749

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Food of Eight Northwest Atlantic Pleuronectiform Fishes

Richard W. Langton and Ray E. Bowman

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U.S. DEPARTMENT OF COMMERCE
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Malcolm Baldrige, Secretary
National Oceanic and Atmospheric Administration
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CONTENTS

Figure

Tables

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RICHARD W. LANGTON[1] and RAY E. BOWMAN[2]

ABSTRACT

The food of eight species of pleuronectid fishes, occurring in the northwest Atlantic, from Cape Hatteras, N.C., to Nova Scotia have been investigated for the years 1969-72.

Gulf Stream flounder, *Citharichthys arctifrons*, are annelid and arthropod predators. Summer and fourspot flounders, *Paralichthys dentatus* and *P. oblongus*, prey on fish, squid, and arthropods. The diet of the windowpane, *Scophthalmus aquosus*, consists of arthropods with mysids, pandalid shrimp, and sand shrimp being especially important prey. Witch flounder, *Glyptocephalus cynoglossus*, are predators of benthic invertebrates, preying heavily on annelids. The primary prey of American plaice, *Hippoglossoides platessoides*, is echinoderms. Yellowtail flounder, *Limanda ferruginea*, are annelid and amphipod predators. Winter flounder, *Pseudopleuronectes americanus*, prey on annelids, coelenterates, and bivalve molluscs.

INTRODUCTION

Since a fish's food and feeding habits influence the productivity of the standing stock, and therefore the fishing yield, there have been a number of studies of the diets of the commercially important flatfishes. Feeding behavior, and consequently the food of many of these fish, also relates to the morphology of the alimentary system and this has led to a number of other studies (reviewed by De Groot 1967, 1969, 1971). Furthermore, the realization that successful management of the various fish stocks must include an understanding of the interactions between the fish populations and their prey (May et al. 1979; Ursin In press) has stimulated much recent study of what and how much fish eat, particularly off the U.S. coast in the northwest Atlantic (Edwards and Bowman 1979; Grosslein et al. 1980; Langton and Bowman 1980).

This paper is the second of two publications (Langton and Bowman 1980) to deal specifically with the food of northwest Atlantic fish populations, and it concentrates on eight species of the Pleuronectiformes.

METHODS

A total of 8,008 stomachs were collected from eight species of flatfish on six bottom trawl survey cruises conducted on the following dates: 8 October-22 November 1969; 3 September-20 November 1970; 9 March-1 May 1971; 30 September-19 November 1971; 8 March-24 April 1972; and 27 September-20 November 1972. Fish collections were made with a #36 Yankee otter trawl with rollers, 9 m legs, and standard 544 kg oval doors. The cod end and upper belly of the net were lined with 13 mm mesh netting to retain smaller fish. A scheme of stratified random sampling was carried out within the five geographic areas of the northwest Atlantic (Fig. 1), and sampling continued over 24 h/d.[3]

Flatfish were selected haphazardly from the bottom trawl catch and the stomachs excised aboard ship. The stomachs were labeled according to species, cruise, and station, and preserved in 10% Formalin. It is assumed that, using this procedure, we obtained a representative sample of the entire fish population without bias towards a specified length or sex for each species. In this report, however, only data on fish above a specified length have been included. The species considered and their minimum total lengths are as follows: Gulf Stream flounder, *Citharichthys arctifrons* (Goode), >3 cm; summer flounder, *Paralichthys dentatus* (Linnaeus), >18 cm; fourspot flounder, *Paralichthys oblongus* (Mitchill), >7 cm; windowpane, *Scophthalmus aquosus* (Mitchill), >10 cm; witch flounder, *Glyptocephalus cynoglossus* (Linnaeus), >7 cm; American plaice, *Hippoglossoides platessoides* (Fabricius), >7 cm; yellowtail flounder, *Limanda ferruginea* (Storer), >12 cm; and winter flounder, *Pseudopleuronectes americanus* (Walbaum), >15 cm.

In the laboratory the various prey items, and parasites, were manually sorted and identified to the lowest possible taxa. Each taxonomically distinct category of prey was damp dried and immediately weighed with the precision of 0.001 g.

The prey was summarized on a weight basis as a percentage of the total weight of the stomach contents for each flatfish species. This creates a bias in the data toward the larger individuals but nevertheless is representative of the population as a whole. In the text the broader taxonomic groupings are discussed in detail, and the percentage weight is included in parentheses after the first mention of a prey group to quantify that particular prey's significance in the diet.

RESULTS

Food

Gulf Stream Flounder, *Citharichthys arctifrons.*—A relatively small total quantity of prey was found in the Gulf Stream flounder stomachs that were examined, but the complete prey list includes 200 different categories. The majority of prey, however, was either annelids (51.2%) or arthropods (42.2%) (Table 1). Twenty-one families of polychaete worms were identified, but the Nephthyidae (24.9%) accounted for almost one-half of the annelid prey. Eleven percent of the polychaetes were identified as *Nephtys incisa*, 0.5% as *N. picta*, and 12.9% at the generic level, *Nephtys*. Other polychaetes of some significance as prey are *Aphrodita hastata*

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[3]More detailed cruise information can be obtained from the Resource Surveys Investigation, Northeast Fisheries Center Woods Hole Laboratory, National Marine Fisheries Service, NOAA, Woods Hole, MA 02543.

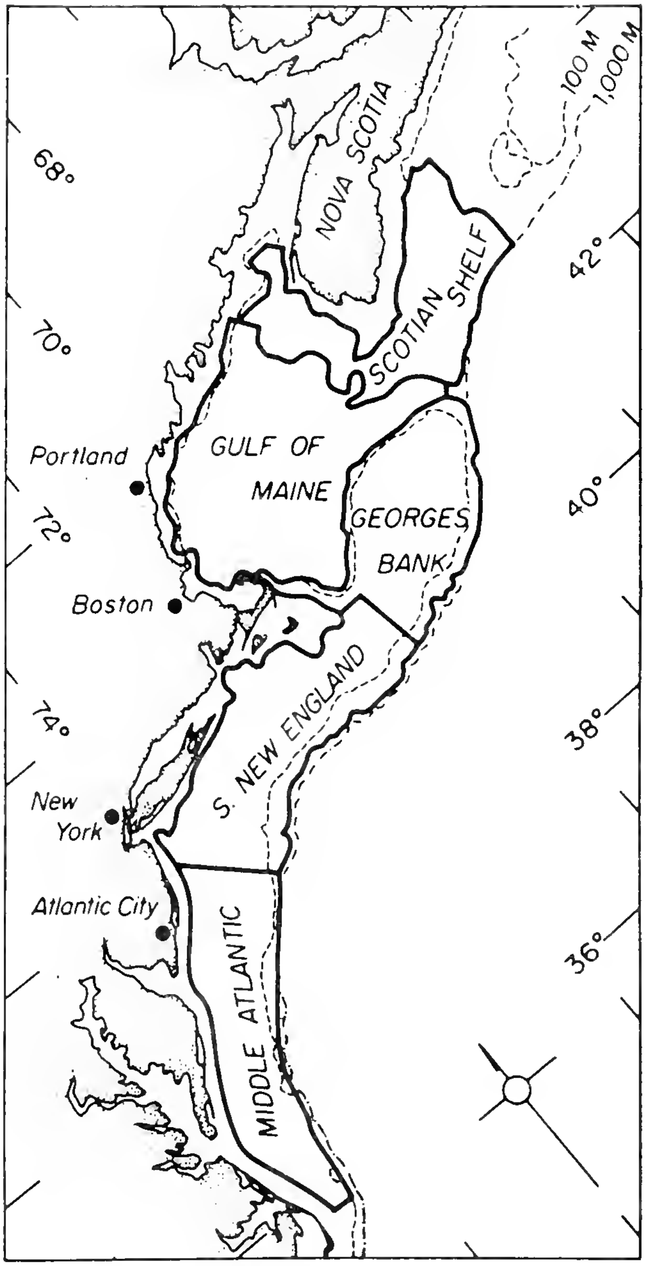

Figure 1.—Five geographic areas of the northwest Atlantic composing the sampling area for flatfish food studies, 1969–72.

(3.3%), *Ninoe nigripes* (2.3%), *Nicomache lumbricalis* (1.4%), *Onuphis* spp. (1.4%) [*O. conchylega* (0.9%), *O. opalina* (0.4%), *O. quadricuspis* (0.1%)], *Lumbrineris* spp. (1.3%) [*L. fragilis* (0.6%), *L. tenuis* (0.4%)], *Notomastus* (1.1%) [*N. latericius* (0.4%)], *Potamilla* (1.0%), *Sabellides octocirrata* (0.6%), *Ampharete acutifrons* (0.6%), *Pherusa* (0.5%), *Sternapsis scutata* (0.5%), *Brada* spp. (0.8%) [*B. granosa* (0.4%), *B. villosa* (0.4%)], *Ammotrypane aulogaster* (0.2%), and *Praxillella* (0.1%). The major prey group within the arthropods was the Amphipoda (24.2%). Within this order, 19 genera and/or species each contributed ≥0.1% to the diet. The following list is in decreasing order of importance at the generic level: *Leptocheirus pinguis* (4.9%), *Erichthonius rubricornis* (4.4%), *Casco bigelowi* (3.0%), *Unciola irrorata* (2.4%), *U. inermis* (0.4%), *U. dissimilis* (0.3%), *Ampelisca agassizi* (1.5%), *A. macrocephala* (1.8%), *A. vadorum* (0.3%), *Byblis serrata* (1.1%), *Photis* (0.3%), *Dyopedos* (0.2%), *Argissa hamatipes* (0.1%), *Orchomenella minuta* (0.1%), *Harpinia propinqua* (0.1%), *Paraphoxus epistomus* (0.1%), and *Stenopleustes* (1.0%). The remaining orders and families of arthropods listed in Table 1 are each represented by a few species. For example, the Euphausiacea that were identified to the species level were *Meganyctiphanes norvegica* (1.9%), *Thysanoessa inermis* (0.8%), or *T. gregaria* (0.2%). The Crangonidae were either *Crangon septemspinosa* (1.4%) or *Pontophilus brevirostris* (0.5%), and the Cumacea were for the most part all members of the genus *Diastylis* (2.1%). The only pandalid shrimp was *Dichelopandalus leptocerus* (2.0%). The Cancridae were identified at the species level as either *Cancer irroratus* (0.8%) or *C. borealis* (0.4%). The other taxa were of little importance as prey, and when combined, only account for 6.6% of the diet. Within these groups, most of the prey were not identified to a generic or specific level, and any that were identified accounted for a very small percentage of the total weight of prey consumed.

Summer Flounder, *Paralichthys dentatus*.—Forty-four summer flounder were examined, but the stomachs of 82% of these fish were empty (Table 1). The prey from the eight stomachs containing food was primarily fish (47.8%) and squid (51.0%). Two species of fish were identified: silver hake, *Merluccius bilinearis* (26.1%), and scup, *Stenotomus chrysops* (21.2%), and the squid was identified as *Loligo* (43.6%). The only other animals identified to the species level were the arthropods *Cancer irroratus* (1.1%) and *Dichelopandalus leptocerus* (0.1%).

