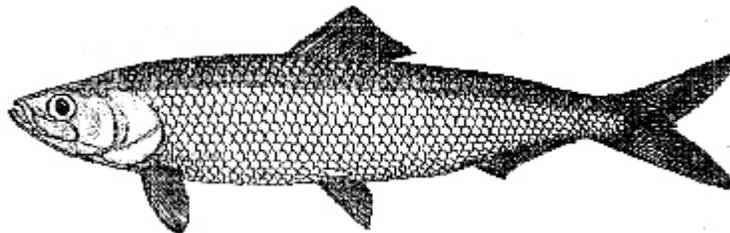


Forage Fish

The more common fish species identified as forage fish within Washington State include Pacific herring (*Clupea harengus pallasii*), surf smelt (*Hypomesus pretiosus*), Pacific sand lance (*Ammodytes hexapterus*), and northern anchovy (*Engraulis mordax*). Less common smelt, including longfin smelt, night smelt and rainbow smelt are generally grouped with surf smelt for management purposes, although their biology may be somewhat different. Anadromous forage fish, such as eulachon or the Columbia River smelt and shad are managed separately.

Forage fish are an important and abundant fish species in Washington State. As the name implies, the significance of forage fish is related to the critical part they play as the prey base for a large variety of other marine organisms, and their significance to commercial and subsistence fisheries. For centuries, various species of forage fish have been utilized for food by aboriginal tribal peoples along the west coast. Today, forage fish are harvested by recreational and commercial fisheries and continue to be utilized for tribal subsistence. The condition of the stocks that comprise each forage fish genera are vitally important for those marine species that use them as a food source. The vitality of the aggregate forage fish resource in Washington is also a valuable indicator of the health and productivity of our marine environment.



Pacific herring
Clupea harengus pallasii

Size: To 9 inches.

Coloration: Bluish green to olive dorsal, silvery sides.

General Characteristics: No adipose fin. Large scales on body none on head and tail.

Name: Pacific herring, *Clupea harengus pallasii*

Geographical Range: Baja California, Mexico, to the Bering Sea and northeast to the Beaufort Sea. Also along the Asian coast from the Arctic Ocean to Japan.

Related species: Common local members of the herring family, Clupeidae, are the Pacific sardine, (*Sardinops sagax*) and the American shad, (*Alosa sapidissima*). Other forage fish species

include surf smelt, sand lance, and anchovy.

Life history: Most Washington State herring stocks spawn from late January through early April. The notable exception is the Cherry Point stock (the largest in the state), which spawns from early April through early June. Herring deposit transparent, adhesive eggs on intertidal and shallow subtidal eelgrass and marine algae. Eggs may be deposited anywhere between the upper limits of high tide to a depth of -40 feet, but most spawning takes place between 0 and -10 feet in tidal elevation. Eggs hatch in about 14 days, producing slender, transparent larvae about 13 mm long. At this stage, they are at the mercy of currents and subject to heavy predation by larger organisms. At about three months of age and at about 38 mm in length, herring metamorphose into their adult form and coloration. They will mature and return to their spawning ground in their second or third year. Herring do not normally die after spawning, and continue to spawn in successive years.

Natural mortality is quite high, approximately 50-70 percent of the adult herring from Washington will fall to predation each year. Thus, the typical Puget Sound herring is relatively short lived, rarely surviving beyond age five. Some herring stocks appear to have an annual migration from inshore spawning grounds to open ocean feeding areas, while others appear to be more "resident", remaining inside the Puget Sound basin year around. Adult herring feed primarily on planktonic crustaceans, and in turn are food for many marine animals such as seabirds, marine mammals, and other fishes.



Surf smelt
Hypomesus pretiosus

Size: To 9 inches.

Coloration: Olive green dorsal, silver or yellow band on sides.

General Characteristics: Adipose fin. Small scales.

Name: Surf smelt, *Hypomesus pretiosus*

Geographic Range: Long Beach, California to Chignik Lagoon, Alaska. An Asian subspecies, *Hypomesus pretiosus japonicus*, is common in the western Pacific. Surf smelt occur throughout the marine waters of Washington, from the Columbia River to the Canadian border and southernmost Puget Sound. They are an abundant schooling forage fish living in the near shore community of Puget Sound. Although their movements within the sound are unknown, a number of genetically distinct stocks are thought to occur.

Related Species: Surf smelt and salmon are members of the same taxonomic order, Salmoniformes. Other common local smelt are the eulachon or Columbia River smelt, (*Thaleichthys pacificus*) and hooligan or longfin smelt (*Spirinchus thaleichthys*). Both are anadromous, running up rivers to spawn in freshwater. Surf smelt can be distinguished from other forage fish such as herring, sand lance and anchovy, by the presence of an adipose fin.

