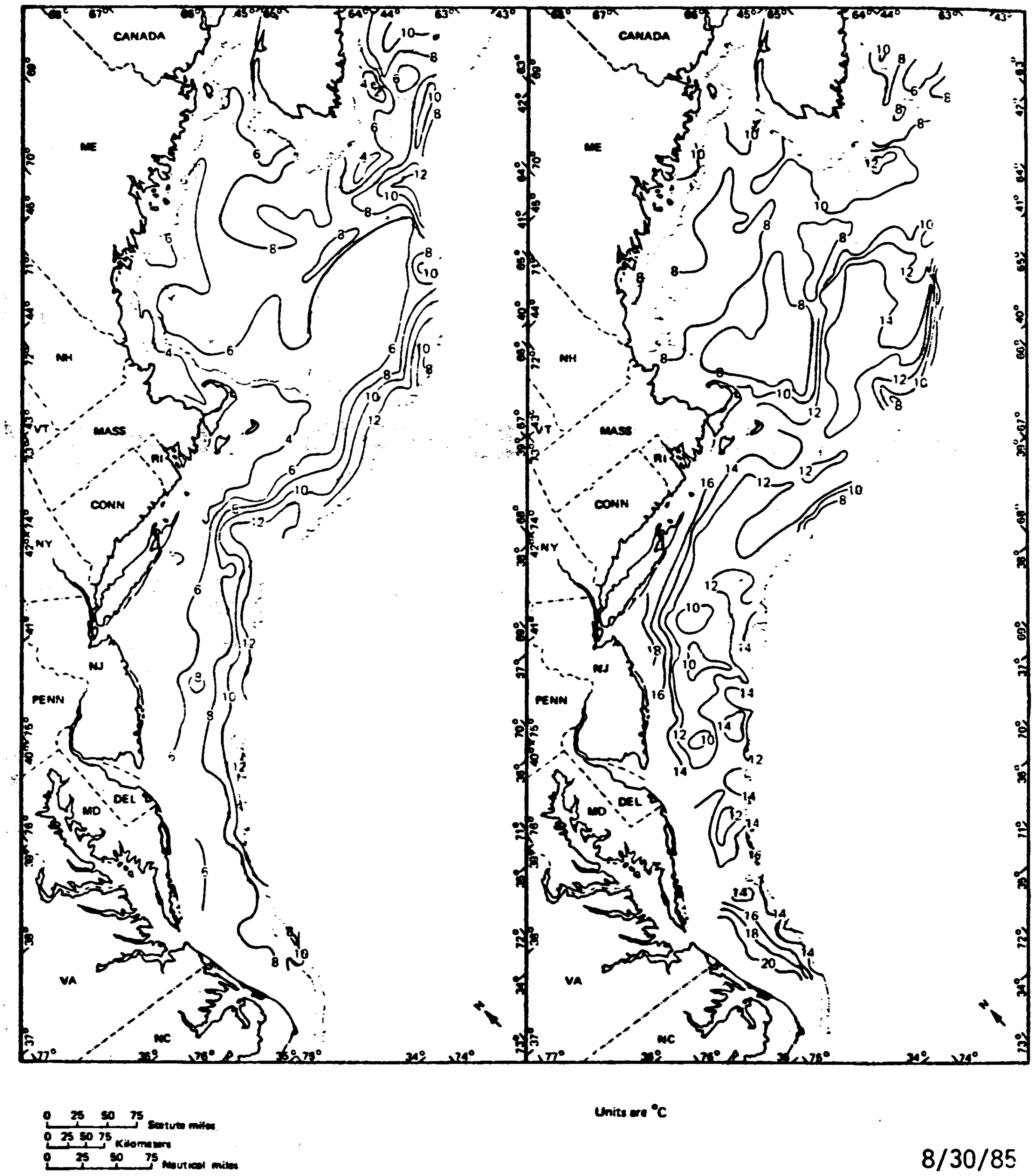


Figure 2A17

Bottom temperatures, 1974 trawl surveys (spring-left, autumn-right)

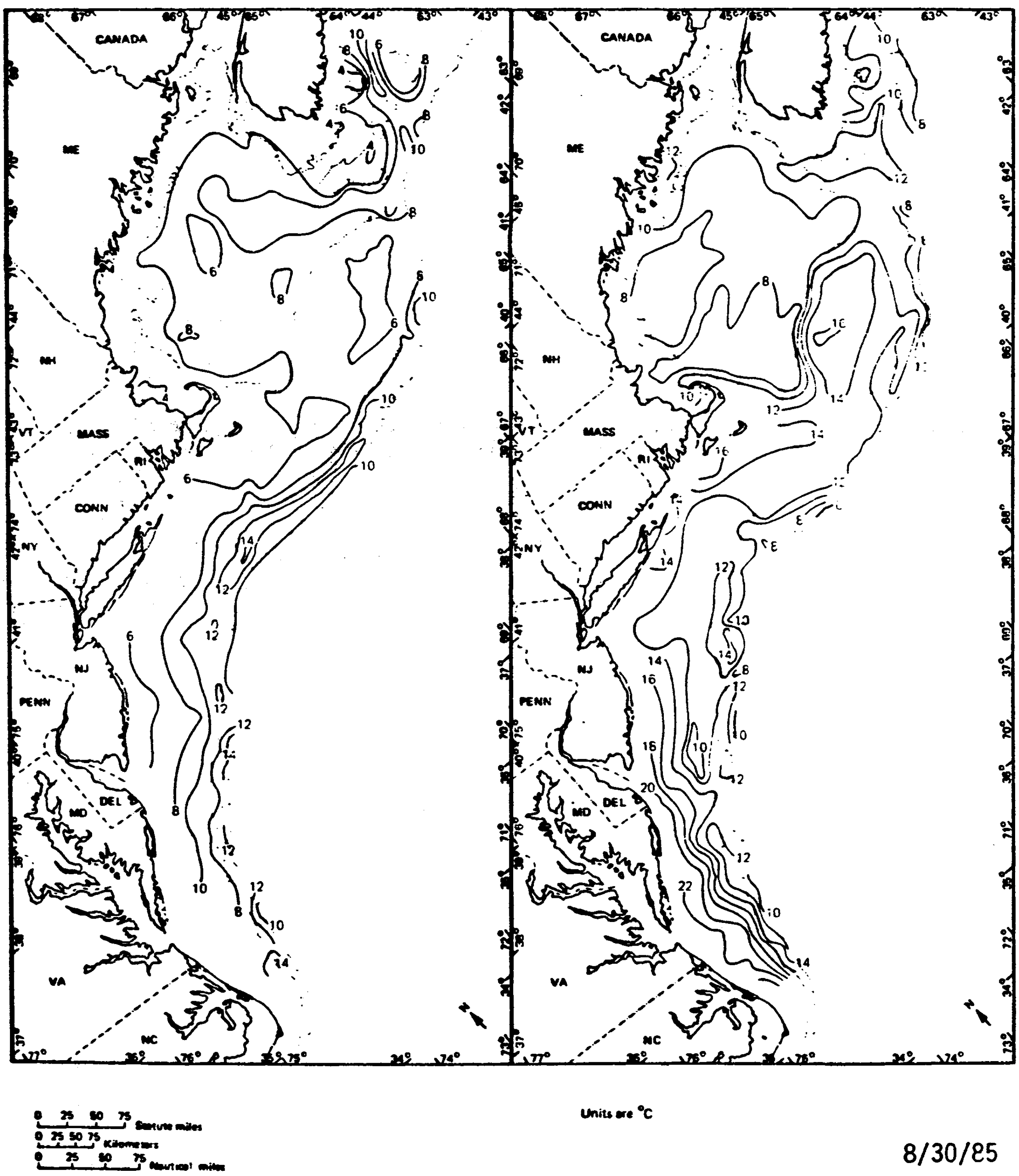


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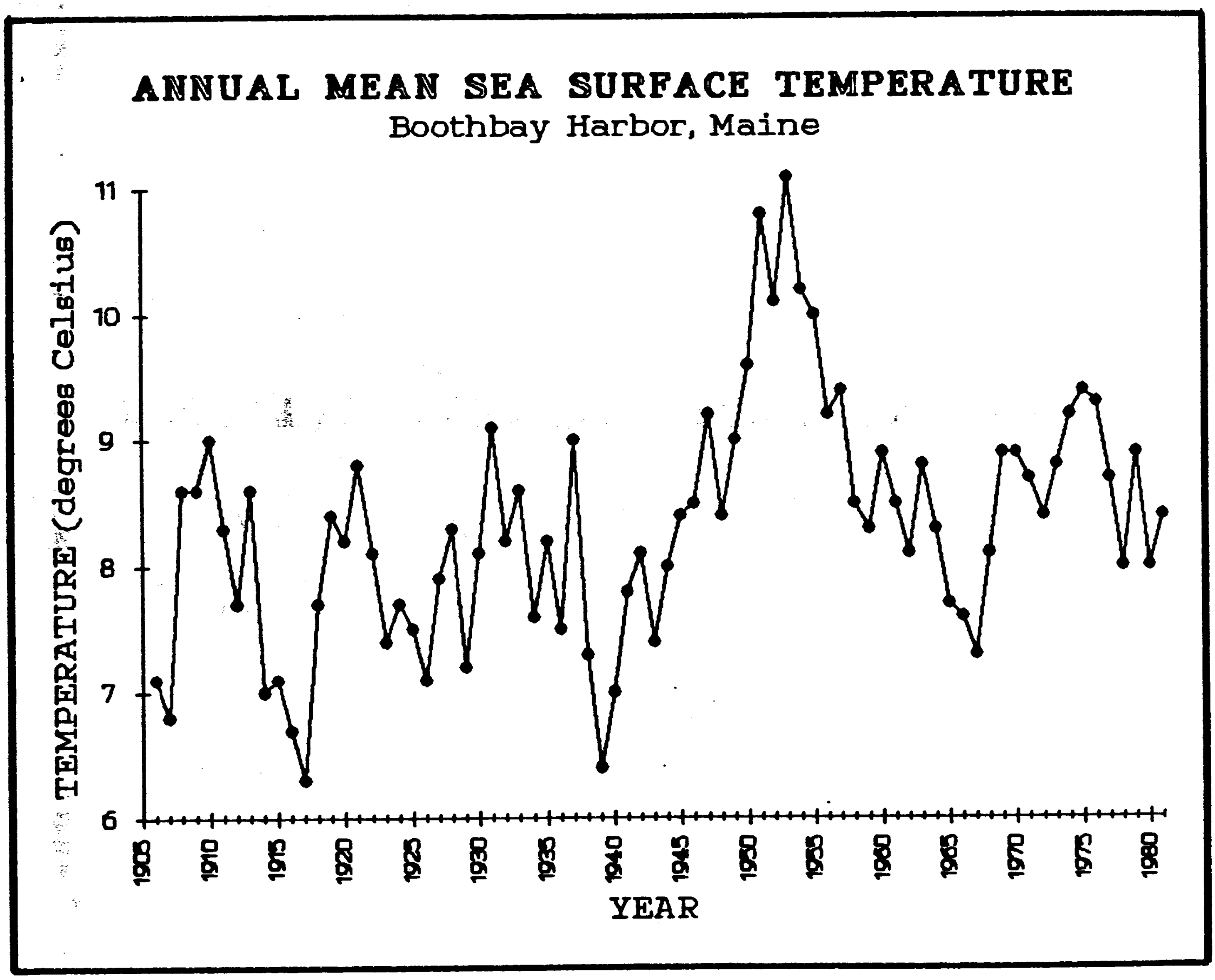
Figure 2A18



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During the following cooling trend from the 1950's to 1967, NMFS trawl surveys indicated slight southward shifts in American plaice and butterfish, plaice extended their southern limit and butterfish contracted their northern limit. In the same series of surveys, however, haddock and yellowtail flounder did not exhibit any change and there were no significant changes in the distribution or composition of the overall demersal fish population. (Grosslein and Azarovitz, 1982)

In general, the degree of effect and association between trends in mean annual temperatures and the abundance of a species in a given area will depend upon whether there is a change in the living space or the reproductive potential. For example, it has been suggested that spawning success of yellowtail flounder on the Southern New England grounds may be related to the extent and temperature of the "cold cell" in the mid-shelf area. Since the environmental factors affecting year-class success probably operate chiefly during the first few months of life, it is unlikely that annual mean temperatures will be significantly correlated with year-class strength. Ideally, comparisons should be made between temperature conditions present at the time and place that egg and larval development of a population occurs and the subsequent strength of that particular year class. A sufficient time span of the requisite data are generally not available.

Biotic Factors

The major biotic factors affecting the distribution and abundance of fish species were briefly examined in the introductory paragraphs of this section. Clearly, the reproductive capacity or the total fecundity sets the theoretical upper limit on the size of fish populations. Among the life-history stages subsequent to egg hatching, fish survival is highly dependent upon there being available a sufficient quantity of the right kinds of food organisms. One of the stronger driving forces in the biotic environment is competition. Fish among the same as well as different species compete for the available food supply through complex predator-prey relationships which are woven into the tapestry characterizing marine food webs.

Obviously, the continued existence of a species of fish requires that successful spawning activity take place. However, among marine fish species more than 99% of the eggs (i.e., potential individual fish) produced fail to survive to recruitment. Most of this staggering level of mortality occurs during the early life history stages of development. The survival of larval fish depends upon the physical (discussed above) and biological characteristics of the environment. The biological dimensions of survival are dynamic processes which match the distribution of fish larvae in space and time with their prey and mismatch their distribution with that of their predators.

Spawning Stock Size - Recruitment. In general, the more extensive and consistent (year after year) the occurrance of spawning, the greater the likelihood that, over the long-term, stocks of fish will be maintained at some optimum level of abundance which maximizes the surplus production available for harvest. In the short run, however, recruitment is highly variable among all species of marine fish that have been examined. But different species exhibit differing levels of variability. Hennemuth et al. (1980) report that the ratio of the largest to the smallest level of recruitment for Georges Bank haddock was 19:1 during the stable period 1931-1965, and increased sharply to 2700:1 after extending the time series to 1973 to encompass the negligible levels of recruitment which occurred after 1966. The ratio for Georges Bank cod, however, was only 2.5:1 over the period 1960-1973. The ratios for Georges Bank sea herring and silver hake (whiting) were intermediate at 5.2:1 and 9.6:1 over the historical periods 1963-1974 and 1955-1973, respectively.

Several stock-recruitment models, most notably by Ricker (1958) and Beverton and Holt (1957), have been formulated in attempts to deal with the variability of recruitment as a mathematical function of the spawning stock size, but they have universally proven to be inadequate in explaining more than a fraction of that variability. The reason is that spawning stock size alone is not a sufficient basis for predicting recruitment. But spawning stock size is obviously a relevent management concern since some spawning stock is necessary or there would be no recruitment. In fact, despite all its variability, the Georges Bank haddock stock provides evidence of the importance of spawning stock size. When stocks have been reduced below 75,000 mt, recruitment exceeded 50 million fish only 10% of the time. But, at stock sizes greater than 75,000 mt, recruitment exceeded 50 million fish about half of the time.

If fisheries management is to evolve from the reactive mode, which characterizes past efforts, to a predictive mode whereby some credible long-term planning becomes possible, then the problem of predicting the magnitude of future recruitment must be solved. Recruitment may not be estimable as a function of stock size, alone, at a level of precision sufficient to serve as a basis for management. However, an alternative approach has been suggested which is based upon the probability distribution function of the observed recruitment levels seen in the historic fishery. Hennemuth et al. (1980) examined the statistical properties of the historic recruitment of a number of fish stocks, world-wide. The conclusion they reached was that, almost without exception, the observed year-class strengths seen in any given stock of fish could be described by a log-normal probability distribution. A log-normal distribution is one in which the natural logarithms of the historic series of recruitment levels conform to the bell-shaped, normal curve. These results may represent a significant step forward in efforts to develop new types of fishery models aimed at achieving a predictive capability in the long-term perspective. However, as seen with haddock in the previous discussion, the size of the spawning stock may act to modify the parameters of the probability distribution function. Short-term predictive models, which are not so complex as to preclude their practicable application, continue to elude the best efforts of fishery scientists.