Fourspot flounder, *Paralichthys oblongus*.—Fourspot flounder were found to prey primarily on animals from three major taxa (Table 1). Arthropods composed 40.7% of the diet with pandalid shrimp (15.8%) being the most important crustacean group. *Dichelopandalus leptocerus* accounted for most of the prey in this family (10.6%), although the genus *Pandalus* was also represented (1.0%). The Cancridae (8.8%) were second in importance among the crustaceans. The rock crab, *Cancer irroratus* (5.0%), accounted for more of the diet than the jonah crab, *C. borealis* (0.8%), but 3.1% of the stomach contents represented by this family could not be identified at the species level. Two other crustacean groups were important as prey. *Crangon septemspinosa* (4.2%) accounted for most of the Crangonidae consumed. Euphausiids were the only other crustaceans of any significance in the diet and they were almost exclusively *Meganyctiphanes norvegica* (3.7%), although *Thysanoessa raschii* (<0.1%) was also identified in the stomach contents. Most of the "Other Decapods" and "Other Crustacea" were unidentifiable, although the crab, *Munida*, accounted for 1.0% of these remains. Fish were the second major category of prey, accounting for 28.5% of the diet. The single most important species preyed upon was the silver hake, *Merluccius bilinearis* (21.0%). Other fish prey were unidentified gadids (1.6%); Gulf Stream flounder, *Citharichthys arctifrons* (1.6%); witch flounder, *Glyptocephalus cynoglossus* (0.4%); an alligator fish, *Aspidophoroides monopterygius* (<0.1%); an unidentified cottid (<0.1%); and other fish remains. The last major taxon of any significance in the diet of fourspot flounder was the Mollusca (19.4%), and specifically the class Cephalopoda (19.3%). Four different squid were identified: *Loligo* (2.4%), *Illex illecebrosus* (1.8%), *Rossia* (1.4%), and *Heteroteuthis tenera* (<0.1%). The remaining cephalopods were classified as unidentified Cirroteuthidae (2.6%), Decapoda (3.3%), or simply Cephalopoda (7.8%).

Table 1.—Stomach contents of eight northwest Atlantic pleuronectiform fishes collected during the spring and autumn bottom trawl survey cruises, 1969-72. Data are expressed as a percentage of the total weight of prey in the stomachs. (+ indicates present but <0.1%.)

	Gulf Stream flounder	Summer flounder	Fourspot flounder	Windowpane flounder	Witch flounder	American plaice	Yellowtail flounder	Winter flounder
CNIDARIA	0.1	–	+	+	1.7	0.2	2.9	26.3
Hydrozoa	–	–	+	+	+	0.1	+	4.1
Anthozoa	+	–	–	–	1.7	0.1	2.9	22.2
Other Cnidaria	0.1	–	–	–	+	–	–	–
ANNELIDA	51.2	–	0.3	+	72.8	4.4	42.0	26.6
Nephthyidae	24.9	–	–	–	3.0	0.3	1.2	0.3
Maldanidae	3.6	–	–	–	0.8	+	0.4	0.9
Lumbreneridae	3.6	–	–	–	7.6	0.2	1.2	0.4
Ampharetidae	0.8	–	–	–	1.6	0.4	0.2	0.8
Terebellidae	1.5	–	–	–	0.6	+	0.1	8.5
Sabellidae	2.7	–	–	–	1.0	0.6	0.8	1.4
Other Annelida	14.1	–	0.3	+	58.2	2.9	38.3	14.3
ARTHROPODA	42.2	1.2	40.7	86.8	6.8	16.0	37.2	5.4
Cumacea	2.1	–	–	+	0.1	+	0.4	–
Amphipoda	24.2	–	0.8	2.1	2.9	0.4	31.4	3.1
Mysidacea	0.8	–	0.2	41.8	+	0.1	0.2	–
Euphausiacea	4.4	–	3.7	0.2	0.9	2.0	+	–
Pandalidae	2.0	0.1	15.8	22.4	0.2	4.8	0.8	–
Crangonidae	2.4	–	4.9	18.4	0.1	0.4	0.6	0.1
Axiidae	+	–	–	–	+	–	+	+
Paguridae	+	–	–	0.1	+	6.2	0.2	–
Majidae	+	–	+	–	–	–	+	0.1
Cancridae	1.6	1.1	8.8	0.1	0.3	–	2.1	0.7
Other Decapoda	0.4	+	3.2	1.0	0.7	0.5	0.5	0.1
Other Arthropoda	4.3	–	3.3	0.7	1.6	1.6	1.0	1.0
MOLLUSCA	0.9	51.0	19.4	1.2	3.2	7.7	1.9	15.7
Gastropoda	–	–	–	+	+	0.3	0.5	0.3
Bivalvia	0.6	–	+	0.1	0.4	7.1	1.2	15.3
Cephalopoda	0.2	51.0	19.3	1.1	2.7	0.1	–	+
Other Mollusca	0.1	–	0.1	–	0.1	0.2	0.2	0.1
ECHINODERMATA	1.4	–	–	1.2	7.8	65.4	2.8	1.0
Holothuroidea	–	–	–	–	7.6	–	0.9	0.6
Echinoidea	–	–	–	1.2	–	42.6	1.9	0.1
Ophiuroidea	1.4	–	–	–	0.2	22.8	+	0.1
Other Echinodermata	+	–	–	–	–	+	+	0.2
PISCES	2.7	47.8	28.5	6.4	0.6	1.0	0.8	0.1
Gadidae	–	26.1	22.6	–	–	+	–	–
Cottidae	2.6	–	+	0.2	–	0.1	0.5	–
Bothidae	–	–	1.6	0.3	–	–	–	–
Other Pisces	0.1	21.7	4.3	5.9	0.6	0.9	0.3	0.1
Other groups	1.1	–	0.5	1.2	1.4	0.7	3.9	3.8
Animal remains	0.3	–	10.4	3.0	5.4	2.8	5.9	16.1
Sand and rock	0.1	–	0.2	0.2	0.3	1.8	2.6	5.0
Number of stomachs	387	44	1,096	716	1,165	1,186	2,645	768
Percentage of empty stomachs	38.5	81.8	41.6	46.2	9.2	40.5	21.6	36.8
Mean weight per stomach (g)	0.04	4.8	0.5	1.1	0.8	1.1	0.5	1.1
Mean predator length (cm)	10	38.1	26	26	44	28	30	35
Number of sampling stations	69	14	98	90	201	187	200	95

Windowpane, *Scophthalmus aquosus.*—Three hundred and eighty-five of the 716 windowpane stomachs examined contained prey, and almost 90% of the diet was arthropods (Table 1). Three arthropod groups accounted for over 80% of the diet, and within these groups only a few species were important. For example, virtually all the Mysidacea (41.8%) were identified as *Neomysis americana* (41.0%). The family Pandalidae (22.4%) was similar in that *Dichelopandalus leptocerus* accounted for 20.4% of this group, and in the family Crangonidae, *Crangon septemspinosa* (18.4%) was the only representative. The only other arthropod group contributing >1% to the diet was the Amphipoda (2.1%), with *Leptocheirus pinguis* (1.4%) and *Gammarus annulatus* (0.2%) being the most important animals. Pisces was of secondary importance in the diet; however, a variety of fish species were identified in the stomach contents. American sand lance, *Ammodytes americanus,* both adults (1.6%) and larvae (1.8%), were preyed upon. The blackbelly rosefish, *Helicolenus dactylopterus* (0.4%); windowpane (0.3%); silverside, *Menidia* (0.3%); and longhorn sculpin, *Myoxocephalus octodecispinosus* (0.2%), were all found in windowpane stomachs. The only other animals of any significance in the diet were squid, *Loligo* (1.1%), and the sand dollar, *Echinarachnius parma* (1.2%).

Witch flounder, *Glyptocephalus cynoglossus.*—Annelids accounted for almost three-fourths (72.8%) of the diet of witch flounder (Table 1). Unfortunately, over half of these annelids could not be identified below the phylum level (35.8%) or were attributed to the occurrence of worm tubes (4.4%) in the fish stomachs. The other 32.6% of the annelid remains were divided among 51 genera of polychaetes representing 30 different families. Because of the diversity of polychaete prey, few of these species contributed more than a few percent to the diet. The more important polychaete prey are *Scalibregma inflatum* (3.1%), *Lumbrineris fragilis* (3.1%), *Sternapsis* (2.8%), *Notomastus latericius* (1.5%), *Onuphis eremita* (1.4%), *Goniada* (0.9%), *Nephtys incisa* (0.8%), *Aphrodita hastata* (0.7%), *Melinna cristata* (0.4%), *Pectinaria* (0.3%), *Onuphis opalina* (0.3%), *Pherusa* (0.2%), *Ammotrypane aulogaster* (0.2%), *Polyphysia crassa* (0.2%), *Capitella capitata* (0.2%), *Amphicteis gunneris* (0.2%), *Eunice* (0.2%), *Ninoe* (0.2%), *Onuphis conchylega* (0.2%), *Maldane sarsi* (0.1%), *Nicomache lumbricalis* (0.1%), *Ampharete acutifrons* (0.1%), and *Antinoella angusta* (0.1%). The remaining quarter of the diet was divided among echinoderms (7.8%), arthropods (6.8%), molluscs (3.2%), and unidentifiable animal remains (5.4%). Cnidaria (1.7%), Pisces (0.6%), and other groups contributed little as prey of witch flounder. Among the echinoderms, holothuroideans of the order Dendrochirotida (5.7%) occurred most frequently in the stomachs. Three genera in this order were identified: *Thyone* (3.6%), *Steroderma* (0.6%), and *Pentamera* (0.4%). As a major taxon, arthropods (6.8%) followed echinoderms in importance. Within this phylum, amphipods (2.9%) were the single most important group, and 11 different families were identified in the witch flounder stomach contents. At the generic and specific level, only *Gammarus annulatus* (0.3%), *Tmetonyx* (0.2%), *Ampelisca* (0.1%), *Unciola* (0.1%), *Casco bigelowi* (0.1%), *Maera* (0.1%), and *Leptocheirus pinguis* (0.1%) accounted for >0.1% of the diet. Molluscs were the next major prey category, but they contributed little to the diet (3.2%). The Cephalopoda were the most important class in this phylum with regard to weight. Two squid, of the genus *Loligo*, accounted for 2.2% of the diet. Although the bivalves were not important on a weight basis (0.4%), eight different genera were found in the witch flounder stomachs together with two genera of gastropods.

