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Food Relationships Between Silver and Red Hakes and Other Fish Species on Georges Bank and in Adjacent Waters

by

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Abstract

Long-term data on feeding of a number of numerous representatives of Georges Bank ichthyofauna of commercial interest are considered. Types of feeding of different species of pelagic, near-bottom and groundfish are studied, and groups of fish singled out according to prevailing food organisms. Comparison is made between food composition of young hake and red hake and adult herring and mackerel, and also between representatives of gadoids and yellowtail flounder, spiny dogfish, goosefish, sea raven and American plaice. Although hake and red hake are shown to be affected by homogeneous ecological factors, production of these species depends on different ecological groups of animals: hake production - on forms keeping to pelagial, and red hake production - on forms keeping to benthal.

One of the most important goals of the rational fishing is the more complete utilization of natural productivity of the pond. This goal may only be achieved in the best way if the commercial fish species could utilize at most the natural food supply of the pond.

During the recent two decades the decline in abundance of some fish populations in the Northwest Atlantic as a consequence of fishery pressure and natural causes resulted in the fact that

a great portion of the food resources was not involved in formation of economically useful production. R.Edwards (1976) considers that unregulated fishery is the main reason of decreasing in the catches of major commercial fish species. Recently (1976-1980) a regulation of fishery by means of introducing of calculation of maximum sustainable yield by each species was suggested. However, as Edwards futher states, the yield calculation alone is insufficient. The impact of predators should be taken into consideration (Edwards, 1976) as well as competitive relationships between fishes for a food be evaluated (Noskov, Vinogradov, 1977). So studies on feeding and food relations between especially hake and red hake, as the most abundant fish species of commercial interest, and other numerous species such as mackerel, herring, spiny dogfish, yellowtail flounder, cod and haddock, are badly needed, and in order to reveal the possibilities for increasing of production and catches the extent of utilization by these species of the food supply in the shelf regions of the ocean should be considered.

Materials and Methods

This paper summarized the material of long-term studies on feeding of hake (12046 specimens) and red hake (3928 specimens) on Georges Bank and adjacent waters carried out by the author, as well as personal and literature data on feeding of a number of numerous representatives of ichthyofauna of commercial interest (Bigelow, Schroeder, 1953; Jensen, 1966; Leim, Scott, 1966; Rikhter, Vinogradov, 1969; Bailey, 1970; Efanov, Vinogradov, 1973; Maurer, 1976; Jones, Geen, 1977; Vialov, Karasiov, 1967; Rass, 1979).

The materials were collected during scientific-research cruises of the AtlantNIRO and Zaprybpromrazvedka vessels, aboard the fishing vessels of "Zapryba" and during the joint USSR-USA trawl surveys in 1968-1974 (fig.1). To analyse the materials a quantative-weight method was used. Total indices of fullness and percentage food composition by weight were calculated. Indices of fullness were calculated by means of a "group method": the ratio of the sum of total food weight from a separate sample or fish group to the summary weight of fishes (including fishes

with empty stomachs) expressed in prodecimil (°/ooo) (Methodic manual..., 1974).

Based on the examination of stomach contents from 15045 specimens of fishes belonging to 25 species of 12 families food relations between hake and red hake and other fish species were analysed (table 1). For quantative assessment of food relationships between fishes an index of food similarity (FS-coefficient) suggested by Shorygin (1952) was used.

Results

The whole water layer is fished with a bottom trawl, so the catches are represented both by the groundfish species and fishes dwelling on pelagically. All the fishes under study may be divided into three groups according to their habits of life, i.e. pelagic, near-bottom and groundfish (table 2). It is worth of noting that the division into fish groups according to their habits of life is arbitrary to a certain extent.

Pelagic fishes feed principally on euphausiids (Meganyctiphanes norvegica) and copepods (primarily Calanus finmarchicus) and to a lesser extent on hyperiids (Hyperia galba), sagitta (mainly Sagitta seratodentata), larval decapods, pteropoda (Limacina retroversa), salps (Salpa spp.), i.e. organisms of meso- and macroplankton.