<u>Food and Feeding Habits - Predation and Competition</u>. Most food habit studies of marine fish have had their primary focus upon the adult forms for the very practical reason that the food remains typically found in the gut of larval fish are usually not identifiable, even to major taxa. Nevertheless, it is known that all species of fish larvae feed upon various forms in the plankton, and to varying degrees, are prey for other planktonic organisms as well as juvenile and adult fish. The appropriate planktonic prey are usually found in a patchy distribution in the water column. Depending upon whether the distribution of the larval fish is coincident in time and space with the patchy aggregations of their prey, food is probably not limiting. However, the caveat may be of critical importance since larval fish must feed almost continuously to survive and undergo normal development.

Since 1963, various studies of the food habits of the major species of adult fish on Georges Bank have been conducted by the National Marine Fishery Service. The most scientifically rigorous of these studies has been ongoing since 1969. Based upon this study, the food habits of a number of demersal fish collected from Georges Bank between 1969 and 1972 have been summarized in Figure 2A19 (Grosslein et al., 1980). The data are expressed as the percent by weight of the total stomach contents for all the fish of each species examined. Included among the crustacean prey organisms are various kinds of shrimp and crabs, and most commonly, the small, shrimplike euphausiids (i.e., krill). Nearly all of the most common forms of fish appear as prey organisms, with the herrings and the mackerels predominating. But the flounders, the various cod-like forms, the sculpins and the sand launces are also represented. Polychaetes, which are an important element in the diet of many bottom fish, are a large grouping of marine worms which typically live in and near the bottom sediments. Echinoderms, also important items in the diet of bottom fish, include starfish, brittle stars, and sea urchins. Molluscan food organisms are the clams and snails living in the sediments as well as squid. The "other phyla" category of food organisms include, principally, other forms in the plankton, and "miscellaneous" is unidentified animal remains, sand, and rock.

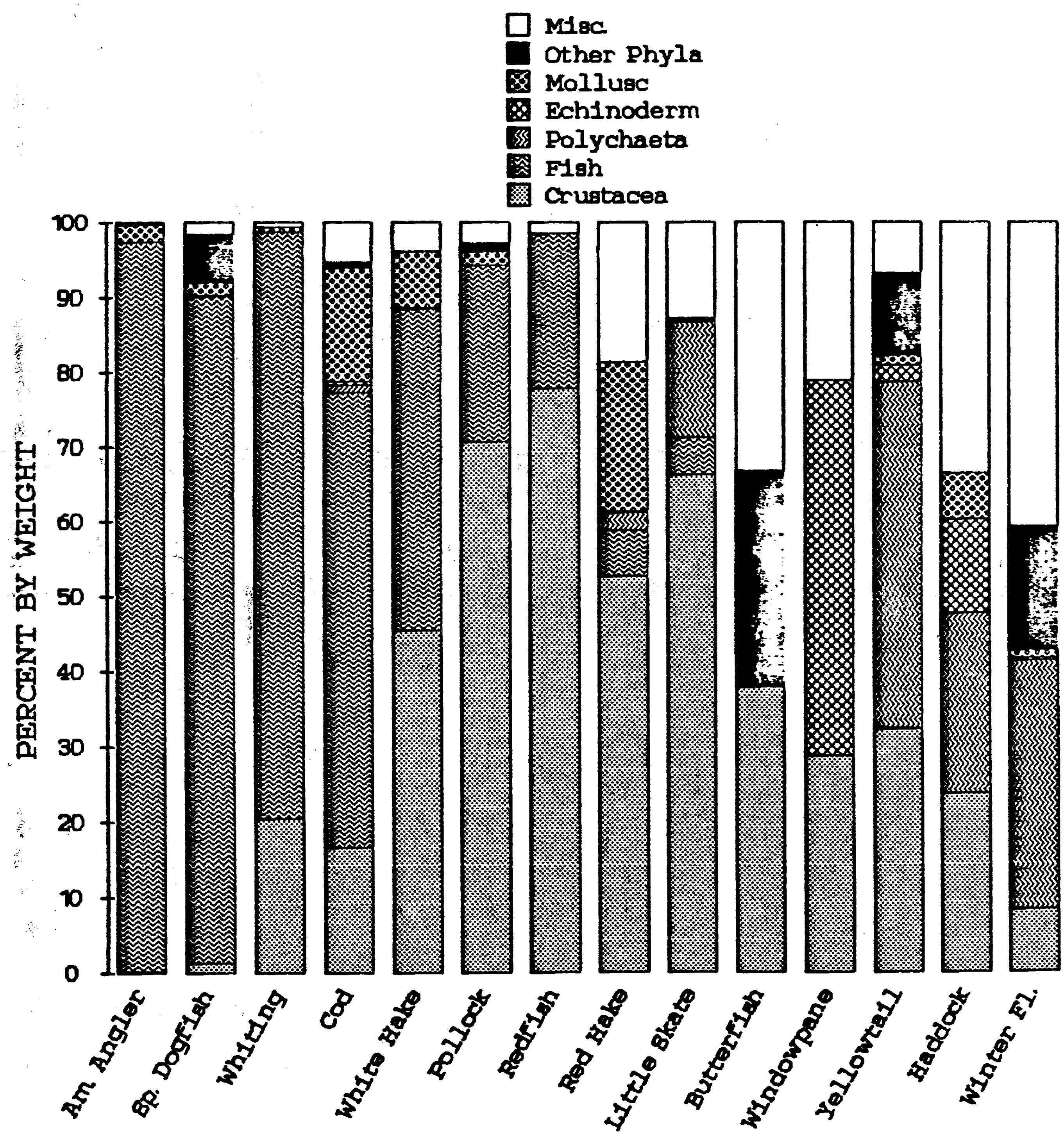
The fish shown in Figure 2A19 have been ordered from left to right in terms of the prevalence of fish in their diets. Thus, the angler (monkfish) and spiny dogfish are the major fish predators, followed by whiting, cod, and white hake. In the center of Figure 2A19 are those fish which feed principally upon crustaceans, white hake, pollock, redfish, red hake, and little skate. Finally, it is seen that for three species of flounder (windowpane, yellowtail, and winter flounder), as well as haddock, a significant portion of their diet consists of benthic organisms (molluscs, echinoderms, and polychaetes).

The data presented in Figure 2A19 are all relative, they do not reflect the absolute magnitudes of predation occurring in the ecosystem. For example, Grosslein et al. (1980) estimated that the total consumption of fish by silver hake (whiting) on Georges Bank far exceeds the total production of exploitable fish of that area. This implies that whiting must eat a considerable quantity of pre-recruit (non-exploitable) fish. It is also likely that they consume significant quantities of exploitable-sized fish.

The emerging knowledge of food habits and predator-prey interactions in marine ecosystems underscores the importance of maintaining an adequate biomass of suitable forage species to support populations of the commercially valuable forms. In past years, huge populations of the herrings filled that need. With collapse of the Georges Bank herring stock, recent years have seen a burgeoning of populations of sand launce to the near-record high levels of about 1-3 million metric tons estimated for 1981-1982. Moreover, the recent increased abundances of Atlantic mackerel, which competes with sea herring for the same or similar food organisms (Maurer, 1976), further emphasizes the dynamic nature of trophic relationships. Thus, the diversity and inherent, short-term, instability of the ecosystem may, in fact, provide for the greatest assurance of stability in the long-term perspective.

Figure 2A19

FOOD TYPES FOR GEORGES BANK DEMERSAL FISH
Based Upon Analysis of Stomach Contents



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§2A4 Biological Management Parameters for Major Species

A summary of important management parameters for the major species of fish within the overall mixed groundfish resource complex is given in Table 2A3. The table has been organized on the basis of the recognized stock structure for each species. For example, where growth parameters differ from one stock to another, such are indicated by a numbering system which corresponds to the same numbering system used to differentiate the separate stocks. The same system applies to estimates of MSY as well as the important benchmarks of fishing mortality, where separate estimates by stock are in existence. The Gulf of Maine cod stock, indicated by "1) GM", has the growth parameters, k=0.120 and L =148.1 cm. The fishing mortality indices for the Gulf of Maine cod stock are, F-0.1=0.16, F-max=0.30, and the most recently available estimate of the current fishing mortality in the fishery (F-current) is 0.38. All cod stocks have a natural mortality, M=0.2. Finally, the estimated MSY for the Gulf of Maine cod stock is 8,000 mt.

The following discussion is an explanation of the significance of the entries in Table 2A3 with regard to fishery management.

Stocks. Stock differentiation is intended to specify those groups of fish of a given species which have a high degree of integrity in their breeding populations and which tend to have similar rates of growth and mortality. Stock differentiation does not imply that there is no intermixing. Nevertheless, there is sufficient separation between stocks over time and space that interactions and effects on a stock from one area are usually not immediately seen in stocks from other areas. Thus, stock structure may have implications in consideration of the definition of management units.

Growth. The growth parameter, k, is a term in the growth equation which is a measure of the rapidity with which fish grow to the average maximum size, L . The absolute maximum age and size indicate the maximum time that a cohort of fish may be expected to remain in the ecosystem and be available to the fishery and the maximum length that individual fish have been observed to attain. Fish of that age and size would not be expected to be abundant in a heavily fished population.

Ages in the Fished Population. The age range given represents the most commonly encountered given the growth characteristics of the species and the prevalent statis of the fishery. The age range is not as broad as would normally occur in an unfished population nor does it include the rare older fish in a moderately fished stock. Also included is an indication of the age at recruitment and the current predominate year classes.

Maturity. The average size and age when fish achieve sexual maturity has been indicated, by sex, when such information is available. These data have relevance in consideration of appropriate mesh sizes for the fishery where an objective for management is the prevention of recruitment overfishing. An indication of the time and place of spawning activity may also be an important management consideration.

Mortality. Estimates of rates of natural mortality (M), as well as important indices of fishing mortality, F-0.1, and F-max, are given with the latter included for comparison with F-current, the latest available estimate of fishing mortality currently being generated in the fishery.

TABLE 2A6. SUMMARY OF IMPORTANT MANAGEMENT PARAMETERS FOR MAJOR SPECIES WITHIN THE OVERALL MIXED GROUNDFISH RESOURCE

STOCKS	GROWTH k L	AGES IN FISHED POPULATION	MATURITY	MORTALITY M	F-0.1	F-max	F-current	MSY	BY-CATCH/ DISTRIBUTION
COD 1) GM 2) GB 3) SNE-MA	1) 0.120 148.1 2) 0.116 146.5 3) 0.257 112.9 Max age=22 yrs Max length = 183 cm (72 in)	2-15+ years GM recruits at age 3 GB recruits at age 2 GM: Currently, 1977-1980 yr classes dominate population GB/SNE-MA: 1978, 1979, and 1980 yr classes dominant	50% maturity: GM: Male 4.2 yr (21.3 in) Female 3.8 yr (19.7 in) GB/south: Male 2.6 yr (17.3 in) Female 2.9 yr (20.3 in) Max egg production: age 12	0.2	1)0.16 2)0.15	1)0.30 2)0.30	1).6-.8 2).6-.8	1) 8,000 mt 2) 35,000 mt	Haddock, pollock, yellowtail, other flounders, other groundfish Demersal GB stock migrates south in autumn
HADDOCK 1) GM 2) GB	1) 0.352 72.91 2) 0.376 73.80 Max age=18 yrs Max length = 112 cm (44 in)	2-9+ years GM recruits at age 2.7 GB recruits at age 2.3 GM: 1975 yr class was strong, 1979 & 1980 cohorts moderate GB: 1975 and 1978 yr classes only major recent recruitment.	50% mature at age 2 Size at maturity: Males, 16.3 in Females, 16.9 in Spawn Feb-May, peak Mar-Apr on GB Max egg production: age 6	0.2	0.26	0.55	1)0.6 2)0.6	1) 5,000 mt 2) 47,000 mt	Cod, yellowtail, other flounders, other groundfish Demersal Move inshore off New England between Jan and June
REDFISH Single stock GM/GB	0.104 37.80 Max age >50 yrs Max length = 45-50cm (20 in)	6-25+ years Recruits at age 5 1971 yr class only major recent recruitment	Mature at age 8-9 Size at maturity: 8.5-9 in Spawning peak in late June-early Aug	0.1	0.14	>1.0	0.3-0.4	14,000 mt	Relatively pure fishery, some taken in mixed trawl and northern shrimp fisheries Demersal Nonmigratory
POLLOCK Single stock NS/GM/GB	0.215 97.77 Max age=23 yrs Max length = 106 cm (42 in)	2-13+ years Recruits at age 3.5 Strong 1971, 1975, 1976, and 1979 yr classes	50% mature by age 5 Males, 19.7-25.6 in Females, 21.7-27.6 in Spawn Nov-Mar, peak late Dec, Western GM	0.2	0.25	0.49	0.26	52,000 mt NS, GM, GB combined	Herring (fall only) Groundfish (when on bottom) Pelagic/Demersal

KEY: NS = Nova Scotia GM = Gulf of Maine GB = Georges Bank SNE = Southern New England MA = Mid-Atlantic

TABLE 2A6 continued.

STOCKS	GROWTH k L	AGES IN FISHED POPULATION	MATURITY	MORTALITY M	F-0.1	F-max	F-current	MSY	BY-CATCH/ DISTRIBUTION
WHITING 1) GM 2) GB 3) SNE-MA	1) 0.182 65.41 2) 0.246 50.72 3) 0.416 46.08 Max age: Males=6 yrs Females=12 yrs Max length = 66 cm (26 in)	2-12+ yrs Recruits at age 2 GM: 1977, 1978, and 1980 yr classes GB: 1978 and 1980 yr classes SNE-MA: 1980 and 1981 yr classes average 1976 and 1978 yr classes stronger	50% mature at age 2 1) Males, 9.2 in Females, 9.4 in 2) Males, 9.6 in Females, 10.3 in 3) Males, 9.9 in Females, 9.9 in Spawn Jun-Sept Max egg production: age 4	0.4	1)0.55 2)0.65 3)0.55	1)>2.0 2)>2.0 3)>2.0	1)0.13 2)0.14 3)0.47	1) 17,000 mt 2) 55,000 mt 3) 35,000 mt	Red hake, mackerel, other groundfish Demersal/Pelagic Move inshore in spring-summer
RED HAKE 1) GM (small) 2) GB 3) SNE-MA	0.37 approx 42.6 Max age=12 yrs Max length = 75 cm (30 in)	2-10+ yrs Recruits at age 3 GB: yr classes since 1977 are average, 1980 may be strong SNE-MA: 1979 yr class is strong, 1980 and 1981 are average	50% mature at age 2 Size at maturity= 11.1 inches Spawn in summer on southern GB	0.4	2)0.85 3)0.45	Unk	2)0.10 3)0.18	2) 13,000 mt 3) 26,000 mt	Whiting, other flounders, other groundfish Demersal Inshore/offshore in autumn, offshore in winter/spring
WHITE HAKE Single stock NS/GM/GB	Males: 0.11 110.6 Females: 0.09 135.3 Max age=23 yrs Max length = 120 cm (47 in)	Unknown	50% maturity age= Unk Size at maturity= 42 cm (16.5 in) Spawn on slope in MA (summer), Scotian Shelf in early autumn	Unk	Unk	Unk	Unk	Unknown	Red Hake, other groundfish Demersal Move inshore in GM and SNE in autumn
YELLOWTAIL FL 1) GB 2) SNE-MA (including Cape Cod)	0.335 50.0 Max age=14+ yrs Max length = 55 cm (22 in)	2-12+ yrs Recruits at age 2 1980 yr class strong, 1979 and 1981 above average. 1982 &1983 classes weak.	50% mature at age 2 Size at maturity= 10 in Spawn Mar-Aug Max egg production: age 7	0.2	0.3	0.5	1)1.0 2)1.0	1) 16,000 mt 2) 23,000 mt	Cod, haddock, other groundfish, other flounder Demersal Little movements Major concentration on GB and SNE

KEY NS = Nova Scotia GM = Gulf of Maine GB = Georges Bank SNE = Southern New England MA = Mid-Atlantic

TABLE 2A6 continued.

