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OCCURRENCE, GROWTH, AND FOOD HABITS OF THE SPOTTED HAKE, *Urophycis regia*, IN THE CAPE FEAR ESTUARY AND ADJACENT ATLANTIC OCEAN, NORTH CAROLINA

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ABSTRACT: From 1973 to 1978, 62,867 *Urophycis regia* were collected from the Cape Fear Estuary, North Carolina, and the adjacent Atlantic Ocean. Most fish were young-of-the-year (25-225 mm SL), but a few age-I individuals (230-295 mm) were present in the estuary from January to June. They moved offshore or northward when water temperatures warmed above 22°C. Average monthly growth increments varied from 12 to 26 mm SL; the greatest increase in length was 92 mm from January to June 1977. Length-weight regressions for the 6-year study period were similar. Important food items were crustaceans (largely mysid shrimp and decapods) and fishes (clupeid and sciaenid larvae). The abundance of *U. regia* in inshore waters and the relatively large size it reaches suggests that marketing needs to be explored.

The spotted hake, *Urophycis regia* (Walbaum), commonly occurs off the coast of North Carolina (Smith 1907; Hildebrand and Cable 1938; Schwartz *et al.* 1981) and is one of the 15 most abundant fishes in the Cape Fear estuary (Schwartz *et al.* 1979a, b). Adults apparently spawn and remain offshore since neither ripe fish nor eggs have been taken in estuaries (Hildebrand and Cable 1938; Barans 1972; Sikora *et al.* 1972). Estuaries serve as important nursery areas for young *U. regia* frequenting North Carolina coastal areas from February to April.

Occurrence, growth, and food habits of coastal western Atlantic populations of *U. regia* have been studied in the York River-lower Chesapeake Bay (Barans 1969, 1972) and along the mid-Georgia coasts (Sikora *et al.* 1972); a brief study of development and sizes was conducted near Beaufort, North Carolina by Hildebrand and Cable (1938). Food habit studies have also been reported from the Gulf of Maine (Bigelow and Welsh 1925; Bigelow and Schroeder 1953), Chesapeake Bay (Hildebrand and Schroeder 1928; Barans 1969), the northwest Atlantic north of Cape Hatteras (Bowman and Michaels 1984), and off Delaware Bay and Atlantic City, New Jersey (Sedberry 1983).

U. regia is of little commercial value, but its abundance and relatively large size make the species a strong candidate for potential fisheries utilization in the United States. Hakes are important to other fisheries in the world (Whitaker 1980). This paper provides information on occurrence, growth, and food habits of *U. regia* from the Cape Fear estuary and nearby Atlantic Ocean, North Carolina.

Study Area

The Cape Fear River is 528 km long, lies entirely within North Carolina, and is the largest river drainage system in the state. The estuarine portion of the river accounts for 880 km^2 of the 14,553 km^2 drainage basin. Most of the estuary is subject to swift tidal excursions of ± 2 m and southwesterly winds prevail during nine months of the year.

The 7,854 hectare study area (Fig. 1) is 17 km long and 1.6 to 3.6 km wide. The estuary width is 2.1 km at Snows Cut and

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2.0 km at its mouth. Depending on season and rainfall runoff, salinities greater than 10 ppt occur south of Snows Cut for 16-23 km to the river mouth near Southport, North Carolina. Salinities increase by fall to 32 ppt at the river mouth and the adjacent ocean off Baldhead and Oak Islands. Average water temperature is 9°C in January and 23°C during July-August.

Nineteen stations in the river, two near Carolina Beach Inlet (CBI-N, CBI-S), and one in the nearby ocean were sampled (Fig. 1). Often 4-12 substations were made along the beach from Oak Island Lighthouse to Yaupon Beach as part of the ocean station (Fig. 1). Depth of water at river, Carolina Beach, or ocean stations varied from 0.6 to 12.0 m. Bottom substrates varied from sand and silt to hard mud and clay or porous rock and shells. See Schwartz *et al.* (1979a, b) for detailed descriptions of each sampling station.

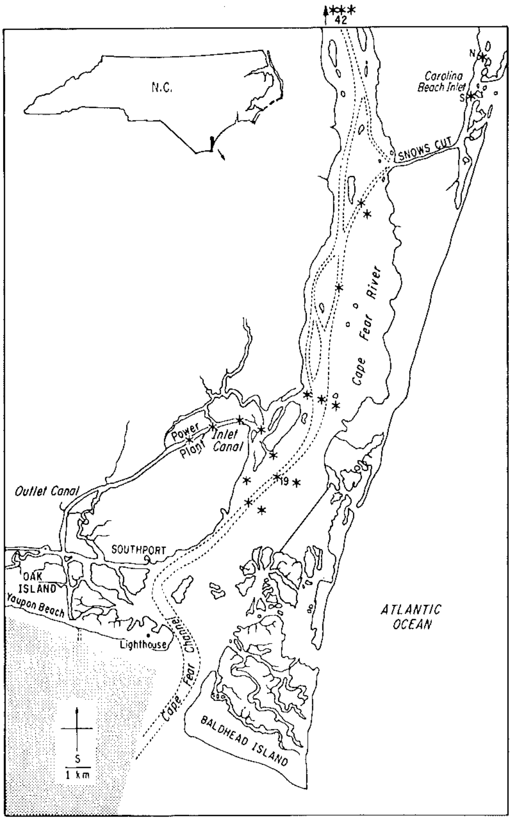

Figure 1. Cape Fear estuary and adjacent ocean illustrating sampling stations (*) and specific sites mentioned in the text. The stippled area delineates the ocean sampling substations. Dashed lines indicate deep ship channel.

METHODS

Daylight sampling was conducted weekly from February through May and September through November, 1973-1978. A single sample was taken at mid-month in June, July, and August. January samples were made, weather permitting, once or twice a month during 1974-1978. No sampling was done at night because of ship traffic and the absence of visual markers.

