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An Overview and History of the Food Web Dynamics Program of the Northeast Fisheries Science Center, Woods Hole, Massachusetts

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[a]Robins, C.R. (chair); Bailey, R.M.; Bond, C.E.; Brooker, J.R.; Lachner, E.A.; Lea, R.N.; Scott, W.B. 1991. Common and scientific names of fishes from the United States and Canada. 5th ed. *Amer. Fish. Soc. Spec. Publ.* 20; 183 p.

[b]Turgeon, D.D. (chair); Quinn, J.F., Jr.; Bogan, A.E.; Coan, E.V.; Hochberg, F.G.; Lyons, W.G.; Mikkelsen, P.M.; Neves, R.J.; Roper, C.F.E.; Rosenberg, G.; Roth, B.; Scheltema, A.; Thompson, F.G.; Vecchione, M.; Williams, J.D. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: mollusks. 2nd ed. *Amer. Fish. Soc. Spec. Publ.* 26; 526 p.

[c]Williams, A.B. (chair); Abele, L.G.; Felder, D.L.; Hobbs, H.H., Jr.; Manning, R.B.; McLaughlin, P.A.; Pérez Farfante, I. 1989. Common and scientific names of aquatic invertebrates from the United States and Canada: decapod crustaceans. *Amer. Fish. Soc. Spec. Publ.* 17; 77 p.

[d]Rice, D.W. 1998. Marine mammals of the world: systematics and distribution. *Soc. Mar. Mammal. Spec. Publ.* 4; 231 p.

[e]Cooper, J.A.; Chapleau, F. 1998. Monophyly and interrelationships of the family Pleuronectidae (Pleuronectiformes), with a revised classification. *Fish. Bull. (U.S.)* 96:686-726.

[f]McEachran, J.D.; Dunn, K.A. 1998. Phylogenetic analysis of skates, a morphologically conservative clade of elasmobranchs (Chondrichthyes: Rajidae). *Copeia* 1998(2):271-290.

[g]ISO [International Organization for Standardization]. 1981. ISO standards handbook 3: statistical methods. 2nd ed. Geneva, Switzerland: ISO.

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Acronyms

BEP = Benthic Ecology Program (predecessor to the FEP)
EMI = Ecosystem Modeling Investigation
FCDI = Food Chain Dynamics Investigation (predecessor to the FWDP)
FEP = Feeding Ecology Project (predecessor to the FCDI)
FWDP = Food Web Dynamics Program
GLOBEC = (U.S.) Global Ocean Ecosystems Dynamics Program
NEFC = Northeast Fisheries Center (predecessor to the NEFSC)
NEFSC = Northeast Fisheries Science Center
NMFS = National Marine Fisheries Service
YOY = young of the year

Abstract

We provide an overview of the National Marine Fisheries Service (NMFS), Northeast Fisheries Science Center (NEFSC), Food Web Dynamics Program (FWDP). The FWDP's food habits database is one of the largest in the world and extends from 1973 to present. This database covers the entire Northeast U.S. Continental Shelf Ecosystem and has over 250,000 stomachs from more than 120 predators, with more than 1,200 different types of prey collected. We discuss the differences in sampling protocols and priorities over the history of the program, and address issues of time-series continuity. For most species, diet can be adequately characterized with an examination of 500-1,000 stomachs. The basic diet composition for 38 predators, including economically and ecologically important species, demonstrates that most members of the fish community of this ecosystem are generalists, exhibiting a broad diet as either a benthivore, planktivore, or piscivore. Many major ecosystem and multispecies issues in fisheries management can only be addressed with a knowledge derived from food habits data such as those described in this document.

INTRODUCTION

As the history of the fishes themselves would not be complete without a thorough knowledge of their associates in the sea, especially such as prey upon them or in turn constitute their food, it was considered necessary to prosecute searching inquiries on these points....

Spencer Baird (1873)

In his seminal report to Congress published in 1873, Baird called for a research program to explore five potential causes of declines in fish stocks in Southern New England waters, and thereby established the precursors to the Woods Hole scientific community and NMFS. Two of the five major causes proposed by Baird consider trophic dynamics.

The research objectives of the FWDP are to: 1) assess predation mortality relative to fishing mortality for commercially important fishes; 2) mechanistically and predictively model species interactions that impact the status of these stocks, particularly critical life stages; 3) relate changes in diet to changes in population level growth rates; and 4) better understand the Northeast U.S. Continental Shelf Ecosystem. In this document, we provide a history of food web dynamics research, review the food habits data collection and analytical methods, and give an overview of the FWDP food habits database at the NEFSC.

PROGRAM HISTORY

Baird's (1873) report was in direct response to declining fish populations in nearshore Southern New England waters. In contrast, there were consistently productive offshore fisheries for Atlantic halibut, haddock, Atlantic cod, and similar species for the next seven or eight decades. However, by the 1950s, after the halibut fishery had effectively collapsed, there were indications that haddock populations were also declining. Specific surveys were initiated in the late 1950s and were expanded in the 1960s to track these trends. Additionally, collection of basic biological information on haddock had begun in 1953 to determine the relationship between the distribution and abundance of this species and the availability of benthic fauna (USFWS 1954). Since there was already an active Benthic Ecology Program (BEP) at the Woods Hole Laboratory (Steimle *et al.* 1995) from Baird's inclusive interest in all aspects of the ecosystem, and since haddock are principally benthivores, the BEP undertook examination of haddock stomachs (Table 1). From the BEP perspective, the examination of stomachs was an alternative sampling method to categorize the benthic fauna of the region. In 1963, a standardized bottom trawl survey was initiated (see "Methods" section), designed to provide quantitative abundance indices for virtually all finfish species and to concurrently collect selected biological data as was feasible. Opportunistic stomach sampling continued on these surveys until 1966.

By the late 1960s, there was a clear, documented decline in the gadid-flatfish species complex of fish. In addition, Atlantic herring began a rapid decline in the late 1960s, followed by Atlantic mackerel in the early 1970s. Given this ubiquitous decline, a multispecies management scheme was formalized in 1974 to include a two-tiered quota system; the first tier placed single species total allowable catch limits on the international fleet prosecuting fisheries in the Northwest Atlantic, while the second placed a limit on the overall multispecies catch (Hennemuth and Rockwell 1987). This approach reaffirmed the need for broad biological information from as many species as possible.

Protocols for stomach sampling during 1969-72 varied and were generally categorical due to a lack of resources. The efforts during this period identified the major trophic interactions during a time of precipitous change in the fish community, and characterized the diets of major groundfish species (Maurer 1975; Maurer and Bowman 1975; Bowman *et al.* 1976; Edwards and Bowman 1979; Langton and Bowman 1980; Bowman 1981).

In 1973, the Feeding Ecology Project (FEP) was formed to initiate more systematic stomach collections. In the mid- to late 1970s, the issue of recruitment became increasingly important due to a massive decline in fish biomass. At this time, Atlantic herring and Atlantic mackerel were added to the stomach sampling protocol due to their potential as larval fish predators (Jossi and Marak 1983). Two new programs were formed in response to the change in focus toward factors affecting recruitment. The Food Chain Dynamics Investigation (FCDI) was formed to extend the work of the FEP, while an Ecosystem Modeling Investigation (EMI) primarily studied the mortality of prerecruits. The need to quantify species interactions was also recognized as an important issue, and reports detailing refined and quantified characterizations of the diet for many major species were produced as a first step to address this issue (Michaels and Bowman 1982; Bowman and Michaels 1984).

In the late 1970s and early 1980s, the focus of the programs remained on attempting to link recruitment variability with predation, particularly to match predator consumption rates to observed larval fish mortalities (Grosslein *et al.* 1980; Sissenwine 1984; GLOBEC 1991). Additionally, attempts to model the energy and production budgets of the region, especially Georges Bank, were initiated. The emphasis on the importance of predation was extended to all life stages for more species throughout the 1980s, with continual effort given to refining estimators of diet and consumption. As the fish community continued to undergo drastic changes, studies to evaluate these patterns were also undertaken.

Through the early 1990s, an emphasis continued on the importance of predation, particularly larval mortality (Almeida *et al.* 1999). In the mid-1990s, the FWDP was formed to extend efforts of the FCDI and EMI, with a focus on the fish community as an entity. Trophodynamic, aggregate biomass, and multispecies modeling efforts were initiated to continue exploring the causal mechanisms responsible for the observed changes in the fish community. The current, broad focus of the FWDP is to examine all trophic aspects of ecosystem dynamics in the U.S. waters of the Northwest Atlantic.

METHODS

DATABASES

The FWDP has two major sources of data. Both sources provide primarily stomach content information, *i.e.*, diet composition, total and individual prey weights or volumes, and prey length. The more extensive source is the standard, multispecies, NEFSC Bottom Trawl Survey Program. These surveys were designed to monitor trends in abundance and distribution and to provide data and samples to study the biology and ecology of the fishes and invertebrates inhabiting the Northeast U.S. Continental Shelf Ecosystem. During the surveys, food habits data are collected for a variety of species.

Additionally, "process-oriented" cruises are conducted periodically to address specific questions related to the trophic dynamics of the fishes in the ecosystem. While an important component of the overall trophic dynamics research program, the data from these cruises are not included in this report. Other databases, not described in this document, encompass the prey fields of these fishes and include zooplankton, ichthyoplankton, and benthos.

THE SURVEYS

The series of standardized bottom trawl surveys conducted in the Northwest Atlantic from Cape Hatteras, NC, to Nova Scotia (approximately 85,300 nm^2, or 293,000 km^2) is the central element in a broadscale ecological and fishery research program at the NEFSC (Figure 1). Surveys have been conducted continuously in the fall since 1963, and in the spring since 1968; seasonal surveys have also been conducted in summer and winter on an intermittent basis.

Trawl stations are selected using a stratified random design that provides unbiased estimates of a species availability to the trawl gear in relation to distribution. Strata were defined based on water depth, latitude, and historical fishing patterns. Within each stratum, stations are assigned randomly. The number of stations allotted to a stratum are in proportion to its area (approximately one station per 200 nm^2, or 690 km^2); however, a minimum of two stations are assigned to small strata in order to calculate their means. The surveys are conducted in depths of approximately 27-366 m; however, greater depths are occasionally sampled in the deep canyons along the continental shelf break. Once onboard, the catch is sorted and weighed (to the nearest 0.1 kg) by species, with individuals measured (to the nearest 1.0 cm) and categorized by sex and maturity stage. Subsamples of key species are eviscerated for feeding ecology and other studies. Geographic location, depth, and hydrographic data are also collected at each station. A complete description and evaluation of the Bottom Trawl Survey Program can be found in Grosslein (1969), Azarovitz (1981), and SWG/NEFC (1988).

Processing the Catch

From 1963 to 1992, all species were weighed and measured prior to biological sampling. If a species was also destined to be sampled for other biological studies (*e.g.*, feeding ecology, age and growth, maturity staging), each individual fish processed was measured a second time. This "double measuring" invariably resulted in some inconsistent, mismatched fish lengths between the overall length frequency records for the species and the individual lengths recorded for biological samples. In addition, routine biological samples were generally collected using length categories (usually 10 cm), with sampling targets based on a 6-hr watch schedule. For example, the scientific crew were required to process 10 silver hake ranging in length from 0-10 cm, 10 ranging in length from 11-20 cm, etc., for special sampling per watch.

Beginning with the 1992 winter survey, the ondeck processing protocols were modified to: 1) eliminate "double measuring", 2) give individual identification numbers to each fish sampled for biological studies, 3) sample on a one-individual-per-one-centimeter basis, and 4) require that samples be collected at every station.

Food Habits Sampling

During 1963-66, the food habits sampling protocol required examination of a random selection of fish species from each station for at-sea prey identification and a qualitative estimate of diet composition. No criteria were set for numbers of samples to collect; the number of stomachs examined was determined by the length of time available between trawl stations and the expertise of the onboard staff (Langton *et al.* 1980). From 1969 to 1972, samples were collected from up to 20 (but not less than 5) stomachs from each species caught at each station. Each stomach sample was preserved by size class at sea in 10% buffered Formalin for later processing in the laboratory. Because these data have not undergone standard audit procedures and are currently unavailable in digital format, they were not used in these analyses.

Beginning in 1973, a systematic approach to collecting stomachs was initiated. The 1973-80 period was divided into two 4-yr blocks with different groups of primary demersal and pelagic species sampled during each block. (See Table 2 for an overview of stomach samples requested by species during the 1973-99 time series. Appendix A contains detailed sampling protocols and lists of species.) The survey area was divided into five broad geographic regions, and a maximum of 100 stomachs per species per cruise, with no more than 10 per station, were requested (Langton *et al.* 1980). In addition, from 1977 to 1980, samples from 42 other, less commonly encountered species were also requested. Individual samples were preserved at sea in 10% buffered Formalin for further processing. Prey composition (percentage), weight (0.01 g), number, total stomach weight (0.01g), and lengths (millimeters) of fish prey were determined upon examination in the laboratory. Prey identification was to the lowest taxon feasible.

In 1981, a significant change to the at-sea sampling protocol was made. While the stomachs of major species such as Atlantic cod, haddock, silver hake, yellowtail flounder, winter flounder, Atlantic herring, and Atlantic mackerel continued to be individually preserved, all other species had prey examined and identified at sea. In addition, a volumetric measurement of stomach contents (0.1 cm^3) was initiated. The protocol also required sampling a specific number of fish for priority species per length class at every station (see Appendix A). Shipboard stomach processing also included percent diet composition, prey number, and prey lengths. These changes were implemented because laboratory processing of large numbers of samples proved too costly, and fish prey identification is assumed to be more accurate when stomach contents are fresh. This change in protocol placed an additional burden on seagoing staff to identify both fish and invertebrate prey while onboard ship. Many workshops were and are still conducted, and a variety of identification aids have been placed onboard ship to educate staff in the identification of prey species.

Since 1985, all stomach samples have been processed, and prey identified, at sea. Because of the time limitation at each station, from 1985 to 1991, systematic sampling focused on eight principal species: white hake, red hake, pollock, Atlantic herring, Atlantic mackerel, Atlantic cod, silver hake, and spiny dogfish (with the latter three receiving the highest priority). Eighteen other species were processed as time permitted (see Appendix A). Each of the eight principal species had target sampling levels per 6-hr watch, with an overall cap of 50 stomachs per station.

In 1992, with the implementation of new ondeck sample processing protocols (described earlier), the focus shifted from per-watch targets to per-station, length-based sampling. During 1992-93, stomach samples from 23 species were requested with maximum levels set by species and station. First priority was assigned to Atlantic cod, silver hake, spiny dogfish, and skates. In 1994, after concerns were eliminated that the per-station protocols would overwhelm the at-sea technical staff, the maxima were removed.

From 1995 to 1998, the primary objective of sampling continued to be to provide data to estimate predation on larval and juvenile stages of fish, particularly gadids, and sampling priorities were given to Atlantic cod, spiny dogfish, silver hake, Atlantic herring, and fourspot flounder, with the addition of little, winter, and thorny skates during the spring surveys.

In 1999, after an examination of data obtained during the previous surveys to determine an adequate sample size for characterizing predator diets (see "Stomach Sampling Effort Coverage" section), the sampling protocol was modified again to collect samples from a broad variety of species. While a low level of monitoring of historically priority species was maintained, the priority was shifted to commercially or ecologically important species that appeared to be undersampled in previous schemes. The sampling focus reemphasized benthivorous fishes, and attempted to be more inclusive of the entire fish community. Sample ranges (in fish length) were set for each species, generally one stomach per 5-cm length range for most species, and one stomach per 10-cm range for elasmobranchs. This protocol assumes that small per-station sample sizes over a wide range of species across many hundreds of stations will allow for adequate characterization of diets.

DATA PROCESSING

Once collected, whether on log sheets recorded at sea or in the laboratory, the data are entered into a computerized database (currently Oracle), audited, documented, and archived for analysis. This database is maintained on the NEFSC network computer system. In addition to the data collected from the Bottom Trawl Survey Program, data from the many special, process-oriented, cruises examining species- or life stage-specific interactions are also online, but are not included in this analysis due to their more focused nature.

DATA CONTINUITY ACROSS THE TIME SERIES

PREY TAXONOMIC RESOLUTION

Taxonomic resolution was more detailed for invertebrate species during the earlier (pre-1981) period of the database. To correct for potential differences in the resolution of prey taxonomy between in-lab and at-sea sampling, we established four prey categories. These categories span the lowest taxonomic level feasible (often genus and species) to a very broad class- or phylum-level category (Table 3). For most analyses, invertebrate prey are grouped into order or family level, while fish prey are maintained at the lowest level feasible. If specific time periods or prey species are of interest, a lower taxonomic resolution is appropriate. However, for most purposes, a broader resolution is preferable given the differences in protocol across the time series.

WEIGHT-VOLUME CONVERSION

In order to convert from stomach volume to stomach weight (or vice versa) to account for differences in sampling protocols across the time series, we executed a least-squares linear regression, with no intercept, to convert stomach-content data from volume (0.1 cm^3) to mass (0.1 g). This regression was done using all species that had simultaneous weight and volume measurements. Both a regression for all species combined and regressions for individual major species were calculated.

A conversion factor for volume to weight of 1.1:1 was determined from simple linear regression to be the most appropriate coefficient for all predator species (Table 4). This coefficient (*i.e.*, 1.1) is similar to those obtained from other studies (Bowman 1982; Tanasichuk *et al.* 1991). For those fishes that are piscivores and molluscivores (*e.g.*, red hake and goosefish), the coefficient is slightly higher, whereas for those that are planktivores (*e.g.*, Atlantic mackerel) and other benthivores (*e.g.*, windowpane and fourspot flounder), the coefficient is slightly lower, reflecting the different densities of different prey items. The variation of coefficients among species does not significantly depart from the overall coefficient of 1.1.

SUMMARY STATISTICS

STOMACH SAMPLING EFFORT COVERAGE

We plotted the number of stomachs sampled versus the number of prey species observed in the diet for each species. The stomach sample size at which an asymptote was reached indicated adequate information to characterize the diet of that predator. Similar to species-area curves (Preston 1962), an asymptote indicates a low probability of revealing novel prey items with examination of additional stomachs.

The number of stomachs examined versus the number of prey items observed generally indicated that an asymptote was reached between 500 and 1,000 stomachs. Figures 2-4 show the relationships graphically. For example, we can categorize the general diets of spiny dogfish, silver hake, Atlantic cod, white hake, pollock, yellowtail flounder, winter skate, and bluefish without expecting many more additional prey items in new stomach observations (Figures 2A-F, and 3A,E). Conversely, the plots indicate that we do not have adequate sample sizes for such species as smooth skate, witch flounder, Atlantic halibut, and alewife (Figures 3B-D,F). The species that are specialists such as the planktivorous Atlantic herring and Atlantic mackerel and the benthivorous thorny skate (Figures 4A-C) generally reach an asymptote at a lower number of stomachs than do more omnivorous species such as spiny dogfish, Atlantic cod, and silver hake.

DATA OVERVIEW

Predators

There are over 250,000 stomach records currently in the database. Predator sizes range from 1 cm to 2.5 m (Table 5). More than 120 species have been sampled, with 27 species having more than 2,000 stomachs sampled, and 42 species having more than 200 stomachs sampled. Approximately 30-40% of the stomachs examined are empty, varying across species.

Mean stomach contents generally reflect the diet composition (discussed later) and maximum size of the predator (Table 5). As a group, elasmobranchs are the largest fishes we sample, are generally piscivorous, and subsequently have the largest mean stomach contents. Exceptions include some of the skates and rays that feed primarily on benthos. Many pelagic piscivores also have large mean stomach contents. Goosefish, Atlantic cod, white hake, pollock, lumpfish, Atlantic halibut, Atlantic sturgeon, and groupers all have large mean lengths and mean stomach weights. Other than Atlantic sturgeon, most of these species are noted piscivores, particularly at the larger sizes. Conversely, the planktivores have the smallest mean stomach weights, reflecting their smaller size and zooplankton diet. Most other species have intermediate stomach weights.

Prey

There are over 500,000 prey records in the database. Prey sizes range from 0.1 mm to 1 m. There are 1,304 distinct prey items comprising 10 major taxa: arthropods, mollusks, fishes, polychaetes, echinoderms, cnidarians, poriferans, ctenophores, bryozoans, and urochords. The top 10 prey items by percentage occurrence for all predators include decapod crustaceans (principally shrimps), gammarids and other amphipods, unidentified and miscellaneous fishes ("other fishes"), unidentified and miscellaneous crustaceans ("other crustaceans"), euphausiids, polychaetes, ctenophores, cephalopods (principally squids), bivalves, and copepods (Figure 5).

Tracking the abundance of these groups can indicate major changes in ecosystem dynamics and foreshadow changes to upper trophic levels, particularly commercially valuable fishes (Christensen 1996; Jennings and Kaiser 1998). Major fish prey include northern sand lance, gadids (principally silver hake), clupeids, anchovies, and Atlantic mackerel. In addition to the large number of empty stomachs, unidentified fish, unclassified crustaceans, and well digested prey were observed most frequently in the stomachs, indicating that much of the observed prey is highly digested and difficult to identify.

DIET SUMMARIES

Statistical Estimators

Various information can be obtained from stomach content examination (Hyslop 1980; Bowen 1996; Cortes 1997) depending upon the question being addressed. Although sampling priorities shifted between species across the history of the program, most of the major species were sampled continuously over the time series (Table 2). Given the slightly different sampling protocols described previously, we treated each stomach as a random sample in one of three possible statistical designs: unweighted random, stratified, or two-stage clustered. From these food habits data, percent frequency of occurrence of prey items, total stomach contents as either volume or weight, and percent mean diet composition of prey items can be estimated for a given species.

The percent frequency of occurrence can be calculated as

$$F_{ij} = \frac{n_{ij}}{N_j} \qquad \text{EQ 1}$$

where n_{ij} is the number of stomachs of predator j in which prey item i occurs, and N_j is the total number of predator j stomachs examined.

The simple, unweighted, percent mean diet composition ($\overline{P_{ij}}$) can be calculated as either weight or volume. For weight, it can be calculated as

$$\overline{P_{ij}} = \frac{\sum_{k=1}^{N_j} w_{ijk}}{\sum_{k=1}^{N_j} w_{jk}} \qquad \text{EQ 2}$$

where k represents an individual fish, w_{ij} is the stomach weight of prey i in predator j, and

$$w_j = \sum_{k=1}^{N_j} \sum_{i=1}^{n_i} w_{ijk} \qquad \text{EQ 3}$$

is the total weight of all n_i prey in the stomach of predator j. Percent mean diet composition may also be calculated as a ratio of means (Malvestuto 1996),

$$\overline{P_{ij}} = \frac{\overline{w_{ij}}}{\overline{w_j}} \qquad \text{EQ 4,}$$

inclusive or exclusive of empty stomachs, where

$$\overline{w_{ij}} = \frac{\sum_{k=1}^{N_j} w_{ijk}}{N_j} \qquad \text{EQ 5}$$

and

$$\overline{w_j} = \frac{\sum_{k=1}^{N_j} w_{jk}}{N_j} \qquad \text{EQ 6.}$$

Although not calculated in this document, these diet parameters can be estimated across several statistical groups or factors (s). Examples include: 1) temporal factors such as decade, year (or year blocks), season, month, or time of day; 2) spatial factors such as geographic region, stratum, or statistical area; 3) abiotic factors such as depth, sediment type, wind speed and direction, current speed and direction, temperature, or salinity; and 4) predator factors such as length, weight, age, condition factor, or sex.

