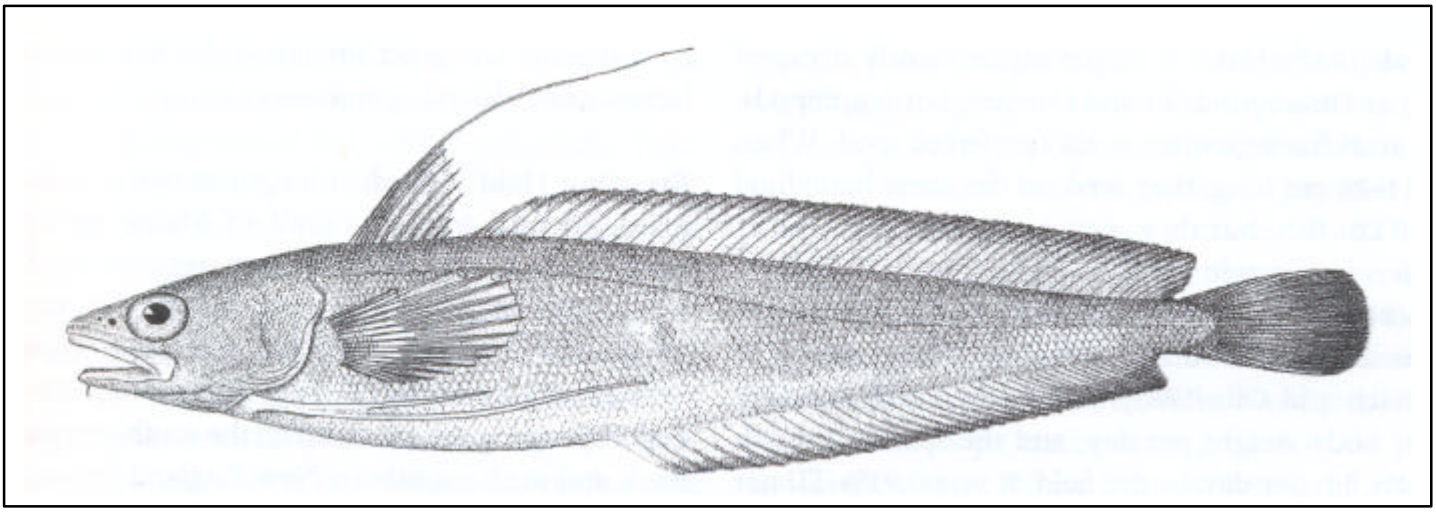
RED HAKE / ***Urophyds chuss*** **(Walbaum 1792)** / **Squirrel Hake, Ling** / Bigelow and Schroeder 1953:223-230



Description. Body rounded in front of vent, somewhat compressed behind, and tapering uniformly to a slender caudal peduncle (Fig. 136). Head pointed; upper jaw projecting. Teeth on vomer and jaws, upper jaw teeth in two indefinite rows, lower jaw teeth very irregular (Hildebrand and Schroeder 1928). A small barbel on lower jaw. Angle of mouth extends postetior to rear margin of large eye. First dorsal fin triangular, third ray at least twice as long as others. Second dorsal fin long. Anal fin low, uniform in height. Pectoral fins large, reaching third ray of second dorsal. Pelvic fins inserted below and in front of pectorals, reduced to two elongate feelerlike rays, longer ray reaching to or slighdy beyond vent. Caudal fin rounded.

Meristics. First dorsal fm rays 9-12; second dorsal fin rays 52-64; anal fin rays 45-57; pectoral fin rays 14-17; total caudal fin rays 29-34; lateral line scales 95-117; gill rakers on upper limb of first arch 3; precaudal vertebrae 14-17 + caudal 33 = total vertebrae 45-50 (Musick 1973a; Markle 1982; Comyns and Grant 1993).

Color. Red hake are reddish, muddy; or olive brown on sides and back, darkest above; sometimes almost black, sometimes more or less mottled, and sometimes plain, with a pale lateral line. The lower parts of the sides are usually washed with yellow and sometimes marked with dusky dots. Belly and lower parts of the sides of the head are pure white, gray, or yellowish; the dorsal, caudal, and anal fins are the same color as the back except the anal is pale at the base. The pelvic fins are very pale pink or yellow.