Trawling was conducted at stations deeper than 5 m with the 12 m R/V SARAH HELEN or 14.1 m R/V MACHAPUNGA and with a 6.1 m outboard skiff at stations less than 5 m depth. Fifteen minute tows were made with a 12.5/15.3-m semi-balloon otter trawl of 31.3-mm stretched mesh at deep stations and a 7.6 m semi-balloon otter trawl of 19-mm stretched mesh at shallow stations. Large catches were subsampled by filling an 8.5-ℓ pail with fishes. These fishes were then sorted by species, weighed, preserved live in 10% sea-water formalin and returned to the lab for analysis. Nine 91.4-m long gill nets, 65 meshes deep and 81-mm stretched mesh were set at shallow stations and checked once daily. Because only 34 *U. regia* were captured in 2,363 gill net sets, gill net catch per unit effort (CPUE) data have been disregarded from further discussion.

All fish were weighed to the nearest 0.1 g and standard lengths (SL) were measured to the nearest millimeter. Length-weight regressions were calculated using only laboratory-measured specimens.

Scale samples were taken mid-dorsally beneath the dorsal fin from 364 fish in 1973, 58 in 1974, 376 in 1975, 308 in 1976, 449 in 1977, and 644 in 1978. They were mounted between glass slides, and viewed with projection at 83X. Yearly, random samples were then selected from each 5-mm size class, when available, as a representative subsample of the entire population for use in age and growth determinations.

Stomachs from at least 10 individuals from each subsampled catch were excised and the percent fullness was estimated visually. Foods were sorted and identified to the lowest possible taxon.

The relative contribution of different food items to the total diet was determined using three methods: 1) percent frequency of occurrence; 2) percent numerical abundance; and 3) percent volume. Numerical, volumetric, and frequency of occurrence percentages were calculated for treatment by year, month, fish length, and sampling station.

An index of relative importance, IRI (Pinkas *et al.* 1971), was calculated: IRI = (N + V)F, where N = numerical percentage, V = volumetric percentage, and F = frequency of occurrence percentage. This index is useful in evaluating the relative importance of different food items found in fish stomachs (e.g., Sedberry 1983).

RESULTS AND DISCUSSION

Occurrence

Between 1973 and 1978 62,867 *U. regia* were trawled at the 22 sampling stations during the colder months, February to April (11,149 were captured in 1973, 702 in 1974, 6,751 in 1975, 3,464 in 1976, 11,916 in 1977, and 28,885 in 1978). Few individuals (21) were present in January and the species presence decreased (.04% in January, 8.1 February, 38.7 March, 40.8 April, 12.3 May, and .06 June) markedly during May and June in any year sampled. Only 13 specimens were collected at any other time of the year, these were caught in September 1973 in the Atlantic Ocean adjacent to the main study area. Most *U. regia* frequented the power plant intake canal, the deep channel stations, and most shoal stations from buoy 19 south, during the 1973-1978 sampling period (Fig. 1).

Few *U. regia* (801 of 62,867; all years combined) were collected when water temperatures exceeded 22°C. The majority occurred in waters ranging from 13 to 20°C. There was no relationship between catch per unit effort and water temperature for the years 1973-1978, although the larger catches of 1973 and 1978 were associated with relatively low average water temperatures of 7-8°C.

U. regia were collected during all years in waters ranging from 0 to 36 ppt salinity, although most were caught in waters 9 to 34 ppt salinity. There was also no distributional relationship with salinity in Georgia estuaries (Sikora *et al.* 1972). Barans (1972), however, found salinities lower than 7 ppt limited upriver movement of *U. regia* in the York River.

U. regia was most abundant from February through April in mid-Georgia estuaries at water temperatures between 8 and 25°C (Sikora *et al.* 1972) and during the same time frame in the Newport River near Beaufort, North Carolina (Hildebrand and Cable 1938). Spotted hake were most common in the York River-lower Chesapeake Bay from April through June (Barans 1972), largely because water temperatures did not rise above 25°C at that latitude until July.

U. regia spawns in the Middle Atlantic Bight from late September through November, and possibly to February

(Barans and Barans 1972). Colton *et al.* (1979) noted that spawning may occur during all months except May through July. A shoreward migration seems characteristic of the species. Juvenile fish frequent coastal areas and estuaries during late winter and spring and disappear from these areas during late spring and early summer concurrent with the return of warming water conditions. If this pattern of movement is correct, a refinement of the spawning season, as noted in Colton *et al.* (1979), is probably necessary, otherwise young *U. regia* would be expected in estuaries during the summer months.

Abundance

Of the 15 most abundant fishes in the Cape Fear estuary, *U. regia* had a mean numerical abundance rank of 7.0 (the mean value excludes 1974 data, a poor catch year for the species) and ranked eighth in weight for the 6-year study period. Of the 2,013,983 fishes of all species caught throughout the study period, 3.2% were *U. regia*. Most *U. regia* (N = 57,002) were caught with the large trawl and fewer (N = 5,831) with the small trawl. Catches of *U. regia* (28,885) in 1978 exceeded those of any of the previous 5-year samples. Struhsaker (1969) regarded *U. regia* as very common (>50%) at trawling station depths less than 101 fathoms off the southeastern Atlantic coast, 1959-1964. The species was taken there most frequently from lower shelf, coastal, open shelf, and shelf-edge habitats.

Growth

Mean length of *U. regia* generally increased during consecutive monthly samples from January (or February) through May (or June) for all years (Fig. 2). The average monthly growth increment ranged from a low of 12 mm in 1973 to a high of 26 mm in 1974, with a mean of 18 mm for the 6 years combined. The 1974 growth was based on a small sample size and may not be indicative of actual growth. With the 1974 data excluded, average monthly growth for the 5 remaining years was 16 mm. Mean monthly growths averaged 17 mm in Georgia estuaries (Sikora *et al.* 1972), 24 mm in the Newport River, North Carolina (Hildebrand and Cable 1938), and 16 to 25 mm in the York River-lower Chesapeake Bay (Barans 1972). Barans (1972) found the greatest increase in mean standard length for York River-lower Chesapeake Bay *U. regia* was 76 mm.