A weighted mean ($\overline{w_{ijs}}$) to estimate mean weight of prey i in predator j for statistical group s may be calculated as

$$\overline{w_{ijs}} = \frac{\sum_{t=1}^{N_{ts}} N_{jts} \overline{w_{ijts}}}{N_{ts}} \qquad \text{EQ 7}$$

where t represents an individual bottom trawl tow, N_{jts} is the number of predator j stomachs in tow t for statistical group s, N_{ts} is the number of tows in statistical group s, and

$$\overline{w_{ijts}} = \frac{\sum_{k=1}^{N_{jts}} w_{ijtsk}}{N_{jts}} \qquad \text{EQ 8.}$$

If one sums across all statistical groups, the weighted mean of prey i in predator j ($\overline{w'_{ij}}$) becomes

$$\overline{w'_{ij}} = \frac{\sum_{s=1}^{N_s} \overline{w_{ijs}} \cdot N_{js}}{N_s} \qquad \text{EQ 9}$$

where N_s is the number of statistical groups and N_{js} is the total number of predator j in statistical group s. Mean stomach weight of predator j for all prey combined ($\overline{w_{js}}$) can similarly be estimated for a statistical group as

$$\overline{w_{js}} = \frac{\sum_{t=1}^{N_{ts}} N_{jts} \overline{w_{jts}}}{N_{ts}} \qquad \text{EQ 10}$$

where

$$\overline{w_{jts}} = \frac{\sum_{k=1}^{N_{jts}} w_{jtsk}}{N_{jts}} \qquad \text{EQ 11,}$$

and across all statistical groups as

$$\overline{w'_j} = \frac{\sum_{s=1}^{N_s} \overline{w_{js}} \cdot N_{js}}{N_s} \qquad \text{EQ 12}$$

which, as in our case, if one evaluates all elements in a cluster such that N_{ts} equals the total number of all tows (N_t), then EQ 12 is a direct simplification of a two-stage weighted cluster mean (Schaeffer *et al.* 1990). From EQ 9 and 12, a weighted mean diet composition can also be estimated for any prey i in predator :

$$\overline{P'_{ij}} = \frac{\overline{w'_{ij}}}{\overline{w'_j}} \qquad \text{EQ 13.}$$

We principally report the simple arithmetic (unweighted mean ratio inclusive of empty stomachs, *i.e.*, EQ 3 with statistical grouping across all factors) mean diet composition for these predators in this document. Variance estimators for each of these estimators can also be calculated, with caveats from normal, Poisson, negative binomial, gamma, lognormal, delta, or similar statistical distributions (*e.g.*, Zar 1984; Pennington 1996; Tirasin and Jorgensen 1999). Given the central limit theorem and generally large sample sizes, we presume underlying normal distributions of the data, although a delta or delta-gamma approach is appropriate given the large number of zero values in the database.

Diet of Major Species

The two sharks regularly sampled for food habits have dissimilar diets. Spiny dogfish (Figure 6A) consume mostly pelagic prey, with clupeids, squids, scombrids, ctenophores, shrimps, and other fishes being major prey items. Smooth dogfish is a benthivore, feeding principally on decapod crabs (Figure 6B).

The skates are principally benthivores (Figures 7 and 8), with amphipods, polychaetes, bivalves, and various decapods (crabs and shrimp) being major prey items. Winter skate is more piscivorous than the other skates, consuming high proportions of northern sand lance and Atlantic herring in its diet. Smooth skate is more pelagic than the other skates, consuming higher proportions of euphausiids and decapod shrimps than other prey in its diet. All skates have a relatively catholic diet.

The planktivores (*e.g.*, Atlantic herring, Atlantic mackerel, alewife, northern sand lance, butterfish) have diets dominated by well digested prey, reflecting both their faster digestion and our difficulty in identifying smaller prey (Figures 9 and 10). Copepods, euphausiids, amphipods (primarily hyperiids), mysids, and northern sand lance are the other major prey items of these fishes. Well digested prey were likely one or more of these zooplankton or small fish prey items.

Similarly, the squids have a diet that is also dominated by well digested prey, probably a result of prey mastication from the beak of these predators (Figure 11). Squids are highly cannibalistic and piscivorous.

The principal gadids Atlantic cod, haddock, and pollock are dietary generalists (Figure 12). These three species' diets form a continuum from benthic to pelagic prey, with the haddock diet more benthic (*e.g.*, brittle stars, polychaetes, amphipods), the cod diet in between, and pollock diet more pelagic (*e.g.*, euphausiids, northern sand lance, decapod shrimps). Clupeids, northern sand lance, and other gadids (mainly silver hake, although there is some cannibalism) are the major fish prey of these species.

The hakes are primarily pelagic predators, consuming mainly euphausiids, clupeids, squids, decapods, and other gadids (Figures 13 and 14). These species exhibit a broad diet that is principally fish and/or shrimp in composition.

The flatfishes can be largely categorized as either squid-and-fish eaters (*i.e.*, Atlantic halibut and fourspot and summer flounders) or worm-and-amphipod eaters (*i.e.*, windowpane and yellowtail, winter, and witch flounders) (Figures 15-17). The notable exception is American plaice which primarily consumes echinoderms (Figure 15B) -- more similar to haddock (Figure 12B) than to other flatfishes. Windowpane and fourspot flounder exhibit a broad diet. The morphology of these flatfishes suggests benthic feeding, thus the high degree of piscivory exhibited by some species is noteworthy.

The other major piscivores (*e.g.*, goosefish, weakfish, and bluefish) consume a broad variety of fishes and squids (Figure 18). Pelagic prey such as anchovies, clupeids, northern sand lance, longfin inshore squid, and gadids (principally silver hake) are the major dietary items of these predators, with weakfish consuming prey whose ranges are centered further to the south (*e.g.*, sciaenids, butterfish), and with goosefish consuming more benthic prey (*e.g.*, sea robins, bothids, pleuronectids, skates) than bluefish.

Scup are primarily benthivores, whereas black sea bass and Acadian redfish consume shrimp and other fishes (Figure 19). Black sea bass and scup both have a broad range of prey represented in their diets, but specialize on decapods and polychaetes, respectively.

Sea raven are benthic piscivores, consuming several different fish prey (Figure 20). Longhorn sculpin are also benthic and piscivorous, but primarily consume a broader mix of benthic invertebrates (*i.e.*, decapod crabs, amphipods). Similar to American plaice, the ocean pout diet consists of a high proportion of echinoderms. All three of these fish exhibit a relatively broad, benthic diet.

DISCUSSION

DIET OVERVIEW

The diet summaries presented here extend previous documentation for many of these fish species (*e.g.*, Wigley 1956; Sherman *et al.* 1978; Edwards and Bowman 1979; Grosslein *et al.* 1980; Bowman 1981, 1983; Cohen *et al.* 1981, 1982; Langton 1982, 1983; Durbin *et al.* 1983; Bowman and Michaels 1984; Bowman *et al.* 1984; Hahm and Langton 1984; Overholtz *et al.* 1991). For further details on a particular species or species group, we refer the reader to these more specific documents. In general, we can categorize the diets of most species with more than 1,000 stomachs examined. For example, we know that Atlantic cod typically consume a wide mix of benthic invertebrates, herrings, silver hake, shrimps, and northern sand lance (Figure 12A), and that spiny dogfish typically consume ctenophores, shrimps, and smaller pelagic fishes (Figure 6A). How the diets of these species alter across seasons, location, size classes, or decades is described elsewhere, although the major diet compositions are generally consistent (Garrison and Link 2000).

Many of the species over the period of this time series have been undersampled (Table 5, Figure 3B-D,F) due to logistical constraints and changing priorities. One of the challenges is to focus on species we know little about despite their limited commercial value. For example, it would have been difficult to predict 30 yr ago that goosefish would currently be the most valuable finfish in the NMFS

Northeast Region (Clark 1998), yet, fortunately, information was collected for this species. These data demonstrated the importance of this species as a piscivore. These undersampled species, as well as protocols to better address the frequency of empty stomachs and well digested prey, merit further examination.

Most species in this fish community are generalists, with a few pelagic or benthic specialists. Garrison and Link (2000) have categorized six major feeding groups, including benthivores (*e.g.*, Figures 7, 8, 15B-C, and 16C), planktivores (*e.g.*, Figures 9 and 10), piscivores (*e.g.*, Figure 18), pelagic (small fish and shrimp) feeders (*e.g.*, Figures 13 and 14), demersal invertebrate feeders (*e.g.*, Figure 12), and crab specialists (*e.g.*, Figure 6B). Given the broad diets, high degree of omnivory (Link 1999), and generalist feeding nature of most species in this community, most predator-prey interaction strengths are mild in this ecosystem (Link 1999; Sissenwine *et al.* 1982). Thus, the population-level impacts of changes in prey (potentially impacting growth) or predators (potentially impacting survivability) are likely less significant than if this were an ecosystem of specialists with strong interactions.

HISTORICAL AND CURRENT RELEVANCE

We have documented the changing priorities and protocols of the food habits sampling over the history of this program (Tables 1 and 2; Appendix A). Despite these caveats, this is a unique data set to assist with understanding the ecosystem dynamics of the Northwest Atlantic. To our knowledge, there are no other data sets that span 25 yr for more than 120 species over an entire continental shelf.

The importance of the food-habits time series is enhanced given its potential role in at least partially explaining the notable dynamic nature of the Northwest Atlantic fish community (Mayo *et al.* 1992; Boreman *et al.* 1997; Clark 1998; Fogarty and Murawski 1998). Briefly, in the past 30-40 yr, the abundance of commercially desirable gadids (*e.g.*, Atlantic cod and haddock) and flatfishes (*e.g.*, yellowtail flounder) has declined, with a concurrent increase in the abundance of less desirable elasmobranchs (*e.g.*, spiny dogfish and skates) and small pelagic species (*e.g.*, Atlantic herring and Atlantic mackerel). These changes were caused primarily by a significant increase in fishing pressure exerted on gadids and flatfishes beginning in the early 1960s with the arrival of distant-water fleets. Even with the foreign fleets largely displaced from the U.S. Exclusive Economic Zone in 1977, effective effort on the fish stocks has remained high, and for many species, stock biomass dropped to historically low levels in the 1990s due to the increased capacity and efficiency of the domestic fleet (Clark 1998; Fogarty and Murawski 1998). These phenomena are not limited to just this ecosystem; other ecosystems around the world exhibit similar patterns (NRC 1999). There is high heuristic value in exploring from a trophic ecology perspective why the multispecies trajectory proceeded as it did in this ecosystem, particularly to assess how the multispecies trajectory may proceed in the future.

Professor Baird's (1873) concerns remain appropriate, and are still relevant to ongoing ecosystem investigations (*e.g.*, Sherman 1991; Sherman *et al.* 1993; Christensen *et al.* 1996; Larkin 1996; Jennings and Kaiser 1998; NRC 1999). Central to ecosystem considerations are species interactions. In many food webs, predation can be a major ecological process affecting fish populations (Sissenwine 1984; Bax 1991, 1998; Christensen 1996) and the major source of mortality for fish (*e.g.*, Sissenwine *et al.* 1984; Keast 1985; Mittelbach and Persson 1998). Multispecies, trophodynamic, food web, and ecosystem models are tools to give insights into fish communities where classical fisheries methods are unable to do so (*e.g.*, Steele 1974; Andersen and Ursin 1977; Helgason and Gislason 1979; May *et al.* 1979; Mercer 1982; Kerr and Ryder 1989; Daan and Sissenwine 1991). For example, how important is natural mortality to a given fish stock (Sissenwine 1984), what are the system-level emergent properties from a fish community and how are they altered with overfishing (Jennings and Kaiser 1998), or what levels of biomass tradeoff are we willing to accept among a given species mix? Quantifying the food habits of these species is at the heart of these and similar questions.

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REFERENCES CITED

Almeida, F.; Fogarty, M.; Grosslein, M.; Kaminer, B.; Link, J.; Michaels, W.; Rountree, R. 1999. Georges Bank predation study: report of the 1994-96 field seasons. *Northeast Fish. Sci. Cent. Ref. Doc.* 99-06; 58 p. Available *from*: National Marine Fisheries Service, Woods Hole, MA 02543.

Andersen, K.P.; Ursin, E. 1977. A multispecies extension to the Beverton and Holt theory, with accounts of phosphorus circulation and primary production. *Medd. Dan. Fisk.-Havunders.* 7:319-435.

Azarovitz, T.R. 1981. A brief historical review of the Woods Hole Laboratory trawl survey time series. In: Doubleday, W.G.; Rivard, D., eds. Bottom trawl surveys. *Can. Spec. Publ. Fish. Aquat. Sci.* 58:62-67.

Baird, S.F. 1873. Report on the condition of the sea fisheries of the south coast of New England in 1871 and 1872. Part I. Washington, DC: U.S. Commission of Fish and Fisheries; 852 p. Available *from*: National Marine Fisheries Service, Woods Hole, MA 02543.

Bax, N.J. 1998. The significance and prediction of predation in marine fisheries. *ICES* [Int. Counc. Explor. Sea] *J. Mar. Sci.* 55:997-1030.

Bax, N.J. 1991. A comparison of the fish biomass flow to fish, fisheries, and mammals on six marine ecosystems. *ICES* [Int. Counc. Explor. Sea] *Mar. Sci. Symp.* 193:217-224.

Boreman, J.; Nakashima, B.S.; Wilson, J.A.; Kendall, R.L., editors. 1997. Northwest Atlantic groundfish: perspectives on a fishery collapse. Bethesda, MD: American Fisheries Society; 242 p.

Bowen, S.H. 1996. Quantitative description of the diet. *In:* Murphy, B.R.; Willis, D.W., eds. Fisheries techniques. Bethesda, MD: American Fisheries Society; p. 513-532.

Bowman, R.E. 1981. Food of ten species of Northwest Atlantic juvenile groundfish. *Fish. Bull. (U.S.)* 79(1):220-226.

Bowman, R.E. 1982. Preliminary evaluation of the results of analysis of the stomach contents of silver hake (*Merluccius bilinearis*) aboard ship and in the laboratory ashore. *Woods Hole Lab. Ref. Doc.* 82-25; 13 p. Available *from*: National Marine Fisheries Service, Woods Hole, MA 02543.

Bowman, R.E. 1983. Food of silver hake, *Merluccius bilinearis*. *Fish. Bull. (U.S.*) 82:21-35.

Bowman, R.E.; Michaels, W.L. 1984. Food of seventeen species of Northwest Atlantic fish. *NOAA Tech. Memo. NMFS-F/NEC*-28; 183 p.

Bowman, R.E.; Eppi, R.; Grosslein, M. 1984. Diet and consumption of spiny dogfish in the Northwest Atlantic. *ICES* [Int. Counc. Explor. Sea] *C.M.* 1984/G:27; 16 p.

Bowman, R.E.; Maurer, R.; Murphy, J. 1976. Stomach contents of twenty-nine fish species from five regions in the Northwest Atlantic. *Northeast Fish. Sci. Cent. Ref. Doc.* 76-10; 37 p. Available *from*: National Marine Fisheries Service, Woods Hole, MA 02543.

Christensen, V. 1996. Managing fisheries involving predator and prey species. *Rev. Fish Biol. Fish.* 6:417-442.

Christensen, N.L.; Bartuska, A.M.; Brown, J.H.; Carpenter, S.; D'Antonio, C.; Francis, R.; Franklin, J.F.; MacMahon, J.A.; Noss, R.F.; Parsons, D.J.; Peterson, C.H.; Turner, M.G.; Woodmansee, R.G. 1996. The report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management. *Ecol. Appl.* 6:665-691.

Clark, S.H., editor. 1998. Status of fishery resources off the northeastern United States for 1998. *NOAA Tech. Memo. NMFS-NE*-115; 149 p.

Cohen, E.; Grosslein, M.; Sissenwine, M.; Serchuk, F.; Bowman, R. 1981. Stomach content studies in relation to multispecies fisheries analysis and modeling for the Northwest Atlantic. *ICES* [Int. Counc. Explor. Sea] *C.M.* 1981/G:66; 14 p.

Cohen, E.; Grosslein, M.D.; Sissenwine, M.P.; Steimle, F.; Wright, W.R. 1982. Energy budget of Georges Bank. *In:* Mercer, M.C., ed. Multispecies approaches to fisheries management advice. *Can. Spec. Publ. Fish. Aquat. Sci.* 59:95-107.

Cortes, E. 1997. A critical review of methods of studying fish feeding based on analysis of stomach contents: application to elasmobranch fishes. *Can. J. Fish. Aquat. Sci.* 54:726-738.

Daan, N.; Sissenwine, M.P., editors. 1991. Multispecies models relevant to management of living resources. *ICES* [Int. Counc. Explor. Sea] *Mar. Sci. Symp.* 193; 358 p.

Durbin, E.R.; Durbin, A.G.; Langton, R.W.; Bowman, R.E. 1983. Analysis of stomach contents of Atlantic cod (*Gadus morhua*) and silver hake (*Merluccius bilinearis*) for the estimation of daily rations. *Fish. Bull. (U.S.)* 81(3):437-454.

Edwards, R.L.; Bowman, R.E. 1979. Food consumed by continental shelf fishes. *In:* Clepper, H., ed. Predator-prey systems in fish communities and their role in fisheries management. Washington, DC: Sports Fishing Institute; p. 337-406.

Fogarty, M.J.; Murawski, S.A. 1998. Large-scale disturbance and the structure of marine systems: fishery impacts on Georges Bank. *Ecol. Appl.* 8(S1):S6-S22.

Garrison, L.P.; Link, J.S. 200. Fishing effects on spatial distribution and trophic guild structure in the Georges Bank fish community. *ICES* [Int. Counc. Explor. Sea] *J. Mar. Sci.* 57:723-730.

GLOBEC [U.S. Global Ocean Ecosystems Dynamics Program]. 1991. GLOBEC Northwest Atlantic Program: GLOBEC Canada/U.S. Meeting on N.W. Atlantic Fisheries and Climate. *U.S. Global Ecosyst. Dyn. Program Rep.* 2; 87 p. Available *from*: U.S. GLOBEC Scientific Steering Committee Coordinating Office, c/o Woods Hole Oceanographic Institution, Woods Hole, MA 02543.

Grosslein, M.D. 1969. Groundfish survey program of BCF Woods Hole. *Comm. Fish. Rev.* 31(8-9):22-25.

Grosslein, M.D.; Langton, R.W.; Sissenwine, M.P. 1980. Recent fluctuations in pelagic fish stocks in the Northwest Atlantic Georges Bank region, in relation to species interactions. *In:* Saville, A., ed. The assessment and management of pelagic fish stocks. *Rapp. P.-V. Reun. Cons. Int. Explor. Mer* 177:374-404.

Hahm, W.; Langton, R.W. 1984. Prey selection based on predator/prey weight ratios for some Northwest Atlantic fish. *Mar. Ecol Prog. Ser.* 19(1-2):1-5.

Helgason, T.; Gislason, H. 1979. VPA-analysis with species interaction due to predation. *ICES* [Int. Counc. Explor. Sea] *C.M.* 1979/G:52; 10 p.

Hennemuth, R.C.; Rockwell, S. 1987. History of fisheries management and conservation. *In:* Backus, R. ed. Georges Bank. Cambridge, MA: MIT Press; p. 430-446.

Hyslop, E.J. 1980. Stomach contents analysis — a review of methods and their application. *J. Fish Biol.* 17:411-429.

Jennings, S.; Kaiser, M.J. 1998. The effects of fishing on marine ecosystems. *Adv. Mar. Biol.* 34:201-352.

Jossi, J.W.; Marak, R.R. 1983. MARMAP plankton survey manual. *NOAA Tech. Memo. NMFS-F/NEC*-21; 258 p.

Keast, A. 1985. The piscivore feeding guild of fishes in small freshwater ecosystems. *Environ. Biol. Fish.* 12:119-129.

Kerr, S.R.; Ryder, R.A. 1989. Current approaches to multispecies analysis of marine fisheries. *Can. J. Fish. Aquat. Sci.* 46:528-534.

Langton, R.W. 1982. Diet overlap between Atlantic cod, *Gadus morhua*, silver hake, *Merluccius bilinearis*, and fifteen other Northwest Atlantic finfish. *Fish. Bull. (U.S.)* 80:745-759.

Langton, R.W. 1983. Food of yellowtail flounder, *Limanda ferruginea* (Storer), from off the northeastern United States. *Fish. Bull. (U.S.)* 81(1):15-22.

Langton, R.W.; Bowman, R.E. 1980. Food of fifteen Northwest Atlantic gadiform fishes. *NOAA* [Natl. Ocean. Atmos. Admin.] *Tech. Rep. NMFS* [Natl. Mar. Fish. Serv.] *SSRF* [Spec. Sci. Rep. Fish.] 740; 23 p.

Langton, R.W.; North, B.M.; Hayden, B.P.; Bowman, R.E. 1980. Fish food habits studies — sampling procedures and data processing methods utilized by the Northeast Fisheries Center, Woods Hole Laboratory, U.S.A. *ICES* [Int. Counc. Explor. Sea] *C.M.* 1980/L:61; 16 p.

Larkin, P.A. 1996. Concepts and issues in marine ecosystem management. *Rev. Fish Biol. Fish.* 6:139-164.

Link, J. 1999. Reconstructing food webs and managing fisheries. *In:* Baxter, B., ed. Ecosystem approaches for fisheries management: proceedings of the Symposium on Ecosystem Considerations in Fisheries Management, September 30 - October 3, 1998, Anchorage, Alaska. *Alaska Sea Grant Rep.* AK-SG-99-01:571-588. Available *from*: University of Alaska Sea Grant, Fairbanks, AK 99775.

Malvestuto, S.P. 1996. Sampling the recreational creel. *In:* Murphy, B.R.; Willis, D.W., eds. Fisheries techniques. Bethesda, MD: American Fisheries Society; p. 591-624.

Maurer, R.O. 1975. A preliminary description of some important feeding relationships. *Int. Comm. Northw. Atl. Fish. Res. Doc.* 75/IX/130; 15 p.

Maurer, R.O.; Bowman, R.E. 1975. Food habits of marine fishes of the Northwest Atlantic. *Woods Hole Lab. Ref. Doc.* 75-03; 90 p. Available *from*: National Marine Fisheries Service, Woods Hole, MA 02543.

May, R.M.; Beddington, J.R.; Clark, C.W.; Holt, S.J.; Laws, R.M. 1979. Management of multispecies fisheries. *Science* 205:267-277.

Mayo, R.K.; Fogarty, M.J.; Serchuk, F.M. 1992. Aggregate fish biomass and yield on Georges Bank, 1960-87. *J. Northw. Atl. Fish. Sci.* 14:59-78.

Mercer, M.C., editor. 1982. Multispecies approaches to fisheries management advice. *Can. Spec. Publ. Fish. Aquat. Sci.* 59; 169 p.