Size. Red hake do not grow as large as white hake, normally reaching a maximum of 50 cm and a weight of 2 kg (Musick 1967). Records of larger fish are probably white hake. Females are both longer and heavier than males of the same age. The all-tackle game fish record is a 3.6-kg fish taken in Mud Hole, *N.l.,* in March 1994 (IGFA 2001).

Distinctions. Red hake closely resemble white hake and differ primarily in having fewer lateral line scales (95-117 vs. 119-148) and three gill rakers on the upper gill arch instead of only two (Musick 1973a).

Habits. As adults, red hake are a coastal species found in relatively deep water. The recorded depth range is 35 m (Svetovidov 1962) to 980 m (Bigelow and Schroeder). Average depths at which the greatest concentrations occur are 110-130 m in summer, and 183-457 m in winter off New England; and 36-358 m on the Scotian Shelf, with a preferred depth of 72-124 m (Grosslein and Azarovitz 1982). Red hake haunt soft bottoms, sand and mud, few being caught on gravelly; shelly; or rocky grounds in the Gulf of Maine, but they are reported to be abundant on hard bottoms in temperate reef areas of Maryland and northern Virginia (Eklund and Targett 1990). Adult fish prefer a water temperature range of 5°-12°C (Grosslein and Azarovitz 1982) and a salinity range of 33-34 ppt (Scott 1982a).

Behavioral responses of red hake to a decrease in oxygen concentration were tested because anoxia has become a periodic problem in such areas as Long Island Sound and Chesapeake Bay (Bejda et al. 1987). Of the three age-groups tested, 0, 1, and 2-3+, young-of-the-year (0) were the most sensitive. At oxygen concentrations below 4.2 mg.liter-l they leave the substrate and their scallop shelters and swim in the water column. Age-l fish showed variable responses indicating a transition stage; and fish age 2-3+ are the least responsive, only leaving the bottom when oxygen falls below 3 g.ml-l. This increased movement could expose the youngest fish to increased predation as they leave their shelters (see the section on early life history).

Red hake produce sounds (Fish and Mowbray 1970); those produced in art aquarium under electronic stimulation consisted of a single or double series of low thumps and knocks. The mechanism for sound production is the large multilobed swim bladder, which is vibrated by contraction of associated, extrinsic musculature as in other gadids.

The modified pelvic fins, chin barbel, and free filament of the dorsal fin contain chemoand mechanosensory organs (Bardach and Case 1965) that function in food gathering (Herrick 1904). Hake swim in midwater with the pelvic fins drawn close to the body; but lower them upon approaching the bottom (Bardach and Case 1965) and swim along the bottom with the pelvic fins spread apart to an angle of 45°. The entire fin is swept from the snout back toward the flank. Commonly; when the barbel touches a morsel of food, the hake

backs up and ingests it. When a hake nears a piece of clam, it further extends its pelvic fins and lowers its head so its barbel is in contact with the substrate (Pearson et al. 1980). The head is often moved from side to side. There are three basic feeding behaviors: emerging from shelter, swimming; and extending the pelvic fins to contact the bottom. Variation in the strength of the chemical food cue determined the onset and duration of food searching and feeding behavior. Detection is accomplished through olfactory and tactile cues, and the final process of seizing the food is visual (Herrick 1904).

