YELLOWTAIL FLOUNDER / ***Limanda ferruginea*** **(Storer 1839)** / Yellowtail, Rusty Flounder /Bigelow and Schroeder 1953:271-275

Description. Body oval, comparatively wide, nearly half as broad as it is long (Fig. 301). Dorsal outline of head more deeply concave than any other Gulf of Maine flounder. Eyes set so close together that their rounded orbits almost touch each other. Each side of jaw has a single series of teeth in about equal numbers. Teeth small, conical, close set. Dorsal fm originates over upper eye, middle rays longest. Anal fin similar in outline to dorsal, but much shorter, preceded by a short, sharp spine (postabdominal bone) pointing forward.
Pelvic fins alike, each separated from anal fin by a considerable space. Pectoral fin on blind side slightly shorter than mate on eyed side. Gill rakers of moderate length. Lateral line distinctly arched over pectoral fm. Scales ctenoid on eyed side, cycloid on blind side.

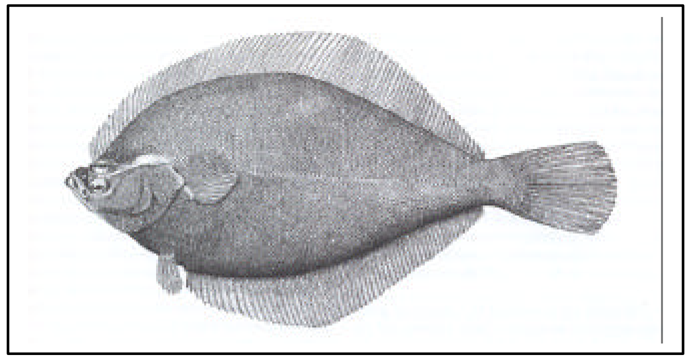
Meristics. Dorsal fin rays 73-91; anal fin rays 51-68; pectoral fin rays 10; lateral line scales 88-100; gill rakers 10-12 on lower arch; vertebrae 40-45 (Norman 1934; Scott and Scott 1988).

Color. Yellowtail are more constant in color than most other Gulf of Maine flatfishes. The eyed side, including the fins, is brown or slaty olive, tinged with red and marked with large irregular rusty red spots. The caudal fin and margins of the dorsal and anal fins are yellow; the yellow tail in particular is a diagnostic character. The blind side is white, except for the caudal peduncle and margins of the dorsal and anal fins, which are yellow.

Size. This is a medium-sized flatfish. Males average 40 cm *(30-47.6* cm) and females 46 cm (39.4-55.3 cm). The largest specimens taken were a 55.4-cm female caught off Cape Cod (Penttila et al. 1989) and a 62.7-cm fish caught off Newfoundland (Scott and Scott 1988).

Distinctions. Small mouth and thick fleshy lips separate yellowtail from the large-mouthed flounders (halibut and plaice). They are easily distinguished from winter flounder by their more pointed snout, thin body, arched lateral line, and more numerous fin rays; from smooth flounder by the last two characters, as well as by the concave dorsal profile of the head and being scaly between the eyes; and from witch by the arched lateral line, fewer fin rays, concave dorsal profile of the head, and lack of mucous pits on the blind side of the head.

Habits. Yellowtail keep to deeper water than either winter or smooth flounder. They are generally an offshore species, found from 10 to 100 m. From the Mid-Atlantic Bight to Georges Bank they are found most often at depths of 37-73 m (Overholtz and Cadrin 1998), but are common in shallow waters (9-64 m) off Cape Cod (Lux 1964). Almost any sandy bottom or mixture of sand and mud suits them, but they shun rocks, stony ground, and very soft mud.
Yellowtail tolerate a wide range of temperatures (-1° to 18°C), but water temperature and year-class strength are correlated-cooler temperatures promoting larger year- classes (Sissenwine 1974). They can also tolerate a considerable range of combinations (Laurence and Howell 1981), but survival is maximized at intermediate temperatures and high salinities (8°-14°C, 32-38 ppt). On the Scotian Shelf the preferred temperature and salinity ranges are 2°-6°C and 32-38 ppt (Scott 1982b).