Michaels, W.L.; Bowman, R.E. 1982. Food of seventeen species of Northwest Atlantic fish. Part II. Examination by year and listing of prey species. *Woods Hole Lab. Ref. Doc.* 82-17; 117 p. Available *from*: National Marine Fisheries Service, Woods Hole, MA 02543.

Mittelbach, G.G.; Persson, L. 1998. The ontogeny of piscivory and its ecological consequences. *Can. J. Fish. Aquat. Sci.* 55:1454-1465.

NRC [National Research Council]. 1999. Sustaining marine fisheries. Washington, DC: National Academy Press; 164 p.

Overholtz, W.J.; Murawski, S.A.; Foster, K.L. 1991. Impact of predatory fish, marine mammals, and seabirds on the pelagic fish ecosystem of the northeastern USA. *ICES* [Int. Counc. Explor. Sea] *Mar. Sci. Symp.* 193:198-208.

Pennington, M. 1996. Estimating the mean and variance from highly skewed marine data. *Fish. Bull. (U.S.)* 94:498-505.

Preston, F.W. 1962. The canonical distribution of commonness and rarity. *Ecology* 43:185-215, 431-432.

Schaeffer, R.L.; Mendenhall, W.; Ott, L. 1990. Elementary survey sampling. Boston, MA: PWS-Kent; 390 p.

Sherman, K. 1991. The large marine ecosystem concept: research and management strategy for living marine resources. *Ecol. Appl.* 1:349-360.

Sherman, K.; Alexander, L.M.; Gold, B.D., editors. 1993. Large marine ecosystems: stress, mitigation and sustainability. Washington, DC: AAAS Press; 376 p.

Sherman, K.; Cohen, E.; Sissenwine, M.; Grosslein, M.; Langton, R.; Green, J. 1978. Food requirements of fish stocks of the Gulf of Maine, Georges Bank, and adjacent waters. *ICES* [Int. Counc. Explor. Sea] *C.M.* 1978/Gen:8 (Symp.); 14 p.

Sissenwine, M.P.; Brown, B.E.; Palmer, J.E.; Essig, R.J.; Smith, W. 1982. Empirical examination of population interactions for the fishery resources off the northeastern USA. *In:* Mercer, M.C., ed. Multispecies approaches to fisheries management advice. *Can. Spec. Publ. Fish. Aquat. Sci.* 59:82-94.

Sissenwine, M.P. 1984. Why do fish populations vary? *In:* May, R.M., ed. Exploitation of marine communities. New York, NY: Springer-Verlag; p. 59-94.

Sissenwine, M.P.; Cohen, E.B.; Grosslein, M.D. 1984. Structure of the Georges Bank ecosystem. *Rapp. P.-V. Reun. Cons. Int. Explor. Mer* 183:243-254.

Steele, J.H. 1974. The structure of marine ecosystems. Oxford, England: Blackwell Scientific; 128 p.

Steimle, F.W.; Burnett, J.M.; Theroux, R.B. 1995. A history of benthic research in the NMFS Northeast Fisheries Science Center. *Mar. Fish. Rev.* 57(2):1-13.

SWG/NEFC [Survey Working Group/Northeast Fisheries Center]. 1988. An evaluation of the bottom trawl survey program of the Northeast Fisheries Center. *NOAA Tech. Memo. NMFS-F/NEC*-52; 83 p.

Tanasichuk, R.W.; Ware, D.M.; Shaw, W.; McFarlane, G.A. 1991. Variations in diet, daily ration, and feeding periodicity of Pacific hake (*Merluccius productus*) and spiny dogfish (*Squalus acanthias*) off the lower west coast of Vancouver Island. *Can. J. Fish. Aquat. Sci.* 48:2118-2128.

Tirasin, E.M.; Jorgensen, T. 1999. An evaluation of the precision of diet description. *Mar. Ecol. Prog. Ser.* 182:243-252.

USFWS [U.S. Fish and Wildlife Service]. 1954. Annual report of the Woods Hole Laboratory for the year ending June 30, 1954. Washington, DC: U.S. Fish and Wildlife Service; 14 p.

Wigley, R.L. 1956. Food habits of Georges Bank haddock. *U.S. Fish Wildl. Serv. Spec. Sci. Rep. Fish.* 165; 26 p.

Zar, J.H. 1984. Biostatistical analysis. Englewood Cliffs, NJ: Prentice-Hall; 718 p.

Table 1. Timeline of research emphasized and hypotheses studied by the Food Web Dynamics Program and its predecessors

Time Period	**Research Emphasis and Hypotheses**

1950s - 1960s	Exploring possible causes of haddock declines
	    Hypothesized relationship of diet and growth
	Transition from benthic research program to using fish as benthic samplers
	    Emphasis on haddock, other gadids

mid-1960s	*Ad hoc* diet studies as part of bottom trawl surveys Emphasis extended to major (commercially valuable) groundfish
late 1960s - early 1970s	Continued *ad hoc* sampling Other species added to sampling priority Multispecies considerations first formalized
through 1970s	Emphasis on characterizing the diets of major fish species Systematic studies of diet (food habits) adopted as part of bottom trawl surveys Herring studies with foreign fisheries
late 1970s - early 1980s	Energy budgets Systemwide production models Qualitative ecosystem models Hypothesized recruitment limitation via predation on larval fish Emphasis on ichthyoplanktivores

mid-1980s	Hypothesized extension of predation on all fish as a significant source of mortality
	    Emphasis on piscivores
	First attempts to quantify predator-prey relationships
	    Consumption rates, species interactions, larval mortality estimated

late 1980s - early 1990s	Detailed consumption rates and refined diet estimators Mechanisms for historical changes in fish community composition from overfishing Refined attempts to assess predation on larval fish Multispecies models and simulations
mid-1990s - late 1990s	Fish community metrics and properties Community as an entity Trophodynamic, aggregate biomass, food web models Ecosystem considerations more explicitly considered Emphasis on less understood (lower economic value) species

Table 2a. Stomach sampling requests made to the NEFSC Bottom Trawl Survey Program during 1973-86 (Sp = spring; Fa = fall; 1 = priority species; 2 = second-level species collected as time allowed)

	1973		1974		1975		1976		1977		1978		1979		1980		1981		1982		1983		1984		1985		1986	
Common Name	**Sp**	**Fa**	**Sp**	**Fa**	**Sp**	**Fa**	**Sp**	**Fa**	**Sp**	**Fa**	**Sp**	**Fa**	**Sp**	**Fa**	**Sp**	**Fa**	**Sp**	**Fa**	**Sp**	**Fa**	**Sp**	**Fa**	**Sp**	**Fa**	**Sp**	**Fa**	**Sp**	**Fa**
Alewife	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	2	2	2	2
Argentines	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Bass, black sea	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Bass, striped	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	2	2	2	2
Bluefish	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	2	2	2	2
Butterfish	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Cod, Atlantic	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Croaker, Atlantic	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Cunner	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Cusk	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Cusk-eel, fawn	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Dogfish, smooth	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	2	2	2	2
Dogfish, spiny	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dory, American John	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Eel, American	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Eel, conger	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
(Flounder) American plaice	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Flounder, fourspot	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	2	2	2	2
Flounder, Gulf Stream	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Flounder, summer	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	2	2	2	2
(Flounder) windowpane	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	2	2	2	2
Flounder, winter	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	-	-	-
Flounder, witch	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Flounder, yellowtail	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	-	-	-	-
Goosefish	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2
Grenadiers	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Haddock	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	-	-	-
Hake, longfin	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Hake, offshore	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Hake, red	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Hake, silver	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Hake, spotted	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	2	2
Hake, white	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
Halibut, Atlantic	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	2	2	2	2
Herring, Atlantic	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Herring, blueback	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Herring, round	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Kingfish, northern	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Kingfish, southern	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Mackerel, Atlantic	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mackerels, snake	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Needlefish, Atlantic	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Pout, ocean	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pollock	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1
Rays	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-

Table 2a. (Cont.)

Common Name	1973 Sp	1973 Fa	1974 Sp	1974 Fa	1975 Sp	1975 Fa	1976 Sp	1976 Fa	1977 Sp	1977 Fa	1978 Sp	1978 Fa	1979 Sp	1979 Fa	1980 Sp	1980 Fa	1981 Sp	1981 Fa	1982 Sp	1982 Fa	1983 Sp	1983 Fa	1984 Sp	1984 Fa	1985 Sp	1985 Fa	1986 Sp	1986 Fa
Redfish, Acadian	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	2	2	2	2
Rosefish, blackbelly	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salmon, Atlantic	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sand Lance, northern	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Sculpin, longhorn	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	2	2
Scup	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	2	2	2	2
Sea raven	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	2	2	2	2
Searobin, armored	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Searobin, northern	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Searobin, striped	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Shad, American	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Shad, hickory	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sharks	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Skate, little	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	2	2
Skate, rosette	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Skate, smooth	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Skate, thorny	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	2	2	2	2
Skate, winter	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	2	2	2	2
Spot	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Squid, longfin inshore	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Squid, northern shortfin	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Tautog	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tilefish	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Weakfish	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	2	2	2	2
Wolffish, Atlantic	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Wrymouth	-	-	-	-	-	-	-	-	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-

Table 2b. Stomach sampling requests made to the NEFSC Bottom Trawl Survey Program during 1987-99 (Sp = spring; Fa = fall; 1 = priority species; 2 = second-level species collected as time allowed)

Common Name	1987 Sp	1987 Fa	1988 Sp	1988 Fa	1989 Sp	1989 Fa	1990 Sp	1990 Fa	1991 Sp	1991 Fa	1992 Sp	1992 Fa	1993 Sp	1993 Fa	1994 Sp	1994 Fa	1995 Sp	1995 Fa	1996 Sp	1996 Fa	1997 Sp	1997 Fa	1998 Sp	1998 Fa	1999 Sp	1999 Fa
Alewife	2	2	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Argentines	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bass, black sea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Bass, striped	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Bluefish	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Butterfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Cod, Atlantic	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Croaker, Atlantic	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cunner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Cusk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Cusk-eel, fawn	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Dogfish, smooth	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Dogfish, spiny	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Dory, American John	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eel, American	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eel, conger	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Flounder) American plaice	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Flounder, fourspot	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	2	2
Flounder, Gulf Stream	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Flounder, summer	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1
(Flounder) windowpane	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Flounder, winter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Flounder, witch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Flounder, yellowtail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Goosefish	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Grenadiers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haddock	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Hake, longfin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hake, offshore	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Hake, red	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Hake, silver	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Hake, spotted	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Hake, white	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Halibut, Atlantic	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Herring, Atlantic	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	2	1	2	1	2	1	1	1
Herring, blueback	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Herring, round	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kingfish, northern	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kingfish, southern	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mackerel, Atlantic	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1
Mackerels, snake	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Needlefish, Atlantic	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pout, ocean	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Pollock	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Rays	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 2b. (Cont.)

Common Name	1987		1988		1989		1990		1991		1992		1993		1994		1995		1996		1997		1998		1999	
	Sp	Fa	Sp	Fa	Sp	Fa	Sp	Fa	Sp	Fa	Sp	Fa	Sp	Fa	Sp	Fa	Sp	Fa	Sp	Fa	Sp	Fa	Sp	Fa	Sp	Fa
Redfish, Acadian	2	2	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Rosefish, blackbelly	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Salmon, Atlantic	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Sand lance, northern	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sculpin, longhorn	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	2	1	2	1	1
Scup	2	2	2	2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Sea raven	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	2	1	2	2	2
Searobin, armored	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Searobin, northern	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Searobin, striped	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shad, American	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Shad, hickory	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Sharks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Skate, little	2	2	2	2	2	2	2	2	2	2	1	1	1	1	2	2	2	2	1	2	1	2	1	2	2	2
Skate, rosette	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Skate, smooth	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Skate, thorny	2	2	2	2	2	2	2	2	2	2	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2
Skate, winter	2	2	2	2	2	2	2	2	2	2	1	1	1	1	2	2	2	2	1	2	1	2	1	2	2	2
Spot	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Squid, longfin inshore	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Squid, northern shortfin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tautog	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Tilefish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weakfish	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Wolffish, Atlantic	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Wrymouth	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3. Levels of taxonomic resolution for selected prey items used in Food Web Dynamics Program analyses and summaries. ("Collection Category" is the minimum level of taxonomic resolution at which these data are sampled, with some grouping of invertebrates and fish prey at the species level. This category and the actual prey name represent the lowest taxonomic resolution, and are used in analyses for specific prey items or a single or small group of predators. "Analytical Category" is a broader taxonomic level that groups invertebrates to a higher level and fish to family. This category is used for many of our multispecies analyses and less-detailed diet summaries. "General Category" groups prey at the phylum or class level, and is used for more cursory diet summaries.)

		Category		
Common Name	**Scientific Name**	**Collection**	**Analytical**	**General**
Atlantic cod	*Gadus morhua*	GADMOR	Gadid fam.	Fish
Fourspot flounder	*Paralichthys oblongus*	PAROBL	Bothid fam.	Fish
Atlantic herring	*Clupea harengus*	CLUHAR	Clupeid fam.	Fish
Atlantic herring eggs	*Clupea harengus* eggs	CLUHAR	Clupeid fam.	Fish
Atlantic herring larvae	*Clupea harengus* larvae	Fish larvae	Fish larvae	Fish
Longfin inshore squid	*Loligo pealeii*	LOLPEA	Cephalapod	Mollusk
Northern shortfin squid	*Illex illecebrosus*	ILLILL	Cephalapod	Mollusk
Sea scallop	*Placopecten magellanicus*	Pectinid fam.	Bivalve	Mollusk
Naked sea butterfly	*Clione limacina*	Pteropod	Gastropod	Mollusk
Brittle stars & basket stars	Ophiuroidea	OPHIU1	OPHIU1	Echinoderm
Comb jellies or sea walnuts	Ctenophora	CTENOP	CTENOP	CTENOP
Atlantic rock crab	*Cancer irroratus*	Cancer fam.	Decapod	Arthropod
Northern shrimp	*Pandalus borealis*	Pandalid fam.	Decapod	Arthropod
Mysids	Mysidacea	Mysida	Mysida	Arthropod
Krill	Euphausiidae	Euphasiid fam.	Euphasiid fam.	Arthropod
Calanoid copepods	Calanoida	Copepod	Copepod	Arthropod
Gammarid	Gammaridea	Gammar	Amphipod	Arthropod

Table 4. Weight-to-volume regression statistics for all species combined and for selected species (N = sample size; R^2 = amount of variance explained; F = F statistic for the regression; P = probability that the slope is significantly different than 0; β = slope parameter; s = standard error of β)

Species	N	R^2	F	P	β	s
Species combined	10,806	90.6	99,999.99	0.0001	1.093	0.00338
Spiny dogfish	1,440	89.5	12,272.25	0.0001	1.040	0.00938
Winter skate	889	85.8	5,367.93	0.0001	1.105	0.01508
Little skate	213	94.9	3,945.33	0.0001	1.087	0.01730
Thorny skate	176	23.5	53.73	0.0001	1.228	0.16754
Silver hake	1,375	94.3	22,920.82	0.0001	1.042	0.00688
Atlantic cod	836	95.1	16,154.51	0.0001	1.090	0.00857
Pollock	216	95.6	4,666.91	0.0001	0.958	0.01402
White hake	105	91.3	1,097.99	0.0001	1.061	0.03201
Red hake	273	96.2	6,929.55	0.0001	1.364	0.01639
Fourspot flounder	649	87.9	4,704.09	0.0001	0.679	0.00989
Witch flounder	200	94.4	3,327.02	0.0001	1.025	0.01778
Windowpane	482	94.3	7,948.93	0.0001	0.967	0.01085
Atlantic herring	601	93.6	8716.15	0.0001	1.102	0.01088
Atlantic mackerel	369	86.9	2,444.78	0.0001	0.939	0.01899
Longhorn sculpin	1,844	86.5	11,852.49	0.0001	0.809	0.00743
Sea raven	469	94.6	8,243.01	0.0001	1.157	0.01274
Ocean pout	151	96.5	4,083.91	0.0001	0.921	0.01441
Goosefish	133	95.7	2,927.13	0.0001	1.236	0.02285
Northern shortfin squid	170	80.2	685.62	0.0001	1.157	0.04417
Longfin inshore squid	116	90.6	1,114.49	0.0001	1.476	0.04422

Table 5. Summary parameters for predators examined by the Food Web Dynamics Program during 1973-98 (units of weight = g; units of length = cm; *s* = standard error of the mean of stomach weight)

Species	Stomach Weights			Predator Length			Predator Weights	
	No.	Mean	*s*	Mean	Min.	Max.	No.	Mean
Gadids & Macrourids								
Silver hake	36,756	2.69	0.060	25.44	3	76	15,733	121.10
Atlantic cod	15,146	30.20	0.704	53.74	1	150	4,870	2,058.77
Red hake	12,994	3.41	0.097	30.88	4	72	5,036	209.23
White hake	11,740	16.93	0.520	42.72	7	136	4,832	771.45
Spotted hake	7,481	2.17	0.067	23.74	5	43	4,731	136.67
Pollock	4,200	18.03	0.876	50.86	10	120	1,561	1,381.05
Haddock	3,618	5.46	0.220	44.77	8	88	167	671.66
Cusk	141	0.84	0.284	66.67	14	104	17	2,357.59
Offshore hake	99	3.94	2.421	33.23	13	52	14	217.71
Longfin hake	25	0.62	0.259	21.56	16	35	0	-
Longnose grenadier	18	0.20	0.056	15.78	10	23	0	-
Fourbeard rockling	10	0.05	0.018	22.20	15	32	0	-
Marlin-spike	10	0.26	0.052	20.10	15	26	0	-
Ling unclassified	4	0.08	0.028	12.75	11	14	0	-
Grenadier unclassified	3	0.14	0.031	26.00	26	26	0	-
Carolina hake	1	11.00	-	28.00	28	28	0	-
Flounders								
Fourspot flounder	10,040	1.10	0.038	27.08	5	49	6,799	162.19
Windowpane	8,982	1.51	0.053	25.69	3	41	5,451	211.55
Summer flounder	8,937	2.23	0.108	36.12	13	82	6,027	582.83
Winter flounder	2,733	2.84	0.117	31.25	8	65	73	430.97
Yellowtail flounder	2,015	1.08	0.049	30.64	3	58	74	326.82
American plaice	1,786	1.03	0.105	29.93	4	70	16	450.00
Witch flounder	1,014	0.62	0.042	41.72	5	65	108	196.16
Atlantic halibut	229	21.16	3.766	58.28	27	134	35	2,660.51
Gulf Stream flounder	219	0.02	0.002	10.26	4	18	0	-
Southern flounder	5	3.30	3.300	26.00	21	33	0	-
Dusky flounder	3	0.06	0.061	20.67	17	23	2	69.50
Greenland halibut	1	0.33	-	15.00	15	15	1	22.00
Pelagic Piscivores								
Bluefish	3,208	21.47	1.237	35.19	8	88	829	978.51
Weakfish	3,102	3.04	0.171	25.95	7	79	1,774	238.75
Striped bass	204	52.48	9.633	56.27	23	118	188	2,787.82
Cobia	22	112.28	26.738	94.91	58	122	12	12,900.83
King mackerel	17	17.20	5.667	81.94	56	117	2	8,710.00
Atlantic bonito	11	29.31	24.674	50.36	23	57	3	2,018.00
Greater amberjack	9	105.65	83.863	59.00	21	114	0	-
Blue runner	2	0.06	0.055	15.00	15	15	0	-
Striped bonito	2	35.75	8.250	56.00	55	57	2	3,130.00
Atlantic salmon	1	2.61	-	34.00	34	34	0	-

Table 5. (Cont.)

Species	Stomach Weights			Predator Length			Predator Weights	
	No.	Mean	*s*	Mean	Min.	Max.	No.	Mean
Elasmobranchs								
Spiny dogfish	41,896	14.82	0.227	69.40	13	117	15,082	1,469.64
Smooth dogfish	3,809	43.41	0.946	86.82	36	150	1,216	2,392.67
Atlantic sharpnose shark	199	18.96	2.334	81.54	34	154	10	3,020.00
Dusky shark	68	36.62	7.631	97.56	49	212	0	-
Sandbar shark	64	78.03	30.213	110.73	60	204	0	-
Chain dogfish	40	2.03	0.693	29.35	15	45	4	323.75
Sand tiger	7	224.29	149.086	196.29	105	246	0	-
Scalloped hammerhead shark	4	20.31	13.098	84.25	54	112	0	-
Shortfin mako	1	141.10	-	146.00	146	146	0	-
Thresher shark	1	33.00	-	169.00	169	169	0	-
Blacknose shark	1	8.80	-	104.00	104	104	0	-
Smooth hammerhead shark	1	2.09	-	92.00	92	92	0	-
Blacktip shark	1	-	-	138.00	138	138	0	-
Little skate	19,063	4.18	0.042	39.71	6	63	11,719	432.71
Winter skate	12,122	10.77	0.226	60.41	13	135	6,444	1,620.10
Thorny skate	2,604	11.72	0.606	49.12	12	108	1,096	1,584.89
Smooth skate	286	4.63	0.388	44.44	11	66	82	451.37
Clearnose skate	244	7.09	0.670	57.38	22	73	72	1,101.04
Rosette skate	34	1.32	0.251	35.18	19	43	10	229.00
Barndoor skate	15	30.33	8.778	74.93	25	114	8	3,631.75
Bullnose say	80	20.60	4.871	56.78	29	119	7	1,108.14
Bluntnose stingray	71	31.62	6.114	54.94	21	118	3	1,928.00
Spiny butterfly ray	51	2.56	1.205	93.77	52	199	0	-
Atlantic torpedo	15	17.96	13.012	70.60	25	125	1	17,500.00
Roughtail stingray	13	84.01	31.269	98.62	74	129	0	-
Cownose ray	11	1.42	1.187	48.73	46	53	0	-
Southern stingray	1	17.22	-	84.00	84	84	0	-
Atlantic stingray	1	-	-	77.00	77	77	0	-
Squids								
Longfin inshore squid	3,002	0.53	0.027	13.07	1	39	0	-
Northern shortfin squid	2,946	1.59	0.162	20.06	3	32	0	-
Pelagic Planktivores								
Atlantic herring	11,576	0.59	0.016	23.49	8	46	10,163	125.49
Atlantic mackerel	4,001	1.43	0.057	28.19	12	47	3,170	235.72
Butterfish	2,048	0.16	0.009	12.95	2	24	17	50.00
Northern sand lance	1,339	0.07	0.005	14.37	4	27	0	-
Alewife	362	0.95	0.077	23.11	7	34	1	68.00
Atlantic argentine	185	0.17	0.055	31.09	9	44	0	-
Round herring	104	0.28	0.061	12.05	10	18	0	-

Table 5. (Cont.)