A mixed type of feeding with prevalence of representatives of nekton (fish and cephalopods) for spiny dogfish, hake and white hake and of benthos and nektobenthos for cod and red hake is indicative for majority of near-bottom fishes. Of plankton organisms near-bottom fishes consumed large crustaceans, such as euphausiids and mysids, while being near the ground shrimps, crabs and gammarids were used as a food. This group is represented by the rather mobile fishes performing migrations off the bottom to the open water, and so the proportion of fish in their food composition varied with age and mobility, this is especially evident in the case of hake.

Groundfishes were mostly predators on bottom and near-bottom crustaceans, polychaetes, echinoderms, mollusks, i.e. benthic and nektobenthic organisms. However, such species as sea raven,goose-

fish consumed mainly large quantities of bottom and near-bottom fish (hake, red hake, longhorn sculpin, flounders, etc.). Pelagic fishes, mainly herring, were also found.

The fishes inhabiting the area under investigation may be divided into four groups according to prevailing food:

1) consumers of meso- and macroplankton;

2) consumers of nekton;

3) consumers of benthos and nektobenthos;

4) mixed type of feeding.

All pelagic species (except pollock) are related to a chozen group of fishes which are consumers of plankton organisms. The food (over 90% by weight) of these species was composed of euphausiids, mysids, hyperiids, larval decapods and pteropods as well as ctenophora and salps (table 3).

Second group of fish consuming mostly (over 60% by weight) organisms of nekton (fish and cephalopoda) consisted of near-bottom and some groundfish species for which the fish such as hake, mackerel and shortfin squid were predominant in the food composition.

Groundfish species which were consumers of benthos and nektobenthos were related to the third group. These species fed mainly on benthic crustacea (over 55% by weight) as well as on detritus (87%) as for thorny skate and echinoderms (63%) as for haddock.

The fourth group of fish was characterized by the mixed type of feeding including nektonic organisms (fish, squids) in combination with organisms of benthos and nektobenthos (echinoderms, mollusks, polychaetes, gammarids, shrimps, etc.) and macroplankton (euphausiids, mysids).

The most numerous fish species (mackerel, herring, spiny dogfish, pollock) in the area under investigation are pelagic or more mobile near-bottom fishes which feeding is supported by the food resources of pelagial (plankton, nekton).

The food resources of pelagial can increase depending on peculiarities of circulation (Sigaev, 1978) and drifting of numerous macro- and mesoplankton to Georges Bank, main feeding area for plankton-eaters, from the Gulf of Maine (Cohen, 1976).

Populations of groundfish and slow-moving near-bottom fish species, such as haddock, skates, sculpin, flounders, cod, white hake, etc., are not numerous. These fishes feed mainly on benthos and nektobenthos. The poorness of the forms and biomass of benthos cannot apparently favour the high abundance of benthophage (Wigley, 1956). Therefore none of the benthophageous species achieves large biomass, and with the increase in abundance the species become the predators on plankton invertebrates.

Hake and red hake pertain to different groups according to the feeding type. Nektonic organisms were predominant in the food (over 75%) for adult hake while red hake consumed basically bottom and near-bottom invertebrates and just less than one-third of its diet was composed of the fish. Common food is found in the diet of young hake and red hake and numerous plankton-eaters, however judging from a type of feeding a similarity is observed between adult hake and only predatory fishes, and between red hake and near-bottom fishes with mixed feeding type and groundfish eating benthos.

A comparison between FS-coefficients of young hake and red hake and numerous plankton-eaters (herring, mackerel) in the areas where the species were found together in the feeding period (northwestern slopes of Georges Bank) showed that food similarity was observed for young hake (11-25 cm) and adult herring and for red hake (16-25 cm) and the same species (table 4). Meganyctiphanes norvegica was a food organism common to young hake and red hake with herring and mackerel. However the significant abundance of euphausiids and copepods on Georges Bank allows to believe that competitive relationships between herring, mackerel, young hake and red hake are not clearly pronounced here. It may also be confirmed by the large biomass of the populations of these species in 1972-1974 (Edwards, 1976).

Similarity in the food composition was observed for young hake and red hake. M.norvegica and Crago septemspinosus were common food organisms for these species.

The observed similarity of food for herring and mackerel constituting over 50% by nearly all food groups found indicates that in some years the food relations and even competition are

clearly pronounced that results in flourishing of one of the two species in separate periods with concomitant decrease in abundance of the other (Grosslein et al., 1978). Thus, the decrease in abundance of herring in recent years was obviously favourable to increase in the mackerel biomass due to releasing of food resources.