Food. Juvenile red hake from the outer continental shelf in the Mid-Atlantic Bight feed primarily on amphipods, especially in the fall when they account for almost all of their food (Sedberry 1983). Decapods and polychaetes are also dominant prey. Copepods are important in fall and winter; arrowworms are eaten in spring and summer. There are two distinct size ranges: 49-147 mm in fall and summer and 238-251 mm in winter and spring. These are undoubtedly juveniles and young adults. Fish over 300 mm change their feeding strategy to larger and fewer prey items. The smallest red hake (about 5 cm) eat large quantities of chaetognaths, along with smaller amounts of copepods, amphipods, and mysids (Bowman 1981;Bowman et al. 1987). Hake 6-10 cm ingest mostly decapod shrimps such as *Dichelopandalus* and *Crangon,* but amphipods, polychaetes, and chaetognaths are also preferred food. When the fish are 11-20 cm long, they feed on the same basic food types as 6-10 cm fish, but they include euphausiids (mostly *Meganyctiphanes)* as a staple food.
In the laboratory; juvenile hake are discontinuous feeders that consume as much food as possible in a short period of time (Luczovich and Olla 1983). Laboratory-held hake ate 7.4% of their body weight per day; and the specific growth rate was 0.94% TL per day. In the field, it was 0.93% TL per day. Growth rate is inhibited in the laboratory at low feeding levels.
Examination of stomach contents of 1,482 red hake (Bowman et al. 2000) shows crustaceans to be the major component of the diet (63.3% by weight) followed by fishes (21.4%). Earlier studies also found crustaceans to be their major prey (Langton and Bowman 1980; Bowman and Michaels 1984; Bowman and Grosslein 1988). The most important crustaceans are euphausiids, mostly *Meganyctiphanes norvegica,* and decapods, such as *Dichelopandalus leptocerus, Crangon septemspinosa,* and rock crab, *Cancer irroratus.* Other invertebrate prey includes bivalves, squids, polychaetes, amphipods, galatheid crabs, and munid crabs. Fish prey include haddock, silver hake, sea robins, sand lance, and mackerel (Bowman et al. 2000). Red hake are cannibalistic on their young. Mollusks make up about 6% of the diet, but most were not identifiable except for squids and *Buccinum.* Polychaetes are a minor dietary component (2.9%). In all five geographic regions sampled (Middle Atlantic, southern New England, Georges Bank, Gulf of Maine, and western Nova Scotia), crustaceans make up at least 50% of the diet. More crustaceans (88.5%), particularly pandalid shrimps, are found in the diet of fish from western Nova Scotia than from other areas. Gastropods are proportionately most important in the diet of fish from Georges Bank (17.~/o). The most important prey of 681 red hake trawled in the Gulf of Maine were euphausiids *(Meganyctiphanes),* pandalid shrimps *(Dichelopanda/us* and *Panda/us),* haddock, and silver hake (Bowman et al. 2000).

Predators. Red hake were found in the stomachs of 15 species of fishes in the NEFSC food habits survey, of which four species had more than ten occurrences: spiny dogfish, cod, goosefish, and silver hake, in order of frequency of occurrence (Rountree 1999). Other fish predators included skates (little, winter, and thorny), hakes (red and white), sea raven, longhorn sculpin, and bluefish.
Parasites. Red hake are parasitized by a protozoan, *Haemogregarina aeglefina;* a monogene, *Diclidophoia maccallumi;* a digene, *Podocotyle simplex,* and 2 nematodes, *Anisakis* sp. and *Hysterothylacium aduncum* (Margolis and Arthur 1979). Scotian Shelf red hake contained 19 species of helminths in their guts (Scott 1987): 12 digenes, 2 cestodes, 3 nematodes, and 2 acanthocephalans. Red hake 20-49 cm long were heavily parasitized

Breeding Habits. Median length at maturity for female and male red hake from the Gulf of Maine-northern Georges Bank region was 26.9 and 22.2 cm, respectively (O'Brien et al. 1993). Median age at maturity was 1.8 years for females and 1.4 years for males. There is no information on fecundity.
Spawning is prolonged, from May through November, with major spawning areas located on the southwest part of Georges Bank and in the southern New England area south of Montauk Point, Long Island (Colton and Temple 1961; Colton and Marak 1969; Sosebee 1998c). The southernmost record for a ripe female is Chesapeake Bay (Hildebrand and Schroeder 1928). Hake larvae occur as far south as Cape Hatteras (Morse et al. 1987) but species were not distinguished. Red hake spawn at depths shallower than 47-108 m at temperatures of 5°-10°C (Hardy 1978a). Larvae have been reported from the coast of Maine inJune (Graham and Boyar 1965) but some of their records may have been misidentifications of white hake (M. Fahay, pers. comm.).

