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NOTE

Food and Ontogenetic Shifts in Feeding of the Goosefish, *Lophius Americanus*

Michael P. Armstrong[1], John A. Musick, and James A. Colvocoresses[2]
Virginia Institute of Marine Science, College of William and Mary
Gloucester Point, Virginia, 23062, USA

Abstract

Food habits were studied in goosefish, *Lophius americanus*, collected off southern New England in the western North Atlantic. Analysis of stomach contents indicated goosefish fed opportunistically on a wide variety of species, primarily fishes. Invertebrates were important in the diet of small (<200 mm total length) goosefish but larger goosefish fed almost exclusively on fishes. In larger goosefish a high incidence of empty stomachs was found, suggesting a low frequency of feeding. Conspecifics were a relatively important prey of larger goosefish.

Key words: Feeding, food habits, goosefish, *Lophius americanus,* New England Area, ontogenetic shifts.

Introduction

The goosefish, *Lophius americanus*, is a benthic fish that occurs in the Northwest Atlantic Ocean from the northern Gulf of St. Lawrence, southward to Cape Hatteras, North Carolina (Bigelow and Schroeder, 1953; Scott and Scott, 1988). It is closely related to the northern European angler, *Lophius piscatorius*, and the two were considered conspecific for many years (Berril, 1929; Caruso, 1977). Although long considered undesirable as a food fish in the United States, its popularity has grown considerably in recent years. Commercial landings of goosefish have risen yearly since 1971 (National Marine Fisheries Service (NMFS), 1993) and it now makes up a significant portion (19 000 metric tons in 1993) of the finfish catch from waters off Northeast United States. Although some research suggests that goosefish are being overfished (NMFS, 1995), management of this species is difficult because detailed biological information is lacking. This paper describes the diet of goosefish and forms part of a wider study on the life history of this species (Armstrong *et al.*, 1992).

Materials and Methods

Goosefish were collected during the NMFS summer scallop survey (8–19 August 1983) off southern New England (Fig. 1). All prey items were identified to their lowest possible taxon. Volume of prey items was estimated by water displacement using graduated cylinders. Net feeding is when a predator consumes prey while confined to a capture device such as a trawl or dredge. In the case of goosefish, it appears to be an instinctive reaction, and does not necessarily reflect natural feeding or prey selection. Because preliminary observations indicated that goosefish often engaged in "net feeding", prey items found in the buccal cavity and esophagus, or obviously fresh in the stomach, were not used in the analyses.

Goosefish were analyzed by separating them into four size classes based on their total length (1–200 mm; 201–400 mm; 401–600 mm; and >600 mm). The relative contribution of different types of food to the total diet was determined using: (1) percent frequency of occurrence (the number of stomachs in which a food type occurred expressed as a percentage of the total number of stomachs containing food), (2) percent volume (the volume of each food type expressed as a percentage of the total volume of food from all stomachs), and (3) percent numerical abundance (the number of individuals of each type of food expressed as a percentage of the total number of food items found in all stomachs). An index of relative importance (IRI) (Pinkas *et al.*, 1971), which incorporates all three of these measurements, was calculated for each prey type from the formula:

$$IRI = (N + V) F$$

where: N = percent numerical abundance,
V = percent volume,
and F = percent frequency of occurrence.

[1] *Present address*: Department of Environmental Protection, Florida Marine Research Institute, 100 Eighth Avenue, S. E., St. Petersburg, FL 33701, USA
[2] *Present address*: Department of Environmental Protection, Florida Marine Research Institute, 2796 Overseas Highway, Suite 119, Marathon, FL 33050, USA