The degree of similarity of food composition for young hake and red hake and herring and mackerel in June 1972 is similar to the 1971 scheme in the same areas with some increase in similarity between herring and young hake as they feed on M.norvegica, and with decrease in similarity between young hake and young red hake when eating shrimps and between herring and mackerel when feeding on C.finmarchicus (table 4). Examination of species composition of adult hake, red hake and other numerous near-bottom and bottom fishes shows that food similarity coefficients for species under study are rather low, and this may be attributed to the difference in the spectrum of species composition of food organisms (table 5).

The highest similarity (FS=61) was found between food composition for hake and white hake in June 1972 in the Georges Bank area with young hake as a predominant food. The degree of similarity of food composition for other near-bottom and groundfish species of commercial interest did not exceed 30.

For species which fed mainly on the fish the similarity of food composition was found to be low when compared by species (table 6).

As is evident from the table 6 data the highest similarity of food composition was observed between representatives of gadoids, as well as between spiny dogfish and sea raven. Young hake was most common food organism for these species.

Sea raven, goosefish and white hake, as competitors and enemies for hake and red hake, do not apparently exert considerable influence on populations of these species because of their small biomass. At the same time for species which biomass is high (spiny dogfish), the similarity is low between food composition for this species and hake and red hake (table 6), and in

the feeding of spiny dogfish these species are of minor importance, constituting about 12% (red hake) of food weight. On Georges Bank the most complex food relations may be supposed to form between the considered species and other gadoids (pollock, cod, haddock) which biomass is close to that of hake and red hake. It may be considered that trophic impact of pollock, cod and haddock, as more cold-water species, on the populations of hake and red hake and on their food resources increases in the periods of weakening of the Gulf Stream influence on the temperature regime of the mixed waters in the Georges Bank areas and decreases during the years of heating when the abundance of subarctic species declines in these areas (Sauskan, 1966).

From the analysis of the food composition for the two populations of hake and red hake the difference in the type of their feeding becomes obvious (table 7). On Georges Bank the hake production depends mainly on the resources of pelagial (plankton and nekton) while red hake forms its production due to near-bottom and bottom organisms of nektobenthos and benthos. In the southern shelf areas some organisms (euphausiids, shortfin squid, Atlantic herring, polychaetes) disappeared completely or to a large extent from the hake diet, whereas others (shrimps, longfin squid, red hake, mackerel, butterfish) became of great importance. Along with benthic and nektobenthic organisms the animals of other ecological groups (plankton and nekton) were predominant in the food of red hake from the northern population, whereas for the diet of this species from the southern population macroplankton organisms were almost of minor importance, and over the half of the food consisted of bottom organisms (sipunculoidea, clams, crabs and detritus, remnants of fish reduction). A smaller variety of food composition for hake than for red hake was observed both on Georges Bank and in the southern New England shelf (table 7).

The given analysis shows that although hake and red hake inhabiting under similar conditions during the long period of life cycle are affected by homogeneous ecological factors, production of these species depends on different ecological groups

of animals: hake production - on forms keeping to pelagial, red hake production - on forms keeping to benthal.

The hake (mostly predator) may achieve large biomass and production owing to abundant food resources - a great many of copepods and especially of euphausiids, as well as young fishes. Compared to hake, red hake (a species with mixed type of feeding) have smaller food resources available in the area under investigation since its food is represented by bottom and near-bottom invertebrates, which are detritophageous animals in majority. Mostly rocky and sand ground on Georges Bank indicates the lack of large accumulation of detritus and consequently the impossibility of producing of rich benthos. Due to the lack of such food red hake have apparently to consume plankton and nekton animals, as it takes place in the Georges Bank area, or to pick up various food remnants (molting skins of benthic crustaceans and perhaps dead animals) and thus to perform a sanitary function, as it occurs on the southern shelf of New England. All this exert influence on the quantity of formation of red hake biomass and production which is smaller by a factor of 3-6 than that of hake according to Edwards' estimate (Edwards, 1976).