Length-frequency data (Fig. 3) for 53,393 *U. regia* indicated that the Cape Fear population was comprised of fish ranging from 25 to 295 (mean 186) mm SL. Bimodal size peaks were evident in the 1974 and 1976 samples. The few relatively large individuals present during the other sampling years (Fig. 3) suggested the presence of two age classes. Aging of scales revealed individuals ≤225 mm were age 0 and those 230 mm to at least 295 mm were age 1. The mean length for all age 0 fish was 112 mm SL, 259 mm for all age 1 fish. Most were in their first year of life; less than 1% were age 1 fish.

Weight-frequency data for 25,259 fish yielded results similar to the length data. All fish were juveniles although a few individuals over 200 g in 1974, 1976, and 1978 represented age 1 fish.

This is the only study to report age 1 *U. regia* from an estuary. Small numbers were collected there only in 1973, 1976, 1977, and 1978. The largest age 1 fish we measured was 295 mm SL; the largest age 0 fish was 230 mm. The largest age 0 Georgia estuary specimen was 200 mm total length (TL) (Sikora *et al.* 1972) or about 169 mm SL (TL = 1.18 SL, N = 334). Maximum size reported in

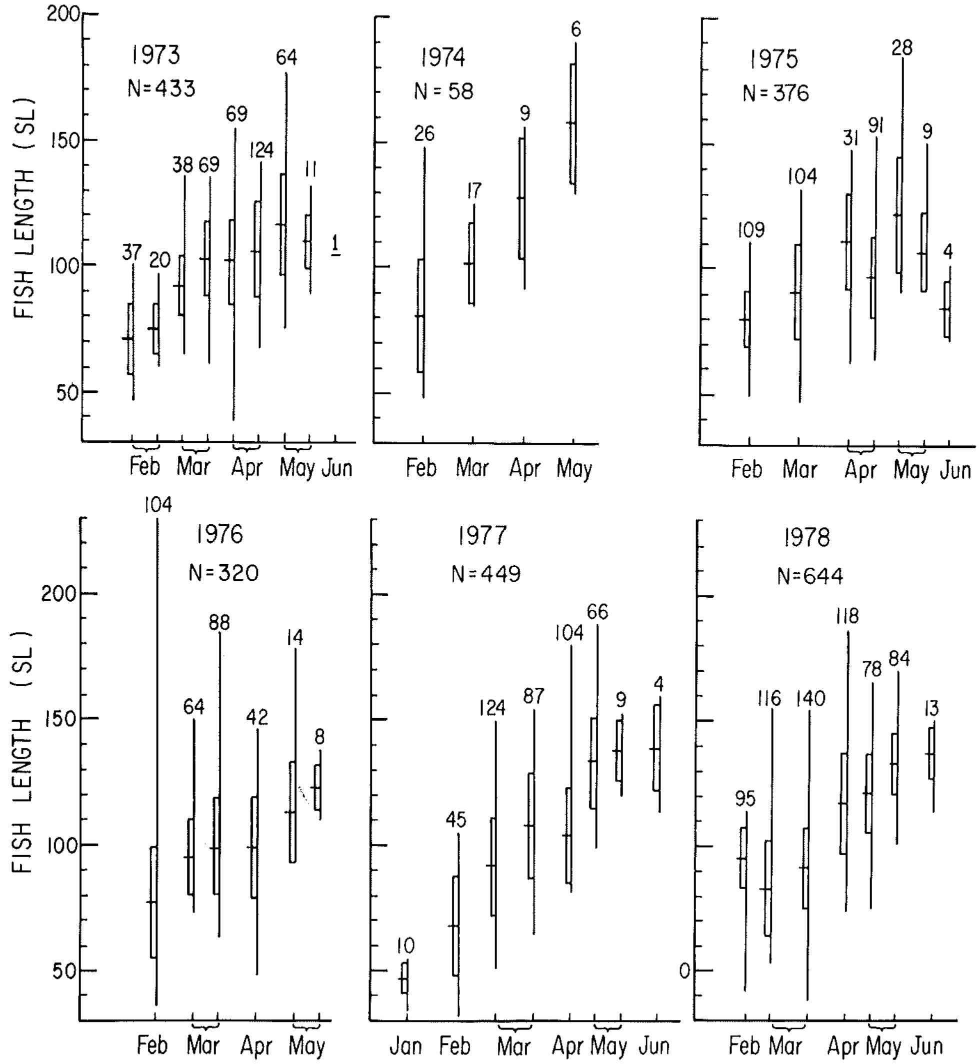

Figure 2. Growth by month of *U. regia* in the Cape Fear estuary, 1973-1978. The diagrams indicate the range in SL (basal line), mean (center point), and one standard deviation on either side of the mean (outer limits of open rectangle). Numbers are sample sizes. When two sampling periods are shown for one month, the first sample indicates the first half of the month and the second the latter half of the month.

the Newport River, North Carolina, was 219 mm TL or 186 mm SL (Hildebrand and Cable 1938), and in the York River-lower Chesapeake Bay was 299 mm TL or 253 mm SL (Barans 1972). Thus, *U. regia* from northern areas may attain a larger size in the first year of life than do those from North Carolina and Georgia.