American plaice, *Hippoglossoides platessoides*.—American plaice preyed primarily on echinoderms (65.4%) (Table 1). Echinoids (42.6%) were the major group, with most of them being identified as the sand dollar, *Echinarachnius parma* (38.1%), although the sea urchin, *Strongylocentrotus droebachiensis* (1.3%), accounted for some of the echinoid remains. Ophiuroids also contributed a significant quantity to the diet (22.8%), and, in this subclass, the genus *Ophiura* (12.3%) was the major contributor with both *O. sarsi* (5.6%) and *O. robusta* (<0.1%) having been identified. Arthropods (16.0%) were the second major taxonomic group that was preyed on by American plaice. Pagurids (6.2%) and pandalid shrimp (4.8%) were the two major families of crustaceans found in the stomachs. Within the Paguridae both *Pagurus acadianus* (6.0%) and *P. pubescens* (0.1%) were identified from the stomach contents. The pandalids identified to species were *Dichelopandalus leptocerus* (1.4%), *Pandalus borealis* (0.5%), and *P. montagui* (0.2%). The only other group of crustaceans to contribute >1% to the diet were the euphausiids (2.0%), and this was almost exclusively due to *Meganyctiphanes norvegica* (1.9%). A total of 11 genera of amphipods were identified in the stomachs examined, but the group constituted a small percentage of the total diet. The genera in the other crustacean groups that contributed at least 0.1% to the diet were: *Crangon* (4.5%), *Spirontocaris* (0.1%), *Pasiphaea* (0.2%), and *Balanus* (0.1%). Mollusca (7.7%) followed the arthropods as the third major taxa that was preyed on by American plaice. The Bivalvia was the most important group, and within this class 11 different genera were identified as prey. The Iceland scallop, *Chlamys islandica* (1.3%), and short and broad clams *Yoldia* spp. (3.6%), *Y. sapotilla* and *Y. thraciaformis*, respectively, were the most important bivalve prey. Annelids contributed a relatively small amount to the diet (4.4%). Nineteen different genera were identified in the stomachs examined, but only *Melinna cristata* (0.3%), *Nephtys* (0.3%), and *Lumbrineris* (0.2%) contributed >0.1% of the total prey consumed. The remaining taxa such as fish (1.0%), coelenterates (0.2%), and all other groups (0.7%) contributed very little to the diet.

Yellowtail flounder, *Limanda ferruginea*.—Over 2,000 of the yellowtail flounder stomachs that were examined contained prey, and 79% of this prey was either annelids (42.0%) or arthropods (37.2%) (Table 1). Over half of the annelids (25.5%) could not be identified below the phylum level. However, 26 genera of polychaetes were identified from the remaining 16.5% of the annelid prey but most of these genera individually accounted for <0.1% of the diet. The more important genera are as follows: *Eunice* (4.1%), *Polydora* (1.6%), *Nereis* (1.5%), *Lumbrineris* (1.0%), *Nephtys* (1.0%), *Aphrodita* (0.5%), *Arenicola* (0.1%), *Ammotrypane* (0.1%), *Scalibregma* (0.1%), *Ninoe* (0.1%), *Potamilla* (0.1%), and *Nothria* (0.1%). Amphipods (31.4%) were the single most important arthropod group, but half of the prey attributed to this group was actually amphipod tubes (15.8%). Three suborders of amphipods accounted for the remainder of the group and are listed in decreasing order of importance as follows: Gammaridae (7.6%), Caprellidae (0.5%), and Hyperidea (0.1%). The Gammaridae were further broken down into the families: Corophiidae (5.0%), Ampeliscidae (2.2%), Haustoridae (<0.1%), Lysianassidae (<0.1%), and Oedicerotidae (<0.1%). The only other arthropod group of any significance in the diet of yellowtail flounder was the family Cancridae (2.1%). The genus *Cancer* accounted for all these remains, with both *C. irroratus* (0.3%) and *C. borealis* (<0.1%) having been identified. The remaining 21% of the diet was divided among the seven other major prey categories, and the only animal to contribute >1% to the diet was the sand dollar, *Echinarachnius parma* (1.6%).

Winter flounder, *Pseudopleuronectes americanus*.—Annelids accounted for 26.6% of the total stomach contents from the 769 winter flounder examined (Table 1). The remains were almost exclusively polychaete worms with representatives from 26 different families. Within these families, a number of different genera and species were identified, and those constituting ≥0.1% of the diet are listed in decreasing importance as follows: *Thelepus cincinnatus* (6.8%), *Nicomache lumbricalis* (0.8%), *Ampharete* (0.8%), *Ophioglycera gigantea* (0.6%), *Pherusa* (0.5%), *Nereis* (0.4%), *Nephtys* (0.3%), *Ninoe* (0.2%), *Lumbrineris* (0.2%), *Chone infundibuliformis* (0.2%), *Nicolea* (0.1%), and *Scalibregma inflatum* (0.1%). Second to the annelids in importance were the Cnidaria (26.3%). Two classes of coelenterates were identified as part of the stomach contents, Anthozoa (22.2%) and Hydrozoa (4.1%). The hydrozoans were not identified below class level, but some of the anthozoans were identified at the subclass and order levels. A small percentage of the anthozoans were identified only at the subclass level Zoantharia (<0.1%), but within this subclass the order Actinaria accounted for most of the remains (13.0%). The only other order of any significance, in the subclass Ceriantipatharia, was the

Ceriantharia (2.8%). The remaining half of the stomach contents was distributed between the other seven major prey groupings with unidentified animal remains alone accounting for 16.1% of the diet. Of the taxonomically distinct groups, the Mollusca were the most important (15.7%), but unfortunately most of these (14.7%) were unidentified bivalves. However, the 1% of the molluscan part of the diet that was identified was attributed to 11 genera of bivalves and 10 genera of gastropods. Arthropods were the only other large taxon to contribute >1% to the diet. Within the arthropods, the most important crustaceans were Amphipoda (3.1%). A number of genera and species were identified but those contributing >0.1% to the diet were *Aeginina longicornis* (0.6%), *Gammarus annulatus* (0.5%), *Leptocheirus pinguis* (0.4%), and *Pontogeneia inermis* (0.1%). The only other animals of any significance in the diet were the crustaceans [*Crangon septemspinosa* (0.7%), *Cancer irroratus* (0.6%), *Pagurus* (0.2%)], the sea cucumber [*Stereoderma unisemita* (0.5%)], and the tunicate [*Amaroucium* (0.3%)].

Geographic Comparisons

Gulf Stream flounder.—Gulf Stream flounder were collected in the Middle Atlantic, Southern New England, and on Georges Bank (Table 2).

In the Middle Atlantic, arthropods accounted for half (49.5%) of the diet, with the Amphipoda (16.3%) and the Euphausiacea (14.1%) being the two most important groups. A variety of amphipods were identified in the stomach contents, and the most important are: *Byblis serrata* (6.1%), several species of *Unciola* (3.7%) [*U. inermis* (1.7%), *U. irrorata* (1.4%)], and *Erichthonius rubricornis* (1.4%). Most of the euphausiid prey was *Meganyctiphanes norvegica* (11.3%); the remainder of the euphausiids (2.8%) were unidentified. Other arthropods of some importance were the crab, *Cancer* (7.6%) [*C. irroratus* (5.2%)]; the sand shrimp, *Crangon septemspinosa* (5.4%); and the isopod, *Edotea triloba* (1.3%). In Southern New England arthropods accounted for one-third of the diet (34.5%), and, as in the other areas, the Amphipoda (21.9%) were extremely important. The amphipods contributing most to the diet were *Leptocheirus pinguis* (7.1%), *Casco bigelowi* (4.4%), *Ampelisca* spp. (4.0%) [*A. agassizi* (1.3%)], and *Unciola* (3.9%). Other arthropod prey such as the cumaceans, *Diastylis* spp. (2.9%) [*D. quadrispinosa* (0.6%); *D. sculpta* (<0.1%)], and the euphausiids, *Thysanoessa inermis* (1.2%) and *Meganyctiphanes norvegica* (0.4%), also contributed to the diet. On Georges Bank, the Arthropoda were the primary prey (68.5%), with the Amphipoda accounting for 41.4% of the diet. A single species of amphipod, *Erichthonius rubricornis*, made up half (22.1%) of the amphipod prey. This same species had been preyed on in both the Middle Atlantic (1.4%) and in Southern New England (0.1%) but occurred much less frequently in the stomachs examined. Apart from *E. rubricornis*, the Ampeliscidae were the other amphipods of any significance, and, within this family, *Ampelisca agassizi* (3.0%) was of major importance. Other arthropods that were important prey on a weight basis were *Dichelopandalus leptocerus* (12.3%), *Mysidopsis bigelowi* (2.9%), copepods of the genus *Centropages* (2.0%), *Thysanoessa gregaria* (1.2%), and *Crangon septemspinosa* (1.0%). Only one pandalid shrimp, *D. leptocerus*, was found in the 53 Gulf Stream flounder stomachs examined, thus the estimate of its importance is imprecise.

In the Middle Atlantic the annelid prey was exclusively polychaetes representing a variety of different families. The most important family was the Nephtyidae (12.8%), with *Nephtys picta* (3.3%) having been identified at a species level. The Maldanidae were also important, but none of these polychaetes were identified below the family level. Families and species classified under "Other Annelida" that contributed significantly to the diet were the Onuphidae (5.0%) [*Onuphis conchylega* (4.9%)], the Flabelligeridae (4.7%) [*Pherusa* (0.1%)], and the Sternaspidae (2.3%) [*Sternaspis scutata* (2.3%)]. In Southern New England annelids were the major prey of Gulf Stream flounder. Virtually all the annelids were polychaetes, although < 0.2% of this phylum were identified as oligochaetes. A number of polychaete families were represented in the stomach contents, and, as in the Middle

Table 2.—Geographic breakdown of the stomach contents of Gulf Stream flounder, *Citharichthys arctifrons*, in the northwest Atlantic. Data are expressed as a percentage weight for fish collected during the spring and autumn bottom trawl survey cruises, 1969-72. (+ indicates present but <0.1%.)