A scheme of trophic relations for hake and red hake is built similar to that for pelagic and groundfish of the Barents Sea suggested by Zenkevich (1951) and for pelagic fish of the open ocean suggested by Parin (1971). The position of different food organisms for hake and red hake and other fish species in the trophic chains is determined by the feeding pattern of these organisms (Yablonskaya, 1976). So salps, copepods and some euphausiids feed mainly on phytoplankton. Gastropods and cephalopods, sagittae, hyperiids, euphausiids, M.norvegica in particular, and young fish and plankton-eating fish belong mostly to zooplankters. Polychaetes (fam.Aphroditae) feed predominantly on small crustaceans, mollusks, annelid worms, hydroids and sponges (Zernov,1934). The group of detritophagous animals is represented by some species of polychaetes, clams, echinoderms, as well as shrimps, crabs, gammarids and mysids.

As is evident from fig.2a, the hake forms its production along the branch beginning from phytoplankton (producer) due to crustaceans (consumers of the 1-2 orders) and fishes (consumers of the 2-3 orders). At the same time detritus is only partly utilized by the hake in consumption of shrimps, crabs and gammarids. The hake itself is a food for white hake, pollock, hake, goosefish, bluefish and spiny dogfish occupying the third and fourth trophic levels and belonging to consumers of the second and third orders. Thus the hake at early age is a plankton-eater and then becomes a nektophage - a consumer of the second and third orders.

Unlike the hake, red hake utilizes the energy of both phytoplankton and detritus, however the detrital branch is of greater omportance than that of phytoplankton (fig.2b). Red hake production depends on gammarids, shrimps, crabs, hermit crabs, clams, gastropods, polychaetes and echinoderms rather than on pelagic crustaceans, cephalopods and small fishes. Polychaetes as well as mentioned benthic crustaceans and mollusks are principally detritophagus animals picking up detritus from the ground surface and consuming simultaneously bacteria of the ground. Majority of polychaetes (fam.Eunieidae, Nereidae, Nephtydidae) found in the red hake stomachs are ground-eaters feeding on bacteria of the ground (Zatsepin, Rittikh, 1968).

Red hake eating detritophageous organisms occupies the lower trophic level and belongs to a consumer of the second order. It is worth of noting since detritus is not a newly formed (primary) organic matter but a product (remnant) of vital activity of organisms at different trophic levels, detritophageous animals may rather relatively be regarded as primary consumers (Yablonskaya,1971).

Conclusions

On the feeding grounds of young hake, red hake and numerous plankton-eaters in the Georges Bank area a certain similarity is observed between feeding spectra of these young fishes and adult herring and mackerel as they feed on euphausiids. However the concentrations of euphausiids and copepods in this area permit to consider that food relations between herring and mackerel and young

hake and red hake are not clearly pronounced. Food relations (competition, prey-predator relationships) are strongly pronounced between adult hake and red hake and other gadoids (pollock, cod, haddock). Small proportion of fishes found in the stomachs of pollock and cod, benthophagous feeding of haddock and small abundance of other consumers of young hake and red hake (sea raven, white hake, goosefish) make it possible to recognize that in the Georges Bank area the hake is the most numerous predator preying on young hake and red hake.

The hake production forms along the branch beginning from phytoplankton due to utilization of vegetation-eating and carnivorous pelagic crustaceans (consumers of the first and second order) and fishes (consumers of the second and third order) and occupies the third and fourth trophic level in the food chain. The food chain of red hake consists of three links, and red hake occupies the third trophic level. However, in the area under consideration the hake population utilizing abundant resources of pelagial (euphausiids, pelagic fishes) forms the biomass several times larger of that of red hake which production depends mainly on food resources of detritus through the consumption of bottom and near-bottom invertebrates.