STOCKS	GROWTH k	GROWTH L	AGES IN FISHED POPULATION	MATURITY	MORTALITY M	MORTALITY F-0.1	MORTALITY F-max	MORTALITY F-current	MSY	BY-CATCH/ DISTRIBUTION
AM. PLAICE 1) GM 2) GB	Unk Slow growing Max age=Unk Max length = 83 cm (33 in)	Unk	1-9 yrs	50% maturity: Male 3.2 yr (10.1 in) Female 3.8 yr (11.7 in) Spawn Mar-Jun Western Gulf of Maine and south of Martha's Vinyard	0.2	0.17	0.34	Unk	Unknown	Other flounders, other groundfish Demersal Concentrated at depths of 50-100 fm
WITCH FL. 1) GM 2) GB	Males: 0.13 Females: 0.08 Max age = Unk Max length = 63 cm (25 in)	61.1 79.1	Unknown	50% mature at 13 inches (age unknown) Spawning peak Jul-Aug Cape Cod to Delaware Bay	Unk	Unk	Unk	Unk	Unknown	Skates, cod, haddock, whiting, pollock, wh. hake, redfish, Am. plaice Demersal Sedentary Deep water
WINTER FL. 1) GM 2) GB 3) SNE	1) 0.69 2) 0.67 3) 0.75 Max age=12+ yrs Max length = 62 cm (24 in)	45.5 57.8 48.2	2-12+ yrs Recruitment appears to be good	50% mature at age 2 Male: 9.8 in Female: 10.2 in Spawn Jan-May inshore GM and SNE Apr-May on GB	Unk	Unk	Unk	Unk	Unknown	Cod, haddock, other groundfish Demersal Winter spawning migrations into estuaries
WINDOWPANE FL. 1) GB 2) SNE-MA	Unk Max age=Unk Max length = 38 cm (15 in)	Unk	Recruit at age 2 Older ages (4+) taken for food	Mature at age 2-4 Spawn Apr-Jun on Nantucket Shoals and south	0.2-0.3	Unk	Unk	Unk	Unknown	Sp. dogfish, little skate, whiting, red hake, scup, btrfish yellowtail, squid, winter flounder Demersal

KEY: NS = Nova Scotia GM = Gulf of Maine GB = Georges Bank SNE = Southern New England MA = Mid-Atlantic

TABLE 2A6 continued.

STOCKS	GROWTH k	GROWTH L	AGES IN FISHED POPULATION	MATURITY	MORTALITY M	MORTALITY F-0.1	MORTALITY F-max	MORTALITY F-current	MSY	BY-CATCH/ DISTRIBUTION
SUMMER FL. Single stock GB/SNE/MA	0.209 Max age=20 yrs Max length = 95 cm (37 in)	92.24	2-7 yrs Recruitment begins at age 1, complete by age 4	50% mature at age 2 Size at maturity= 12.6 in Spawns Sept-Apr Max egg production: age 7	0.2	0.16	0.19	Unk	15-20,000 mt	Mixed groundfish, winter fl, Loligo, scup Demersal Migrates offshore in autumn
SCUP 1) SNE 2) New Jersey	1) 0.195 2) 0.216 Max age=19 yr Max length = 43 cm (17 in)	40.79 39.58	2-15 yrs Catch dominated by 2-3 yr old fish	50% mature at age 2 Spawn May-Aug	--Current Data-- --Not Available--				15,000 mt	Demersal Seasonal migration in/offshore
BUTTERFISH 1) No. of Cape Hatteras 2) So. of Cape Hatteras	0.862 Max age=6 yrs Max length = 30 cm (12 in)	21.02	1-6 yrs Age 3 dominate catch during Jan-Jun Age 0-1 dominate catch during Jul-Dec	50% mature at age 1.5 Spawn May-Aug in MA to southwest GB	0.8	0.69 (60 mm mesh)	1.33	Unk	16,000 mt	Loligo offshore; mixed gfish inshore Pelagic/Demersal Move offshore and south in autumn, inshore in April

KEY: NS = Nova Scotia GM= Gulf of Maine GB = Georges Bank SNE = Southern New England MA = Mid-Atlantic

Maximum Sustainable Yield. MSY provides a useful guide to the long-range biological productivity of the stocks, provided that the limitations of MSY are kept in mind. The indicated estimates of MSY are, in some cases, based upon analytical models, and in other cases are based upon long-term historical catch averages. MSY is not necessarily an indication of what may be taken in any given year, but what might be taken on the average over a similar long-term historical period. If catches were maintained at the MSY level for a period of time, stocks would likely decline due to annual variations in the strength of recruitment. Catches would then decline since productivity from the reduced stock would be less than before. The estimates of MSY, where given by stock, give an indication of the relative productivity of those stocks.

By-Catch and Distribution. The data under this category demonstrate that a unit of fishing effort in the mixed groundfish fishery may be directed at several species, simultaneously. A unit of fishing effort directed at one species may catch, perhaps less effectively, other species that are associated with it in the environment. Moreover, in the mixed fishery, fishing trips which are initially directed towards one species may often be switched to other species through conscious effort by the vessel captain in order to make an economically viable trip. Other information in this category attempt to characterize the predominate portion of the water column where fish reside and to give some indication of patterns of movement and migration.

§2A5 Prediction of Resource Abundance

In support of the fishery management decision-making process, the New England Fishery Management Council has a requirement for up-to-date assessment information pertaining to the stocks of fish under management. Current information with respect to health of the stocks is most useful when it may be viewed against a background of trends in the historical fishery, and has particular relevance within the overall management process when formulating management objectives and setting optimum yields. When comprehensive historical fishery data are available then more complete stock assessments may be generated which have short-term predictive capabilities of future stock conditions. Thus, feasible planning of future management action, predicated upon the attainment of long-range objectives, is contingent on a comprehensive fishery data base and an enhanced predictive capability.

The spectrum of currently available stock assessment information ranges from the series (since 1963) of relative abundance indices derived from NMFS research vessel bottom trawl surveys to complete stock assessments developed for selected, economically important species. Survey catch data provide a relative index of stock abundance and recruitment prospects and indicate, in the context of prior year's data, trends over time of these parameters. Until recently, survey data alone could provide no indication of absolute stock abundances (i.e., in the context of minimum stock size constraints). Collie and Sissenwine (1983) have demonstrated a method for estimating population sizes from standardized survey data which should prove to be extremely useful in cases where insufficient fishery catch data are available for development of traditional stock assessments (e.g., virtual population analysis) such as the Gulf of Maine cod stock. Their method, however, has a limited predictive value since the relative abundance of the most recent recruiting year class does not enter into the analysis. Other techniques are available for estimating the absolute level of recruitment from survey relative abundance indices broken down by age class, such as regression analysis of historical recruitment data which are provided by another method (e.g., virtual population analysis).

The estimation procedure, virtual population analysis (VPA), developed by Gulland (1965), marked the initiation of the quantitative stock assessment in fishery management, worldwide. Prior to its development, only qualitative models (such as yield per recruit analysis) were available for providing specific advice to fishery managers. VPA is essentially a technique for estimating the instantaneous fishing mortality rates and stock sizes at age necessary to explain the observed landings plus losses from an assumed level of instantaneous natural mortality (i.e., all other sources of mortality other than from fishing). VPA has proven to be a powerful tool for fishery management, but not without discrimination in its use and interpretation of its results. The major sources of error in the VPA concern the assumptions regarding natural mortality, the accuracy of the catch-at-age information, and the level of fishing mortality assigned to the oldest age which is used to start the analysis. Landings-at-age information, regardless of the precision of estimation, may not necessarily reflect the actual removals from the stock with discards being the major source of error. The assumed level of natural mortality (M) may only partially compensate for such losses since the VPA assumes a constant M over all age classes.

Finally, to begin a VPA, the level of fishing mortality (F) appropriate to the oldest age class in the catch (the so-called "starting F") must be either assumed or estimated by another method. With a sufficient time span of historical catch data, errors associated with an incorrect "starting F" are quickly dampened out, particularly if fishing mortalities are high, but the results for the most recent 1-3 years are usually subject to considerable uncertainty.

Typically, in a complete stock assessment using the VPA, the estimates of the strength of the most recently recruiting year classes may be improved through regression analysis of historic VPA-derived estimates of recruitment on the corresponding year's bottom trawl survey catches. Thus, with a derived relationship, current survey catches may be converted to estimates of absolute abundance. With such estimates of current levels of recruitment, alternative scenarios of catch and resulting stock size may be projected 1-2 years in advance. Thus, fishery managers have the opportunity to evaluate the near-future consequences of possible management actions.

As an outgrowth of inquiries into the overall relationship between the size of the spawning stock and the number of progeny resulting from spawning activity, the effect of certain environmental variables, mediated through egg and larval survivability, has received attention in recent years. The effect of temperature has received particular attention. It has long been known that many stocks of marine fish and shellfish exhibit more or less well defined long-term cycles in catch levels. Whether such cycles are also descriptive of actual stock abundances may be problematic. Seawater temperature has been of particular interest since, as with catches of certain species, long-term cycles are demonstrable. For example, the Boothbay Harbor, Maine, sea surface temperatures depicted in Figure 2A18 may be shown to exhibit strong autocorrelation with a remarkably smooth 22-year cycle (NEFMC, unpublished data). Moreover, historic catch levels of yellowtail flounder are similarly autocorrelated.

A number of investigators (Dow, 1977; Edwards, 1965; Flowers & Saila, 1972; Sissenwine, 1974; Sutcliffe et al., 1977) have examined the overall question of the relationship between sea water temperature and the abundance of fish and invertebrates with the view of developing a short-term predictive capability. Based upon these studies, qualitative comparisons between temperature and trends in population abundance of selected species are shown in Table 2A7 (Grosslein and Azarovitz, 1982). It is seen that all eight species showing negative (inverse) correlations with temperature are northern species - yellowtail flounder, mackerel, cod, winter flounder, Illex squid, American lobster, silver hake and red hake. On the other hand, all but one of the species showing positive correlations with temperature (sea scallop, Loligo squid, summer flounder and scup) are resident to the New England-Middle Atlantic Bight area. Menhaden, showing a weak positive correlation, is a southern species.

This overall pattern is what may be expected if lower temperatures are presumed to enhance the suitability of the New England-Middle Atlantic area for northern species while warmer temperatures presumably enhance conditions for resident or southern species. This consistency with expectations lends

Table 2A7. Qualitative associations between temperature trends and abundance of selected species.

	Species	Relative Strength of Correlation	Faunal Group
Positive Correlation With Temperature	Sea Scallop	Moderate	Resident
	Loligo Squid	Moderate	Resident
	Summer Flounder	Weak	Resident
	Scup	Weak	Resident
	Menhaden	Weak	Southern
Negative Correlation With Temperature	Yellowtail Flounder	Strong	Northern
	Mackerel	Moderate	Northern
	Cod	Moderate	Northern
	Winter Flounder	Moderate	Northern
	Illex Squid	Moderate	Northern
	American Lobster	Moderate	Northern
	Silver Hake	Weak	Northern
	Red Hake	Weak	Northern

credence to the idea that temperature may have a real association with fish abundance. Unfortunately, the data are not adequate to distinguish between simple extensions of seasonal migrations and real population changes, except for sea scallops and possibly the American lobster. Yellowtail flounder may be another case where real changes occur since this species exhibits little or no migratory activity.

All of the studies cited above have demonstrated significant correlations between mean temperature data and subsequent lagged catch data for a number of important commercial species of fish and invertebrates. The results suggest that, in selected cases, fish abundance is related to the sea water temperature at the time fish were spawned or during the first winter of life. The actual mechanism involved is not explained on the basis of the correlation, thus a causal relationship is yet to be demonstrated. This does not imply that the association between fish abundance and temperature is spurious. On the contrary, that association may be useful, at least as a qualitative consideration, in short-term predictions of resource abundance.

SUBPART B: DESCRIPTION OF THE HABITAT

§2B1 Ecological Relationships

§2B1.1 Bathymetry

The fishery resources of importance to the multi-species fisheries off the northeast coast of the United States are typically distributed along the continental shelf from Georges Bank southward to the Mid-Atlantic Bight and in the Gulf of Maine. The continental shelf on the U.S. east coast is narrowest off Cape Hatteras, North Carolina, where the 100 fathom contour is only about 20 miles offshore. As one travels northward, the shelf extends out considerably further with the 100 fathom counter located about 80 miles off Cape May, New Jersey, and about 100 miles off Cape Cod.

Between Cape Cod and Nova Scotia is the expansive Gulf of Maine, enclosed to the seaward by Brown's Bank and Georges Bank. The topography of the Gulf, scoured by glaciation, includes many deep basins and shallow banks and ledges. Water exchange with the Atlantic Ocean takes place primarily through the deep Northeast Channel region and the shallow Great South Channel.

Georges Bank is a large, relatively shallow bank located between the Great South Channel and the Northeast Channel. The shallowness of the water, in combination with the mixture of nutrient rich water within the circulation pattern, makes Georges Bank an area of high biological productivity and a rich fishing ground.

§2B1.2 Sediments

From Cape Hatteras north to Cape Cod, the bottom sediments of the shelf are mostly sand, with areas of silt/clay, gravel and gravel/sand mixtures. Gulf of Maine sediments vary considerably, from rocks to silt, gravel and sand. Georges Bank is primarily sand, with pockets of gravel and sand/gravel, and large rocky areas on the Northeast peak.

§2B1.3 Hydrography

Nearshore surface circulation from Cape Cod to Cape Hatteras is generally southwesterly throughout the year. Further offshore, the Gulf Stream flows northwesterly. Shelf waters along the cost are strongly influenced by the extensive extuaries of the region, including Chesapeake Bay, Delaware Bay, Hudson River, Narragansett Bay, and the estuaries behind the barrier beach systems.

On Georges Bank itself, a clockwise gyre forms during the early spring. Currents outside of the 60 meter isobath on the north side of the Bank are northeasterly at up to 30 cm/sec; on the eastern side of the Bank the flow is to the south, and on the southern side the flow is southwesterly. The flow along the eastern side of the South Channel at depth is toward the north, completing the clockwise gyre on the Bank. Currents on the west side of the South Channel are weak, resulting in sediment deposition in the general area of Nantucket Shoals. Currents along the southern flank of Georges Bank are westerly at about 10 cm/sec toward the Mid-Atlantic Bight. By summer, the flow at the eastern edge of the bank is southerly and offshore. By autumn, the flow over the western edge becomes westerly and southerly, marking a weakening of the clockwise gyre. In winter, the surface drift over Georges Bank is, in general, southwesterly. Throughout the year, the water over Georges Bank shallower than 60 minutes is vertically well mixed, owing to the combined effects of tidal currents, winds, waves and storms.

Surface circulation in the Gulf of Maine is basically counterclockwise. Slope water enters through the Northeast Channel and shelf water enters over the Scotian Shelf and Brown's Bank. Water flow continues to the Bay of Fundy. During the winter, a southerly flow exists along the western side of the Gulf, and washes out over Georges Bank. Several eddies develop near the northeastern part of the Gulf at this time. Propelled by fresh water run-off from river systems along the Bay of Fundy and the Maine coast in the spring the Gulf of Maine eddy develops into a strong counterclockwise gyre, and then starts to break down in early summer as river flows abate. By late autumn the currents are weak, and water flow begins to resemble the winter pattern. There is very slow (0.1 miles/day) movement of water, primarily shoreward, in the deeper parts of the Gulf. Pronounced upwelling of nutrient-laden bottom waters occurs, particularly in the eastern and northeastern edges of the Gulf, as a result of tidal forces and circulation patterns.