Yearly length-weight regressions for 12,584 *U. regia* captured in the Cape Fear estuary and nearby Atlantic Ocean from 1973-1978 were similar (Fig. 4). The length-weight relationships were expressed by the following curvilinear equations: 1973, $W = 0.00003L^{2.897}$ (N = 2835, r = .95); 1974, $W = 0.00001L^{3.233}$ (N = 81, r = .99); 1975, $W = 0.0005L^{2.221}$ (N = 1341, r = .86); 1976, $W = 0.00003L^{3.049}$ (N = 522, r = .98); 1977, $W = 0.00002L^{2.987}$ (N = 1733, r = .97); 1978, $W = 0.00003L^{2.885}$ (N = 6072, r = .97), where W is the weight in grams and L is the SL in millimeters. Specimens collected in 1975 generally weighed less (mean 15 g) than those caught in other years and this may account for the small

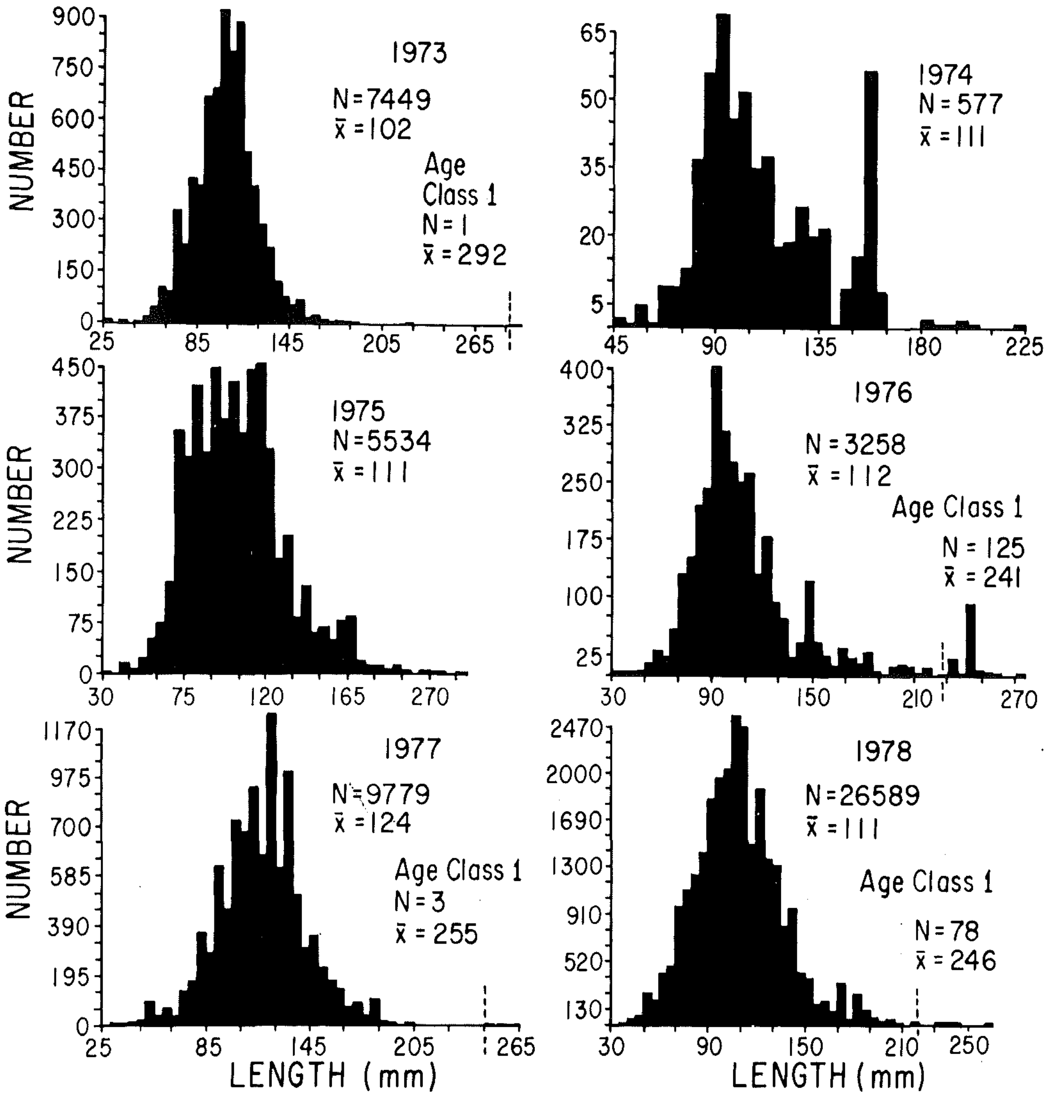

Figure 3. Length-frequency distributions of *U. regia* from the Cape Fear estuary, 1973-1978. Dashed vertical line indicates smallest length of age-1 fish.

slope value noted. Barans (1969) included length-weight regressions for 1,593 spotted hake (683 males: $W = 0.00001L^{3.066}$; 910 females: $W = 0.00001L^{3.063}$) from the York River-lower Chesapeake Bay with slope values similar to those reported here.

Food Habits

A total of 2,416 specimens, 30 to 229 mm SL, was examined during 1973-1978. Stomachs of 2,105 (87%) contained food. There was no variation by month or station in food eaten. Arthropods and fishes (Fig. 5) were the most important food categories. Arthropods occurred in an average of 78.4% (range 70.5-83.0), and fishes in 34.9% (range 23.9-41.6), of the stomachs. By volume, arthropods averaged 54.6% (range 42.1-63.0) and fishes 33.0% (range 25.7-45.1) of the stomach contents.

The most frequently consumed arthropods were mysids which occurred in 63.1% (range 52.8-82.0) of the stomachs and accounted for 34.8% (range 24.6-53.3) of the volume. For the years 1975-1978, *Neomysis americana* was the

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Table 1. Percent volume of foods (listed phylogenetically) eaten by *U. regia* captured from the Cape Fear estuary and adjacent Atlantic Ocean, 1973-1978.