Food. Adult yellowtail feed chiefly on amphipods (41.5% by weight), especially *Ericthonius ntbricornis,* and polychaetes (38.5%) (Bowman et al. 2000). They also eat cnidarians, small crabs and shrimps, mysids, cumaceans, isopods, univalve and bivalve mollusks, echinoderms, and sometimes even small fishes such as sculpins, sand lance, and cusk (Langton and Bowman 1981; Langton 1983; Bowman et al. 1987; Collie 1987; Bowman et al. 2000).
Yellowtail feed primarily during daylight hours. Stomachs contain the least amount of food at dawn and the most at dusk, an indication that feeding begins near sunrise and ends, for the most part, around sunset (Bowman et al. 2000). Stomachs of spawning fish contain on average only small quantities of food; stomachs of fish with developing gonads are the fullest (Langton 1983). Yellowtail caught on Georges Bank had more food in their stomachs than those caught in the Mid-Atlantic or southern New England (Efanov and Vinogradov 1973; Langton 1983). In the Gulf of Maine, the diet of this flounder is generally the same as in other areas except that it includes larger quantities of a sea cucumber, *Stereoderma unisemita* (Langton and Bowman 1981). Comprehensive lists of prey and other information on yellowtail feeding habits and behavior can be found in reports by Langton and Bowman (1981), Langton (1983), Bowman and Michaels (1984), Collie (1987), Martel and McClelland (1992), and Bowman et al. (2000).

Predators. Yellowtail flounder were found in stomachs of 11 species of fishes in the NEFSC food habits study; of which only spiny dogfish and Atlantic cod are significant predators (Rountree 1999). Other fish predators include blue shark, skates (little, winter, and smooth), goosefish, hakes (spotted, white, and silver), longhorn sculpin, bluefish, Atlantic halibut, and fourspot flounder (Lux and Mahoney 1972; Maurer and Bowman 1975; Bowman and Michaels 1984; Rountree 1999; Bowman et al. 2000). On Sable Island Batik, Atlantic mackerel 6-14 mm in length prey on larval yellowtail flounder, which account for 18% of their diet (Fortier and Villeneuve 1996). Predation on fish larvae declined with increasing density of copepod nauplii in the environment. Yellowtail are also preyed upon by gray seal on the Scotian Shelf (Bowen et al. 1993).

Parasites. Yellowtail are parasitized by 3 species of protozoans, *Haemohormidium terraenovae, Glugea stephani,* and *Trypanosoma murmanesis;* 15 trematodes; 7 nematodes; 5 cestodes; 2 acanthocephalans; and a copepod, *Acanthochondria cornuta* (Bray 1979; Margolis and Arthur 1979).

Yellowtail from Delaware to Georges Bank have been found with epitheliocystis, an infection that is visible as cystlike lesions on the gills and fins. About 9% of the fish collected were infected. Some yellowtail caught on Sable Island Bank off Nova Scotia were infected with a fungus, *Ichthyophonus,* which was evident as white cysts on the liver and other internal organs (Powles et al. 1968).

Breeding Habits. Yellowtail are batch spawners (Howell 1983). Median age at maturity for females is 1.6 years in southern New England (Royce et al. 1959), and 1.8 years on Georges Batik, 2.6 years off Cape Cod (O'Brien et al. 1993), but 5.0 years on the Grand Banks (Pitt 1970). Females produce 350,000- 4,570,000 eggs, depending on body length and, to a lesser extent, age (Pitt 1971). The southern New England stock has a higher fecundity at a given length and age (Howell and Kesler 1977) than the Grand Banks stock described by Pitt (1971), correlated with higher water temperatures (4.9° to 12.3°C vs. -1° to 6.5°C) in southern New England.

Yellowtail eggs were collected by the MARMAP surveys from February to September with peak abundances from April to June (Berrien and Sibunka 1999: Fig. 103). Spawning began in February or March, occurring first in the northern half of the Mid-Atlantic and then extending rapidly into southern New England and Georges Bank. In April and May spawning increased in intensity in these areas and began in the Gulf of Maine. Eggs were found in the Gulf of Maine from April to September. Spawning occurs at water temperatures ranging from 4.5° to 8.1°C and over depths of 45-75 m (Smith et al. 1975).

Laboratory studies of estimates of the ovulatory periodicity of yellowtail flounder indicate that a 1-day interval may characterize regular ovulation patterns. Females produced a mean number of 14-22 batches for about a month, and batch fecundities usually remained within a range of 10,000-60,000 eggs.

Maternal variation in egg production and egg quality was large and independent of size differences among females. Some females had disrupted ovulation patterns that affected the realization of potential fecundity contained within the prespawning ovary. High interbatch variation in egg quality was not related to progressive decreases in egg diameter and dry weight over time. Batches with high survival rates appeared at random during a female's period of ovulation (Manning and Crim 1998). Temperature interacts with maternal contributions to egg size to affect development time and size of yellowtail flounder larvae at hatch. Maternal effects contributed significantly to differences in egg sizes but development time was most affected by temperature. Average length at hatch varied significantly among females and with temperature, as did the variance in hatching length within a population. Overall, the nonadditive interaction between maternal contributions and the environment suggests that female effects must be considered over the entire range of environmental conditions experienced by their progeny. The results also suggest that it is inappropriate to quantify female effects among eggs and extrapolate these difference to larvae (Benoit and Pepin 1999).