Species	Stomach Weights No.	Stomach Weights Mean	Stomach Weights *s*	Predator Length Mean	Predator Length Min.	Predator Length Max.	Predator Weights No.	Predator Weights Mean
Blueback herring	85	0.73	0.136	21.51	9	28	0	-
American shad	52	7.06	1.844	28.83	10	52	11	1,087.45
Spanish mackerel	43	3.51	1.331	34.63	16	62	3	984.33
Inshore lizardfish	42	2.13	0.571	24.10	16	35	1	87.00
Chub mackerel	35	0.44	0.123	19.31	14	23	0	-
Atlantic menhaden	34	0.08	0.022	20.82	12	28	0	-
Striped anchovy	15	0.07	0.036	11.87	10	13	0	-
Round scad	15	<0.01	0.002	16.33	14	18	0	-
Rough scad	11	0.03	0.004	13.64	12	15	0	-
Lanternfish unclassified	10	0.06	0.021	8.30	8	10	0	-
Bigeye scad	10	0.02	0.004	13.70	13	15	0	-
Hygophum taaningi	9	0.02	0.007	6.67	6	7	0	-
Offshore lizardfish	9	0.98	0.560	14.22	7	23	3	78.67
Spanish sardine	8	-	-	5.25	5	6	0	-
Shortnose greeneye	6	0.04	0.020	12.50	11	14	0	-
Atlantic saury	1	-	-	32.00	32	32	0	-
Striated argentine	1	-	-	8.00	8	8	0	-
Rockfishes								
Acadian redfish	1,244	1.24	0.116	30.89	8	45	2	38.50
Blackbelly rosefish	98	0.44	0.160	16.95	6	36	0	-
Bigeye	9	1.64	0.604	27.67	15	39	0	-
Armored Fishes								
Longhorn sculpin	8,029	2.63	-	25.12	3	38	5,072	181.11
Sea raven	4,486	14.60	0.717	31.19	7	67	2,554	802.62
Northern searobin	110	0.71	0.124	22.69	13	34	17	217.53
Armored searobin	33	0.09	0.046	25.91	7	32	0	-
Moustache sculpin	28	0.07	0.021	10.57	7	15	0	-
Striped searobin	23	2.80	0.773	27.00	19	39	0	-
Hookear sculpin	22	0.01	0.008	6.41	4	8	0	-
Searobin unclassified	8	<0.01	0.001	8.63	5	11	0	-
Shorthorn sculpin	1	0.04	-	33.00	33	33	0	-
Horned searobin	1	-	-	5.00	5	5	0	-
Bluespotted searobin	1	-	-	16.00	16	16	0	-
Bighead searobin	1	-	-	20.00	20	20	0	-
Eel-like Fishes								
Ocean pout	673	6.20	0.503	48.54	13	95	43	551.86
Fawn cusk-eel	146	0.03	0.004	21.64	14	30	0	-
Atlantic wolffish	89	10.50	2.214	47.64	3	137	12	3,397.08
Northern pipefish	38	<0.01	0.001	18.87	14	24	0	-
Snakefish	25	1.66	0.757	17.84	13	23	0	-
Conger eel	14	10.70	4.736	65.50	39	109	1	3,280.00

Table 5. (Cont.)

Species	Stomach Weights No.	Stomach Weights Mean	Stomach Weights *s*	Predator Length Mean	Predator Length Min.	Predator Length Max.	Predator Weights No.	Predator Weights Mean
Atlantic cutlassfish	11	0.08	0.033	48.36	44	53	0	-
Striped cusk-eel	11	0.03	0.017	20.91	16	30	0	-
Red cornetfish	5	6.33	4.066	83.60	43	103	0	-
Atlantic hagfish	4	0.01	0.005	42.75	33	55	0	-
Margined snake eel	3	0.12	0.055	39.00	36	42	0	-
Daubed shanny	3	0.01	0.002	11.67	11	13	0	-
Radiated shanny	3	0.04	0.019	13.00	12	14	0	-
Wrymouth	3	0.40	0.202	34.67	23	41	0	-
Atlantic soft pout	3	<0.01	0.001	11.00	11	11	0	-
Snubnose eel	1	-	-	11.00	11	11	0	-
Wolf eelpout	1	-	-	12.00	12	12	0	-
Unaesthetic Fishes								
Goosefish	5,600	38.99	2.253	44.24	6	124	3,039	1,410.41
Atlantic midshipman	10	0.11	0.050	14.00	14	14	0	-
Lumpfish	2	27.87	7.386	35.50	31	40	0	-
Northern stargazer	2	10.45	1.650	21.00	19	23	0	-
Alligatorfish	1	0.01	-	9.00	9	9	0	-
Southern stargazer	1	2.12	-	22.00	22	22	0	-
Miscellaneous Mid-Atlantic Species								
Scup	1,500	0.33	0.024	15.93	6	37	2	169.50
Black sea bass	838	1.31	0.118	21.91	5	55	11	155.00
Spot	488	0.12	0.014	17.03	10	26	10	108.90
Atlantic croaker	377	0.95	0.096	24.48	11	45	10	98.30
Buckler dory	112	4.29	1.514	22.14	11	53	1	2,160.00
Northern kingfish	79	0.53	0.079	23.37	10	30	6	173.50
Cunner	60	0.75	0.239	26.25	5	47	1	734.00
Pigfish	10	0.40	0.194	18.40	16	24	0	-
Tilefish	10	0.71	0.309	42.00	25	61	0	-
Tautog	5	0.22	0.220	35.40	24	64	0	-
Atlantic sturgeon	3	119.17	9.167	97.00	84	120	0	-
Sharksucker	1	6.60	-	43.00	43	43	0	-
Miscellaneous Southern Species								
Southern kingfish	119	1.43	0.316	23.84	15	32	12	163.08
Whitebone porgy	24	1.03	0.656	27.79	20	34	0	-
Tomtate	23	0.07	0.050	15.83	11	19	0	-
Deepbody boarfish	15	1.08	0.195	15.40	12	19	0	-
Vermilion snapper	15	0.69	0.436	19.07	12	24	0	-
Sheepshead	15	13.64	3.435	46.87	31	55	0	-
Banded rudderfish	13	1.44	0.478	23.23	18	27	0	-
White grunt	13	1.49	0.469	29.23	24	35	0	-
Saucereye porgy	12	0.92	0.354	21.50	12	30	0	-

Table 5. (Cont.)

Species	Stomach Weights No.	Stomach Weights Mean	Stomach Weights *s*	Predator Length Mean	Predator Length Min.	Predator Length Max.	Predator Weights No.	Predator Weights Mean
Banded drum	11	0.02	0.006	15.09	14	20	0	-
Spottail pinfish	9	0.25	0.124	20.44	12	29	0	-
Pinfish	9	0.17	0.076	16.44	15	18	0	-
Red porgy	9	1.47	0.750	29.89	21	40	0	-
Snowy grouper	8	23.24	13.444	69.38	46	90	0	-
Planehead filefish	7	<0.01	0.001	6.43	5	8	0	-
Yellowfin bass	7	0.27	0.150	23.57	20	27	0	-
Scamp	6	7.10	6.745	68.17	51	99	0	-
Silver perch	5	<0.01	0.001	19.00	18	20	0	-
Atlantic spadefish	4	2.75	0.710	41.50	38	45	0	-
Sand perch	3	0.41	0.399	20.33	18	24	0	-
Hogchoker	2	0.06	0.055	17.50	17	18	0	-
Warsaw grouper	2	203.50	126.500	104.50	84	125	0	-
Hogfish	2	4.49	1.186	57.00	55	59	0	-
Gray triggerfish	2	-	-	33.50	10	57	0	-
Longspine snipefish	2	-	-	12.50	12	13	0	-
Almaco jack	1	209.00	-	94.00	94	94	0	-
Black drum	1	165.00	-	108.00	108	108	0	-
Blueline tilefish	1	13.20	-	50.00	50	50	0	-
Conejo	1	-	-	25.00	25	25	0	-
Striped burrfish	1	-	-	14.00	14	14	0	-
Beardfish	1	-	-	16.00	16	16	0	-
Yellowmouth grouper	1	-	-	76.00	76	76	0	-
Gag	1	-	-	108.00	108	108	0	-
Atlantic bumper	1	-	-	16.00	16	16	0	-
Spotted seatrout	1	-	-	56.00	56	56	0	-

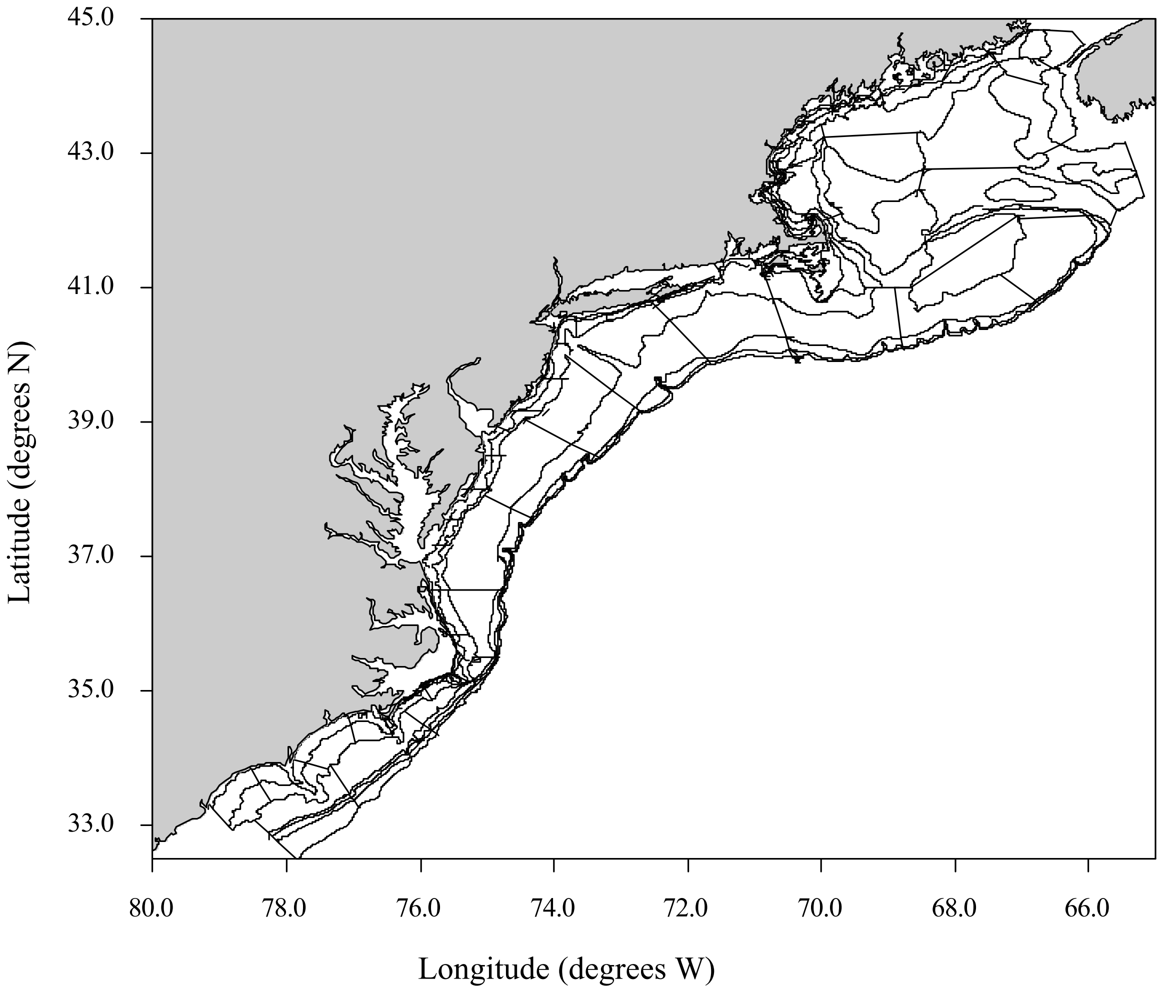


Figure 1. Map of the Northeast U.S. Continental Shelf Ecosystem depicting the area covered by the NEFSC Bottom Trawl Survey Program.

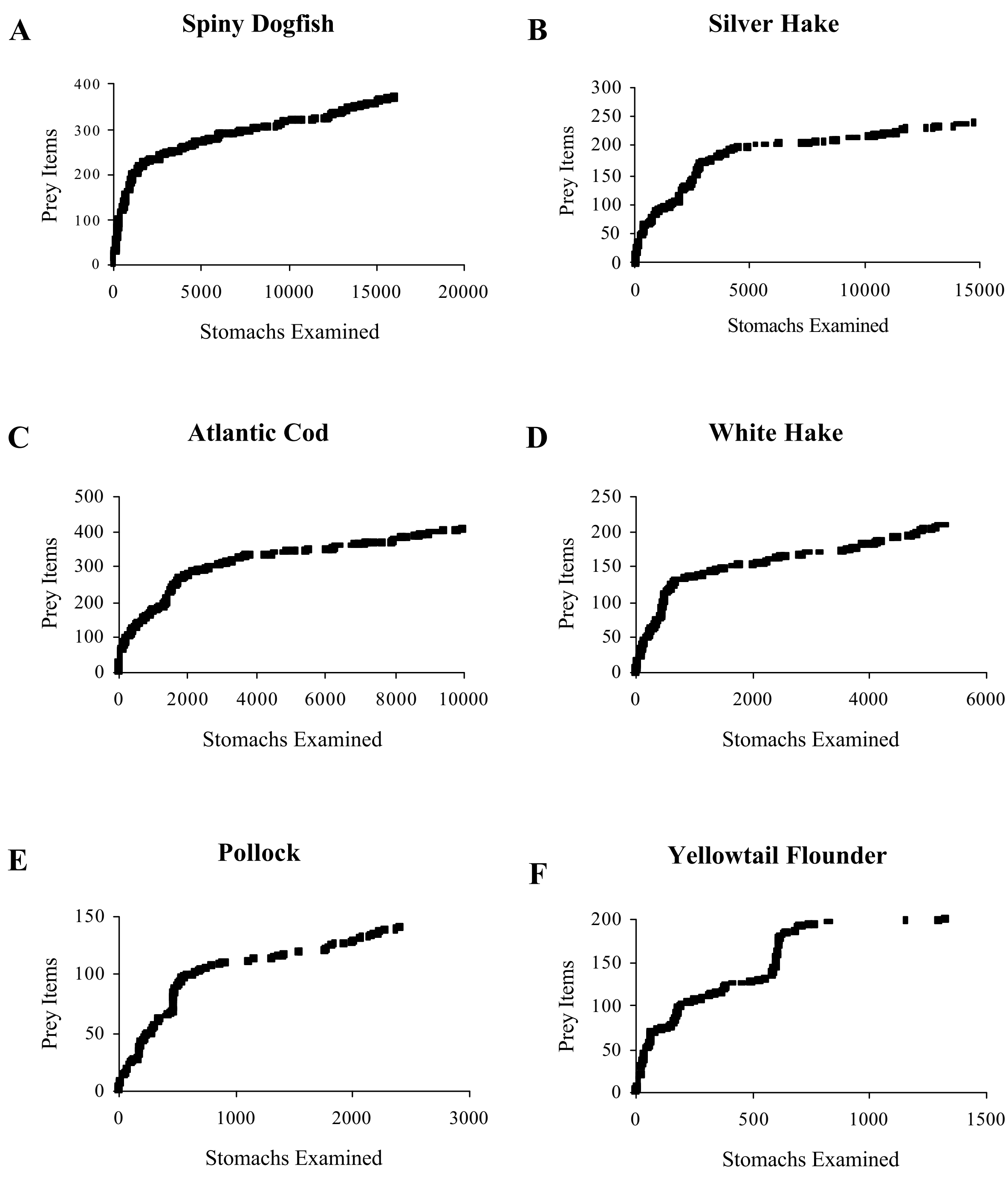


Figure 2. The number of stomachs examined versus the number of prey items observed for spiny dogfish, silver hake, Atlantic cod, white hake, pollock, and yellowtail flounder.

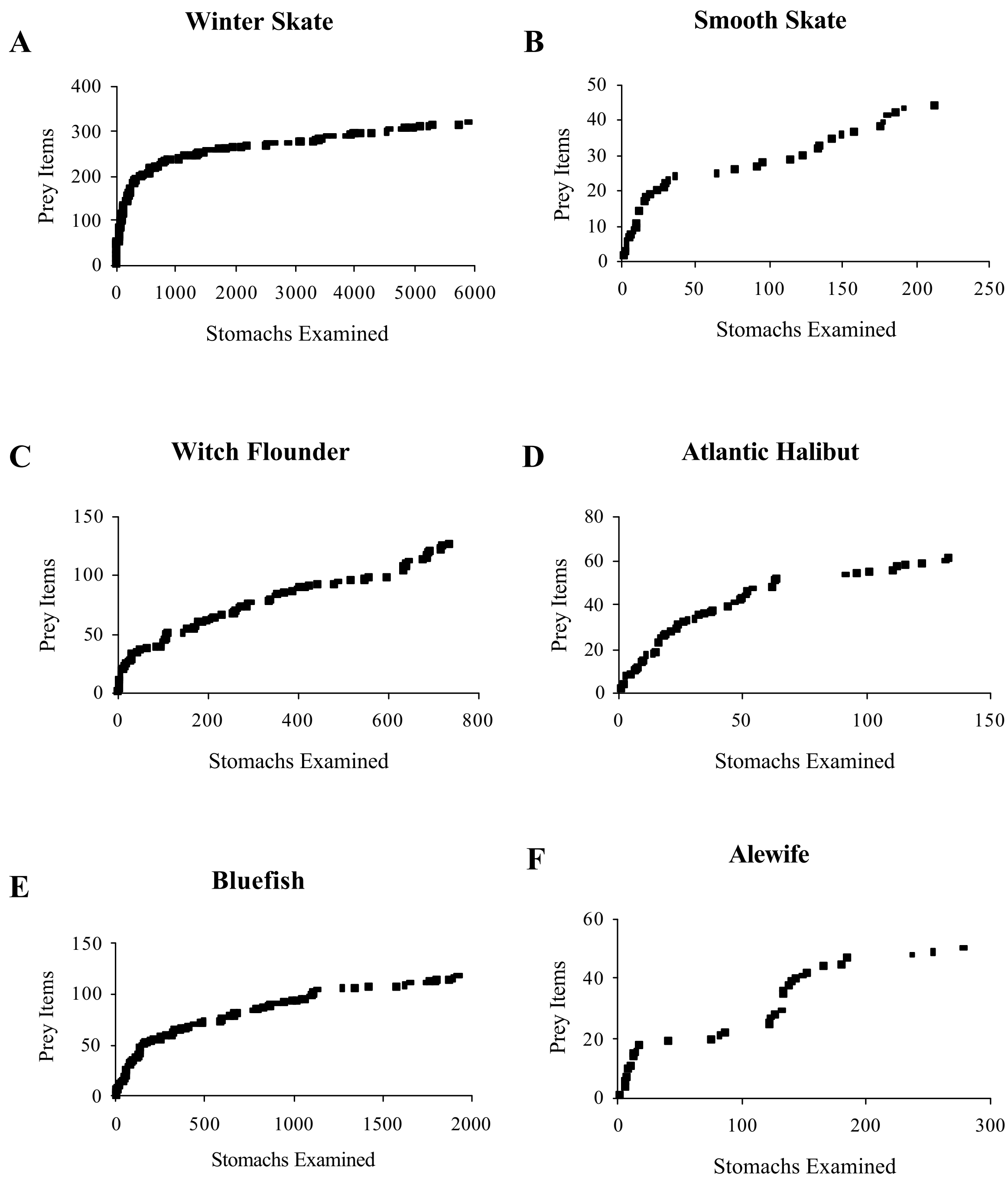


Figure 3. The number of stomachs examined versus the number of prey items observed for winter skate, smooth skate, witch flounder, Atlantic halibut, bluefish, and alewife.

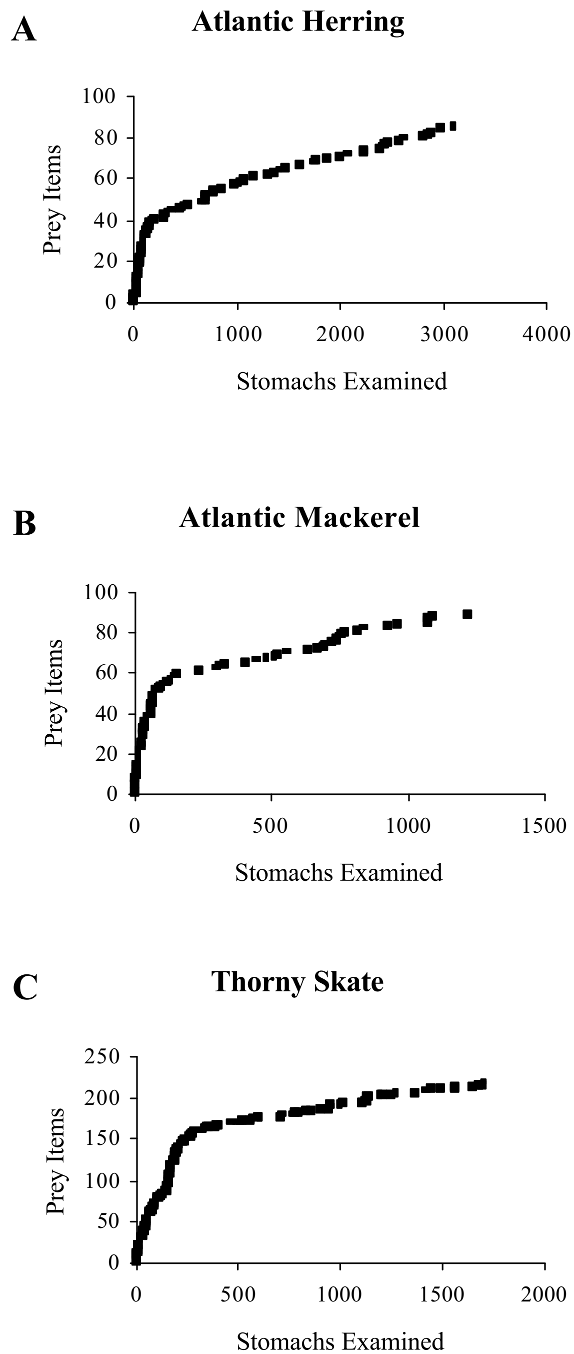


Figure 4. The number of stomachs examined versus the number of prey items observed for Atlantic herring, Atlantic mackerel, and thorny skate.