Food Items	1973	1974	1975	1976	1977	1978
Stomachs: Examined	544	50	380	307	448	687
: Containing Food	490	46	317	252	400	600
Porifera			TR			
Cnidaria				TR		
Hydrozoa				TR		
Rhynchocoela			TR	TR		
Aschelminthes	TR	0.5	TR	TR	TR	TR
Nematoda	TR	0.5	TR	TR	TR	TR
Mollusca	1.1		TR	1.1	1.0	0.7
Gastropoda	TR				TR	TR
Nassariidae					TR	
Bivalvia				0.5	0.5	0.6
Cephalopoda	TR				TR	TR
Teuthidida	TR				TR	TR
Annelida	2.2	3.9	5.3	3.4	2.8	7.6
Polychaeta	2.1	3.9	5.3	3.3	2.4	6.6
Nereidae	TR		0.7			
Chaetopteridae	TR					
Chaetopterus variopedatus	TR					
Oligochaeta						TR
Hirudinea			TR		TR	0.7
Sipuncula	TR					
Arthropoda	63.0	59.5	61.6	42.1	45.8	55.7
Arachnida				TR		
Crustacea	63.0	59.5	61.6	42.1	45.7	55.7
Copepoda	TR		1.4	1.0	1.5	4.3
Calanoida			1.4	0.9	1.5	4.3
Harpacticoida				TR	TR	
Lernaeopodoida	TR					
Hoplocarida				0.6		TR
Squilla empusa				0.6		TR
Mysidacea	53.3	26.5	41.4	24.6	31.3	31.6
Larvae	TR					
Mysidopsis bigelowi				TR		
Neomysis americana			35.6	19.1	22.6	26.4
Cumacea				TR		
Tanaidacea			TR			
Isopoda	0.5		0.5	0.6	TR	TR
Anthuridae	TR					
Flabellifera	TR		TR	TR	TR	TR
Olencira praegustator				TR	TR	TR
Lironeca ovalis	TR					
Valvifera			TR	TR	TR	
Idotea sp.				TR		
Amphipoda	1.1	5.5	6.9	4.2	2.2	5.0
Eggs				TR		
Gammaridea	TR	1.0	3.8	3.2	1.8	4.1
Corophiidae			TR	TR		
Caprellidea		2.8	TR	TR		
Decapoda	6.9	27.3	10.0	8.1	9.0	13.1
Natantia	1.3	13.6	3.7	5.5	5.0	7.7
Zoeae	0.5					
Penaeidea		0.7	TR	1.8	1.9	1.4
Penaeidae		0.7				0.9
Penaeus sp.						0.9
Sergestidae			TR	TR		
Acetes americanus			TR	TR		
Caridea	0.5	10.3	1.1	2.0	1.6	5.7
Palaemonidae	0.5	5.7		TR	0.6	2.9
Palaemonetes sp.	0.5	5.7		TR	0.5	2.9
Palaemonetes pugio						0.7
Palaemonetes vulgaris		5.7			TR	0.6
Alpheidae		4.5		0.7		
Alpheus sp.		3.1		0.7		
Alpheus heterochaelis				TR		
Ogyrididae				TR		
Ogyrides alphaerostris				TR		
Reptantia	5.5	13.8	5.3	1.8	3.0	4.8
Macrura	2.6			TR	10.0	3.2
Callianassa sp.						TR
Upogebia affinis	2.6					2.5
Anomura	TR	0.7		TR	0.9	TR

Table 1. Cont

Food Items	1973	1974	1975	1976	1977	1978
Stomachs: Examined	544	50	380	307	448	687
: Containing Food	490	46	317	252	400	600
Paguridea	TR			TR	0.6	TR
Pagurinae				TR		
Hippidea		0.7		TR		
Emerita talpoida		0.7		TR		
Brachyura	2.2	12.1	3.9	TR	TR	0.6
Megalops			TR			
Portunidae	TR	4.1	TR		TR	TR
Ovalipes sp.	TR					TR
Ovalipes stephensoni	TR					
Xanthidae	TR	2.8	0.7			TR
Pinnotheridae	1.4	5.3	2.9	TR		
Pinnixa sp.	1.4	3.2	2.9			
Pinnixa chaetoptera	0.8					
Pinnotheres sp.		2.0				
Echinodermata	TR					
Holothuroidea	TR					
Chordata	30.0	25.7	28.1	45.1	42.7	26.1
Pisces	30.0	25.7	28.1	45.1	42.7	26.1
Larvae	1.6	1.4	0.8		TR	TR
Anguilliformes	TR					
Clupeidae				1.4	1.4	1.0
Brevoortia tyrannus				TR	1.0	TR
Anchoa sp.	0.7			5.4	TR	TR
Anchoa hepsetus			TR		0.6	
Anchoa mitchilli	1.8			1.8	TR	1.5
Sciaenidae		3.7			TR	
Sciaenidae Larvae			0.7			
Membras martinica	TR					
Leiostomus xanthurus					TR	
Leiostomus xanthurus Larvae		0.5		1.6	1.4	TR
Menticirrhus sp.				TR		
Micropogonias sp.			TR			
Micropogonias undulatus	1.4		0.6		0.6	
Micropogonias undulatus Larvae	9.2			TR		
Stellifer lanceolatus			TR	TR		
Stellifer lanceolatus Larvae			TR			
Blenniidae						
Hypsoblennius hentzi			TR			
Triglidae						
Prionotus sp.	TR					
Prionotus carolinus	TR					
Prionotus tribulus			TR			
Bothidae						TR
Bothidae Larvae				TR		
Etropus sp.			TR			
Paralichthys sp.						TR
Paralichthys sp. Larvae						TR
Paralichthys dentatus						TR
Cynoglossidae						
Symphurus plagiusa	TR		TR		TR	
Organic Remains	3.2	9.3	4.8	7.8	7.7	9.3
Digested Organic Matter	1.3	1.3	0.8	6.7	6.6	5.2
Detritus	TR		3.4	0.6	TR	TR
Animal Remains	TR	3.3		TR	TR	2.8
Fecal Pellets						TR
Plant Matter	TR	4.6	0.7	TR	TR	0.9
Algae		3.9	TR		TR	TR
Diatoms			TR			
Ulva sp.		3.9				
Grass	TR					TR
Wood	TR		TR		TR	TR
Inorganic Remains	TR	1.0	TR	TR	TR	0.7
Mud	TR		TR		TR	TR
Rock	TR	1.0		TR		
Sand	TR		TR	TR	TR	TR
Unidentified	TR					TR