Surface water temperatures in shelf waters of the Mid-Atlantic Bight vary from less than 3°C in February in the northern region to 27°C off Cape Hatteras in late summer. The annual temperature range of shelf waters may exceed 20°C. Water temperatures vary at different depths, especially in the summer. Salinity of the region is lowered by large estuarine fresh water inflow in the spring. Intrusion of offshore saline water eventually raises salinity to maximum again in the winter. Salinities in this area average 32 parts per thousand.

Frequent vertical mixing of waters at the eastern edge of the Gulf of Maine and Georges Bank minimizes vertical salinity and temperature gradients in those regions. The western part of the Gulf is stable in summer, resulting in warm temperatures and low salinities at the surface, and little vertical mixing. Water temperatures range from 2°C to 17°C at the surface of the Gulf and Georges Bank, while the cold deeper waters of the Gulf range from 4°C to 9°C. Surface temperatures decrease easterly and northeasterly across the Gulf in summer, while deep water temperatures and salinities generally increase easterly and northeasterly at all seasons. Average salinity is 32 parts per thousand.

§2B1.4 The Biotic Assemblage

Zoogeographically, the Gulf of Maine region is boreal, and the fauna is typically Acadian. South of Cape Cod to Cape Hatteras is warm temperate, and the fauna is Virginian. Although Cape Cod is the general dividing line, many species are found throughout the region from the Gulf of Maine to Cape Hatteras. Gulf of Maine fauna may include subtropical, tropical, temperate, and arctic immigrants at various times of the year.

The Plankton. The plankton are microscopic plants (phytoplankton) and animals (zooplankton) that drift in the water column. The annual cycle of the plankton community is typical of the temperate zone. Nutrients are abundant in the water but phytoplankton abundance is low because productivity is suppressed by low levels of solar radiation and temperature. The level of solar radiation increases as spring approaches, and causes an intense phytoplankton bloom which is comprised primarily of diatoms. This level of productivity results in a decrease of inorganic nutrients, and as summer approaches, phytoplankton abundance begins declining.

Zooplankton feed predominantly on phytoplankton, but fish larvae commonly feed on zooplankton (often copepods). During summer, zooplankton reach maximum abundance, while the phytoplankton decline to near winter levels. Dinoflagellates and other phytoplankters, apparently more suited to warm, nutrient-poor waters, become abundant during summer. Although bacteria in the sediments actively remineralize nutrients from organic debris (detritus), summer stratification of the water column may prevent nutrients from being returned to the near surface (euphotic zone) where they may contribute to primary productivity through photosynthesis. On Georges Bank and the eastern and northeastern edge of the Gulf of Maine, vertical mixing of the water column occurs during the summer, thereby recirculating nutrients and maintaining high plankton productivity. Water column stability may be affected by severe storms, and anomalies in temperature may disturb the timing between annual cycles of interacting species. In the autumn, decreasing water temperatures result in a breakdown of the vertical temperature gradient, and nutrients are again circulated up into the euphotic zone. Another phytoplankton bloom results, and lasts until low solar radiation levels inhibit photosyntheses. Phytoplankton and zooplankton levels then decline to the winter minimum, and nutrient levels increase to their winter maximum.

The Nekton. The nekton are animals that swim in the water column. They are predominantly fish, but also include other animals such as squid, whales and porpoises. The ability to swim allows nektonic organisms to migrate between locations or to maintain a specific breeding location with some consistency year after year.

The feeding habits of nekton vary by species, by the size of the individual, and probably by season and food availability. Adults of many commercially important species of the region feed on either fish or invertebrates, but small fish, including the young of some large species, often feed on plankton. Adults of some large species, such as various whales, basking sharks and ocean sunfish, are plankton eaters throughout life.

The Benthos. The benthos are animals that live on or within the bottom sediments. They are predominantly invertebrates (e.g., tube worms, starfish), although strongly bottom-oriented fishes are considered benthic. Benthic organisms are extremely diversified, and include species from several phyla. They can be classified by size (meiobenthos, macrobenthos), by their location on or in the sediments (epifauna, infauna), by the type of bottom in which they live (sand, mud, gravel, rock, etc.), by feeding type (deposit feeders, suspension feeders, herbivores, carnivores), and by the type of community with which they are associated.

§2B2 Habitat Characteristics and Requirements

The fishery resources of a region are influenced by the quantity and quality of available habitat. Depth, temperature, substrate, circulation, nutrient supply, and contaminant concentrations are important physical and chemical parameters of a given habitat which, in turn, determine the type and level of resource populations that the habitat supports. Among continental shelf ecosystems, the Georges Bank region ranks among the most highly productive marine habitats, exclusive of upwelling zones.

Industrial, urban and agricultural activities are major contributors to marine habitat degradation in the Northeast. Developmental pressures in coastal areas have altered the type and decreased the amount of habitat available for fishery production, while point and non-point source pollution have degraded the quality of what remains. Impacts on fish include mortality, disease, increased susceptibility to predation, or reduced reproductive success, all potentially resulting in significant population declines of important commercial and recreational species, or those species upon which they depend for food.

The effects of habitat alteration on fishery yield offshore are not as well-defined as inshore, but concern is warranted to the extent that (1) the offshore environment is subject to habitat degradation from either inshore activities or offshore uses, and (2) offshore species are dependent either directly or indirectly on inshore habitats for reproduction and food supply.

The major causes of habitat alteration that may be affecting groundfish populations in the New England area are located within the coastal drainage basins along the Northeast coast. Point source discharges from power plants, sewage treatment plants, and various industrial processes discharge polychlorinated biphenyls (PCBs), other chlorinated hydrocarbons, petroleum by-products, nutrients, and metals into rivers, bays, and estuaries. Urban and agricultural run-off contributes even greater amounts of these contaminants. Coastal construction, dredging, and filling degrades or destroys productive wetlands and nearshore areas that often serve as nursery grounds for commercial fish and their food species. Ocean disposal of dredged material and industrial wastes, discharge of oil from ships, and other commercial and recreational uses of the ocean also contribute significant amounts of contaminants and debris.

The purpose of this section is to relate the biological requirements of the species of this FMP to existing or potential causes of habitat alteration in both the inshore and offshore regions. In this way, threats to the resource as well as data gaps can be identified, and appropriate measures to respond to identified threats can be recommended.

Atlantic cod, in the Southern New England and Middle Atlantic area, move into the New York Bight to overwinter, but generally avoid the Bight during the summer when temperatures exceed 20°C. The majority of cod between Cape Cod and the Grand Banks exhibit only minor inshore-offshore seasonal migrations. In the Gulf of Maine, large cod are found at depths greater than 40 m during summer, but as shallow as 5 m during winter. Few cod are caught deeper than 200 m.

Cod prefer temperatures between 0°C and 10°C. Small cod are more tolerant of higher temperatures, spreading into warm, shoal waters during the summer.

The largest catches of cod are made on rocky and pebble grounds, and on gravel, sand, and gritty types of clay with broken shells. Young cod may be found foraging among Irish moss and other seaweeds. Cod usually lie within a few meters of the bottom, the larger the cod the closer to the bottom.

Cod prefer shoal areas for spawning. Spawning grounds include eastern Georges Bank, Nantucket Shoals, western Massachusetts Bay, and just north of Cape Ann. Optimum spawning and hatching temperatures range from 5° to 7°C. Spawning takes place near the bottom but eggs and larvae are pelagic. After taking to the bottom, many young cod live in shoal water extending into the littoral zone.

Small cod (less than 50 cm) eat mainly decapod crustaceans. The larger fish (greater than 50 cm) consume significant quantities of fish including herring and other clupeids, silver hake and other hakes, sand lance, sculpin, mackerel and redfish. Decapod crabs, particularly Cancer irroratus, are also important forage species.

Haddock are found in the Gulf of Maine, on the Scotian Shelf and on Georges Bank. Few are caught in less than 10-20 m or deeper than 200 m; most are caught between 50 and 150 m. They generally do not cross the deep Northeast Channel separating Georges Bank from Browns Bank and the Scotian Shelf.

Haddock prefer a temperature range of 2°C to 11°C. This implies that the shoaler areas of the Gulf of Maine are too warm in late summer and too cold in late winter. Few haddock occur south of Cape Cod as temperatures, particularly during summer, exceed the optimum range.

Haddock tolerate a salinity range of 31.5°/°° to 34.5°/°°; most are caught in salinities greater than 32°/°°. Haddock enter the bays of Maine but never run up estuaries into brackish water. They are chiefly taken on broken ground, gravel, pebbles, clay, smooth hard sand, sticky gritty sand, and broken shell; but not in kelp beds or over ledges, rock, or silty mud.

Spawning on Georges Bank occurs at a temperature of 2°-6°C. Active spawning occurs at temperatures from 1.5 to 7°C. Eggs are buoyant. During their first few months as pelagic organisms, fry feed on copepods. Depending on temperature, the pelagic stage can last about three months during which time considerable drift may occur.

Haddock may spawn anywhere on Georges Bank, except Georges Shoal which is too shallow. The northeast part of the Bank is the center of spawning. There are secondary spawning areas around the Great South Channel and Nantucket Shoals. Spawning occurs along the Maine coast in 30-100 m.

Small haddock (less than 25 cm) feed on various crustaceans (euphausiids, amphipods and decapods), and polychaetes. Larger haddock (greater than 25 cm) feed on amphipods, polychaetes and echinoderms.

Redfish prefer rocky, hard ground or mud but not sand. They range in depth from near the tidal zone to more than 700 m. Most of the redfish catches are between 80 and 350 m. Redfish have a temperature range of 0.5°C to 10°C, preferring the bottom of the deep channels in the Gulf of Maine in winter. Redfish are ovoviparous, bearing their young alive from early May to early September (peaking during June and July) in temperatures of 3° to 9°C and salinities of at least 32°/°°. The pelagic fry may be found in large numbers in the Gulf near the 50 fathom contour; fish are about 2.5 cm long when they seek the bottom. Redfish prey heavily on crustacea, principally euphausiids and pelagic shrimp.

Pollock are active schooling fish. They live throughout the water column depending on food supply and season. In the Gulf of Maine, they may be found at any depth from the surface to at least 200 m. Adults avoid surface water temperatures greater than 11°C. Small "harbor pollock" (up to 20 cm in length) are rarely found in water temperatures above 16°C.

Pollock spawn in the area of Massachusetts Bay to the Isle of Shoals in 100-120 m depth. At least 3°C is needed for eggs to incubate, this probably sets the northern limit of a permanent resident population. Spawning is in late autumn and early winter. On Massachusetts Bay grounds, spawning starts at 9°C and ends (in late December) at 6°C.

Eggs are buoyant. In European waters the young live near the surface for the first three months; the same behavior is assumed to apply to New England stocks. Harbor pollock appear inshore after early April. South of Cape Ann, they move offshore in June to avoid rising temperatures. In more northerly waters, they remain inshore throughout the summer and autumn. The larger fish tend to stay offshore year-round.

Pollock less than 75 cm in length feed primarily on crustaceans, with euphausiids and pelagic shrimp making up more than 60% of their diet. Larger pollock feed heavily on fish (more than 50% of their diet) including clupeids, silver hake, pollock, lantern fish, mackerel and redfish.

Silver hake have a temperature range from 4° to 18°C. Spawning silver hake migrate from deep overwintering grounds to shallower regions along the continental shelf and in the Gulf of Maine. Spawning in the Gulf of Maine occurs particularly on the eastern side of Cape Cod north to Cape Ann and to some extent to Grand Manan Island. Major spawning grounds on the continental shelf are along the southeast and southern slope of Georges Bank, around Nantucket Shoals, and south of Martha's Vineyard. Spawning occurs from May through November; peak spawning in the Gulf of Maine is during July and August, while peak spawning in the continental shelf area is during June and July. The lowest temperature at which spawning occurs is 5°C, most eggs are produced at 8°-13°C. Silver hake spawn near the bottom but their eggs are pelagic. Pelagic eggs and larvae drift with the currents for two months and then descend to the bottom. Juveniles stay in deep water during the following year before participating in annual spawning migrations.

Small silver hake (less than 20 cm) feed predominantly on crustaceans. more than 80% of their diet is amphipods, decapods, euphausiids, mysids, and copepods. Larger fish (greater than 20 cm) eat fish and some squid including clupeids, silver hake, sand lance, mackerel, butterfish and Loligo squid.

Red hake are demersal and are found over sand or mud bottom. Adult fish prefer a temperature range of 5° to 12°C. They exhibit a seasonal inshore-offshore migratory pattern, with overwintering in deeper offshore waters. Edwards, Livingstone and Hamer (1962) found fish most abundant between 60 m and 180 m off Southern New England in winter where bottom temperature was 8° to 10°C. In late spring, mature fish migrate inshore. In the Southern New England area they move offshore again as water temperature increases towards 10°C. During summer they are concentrated in less than 110 m between Martha's Vineyard and Long Island and southwestern Geoges Bank. In the Gulf of Maine, mature fish remain inshore throughout the summer where water temperatures remain less than 10°C.

Spawning begins in May in the Southern New England area and June in the Gulf of Maine. Domanevsky and Nozdrin (1963) report peak spawning on Georges Bank during mid-July in the 110 to 120 m depth range.

Red hake eggs and larvae are pelagic. During their first year of life, many juveniles live in the mantle of scallops. Musick (1969) suggested that as the number and size of scallops decrease from fishing, red hake populations may be affected. Juvenile red hake are generally found in less than 110 m depth and appear to avoid temperatures less than 4°C.

Small red hake (less than 25 cm) feed primarily on amphipods and decapod crustaceans. Medium size fish (25-40 cm) feed on decapod crustaceans. Larger fish (greater than 40 cm) consume a significant amount of fish.

White Hake are most abundant in deeper muddy basin areas of the Gulf of Maine. Seasonal movements between shallow (30 m) inshore and offshore areas to 400 m may be coordinated with spawning activity. A protracted spawning period probably occurs from November to April. Juveniles are pelagic, generally occurring in shoaler waters. They reportedly move inshore into harbors and estuaries in the spring, especially in more northerly areas of the Gulf, returning to offshore waters in the autumn.

Juvenile white hake are slightly more temperature-tolerant (2°C - 15°C) than the adults (upper range about 13°C). By the time they have attained lengths of about 32 cm, most juveniles have settled to the bottom in deeper areas to take up the adult pattern of existence. Most of the commercially important populations occur at depths greater than 120 m, but significant numbers of fish are taken in shoal water in the summer by gillnets.

Juvenile white hake feed principally on decapod shrimp and euphausiids. White hake larger than 40 cm in length feed primarily on fish including juvenile white hake, silver hake, argentines, winter flounder, and clupeids.

Yellowtail flounder occur in depths from about 10 to 100 m, but they are mostly caught in the depth range 27 to 64 m. They occur on coarse, medium and fine sand, mixtures of sand, and mud and tend to avoid soft mud and rock bottoms, at least in the late juvenile and adult stages. Off New England, their temperature range is from 1°C in winter to 18°C in summer.

Tagging studies show that fish move easterly from Block Island to Southern Nantucket Shoals during spring and summer with 3% going as far as

Georges Bank. They return westerly in the autumn-winter. Similarly, Georges Bank fish move west in winter with about 5% going off the Bank to Southern New England and back to the Bank in summer. Yellowtail flounder from east of Cape Cod show little movement.

Yellowtail flounder spawn from March through July, peaking in mid- May. Eggs and larvae are pelagic, drifting for three to four months. Juveniles seek the bottom by late summer. There is some evidence indicating that cold water temperature promotes the production of strong year classes. Large year classes of the late 1950's and 1960's were spawned during a cold period.

Small yellowtail flounder (less than 30 cm) feed primarily on amphipods with polychaetes being of secondary importance. The relative importance of amphipods and polychaetes is reversed for larger (greater than 30 cm) yellowtail flounder.