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Table 1 Bulk of examined materials on feeding of fishes (except hake and red hake) on Georges Bank and adjacent waters

Family	Scientific name	English name	No. of stomachs examined, sp.
1	2	3	4
Squalidae	Squalus acanthias Linne	Spiny dogfish	815
	Raja erinacea Mitchill	Little skate	253
Rajidae	Raja ocelata Mitchill	Big skate	52
	Raja radiata Donovan	Thorny skate	47
	Alosa aestivalis (Mitchill)	Blueback herring	431
Clupeidae	Alosa pseudoharengus (Wilson)	Alewife	835
	Clupea harengus harengus Linne	Atlantic herring	2215
	Etrumeus sadina (Mitchill)	Round herring	176
Argentinidae	Argentina silus Ascanius	Atlantic argentine	174
	Gadus morhua morhua Linne	Atlantic cod	537
	Melanogrammus aeglefinus (Linne)	Haddock	811
Gadidae	Pollachius virens (Linne)	Pollock	97
	Urophycis regius (Walbaum)	Spotted hake	35
	Urophycis tenuis (Mitchill)	White hake	88
Scombridae	Scomber scombrus Linne	Atlantic mackerel	4370
Zoarcidae	Macrozoarces americanus (Bloch)	Ocean pout	83
Stromateidae	Poronotus triacanthus (Peck)	Butterfish	506
Scorpaenidae	Sebastes marinus mentella (Linne)	Redfish	402
	Hemitripterus americanus (Gmelin)	Sea raven	19
Cottidae	Myoxocephalus octodecimspinosus (Mitchill)	Longhorn sculpin	240
	Hyppoglossoides platessoides (Fabric.)	American plaice	767
	Limanda ferruginea (Storer)	Yellowtail flounder	1784
	Pseudopleuronectes americanus (Walbaum)	Winter flounder	106
	Paralichtys oblongus (Mitchill)	Fourspot flounder	126
Lophiidae	Lophius americanus Valencinnes	American goosefish	76
		TOTAL:	15045

Table 2 Fish groups and species biomass on Georges Bank and adjacent waters

Fish groups and species	Mean biomass, thous.tons (Edwards, Bowman, 1978)		
	1963-1965	1968-1969	1972-1974
Pelagic			
Alewife	102 (15)*	43 (14)	29 (18)
Atlantic herring	3566 (1)	1137 (2)	310 (4)
Atlantic argentine	26 (21)	11 (22)	8 (21)
Pollock	216 (8)	213(8)	245 (5)
Atlantic mackerel	472 (5)	3266(1)	1410 (1)
Butterfish	148 (11)	168 (10)	160 (9)
Redfish	165 (9)	287 (6)	195 (7)
Total	4695	5125	2357
Near-bottom			
Spiny dogfish	1002 (2)	1024 (3)	362 (3)
Atlantic cod	156 (10)	106 (11)	141 (10)
Silver hake	999 (3)	414 (4)	523 (2)
White hake	35 (20)	50 (13)	72 (14)
Red hake	279 (6)	186 (9)	84 (12)
Total	2471	1780	1182
Groundfish			
Little skate	146 (12)	43 (15)	97 (11)
Big skate	129 (13)	40 (16)	83 (13)
Thorny skate	272 (7)	289 (5)	236 (6)
Haddock	783 (4)	254 (7)	161 (8)
Ocean pout	105 (14)	36 (20)	27 (20)
Sea raven	3 (24)	1 (24)	2 (24)
Longhorn sculpin	11 (22)	18 (21)	7 (22)
American plaice	64 (19)	39 (17)	28 (19)
Yellowtail flounder	77 (16)	94 (12)	41 (16)
Winter flounder	71 (18)	36 (19)	38 (17)
Fourspot flounder	9 (23)	4 (23)	5 (23)
American goosefish	74 (17)	37 (18)	47 (15)
Total	1744	891	772
Other fish	810	869	1039
TOTAL	9720	8665	5350

* Place by biomass is shown in brackets

Table 3 Role of organisms of ecological communities in feeding of chozen groups of fish on Georges Bank and adjacent waters, % by weight