TR = Trace volume of less than 0.5%.

most important mysid eaten (frequency = 43.0%; volume = 24.7%). Decapods were the second most important arthropods consumed and occurred in an average of 24.9% (range 18.8-30.4) of stomachs and accounted for 12.4% (range 6.9-27.3) of the volume. The most frequently eaten fishes were clupeid and sciaenid larvae. Atlantic croaker, *Micropogonias undulatus*, larvae were the most common fish consumed (11.8% frequency and 9.2% volume) in 1973 and *Anchoa* sp. was the most commonly identified larval fish in 1976. Organic matter ("other" category in Fig. 5) averaged 7.0% of the food volume and included a relatively small variety of plant and animal remains (Table 1).

There was little change in major foods consumed by *U. regia*, during the 6-year study period. Mysidacea had the highest IRI values of any food organism from 1973 to 1976, but ranked second to fishes in 1977 and 1978 (Fig. 5). Other important food organisms with high IRI values included annelid worms in 1973 (IRI = 3901) and decapods in 1974 (IRI = 3480). Mollusca and Aschelminthes contributed little to the diet.

Throughout the study, mysids and fishes dominated the diets of all size classes (5-mm size classes). Mysids had the highest IRI values in specimens of about 30 to 140 mm. Fish generally dominated the diet of larger *U. regia* and registered the highest IRI values.

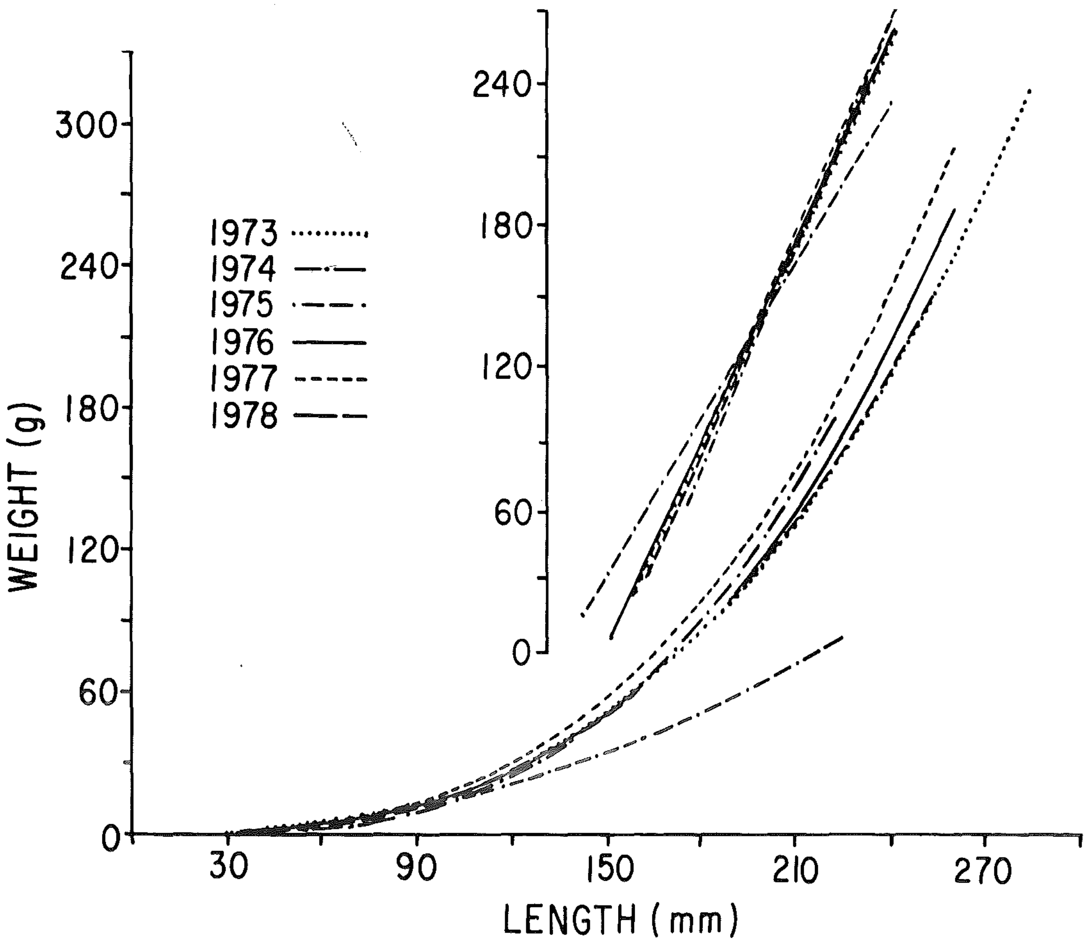

Figure 4. Length-weight curvilinear and logarithmic regressions of *U. regia* from the Cape Fear estuary, 1973-1978.