American plaice avoid rocky or hard bottom, they prefer fine, sticky, gritty mixtures of sand and mud. This bottom type is found on the floor of the Gulf of Maine between hard patches, from 40-200 m depth. American plaice are also found on soft mud in the deeper basins on the western side of the Gulf.

American plaice prefer a temperature of 1.5°-7°C, although they can tolerate a range of -1.5° to 13°C. They are never found in brackish water. Plaice do not exhibit significant migratory behavior, although an inshore movement to spawn can be inferred from the distribution of eggs and larvae.

Spawning in the Gulf of Maine occurs from March to mid-June, peaking in April and May. Eggs are found in coastal waters (less than 100 m depth) from Cape Cod to Cape Sable. The optimal spawning temperature is 3°-4°C. Eggs and larvae are pelagic. The pelagic stage probably lasts three or four months before juvenile fish seek the bottom.

Small American plaice (less than 25 cm) feed on polychaetes, crustaceans, mollusks and echinoderms. In larger fish (greater than 25 cm) the percentage of echinoderms increases until it reaches about 75% for fish larger than 40 cm. Sand dollars and brittle stars predominate in the diet.

Witch flounder are seldom found in water shallower than 10-15 m, the majority of the catches occur between 120 and 300 m. They are most abundant in fine mud, sand, clay, or mud. They are quite stationary with no evidence of inshore/offshore seasonal migrations.

Witch flounder occur in a temperature range of 2° to 9°C. They have an extended spawning season. Eggs and larvae are pelagic. The pelagic stage may last 4-6 months which is longer than for most flatfish. Small witch flounder (less than 20 cm) eat mostly euphausiids. More than 60% of the diet of larger fish (greater than 20 cm) is polychaetes. Echinoderms play a minor role.

Winter flounder populations inhabit soft mud, clay, sand or pebble in the shoal water (less than 55 m) of bays and estuaries and on Georges Bank on hard bottom in the typical depth range 45-80 m.

Discrete local stocks result from females laying demersal non-dispersive eggs. Except for the stock on Georges Bank, winter flounder spawn in estuaries. Estuarine-spawned fish exhibit a general tendency to gradually move offshore to coastal waters as they grow older. South of New York, fish regularly migrate to deeper water in the summer and return to bays and estuaries in the winter.

South of Cape Cod, adult winter flounder migrate out of bays and estuaries to cooler coastal waters as temperatures rise in late spring. North of Cape Cod, with cooler summer water temperatures, they remain in bays and harbors but may seek deeper holes as water temperatures reach the annual maximum. Winter flounder prefer water temperatures below 15°C.

Winter flounder spawn during winter, usually in shallow (2- 6 m) estuaries. Reproductive success among coastal populations is most dependent on upper estuarine spawning. Metamorphosis is completed after two to three months. Early life stages are most abundant in upper portions of estuaries. They gradually move into the lower portions of estuaries as they grow and are less susceptible to currents. Juveniles eventually leave estuaries to summer in coastal waters before returning to spawn for the first time.

Winter flounder feed predominantly on polychaetes, sea anemones are of secondary importance. Bigelow and Schroeder (1953) report that plant material may be an important part (up to 40%) of their diet. Winter flounder feed only during the day, being visual feeders.

Windowpane flounder are generally found on sandy bottom at depths to 80 m. They are common in inshore waters and estuaries south of Cape Cod. Spawning occurs primarily in water depths less than 40 m in the temperature range 8.5°-13.5°C from Chesapeake Bay to Cape Cod. Eggs are pelagic.

Windowpane flounder feed primarily on mysids. Other crustaceans are of secondary importance.

§2B3 Effects of Habitat Alteration

Habitat alteration can potentially lower both the quantity and quality of Atlantic groundfish products through physical changes or chemical contamination of habitat. It is difficult to separate the effects of habitat alteration from those of other factors such as fishing mortality, predation, and natural environmental fluctuations. Moreover, species and individuals within species differ in their tolerance to habitat alteration. Although a clear cause and effect relationship has not been demonstrated, that does not imply that habitat alteration is not affecting individuals or populations of species of interest. Species dependent on coastal areas during various stages of their life, particularly for reproduction, are more vulnerable to these effects than are species that remain offshore. Important groundfish species such as cod, winter flounder, pollock, silver hake, and windowpane flounder, which are especially dependent on the condition of near-shore habitat, are particularly vulnerable to the threats discussed below.

§2B3.1 Physical Alteration of Habitat

Tremendous developmental pressures exist along the Northeast coast. Approximately 2,000 permit applications for commercial, industrial, and private marine construction projects are reviewed annually by the Northeast Region of the National Marine Fisheries Service. These activities may result in habitat loss or modification, imposing significant impacts on marine biota. More often, projects are small-scale, causing minor losses or temporary disruptions to organisms and habitat. The significance of small-scale projects lies in the cumulative and synergistic effects from the large number of projects.

Construction or mining in and adjacent to waterways often involves dredging, which results in elevated suspended solids near the project area. The effect of the increased turbidity depends on tides, currents, the type and amount of substrate being dredged, and preventive measures employed by the contractor. Excessive turbidity can clog fish gills, decrease egg buoyancy, abrade sensitive tissues, lower dissolved oxygen concentrations, and reduce light penetration which affects photosynthetic activity.

The effects of turbidity and siltation are usually temporary. Other effects of construction can result in long-term habitat disruption. For example, dredging can degrade habitat by resuspending pollutants that have settled in the sediment. Further, filling to create uplands destroys productive marsh and shallow water habitats.

Thermal effluents from fossil fuel or nuclear power plants may cause stress or mortality to local populations. Reverse thermal shock occurs when fish, accustomed to artificially elevated water temperatures, are exposed suddenly to colder water during a plant shutdown. Entrainment of early life stages of fish and adults may cause significant mortalities in localized areas. Biocides used to reduce fouling may cause lethal or sublethal effects to egg and larval stages of fish and shellfish.

Oil and gas exploration in the Mid-Atlantic and North Atlantic lease areas may result in loss or degradation of benthic habitat from the deposition of discharged drilling muds and cuttings. Exploratory drilling for oil and gas is believed to have caused only minimal habitat degradation or biological impact thus far. However, should oil and gas development and production occur in these areas, the transport of the products inshore could threaten already stressed coastal ecosystems.

Demand is increasing for sand and gravel as a construction aggregate. As a result, mining may be expected to expand from shallow coastal areas to deeper waters as economic conditions permit. Adverse effects associated with sand and gravel mining include disruption of benthic habitat, burial of aquatic organisms by siltation, and altered sedimentation patterns. Coastal borrow pits created by mining are known to persist and accumulate very fine sediments which cause anoxic or hypoxic conditions in bottom waters. It is not known whether similar impacts would occur in offshore areas.

§2B3.2 Chemical Contamination of Habitat

Acute and sublethal effects on marine organisms can occur following exposure to chemical contaminants, including types of pesticides, synthetic organics and petroleum hydrocarbons. General effects include mortality, disease, reduced reproductive success, or increased susceptibility to predation. It is unclear whether effects observed in individual fish are affecting the overall populations, or if contaminant concentrations in fish pose a risk to consumers since the edible portions often contains lower amounts of contaminants than do the organs such as the liver, kidney or gonad. Contaminant burdens in organs can conceivably be high enough to affect the health of organisms even when levels in edible tissues are not an apparent threat to consumers.

Trends in contaminant effects on populations could be better anticipated by combining data on fish tissue concentrations with data on contaminant inputs into the environment. Estimates of discharge for over twenty pollutant categories for U.S. coastal areas have been compiled by NOAA's Ocean Assessments Division. This data base, the National Coastal Pollutant Discharge Inventory (NCPDI), provides useful information for comparing relative amounts of discharges among different coastal areas. Preliminary NCPDI data for discharges from Maine to Cape May indicate that the waters off the major Northeast metropolitan centers, Massachusetts Bay and the New York Bight, consistently receive the highest amounts of pollutants, and are therefore among those areas where habitat alteration problems are the most severe (Figures 2B1-2B5). For chlorinated hydrocarbons and PCBs, Narragansett Bay joins Massachusetts Bay and the New York Bight in the top category.

Effects of Contamination: Metals Analysis of metal concentrations in seven groundfish species in the New York Bight (could be considered the "worst case") revealed that concentrations were below the U.S. Food and Drug Administration's (FDA) action level (NMFS, Microconstituents Program). Chronic exposure to metals, however, can disrupt respiratory patterns and metabolic function. Some species appear to possess a mechanism for immobilizing certain metals, thereby allowing a buildup of the contaminant in tissue without disruption of normal metabolic function. Adult winter flounder may possess this ability for mercury or silver (Sindermann et al., 1982).

Effects of Contamination: Organics Acute and sublethal effects on fish and their food species may occur following exposure to pesticide residues, industrial organics and petroleum hydrocarbons. Impacts can include mortality, reduced fecundity, decreased survival of larvae and juveniles, disease and behavioral modifications.

Concentrations of organic contaminants are higher in degraded coastal and estuarine areas than offshore. In a survey of the New Bedford area, winter flounder had a mean of 6.4 ppm PCB, and a maximum of 22 ppm (Massachusetts Coastal Zone Management, 1982), significantly exceeding the FDA's action level of 2 ppm. Conversely, PCBs in flounder and plaice from Boston Harbor and Cape Cod Bay were below 0.14 ppm (Boehm et al., 1984), though sediments at several of the trawl stations were heavily contaminated with PCBs. In another study (Boehm and Hertzer, 1982), concentrations of petroleum hydrocarbons, PCBs and DDT in groundfish species in the Northwest Atlantic and Gulf of Maine were found to be of little concern. Silver hake had the highest levels of all

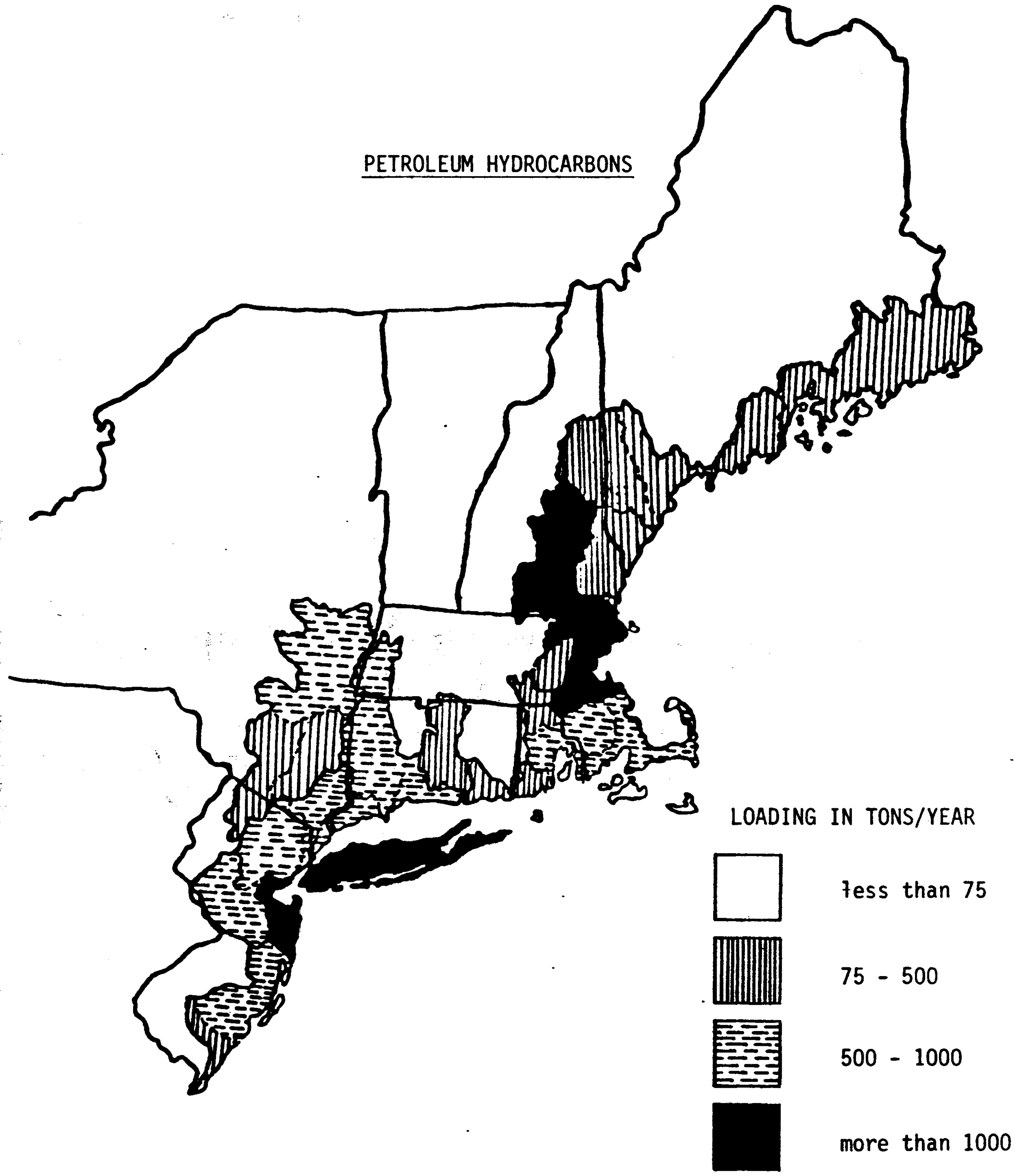

Figure 2B1. Petroleum hydrocarbon loading by hydrologic unit in tons/year, based on data from the National Coastal Pollutant Discharge Inventory.

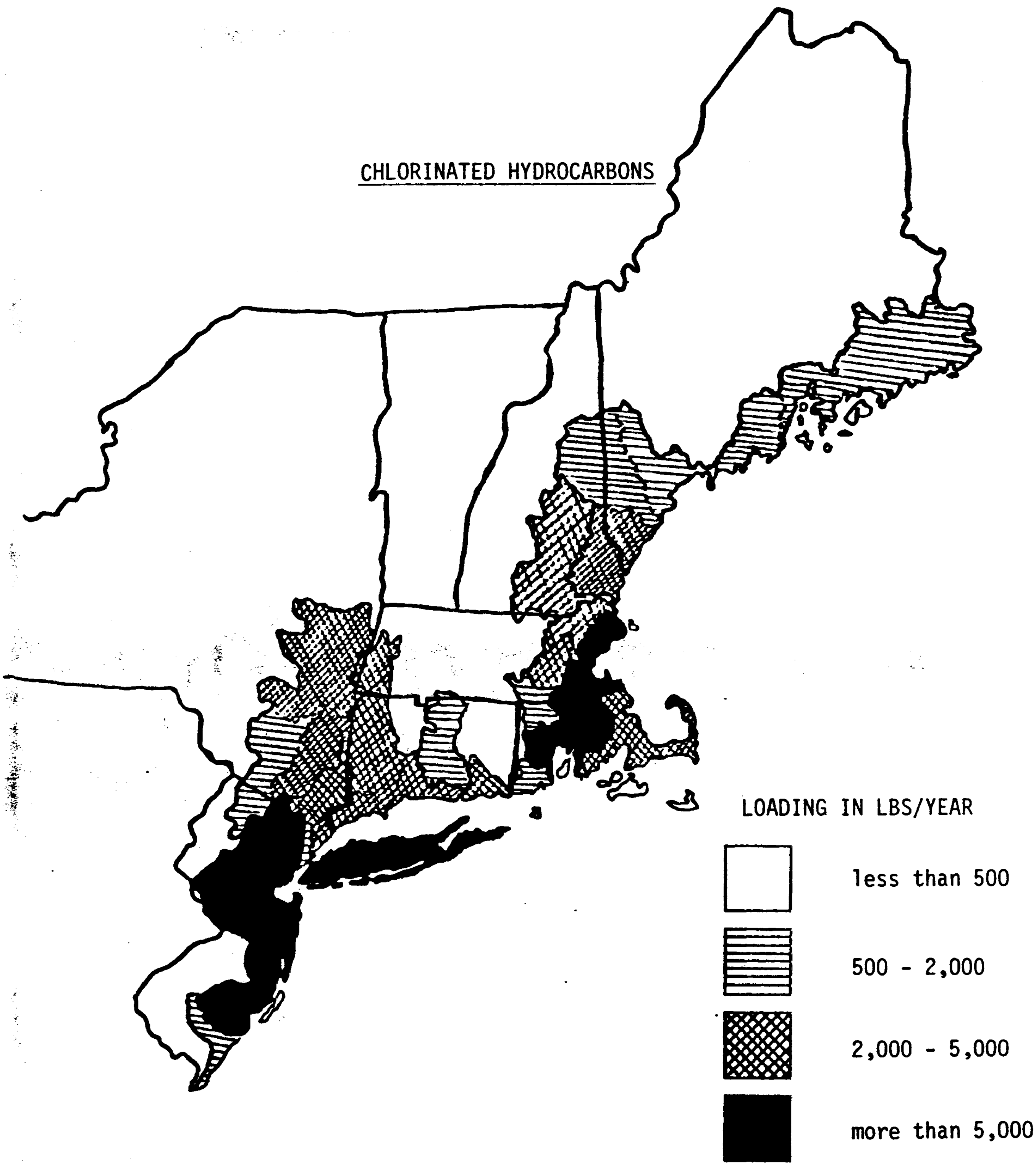

Figure 2B2. Chlorinated hydrocarbon loading by hydrologic unit in lbs/year, based on data from the National Coastal Pollutant Discharge Inventory.