Prey	Middle Atlantic	Southern New England	Georges Bank
CNIDARIA	–	0.1	–
Hydrozoa	–	–	–
Anthozoa	–	+	–
Other Cnidaria	–	0.1	–
ANNELIDA	46.6	58.1	25.7
Nephthyidae	12.8	32.7	2.7
Maldanidae	6.4	1.9	8.6
Lumbreneridae	0.6	4.7	1.9
Ampharetidae	0.5	0.6	2.2
Terebellidae	4.2	1.2	–
Sabellidae	2.5	3.3	+
Other Annelida	19.6	13.7	10.3
ARTHROPODA	49.5	34.5	68.5
Cumacea	0.1	2.9	0.4
Amphipoda	16.3	21.9	41.4
Mysidacea	0.1	0.5	3.1
Euphausiacea	14.1	3.0	1.2
Pandalidae	–	–	12.3
Crangonidae	6.1	1.8	1.2
Axiidae	–	+	–
Paguridae	–	+	0.1
Majidae	0.1	+	–
Cancridae	7.6	0.7	–
Other Decapoda	0.3	0.5	–
Other Arthropoda	4.8	3.2	8.8
MOLLUSCA	0.2	1.2	0.1
Gastropoda	–	–	–
Bivalvia	0.2	0.8	–
Cephalopoda	–	0.3	0.1
Other Mollusca	0.2	0.1	–
ECHINODERMATA	1.1	1.7	0.1
Holothuroidea	–	–	–
Echinoidea	–	–	–
Ophiuroidea	1.1	1.7	0.1
Other Echinodermata	–	+	–
PISCES	2.5	3.4	–
Gadidae	–	–	–
Cottidae	2.5	3.3	–
Bothidae	–	–	–
Other Pisces	–	0.1	–
Other groups	–	0.5	5.1
Animal remains	–	0.4	0.5
Sand and rock	0.1	0.1	–
Number of stomachs	121	213	53
Percentage of empty stomachs	41.7	39.9	13.2
Mean weight per stomach (g)	0.02	0.05	0.04
Mean predator length (cm)	7.8	11.2	10.9
Number of sampling stations	18	43	8

Atlantic, the Nephtyidae (32.7%) were the most important. The prey species, however, was different. In Southern New England, *Nephtys incisa* (16.1%) was the only species of this family found in the stomachs, with most of the rest being identified to the generic level, *Nephtys* (16.3%). The Lumbrinereidae were second in importance (4.7%), with three species having been identified—*Ninoe nigripes* (3.3%), *Lumbrineris fragilis* (0.7%), and *L. tenuis* (0.2%). None of these species were preyed on in the Middle Atlantic, and only *L. tenuis* (1.1%) was eaten on Georges Bank. The Maldanidae (1.9%) were of some importance as prey of Southern New England Gulf Stream flounder and five genera and three species were distinguished in the stomach contents: *Lumbriclymene cylindricaudata* (0.2%), *Praxillella* (0.2%), *Nicomache lumbricalis* (<0.1%), *Petaloproctus tenuis* (<0.1%), and *Maldane sarsi* (<0.1%). Other annelid species of some significance in the diet of Gulf Stream flounder from Southern New England were *Aphrodita hastata* (4.8%), *Potamilla* (1.5%), *Sternaspis scutata* (0.2%), and *Chone infundibuliformis* (0.1%). Annelids were also a major prey taxon for Georges Bank Gulf Stream flounder, and here the Maldanidae and Nephytidae were important components of the diets. The Nephytidae (2.7%), *Nephtys* (2.3%), were not as important as in the other areas, while the Maldanidae, exlusively *Nicomache lumbricalis* (8.6%), were more important. Two other species, from other families, also contributed to the diet: the capitellid, *Notomastus latericius* (2.6%), and the ampharetid, *Ampharete acutifrons* (2.2%). Among the "Other Annelida," the most important group were the obligochaetes, which accounted for 5.0% of the diet.

Summer flounder.—All the summer flounder collected for stomach analysis were taken from the Middle Atlantic. Table 1 summarizes the available data on the food of this species in that geographic area.

Fourspot flounder.—Fourspot flounder were collected in for of the five geographic areas, but too few fish were taken from the Gulf of Maine to make valid comparisons between this area and the three other regions. The following discussion is therefore limited to comparisons between the Middle Atlantic, Southern New England, and Georges Bank.

Arthropods, Pisces, and Molluscs are the three major taxa which are preyed on by fourspot flounder (Table 3). Arthropods are generally the major prey although in Southern New England fish are slightly more important. Usually the same groups of arthropods are preyed on in the different areas although the proportions that the individual groups contribute to the diet differ. In the Middle Atlantic, for example, the Pandalidae are an extremely important prey with *Dichelopandalus leptocerus* accounting for 29.0% of the diet. In Southern New England the Pandalidae are also preyed upon but only accounted for 7.9% of the diet, and only 3.9% of this was attributable to *D. leptocerus.* On Georges Bank the pandalid shrimp were again extremely important prey (26.3%). Although a significant part of the remains were only identified at the family level (15.4%), the majority of this group identified at the species level was *D. leptocerus* (9.7%). Other arthropods such as the Crangonidae and Cancridae were also preyed on in the different areas but to differing degrees. In the Middle Atlantic, *Crangon septemspinosa* accounted for 5.3% of the diet, in Southern New England, 2.7%, and on Georges Bank, 13.1%. In the Middle Atlantic the Cancridae were preyed on heavily with *C. irroratus* accounting for 11.1% of the diet. In Southern New England the *Cancer* crabs, both *C. irroratus* (4.2%) and *C. borealis* (1.1%), were preyed on, but on Georges Bank no representatives of this family were identified in the stomach contents. Finally, two other crustacean species were important prey but only in one of the three geographic areas; *Munida iris* accounted for 3.2% of the fourspot flounder's diet in the Middle Atlantic and *Meganyctiphanes norvegica* accounted for 5.9% of the diet in Southern New England.

Pisces were preyed on in all three geographic areas and in at least two areas, Southern New England and Georges Bank, silver hake, *Merluccius bilinearis,* was the primary fish prey (28.1 and 20.1% of the diet, respectively). Silver hake was also preyed on in the Middle

Table 3.—Geographic breakdown of the stomach contents of fourspot flounder, *Paralichthys oblongus*, in the northwest Atlantic. Data are expressed as a percentage weight for fish collected during the spring and autumn bottom trawl survey cruises, 1969-72. (+ indicates present but <0.1%.)

Prey	Middle Atlantic	Southern New England	Georges Bank	Gulf of Maine
CNIDARIA	—	+	–	–
Hydrozoa	–	+	–	–
Anthozoa	–	–	–	–
Other Cnidaria	–	–	–	–
ANNELIDA	0.3	0.3	+	2.4
Nephthyidae	–	–	–	–
Maldanidae	–	–	–	–
Lumbreneridae	–	–	–	–
Ampharetidae	–	–	–	–
Terebellidae	–	–	–	–
Sabellidae	–	–	–	–
Other Annelida	0.3	0.3	+	2.4
ARTHROPODA	71.7	28.7	46.4	35.3
Cumacea	–	–	–	–
Amphipoda	0.1	1.3	+	1.4
Mysidacea	0.5	0.1	0.2	–
Euphausiacea	0.2	5.9	–	–
Pandalidae	30.9	7.9	26.3	24.7
Crangonidae	5.3	2.7	13.1	8.0
Axiidae	–	–	–	–
Paguridae	–	–	–	–
Majidae	+	–	–	–
Cancridae	20.7	7.0	–	–
Other Decapoda	6.8	1.7	4.5	–
Other Arthropoda	7.2	2.1	2.3	1.2
MOLLUSCA	10.4	25.1	10.3	–
Gastropoda	–	–	–	–
Bivalvia	0.2	–	–	–
Cephalopoda	10.1	25.0	10.3	–
Other Mollusca	0.1	0.1	–	–
ECHINODERMATA	–	–	–	–
Holothuroidea	–	–	–	–
Echinoidea	–	–	–	–
Ophiuroidea	–	–	–	–
Other Echinodermata	–	–	–	–
PISCES	14.0	34.6	23.9	39.5
Gadidae	2.4	30.7	20.1	–
Cottidae	–	–	–	–
Bothidae	7.6	–	–	–
Other Pisces	4.0	3.9	3.8	39.5
Other groups	0.5	0.6	0.1	2.6
Animal remains	2.9	10.6	19.3	20.2
Sand and rock	0.2	0.1	–	–
Number of stomachs	211	768	111	6
Percentage of empty stomachs	28.0	45.4	41.4	33.3
Mean weight per stomach (g)	0.6	0.5	0.8	1.0
Mean predator length (cm)	24.4	25.0	28.2	30.0
Number of sampling stations	22	61	13	2

Atlantic but contributed significantly less to the diet (1.9%). In this region predation on silver hake was somewhat overshadowed by predation on Gulf Stream flounder, *Citharichthys arctifrons* (7.6%). None of the other fish could be identified to the species level.

Molluscs were the third and final taxon that played an important role in the diet of fourspot flounder. Within this phylum the Cephalopoda accounted for most of the prey. In the Middle Atlantic most of the cephalopods could not be identified below the class level (9.8%), and the only genus identified was *Rossia* (0.3%). On Georges Bank most of the caphalopods, again, were not identified below class (10.3%) and here the one genus identified was *Loligo* (2.1%). In Southern New England three different squid were identified in the flounder stomachs. *Loligo, Rossia* [*R. tenera* (0.1%)], and *Illex illecebrosus* accounted for 3.8, 2.6, and 2.8% of the diet, respectively.

Windowpane.—The diet of windowpane can be compared in three of the four areas where fish were collected for stomach contents analysis. In all three areas, arthropods accounted for at least three-fourths of the diet, and most of the prey within this phylum were the more pelagic crustaceans (Table 4). The actual composition of the diet, although very similar in terms of the type of prey, varied quite appreciably in percentage composition.

In the Middle Atlantic, mysids, especially *Neomysis americana* (73.2%), were the primary prey. *Crangon septemspinosa* (6.1%), *Dichelopandalus leptocerus* (4.2%), and *Caridion gordoni* (2.2%) were of secondary importance. In Southern New England, mysids, *Neomysis americana* (50.2%), were again a major prey, but *Dichelopandalus leptocerus* (31.9%) was also very important, and *Crangon septemspinosa* accounted for approximately the same percentage of the diet (3.3%) as in the Middle Atlantic. In contrast, on Georges Bank, *Crangon septemspinosa* (45.9%) was the major prey, while *Neomysis americana* (19.1%) and *Dichelopandalus leptocerus* (6.0%) were of secondary importance.

On Georges Bank, Pisces was the only taxon, besides the Arthropoda, to contribute significantly to the diet (13.1%). Four species of fish were identified from the Pisces remains: American sand lance (*Ammodytes americanus*) larvae (5.1%) and adults (4.4%); silverside, *Menidia* (0.8%); longhorn sculpin, *Myoxocephalus octodecimspinosus* (0.7%); and finally other windowpane (1.0%). The only other fish prey that was identified to species was one blackbelly rosefish, *Helicolenus dactylopterus* (0.7%), which was eaten by Southern New England windowpane.

Table 4.—Geographic breakdown of the stomach contents of windowpane flounder, *Scophthalmus aquosus*, in the northwest Atlantic. Data are expressed as a percentage weight for fish collected during the spring and autumn bottom trawl survey cruises, 1969-72. (+ indicates present but <0.1%.)

Prey	Middle Atlantic	Southern New England	Georges Bank
CNIDARIA	–	+	–
Hydrozoa	–	+	–
Anthozoa	–	–	–
Other Cnidaria	–	–	–
ANNELIDA	0.4	+	0.1
Nephthyidae	–	–	–
Maldanidae	–	–	–
Lumbreneridae	–	–	–
Ampharetidae	–	–	–
Terebellidae	–	–	–
Sabellidae	–	–	–
Other Annelida	0.4	+	0.1
ARTHROPODA	94.0	92.0	77.0
Cumacea	–	+	–
Amphipoda	0.6	3.0	0.8
Mysidacea	74.5	50.8	20.4
Euphausiacea	–	–	0.4
Pandalidae	8.8	33.5	6.7
Crangonidae	6.1	3.3	45.9
Axiidae	–	–	–
Paguridae	–	–	0.2
Majidae	–	–	–
Cancridae	0.3	–	0.4
Other Decapoda	3.7	0.2	1.7
Other Arthropoda	–	1.2	0.5
MOLLUSCA	2.3	1.7	–
Gastropoda	–	+	–
Bivalvia	1.4	+	–
Cephalopoda	0.9	1.7	–
Other Mollusca	–	–	–
ECHINODERMATA	–	–	3.3
Holothuroidea	–	–	–
Echinoidea	–	–	3.3
Ophiuroidea	–	–	–
Other Echinodermata	–	–	–
PISCES	0.1	3.1	13.1
Gadidae	–	–	–
Cottidae	–	–	0.7
Bothidae	–	–	1.0
Other Pisces	0.1	3.1	11.4
Other groups	1.1	1.2	1.3
Animal remains	2.0	1.9	4.9
Sand and rock	0.1	0.1	0.3
Number of stomachs	163	318	228
Percentage of empty stomachs	60.1	43.1	39.5
Mean weight per stomach (g)	0.3	1.4	1.2
Mean predator length (cm)	24.9	25.3	18.0
Number of sampling stations	25	27	33

Witch flounder.—Witch flounder were collected in all five geographic areas, but the average total fish length varied by as much as 24 cm between regions. Despite this range in length, the composition of the witch flounder's diet is very similar. In all regions, annelids were the major prey (Table 5). Annelids made up more than half the diet in each area except Southern New England, and here the Mollusca (40.4%) offset the importance of annelids primarily because two specimens of the squid, *Loligo*, accounted for 32.8% of the diet by weight.