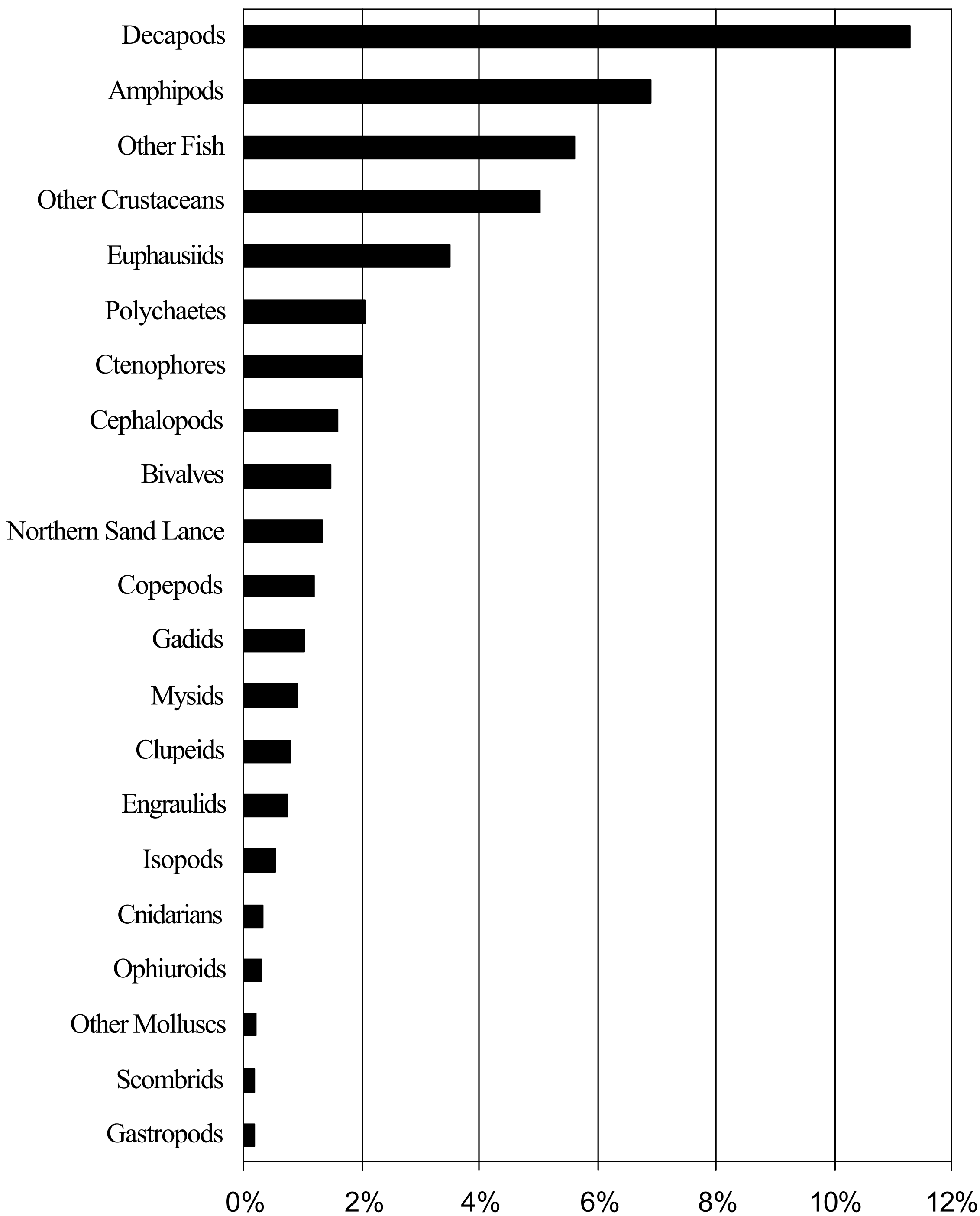


Figure 5. Percent frequency of occurrence of major prey items, excluding well digested prey and empty stomachs, for all predators in the database.

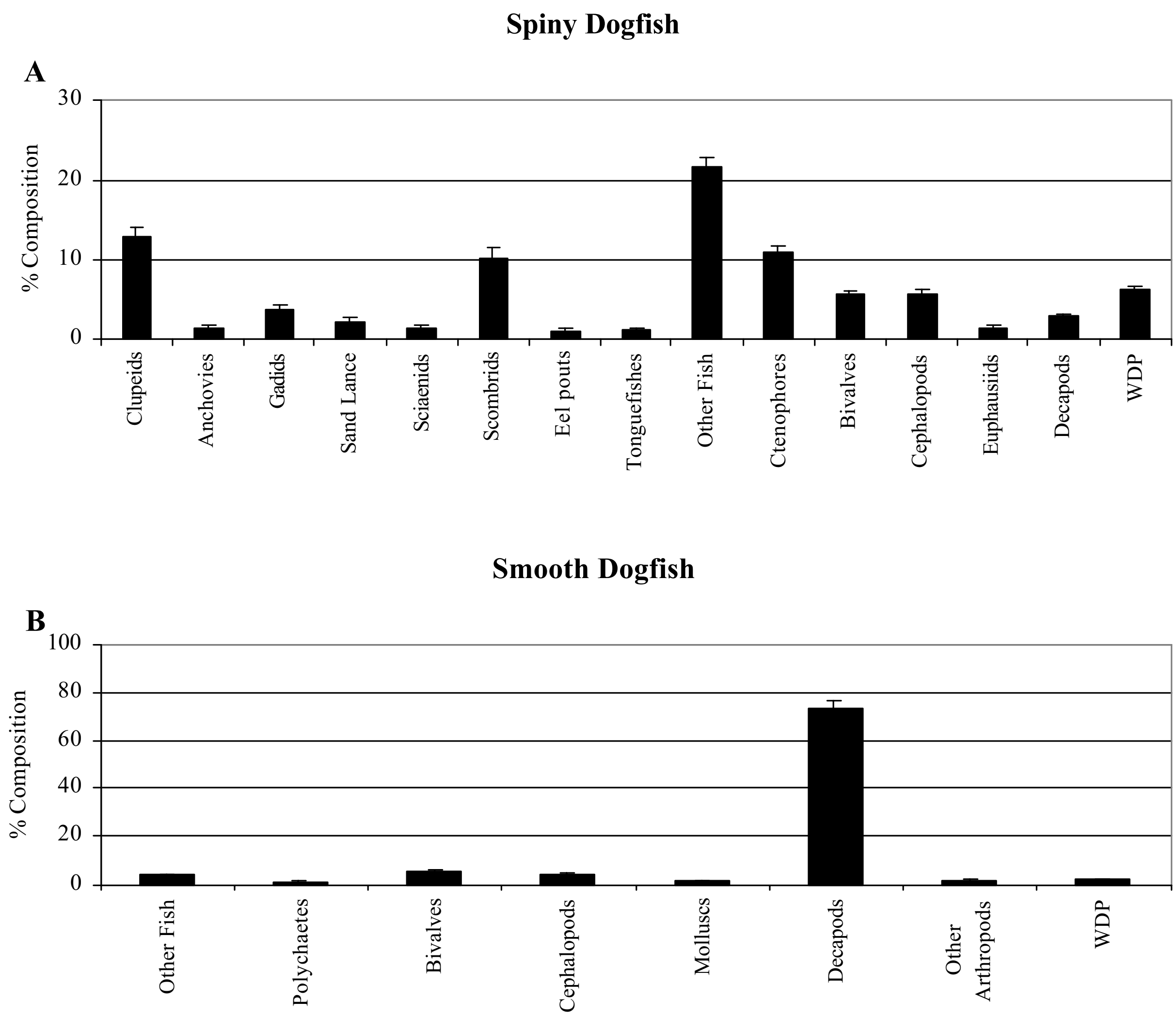


Figure 6. Percent diet composition by weight of major prey items for spiny dogfish and smooth dogfish. Throughout WDP is well digested prey.

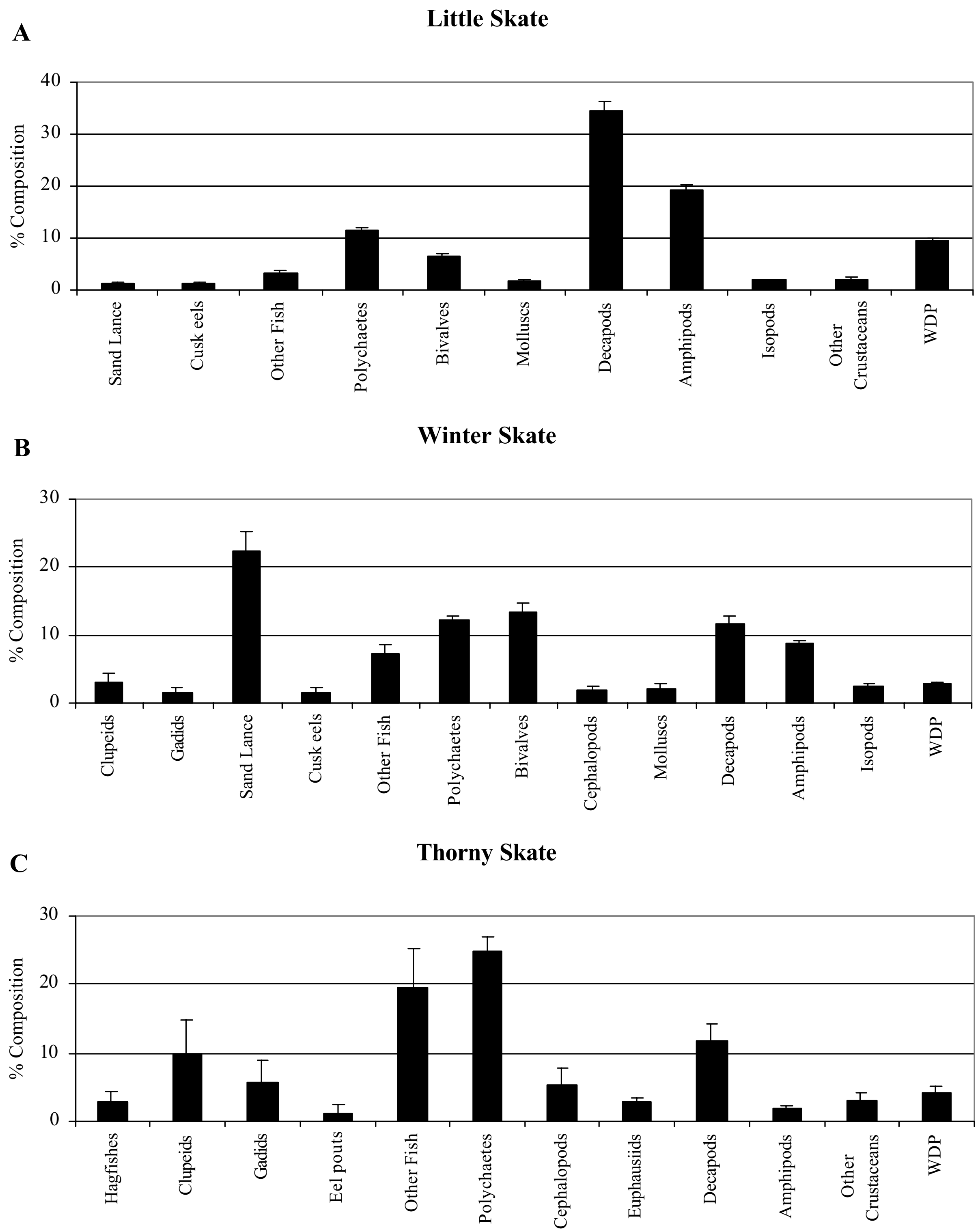
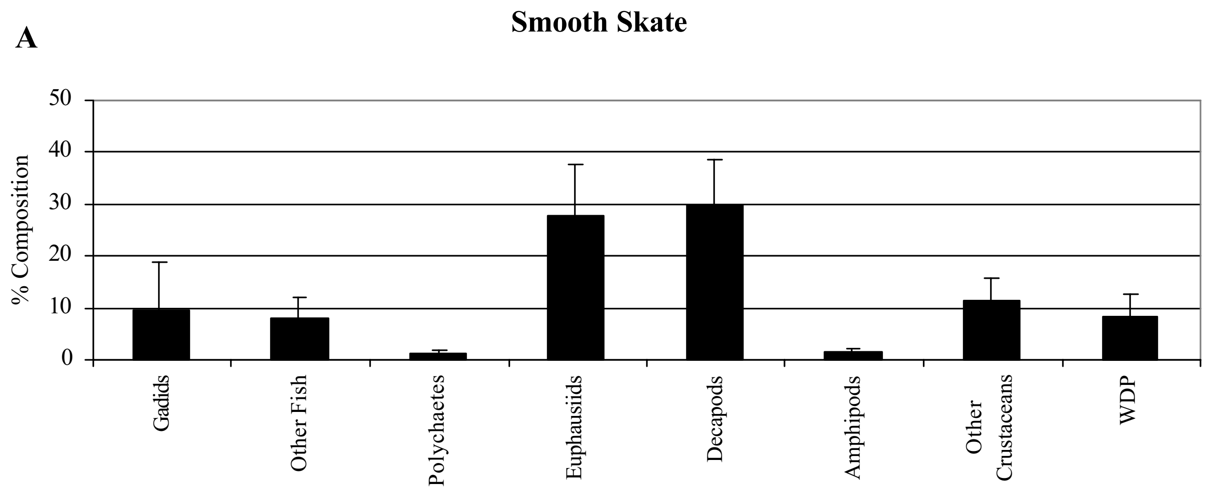


Figure 7. Percent diet composition by weight of major prey items for little skate, winter skate, and thorny skate.



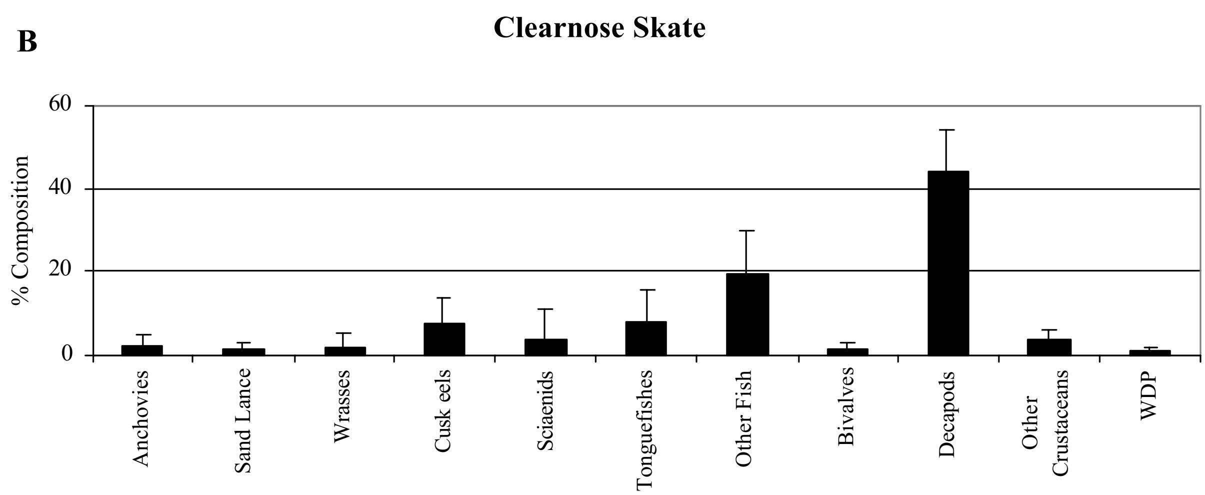


Figure 8. Percent diet composition by weight of major prey items for smooth skate and clearnose skate.

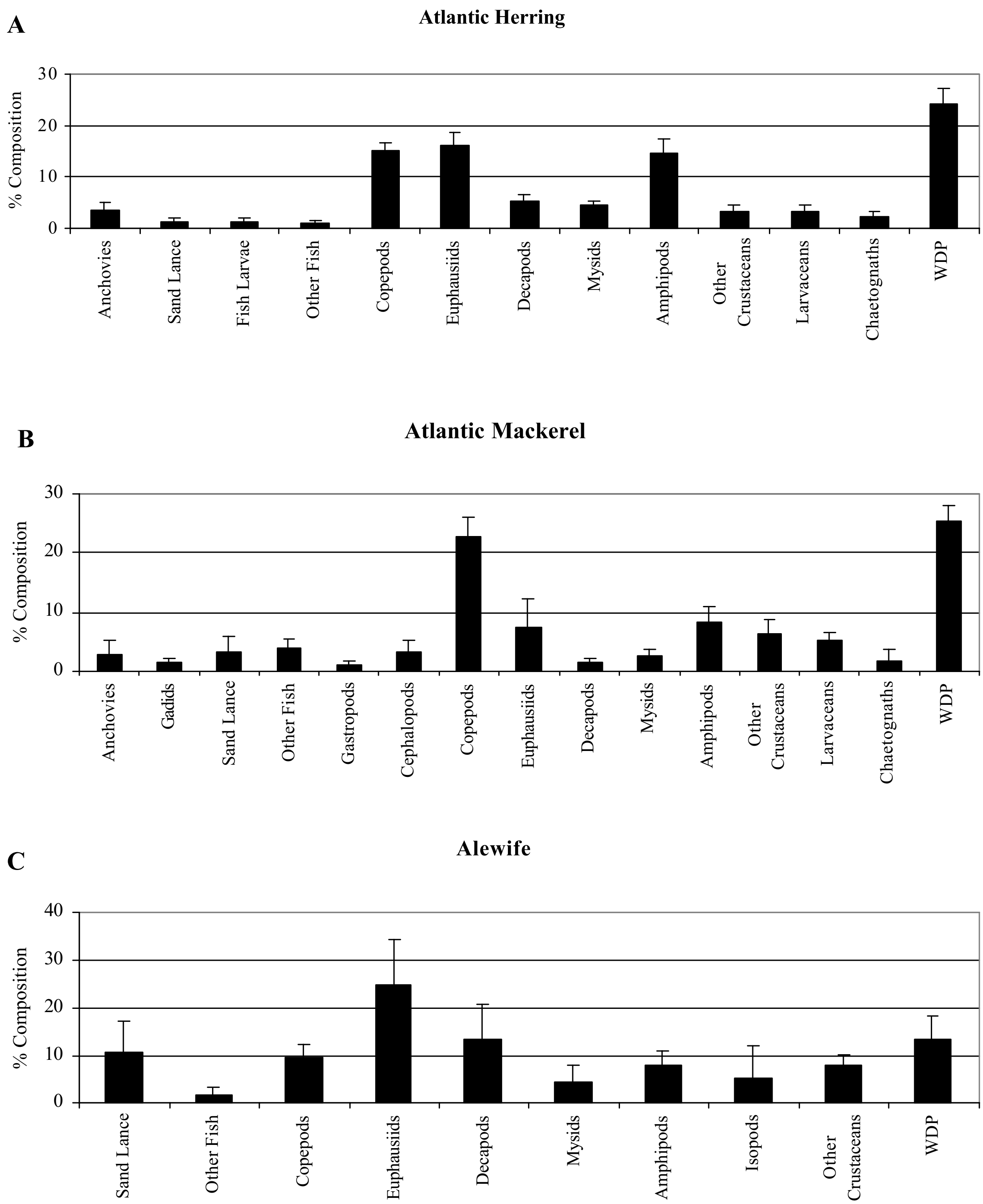


Figure 9. Percent diet composition by weight of major prey items for Atlantic herring, Atlantic mackerel, and alewife.

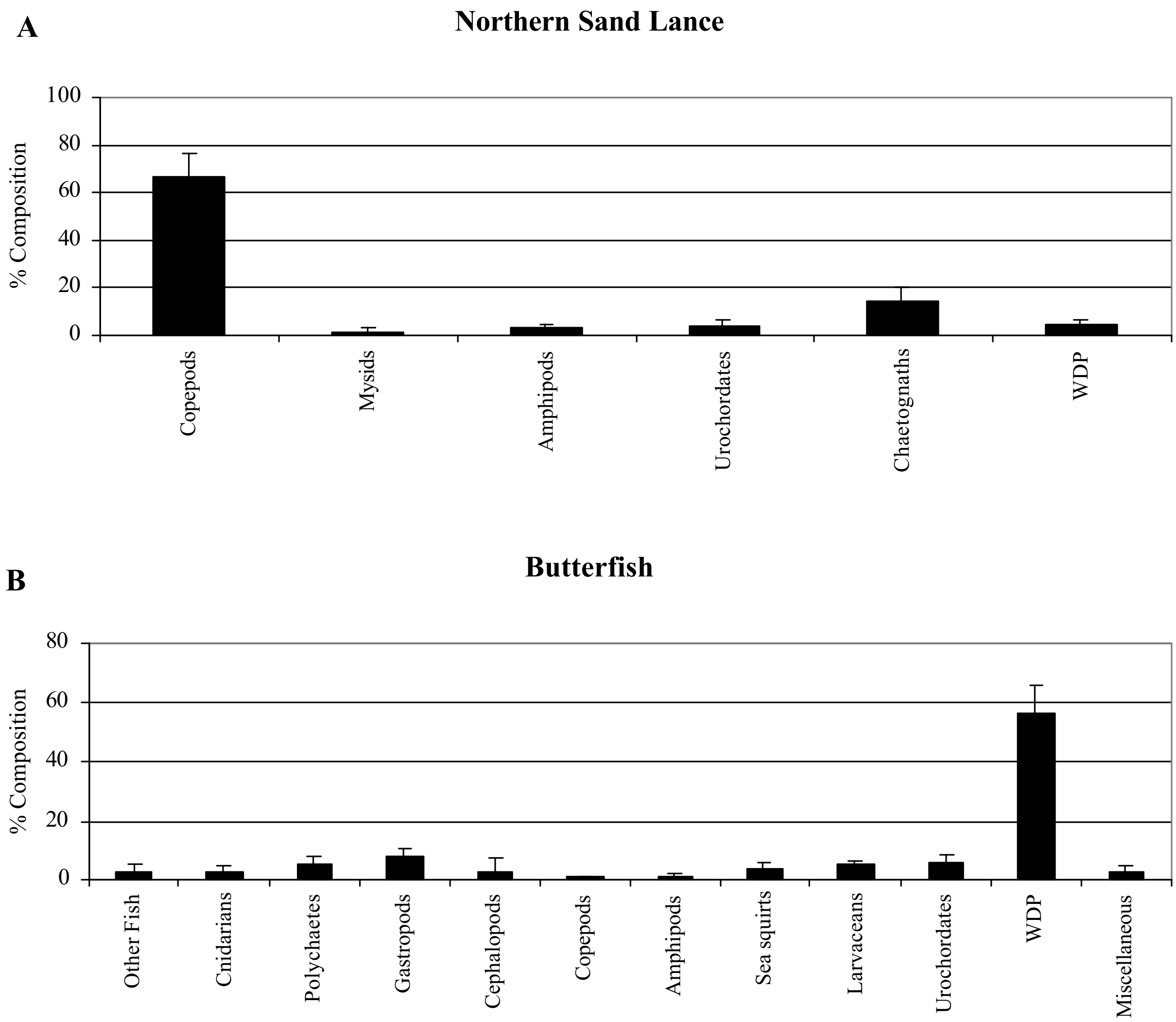


Figure 10. Percent diet composition by weight of major prey items for northern sand lance and butterfish.