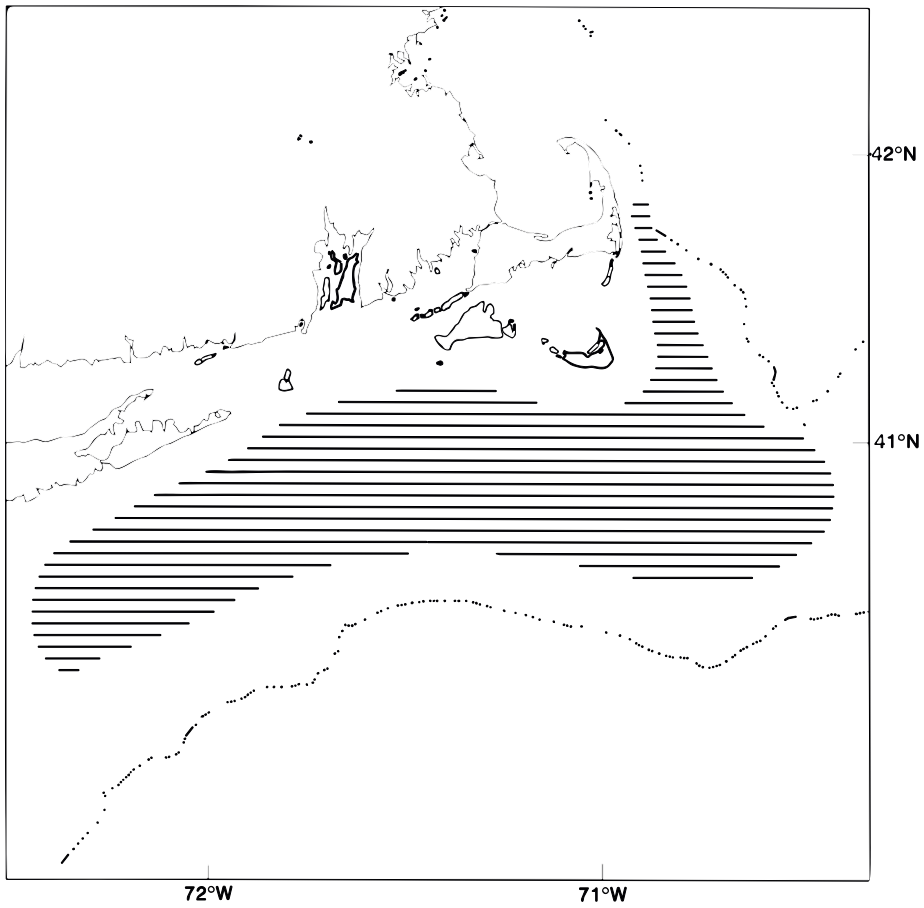

Fig. 1. Map of sampling area off the southern New England coast. Samples were taken from 65 scallop dredge hauls distributed throughout the hatched area.

Index of relative importance values were calculated for each size group separately in order to observe possible ontogenetic shifts in diet. Additionally, prey taxa were placed into four major groupings: Teleostei, Chondrichthyes, Crustacea and Cephalopoda.

Results

Two-hundred fifty-nine goosefish stomachs were examined. A total of 16 species of fish and 4 species of invertebrates could be identified as prey items (Table 1). In goosefish, of the 0–200 mm size class, a much higher percentage of stomachs containing food (91%) was found than in the larger size classes in which the percentages were approximately equal (54–58%). Teleostei were the most important prey for all size classes (Fig. 2) except the 1–200 mm size class in which crustaceans were more important based on number, frequency of occurrence and IRI. In this smallest size class, red shrimp, *Dichelopandalus leptocerus*, and sand lance, *Ammodytes spp.*, were dominant prey items. Other prey items encountered, in descending order of IRI were sand shrimp, *Crangon septemspinosus*, long-finned squid, *Loligo pealeii*, and juveniles of several species of demersal fishes.

Invertebrates were much less numerous in the diet of the 201–400 mm size class. The only invertebrate species that occurred in significant amounts was *L. pealeii*. The main prey items were Teleostei, with red hake, *Urophycis chuss*, and unidentified, well-digested teleost remains having the highest IRI.

No invertebrates occurred in stomachs from goosefish of the 401–600 mm size class. The diet was dominated by teleosts but small amounts of little skate, *Raja erinacea*, also occurred. The most important prey species were sand lance and red hake.

Goosefish in the largest size class (>600 mm) also preyed primarily on teleosts. Of the teleost remains that could be identified, sand lance was the most numerous. In contrast to the smaller size classes, in this size class the little skate was found in substantial amounts, having an IRI second only to sand lance. Smaller goosefish were also an important prey item.

TABLE 1. Relative frequency of occurrence (F), volume (V) and number (N), and Index of Relative Importance (IRI) for prey items of four size classes of *Lophius americanus*. Calculation of IRI follows Pinkas *et al.* (1971).