The total quantity of prey in the stomachs also puts some limitations on detailed areal comparisons. In the Middle Atlantic, for example, only 38 fish were collected which had consumed slightly >10 g of prey. Although annelids accounted for 92.8% of the diet, over 90% of these were unidentified polychaetes. Two species were identified, *Lumbrineris fragilis* (<0.1%) and *Eteone longa* (<0.1%). *Lumbrineris fragilis* was identified in the stomachs from other areas, which shows that Middle Atlantic witch flounder prey on at least one of the same species as in the other areas.

A comparison of the annelid prey from the fish collected on Georges Bank, in the Gulf of Maine, and from Western Nova Scotia will be the best indicator of changes in feeding behavior, since a reasonable number of fish were collected in these areas, and the average fish size was virtually the same. On Georges Bank, 40.3% of the annelid prey was unidentified, but, of the remaining 47.5%, *Scalibregma inflatum* (28.4%) was the most important. In the other two areas, the Scalibregmidae were also preyed on, but they accounted for <0.5% of the prey, e.g., in the Gulf of Maine,

Table 5.—Geographic breakdown of the stomach contents of witch flounder, *Glyptocephalus cynoglossus*, in the northwest Atlantic. Data are expressed as a percentage weight for fish collected during the spring and autumn bottom trawl survey cruises, 1969-72. (+ indicates present but <0.1%.)

Prey	Middle Atlantic	Southern New England	Georges Bank	Gulf of Maine	Western Nova Scotia
CNIDARIA	+	0.5	—	1.4	3.1
Hydrozoa	+	–	–	–	–
Anthozoa	+	0.5	–	1.4	3.1
Other Cnidaria	–	–	–	+	–
ANNELIDA	92.8	42.0	87.8	81.8	60.0
Nephthyidae	–	5.9	1.8	3.9	1.7
Maldanidae	–	–	0.1	0.7	1.4
Lumbreneridae	0.2	14.3	5.0	10.5	3.0
Ampharetidae	–	0.3	2.0	2.4	0.6
Terebellidae	–	–	1.0	0.6	0.6
Sabellidae	–	4.3	–	1.5	+
Other Annelida	92.6	17.2	77.9	62.2	52.7
ARTHROPODA	3.0	12.1	6.2	3.2	11.4
Cumacea	–	–	+	+	0.3
Amphipoda	+	2.8	3.5	0.9	5.7
Mysidacea	–	+	–	+	–
Euphausiacea	–	–	0.1	0.9	1.4
Pandalidae	–	–	1.3	0.1	–
Crangonidae	–	0.1	1.0	+	+
Axiidae	–	–	+	–	–
Paguridae	–	0.1	0.2	–	–
Majidae	–	–	–	–	–
Cancridae	–	4.3	–	–	–
Other Decapoda	2.9	0.1	–	0.3	1.7
Other Arthropoda	0.1	4.7	0.1	1.0	2.2
MOLLUSCA	0.3	40.4	0.2	0.4	0.8
Gastropoda	0.1	–	–	+	0.1
Bivalvia	0.1	0.1	0.2	0.4	0.6
Cephalopoda	0.1	40.3	–	+	+
Other Mollusca	–	–	–	+	0.1
ECHINODERMATA	–	–	0.2	4.9	16.3
Holothuroidea	–	–	0.2	4.5	16.3
Echinoidea	–	–	–	–	–
Ophiuroidea	–	–	–	0.4	+
Other Echinodermata	–	–	–	–	–
PISCES	–	0.4	–	1.2	0.1
Gadidae	–	–	–	–	–
Cottidae	–	–	–	–	–
Bothidae	–	–	–	–	–
Other Pisces	–	0.4	–	1.2	0.1
Other groups	–	+	0.3	1.3	2.5
Animal remains	3.9	4.6	5.2	5.4	5.5
Sand and rock	–	–	0.1	0.4	0.3
Number of stomachs	38	94	98	597	338
Percentage of empty stomachs	0.0	37.2	6.1	7.5	6.2
Mean weight per stomach (g)	0.3	0.6	1.0	0.7	0.8
Mean predator length (cm)	30.0	54.5	42.2	43.7	42.6
Number of sampling stations	5	24	19	96	57

Polyphysia crassa (0.3%) and *S. inflatum* (<0.1%); in Western Nova Scotia, *S. inflatum* (0.2%). Other groups of polychaetes were preyed on by Georges Bank witch flounder, but on a comparative basis these were of secondary importance. The Lumbrinereidae, for example, accounted for 5.0% of the diet, with both *Lumbrineris* (0.1%) and *Ninoe* (<0.1%) having been found in the stomach contents. In contrast, in the Gulf of Maine, the Lumbrinereidae were the most important polychaete prey (10.5%), with three species having been identified: *Lumbrineris fragilis* (5.2%), *L. brevipes* (<0.1%), and *Ninoe nigripes* (<0.1%). In Western Nova Scotia, much of the other annelid prey was unidentified (28.7%), and the remainder of the polychaete prey was divided among many of the same taxa as found in the witch flounder stomachs from the other areas. The most important family was, however, the Sternaspidae (5.1%), with *Sternapis scutata* (3.1%) being the single most important species.

All taxa, other than the Annelida, were generally insignificant as witch flounder prey. The only exceptions, apart from the previously described squid predation by Southern New England witch flounder, are the arthropods and echinoderms. In Southern New England, arthropods accounted for 12.1% of the diet, and the most important prey species was the rock crab, *Cancer irroratus* (3.7%). In Western Nova Scotia, arthropods made up 11.4% of the diet, but amphipods were the most important prey in this phylum

(5.7%). The Lysianassidae (1.8%) and amphipod tubes (1.4%) accounted for most of this group. Although unimportant as prey, we recorded one instance of predation on the American lobster, *Homarus americanus* (1.2%), which is interesting to note because of its rarity as prey. The only other taxon of any importance was the echinoderms in Western Nova Scotia (16.3%), where most of this prey group was identified as the sea cucumber, *Stereoderma unisemita* (10.5%).

American plaice.—American plaice were collected for stomach content analysis in four of the five geographic areas (Table 6). In Southern New England the sample size, number of sampling stations, and, more importantly, the total quantity of prey was relatively small so that comparisons between this region and the three other areas may not be very meaningful. In fact, the diet of American plaice in Southern New England differed substantially from the other areas. In contrast to all other areas echinoderms (3.8%) were of little importance while arthropods (57.6%), especially amphipods (38.4%), were preyed on heavily. A large proportion of the amphipod prey was, however, identified as amphipod tubes (26.6%). The other arthropod of importance in the fish stomachs from Southern New England was the sand shrimp, *Crangon septemspinosa* (15.2%), but like the Amphipoda, sand shrimp were also preyed on in other geographic areas and a greater number of stomachs would need to be examined before this relatively high level of predation could be considered unusual. In the three remaining geographic regions the number of fish stomachs examined, the total quantity of prey consumed, and the average size of fish were similar so that a comparison of the diets should reflect true regional differences in feeding.

On Georges Bank echinoderms were the primary prey totalling slightly >90% of the diet. The sand dollar, *Echinarachnius parma,* accounted for 70.3% of this prey group. In the Gulf of Maine and Western Nova Scotia echinoids were also preyed on but to a lesser extent. The echinoid remains from the Gulf of Maine plaice stomachs (7.1%) were not identified below the family level, but in Western Nova Scotia *Echinarachnius parma* (38.4%) was again the single most important prey. Ophiuroids were also an important prey and in all areas the ophiuroid remains were identified to the generic level as *Ophiura* (5.9, 26.7, and 5.6% for Georges Bank, Gulf of Maine, and Western Nova Scotia, respectively) and in each area a percentage of this generic classification was identified to the species level as *O. sarsi* (1.3, 10.7, and 1.5% for the areas as listed above).

Arthropods were generally the second major taxon preyed on by American plaice in all three geographic regions. In all areas the Pandalidae were of primary importance. Both *Dichelopandalus leptocerus* and *Pandalus* were identified in the stomach contents. On Georges Bank *D. leptocerus* (1.5%) was more important than *Pandalus* but in the Gulf of Maine the reverse was true [*Pandalus* (4.3%) vs. *D. leptocerus* (1.8%)]. In Western Nova Scotia both were preyed on equally (2.0% vs. 2.3%). In Western Nova Scotia the Euphausiacea contributed slightly more to the diet than the Pandalidae (6.3% vs. 5.7%, respectively) and virtually all the euphausiids were identified as *Meganyctiphanes norvegica* (6.2%). In two of the areas, Georges Bank and Western Nova Scotia, the only other important arthropod family was the Paguridae. In both regions *Pagurus acadianus* (Georges Bank 2.4% and Western Nova Scotia 16.7%) was the primary species but on Georges Bank *P. pubescens* (0.1%) was also identified in the stomach contents.

Table 6.—Geographic breakdown of the stomach contents of American plaice, *Hippoglossoides platessoides*, in the northwest Atlantic. Data are expressed as a percentage weight for fish collected during the spring and autumn bottom trawl survey cruises, 1969-72. (+ indicates present but <0.1%.)