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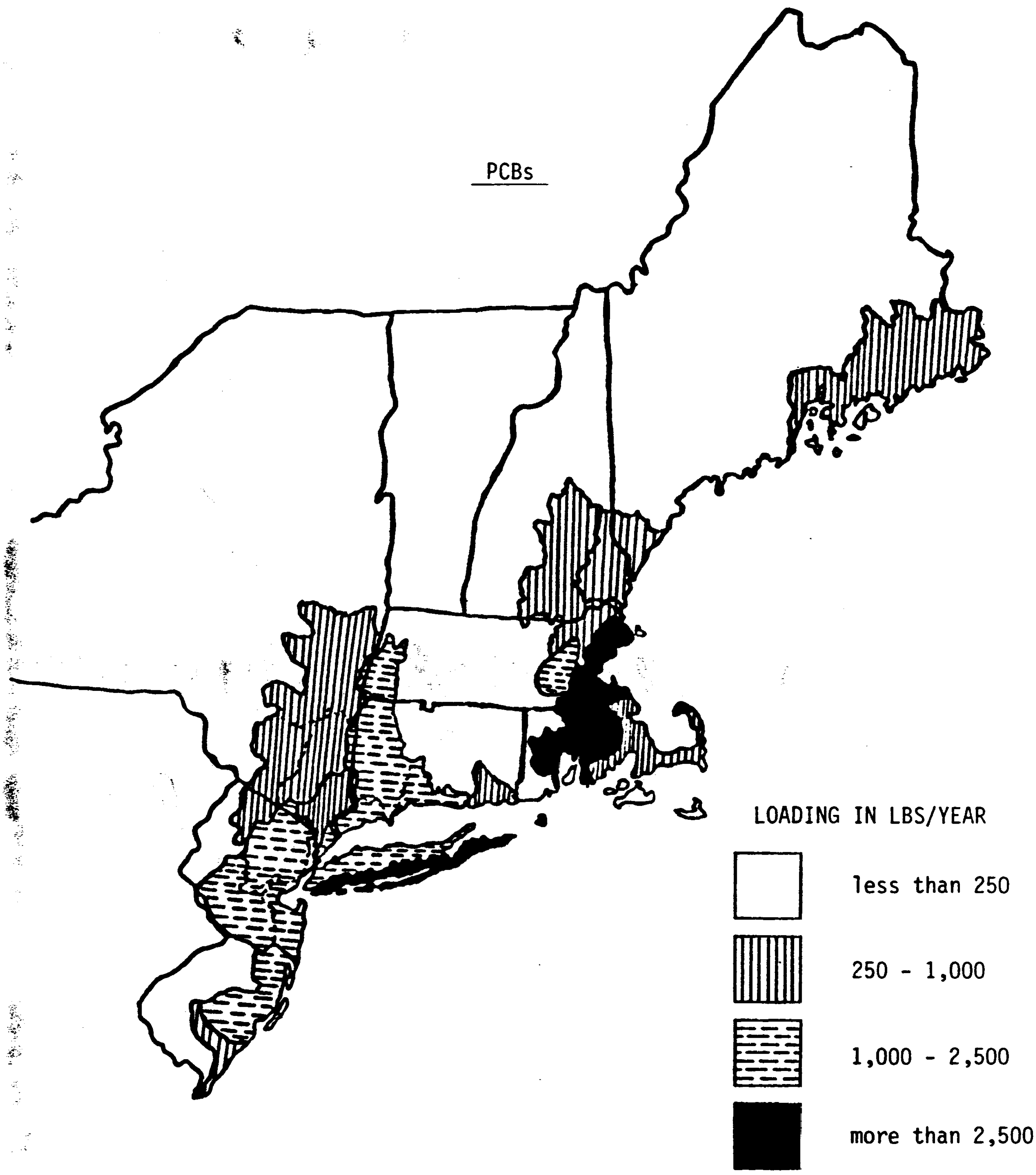

Figure 2B3. PCB loading by hydrologic unit in lbs/year, based on data from the National Coastal Pollutant Discharge Inventory.

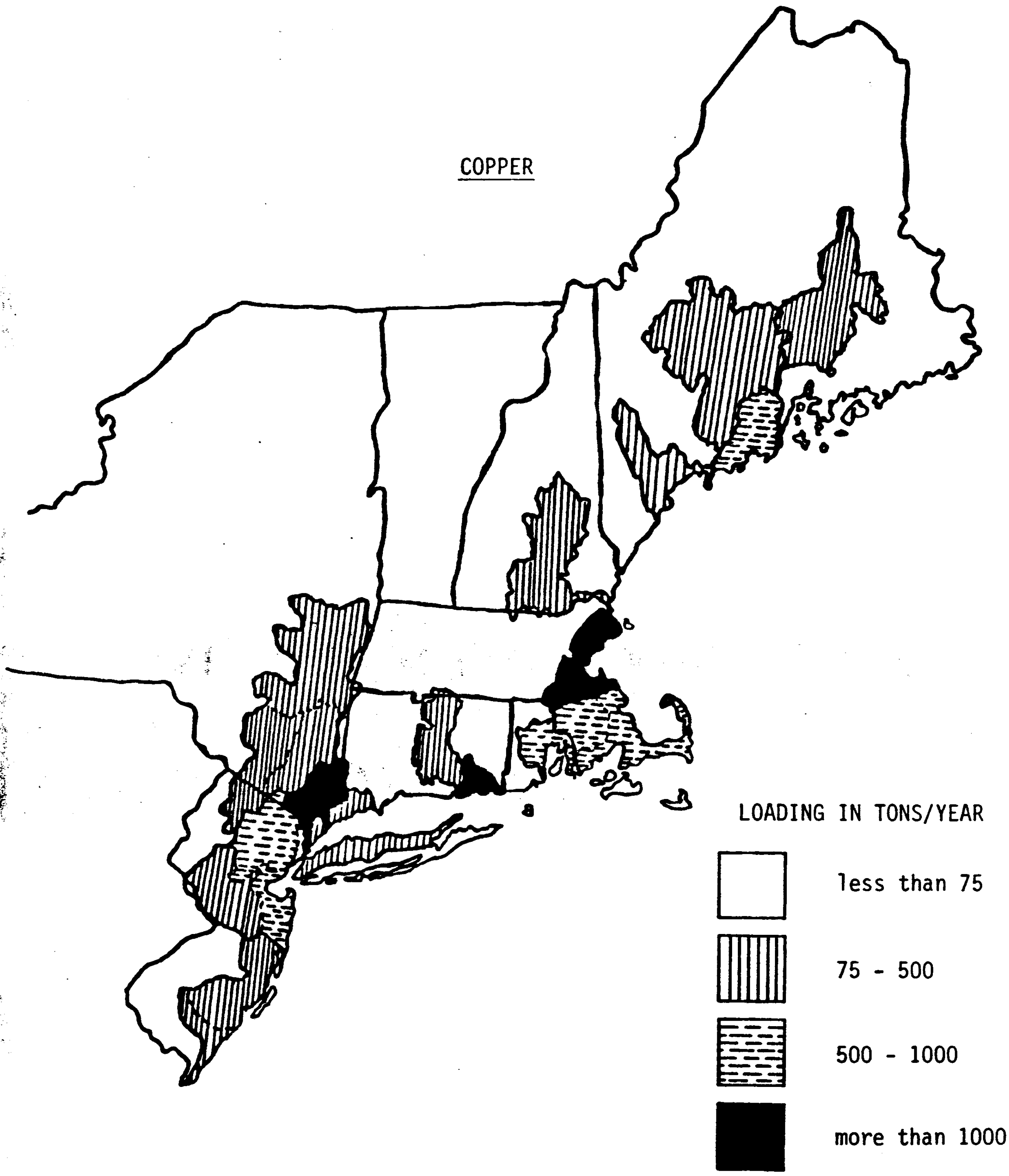

Figure 2B4. Copper loading by hydrologic unit in tons/year, based on data from the National Coastal Pollutant Discharge Inventory.

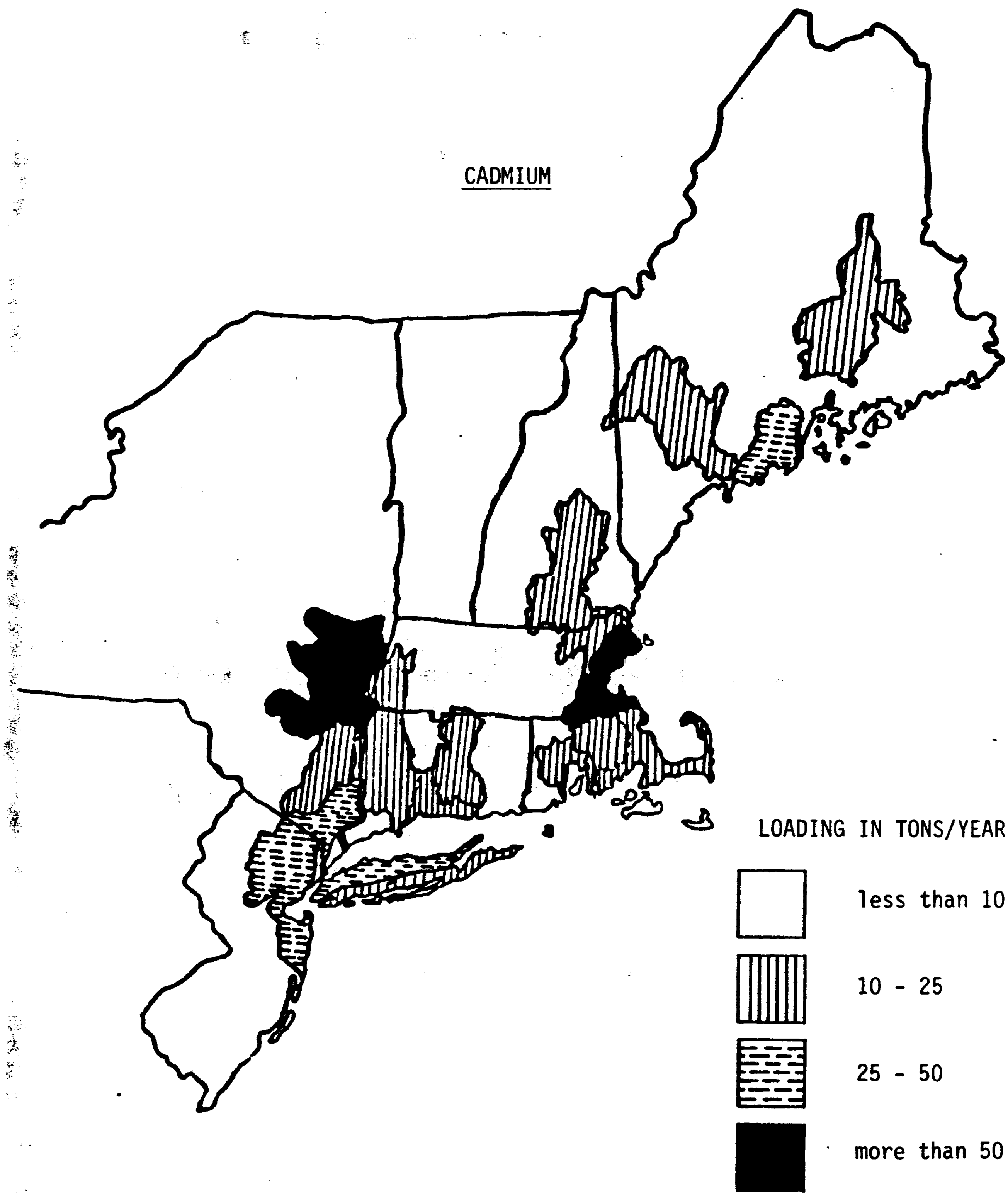

Figure 2B5. Cadmium loading by hydrologic unit in tons/year, based on data from the National Coastal Pollutant Discharge Inventory.

three classes of contaminants, which may be related to its higher fat content (fatty tissue attracts organic contaminants) and/or its diet.

PCBs are a major threat since they are very persistent in the environment, and concentrations in marine organisms may be increasing. PCBs have been documented to affect fish reproduction at levels that might be encountered in contaminated areas (Massachusetts Coastal Zone Management, 1982). The amounts of PCB residues in the edible tissues of commercially and recreationally important finfishes rarely exceed a few parts per million.

PCB residues are not distributed equally in all the tissues of the fish, but concentrate in fatty tissues. Fish concentrate PCB residues into their tissues directly from water, mainly through the gills, and from feeding on invertebrates which contain the chemical. The amount of residues in the muscle of fish are of concern because of the importance of fish as a food source for humans.

Most petroleum hydrocarbons are toxic only at fairly high concentrations, but these concentrations are reached or exceeded during spills. The juxtaposition of a large spill with a spawning stock or concentration of eggs, larvae or juveniles could have population-level effects. Models have been developed (e.g. Reed et al., 1984), and are being refined to predict impacts of various spill scenarios on resource species, including those in the Atlantic groundfish group. Information compiled on the effects of petroleum hydrocarbons on winter flounder show that effects are dependent on what type of dispersant the oil was mixed with (Sprague and Carson, 1978). Cod eggs sampled near the Argo Merchant oil spill showed high mortality (20%-98%), while many of the surviving embryos had abnormal chromosome patterns and were malformed and moribund (Longwell, 1977). Effects on pollock eggs following the Argo Merchant were similar to those noted for cod.

Polynuclear aromatic hydrocarbons (PAHs) are an important class of persistent petroleum hydrocarbons which can be carcinogenic or mutagenic. Concentrations of PAHs have been correlated with disease incidence in bottom fish in industrialized areas of Puget Sound, and they have been implicated in the appearance of cancers in winter flounder from the Boston Harbor area. As was the case for PCBs, however, concentrations of PAH in winter flounder and American plaice from Boston Harbor and Cape Cod Bay are quite low even though sediment concentrations were moderate to high.

Synthetic organics are another relatively hazardous class of contaminants. DDT and related compounds are among the few for which there is clear evidence of effects on marine populations, although the observed effects have been more dramatic in bird populations than in the fish they feed on. Most DDT is broken down within several months to years in the environment, and there is little or no input in the Northeast, so this hazard may be lessening. In a study of the sensitivity of ten marine fish species to endrin, P,p'-DDT and heptachlor, increased larval mortality in winter flounder was observed in areas receiving pesticide runoff, such as from cranberry bogs and mosquito control efforts along the Wewantic River in Massachusetts (Topp, 1968).