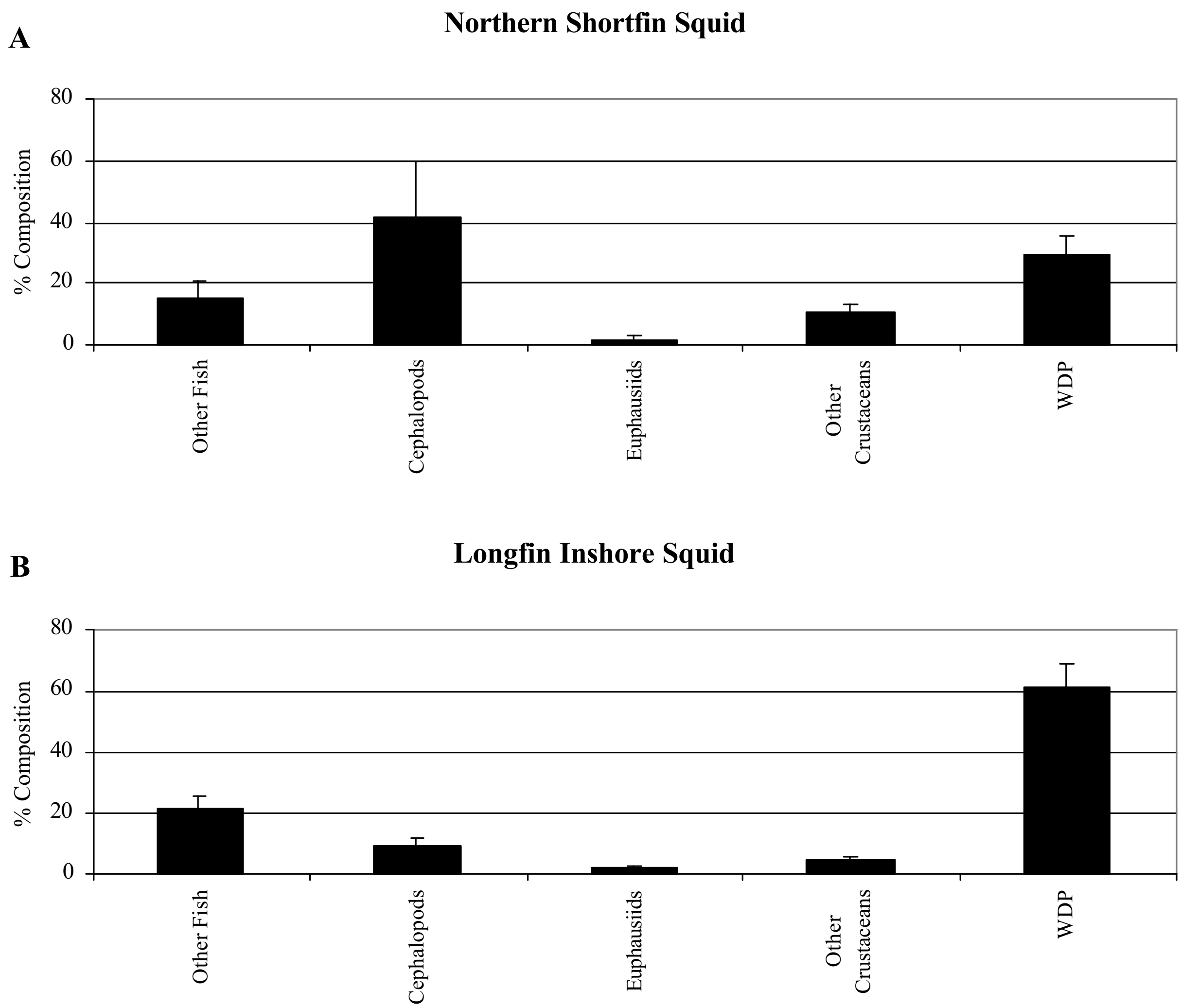


Figure 11. Percent diet composition by weight of major prey items for northern shortfin squid and longfin inshore squid.

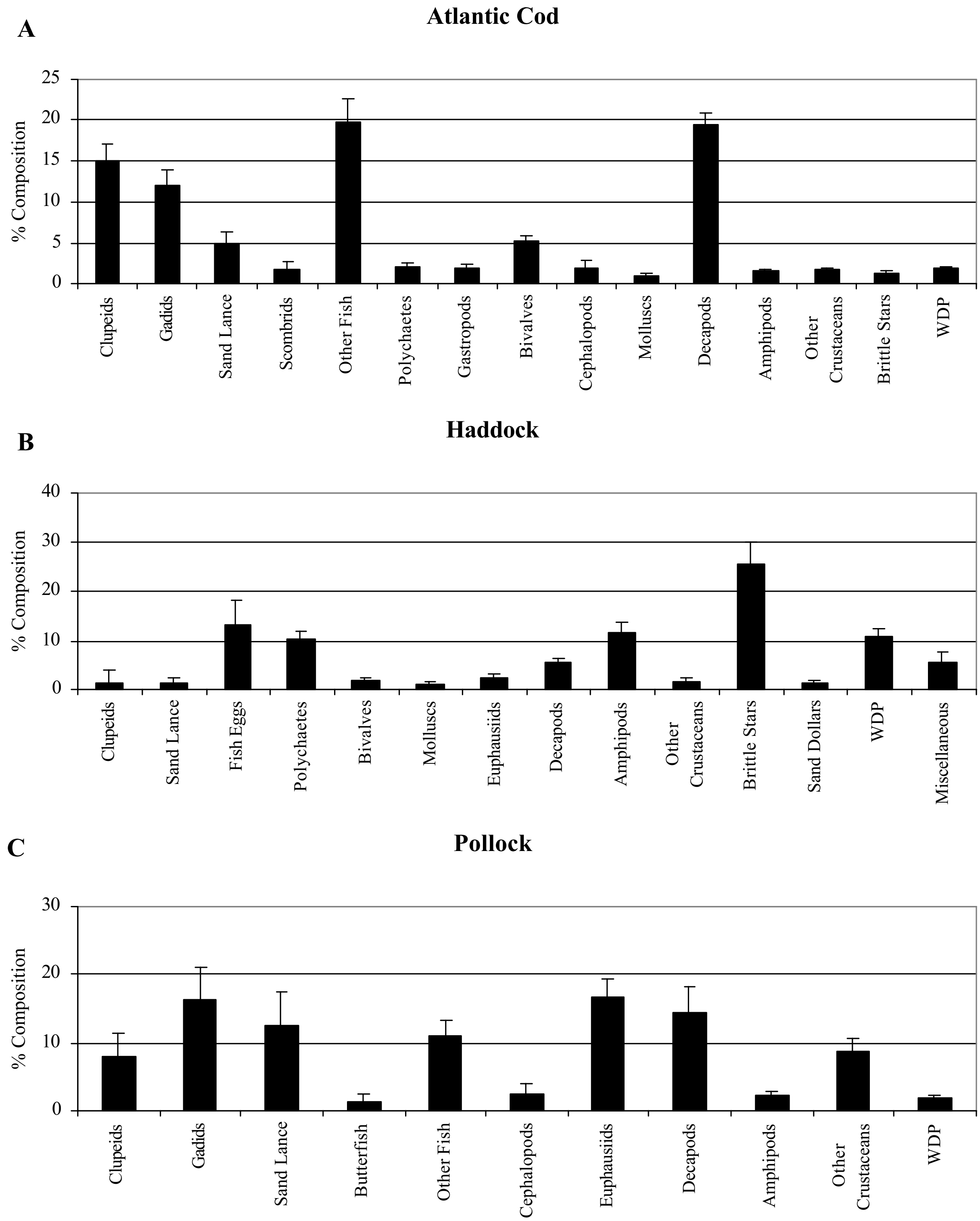
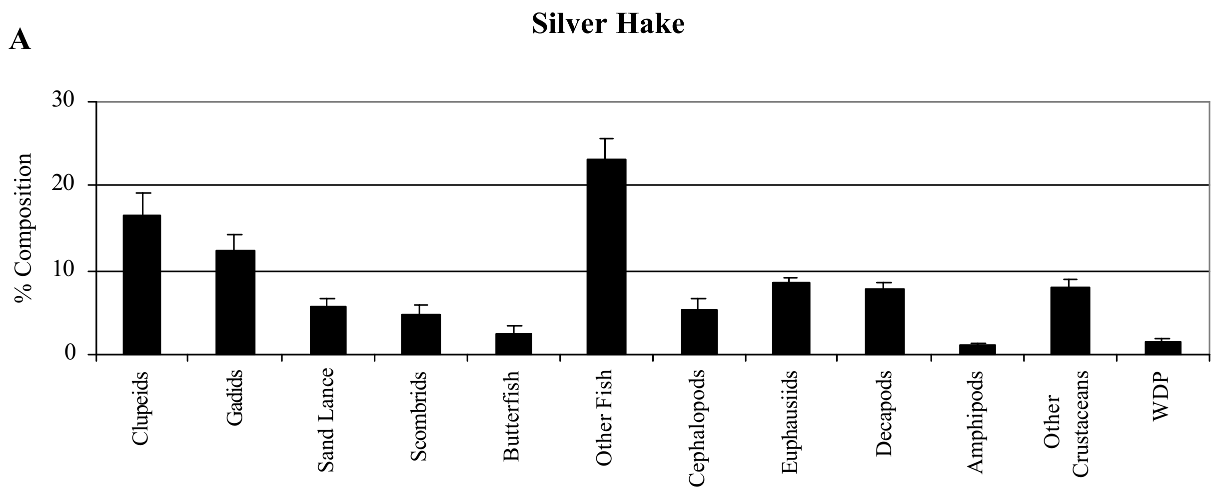


Figure 12. Percent diet composition by weight of major prey items for Atlantic cod, haddock, and pollock.



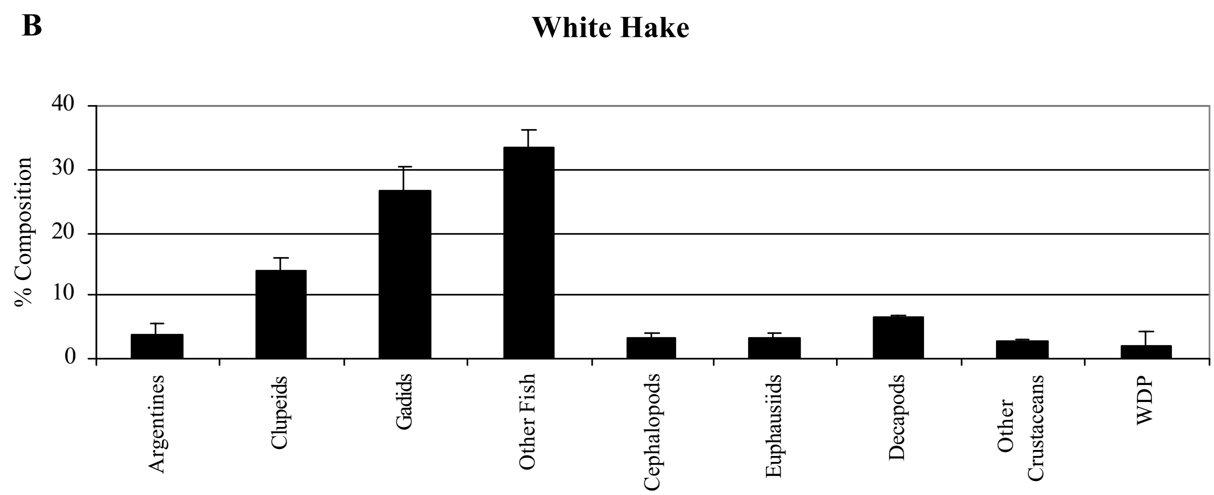
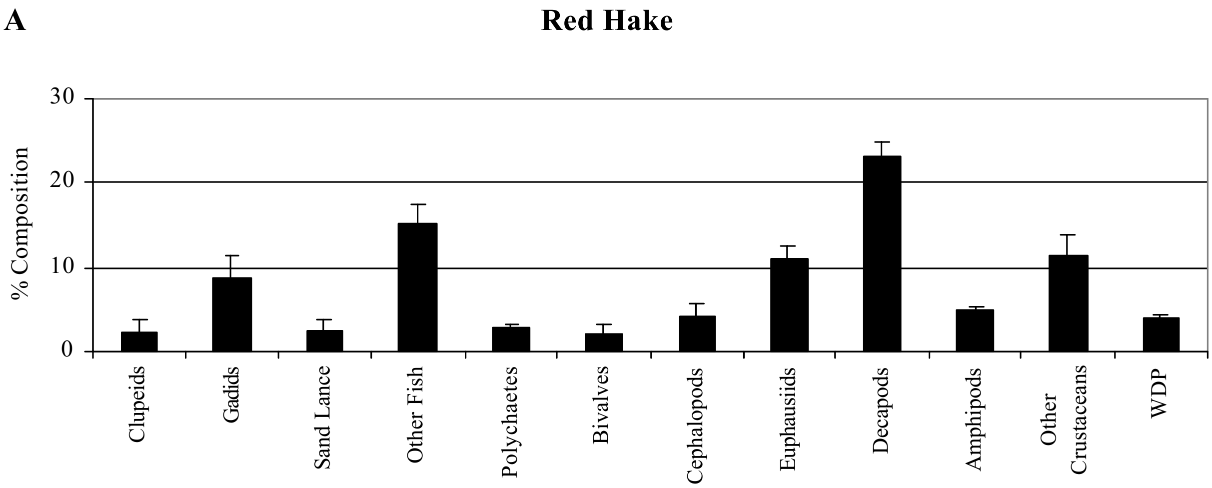


Figure 13. Percent diet composition by weight of major prey items for silver hake and white hake.

A



B

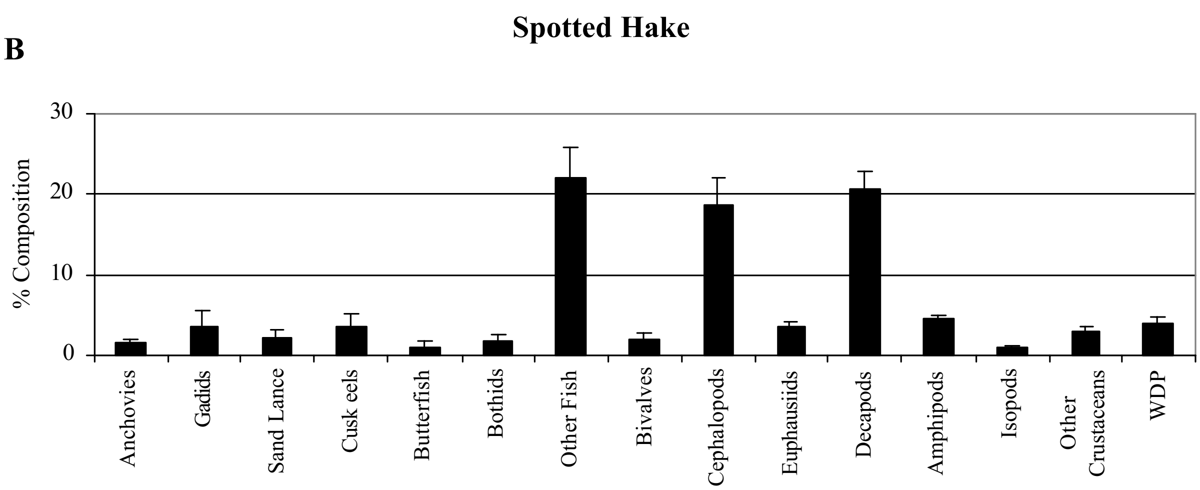


Figure 14. Percent diet composition by weight of major prey items for red hake and spotted hake.

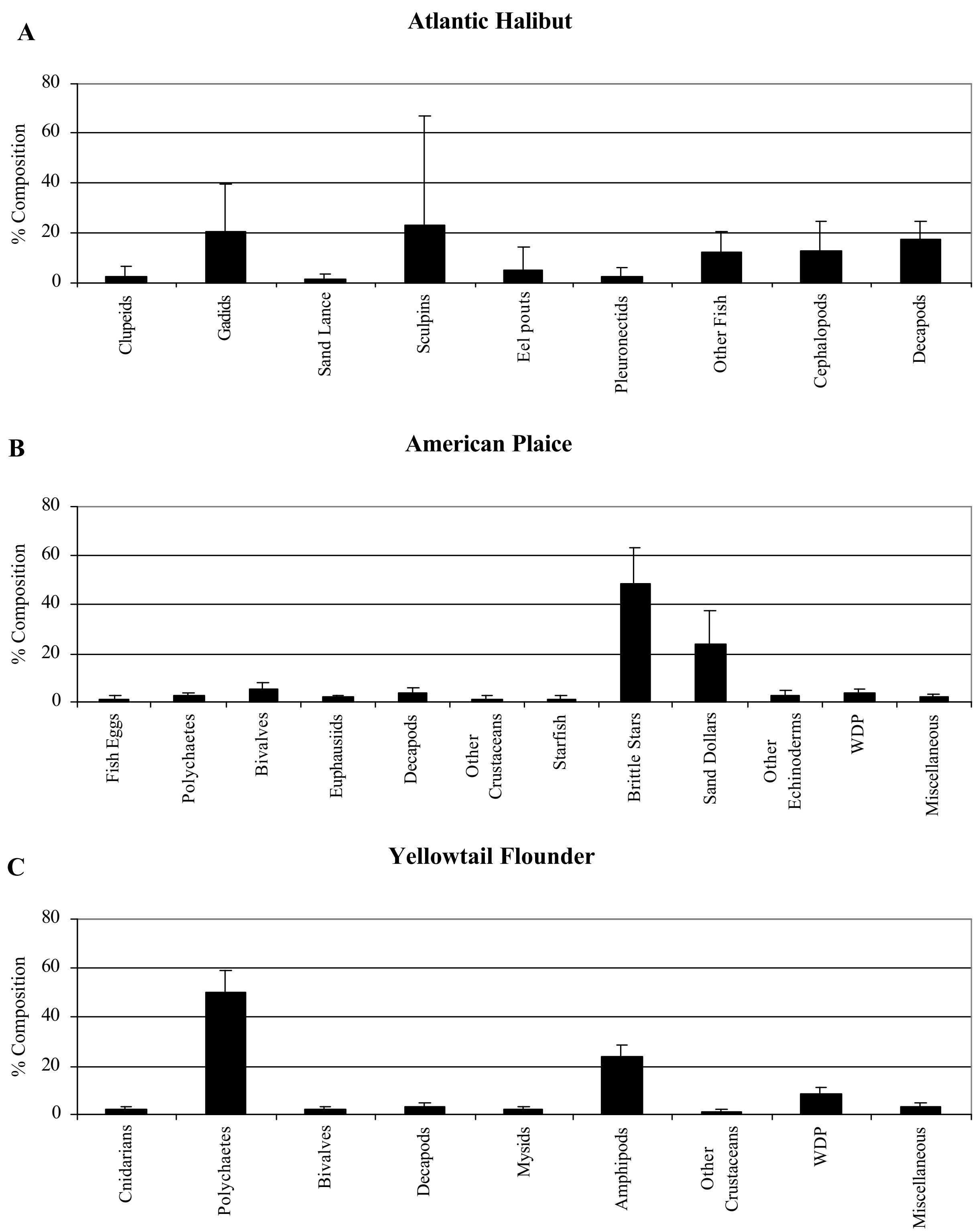


Figure 15. Percent diet composition by weight of major prey items for Atlantic halibut, American plaice, and yellowtail flounder.

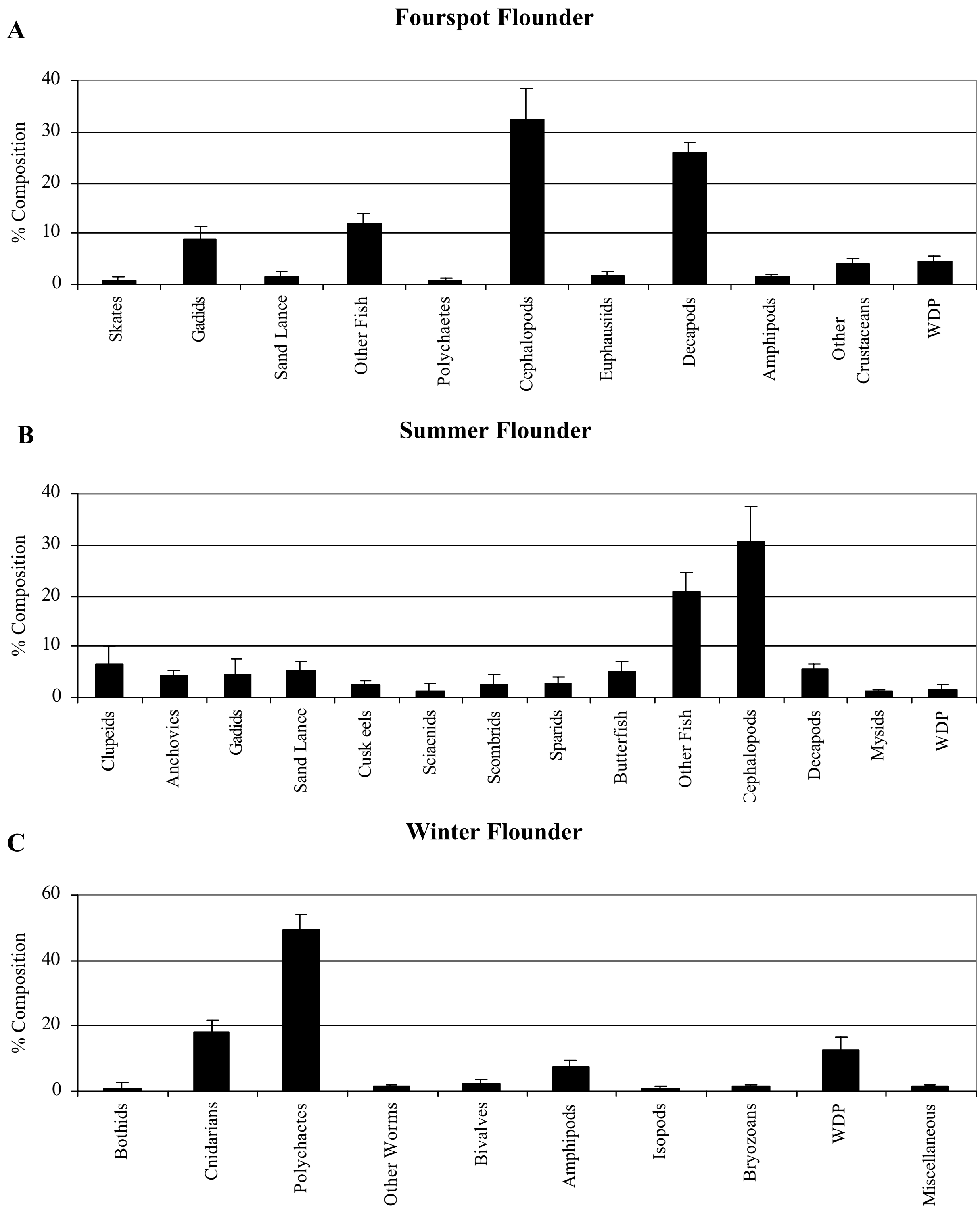


Figure 16. Percent diet composition by weight of major prey items for fourspot flounder, summer flounder, and winter flounder.