Prey	Southern New England	Georges Bank	Gulf of Maine	Western Nova Scotia
CNIDARIA	–	+	0.5	0.3
Hydrozoa	–	+	0.4	–
Anthozoa	–	–	0.1	0.3
Other Cnidaria	–	–	–	–
ANNELIDA	18.2	0.4	9.5	3.9
Nephthyidae	–	–	1.0	+
Maldanidae	–	–	0.1	+
Lumbreneridae	–	–	0.5	–
Ampharetidae	–	–	1.2	+
Terebellidae	–	–	0.1	–
Sabellidae	0.2	0.2	0.8	0.9
Other Annelida	18.0	0.2	5.8	3.0
ARTHROPODA	57.6	7.0	12.5	30.2
Cumacea	+	–	–	–
Amphipoda	38.4	0.2	0.1	0.2
Mysidacea	1.0	0.1	0.1	–
Euphausiacea	2.8	+	0.3	6.3
Pandalidae	–	2.8	6.6	5.7
Crangonidae	15.2	0.9	+	–
Axiidae	–	–	–	–
Paguridae	0.2	2.6	0.2	16.9
Majidae	–	–	–	–
Cancridae	–	–	–	–
Other Decapoda	–	0.2	0.3	1.1
Other Arthropoda	–	0.2	4.9	+
MOLLUSCA	10.6	0.3	22.6	1.3
Gastropoda	–	0.1	+	1.0
Bivalvia	10.6	+	22.3	0.2
Cephalopoda	–	0.1	–	+
Other Mollusca	–	0.1	0.3	0.1
ECHINODERMATA	3.8	90.7	45.9	55.3
Holothuroidea	–	–	–	–
Echinoidea	–	72.2	7.1	43.4
Ophiuroidea	3.8	18.5	38.8	11.9
Other Echinodermata	–	–	+	–
PISCES	–	0.3	2.2	0.6
Gadidae	–	–	–	0.2
Cottidae	–	–	0.5	–
Bothidae	–	–	–	–
Other Pisces	–	0.3	1.7	0.4
Other groups	2.8	0.1	1.7	0.2
Animal remains	7.0	1.2	4.2	3.1
Sand and rock	–	+	0.9	5.1
Number of stomachs	31	287	562	306
Percentage of empty stomachs	58.1	48.4	35.2	40.9
Mean weight per stomach (g)	0.3	1.9	0.7	1.8
Mean predator length (cm)	28	32.8	27.5	25.2
Number of sampling stations	8	54	72	53

Other taxa were generally of relatively minor importance as prey except in the Gulf of Maine where both Mollusca (22.6%) and Annelida (9.5%) contributed significantly to the diet. The Bivalvia were the most important class of molluscs (22.3%) and *Yolida* (11.2%) and *Chlamys islandica* (4.1%) were the primary prey within the class. Most of the annelids were identified as either polychaete tubes (2.6%) or annelid remains (1.8%) but the single most important family was the Ampharetidae (1.2%) and the two species identified within this family were *Ampharete acutifrons* (<0.1%) and *Melinna cristata* (1.0%).

Yellowtail founder.—Yellowtail flounder were collected for stomach contents analysis in reasonably large numbers from all

Table 7.—Geographic breakdown of the stomach contents of yellowtail flounder, *Limanda ferruginea*, in the northwest Atlantic. Data are expressed as a percentage weight for fish collected during the spring and autumn bottom trawl survey cruises, 1969-72. (+ indicates present but < 0.1%.)

Prey	Middle Atlantic	Southern New England	Georges Bank	Gulf of Maine	Western Nova Scotia
CNIDARIA	0.7	0.2	10.3	1.9	6.3
Hydrozoa	+	+	–	–	–
Anthozoa	0.7	0.2	10.3	1.9	6.3
Other Cnidaria	–	–	–	–	–
ANNELIDA	44.0	34.5	47.2	27.7	81.1
Nephthyidae	1.2	1.8	+	0.4	–
Maldanidae	0.3	0.3	0.9	0.3	0.1
Lumbreneridae	2.1	1.0	1.4	+	–
Ampharetidae	0.1	0.1	–	–	1.0
Terebellidae	–	+	–	+	1.3
Sabellidae	0.7	0.7	0.3	3.5	3.0
Other Annelida	39.6	30.6	44.6	23.5	75.7
ARTHROPODA	32.0	46.3	32.3	27.7	7.7
Cumacea	0.7	0.6	0.1	–	–
Amphipoda	21.4	41.1	28.0	26.3	7.4
Mysidacea	0.9	+	+	–	–
Euphausiacea	0.1	+	–	–	–
Pandalidae	0.4	1.4	0.1	–	–
Crangonidae	0.3	0.4	1.4	–	+
Axiidae	+	–	–	–	–
Paguridae	+	+	0.7	–	0.2
Majidae	–	+	–	–	–
Cancridae	6.7	1.2	+	0.1	–
Other Decapoda	0.2	0.5	0.7	1.0	+
Other Arthropoda	1.3	1.1	1.3	0.3	0.1
MOLLUSCA	4.0	1.6	1.5	0.2	–
Gastropoda	1.5	0.2	0.2	–	–
Bivalvia	1.4	1.2	1.2	0.2	–
Cephalopoda	–	–	–	–	–
Other Mollusca	1.1	0.2	0.1	–	–
ECHINODERMATA	3.1	2.1	2.3	21.0	0.2
Holothuroidea	0.6	0.2	0.3	20.9	0.1
Echinoidea	2.5	1.9	2.0	0.1	+
Ophiuroidea	+	+	+	–	0.1
Other Echinodermata	–	+	+	–	–
PISCES	2.6	0.3	0.1	–	0.4
Gadidae	–	–	–	–	–
Cottidae	2.3	–	–	–	–
Bothidae	–	–	–	–	–
Other Pisces	0.3	0.3	0.1	–	0.4
Other groups	4.9	5.2	0.4	7.5	0.1
Animal remains	5.6	8.3	2.1	4.9	3.3
Sand and rock	3.1	1.5	3.8	9.1	0.9
Number of stomachs	464	1,415	652	44	70
Percentage of empty stomachs	12.7	21.4	25.7	29.6	40.0
Mean weight per stomach (g)	0.7	0.5	0.5	0.9	1.2
Mean predator length (cm)	29.1	29.5	29.9	28.6	25.3
Number of sampling stations	33	86	54	12	15

five geographic areas (Table 7). The smallest sample number for any one area was 44 fish collected from 12 different stations. Since the average fish size was also similar between areas, the geographic comparisons should reflect true differences in the prey of the fish from the different regions.

In all five geographic areas, either annelids or arthropods were the primary prey of yellowtail flounder. In four of the areas, annelids were equal to or at least marginally more important as prey than arthropods. Annelids accounted for the majority of all prey consumed in Western Nova Scotia (81.1%). A single genus, *Eunice*, accounted for two-thirds of the diet alone (66.8%), while no eunicids were eaten in any of the other four regions. The majority of the other annelid prey in Western Nova Scotia were either unidentifiable remains (6.8%) or identified at a family level as belonging to the Sabellidae (3.0%) or Terebellidae (1.3%). In the four remaining regions, no single genus or species accounted for a very large percentage of the prey. In fact, a large percentage of the annelids could not be identified to below phylum. For example, on Georges Bank 40.4% of the annelids were unidentified, and in the other areas 23.2, 22.9, and 21.8% were unidentified because of their stage of digestion in the stomachs of fish from the Gulf of Maine, Southern New England, and the Middle Atlantic, respectively. The polychaete prey that could be identified were: Middle Atlantic—Spionidae (8.6%) [*Polydora* (7.3%)], polychaete tubes (4.1%), *Lumbrineris* (1.3%), *Nephthys* (1.1%); Southern New England—*Nereis* (3.0%), *Nephthys* (1.7%), *Aphrodita hastata* (1.0%); Georges Bank—Spionidae (1.1%), *Lumbrineris* (1.4%); Gulf of Maine—*Potamilla neglecta* (2.6%).

Arthropods contributed from 7.7 to 46.3% of the diet depending on the geographic area, but in all cases amphipods were the most important category of crustaceans. Amphipod tubes accounted for a fair percentage of this prey group in four of the five areas: Southern New England (20.3%), Georges Bank (18.6%), Gulf of Maine (13.8%), Middle Atlantic (7.9%), and Western Nova Scotia (0.7%). The Corophiidae and the Gammaridae were the most important families of amphipod prey in all areas. In three areas, the Gammaridae were more important than the Corophiidae, 9.1% vs. 6.0%, 8.7% vs. 2.5%, 6.1% vs. 3.1% for Southern New England, the Middle Atlantic, and Georges Bank, respectively. In the Gulf of Maine, corophiids (10.3%), especially *Unciola* (8.8%), were preyed on more heavily than the Gammaridae (1.0%), and in Western Nova Scotia the Lysianassidae (3.6%) were more important than the Corophiidae (2.5%).

Other major taxa were of secondary importance in the yellowtail diet when compared with the annelids and arthropods. In certain geographic areas, however, specific taxa contributed significantly to the diet. For example, in the Gulf of Maine, 21.0% of the stomach contents were identified as echinoderms, and the sea cucumber, *Stereoderma unisemita*, accounted for almost all (20.9%) of these remains. *Stereoderma unisemita* (0.1%) were also preyed on in Western Nova Scotia, but in the remaining three areas, Middle Atlantic, Georges Bank, and Southern New England, the sand dollar, *Echinarachnius parma*, was the most important echinoderm prey (2.5, 1.8, 1.5%, respectively). Like echinoderms, Cnidaria were important prey in one or two of the areas. On Georges Bank, actinarians (5.2%) and the ceriantharians (5.1%) [*Cerianthus* (3.4%)] were members of the two orders of coelenterate prey identified. In Western Nova Scotia, the Actinaria (5.1%) again accounted for a majority of the coelenterates eaten. Among the "Other Groups" category, the Ascidiacea was the taxon that made the largest contribution. In the Gulf of Maine, *Cnemidocarpa* (6.5%) accounted for most of the prey in this class, and in Southern New England *Cnemidocarpa* (0.1%) and *Mogula* (1.2%) were identified among the ascidian remains (3.4%). In the Middle Atlantic (1.5%) and on Georges Bank (1.2%), ascidians were also preyed on, but none were identifiable below the class level. Pisces were of very little importance as prey in any of the areas, although in the Middle Atlantic an unidentified cottid (2.4%) and a shanny, *Lumpenus maculatus* (0.1%), were found in the stomach contents.

Winter Flounder.—When all five geographic areas are considered together (Table 8), the prey of winter flounder is generally divided among three taxa: Annelida, Cnidaria, and Mollusca. On a regional basis, however, the diet is quite variable, with different taxa being important in the different areas even when the average fish length is similar. These differences may be a reflection of regional changes in feeding activity or at least prey availability and are therefore discussed below.

Winter flounder collected in the Middle Atlantic preyed heavily on Cnidaria (52.8%). Most of the cnidarians were identified to the order level as Actinaria (48.8%) or Ceriantharia (1.0%), although a small percentage were placed in the class Hydrozoa (3.0%). In the other geographic areas, most of the cnidarians were also identifiable at the order level. On Georges Bank, for example, where 30.4% of the diet was coelenterates, the cnidarian prey were identified as Actinaria (16.1%), Ceriantharia (0.4%), or as unidentified Anthozoa (8.3%) or Hydrozoa (5.7%). In Western Nova Scotia, the anthozoan prey were again broken down into Ceriantharia (9.3%) and Actinaria (3.1%), while in Southern New England the Ceriantharia (9.9%) was the only representative of this class.