	Total Length (mm)															
	0–200				201–400				401–600				>600			
Prey Type	F	V	N	IRI	F	V	N	IRI	F	V	N	IRI	F	V	N	IRI
Mollusca																
Cephalopoda																
Loligo pealeii	4.0	11.8	1.1	52	8.7	5.7	9.7	134	0	0	0	0	4.5	2.2	2.0	19
Unidentified	0	0	0	0	0	0	0	0	0	0	0	0	4.5	0.2	2.0	10
Crustacea																
Euphausiacea	0	0	0	0	4.3	3.2	0.1	14	0	0	0	0	0	0	0	0
Decapoda																
Dichelopandalus leptocerus	57.6	18.9	65.0	4 833	0	0	0	0	0	0	0	0	0	0	0	0
Crangon septemspinosus	9.1	2.5	6.9	86	0	0	0	0	0	0	0	0	0	0	0	0
Chordata																
Pisces																
Chondrichthyes																
Raja erinacea	0	0	0	0	13.0	13.5	9.7	302	5.1	7.9	2.2	52	22.7	41.5	10.2	1 174
Squalus acanthias	0	0	0	0	0	0	0	0	0	0	0	0	4.5	1.2	2.0	14
Teleostei																
Conger oceanicus	0	0	0	0	0	0	0	0	2.6	1.3	1.5	7	0	0	0	0
Ophichthus cruentifer	0	0	0	0	0	0	0	0	10.3	8.5	6.7	157	0	0	0	0
Lophius americanus	0	0	0	0	0	0	0	0	0	0	0	0	10.2	27.8	17.7	464
Gadus morhua	0	0	0	0	0	0	0	0	0	0	0	0	4.5	0.8	2.0	13
Urophycis chuss	3.0	0.6	0.9	5	21.7	29.7	12.9	924	15.4	19.8	5.2	385	0	0	0	0
Urophycis tenuis	1.0	6.6	0.3	7	0	0	0	0	0	0	0	0	0	0	0	0
Merluccius bilinearis	0	0	0	0	4.3	14.8	6.5	92	2.6	1.6	0.7	6	0	0	0	0
Lepophidium cervinum	0	0	0	0	4.3	4.6	3.2	34	7.7	5.8	3.0	68	0	0	0	0
Pholis gunnellus	0	0	0	0	8.7	5.7	6.5	106	0	0	0	0	0	0	0	0
Ammodytes spp.	21.2	41.0	20.6	1 306	4.3	4.6	16.1	89	23.1	38.1	67.4	2 437	22.7	6.0	51.0	1 294
Peprilus triacanthus	0	0	0	0	0	0	0	0	0	0	0	0	4.5	10.8	8.2	86
Paralichthys oblongus	0	0	0	0	4.3	9.1	3.2	53	0	0	0	0	0	0	0	0
Citharichthys arctifrons	3.0	4.1	0.9	15	4.3	1.1	3.2	18	7.7	4.8	2.2	54	0	0	0	0
Pleuronectes americanus	4.0	3.1	1.7	19	0	0	0	0	0	0	0	0	4.5	15.5	2.0	79
Unidentified flatfish	0	0	0	0	0	0	0	0	2.6	2.8	1.5	11	0	0	0	0
Unidentified teleost	3.0	4.1	0.9	15	26.1	7.0	19.4	689	28.2	8.4	8.1	465	27.4	12.5	12.9	696
Total number of stomachs examined	109				40				72				38			
Number with food present (percent)	99(90.8)				23(57.5)				39(54.2)				22(57.9)			