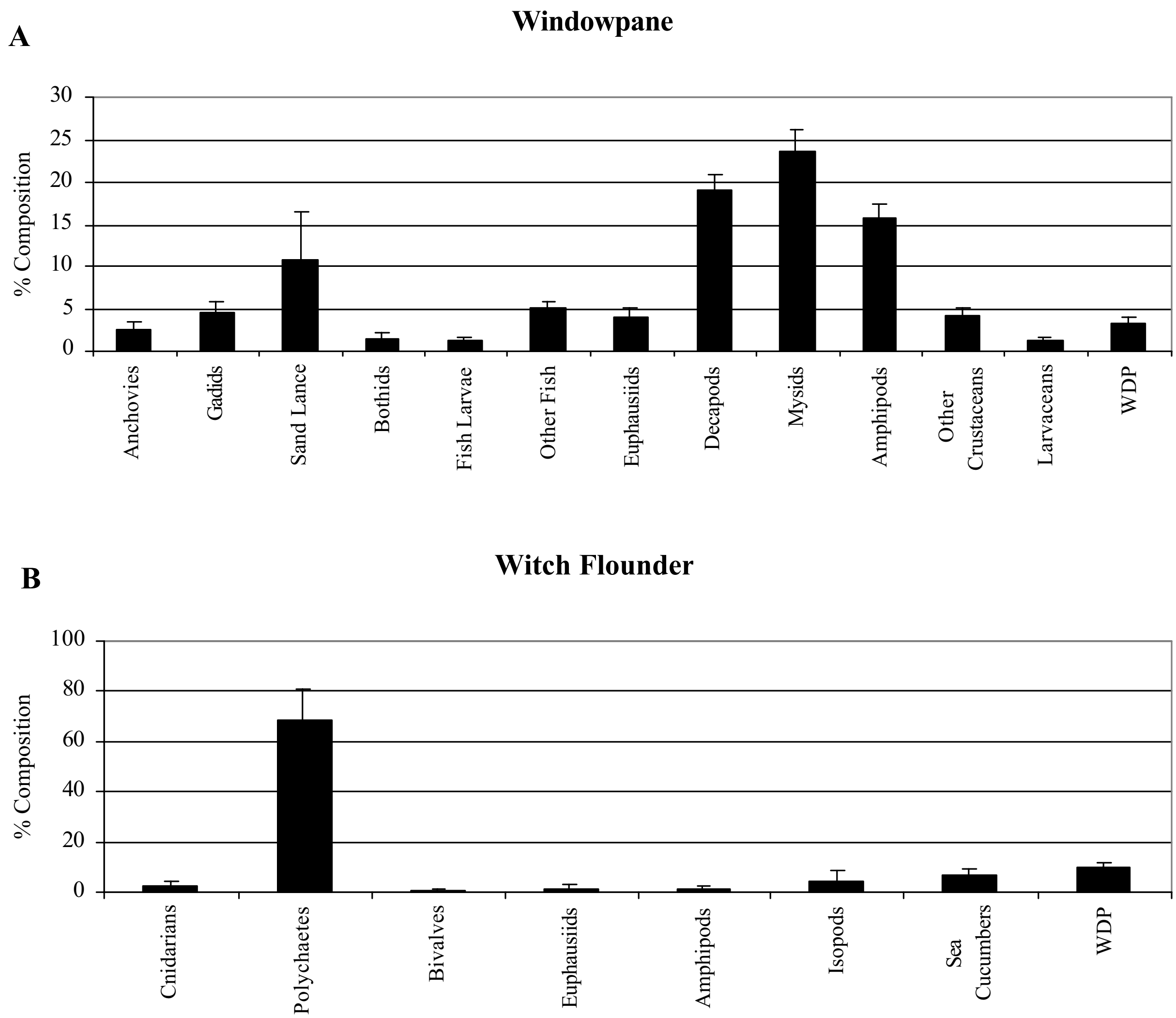


Figure 17. Percent diet composition by weight of major prey items for windowpane flounder and witch flounder.

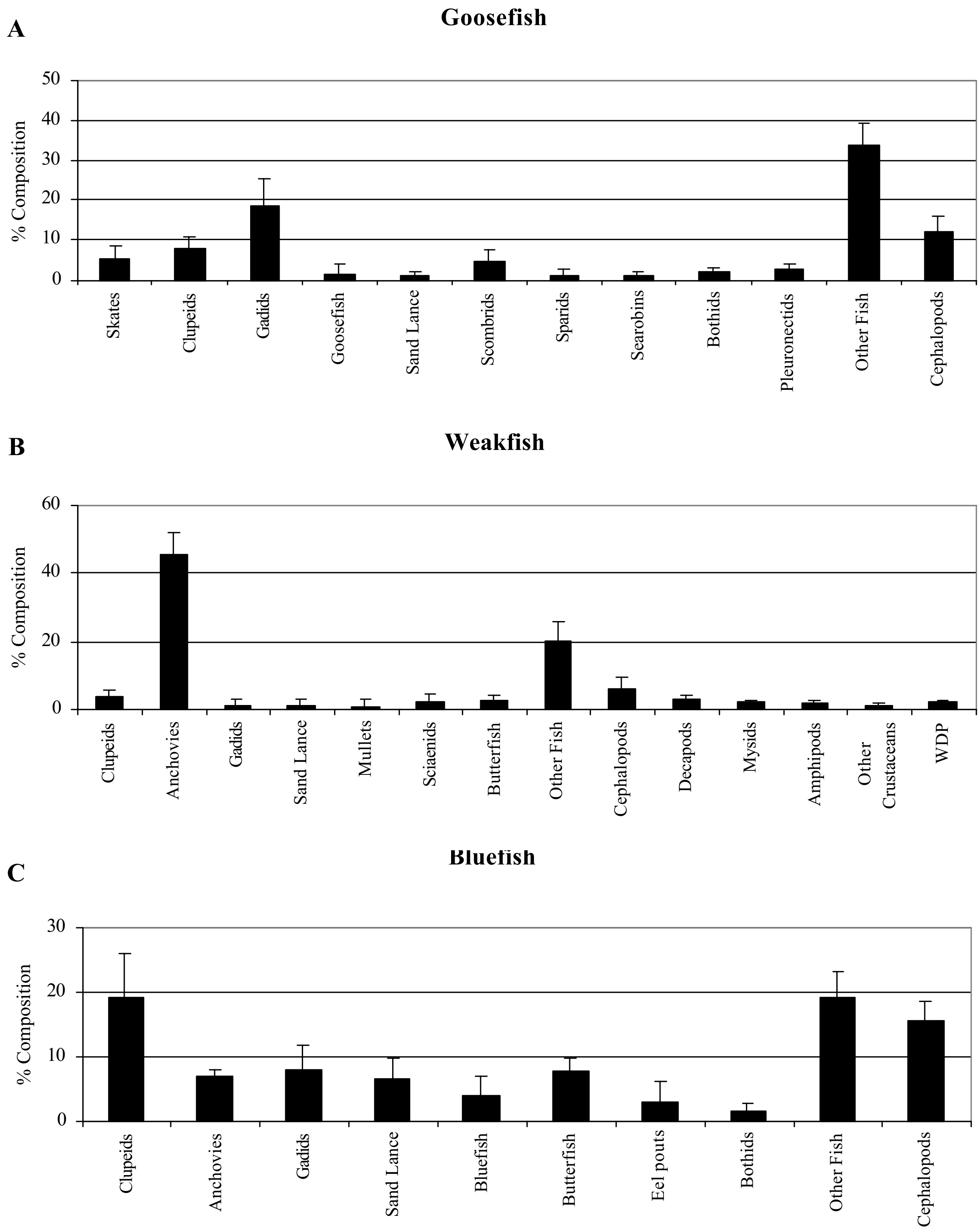


Figure 18. Percent diet composition by weight of major prey items for goosefish, weakfish, and bluefish.

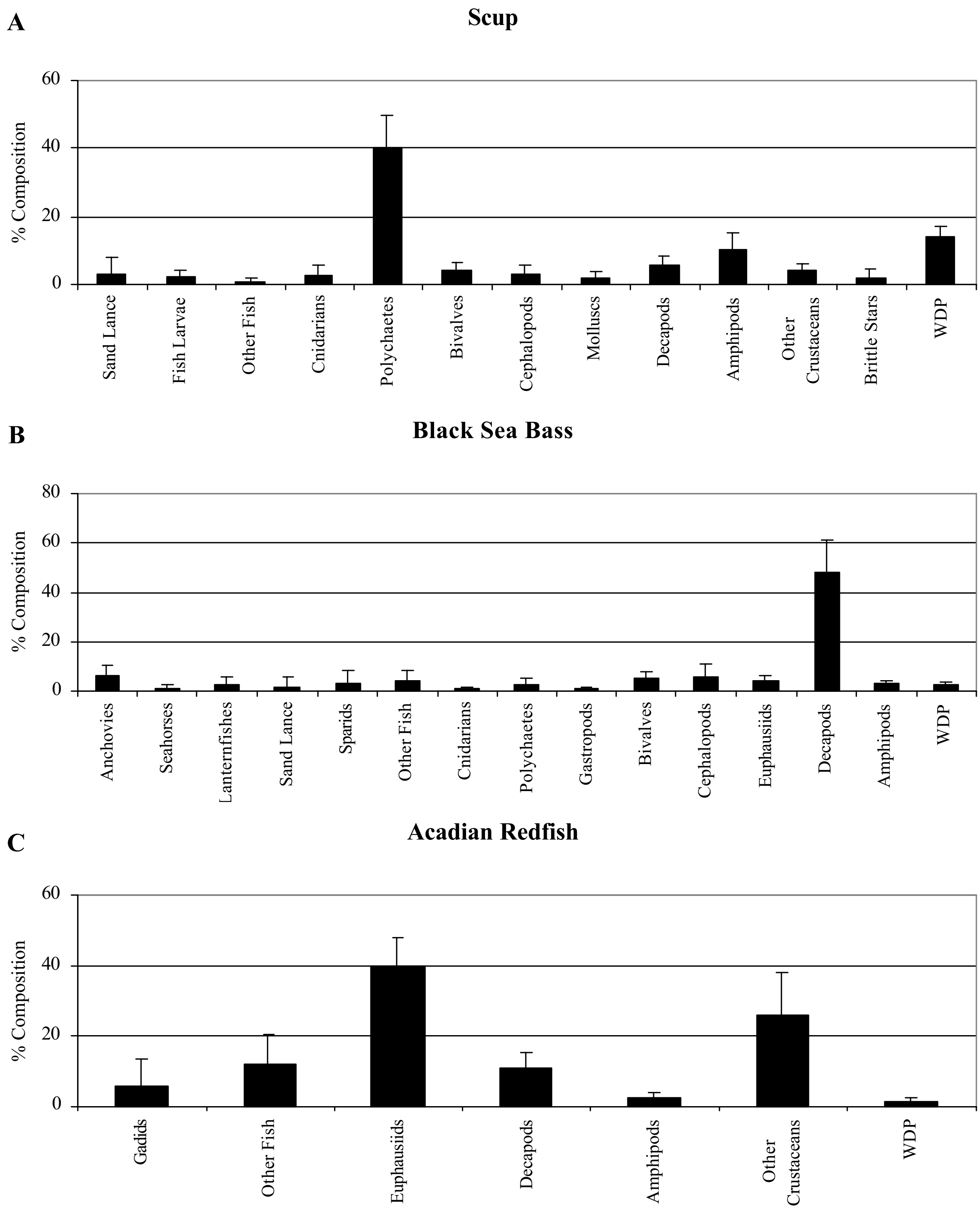


Figure 19. Percent diet composition by weight of major prey items for scup, black sea bass, and redfish.

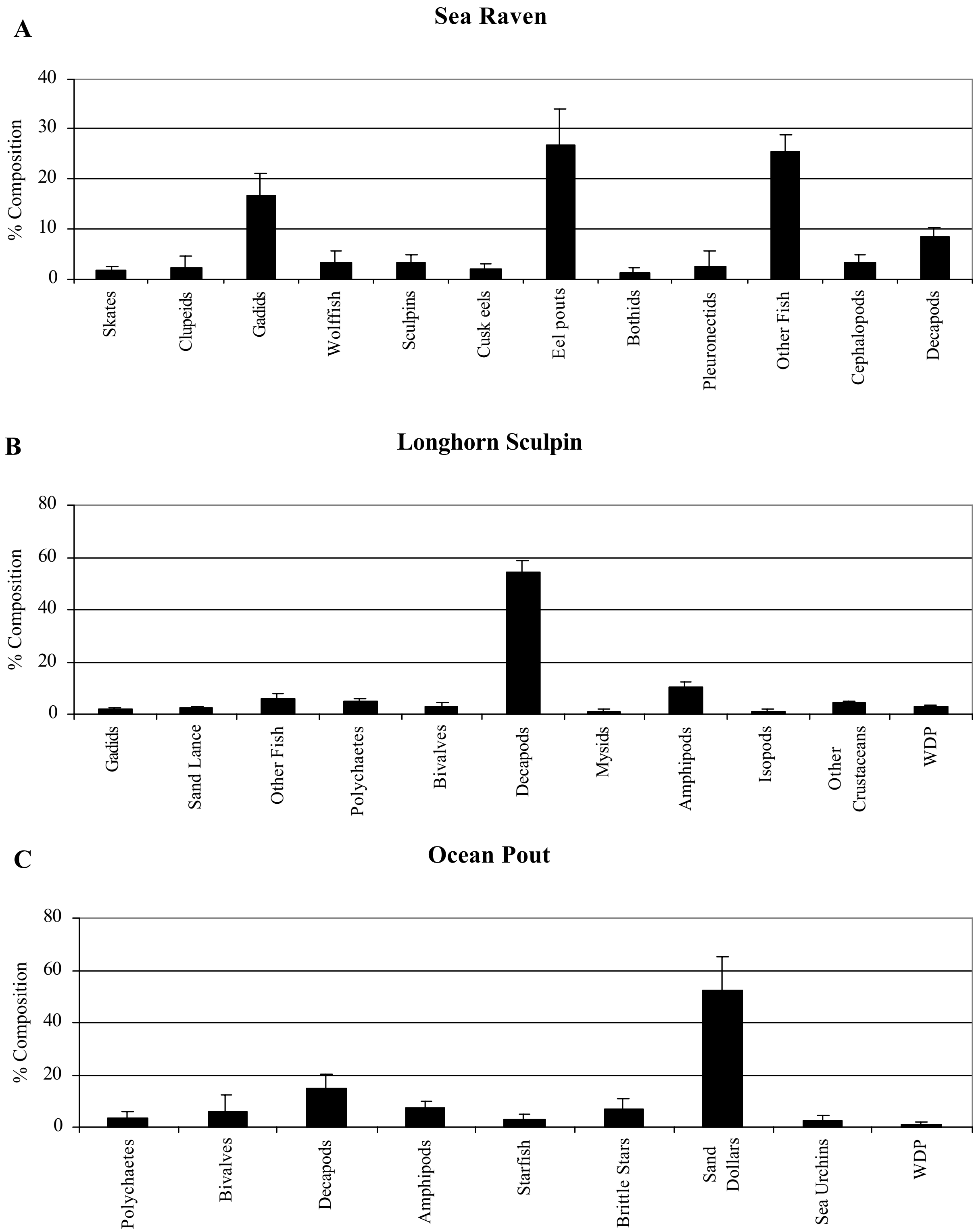


Figure 20. Percent diet composition by weight of major prey items for sea raven, longhorn sculpin, and ocean pout.

APPENDIX A

Stomach Sampling Protocols Used during NEFSC Bottom Trawl Surveys, 1963-99

STOMACH SAMPLING PROTOCOL DURING 1963-66

General procedures are as follows:

1. After completion of other duties, randomly select fish from baskets for stomach content examination.
2. Record cruise number, station number, and species sampled at top of log. Record length (cm), sex, and maturity stage of each fish examined.
3. Dissect out stomach and empty contents onto measuring board. Sort, identify, and record prey items (record as empty when applicable).
4. Measure all fish and crab prey (total or fork length for fish and carapace width for crabs).

STOMACH SAMPLING PROTOCOL DURING 1967-72

Preserve in 10% neutral buffered Formalin up to 20 (but not less than 5) stomachs per species per catch, selecting individuals at random (*i.e.*, without regard to size) from the sorted catch. If time does not permit sampling all those species with >5 individuals in each catch (usually there are 4-6 species with >5 individuals), then give first priority to the most abundant species, but seek to obtain some samples of all but the rare species for the entire cruise. Note that certain species (*e.g.*, Atlantic herring, silver hake) may yield only small or occasional catches but they should get high priority because they represent a large biomass.

In a few cases when there is a very wide range in size for a given species (*e.g.*, "small" versus "whale" size category of Atlantic cod), random selection will not be suitable, and separate samples from each size category will be desirable.

Label jar tops with cruise number, station number, species, and number of stomachs, and repeat data on label inside jar. Do not overfill jars; allow about 2-inch air space at top.

STOMACH SAMPLING PROTOCOL DURING 1973-76

Stomachs will be collected only from species listed in Table A1. Fifty stomachs should be collected for each species in each strata set per cruise. No more than 10 stomachs per species should be collected for any one station, and the same species should not be sampled at two consecutive stations.

When the catch of a species is large, the stomach samples should be taken randomly with respect to fish length. When fish are small, they should be preserved whole after puncturing the gut cavity. Only one species shall be placed in any one jar. After removing the stomach from a large fish, make a label showing cruise number, station number, maturity stage, species, sex, and length (cm). Wrap the stomach and the label in cheesecloth, and secure with a cable tie. Stomachs from the same species collected at the same station may be preserved together in one jar. NEVER PUT MORE THAN ONE SPECIES OR FISH FROM DIFFERENT STATIONS IN THE SAME JAR. Label the jar cap with cruise number, station number, species, and the number of stomachs in the jar. See Table A2 for examples of stomach and jar cap labels. Use 10% Formalin as a preservative.

Collect 50 young of the year (YOY) of the species listed in Table A1 for each strata set. They should be preserved whole, and the jar cap labeled as aforementioned. The lengths which are less than or equal to those listed in Table A1 signify YOY. Be sure to slit the gut cavity.

If it appears that the necessary stomachs from each strata set will not be collected as the cruise progresses, disregard the above directions and take all stomachs possible until 50 have been collected for each species, then collect using the normal procedure.

STOMACH SAMPLING PROTOCOL DURING 1977-80

SAMPLING ROUTINE

Fish and squid stomachs will be collected from the species listed in Tables A3-A5. The collection is based on three separate needs as follows: 1) offshore priority species, 2) inshore priority species, and 3) miscellaneous species. Stomach sampling takes priority over any other non-NEFC sampling.

On all groundfish cruises sampling inshore strata, the inshore priority species listed in Table A4 will be sampled for food habits studies. Collect 150 fish representing the entire size range of each species listed.

The species chosen for the miscellaneous collection were selected because little or no food habit data have previously been collected, or additional information about their food habits is needed. Table A5 is a guide to those miscellaneous species needed from specific areas, and to those miscellaneous species needed from any area. Many of the fish included in this collection are not very abundant, and few will probably be encountered.

SAMPLING METHODS

Stomach samples should be taken from fish representing the length range of a given species caught at any station. It is important that the largest and smallest fish be included in the collection, along with the predominant size group (*i.e.*, stratified by length). No more than 10 stomachs per given species need to be collected at any one station, and the same species should not be sampled at two consecutive stations. If it appears that the necessary number of stomachs will not be collected as the cruise progresses, disregard the above directions and take all stomachs necessary to complete the collection, then sample normally.

Stomachs from large fish will be excised, and a label indicating cruise number, station number, species, length (cm), sex, and maturity stage will be completed (see Table A6), and together they shall be wrapped in cheesecloth and secured with a cable tie. Smaller fish may be preserved whole after puncturing the gut cavity and completing a label denoting cruise number, station number, and species. Stomachs of the same species collected at the same station may be preserved together in one jar. NEVER PUT STOMACHS OF MORE THAN ONE SPECIES OR ONE STATION IN THE SAME JAR. Use 10% Formalin as a preservative. Label the jar cap with cruise number, station number, species, and number of stomachs in the jar (see Table A6). List stomachs collected on the tally sheet provided by the Food Habits Project for your convenience.

Juvenile fish may be identified by utilizing the lengths listed with each species in Table A3. The lengths of fish less than or equal to those indicated signify juvenile fish.

Additional samples may be collected if time permits.

STOMACH SAMPLING PROTOCOL DURING 1981-84

The Feeding Ecology Project requires stomach content samples from the species listed in Table A7 whenever they occur in trawl catches. It is especially important that we document the size and species of fish prey being consumed by piscivorous predators in the Georges Bank - Nantucket Shoals area (Strata 9-25). Predators of immediate concern are silver hake, Atlantic cod, and spiny dogfish. Sampling of these and other species, which are listed in their order of priority in Table A7, should be conducted as follows.

PRESERVED SAMPLES

Stomach contents (and stomach tissue) of silver hake, Atlantic cod, yellowtail flounder, haddock, winter flounder, Atlantic mackerel, and Atlantic herring are to be preserved according to the length categories and numbers given in Table A7, throughout the entire survey area. Stomachs from different species, length categories, or stations should never be put in the same jar. Small fish may be preserved whole. All jars shall be labeled on the inside and outside (jar cap) to indicate ship, cruise number, station number, species, number of fish, and length category. Samples will be preserved in 10% Formalin.

STOMACH CONTENTS EXAMINED AT SEA

Stomach contents of spiny dogfish, pollock, white hake, red hake, and goosefish are to be examined at sea. Details are given in the "Procedure for Examining Stomach Contents at Sea [1981-84]" section. If time permits, the examination of nonpriority species such as large sharks, skates, rays, summer flounder, bluefish (*i.e.*, fish eating species) or predominant species in the catch, other than those listed in Table A7, will be useful to personnel in the Feeding Ecology Project. Any additional samples received will be appreciated.

NUMBER OF SAMPLES

If sampling time becomes critical at any particular station, only five randomly chosen individual fish of the three top priority species (*i.e.*, silver hake, Atlantic cod, and spiny dogfish) need be sampled. No more than 40 individual fish, in total, need be sampled at any one station under any circumstances.

PROCEDURE FOR EXAMINING STOMACH CONTENTS AT SEA [1981-84]

1. Record pertinent information such as vessel, cruise number, station number, and predator species in the space provided at the top lefthand corner of the log.
2. Inspect the buccal cavity (inside of mouth) for signs of regurgitated food and the esophageal area (via the body cavity) for inversion. Also check the gills to be sure the fish was freshly caught (white or pink gills indicate the fish was probably from a previous station). If any of the above conditions exist, discard the fish.

3. Determine the length (cm), sex, and maturity stage of the fish, and record this information on the appropriate line of the log (simply circle the sex and maturity stage; *i.e.*, F = female, M = male, I = immature, D = developing, R = ripe [or spawning], S = spent, and R_t = resting).
4. Excise the stomach and empty the contents onto a tray or sieve. The fullness measurement is recorded on the "Fullness" line of the log as the estimated volume (in cubic centimeters) made up by the stomach contents. If the stomach is empty, record the fullness measurement as "0" and proceed to the next fish. The volume may be estimated to the nearest 0.5 cm^3 by comparing the appropriately sized, premeasured piece of wood to the volume made up by the stomach contents.
5. It will be helpful if the relative state of digestion of the prey items is recorded. If the stomach contents (as a whole) appear relatively fresh ("FR"), partly digested ("PD"), or well digested ("WD"), they should be recorded as such in the "State of Digestion" column of the log.
6. The stomach contents may now be spread apart and separated into prey groups. An estimate of the percentage that each prey group makes up of the total stomach content volume should be written on the line of the log corresponding to the particular prey. If prey can readily be identified to species, the name may be written into one of the open spaces, and the percentage recorded as indicated earlier. The number and size (or mean size) of organisms may also be recorded, either along with the percentage, or in the "Comments" section of the log. A small number of prey species (or groups) usually account for a large percentage of a fish's food. Some organisms are common food for many species of fish. Organisms repeatedly noted in the stomachs of a particular species (or in the stomachs of several species), and not identified to species, should be preserved in 10% Formalin and brought back to the laboratory for identification. The stomach contents of all fish recorded on a particular log should be saved in the same jar when returning material to the laboratory for identification. The "Pisces" (*i.e.*, fish) column of the log should never be used if the fish found in the stomach can be identified to any lower classification. The length(s) and number of fish prey should always be recorded (the total length at time of ingestion may be estimated if fish prey are in pieces or partially digested).
7. Space for pathological information is provided at the bottom of the log. Simply circle the abbreviation for the affected organ and/or record additional information in the "Comments" section of the log.