Fish groups and species	Plankton		Benthos and nektobenthos				Nekton		Others (mainly remnants of fish reduction, detritus, non-identified remains)
	crustacea	Others	polychaetes	crustacea	mollusk	echinoderms	fish	squids	
1	2	3	4	5	6	7	8	9	10
Group I (consumers of plankton)									
Blueback herring	78	22	-	-	-	-	-	-	-
Alewife	56	37	+	7	-	-	-	-	-
Atlantic herring	89	11	-	+	-	-	-	-	-
Round herring	85	9	-	6	-	-	-	-	-
Atlantic argentine	97	3	-	-	-	-	-	-	-
Atlantic mackerel	84	14	+	2	-	-	-	+	+
Butterfish	46	53	+	1	-	-	-	-	-
Redfish	100	-	-	-	-	-	-	-	-
Group II (consumers of nekton)									
Spiny dogfish	4	-	-	+	-	-	78	18	-
Hake	17	-	+	2	+	-	75	6	+
White hake	25	-	+	10	1	+	64	+	-
Sea raven	-	-	-	6	-	-	94	-	-
American goosefish	-	-	-	+	-	-	62	38	-
Group III (consumers of benthos)									
Little skate	7	-	22	60	-	+	11	-	+
Big skate	-	-	19	79	-	-	2	-	-
Thorny skate	-	-	3	5	-	-	5	-	87
Haddock	1	-	5	12	2	63	2	9	6
Ocean pout	-	-	11	71	+	7	9	-	2
Longhorn sculpin	3	-	9	84	4	-	-	-	-
Yellowtail flounder	3	-	27	58	+	1	-	+	11
Winter flounder	-	-	45	55	-	-	-	-	-
Group IV (consumers of mixed food)									
Atlantic cod	8	-	2	38	6	4	26	15	1
Pollock	70	-	-	-	-	-	30	-	-
Red hake	6	-	2	44	6	1	26	7	8
American plaice	+	-	6	6	10	22	40	-	16
Fourspot flounder	-	-	-	74	-	-	26	-	-

Table 4 Degree of similarity of food composition (FS-coefficient) for young hake, red hake and adult herring and mackerel on Georges Bank in June 1971 and 1972.

Fish species	Young hake	Young red hake	Mackerel
Herring	31/49*	26/0	52/41
Young hake	-	44/28	13/1
Young red hake	-	-	13/0

* 1971/1972 values

Table 5 Degree of similarity of food composition (FS-coefficients) for gadoids and yellow-tail flounder in June 1971 and 1972

Fish species	Red hake	White hake	Cod	Haddock	Yellow-tail flounder
Hake	18/7	-/61	6/16	22/4	1/1
Red hake	-	-/8	28/14	29/8	18/8
White hake	-	-	-/14	-/2	-/1
Cod	-	-	-	3/17	0/4
Haddock	-	-	-	-	4/6

Table 6 Degree of similarity of food composition (FS-coefficient) for different fish-consumers feeding on fishes on Georges Bank in summer period

Fish consumers	Cod	Hake	Pollock	White hake	Red hake	Sea raven	American plaice	Goosefish
Spiny dogfish	10	11	0	0	2	40	0	9
Cod	-	22	10	10	12	20	0	18
Hake	-	-	30	34	18	31	1	22
Pollock	-	-	-	30	15	20	0	15
White hake	-	-	-	-	15	20	0	15
Red hake	-	-	-	-	-	17	0	17
Sea raven	-	-	-	-	-	-	0	22
American plaice	-	-	-	-	-	-	-	0

Table 7 Comparative characteristic of food composition for hake and red hake, % by weight

Food items and other characteristics of feeding	Georges Bank		Southern shelf of New England	
	hake	red hake	hake	red hake
1	2	3	4	5
Algae	-	+	-	-
Actinia	-	0,1	-	-
Polychaetes	0.5	2.1	+	0.9
Sipunculoidea	-	0.7	-	19.0
Gammarids	0.2	17.8	0.3	7.3
Caprellidea	-	0.8	-	1.5
Euphausiids	28.4	11.6	3.4	2.4
Shrimps	2.0	21.2	4.6	9.4
Hermit crabs	-	6.5	+	1.1
Crabs	+	8.5	0.1	12.5
Other crustaceans	0.1	2.6	0.1	1.1
Remnants of lobsters after molting (chelas, carapace)	-	1.8	-	-
Clams	-	3.0	-	6.0
Gastropods	-	1.3	-	-
Cephalopods	6.6	3.5	7.7	9.1
Ophiurans	-	0.7	-	-
Holoturians	-	-	-	1.9
Atlantic herring	5.3	-	0.3	-
Round herring	0.5	-	0.2	-

Table 7 (continued)