Annelids were a major prey in all of the geographic areas, accounting for 15 to 60% of the diet in any one area. In the Middle Atlantic, 44.1% of the diet was annelids and most of these were identified only at the phylum level (36.2%). In the other regions, the greater proportion of the annelids could usually be identified from the partially digested remains although a percentage were always only recognizable at the phylum level: Gulf of Maine (23.3%), Southern New England (7.7%), and Georges Bank (5.7%). Three groups of annelids were identified in the stomachs of winter flounder from the Middle Atlantic. The Goniadidae accounted for 3.7% of the diet, and the two polychaetes identified at a generic level were *Lumbrineris* (2.1%) and *Nereis* (2.1%). *Lumbrineris* (1.1%) was also identified in flounder stomachs from Southern New England, and *Nereis* made up 2.3% of the diet of the fish from the Gulf of Maine, although small quantities of these genera of polychaetes were also found in the stomachs from all other areas. Representatives of the Goniadidae were found in the winter flounder stomachs from Southern New England, *Ophioglycera gigantea* (8.2%), and in the Gulf of Maine, *Goniada* (8.4%) [*Goniada norvegica* (4.6%)]. In Southern New England, several other taxa of polychaetes were important prey: unidentified Sabellidae (5.6%) and Ophellidae (3.3%), *Ninoe* (3.2%), *Nephthys incisa* (2.9%), and *Nicolea venustula* (1.7%). A variety of polychaetes were identified in the winter flounder stomachs from Georges Bank, but only one, *Ampharete*, made up at least 1.0% of the diet. In the Gulf of Maine, the Terebellidae (10.2%), especially *Thelepus cincinnatus* (3.4%), were important prey, together with *Polydora ciliata* (1.8%), *Eteone* (1.4%), and polychaete tubes (8.4%). The Terebellidae (37.6%), particularly *Thelepus cincinnatus* (32.2%), were again important prey in Western Nova Scotia, as were *Nicomache lumbricalis* (3.9%), *Pherusa* (2.2%), *Chone infundibuliformis* (1.1%), and polychaete tubes (2.0%).

None of the other taxonomic groups were important in all the geographic areas, although in any particular area molluscs, echinoderms, or arthropods were an important prey category. On Georges Bank, for example, bivalve molluscs accounted for 20.4% of the diet, but, unfortunately, 19.4% of these could only be identified at the class level. Bivalves were important in three other areas also (Table 8), but most of them were not identifiable below class. In Southern New England, echinoderms were of secondary importance, and this was primarily due to predation on the sea cucumber, *Stereoderma unisemita* (5.4%). Arthropods accounted for no more than 13% of the diet in any area, and in Southern New England, where they were preyed on most heavily, the rock crab, *Cancer irroratus* (7.8%) and the caprellid, *Aeginina longicornis* (1.3%), were the two important prey species. Arthropods were generally not very important in the other areas, except in Western Nova Scotia, where amphipods (7.6%) were preyed on and in particular the caprellid, *A. longicornis* (2.4%), and the gammarid, *Leptocheirus pinguis* (1.8%).

DISCUSSION

Food

Gulf Stream flounder.—The authors know of no published reports on the food of the Gulf Stream flounder, *Citharichthys*

Table 8.—Geographic breakdown of the stomach contents of winter flounder, *Pseudopleuronectes americanus*, in the northwest Atlantic. Data are expressed as a percentage weight for fish collected during the spring and autumn bottom trawl survey cruises, 1969-72. (+ indicates present but < 0.1%.)

Prey	Middle Atlantic	Southern New England	Georges Bank	Gulf of Maine	Western Nova Scotia
CNIDARIA	52.8	10.1	30.4	0.4	17.4
Hydrozoa	3.0	0.2	5.7	0.2	0.8
Anthozoa	49.8	9.9	24.7	0.2	16.6
Other Cnidaria	–	–	–	–	–
ANNELIDA	44.1	38.6	15.1	60.5	55.8
Nephthyidae	–	2.9	+	–	0.2
Maldanidae	–	0.2	0.1	0.6	4.2
Lumbreneridae	2.1	4.3	0.1	0.5	0.1
Ampharetidae	–	0.1	1.0	0.5	0.5
Terebellidae	–	1.9	1.4	10.2	37.6
Sabellidae	–	6.1	0.6	1.1	2.7
Other Annelida	42.0	23.1	11.9	47.6	10.5
ARTHROPODA	2.2	13.0	3.9	1.9	9.0
Cumacea	–	+	–	–	+
Amphipoda	1.3	3.6	2.0	1.2	7.6
Mysidacea	–	–	–	–	–
Euphausiacea	–	–	–	–	+
Pandalidae	+	0.1	0.1	0.7	+
Crangonidae	0.1	–	0.1	–	+
Axiidae	–	+	–	–	–
Paguridae	–	–	0.1	+	0.5
Majidae	–	+	0.1	–	–
Cancridae	0.4	7.8	0.2	–	–
Other Decapoda	0.4	+	0.1	–	+
Other Arthropoda	–	1.5	1.2	+	0.9
MOLLUSCA	–	12.5	20.4	4.8	4.3
Gastropoda	–	+	0.1	–	1.1
Bivalvia	–	12.5	20.3	4.8	2.8
Cephalopoda	–	–	–	–	+
Other Mollusca	–	+	+	–	0.4
ECHINODERMATA	–	7.4	0.5	0.1	0.7
Holothuroidea	–	5.4	0.3	–	0.2
Echinoidea	–	0.1	0.1	–	0.5
Ophiuroidea	–	+	0.1	0.1	–
Other Echinodermata	–	1.9	+	–	–
PISCES	+	0.3	0.1	0.5	0.2
Gadidae	–	–	–	–	–
Cottidae	–	–	–	–	–
Bothidae	–	–	–	–	–
Other Pisces	+	0.3	0.1	0.5	0.2
Other groups	0.3	6.1	2.6	4.0	7.7
Animal remains	0.4	8.9	20.4	27.6	3.7
Sand and rock	0.2	3.1	6.6	0.2	1.2
Number of stomachs	46	154	321	120	128
Percentage of empty stomachs	23.9	64.3	35.5	37.5	10.9
Mean weight per stomach (g)	0.6	0.4	1.9	0.2	1.5
Mean predator length (cm)	28.3	29.3	39.4	33.7	38.4
Number of sampling stations	7	19	38	14	17

arctifrons, but there are some data on two congeneric species, the bay whiff, *C. spilopterus*, and Pacific sand dab, *C. sordidus*. The bay whiff occurs along the Atlantic coast, and in a study of the food of Georgia estuarine fishes Stickney et al. (1974) found that the diet of this species was dominated by the mysid, *Neomysis americana*, for fish from 5.0 to 12.4 cm standard length, while the penaeid shrimp, *Trachypeneus constrictus*, was the major prey for fish between 12.5 and 14.9 cm. The Pacific sand dab, off the Oregon coast, was found to be a pelagic-feeding type, preying on the northern anchovy, *Engaulis mordax*, euphausiids, shrimp, amphipods, and crab larvae (Pearcy and Vanderploeg 1973; Kravitz et al. 1976; Pearcy and Hancock 1978). The diet of the Gulf Stream flounder in the northwest Atlantic is different from its congenerics. Annelids and arthropods were of about equal importance in the diet (Table 1), while neither the bay whiff nor the Pacific sand dab were found to prey on annelids to any great extent (see Pearcy and Hancock 1978). Furthermore, within the Arthropoda, mysids were noticeably unimportant, which is in sharp contrast to the report of Stickney et al. (1974) for *C. spilopterus*. Pearcy and Hancock's (1978) description of *C. sordidus* as a strictly pelagic-feeding type is not applicable to *C. arctifrons*. Although the Gulf Stream flounder feeds on some pelagic prey, benthic invertebrates account for a very large part of its diet and this species of *Citharichthys* has to be considered more of a benthic or bentho-pelagic feeder.

Summer flounder.—Bigelow and Schroeder (1953) described the fluke or summer flounder as spending most of its life on the bottom, but they also describe it as a swift swimmer and very fierce and active in the pursuit of prey. They reported that fluke will readily chase prey fish to the water's surface. In a more recent publication, Olla et al. (1972) confirmed this type of feeding behavior based on aquarium observations, noting that the fish can feed as easily on the b .tc a in the water column. The various reports, and our limited data, on the stomach contents of summer flounder corroborate these observations. Ginsberg (1952) and Bigelow and Schroeder (1953), for example, noted that the prey of fluke was smaller fish, squid, crabs, shrimp, other crustaceans, molluscs, worms, and sand dollars. Poole (1964, 1966) also cited many of the same types of prey for summer flounder collected from the Great South Bay, N.Y. In Poole's 1964 report the prey were identified to species and, on a weight basis, *Neomysis americana* was the major prey. Mysids were followed in importance by three species of fish: *Synagnathus fuscus*, *Brevoortia tyrannus*, and *Anchoa mitchilli*. Other fish, molluscs, and crustaceans made up the remainder of the diet. In Magothy Bay, Va., Kimmel (1973) also found that the mysid, *Neomysis americana*, was the major prey for summer flounder ranging in standard length from 4.2 to 47.6 cm. In another study conducted by Milstein et al[4] off the New Jersey Coast, the sand shrimp, *Crangon septemspinosa*, ranked first in importance as a percentage of the total prey volume in the stomachs of summer flounder. Unidentified fish remains ranked second, *Anchoa mitchilli* was third, and *Neomysis americana*, fourth. The diets of three size classes of flounder were also compared (0–20 cm, 20–30 cm, and 30+ cm), and it was found that there was a size related shift in diet such that more fish and less invertebrates were consumed as the fluke increased in size. They also observed a higher percentage of empty stomachs (33%) in the larger fish. Our data, although limited to the prey of eight fish because of the high percentage of empty stomachs (Table 1), is for fish which on the average fall in the largest of the three size categories mentioned above. It is not surprising, therefore, that fish and squid were the major prey. A more extensive survey of summer flounder would no doubt show that their diet and habits are similar to those described in the various extant published reports.

Fourspot flounder.—The fourspot flounder is similar in its general appearance to the summer flounder, although it is a much smaller fish. Their diets are also reported to be similar and consist of small fish and squid, crabs, shrimps, bivalves, and worms (Bigelow and Schroeder 1953). Other published data on its feeding habits are rare. Sumner et al. (1913 a,b) listed the food of the fourspot flounder around Woods Hole as consisting of shrimps, amphipods, small crabs (*Cancer*), annelids, molluscs, small crustaceans, and small fish. De Sylva et al. (1962) examined the stomachs of eight fourspot flounder from the Delaware River estuary and found that five of the stomachs contained *Crangon*; two, *Neomysis*; and one, empty. Our data were based on the examination of 1,096 stomachs from 98 stastions and gave more details of the prey of this fish than those of previous reports. Arthropods, fish, and molluscs were the three major taxa preyed upon (Table 1). Pandalid shrimp, particularly *Dichelopandalus leptocerus*, was of major importance within the Arthropoda as were the decapod crabs in the family Cancridae. Gadids such as *Merluccius bilinearis* were the primary fish prey, and the cephalopod squid were the only molluscan group of any significance in the diet.