Early Life History. Yellowtail eggs are buoyant, spherical, very transparent, have a narrow perivitelline space, and do not have an oil globule. Eggs range from 0.68 to 1.01 mm in diameter, averaging about 0.9 mm (Howell 1980; Colton and Marak 1969). The surface of the egg is covered with very minute striations, and the germinal disc is a very pale buff color in life. Embryonic pigment gathers in three groups shortly before hatching (which takes place in 5 days at a temperature of 10°-11°C); one group in the region of the head, one near the vent, and a third halfway between the vent and the tip of the tail (Bigelow and Schroeder).

Laurence and Howell (1981) gave more detailed descriptions of the early life-history stages. They did not see striations on the egg surface. Newly hatched larvae are 2.1-2.5 mm and display the three pigment patches described above, although head pigment may be absent. Larvae have unpigmented eyes, a large yolk sac, no functional mouth, and fin buds only in the pectoral region. Pigmentation increases during yolk-sac absorption. A group of five or six melanophores is seen near the anus, which is just posterior to the yolk sac; a second group of black pigment spots is seen midway between the anus and the tip of the tail; and a row of fine pigment spots is seen in the ventral finfold below the notochord. These are useful in distinguishing yellowtail from other flatfish larvae. When larvae reach 4-14 mm, four vertical bars are present at the pectoral fin and evenly spaced caudally (Martin and Drewry 1978). In the New England area metamorphosis occurs at about 14 mm.

Yellowtail and winter flounder larvae co-occur in March- May in New England, but the former can be distinguished at the yolk-sac stage by their lighter pigmentation and more extensive dorsal pigmentation. Ventral pigmentation extends to the tail tip in yellowtail but not in winter flounder. The midtail band extends onto the finfolds in winter flounder but not in yellowtail, and there is little or no lateral line pigmentation. Winter flounder metamorphosis occurs at 9 mm and that of yellowtail at 14 mm (Elliott and Jimenez 1981). Yellowtail larvae co-occur with American plaice on the Scotian Shelf. Yellowtail have 41-44 vertebrae, 38-41 myomeres, and 51-67 anal fin rays, and metamorphose at about 16 mm SL (Van Guelpen 1980); American plaice have 45-48 vertebrae, 44-47 myomeres, and 62-76 analfin rays, and metamorphose at greater than 25 mm SL.

Yellowtail eggs and larvae are pelagic. Larvae are near the surface at night and move down to 20 m with ascent and descent occurring at sunset and sunrise, respectively (Smith et al. 1978). Larger larvae make longer migrations. This habit may assist in dispersal of larvae because circulation at the surface transports the larvae further. Distributional maps of yellowtail eggs and larvae are given in Colton and St. Onge (1974) and Smith et al. (1975). After young yellowtail become benthic they are not readily caught by trawlers, so nursery grounds for this species are not well defined. Recent studies on the continental shelf of the New York Bight found that age-O yellowtail flounder (minimum size 5.7 mm SL, mean 17.4 mm SL, maximum 34.9 mm SL) were the most abundant fish collected. Collections included larval, age-O, and adult fish. Settlement took place in the summer primarily in the midshelf area (41-70 m), and fish tended to remain in this vicinity, which was both a settlement and a nursery area. Mortality was high after settlement. Bottom temperature and depth were the most important parameters for determining habitat associations. Higher abundances occurred above 3 ° C and the preferred temperature appeared to be between 4° and 8°C. The midshelf area is a "cold pool" and catches decreased in the fall when the bottom temperature rose owing to cold pool turnover. Densities in the midshelf area averaged 49.81 fish per 1,000 m2. Given the large areal extent of settlement, this represents a very large number of fish (Steves et al. 2000).

Immature yellowtail flounder «20 cm TL) are found well inshore of 100 m. In the Gulf of Maine, they are concentrated between Massachusetts Bay and Cape Cod Bay in spring and autumn. They are found along the southern edge of Georges Bank in spring, but the concentration shifts northward to near the Great South Channel and primarily eastward to slightly deeper waters along the southeastern part of Georges Bank. In southern New England, immature fish are found midshelf at depths around 45 m in spring and 60 m in autumn. Mean depth distribution for immature yellowtail in all regions is 47.3 m in spring (range 9-179 m) and 63 m in fall (14-287 m) (Wigley and Gabriel 1991).

Age and Growth. Historically, scales have been used for age determinations of yellowtail flounder (Royce et al. 1959; Lux and Nichy 1969; Penttila 1988). Their growth off southern New England is rapid in the first 3 years, then slows down (Lux and Nichy 1969). In the third year, females begin to grow faster than males; they also live longer. Cape Cod yellowtail reach greater maximum lengths than those from Georges Bank and southern New England (Fig. 302). The maximum age recorded for yellowtail is 17 years, although individuals older than age 7 are not common (Penttila et al. 1989). Canadian stocks grow more slowly but reach a greater maximum length; both sexes have the same growth rate for 7 years, after which females grow faster (Scott and Scott 1988).