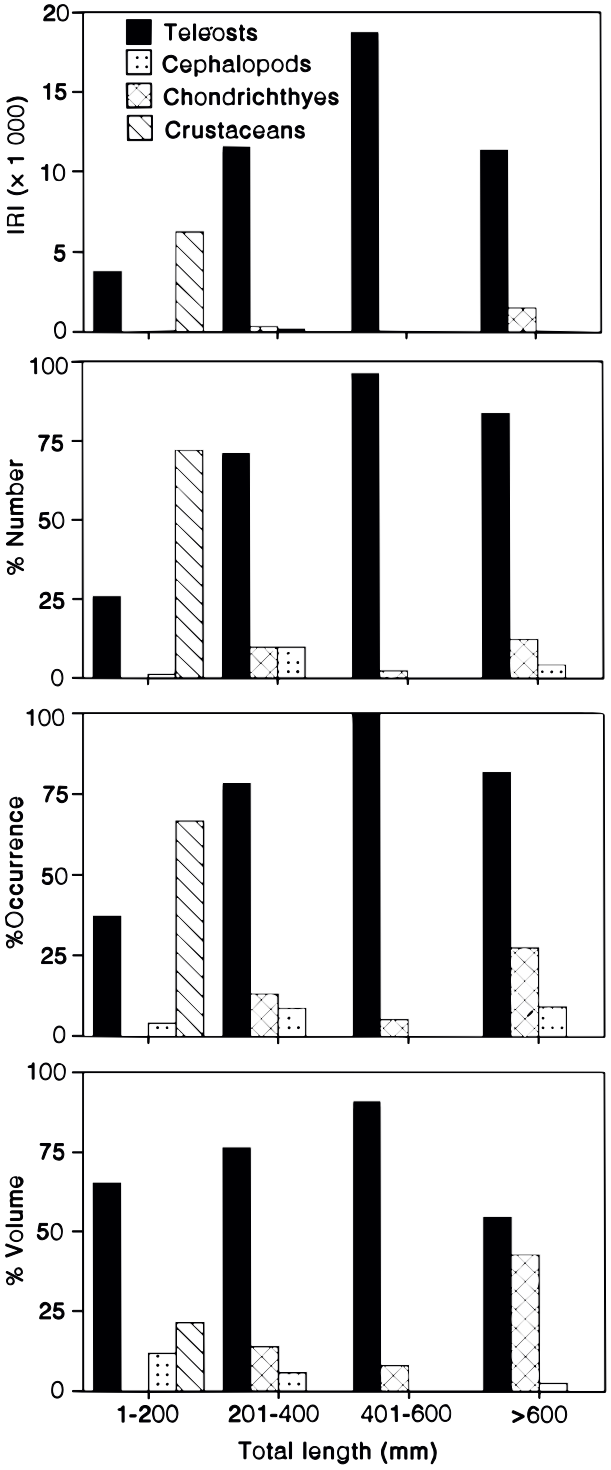

Fig. 2. Relative proportions of four prey types in the diets of four size classes of *L. americanus* collected off southern New England. IRI = Index of relative importance (Pinkas *et al.*, 1971).

Discussion

The feeding behaviour of lophiid anglerfishes has been well documented by several authors (Bigelow and Welsh, 1925; Chadwick, 1929; Wilson, 1937; Gudger, 1945). Lophiids are sit-and-wait predators that ambush prey that pass within range or make use of their angling apparatus (illicium) to actively attract prey to the vicinity of their mouths.

In the present study, goosefish fed on a wide range of prey types, preying primarily on benthic/demersal species. They exhibited an ontogenetic shift away from the consumption of invertebrates as they grew larger. Most demersal invertebrates (e.g. red shrimp) are relatively small and therefore not preferred food items for larger goosefish that are able to feed on larger prey items (Sedberry, 1983; Gordoa and Macpherson, 1990). An exception appears to be long-finned squid, which grows to a relatively large size and were found in all size classes of goosefish.

Feeding frequency appeared to differ between small and large goosefish. A higher percentage of stomachs containing food in the 1–200 mm size class compared to the larger size classes suggests a higher frequency of feeding, although a slower rate of digestion of crustaceans as compared to fish might cause the same results. A higher frequency of feeding in the young stages could be related to higher energy demands resulting from rapid growth during this period of their life (Armstrong *et al.*, 1992). A high proportion of empty stomachs is characteristic of *Lophius* species (Fulton, 1903; Maurer and Bowman, 1975; Crozier, 1985), suggesting relatively infrequent periods of feeding (Wilson, 1937; Tsimenidis, 1980).

Sedberry (1983) sampled goosefish from the Middle Atlantic outer continental shelf off New Jersey. He found goosefish fed mainly on fishes and to a lesser extent on benthic invertebrates during all seasons. The most important invertebrates were long-finned squid and red shrimp. Red hake and unidentified teleost remains were the most important piscine prey items. He also found that larger goosefish ate larger prey. Goosefish larger than 400 mm standard length preyed exclusively on fish. A small amount of chaetognaths was found in the 1–100 mm size class and relatively small amounts of crustaceans and cephalopods were found in goosefish from 101–400 mm, however, fish were by far the dominant prey item (by volume, occurrence, number and IRI) in these smaller size groups also. This is in contrast to the results of this study for the

1–200 mm size class in which crustaceans were most important (by occurrence, number and IRI but not volume) compared to predation on other species. The studies would be in agreement if only prey volume was considered.

It is interesting to note that cannibalism was relatively important in this study and in several other studies on the feeding ecology of *Lophius* species (Maurer and Bowman, 1975; Gordoa and Macpherson, 1990). The type of cannibalism found here is classified as non-kin intercohort cannibalism (Smith and Reay, 1991), which is defined as predation by older conspecifics. It is the most common type of cannibalism found in fishes.

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