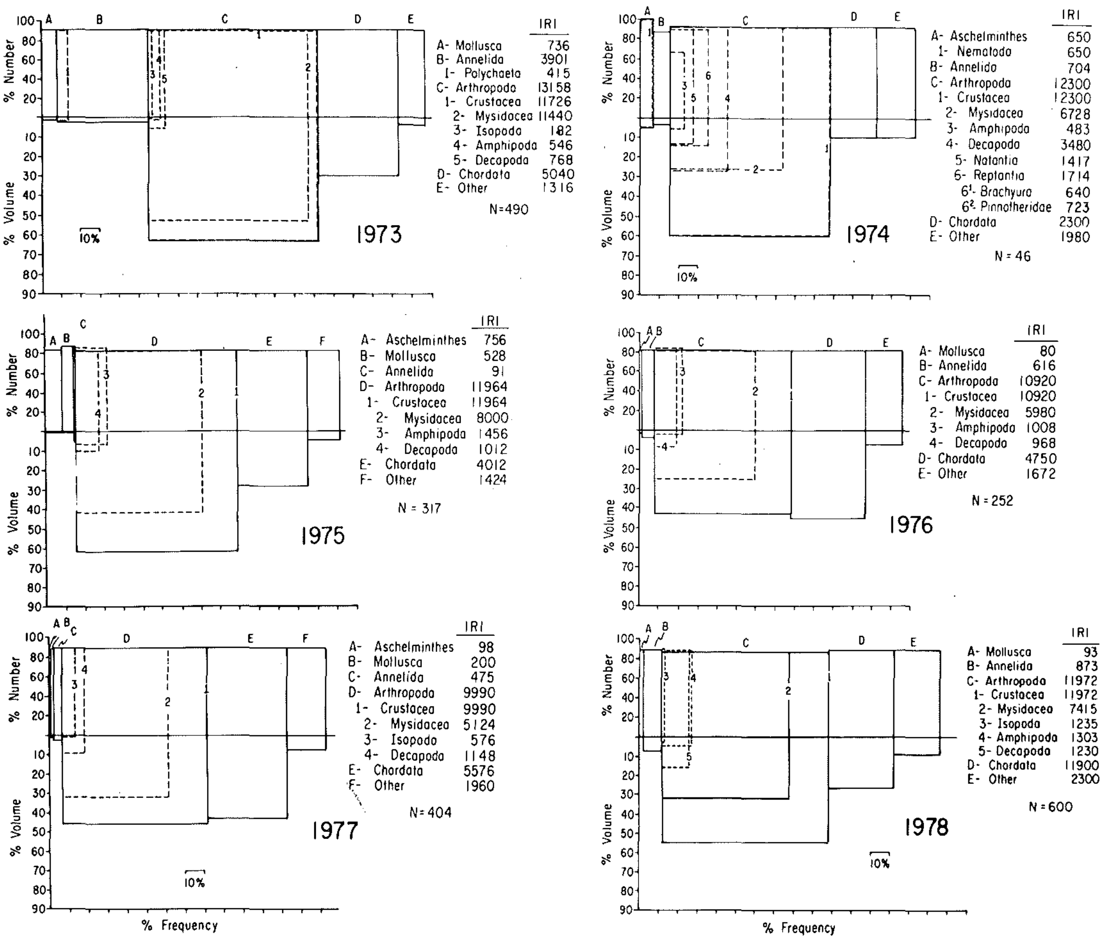

Figure 5. Percent frequency of occurrence, percent number, percent volume, and index of relative importance (IRI) of higher taxonomic groups of food in the diet of *U. regia* in the Cape Fear estuary, by year. Chordata = Pisces.

Specimens ranging from 70 to 135 mm ate the greatest variety of foods including members of Polychaeta (especially *Nereis*), Natantia (especially Penaeidae and Caridea), Reptantia (especially *Upogebia* and *Pinnixa*), Amphipoda (especially Gammaridea), Isopoda, and Hoplocarida (especially *Squilla*).

Bigelow and Welsh (1925), Hildebrand and Schroeder (1928), Bigelow and Schroeder (1953), Richards (1963), Barans (1969), Sikora *et al.* (1972), Sedberry (1983), and Bowman and Michaels (1984) have noted the food habits of *U. regia*. Those studies also revealed a preference for crustaceans and fishes. Bigelow and Welsh (1925) and Bigelow and Schroeder (1953), reporting on the diet of a few *U. regia* from the Gulf of Maine, noted that crustaceans, such as shrimp, amphipods, and other small crustaceans were the dominant prey, but small fishes and squid also contributed significantly to the diet. In Long Island Sound, 17 *U. regia* ate mostly the sand shrimp, *Crangon septemspinosa*, and the amphipod, *Leptocheirus pinguis*, but other crustaceans, polychaetes, molluscs, and fishes were also ingested (Richards 1963). Hildebrand and Schroeder (1928) found stomach contents of 141 *U. regia* from Chesapeake Bay contained 95% crustaceans (82% were mysids). Stomach con-

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tents of 600 fish in Chesapeake Bay and adjacent waters contained primarily crustaceans, including sand shrimp, sergestids, and mysids, and some squid, polychaetes, and fishes (Barans 1969). In Georgia estuaries, 80% of the biomass ingested by 341 spotted hake consisted of crustaceans, of which the mud shrimp accounted for 45%, amphipods and mysids the remainder (Sikora *et al.* 1972). Fishes, followed by polychaetes and molluscs, were of lesser importance in the diet. This indicated that hake fed primarily on the bottom during the day when many organisms, which migrate vertically, were also near the bottom (Edwards and Emery 1968; Barans 1969).

Food habits, feeding behavior, and morphological adaptations of *U. regia* reveal that it is a benthic feeder. The species possesses a subterminal mouth, a barbel, a well developed air bladder, and chemoreceptive pelvic fins (Barans 1969). *U. regia* swim slowly across the bottom with their pelvic fins extended forward and downward, touching the substrate when searching for food. The sensory capabilities of the pelvic fins are restricted to a chemical stimulus (Bardach and Case 1965). Stimulation of the chemoreceptors by food triggers a snapping response of the jaws independent of vision, and thus may have some value in nocturnal feeding (Barans 1969). However, hake find and recognize food by sight using the pelvic fins only to test the "palatability" of the food rather than to locate a distant scent source (Herrick 1904; Bardach and Case 1965; Barans 1969; Pearson *et al.* 1980; Luczkovich and Olla 1983).