General Range. North American continental waters from the Labrador side of the Strait of Belle Isle (Backus 1957b), northern Newfoundland and the Newfoundland Banks, the north shore of the Gulf of St. Lawrence, southward to the lower part of Chesapeake Bay (Bigelow and Schroeder 1939).

Occurrence in the Gulf of Maine. Yellowtail occur throughout the Gulf of Maine from 10 to 100 m. They are abundant in the region of Nantucket Shoals in the South Channel, on the western part of Georges Bank, along the eastern side of Cape Cod Bay and Stellwagen Bank, and in deeper parts of Massachusetts Bay: They are also numerous between the Isle of Shoals and Great Boars Head, Maine, but are less common to the north and northeast. They are less common in the Bay of Fundy and Nova Scotia.

Migrations. Tagging experiments (Royce et al. 1959; Lux 1963) show that yellowtail may migrate for considerable distances. Fish tagged off Block Island moved eastward in spring and summer to the vicinity of southern Nantucket Shoals, some as far as Georges Bank. Those on the Bank moved westward in the winter and eastward in summer. Some moved as far south as the southern New England grounds. Cape Cod fish dispersed northward but none were captured on the other two grounds. Lux (1963) also noted that fish on the Cape Cod grounds are often infested with a trematode parasite that is not found in fish from the other two grounds, indicating that this group does not mingle with the others. Lux found no difference in meristic characters among the three groups and some mixing did occur seasonally when some fish from southern New England migrated to the Cape Cod grounds. Scott (1954a) compared yellowtail groups from three Atlantic fishing areas and did find meristic differences in dorsal and anal fin ray counts between Nova Scotian yellowtail and those from southern New England.

Importance. Yellowtail are among the most valuable flatfishes in the Gulf of Maine. They compare favorably in quality with summer and winter flounder, but because the body is thinner, they bring a lower price to fishermen. The commercial catch is made by otter trawls, and most of the fish are caught from Georges Bank to the New York Bight. The fishery began in the 1930s, and catches increased rapidly until 1934 before declining. Catches have fluctuated considerably since then, rising in the late 1950s to early 1970s, but since then recruitment has declined, especially in southern New England and Georges Bank. There was a brief increase in the early 1980s owing to a strong year-class, but catches declined thereafter.

Catch quotas were imposed on the southern New England and Mid-Atlantic stocks in 1971 and 1975, respectively; but recruitment continued to be low. There are three yellowtail fishing grounds in the region: the southern New England region, extending from eastern Long Island to south of Nantucket; Georges Bank; and the Cape Cod grounds, which extend north along the Massachusetts coast. A 1997 assessment indicated that the stock was at very low levels on Georges Bank and in southern New England. On Georges Bank, spawning stock biomass suffered a severe decline from 1973 to 1988, fluctuated from 1989 to 1994, and began to increase in 1997. During this time fishing mortality decreased from 1.7 (76% exploitation rate) to 0.2 (16% exploitation rate in 1996-1997).

The stock is considered fully exploited and rebuilding. In southern New England, landings declined abruptly after 1969 and have continued to decline except for some increased landings in 1981-1983 and in 1990 owing to two strong year-classes. Fishing mortality averaged 1.6 (74% exploitation rate) from 1980 to the early 1990s and has since declined to 0.12 (10% exploitation rate). In 1997 the stock was assessed at low levels with a slight increase and is considered to be fully exploited. The Cape Cod stock has shown increased landings since 1993, probably indicative of the high degree of decimation of the other stocks. Stock biomass was reduced by high catches in the 1970s and 1980s. Trends in the Mid-Atlantic stock are similar to those in the southern New England stock (Overholtz and Cadrin 1998). Commercial landings and spawning stock biomass are shown in Fig. 303 for Georges Bank (Overholtz and Cadrin 1998). Because of the depth at which most of the resource occurs combined with their small mouth in relation to the size of hooks used in the coastal recreational fishery, there is very little recreational fishery for yellowtail. Work on developing the species for commercial aquaculture production in Newfoundland has been going on since 1994. Principal areas of work have focused on developing broodstock, larviculture, and juvenile grow-out protocols (Brown and Crim 1998).

Stocks. Based on tagging data, larval distributions, geographical patterns of landings, and bottom trawl survey data, there are four relatively discrete stocks in u.s. waters: southern New England, Georges Bank, Cape Cod, and Mid-Atlantic. Intermingling among these groups has not been quantified but is probably very limited (Overholtz and Cadrin 1998). Based on the distribution of sexually mature females and eggs, there appear to be two stocks on the Scotian Shelf (Neilson et al. 1988). There is also an isolated stock on the Grand Banks.