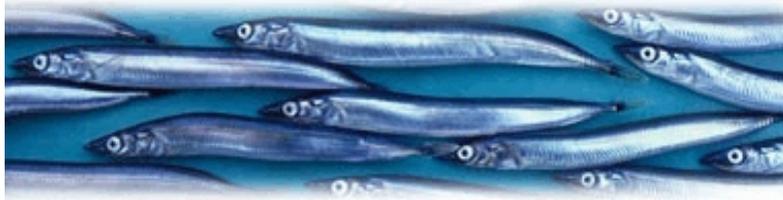
Life History: Surf smelt deposit adhesive, semitransparent eggs on beaches which have a specific mixture of coarse sand and pea gravel. Inside Puget Sound, surf smelt spawning is thought to be associated with freshwater seepage, where the water keeps the spawning gravel moist. Eggs are deposited near the water's edge in water a few inches deep, around the time of the high water slack. Observations of surf smelt spawning activity describe a highly adapted and ritualized behavior. Several males will align themselves with a ripe female, keeping their position by the use of spawning tubercles which cover their scales and fin rays. The female and males vibrate in unison, causing the release of eggs and sperm. Neither the female nor the males release all of their gametes during any single spawning event, and multiple spawnings within and between tide cycles are common.

Fertilized surf smelt eggs have morphological features which cause the eggs to adhere to sand grains in which they are laid, giving stability to the deposited spawn. The outer membrane of the egg ruptures and turns inside out, forming a pedestal which is the point of the attachment. Wave action and tidal exchange buries the weighted eggs to a depth of several millimeters. While the eggs incubate in the sand they are "extra-aquatic", meaning they are submerged in saltwater during a portion of the tidal cycle. Extra-aquatic development is thought to be adaptive because the eggs are subjected to warmer temperatures and therefore develop quicker. The eggs are also less available to predation from birds and other fishes.

Development rates of surf smelt eggs vary greatly with seasonal ambient temperature. Surf smelt eggs brooded in winter months may require between 27 and 56 days to hatch, while those brooded in summer months may required between 11 and 16 days. Regardless of the brooding time, hatching surf smelt eggs release larva measuring about 3 mm which are at the mercy of the local tides and currents. After about 3 months they have grown to about 30 mm and taken on their adult form and coloration. Juvenile surf smelt rear in the near shore waters throughout Puget Sound.

The majority of surf smelt will mature to spawn in their second year, although a small proportion will spawn in their first year. Surf smelt do not die after spawning and may spawn in successive seasons. Like herring, surf smelt are thought to display some degree of homing, based on studies of their geographically and temporally distinct spawning behavior, parasitology and serology. The frequency of individual spawning and the degree to which individual surf smelt stray between spawning grounds are unknown.

Like all other forage fish, surf smelt experience high predation levels as eggs, juveniles and adults. As a result the maximum life span of a surf smelt is thought to be 5 years. Adult surf smelt feed primarily on planktonic organisms, and in turn are food for many marine animals such as seabirds, marine mammals, and other fishes. The movements of juveniles and adults between spawning seasons is virtually unknown.



Pacific Sand Lance *Ammodytes hexapterus*

Size: To 8 inches.

Coloration: Gray to green dorsal, silver sides.

General Characteristics: Large dorsal fin. Elongated pointed body. No adipose fin. Scales almost invisible.

Name: Pacific sand lance, *Ammodytes hexapterus*

Geographical range: The Pacific sand lance occurs throughout the coastal northern Pacific Ocean from the Sea of Japan to southern California and across Arctic Canada.

Related species: Sand lance fish are occasionally referred to as "candlefish", however, on the Pacific Coast "candlefish" correctly refers to the eulachon (Columbia River smelt), an unrelated species. Several closely related species occur on both shores of the north Atlantic Ocean, Greenland and the European Arctics, where they are commonly called "sand eels". While no closely related species are found in Washington, other forage fish include herring, surf smelt and anchovy.

Local Distribution: Sand lance populations are widespread within Puget Sound, the Strait of Juan de Fuca and the coastal estuaries of Washington. They are most commonly noted in more localized areas, such as the eastern Strait and Admiralty Inlet. However, WDFW plankton surveys and ongoing exploratory spawning habitat surveys suggest that there are very few if any bays and inlets in the Puget Sound basin that will not be found to support sand lance spawning activity.