Early Life History. The eggs are pelagic, buoyant, spherical, and transparent (Miller and Marak 1959). The diameter is 0.64--{).78 mm, perivitelline space 0.02-0.10 mm, oil globule 0.13-0.27 (Markle and Frost 1985: Table 3). There is one large oil globule with several smaller ones. Incubation takes 30 h at 21°C.
Pigment patterns of the egg are distinctive; one of the most characteristic features is development of black chromatophores on the embryo, yolk, and oil globule. In late stages of incubation, this feature, combined with the small size of the egg and multiple oil globules, distinguishes eggs of red hake from other species in the Gulf of Maine except for rockling eggs, which may have a pigmented oil globule.
Eggs are most numerous in May and June in the New York Bight and off Georges Bank (Colton and St. Onge 1974). Larvae are most numerous in September and October on Georges Bank and in the New York Bight, but are present from May to December. Because few larvae have been collected in the Gulf of Maine, it has been suggested that spawning further south supplies most of the recruits to the Gulf of Maine (Steimle et al. 1999c).
First cleavage occurred in 1.5 h at 15.6°C; by 50 h eyes were evident, the embryo was halfway around the yolk and there were melanophores on the body and yolk; by 74 h the oil globule was pigmented and the larvae began to move; hatching occurred between

96 and 98 h (Hildebrand and Cable 1938). Length at hatching is 1.76-2.2 mm. The larva has a large yolk mass extending far forward under the head; the oil globule is in the posterior part of the yolk sac. The mouth is not yet developed, and fins are present only as finfolds and a small pectoral fin bud. The anus is located laterally and at the base of the finfold. Lateral line sensory organs are present as delicate, transparent membranous extensions from the body; Elongate pelvic fins are noticeable at 5 mm and are black at the tips. The chin barbel becomes evident at 15 mm and scales form at 25 mm.

Methven (1985) distinguished red, white, and longfin hake larvae. Red hake larvae differ from spotted hake by the closely crowded pigment blotches on the head. Spotted hake have two widely separated blotches on the crown and the snout. Older spotted hake larvae lack pigment on the pelvic fins.

Red hake spend their first months drifting at or near the surface, and larvae 12.7-100 mm are often taken in summer under floating eelgrass or rockweed. On calm days they have been seen darting to and fro on the surface. Larvae become demersal at a length of 25-30 mm (Methven 1985). In New Jersey waters, this occurs from August through December. Most descend after the autumn breakdown of the thermocline (Steiner and Olla 1985).

Following descent from the plankton, red hake juveniles are commonly found within mantle cavities of sea scallops, *Placopecten magellanicus*. They appear to maintain this association until they reach a maximum size of 136 mm (Musick 1969). In the laboratory and in the field, red hake live in symbiotic assodation within or underneath sea scallops, sheltering from predators (Steiner et al. 1982). It is not clear what benefit, if any, the scallop receives in return. Hake inhabiting scallops ranged in size from 23 to 116 mm. Small scallops «100 mm) contained mostly small hake (25-65 mm), but large scallops contained a wide size range (26-116 mm). Hake were primarily nocturnal, but there was some variation in this. In laboratory preference tests, hake selected nonliving shelters over living scallops.

Recruitment of hake from the plankton to the benthos occurred from September to December, with the highest rates from October to November. Most left the scallop beds by February, but a few late recruits stayed until May; Hake are believed to leave the scallops in response to decreasing temperatures and their increasing size, and they then move to deeper, warmer waters offshore.

Hake appear to associate with scallops whenever they are available, but are also associated with other objects, and structure appears to be critical to their survival (Able and Fahay 1998). A small hake was found curled inside a moon snail egg collar, and other hake were curled around or sheltered under surf clams (Ogren et al. 1968). Larger hake have been seen hiding under shells, sponges, and rocks at depths of 40-50 m (Edwards and Emery 1968).