It has been reported that chlorinated hydrocarbon insecticides lower the resistance of fish to disease and may cause degeneration of reproductive functions. Other effects have included thickening of the gill membranes, lack of osmoregulation, lower blood counts, brain damage and reduced body weight. Until there is more systematic and regular monitoring of numbers of fish and targeted tissues, it will be impossible to assess whether or not pesticides seriously deplete overall numbers of fish. Present evidence makes this appear very unlikely, because there seems to be little difference in susceptibility of different species to pesticides.

Effects of Contamination: Disease Disease is a contributing factor to natural mortality in Atlantic groundfish species. However, the incidence of disease has only begun to be quantified. Disease removes individuals from populations continuously, and may reduce marketability of food fish. Environmental stress might be an important factor in disease incidence. For instance, correlations have been made between sediment contaminants and liver neoplasms and other diseases of bottom-dwelling fish in Puget Sound (Malins et al., 1984).

Many diseases of fish are caused by microorganisms. Contaminated environments may be enhancing the probability of infection, either by creating conditions that favor the microorganism or by increasing the susceptibility of the host to infection. Other environmental stresses, such as starvation (Segner and Moller, 1984) may also induce pathologies.

Nine of the Atlantic groundfish species (all except redfish, windowpane, and witch flounder) were included in a study of the diseases of Northeastern fish (Ziskowski et al., in prep.). The data revealed elevated prevalence of: (1) fin rot in winter flounder, yellowtail flounder and silver hake of the inner New York Bight; (2) fin rot on Atlantic cod, red hake, and white hake from eastern Massachusetts coastal waters; (3) abnormal pigmentation in winter flounder from southern Massachusetts coastal waters, and (4) bent fin rays in winter flounder for eastern Massachusetts coastal waters. This information suggests a possible relationship between environmental stress and disease. The study also revealed significantly higher incidence of ulcers on Atlantic cod and red hake on Georges Bank and lymphocystis on winter flounder from offshore Middle Atlantic Bight. These findings are being examined in light of possible environmental stress in those areas.

Scientists have recently found a significant incidence of types of neoplasms in adult winter flounder from the Boston Harbor area (Murchelano and Wolke, in press). No causative agent(s) have yet been identified, but the high concentrations of PAHs found in the sediments (Boehm et al., 1984), and their correlation with neoplasms observed in other areas (Malins et al., 1984), make these compounds likely candidates. These neoplasms may have adverse impacts on both population levels and marketability.

Effects of Contamination: Products and Marketability Epidemiological data suggests that 60-90% of all cancers occurring in human occupants of industrial societies are caused by environmental carcinogens. To date, no definitive data are available on the proportion of human cancers which develop as a consequence of exposure to chemical carcinogens. However, environmental chemicals are suspected to be etiologic agents on the basis of man's proven susceptibility to some chemical carcinogens. The effects of chronic exposure of indigenous plant and animal species to environmental carcinogens are not thoroughly known.

Polynuclear aromatic hydrocarbons (PAH) are persistent, carcinogenic compounds that are widely distributed in air, water and soil. It is well established that PAHs can be found in a variety of marine organisms, including those which may be used for human consumption. High levels of PAHs in edible tissue could represent a threat to consumers and the marketability of seafoods in the Northeast.

PCBs in edible fish remain far below existing or proposed maximum permissible levels for the majority of species investigated. However, both the Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA) have advised U.S. consumers and state health department agencies of the potential risks of high PCB contamination. Several states have issued advisories and regulations dealing with the eating and taking of a number of species of fish due to PCB concentrations. New York has prohibited the sale of striped bass taken from the Hudson and Hackensack River areas; New Jersey advised limited consumption of fish from designated areas, and several states have issued warnings about PCBs in bluefish.

There have been few instances in which marketability of Atlantic groundfish species has been compromised by contaminants. In 1977, the Massachusetts Department of Public Health issued a warning against consumption of bottom-feeding fish from the New Bedford Harbor area because they could contain PCBs in excess of the federal action level (5 ppm at that time). In 1979, the harbor area inshore of a line between Ricketson Point and Wilbur Point was closed to the taking of all bottom-feeding fish. Chiefly affected was the recreational fishery for winter flounder. It is not known whether the reduction of the PCB action level from five to two ppm will extend the closed area and increase losses.

§2B4 Habitat Conservation Programs

§2B4.1 Federal Regulatory Programs

The U.S. Army Corps of Engineers (COE), under Section 10 of the River and Harbor Act of 1899, regulates all in-water construction and dredge-and-fill activities in navigable water (to extreme high water shoreline). The U.S. Environmental Protection Agency (EPA), under Section 404 of the Clean Water Act of 1977 (CWA), regulates the discharge of fill materials into waters of the U.S. and adjacent wetlands, in accordance with guidelines and standards established by EPA. EPA has delegated authority to the COE to administer all dredge and fill activities under one Section 10/404 program. Section 401 of the CWA requires the issuance of a State water quality certificate before dredging or disposal in State waters.

Point source pollutant discharges into aquatic areas are regulated either by EPA or the States. Section 402 of the CWA requires a National Pollutant Discharge Elimination System (NPDES) permit. Under Section 301(h) of the CWA, municipal wastewater treatment plants may request waivers from EPA that exempt them from secondary sewage treatment. Section 401 of the CWA requires State (or interstate) certification that all discharges into waters of the U.S. will not violate applicable water quality standards. Discharges covered by NPDES permits must meet ocean discharge criteria established under Section 403 of the CWA.

Responses to discharges of oil and releases of hazardous substances regulated under the CWA and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA, or the "Superfund Act") are implemented through the National Oil and Hazardous Substances Contingency Plan (NCP). EPA and the U.S. Coast Guard are responsible for responding to spills in inland areas and in coastal or marine areas, respectively. NOAA assists these agencies by coordinating the scientific studies to assess the effects of accidental spills and is designated in the NCP as a "federal trustee for natural resources under its management or protection that may be destroyed or damaged by releases of oil or hazardous substances."

The U.S. Coast Guard regulates ship design, construction, and operation, and establishes vessel traffic control systems for ports and hazardous areas under the Ports and Waterways Safety Act of 1972, Port and Tanker Safety Act of 1978, and Deepwater Ports Act of 1974.

Ocean dumping of materials in the FCZ is regulated by the EPA under Title I, Sections 102 and 103, of the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA, or the "Ocean Dumping" Act). Ocean disposal can occur only at sites designated by EPA; only if ocean discharge criteria established under the MPRSA and the CWA are met; and only if "such dumping will not unreasonably degrade or endanger human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities."

Title III of the MPRSA authorizes NOAA to designate areas of the ocean as National Marine Sanctuaries for the purpose of "preserving or restoring such areas for their conservation, recreational, ecological, or esthetic values," and to issue "necessary and reasonable regulations" to control activities permitted within designated sanctuaries.

The Outer Continental Shelf Lands Act of 1953 (OCSLA), as amended, authorizes the Department of the Interior's (DOI) Minerals Management Service (MMS) to lease lands seaward of State marine boundaries, design and oversee environmental studies, prepare environmental impact statements, enforce special lease stipulations, regulate drilling activities, and issue pipeline rights-of-way. Effluent discharges are subject to EPA's NPDES or ocean dumping permit regulations.

Under the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973, NMFS and the U.S. Fish and Wildlife Service (FWS) share responsibilities for protecting marine mammals and endangered species.

Activities regulated by other agencies such as the U.S. Soil Conservation Service, U.S. Forest Service, Federal Highway Administration, and Federal Energy Regulatory Commission also may indirectly affect groundfish habitat by influencing run-off of sediments and contaminants from agricultural, forested, industrial, and urban areas. Existing Federal and State regulatory programs do not adequately control non-point source pollution. To determine levels of pollution from all sources, NOAA's Ocean Pulse and Northeast Monitoring programs monitor materials entering estuarine and marine waters.

§2B4.2 Advisory Programs

NMFS's Habitat Conservation Program, and similar programs conducted by he FWS, EPA, and State fish and wildlife agencies, reviews the above activities, assesses their potential impacts on resources within their jurisdiction, and makes recommendations to mitigate those impacts. The Fish and Wildlife Coordination Act of 1934, as amended (FWCA), and the National Environmental Policy Act of 1969 (NEPA) provide consultative authority for all projects requiring federal permits or licenses, or that are implemented with Federal funds.

NOAA, FWS, EPA, and the States also share responsibilities for the protection of fish and wildlife resources and their habitats, and act in an advisory capacity in the formulation of OCS leasing stipulations that MMS develops for conditions or resources that are believed to warrant special regulation or protection. Standard mitigating measures include the Oil Spill and Fisherman's Contingency Funds, oil spill containment and clean-up equipment and contingency plans, and OCS Operating Orders and Notices to Lessees and Operators.

§2B4.3 State Programs

Many State programs also regulate proposed activities in wetlands and state waters. These programs are based on State laws that require State agencies to regulate the use of natural areas and their resources. For example, the following are some of the programs that exist in the State of Massachusetts:

a) The Coastal Wetlands Restriction Act imposes land-use restrictions on wetlands for the purpose of promoting the public safety, health, and welfare, and protecting public and private property, wildlife and marine fisheries.

b) The Wetlands Protection Act requires a permit for work in or within 100 feet of a wetland or floodplain, and prohibits activities that would have a significant adverse effect on prevention of pollution, protection of fish and shellfish, etc.

c) The Massachusetts Environmental Policy Act requires an evaluation of the environmental impacts of State actions, including permitting, project approval, and funding.

d) The Massachusetts Coastal Zone Management Act (MCZMA) established a program for the management, beneficial use, protection, and development of the land and water resources in the coastal zone. Federal licenses, permits, or funding must be certified consistent with the policies of the MCZMA.

e) The Scenic Rivers Act designates certain rivers or streams as scenic resources, and restricts or prohibits certain uses in these waters and their contiguous banks.

f) The Industrial Waste Treatment Facilities Act requires an evaluation to determine if proposed treatment will meet water quality standards, effluent limitations, and other applicable regulations.

g) A Marine Oil Treatment License is required for facilities that load, discharge, and store petroleum products from self-powered or towed vessels carrying more than 5,000 gallons of bulk oil.

h) The Subsurface Sewage Disposal Facilities Act requires approval for any subsurface sewage disposal system prior to construction.

i) State Water Quality Certification must be obtained for any project that would result in discharges to State waters.

j) State Dredging and Disposal of Dredged Material Permits must be obtained for all dredging in tidewaters or disposal of dredged materials.

k) A State Waterways License is required for any structure built seaward of the high tide line and for any structure involving government expenditure in or over great ponds and certain rivers and streams.

l) The Ocean Sanctuaries Act prohibits sand, gravel, and mineral mining; alteration of salinity; alteration of sediment flow; dumping or discharging of any material that could significantly degrade water quality, or erection of structures that could adverely affect plant and animal life.

m) Finally, the State has established a program to identify, acquire, protect, and promote or restrict uses in Areas of Critical Environmental Concern.

§2B5 Habitats of Concern

Many of the finfish species that are potentially subject to the northeast region's multi-species fisheries are heavily dependent on the bottom for feeding and spawning, and therefore the integrity of the benthic environment is of prime concern in areas where there exist concentrations of bottom tending finfish (groundfish). The relationship of any one of these species to the habitat is somewhat unique, and argues for active efforts to maintain the quality of the environment. Areas that have been described as harboring concentrations of groundfish should be considered prime habitats, and any alteration or contamination of these environments should be minimized. Likewise, spawning areas, particularly of cod and haddock, should be considered sensitive habitats during the time that the fish are concentrating for spawning.

The fish species subject to the multi-species fisheries share a common distribution in the Northwest Atlantic with marine mammals, sea turtles and, of course, other fish species. This common distribution becomes an important factor in multi-species plan development with regard to the several marine mammals and endangered species that occur in the area. Under the Marine Mammal Protection and Endangered Species Acts, these species receive special protection from activities which may affect the species adversely, or otherwise contribute to a population decline. Fishing is one activity that carries a potential for impact on these protected populations that may be either significant or negligible, depending upon the areas fished, gear and the species sought. This section contains a description of the marine mammal and endangered species habitats of concern in order that the relationships to fishing activity can begin to take form. The discussion of fishery impacts on marine mammals and endangered species follows in Part 7 of the FMP.

Marine Mammals[1/]

Numerous species of marine mammals inhabit the Gulf of Maine, Georges Bank and Southern New England waters in their range. Five of these, the finback, *Balaenoptera physalus*; humpback, *Megaptera novaeangliae*; right, *Eubalaena glacilis*; sei, *Balaenoptera borealis* and sperm whale, *Physeter catodn* are particularly important because they are endangered populations. Other marine mammals that are not endangered are the pilot whale, *Globicephala spp.*; harbor porpoise, *Phocoena phocoena*; white-sided dolphin, *Lagenorhynchus acutus*; bottlenosed dolphin, *Tursiops truncatus*; common dolphin, *Delphinus delphis*; grampus dolphin, *Grampus griseus*; and the harbor seal, *Phoca vitulina*.

The general distribution of these marine mammals is shown in Figure 2B6(a)-(d). Their distributions are presented on four graphics primarily for ease of discussion. In Figure 2B6(a), the sperm and pilot whale populations are concentrated in the vicinity of the continental slope from the Carolinas to the eastern point of Georges Bank. Pilot whales, however, will move into shallow waters such as northern portions of Georges Bank, most likely in

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1/ Information presented above taken from CeTAP, 1982, and DEIS, Proposed February 1984 North Atlantic Outer Continental Shelf Oil and Gas Lease Offering, 1983.

pursuit of food. Both whales are deep divers and utilize the entire water column in pursuit of their diet of cepalopods, and gadoids in the case of pilot whales. The white-sided dolphin, in contrast, is found in shelf waters with concentrations extending from Cape Ann to the Great South Channel. It, too, feeds on cephalopods and gadoids (i.e. silver hake) and utilizes the entire water column to pursue its food. Their observed close association with baleen whales, known to feed on small schooling fish, may indicate a mutual relationship taking advantage of the plentiful sand launce.

The bottlenosed and common dolphins and grampus (Figure 2B6(b)) also show deep water distribution along the continental slope. The grampus dolphin adheres quite strictly to this area with only casual meanderings to shallower bank waters. The common dolphin, however, moves significantly into bank waters, as does the bottlenosed dolphin along inshore areas of Maryland and the Carolinas where the shelf narrows. All three pursue pelagic schooling fish and cephalopods as their primary foods. The harbor seal populations of interest to this plan are located in rocky coastal areas from Maine to Massachusetts where they feed on a variety of marine species.

The fin, right and humpback whales (Figure 2B6(c)) are common inhabitants of shelf waters. The fin whale is the most abundant and most widely distributed of the three, as its range extends well south of the others. All three, however, concentrate in the waters of Jeffreys Ledge, Stellwagen Bank, Cape Cod, the great South Channel and Georges Bank, their preferred feeding locations. The right whale is known as a zooplankton feeder, as is the fin whale which adds schooling fish such as herring and sand launce to its diet. The humpback feeds almost exclusively on the sand launce in this region.

The minke whale and harbor porpoise are also common in shelf waters, whereas the sei whale is concentrated in the same deep slope waters as the previously mentioned sperm and pilot whales (Figure 2B6(d)). The minke prefers near shore waters where it pursues sand launce, clupeids and gadoids. The harbor porpoise, too, prefers inshore waters concentrating in areas north of Cape Cod. It has a varied diet of cod, mackerel, squid and herring. The sei whale, like its baleen cousins, the right and fin whales, feeds on plankton such as copepods and krill.