Life History: The sand lance is a common but poorly known near shore schooling fish in Washington waters. The abundance and broad distribution of planktonic sand lance larvae throughout the bays and inlets of Puget Sound in late winter suggested that their spawning habitats and spawning activity are widespread in the region. Since 1991, WDFW's Forage Fish Unit has undertaken a systematic intertidal beach substrate sampling strategy along a significant proportion of the shoreline of the Puget Sound basin. Sand lance were first found to have deposited spawn in the upper intertidal zone in 1989 by WDFW investigators. Evidence of sand lance spawning activity has now been documented at numerous locations totaling about 130 miles of Puget Sound shoreline, and many potential sand lance spawning areas remain to be surveyed.

Sand lance deposit eggs on a rather broad range of beach surface substrates, from soft, pure fine sand beaches to beaches armored with gravel up to 3 cm in diameter, although most spawning appears to occur on the finer grained substrates. Sand lance eggs acquire a partial coat of sand grains which adhere during deposition. The sand coating may serve to assist in capillary moisture retention when the eggs are exposed during the low tide. The coated sand lance eggs are dispersed along the beach with each tide exchange.

Fresh, intact sand lance spawn deposits commonly consist of small (less than 10 cm in diameter) patches of eggs, either resting in the bottom of shallow pits in the beach or scattered irregularly over a broad zone of disrupted beach surface. Such features suggest a certain degree of vigor in the sand lance mass spawning act.

Spawning occurs at tidal elevations ranging from +5 feet to about the mean higher high water line. After deposition, sand lance eggs may be scattered over a wider range of the intertidal zone by wave action. The incubation period is about four weeks.

Upon hatching, the larval sand lance measures about 5 mm, and are virtually transparent. Like other forage fish, larvae and juvenile sand lance are subject to predation. As larvae they are at the mercy of the local currents and tides until they are about 22 mm in length. They then "school up", adopt their adult coloration and can be found in bays and inlets throughout Puget Sound.

Sand lance are somewhat unique in their generalized diurnal behavior pattern, feeding in the open water during the day and burrowing into the sand at night to avoid predation. Sand lance do not appear to be amenable to the acoustic or spawn survey techniques currently used by WDFW for herring and surf smelt stock assessment.

The movements and age structure of adult sand lance populations are currently unknown. Sand lance are most frequently observed when "balling", a behavior also demonstrated by Pacific herring. When schooling sand lance are attacked, usually by diving birds, the individuals begin swimming in a compressed circular pattern, forming a tight swirling ball. This behavior is thought to be adaptive for individual survival. By compressing the school and circling, the chance of any individual herring being eaten is reduced as compared to that of an individual herring traveling in a normal schooling pattern. Once the sand lance have "balled", other predators may join in the attack including seals, sea lions, dogfish, gulls and humans.



Anchovy
Engraulis mordax

Size: To 10 inches.

Coloration: Green dorsal, silver sides. No adipose fin.

General Characteristics: Large mouth.

Name: Northern Anchovy, *Engraulis mordax mordax*

Geographical range: Baja California to the Queen Charlotte Islands. The center of their abundance is from Magdalena Bay to San Francisco. Their occurrence in Washington waters is sporadic and unpredictable. In some years, larval anchovies can be found in the Strait of Georgia, although the spawning ground for these fish is unknown.

Related species: The northern anchovy is the only member of the Engraulidae family found in Washington waters. Anchovies are not related to, but are frequently associated with the sardine (*Sardinops sagax*) or sand lance. Anchovies can be distinguished from other forage fish species include herring, surf smelt and sand lance by their large eyes and mouth.

Life history: Little is known about the life history of the anchovy in Washington, or if in fact anchovies spawn in Washington waters, or are merely transient visitors. In California, where the species is abundant and utilized commercially, more is known about this species.

Spawning is temperature dependant, requiring 10-23.3 degrees Celsius. A single female may spawn several times each year with an annual fecundity of about 25,000 eggs. Fertilization is external and the eggs positively buoyant and pelagic. Eggs incubate for 2 to 4 days, depending on water temperature, producing larvae which are about 3 mm in length. Larvae metamorphose to their adult form and coloration in about 3 months. A small percentage of the larvae reach maturity at the end of the first year (100 mm in length), with the vast majority reaching maturity at the end of the second year (about 150 mm in length). The maximum life span is thought to be about 7 years in non-exploited populations. Anchovies have been observed to demonstrate the nocturnal behavior similar to herring; remaining at depth during the day and coming to the surface at night. They feed similarly to sardines, randomly filtering the water, although some anchovies have demonstrated particulate biting, similar to herring.