1	2	3	4	5
Hake	31.6	4.9	41.9	3.5
Red hake	3.6	0.1	10.0	3.8
Sand lance	+	-	3.0	-
Atlantic mackerel	16.6	-	20.8	-
Butterfish	0.4	-	2.9	0.7
American plaice	+	0.2	0.1	-
Other fish	3.4	12.5	4.6	5.8
Total fish	61.4	17.7	83.8	13.8
Fish eggs	-	0.1	-	-
Remnants of fish reduction (heads, tails, intestines)	-	-	-	14.0
Digested food	0.8	-	+	-
No. of species of food organisms	38	46	31	49
Total index of fullness, °/ooo	180	70	170	90
No. of stomachs, sp.	4416	1956	3233	1892
including empty stomachs, %	36	21	40	20
Percent by weight:				
plankton	29	12	3	4
nekton	68	21	92	23
nektobenthos	2	42	5	17
benthos	1	25	+	56

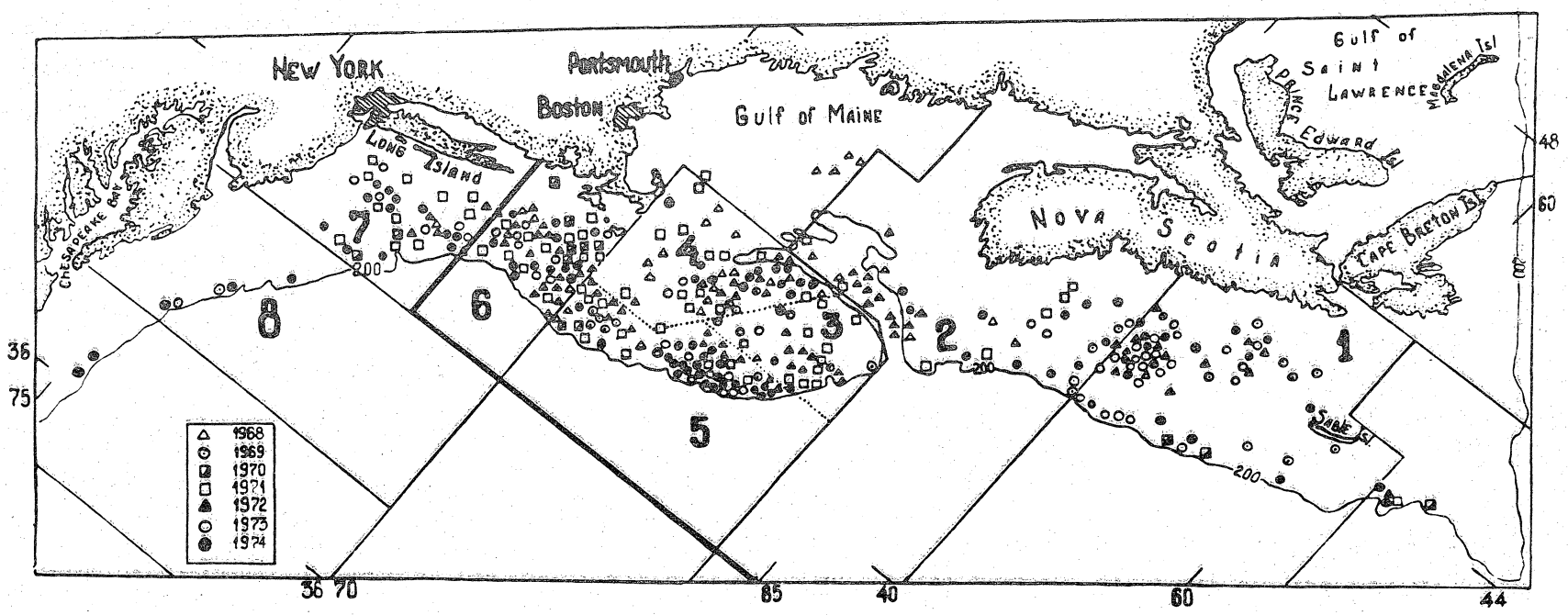

Fig.1 A scheme of area and locations of sampling of fish stomachs for feeding studies in different years

(1-Emerald Bank; 2-Browns Bank;

3-eastern Georges Bank; 4-northwestern Georges Bank;

5-southern Georges Bank;

6-shelf area between shallow of Nantucket Island and Black canyon;

7-shelf area between Long-Island and Hudson canyon;

8-shelf area between Willington and Norfolk canyons).