Windowpane.—Moore (1947) carried out an extensive study on various aspects of the life history of windowpane. She reviewed much of the earlier literature on the food of windowpane and also conducted some additional stomach contents analyses herself. The reports reviewed by Moore note the occurrence of fish and invertebrates, particularly mysids, in the stomachs. Moore's own quantitative analyses showed that a single species of mysid, *Neomysis americana*, was the predominant prey throughout the year in Southern New England. Sand shrimp (*Crangon septemspinosa*?) were second in importance, and fish were quite unimportant. One interesting exception to this general pattern was the occurrence of large numbers of chaetognaths (*Sagitta elegans*) in the stomachs of windowpane collected from deep water in one sample taken in February. Bigelow and Schroeder (1953) also reviewed the earlier published reports on the windowpane's dietary habits, noting the occurrence of invertebrates and fish in the stomachs. They went on to state that they suspected that small fish would be readily preyed upon whenever available, which is in contrast to Moore's observation. More recent papers by de Silva et al. (1962), Richards (1963), Kimmel (1973), Stickney et al. (1974), and Hickey (1975) support the conclusions of both Moore and Bigelow and Schroeder. All of these papers concluded that mysids, *Neomysis americana*, were a major prey, with *Crangon septemspinosa* usually being of secondary importance. Furthermore, Hickey (1975) discussed the diet of *S. aquosus* in relation to predator size and described a shift in diet from exclusively small crustaceans to small crustaceans, fish, and decapods with an increase in predator size. Our data (Tables 1, 4) are in agreement with these reports. Throughout the northwest Atlantic, we found that mysids, *Neomysis americana*, were a major prey. Only on Georges Bank were mysids second in importance in the diet, and here *Crangon septemspinosa* was the major prey. In addition to these two species, pandalid shrimp also contributed significantly to the diet. Overall, pandalids were slightly more important than sand shrimp (Table 1), but they were particularly important in Southern New England (Table 4). Fish were generally of minor importance but did account for > 10% of the diet on Georges Bank (Table 4). Our data support the conclusion of Hickey (1975), which was that windowpane are capable of feeding on a variety of swift-moving prey and quailify as an opportunistic first-level carnivore.

Witch flounder.—The witch flounder is a smallmouthed pleuronectid that occurs on both sides of the northern Atlantic Ocean in rather deep water. The food of witch flounder from the United States and Canadian coasts has been described by Bigelow and Schroeder (1953), Leim and Scott (1966), and Scott (1975). All of these reports list polychaete worms and small crustaceans as the major prey, although molluscs and fish also occurred in the stomachs. Rae (1969) conducted the most complete study of the witch flounder's dietary habits off Scotland from the Icelandic grounds. Like the United States and Canadian stocks, polychaete worms were the major prey group, providing more than half the diet on a volumetric basis. Rae also observed a slight shift in diet with a change in fish size. Crustaceans, particularly amphipods and cumaceans, occurred more frequently in the stomachs of the smaller fish (11-20 cm) than polychaetes, yet for all other size groups, up to 50

[4]Milstein, C. B., D. L. Thomas, and Associates. 1976. Ecological studies in the bays and other waterways near Little Egg Inlet and in the ocean in the vicinity of the proposed site for the Atlantic Generating Station, New Jersey. Progress report for the period January–December 1975, 572 p. Prepared for the Public Service Electric and Gas Company by Ichthyological Associates, Inc., 301 Forest Drive, Ithaca, NY 14850.

cm, the reverse was found to be true. Our data from the northwest Atlantic are very similar to Rae's (1969). Annelids accounted for almost three-quarters of the diet overall, and on a regional basis they constituted up to 80-90% of the prey (Tables 1, 5). Other groups such as echinoderms, arthropods, and molluscs made up the remainder of the diet. Although there are regional differences in diet, presumably due to differing environmental conditions and species availability, the food habits of the witch flounder are reasonably constant throughout its geographic range.

American plaice.—Information on the food of *Hippoglossoides platessoides* was first published by Huntsman (1918). He stated that once the young plaice take up a bottom mode of living, they eat small crustaceans such as amphipods and cumaceans as well as small worms. As they grow, Huntsman observed a size-related shift in the fishes' diet with the larger plaice preying very heavily on echinoderms, in particular, sand dollars, sea urchins, and serpent stars. In addition, he found a variety of other crustaceans, worms, and clams in the stomachs but very few fish. Powles (1965) examined the stomachs of American plaice taken from the Magdalen Shallow area in the southwestern part of the Gulf of St. Lawrence. Plaice >30 cm TL (total length) were found to feed more frequently on mysids, amphipods, small echinoderms, and annelids than other types of prey, while larger plaice (>30 cm TL) fed on echinoderms and bivalves. Pitt (1973), in an extensive study of Grand Bank American plaice food (International Commission for the Northwest Atlantic Fisheries, Divisions 3L and 3N), found that, overall, echinoderms were the principal prey, especially brittle stars, *Ophiura sarsi* and *O. robusta*; sand dollars, *Echinarachnius parma*; and sea urchins, *Strongylocentrotus droebachiensis*. Other prey included representatives of most crustacean forms, polychaetes, molluscs, and fish. Pitt, like Powles and Huntsman, found a size-related shift in predation. Our data on American plaice food (Table 1) from farther south in the northwest Atlantic are similar to the above reports. Echinoderms such as sand dollars, brittle stars, and sea urchins were the major prey. Our data is not broken down into size classes but instead is a subsample of the entire plaice survey catch. The average fish size was, however, around 30 cm in all the geographic areas where fish were collected (Table 6), and according to Pitt's data, at this size the most noticeable shift in diet begins to show up. For Grand Banks plaice >30 cm in length, fish became an increasingly important prey. We did not find fish to be important at all in the American plaice we examined, and this may be due to the relatively small average size for the entire population within our survey area (Fig. 1). In all other respects, the diet of American plaice off the U.S. coast is very similar to its Canadian counterpart, preying heavily on echinoderms and to a lesser degree on arthropods and molluscs.

Yellowtail flounder.—Although yellowtail flounder are of commercial importance, their feeding habits have been little studied. Sumner et al. (1913 a,b) in a survey of the fauna of Woods Hole, Mass., described the stomach contents of yellowtail flounder as containing enormous numbers of Crustacea, especially amphipods, shrimp, mysids, and small crabs. The two crustacean genera they listed are *Caprella* and *Squilla*. In addition to the Crustacea, they also found annelids, bivalve and univalve molluscs, and small fishes. Bigelow and Schroeder (1953) also described the diet of yellowtail flounder as consisting mainly of the above-mentioned items. More recently, there have been several papers which quantitatively describe the food of yellowtail flounder for Southern New England, Georges Bank, and the Canadian Grand Banks (Efanov and Vinogradov 1973; Pitt 1976; Bowman and Langton 1978). In these three areas, as in the five geographic areas we investigated (Table 7), arthropods and annelids were the major prey. From our data and the published reports on the food of the northwest Atlantic yellowtail flounder stocks, one can conclude that this species is exclusively a benthic predator with similar food habits throughout its geographic range.

Winter flounder.—Winter flounder is an omnivorous fish whose feeding behavior and food have been studied extensively. Much of the data have been summarized by Klein-MacPhee (1978) in a synopsis of the biological data on this species. As far as the food of winter flounder is concerned, the most extensive studies are those of Linton (1921), Pearcy (1962), Richards (1963), Mulkana (1966), MacPhee (1969), Kennedy and Steele (1971), Tyler (1972), Wells et al. (1973), and Frame (1974). Both MacPhee (1969) and Frame (1974) have shown that the diet of winter flounder reflects the environmental conditions under which the fish lives, and this may explain some of the variation in the published data on its diet. Nevertheless, based on the prey lists from the above-mentioned papers, it is clear that this flounder is a bottom-feeding fish, usually relying heavily on polychaete worms, bivalve molluscs, and crustaceans as food. It is also interesting to note that because of its habit of feeding in the intertidal zone, algae have been found in the stomach contents, and it has been postulated that the fish may be using plants as a food source (MacPhee 1969; Kennedy and Steele 1971; Wells et al. 1973). Our data are for offshore fish and, consequently, plants contributed an insignificant quantity to the diet, but many of the other taxa listed in the papers mentioned above, especially annelids and molluscs, were found to be important prey groups. In addition to annelids and molluscs, however, the Cnidaria also contributed substantially to the diet (Table 1). The occurrence of coelenterates in the diet is widespread, as they occurred in the diet in significant quantities (up to 53% of the diet in the Middle Atlantic) in four out of five of the geographic areas surveyed (Table 8) and therefore must be considered a normal prey item of offshore winter flounder.

Species Comparisons

In comparing the prey of the flatfish populations described in this paper, and considering only phyla that account for >10% of the diet, there are five arthropod, four annelid, three molluscan, two fish, one echinoderm, and one coelenterate predators.

Arthropods were a major dietary component of five of the flatfish species examined (Table 1). Arthropods accounted for 86.8% of the diet of windowpane, 42.2% of the Gulf Stream flounder's diet, 40.7% of the fourspot flounder's diet, 37.2% of the yellowtail flounder's diet, and 16.0% of the American plaice's diet (Table 1). Two of these arthropod predators preyed on pandalid shrimp: the windowpane (22.4%) and fourspot flounder (15.8%). The windowpane, however, relied heavily on mysids (41.8%) but also preyed on the Crangonidae (18.4%), while the fourspot flounder consumed a variety of arthropods, including brachyurans and other caridians. Only two species of fish relied on the same arthropod group as prey. Both the yellowtail and Gulf Stream flounders preyed on amphipods, 31.4 and 24.2%, respectively.

Annelids were the major prey of witch flounder (72.8%) and also accounted for approximately half the diet of Gulf Stream (51.2%) and yellowtail flounders (42.0%) and one-quarter of the diet of winter flounder (26.6%) (Table 1). For all these predators, the annelid prey was represented by a number of different families, and, in all but one instance, none of the families individually added up to >10% of the diet. Only the Nephthyidae accounted for a high percentage of any of the predators' diets; 24.9% of the diet of Gulf Stream flounder. Much of the annelid remains were unidentified, and so it is difficult to conclude if any of the four flatfish are relying on the same specific annelid prey.

Molluscs were the major prey of three of the eight flatfish (Table 1). Cephalopods were a major component of the prey of summer flounder (51.0%) and fourspot flounder (19.3%), and bivalves accounted for 15.3% of the diet of winter flounder. The cephalopods found in the stomachs of summer and fourspot flounder were all squids, and both fish shared the same genus, *Loligo*, as prey.

Pisces were important prey for two of the species under consideration. Summer flounder preyed heavily on fish (47.8%) and particularly the gadid *Merluccius bilinearis* (26.1%). This dependence on silver hake, however, may be slightly overemphasized because of the small number of fish stomachs examined. Nevertheless, the fourspot flounder also preyed on fish (28.5%), and, in this case, silver hake were a legitimate prey item (21.0%) together with several other species of fish.

Echinoderms were preyed on extensively by American plaice (Table 1). As a major phylum, this taxon is noteworthy as being of very little significance as prey of other flatfish. Apart from American plaice, only witch flounder had >5% of its diet represented by echinoderms, and most of these were holothuroideans rather than the echinoids and ophiuroids preyed on by the plaice.

The Cnidaria are the only other taxa that can be considered as major prey, and, like the echinoderms only one of the eight potential predators, the winter flounder, consumed a significant quantity of these animals (Table 1).

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