Juveniles have been recorded at salinities of 31-32.8 ppt and temperatures of 4.2°-7.5°C (Richards and Castagna 1970). Steiner and Olla (1985) exposed pre juveniles to a thermocline in the laboratory as they were just reaching the size at which they would be expected to descend from the plankton. Water temperatures in the experimental thermocline ranged from ZO°C at the top to lo°C at the bottom. The fish did not descend through the thermocline immediately, but remained in the water column above 15°C. Those in a tank without the thermocline (20{)C) went to the bottom immediately; Those in the thermocline began to descend and then went back up as they reached water colder than 15°C. These results indicated that the fish must undergo an acclimation period while descending through thermoclines to the bottom.

Juvenile hake that have migrated offshore return with adults in April and become mature in summer 0. A. Musick 1974). Juveniles of several year-classes, 50-225 mm long, in Chesapeake Bay in late fall and spring move to offshore waters by the end of June (Hildebrand and Cable 1938).

Red and white hakes have quite different life-history strategies (Markle et al. 1982). Red hake avoid predation by associating with scallops, concentrate growth in the juvenile stage, and mature early. White hake achieve large sizes quickly by delaying maturity and concentrating efforts on body growth.

Age and Growth. Maximum age of red hake taken by NEFSC survey cruises from 1970 to 1985 was 14 years (Penttila et al. 1989), but few fish survive beyond 8 years (Sosebee 1998c). A combined age-length curve for red hake from the Gulf of Maine and the Mid-Atlantic is shown in Fig. 137. Age determination using otoliths is easy for fish from southwest Georges Bank to Cape Hatteras but more difficult for fish from northern Georges Bank because they exhibit anomalous patterns (Penttila and Dery 1988).

General Range. Red hake are exclusively North American, occurring in continental waters from North Carolina to Nova Scotia, straying to the Gulf of St. Lawrence (Cohen et al. 1990: Fig. 162).

Occurrence in the Gulf of Maine. Red hake are present throughout the Gulf of Maine, but are particularly abundant in the Great South Channel and on Georges Bank (Map 19).

Migrations. Red hake make seasonal inshore-offshore rnigrations, which are apparently governed by temperature since they avoid temperatures below 5°C. In New England these movements are generally inshore in April and May and again in October and offshore to the edge of the continental shelf in winter (Musick 1973a).

Importance. Hakes have soft meat and poor keeping qualities, but larger ones fmd a market for human consumption and smaller ones for animal food. Commercial processing trials have shown that red hake make excellent surimi when prepared without the belly flaps (Lanier 1984), and this should enhance their commercial desirability. Bigelow and Schroeder summarized historical fisheries data and noted that red and white hake landings were not reported separately until after 1944.

Trends in landings of the Gulf of Maine-northern Georges Bank stock have shown three distinct periods (Sosebee 1998c). The first period, from the early 1960s through 1971, was characterized by relatively low landings of 1,000-5,600 mt. The second period, 1972-1976, showed a sharp increase, with landings ranging from 6,300 to 15,300 mt. During this time about 93% of the total annual landings were taken by distant-water fleets on northern Georges Bank. Following implementation of the Magnuson Fisheries Conservation and Management Act in 1977, both total landings and the proportion of landings by the distant-water fleet dropped sharply; From 1977 to the present, annual landings of this stock have averaged 1,100 mt or less (Fig. 138). Otter trawls are the principal commercial fishing

gear. The fishery is managed under the New England Fishery Management Council's Multispecies Management Plan under the "nonregulated multispecies" category. Both stocks are underexploited and could support substantially higher catches (Sosebee 1998c).

Hakes are such inactive fish that they are of no special interest to anglers, and recreational catches are insignificant. However, a good many fair-sized ones are caught handlining from party boats for they bite readily, and small hake are caught from small boats in harbors and bays along the coast of Maine.

Stocks. Two stocks of red hake have been assumed. divided north and south in the central Georges Bank region (Sosebee 1998c): Gulf of Maine-northern Georges Bank and southern Georges Bank-Mid-Atlantic.