Several endangered whales discussed above, the fin, right, humpback and sperm whales, show particular affinity to certain areas within their distribution. This has led NMFS to identify these areas as "preferred areas" in relation to oil and gas development activities in the region (see Figure 2B7). While these preferred areas have not been legally defined as critical to the species survival, they are areas in which these species concentrate while in the region. These areas, as well as the general distributions discussed above, will be considered under the discussion of impacts.

<u>Sea Turtles</u>

Three endangered and two threatened species of marine sea turtles occur in the waters of the North Atlantic. The three endangered species include the hawksbill (<u>Eretmochelys imbricata</u>), the leatherback (<u>Dermochelys coriacea</u>), and the Atlantic ridley (<u>Lepidochelys kempii</u>). The two threatened species are the loggerhead (<u>Caretta caretta</u>) and the green sea turtle (<u>Chelonia mydas</u>).

The loggerhead is the most abundant of these. It is distributed from the Carolinas to Cape Cod, though rarely occurs in the Gulf of Maine and only occasionally on Georges Bank. The population is concentrated along the shelf southward of Long Island and south of Cape Cod where its preferred feeding grounds are located. Loggerheads subsist on bottom organisms and flotsam.

Leatherbacks visit the Gulf of Maine regularly, but concentrate south of New England in the New York Bight and near shore Mid-Atlantic areas. Their major food item is jellyfish.

The Atlantic ridley prefers shallow coastal waters ranging as far north as Nova Scotia. Observations in New England waters are low, probably due to its shallow water preference and its low population size.

Green and hawksbill turtles are uncommon visitors in north Atlantic waters.

Fish

Only one endangered fish species occurs in northwest Atlantic waters, the shortnose sturgeon, Acipenser brevirostrom. This is an anadromous fish distributed along the eastern seaboard that dwells entirely within the influence of the river systems, therefore, is not encountered in FCZ waters.

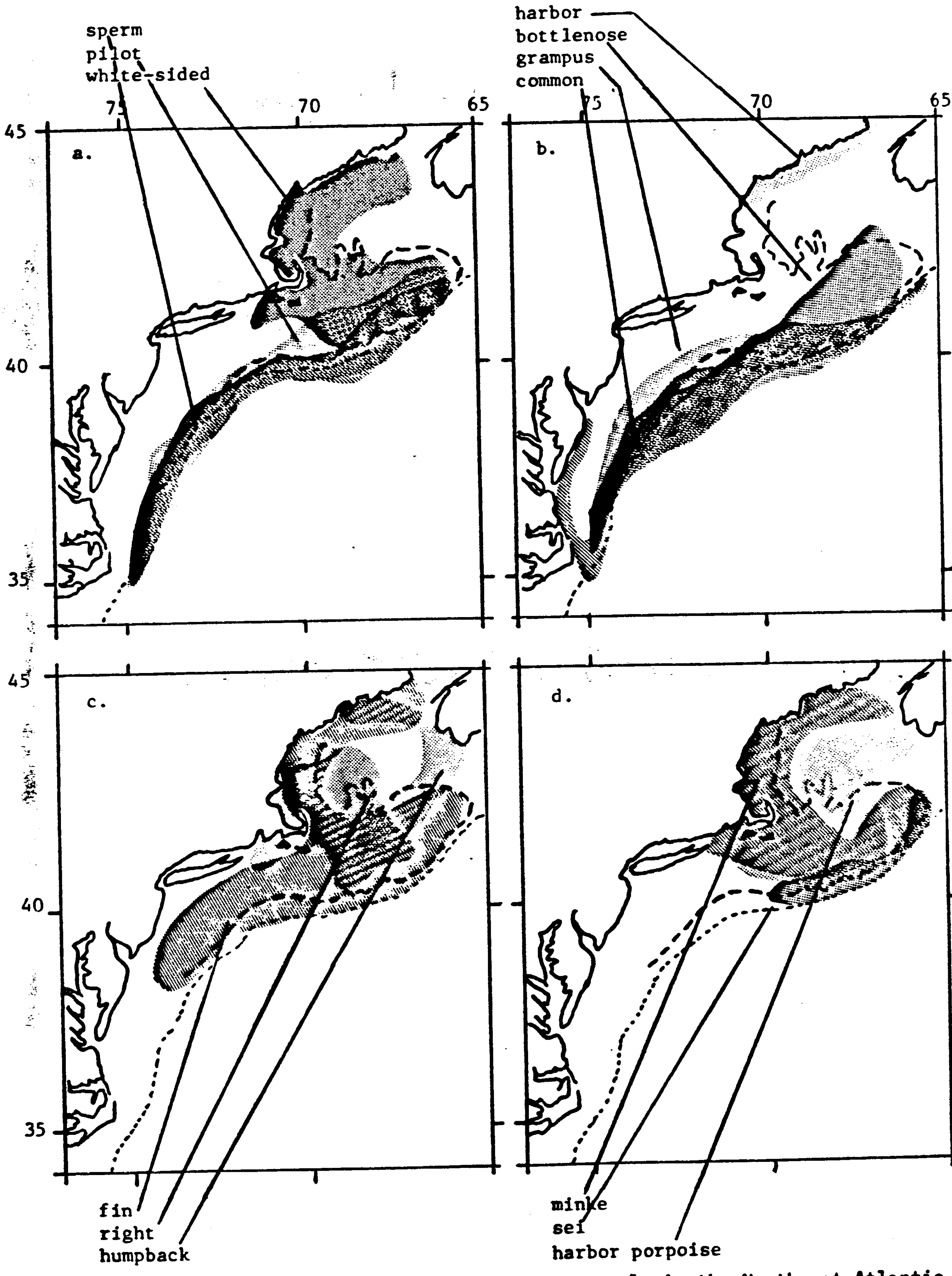

Figure 2B6 a-d. General distribution of marine mammals in the Northwest Atlantic common to the Multi-Species FMP management unit. (from CeTAP data, 1982)

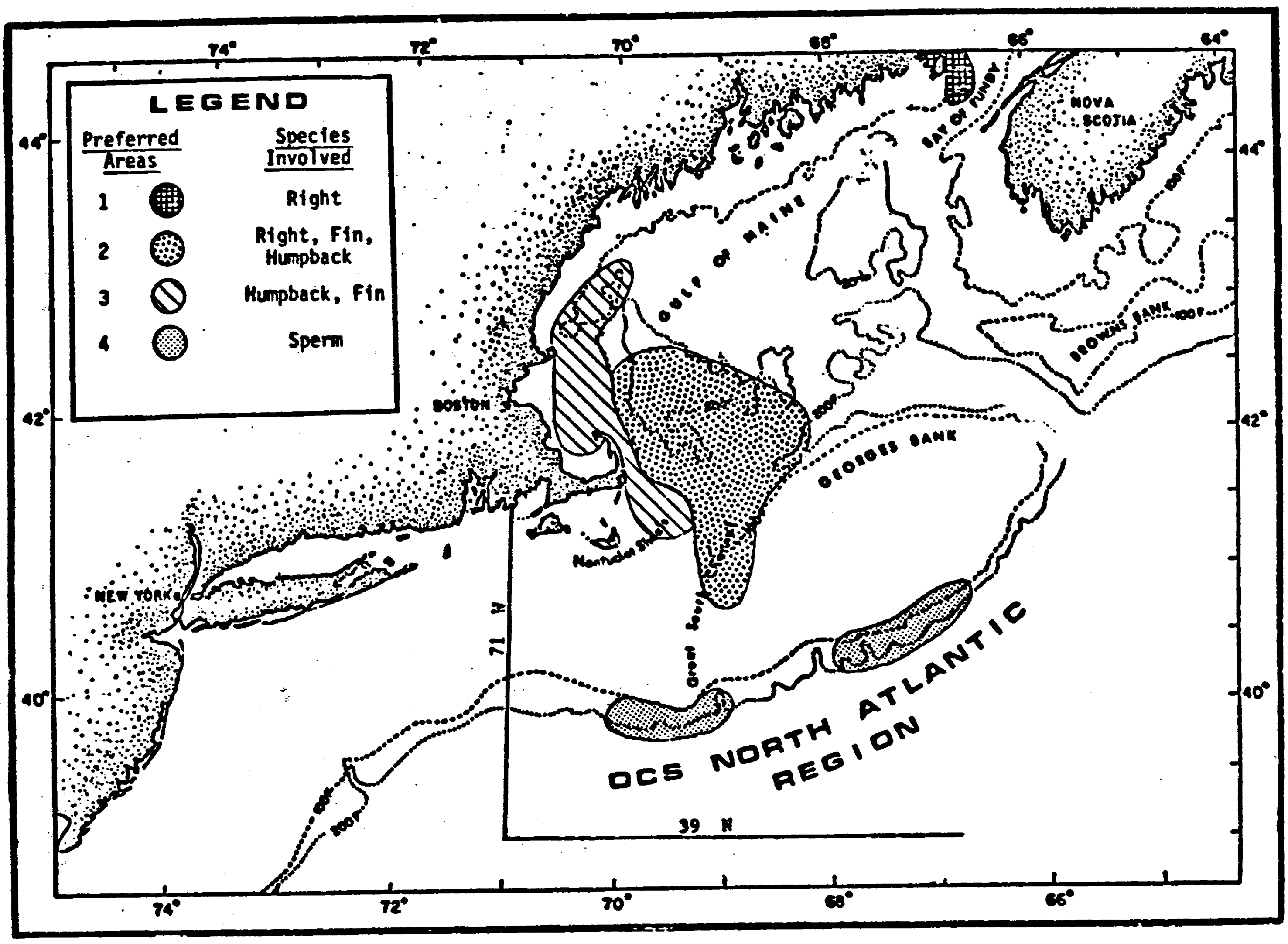

Figure 2B7. Preferred areas for whales in the OCS North Atlantic Region.

§2B6 Recommendations for Habitat Conservation and Restoration

The New England Fishery Management Council, under the authority of the Magnuson Fishery Conservation and Management Act, has the responsibility to prepare fishery management plans which address habitat requirements, describe potential threats to that habitat, and recommend measures to conserve and protect those habitats critical to the survival and continued optimal production of the species under management. The NMFS Habitat Conservation Policy establishes the basis for a partnership between NMFS and the Council to assess habitat issues specific to the resource being managed. The following recommendations are made in light of this mandate.

1. All natural habitat for groundfish stocks should be preserved by encouraging management of conflicting uses to assure continued access by fish to essential habitat. High water quality standards should be maintained to protect migratory routes and spawning, rearing, and feeding areas. Spawning and nursery areas are particularly important to continued productivity of the groundfish resource.

2. Filling of wetlands and shallow water areas is discouraged. Mitigating or compensating measures should be employed where filling is unavoidable. Filling should be permitted only for water-dependent projects found to be in the public interest when no feasible alternatives are available. Project proponents should be required to address the full range of impacts on groundfish stocks, their habitat, or food sources which may be associated with project implementation.

3. Coastal in-water construction and dredging projects should employ best engineering and management practices (e.g. seasonal restrictions, dredging methods, disposal options, etc.). Such projects should be permitted only for water-dependent projects found to be in the public interest when no feasible alternatives are available. Project proponents should be required to address the full range of impacts on groundfish stocks, their habitat, or food sources which may be associated with project implementation.

4. Potentially sited artificial reefs should enhance groundfish habitat, and should be constructed using best available technology, and not preclude access to important fishing areas. Such reef construction is supportable where substantial natural cover is absent; hydrographic conditions, materials used, and construction methods employed will ensure long term usefulness; the physical and biological oceanographic conditions will support reef species; and where it will not adversely affect other fisheries.

5. Coastal and open ocean waters should be protected from significant adverse effects of domestic and industrial waste disposal. The selection of methods and sites for disposal of sewage sludge, contaminated dredged material, and other domestic and industrial waste should be based on a comprehensive scientific assessment of all options (e.g. pretreatment, land based disposal, incineration, and ocean dumping). Ocean disposal should be allowed only if there is demonstration that there is no practicable alternative with less impact on the total environment. In such event, deepwater (off-shelf) sites should be used with disposal techniques that minimize impacts on the groundfish stocks and their habitat.

6. Sewage treatment plants should utilize best available technology to improve water quality. Such action is particularly important to facilitate recovery of presently degraded areas. EPA water quality standards should be enforced. Applications for Clean Water Act 301(h) waivers from secondary sewage treatment facilities should be reviewed on a case-by-case basis to prevent further degradation of water quality and additional accumulation of contaminants in areas important to winter flounder, pollock, cod and other groundfish that may frequent nearshore areas.

7. Dechlorination or effluent holding ponds should be used to reduce total residual chlorine to non-toxic levels in the mixing zones of sewage treatment and power plants currently operating in groundfish spawning or nursery areas. Where possible, the siting of new sewage treatment facilities and power plants should be avoided in areas important to groundfish.

8. Use of best available technology to control industrial wastewater discharges should be required in areas important to the reproduction and survival of pollock, winter flounder, windowpane flounder, and other groundfish species that frequent estuarine and nearshore areas. The EPA's Water Quality Criteria Series should be used as guidelines for determining harmful concentration levels of toxic substances in wastewater discharges. Prior to the siting of any potential new discharge, project proponents should be required to address the full range of impacts on groundfish stocks, their habitat, or food sources which may be associated with project implementation.

9. Except in designated mixing zones, industrial and power generating facilities should not discharge thermal effluents that would raise ambient water temperatures to levels harmful to affected groundfish stocks or their food supply. Important components of the overall groundfish complex (especially cod, pollock, winter flounder, and windowpane flounder) utilize the coastal and estuarine habitat as spawning and/or nursery areas. To minimize entrainment and impingement mortality, new facilities should not be located in spawning or nursery areas. Power plants should avoid shut-down operations at times when significant induced mortality may result from reverse thermal shock. Potential dischargers should be required to address the expected impacts such projects will have on groundfish habitat or food supply. Best management practices should be encouraged at existing facilities.

10. All available or potential natural habitat for groundfish stocks should be protected from significant adverse impacts from offshore oil and gas and non-energy mineral exploration and development activities. Siting and regulation of these activities should be conducted such that groundfish access to essential habitat is ensured, and the quality of the habitat is maintained to protect groundfish migratory routes, and spawning, nursery, overwintering, or feeding areas.

11. Dredge and fill permits issued by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act and Section 10 of the River and Harbor Act should require that project proponents address the full range of impacts on groundfish stocks, their habitat, or food sources which may be associated with project implementation. The 1982 Memorandum of Agreement between the Department of the Army, Department of Commerce, Environmental Protection Agency, and U.S. Fish and Wildlife Service should be revised so as to allow estimation of the biological and economic impact that proposed projects may have on groundfish and groundfish habitats. In the planning phase of proposed projects, sufficient lead time should be provided for concerned resource agencies to properly evaluate impacts on natural habitats which may be associated with project implementation.

12. The U.S. Soil Conservation Service, U.S. Forest Service, and other concerned Federal and State agencies should evaluate present agricultural and forestry practices to develop standards for best management practices to prevent further degradation of groundfish habitat by non-point source pollution. All options including vegetated buffer strips should be considered in agricultural and forested areas adjacent to groundfish spawning or nursery areas to minimize pesticide, herbicide, fertilizer, and sediment loads to those areas important for groundfish survival.

13. The New England Fishery Management Council will cooperate with the Mid-Atlantic Fishery Management Council in a review of the broad range of human activities having the potential to adversely impact groundfish habitat areas of mutual concern.

14. Future scientific investigations on groundfish should examine the possible long-term, synergistic effects of combinations of environmental stresses. One focus of these investigations should be the consequences of chronic environmental loading of all types of pollutants (e.g. heavy metals, insecticides, herbicides, petroleum products, halogenated hydrocarbons, other organics, etc.) in terms of early life and adult fish survival, reproductive capacity, and genetic effects. Another focus of needed studies is the cumulative impact of all projects involving habitat modification (including dredge and fill operations, in-water construction projects, and OCS drilling and mining activity) on the total production of the groundfish fishery resource.