Food habits of *U. regia* have been analyzed by length in three previous investigations. Richards (1963) noted hake 55-98 mm SL had a more varied diet than those 140-144 mm SL, which fed only upon crustaceans. Sedberry (1983) examined stomachs of 234 spotted hake 151-350 mm SL from the New Jersey and Delaware coasts and found more decapods and then fishes as predator size increased. Conversely, amphipods decreased in numerical importance in the stomachs of larger fish, and cephalopods became volumetrically important only in the stomachs of the largest *U. regia*. Bowman and Michaels (1984) found *U. regia* 1-10 cm TL ate large quantities of amphipods, those 11-25 cm consumed mostly amphipods, decapods and euphausids, and those >25 cm contained mostly decapods and fishes.

U. regia utilizes estuaries as nursery grounds along the Middle and South Atlantic Bights during late winter and spring. Disappearance from inshore waters when the temperature exceeds 25°C may relate to feeding behavior, which is inhibited by warm water temperatures in fishes that normally frequent cold waters.

Use

In the last 10-15 years, hakes have become increasingly important in the world fishery (Whitaker 1980); the United State consumes all the hake it produces and imports considerable quantities. Europe, the second largest hake consuming area, is expected to import more hake in the near future. *U. regia* is presently of no commercial value, but large numbers of juveniles in inshore waters and the reported large catches of adults offshore (Struhsaker 1969) indicate that the species is potentially important as a food fish. Because *U. regia* is abundant and reaches a reasonably large size (350 mm SL) market development and use of the species needs to be more adequately explored.

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LITERATURE CITED

Barans, C.A. 1969. Distribution, growth and behavior of the spotted hake in the Chesapeake Bight. Masters Thesis, College of William & Mary, Williamsburg, Virginia. 53 p.

__________. 1972. Spotted hake, *Urophycis regius*, of the York River and lower Chesapeake Bay. Chesapeake Sci. 13(1):59-68.

__________and A.C. Barans. 1972. Eggs and early larval stages of the spotted hake, *Urophycis regius*. Copeia 1972(1): 188-190.

Bardach, J.E. and J. Case. 1965. Sensory capabilities of the modified fins of squirrel hake (*Urophycis chuss*) and sea robins (*Prionotus carolinus* and *P. evolans*). Copeia 1965(2):194-206.

Bigelow, H.B. and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. U.S. Fish Wildl. Serv., Fish. Bull. 74(53):1-577.

__________and W.W. Welsh. 1925. Fishes of the Gulf of Maine. Bull. U.S. Bur. Fish. 40 (part 1):1-567.

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

Colton, J.B., Jr., W.G. Smith, A.W. Kendall, Jr., P.L. Berrien, and M.P. Fahay. 1979. Principal spawning areas and times of marine fishes, Cape Sable to Cape Hatteras. Fish. Bull. NOAA 76(4):911-914.

Edwards, R.L. and K.O. Emery. 1968. The view from a storied sub the 'Alvin' off Norfolk, Va. Comm. Fish. Rev. 30(8-9):48-55.

Herrick, C.J. 1904. The organ and sense of taste in fishes. U.S. Fish Comm. Bull. 22:237-272.

Hildebrand, S.F. and L.E. Cable. 1938. Further notes on the development and life history of some teleosts at Beaufort, N.C. Bull. U.S. Bur. Fish. 48:505-642.

____________and W.C. Schroeder. 1928. Fishes of the Chesapeake Bay. Bull. U.S. Bur. Fish. 43 (part 1):1-366.

Luczkovich, J.J. and B.L. Olla. 1983. Feeding behavior, prey consumption, and growth of juvenile red hake. Trans. Am. Fish. Soc. 112(5):629-637.

Pearson, W.H., S.E. Miller, and B.L. Olla. 1980. Chemoreception in the food-searching and feeding behavior of the red hake, *Urophycis chuss* (Walbaum). J. Exp. Marine Biol. Ecol. 48:139-150.

Pinkas, L., M.S. Oliphant, and I.L.K. Iverson. 1971. Food habits of albacore, bluefin tuna, and bonito in California waters. Calif. Dep. Fish Game, Fish. Bull. 152, 105 p.

Richards, S.W. 1963. The demersal fish population of Long Island Sound. II. Food of the juveniles from a sand-shell locality (station I). Bull. Bingham

Oceanogr. Coll. 18(2):32-72.

Schwartz, F.J., W.T. Hogarth, and M.P. Weinstein. 1981. Marine and freshwater fishes of the Cape Fear estuary, North Carolina, and their distribution in relation to environmental factors. Brimleyana 7:17-37.

__________, P. Perschbacher, M. McAdams, L. Davidson, K. Sandoy, C. Simpson, J. Duncan, and D. Mason. 1979a. An ecological study of fishes and invertebrate macrofauna utilizing the Cape Fear estuary, Carolina Beach Inlet, and adjacent Atlantic Ocean. Summary Rep. 1973-1977. Inst. Marine Sci., Univ. North Carolina, Morehead City, 568 p.

__________, P. Perschbacher, M. McAdams, L. Davidson, K. Sandoy, C. Simpson, J. Duncan, D. Mason, and J. Tate. 1979b. An ecological study of fishes . . . Ann. Rep. for 1978. Inst. Marine Sci., Univ. North Carolina, Morehead City, 326 p.

Sedberry, G.R. 1983. Food habits and trophic relationships of a community of fishes on the outer continental shelf. NOAA Tech. Rep. NMFS SSRF-773, 57 p.

Sikora, W.B., R.W. Heard, and M.D. Dahlberg. 1972. The occurrence and food habits of two species of hake, *Urophycis regius* and *U. floridanus* in Georgia estuaries. Trans. Am. Fish. Soc. 101(3):513-525.

Smith, H.M. 1907. The fishes of North Carolina. North Carolina Geol. & Econ. Surv., Raleigh 2:1-453.

Struhsaker, P. 1969. Demersal fish resources: composition, distribution, and commercial potential of the continental shelf stocks off southeastern United States. U.S. Fish Wildl. Serv. Fish. Industr. Res. 4(7):261-300.

Whitaker, D.R. 1980. World utilization of hake. Marine Fish. Rev. 42(1):4-7.