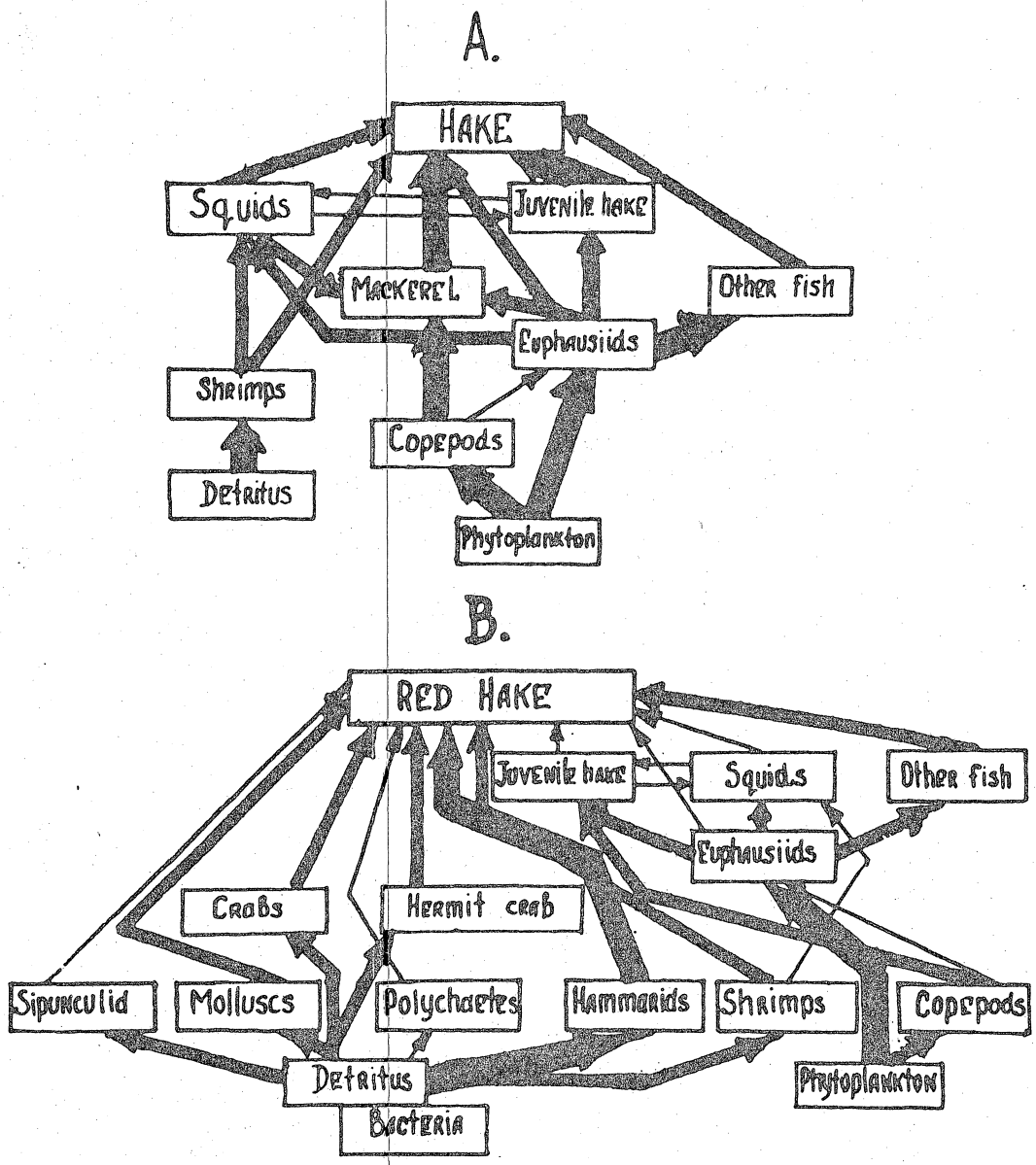

Fig.2 A scheme of food relations of hake (a) and red hake (b) in the Northwest Atlantic (quantitative relationships are only outlined in the schemes; the thicker line connecting consumer with consumed animal, the more frequent consumed animal and in greater amounts is used as a food for consumer).