STOMACH SAMPLING PROTOCOL DURING 1985-91

The Northeast Fisheries Center seeks stomach content data for the priority species listed in Table A8 whenever they occur in trawl catches. It is especially important to document the size and species of fish prey being consumed by piscivorous predators in the Georges Bank - Southern New England area (Strata 1-25). The stomach contents of all fish are to be examined at sea (see "Procedure for Examining Stomach Contents at Sea [1985-91]."). If time permits, the sampling of species not listed in Table A8 such as large sharks and rays (*i.e.*, fish-eating species) or any other predominant species in the catch will also be desirable. Table A9 lists 18 secondary species for which a random sample of 10 fish should be taken for each watch.

If sampling time is inadequate to achieve target numbers of priority species, then try to obtain at least five individual fish (randomly chosen) of each of the top three priority species in the catch. However, if possible, it is desirable to sample about 50 fish in total at each station to provide large enough samples to detect spatial and temporal shifts in diet.

PROCEDURE FOR EXAMINING STOMACH CONTENTS AT SEA [1985-91]

1. Record pertinent information such as vessel, cruise number, station number, and predator species in the spaces provided at the top of the log. Please use entire common name of predator (and prey) fishes when completing the log.
2. Inspect the buccal cavity (inside of mouth) for regurgitated food and the esophageal area (via the body cavity if necessary) for signs of stomach inversion. Also inspect the gills to be sure the fish was freshly caught (white or pink gills indicate the fish is probably from a previous station). If any of the above conditions exist, discard the fish.
3. Determine the length (cm) (as per standard survey measurements), sex, and maturity stage of the fish, and record that information in the appropriate spaces of the log (see codes for sex and maturity stage at the top of log).
4. Excise the stomach and empty the contents onto a clean measuring board. Determine and record the stomach fullness (volume to the nearest 0.5 cm^3) by comparing the appropriately sized volumetric gauge to the entire volume of the bolus. If the stomach is empty, record stomach fullness as "0.0" and proceed to the next fish.
5. Separate the stomach contents into prey groups and record each group to the lowest taxon practical (see

Watch Chief if necessary). Estimate the percentage that each prey group makes up of the total stomach content volume and write it on the corresponding line of the log. For each prey category, record the number (you may estimate for small organisms), individual sizes as per survey standards (or minimum, maximum, and average size in millimeters if more than 10 organisms are present), and state of digestion (see codes at top of log). It is only necessary to measure organisms >15 mm in length (*e.g.*, fish, squid, crabs, and decapod shrimp). The length(s) and number of fish prey should be estimated to reflect the number and size at time of ingestion if only pieces or partly digested fish are present. Larvae and juvenile fish which can't be identified should be preserved (with pertinent station information) for microscopic examination at the Woods Hole Laboratory. Organisms repeatedly observed as prey, but not identified to species, may occasionally be preserved (10% Formalin) and brought to the laboratory for positive identification.

STOMACH SAMPLING PROTOCOL DURING 1992-99

Information on predator-prey interactions among fishes is critical for recruitment and multispecies models. Routine stomach sampling on groundfish surveys provides an extremely valuable time series of gut-content data which is needed for evaluating major changes in the diets of fishes in relation to composition and abundance of their prey. The primary objective is to estimate predation on fish (particularly larval and juvenile stages). The current focus is on piscivorous species representing major components of the finfish biomass along the continental shelf off the northeastern United States.

First priority is assigned to silver hake, Atlantic cod, spiny dogfish, and skates. Sampling guidelines for these and other species are outlined in the accompanying Tables A10-A12. Any unusual or interesting species not included in Tables A10-A12 can be sampled as time permits.

PROCEDURE FOR VOLUMETRIC EXAMINATION OF FISH STOMACHS AT SEA

1. Select fish according to priorities in Tables A10-A12.
2. Inspect gills to be sure fish was freshly caught (pale pink or white gills means fish is probably from an earlier station).
3. For each species sampled, use a separate log sheet. Print complete name of species. Abbreviations can be confused (*e.g.*, "s. hake" could be silver hake or spotted hake).
4. Record each predator length to nearest centimeter following standard NEFSC survey methods. Record individual fish weight to the nearest gram. Record sex and maturity stage. Fill in "F" block with an "E" to show that the stomach was examined at sea. Excise stomach and empty stomach contents onto a clean measuring board or into a sorting tray.
5. If stomach is everted (blown) or shows signs of regurgitation (food in mouth), leave the "F" block and the "Fullness" section of the log blank. Record "BLOWN" as the prey name. Continue on to next fish.
6. If stomach is empty, record "0.0" in the "Fullness" section and record "EMPTY" as the prey name. Continue on to next fish.
7. If stomach contains food, estimate total volume of bolus using the volumetric gauges (*i.e.*, "wind chimes"). Record volume to nearest 0.1 cm^3. Trace amounts <0.1cm^3 in volume should be recorded as 0.1cm^3. ALWAYS USE GAUGE.
8. Sort stomach contents into separate piles of prey groups whenever possible. Prey should be identified to the lowest taxon practical. Fish prey should be identified to species as much as possible. Unidentified larval fish should be measured, recorded as "larval fish," and preserved in the provided vials. Label vial lid with cruise number, station number, predator, and identification number. Invertebrate prey should at least be recorded to major taxonomic group (*e.g.*, crab, polychaete, gammarid, bivalve) Use the illustrated prey sheet to aid identification and spelling, or ask the food habits representative on your watch. Unidentifiable remains should be recorded as "AR."
9. Estimate and record percentage of total volume represented by each prey group. Record the average digestion for each group.
10. All fish, crabs, and squid should be measured using standard NEFSC survey methods. ALL species should be counted or have the count estimated by volume if possible. It is of critical importance to record the number and individual lengths of all fish prey. A MAXIMUM of 10 individuals should be measured to the nearest millimeter. If over 10 animals are present select a random subsample of 10 individuals and record their lengths to the nearest mm. For partly digested prey remains or large fragments of prey that cannot be accurately measured, estimate the length of the animal to nearest 10 mm at time of ingestion. Record these estimated lengths, followed by an "E" (*e.g.*, 250E, 110E). Be sure to record the total number of prey present, not the number of prey measured. RECORD ALL PREY LENGTHS IN MILLIMETERS.
11. Use the "Remarks" section to note larval fish preserved for further identification, comments on prey, or general comments on feeding (*i.e.*, net feeding or scallop draggers in vicinity). Remember to check "R" block if "Remarks" section is used.

IF YOU HAVE ANY QUESTIONS, ASK THE FOOD HABITS REPRESENTATIVE ON YOUR WATCH.

CRITERIA FOR ASSESSING DIGESTION STAGE

FRESH	=	No obvious sign of digestion. No skin discoloration. Crustacean carapace is hard. Prey are easily identifiable to family or species, but do not have to be identified to this level to fit category.
PARTIAL	=	Some recognizable external characteristics remain. Crustacean carapace is intact but soft. Prey can frequently be identified to family or species, but do not have to be identified to this level to fit category.
WELL	=	No external characteristics remaining. Prey cannot be identified to family or species using external features. Prey may sometimes be identified using otoliths or other remaining hard internal structures.

STOMACH SAMPLE PROCESSING

During 1992-93 surveys, sampling ranges (*i.e.*, number of fish per range of length) and maximum stomach sampling levels were set by species and station. Refer to Table A10. Maxima were removed in 1994, and priority species were designated for each survey beginning in 1995. Refer to Table A11. In 1999, the composition of species to be sampled, sampling ranges, and sampling priorities changed. Refer to Table A12.

An effort should be made to complete all food habits sampling requested. If catches become overwhelming, complete stomach analyses in order of priority. At the Watch Chief's discretion, a cap of five randomly selected fish may be placed on the number of stomachs examined, excluding empty or blown stomachs.

Table A1. Species to be sampled, and maximum lengths for sampling YOY, for the five regions (strata sets) during 1973-76

Middle Atlantic (Strata 61-76)		**Southern New England (Strata 1-12)**		**Georges Bank (Strata 13-23, 25)**		**Gulf of Maine (Strata 24, 26-30, 36-40)**		**Scotian Shelf (Strata 31-35, 41-49)**	
Species	**Max. YOY Length (cm)**	**Species**	**Max. YOY Length (cm)**	**Species**	**Max. YOY Length (cm)**	**Species**	**Max. YOY Length (cm)**	**Species**	**Max. YOY Length (cm)**
Silver hake	20	Yellowtail flounder	12	Yellowtail flounder	12	Acadian redfish	7	Atlantic cod	20
Spotted hake	13	Silver hake	20	Atlantic cod	20	Atlantic cod	20	Haddock	20
Fourspot flounder	7	Red hake	20	Haddock	20	Pollock	20	Pollock	20
Butterfish	13	Ocean pout	13	Ocean pout	13	White hake	20	Witch flounder	7
Scup	13	Little skate	20	Little skate	20	Witch flounder	7	American plaice	7
		Butterfish	13	Silver hake	20	American plaice	7		
		Scup	13	Longhorn sculpin	7	Haddock	20		

Table A2. Examples of stomach and jar cap labels, and codes for sex and maturity stage, during 1973-76

Label		Code	
Stomach	**Jar Cap**	**Sex**	**Maturity Stage**
Alb IV 73-1	Alb IV 73-1	M = male	I = immature
Sta 149	Sta 149	F = female	R_1 = ripening 1
Silver hake	Silver hake	U = unknown	R_2 = ripening 2
45 cm, M, S_1	10 stomachs		R_3 = ripening 3
			S_1 = spawning 1
			S_2 = spawning 2
			R_c = spent-recovering
			R_t = resting

Table A3. Offshore species to be sampled, and maximum lengths for sampling juveniles, for the five regions (strata sets) during 1977-80

Middle Atlantic (Strata 61-76)		Southern New England (Strata 1-12)		Georges Bank (Strata 13-23, 25)		Gulf of Maine (Strata 24, 26-30, 36-40)		Scotian Shelf (Strata 31-35, 41-49)	
Species	**Max. Juv. Length (cm)**	**Species**	**Max. Juv. Length (cm)**	**Species**	**Max. Juv. Length (cm)**	**Species**	**Max. Juv. Length (cm)**	**Species**	**Max. Juv. Length (cm)**
Spiny dogfish	60	Spiny dogfish	60	Spiny dogfish	60	Spiny dogfish	60	Spiny dogfish	60
Smooth dogfish	60	Smooth dogfish	60	Winter skate	50	Red hake	20	Red hake	20
Black sea bass	15	Atlantic cod	20	Red hake	20	Haddock	20	Silver hake	20
Windowpane	10	Goosefish	40	Goosefish	40	Silver hake	20	Goosefish	40
Longfin inshore squid	15	Winter flounder	15	Winter flounder	15	Goosefish	40	Acadian redfish	7
Northern shortfin squid	15	Longfin inshore squid	15	Atlantic mackerel	25	Atlantic herring	15	Northern shortfin squid	15
		Northern shortfin squid	15	Longfin inshore squid	15	Northern shortfin squid	15		
				Northern shortfin squid	15				

Table A4. Species to be sampled for inshore strata north and south of Cape Cod during 1977-80

South of Cape Cod		North of Cape Cod	
All sharks, skates, and rays	Weakfish	All sharks, skates, and rays	Cunner
Smooth dogfish	Black sea bass	Spiny dogfish	Alewife
Summer flounder	Spot	Thorny skate	Atlantic cod
Winter flounder	Atlantic croaker	Atlantic wolffish	Silver hake
Windowpane	Striped bass	Winter flounder	Haddock
Butterfish	Northern kingfish	Witch flounder	Red hake
Scup	Southern kingfish	Atlantic halibut	White hake
Bluefish	Longfin inshore squid	American plaice	Northern shortfin squid

Table A5. Miscellaneous species to be sampled from specific areas or from any area during 1977-80

Middle Atlantic	Southern New England	Georges Bank	Gulf of Maine	Western Nova Scotia	Any Area
Sharks	Sharks	Sharks	Sharks	Sharks	Conger eel
Skates	Skates	Skates	Skates	Skates	American eel
Rays	Rays	Rays	Rays	Rays	Tilefish
Spot	Atlantic mackerel	Sea raven	Cusk	Cusk	Bluefish
Weakfish	Summer flounder	Gulf Stream flounder	Sea raven		Atlantic halibut
Summer flounder	Gulf Stream flounder	Windowpane	Atlantic mackerel		Offshore hake
	Windowpane	Fourspot flounder	Argentines		American John Dory
	Fourspot flounder	White hake	Winter flounder		Alewife
		Butterfish			American shad
		Atlantic wolffish			Atlantic croaker
		Thorny skate			Snake mackerels
		Northern sand lance			Wrymouth
		Pollock			Round herring
		Summer flounder			Longfin hake
		Witch flounder			Fawn cusk-eel
					All grenadiers
					Atlantic needlefish
					American sand lance
					Northern sea robin
					Striped sea robin
					Armored sea robin
					Any other unusual fish obtained

Table A6. Examples of stomach and jar cap labels, and codes for sex and maturity stage, during 1977-80

Label		**Code**	
Stomach	**Jar Cap**	**Sex**	**Maturity Stage**
Alb IV 77-1	Alb IV 77-1	M = male	I = immature
Sta 149	Sta 149	F = female	D = developing
Silver hake	Silver hake	U = unknown	R = ripe
45 cm, M, S	10 stomachs		S = spent
			R_t,T = resting

Table A7. Order of sampling priority for species from which stomach contents will be sampled for the Feeding Ecology Project during 1981-84. (Shown are the number of fish to be sampled per watch in each length category, and the method of sampling.)

Species	Length Category (cm)[a]	No. to Sample/ Watch	Sampling Method to Use	Species	Length Category (cm)[a]	No. to Sample/ Watch	Sampling Method to Use
Silver hake	0-10	10	Preserve samples	White hake	0-20	5	Examine at sea
	11-20	10			21-40	5	
	21-30	20			>40	5	
	31-35	20					
	>35	20		Red hake	0-10	5	Examine at sea
					11-20	5	
Atlantic cod	0-10	5	Preserve samples		21-30	5	
	11-30	20			31-35	5	
	31-50	20			>35		
	51-70	20					
	71-90	30		Goosefish	All	5	Examine at sea
	>90	All					
Spiny dogfish	0-65	20	Examine at sea	Winter flounder	0-15	5	Preserve samples
	66-85	20			16-30	5	
	>85	20			31-50	5	
					>50	5	
Yellowtail flounder	0-10	5	Preserve samples				
	11-20	5		Atlantic mackerel	0-20	5	Preserve samples
	21-30	5			21-25	5	
	31-40	5			26-30	5	
	>40	5			>30	5	
Haddock	0-25	5	Preserve samples	Atlantic herring	0-15	5	Preserve samples
	26-50	5			16-25	5	
	>50	5			26-30	5	
					>30	5	
Pollock	0-15	5	Examine at sea				
	16-25	5					
	26-50	5					
	51-80	5					
	>80	5					

[a]Length categories are to be consistent with those of the Age and Growth Project.

Table A8. Priority species to be sampled for stomach contents analyses at sea during 1985-91. (Given for each species are the minimum target numbers to be sampled per watch.)

Species	Length Category (cm)	Minimum No. to Sample	Species	Length Category (cm)	Minimum No. to Sample
Silver hake[a]	1-20	5	Pollock	1-25	5
	21-25	5		26-50	5
	26-30	10		51-80	5
	31-35	10		>80	5
	>35	10			
			Red hake	1-20	5
Atlantic cod[a]	1-30	5		21-25	5
	31-50	10		26-30	5
	51-70	15		31-35	5
	71-90	15		>35	5
	>90	All			
			Atlantic mackerel	1-25	5
Spiny dogfish[a]	1-65	20		26-30	5
	66-85	25		>30	10
	>85	25			
			Atlantic herring	1-25	5
White hake	1-20	5		26-30	5
	21-40	5		>30	10
	>40	5			

[a]Highest priority species.

Table A9. Secondary species to be sampled for stomach contents analyses at sea during 1985-91. (A random sample of 10 of each species should be taken for each watch.)

Acadian redfish	Alewife	Atlantic halibut	Bluefish	Fourspot flounder	Goosefish
Little skate	Longhorn sculpin	Scup	Sea raven	Smooth dogfish	Spotted hake
Striped bass	Summer flounder	Thorny skate	Weakfish	Windowpane	Winter skate

Table A10. Species to be sampled, sampling ranges, and maximum stomach sampling levels per station for 1992-93 bottom trawl surveys

		Bottom Trawl Survey			
	Sampling	1992		1993	
Common Name	**Range (cm)**	**Spring**	**Fall**	**Spring**	**Fall**
Bass, striped	1 per 1	All	All	All	All
Bluefish	1 per 1	10	10	10	10
Cod, Atlantic	3 per 3	25	25	25	25
Dogfish, smooth	1 per 3	10	10	10	10
Dogfish, spiny	1 per 3	30	30	30	30
Flounder, fourspot	1 per 1	10	10	10	10
Flounder, summer	1 per 1	10	10	10	10
(Flounder) windowpane	1 per 1	10	10	10	10
Goosefish	1 per 1	All	All	All	All
Hake, red	1 per 1	10	10	10	10
Hake, silver	1 per 1	10	10	10	10
Hake, spotted	1 per 1	10	10	10	10
Hake, white	3 per 3	10	10	10	10
Halibut, Atlantic	1 per 1	All	All	All	All
Herring, Atlantic	1 per 1	10	10	10	10
Mackerel, Atlantic	1 per 1	10	10	10	10
Pollock	1 per 1	20	20	20	20
Sculpin, longhorn	1 per 1	10	10	10	10
Sea raven	1 per 1	10	10	10	10
Skate, little	1 per 2	10	10	10	10
Skate, thorny	1 per 2	10	10	10	10
Skate, winter	1 per 2	10	10	10	10
Weakfish	1 per 1	10	10	10	10

Table A11. Species to be sampled, sampling ranges, and designated priorities for stomach sampling per station for 1994-98 bottom trawl surveys. (A “√” indicates that samples were requested with no particular priority ranking.)

Common Name	Sampling Range (cm)	Bottom Trawl Survey 1994 Spring	1994 Fall	1995 Spring	1995 Fall	1996 Spring	1996 Fall	1997 Spring	1997 Fall	1998 Spring	1998 Fall
Bass, striped	1 per 1	√	√	√	√	√	√	√	√	√	√
Bluefish	1 per 1	√	√	√	√	√	√	√	√	√	√
Cod, Atlantic	3 per 3	√	√	1	1	1	1	1	1	1	5
Dogfish, smooth	1 per 3	√	√	√	√	√	√	√	√	√	√
Dogfish, spiny	1 per 3	√	√	2	2	2	2	2	2	2	√
Flounder, fourspot	1 per 1	√	√	5	5	6	5	6	5	6	4
Flounder, summer	1 per 1	√	√	√	√	√	√	√	√	√	√
(Flounder) windowpane	1 per 1	√	√	√	√	√	√	√	√	√	√
Goosefish	1 per 1	√	√	√	√	√	√	√	√	√	√
Hake, red	1 per 1	√	√	√	√	√	√	√	√	√	√
Hake, silver	1 per 1	√	√	3	3	3	3	3	3	3	1
Hake, spotted	1 per 1	√	√	√	√	√	√	√	√	√	√
Hake, white	3 per 3	√	√	√	√	√	√	√	√	√	√
Halibut, Atlantic	1 per 1	√	√	√	√	√	√	√	√	√	√
Herring, Atlantic	1 per 1	√	√	4	4	√	4	√	4	√	2
Mackerel, Atlantic	1 per 1	√	√	√	√	√	√	√	√	√	3
Pollock	1 per 1	√	√	√	√	√	√	√	√	√	√
Sculpin, longhorn	1 per 1	√	√	√	√	8	√	8	√	8	√
Sea raven	1 per 1	√	√	√	√	7	√	7	√	7	√
Skate, little	1 per 2	√	√	√	√	4	√	4	√	4	√
Skate, thorny	1 per 2	√	√	√	√	√	√	√	√	√	√
Skate, winter	1 per 2	√	√	√	√	5	√	5	√	5	√
Weakfish	1 per 1	√	√	√	√	√	√	√	√	√	√

Table A12. Species to be sampled, sampling ranges, and designated priorities for stomach sampling for 1999 bottom trawl surveys.

Common Name	Sampling Range (cm)	Priority
Bass, black Sea	1 per 5	-
Bass, striped	1 per 5	-
Bluefish	1 per 5	-
Butterfish	1 per 5	-
Cod, Atlantic	1 per 5	-
Cunner	1 per 5	-
Cusk	1 per 5	-
Cusk-eel, fawn	1 per 5	-
Dogfish, smooth	1 per 10 (by sex)	-
Dogfish, spiny	1 per 10 (by sex)	-
(Flounder) American plaice	1 per 5	-
Flounder, fourspot	1 per 5	-
Flounder, summer	1 per 5	3
(Flounder) windowpane	1 per 5	-
Flounder, winter	1 per 5	-
Flounder, witch	1 per 5	-
Flounder, yellowtail[a]	1 per 5	2
Goosefish	1 per 5	-
Haddock	1 per 5	1
Hake, offshore	1 per 5	-
Hake, red	1 per 5	-
Hake, silver	1 per 5	-
Hake, spotted	1 per 5	-
Hake, white	1 per 5	-
Halibut, Atlantic	1 per 5	-
Herring, Atlantic	1 per 5	7
Herring, blueback	1 per 5	-
Mackerel, Atlantic	1 per 5	8
Ocean pout	1 per 5	5
Pollock	1 per 5	-
Redfish, Acadian	1 per 5	-
Rosefish, blackbelly	1 per 5	-
Salmon, Atlantic	1 per 5	-
Sculpin, longhorn	1 per 5	4
Scup	1 per 5	-
Sea raven	1 per 5	-
Shad, American	1 per 5	-
Shad, hickory	1 per 5	-
Skate, little	1 per 10	-
Skate, rosette	1 per 10	-
Skate, smooth	1 per 10	-
Skate, thorny	1 per 10	-
Skate, winter	1 per 10	-
Spot	1 per 5	-
Tautog	1 per 5	-
Weakfish	1 per 5	-
Wolffish, Atlantic	1 per 5	6

[a]Sample ALL yellowtail flounder from Strata 5, 6, 9, and 10. Continue to sample one fish per 5-cm length interval in all other strata.