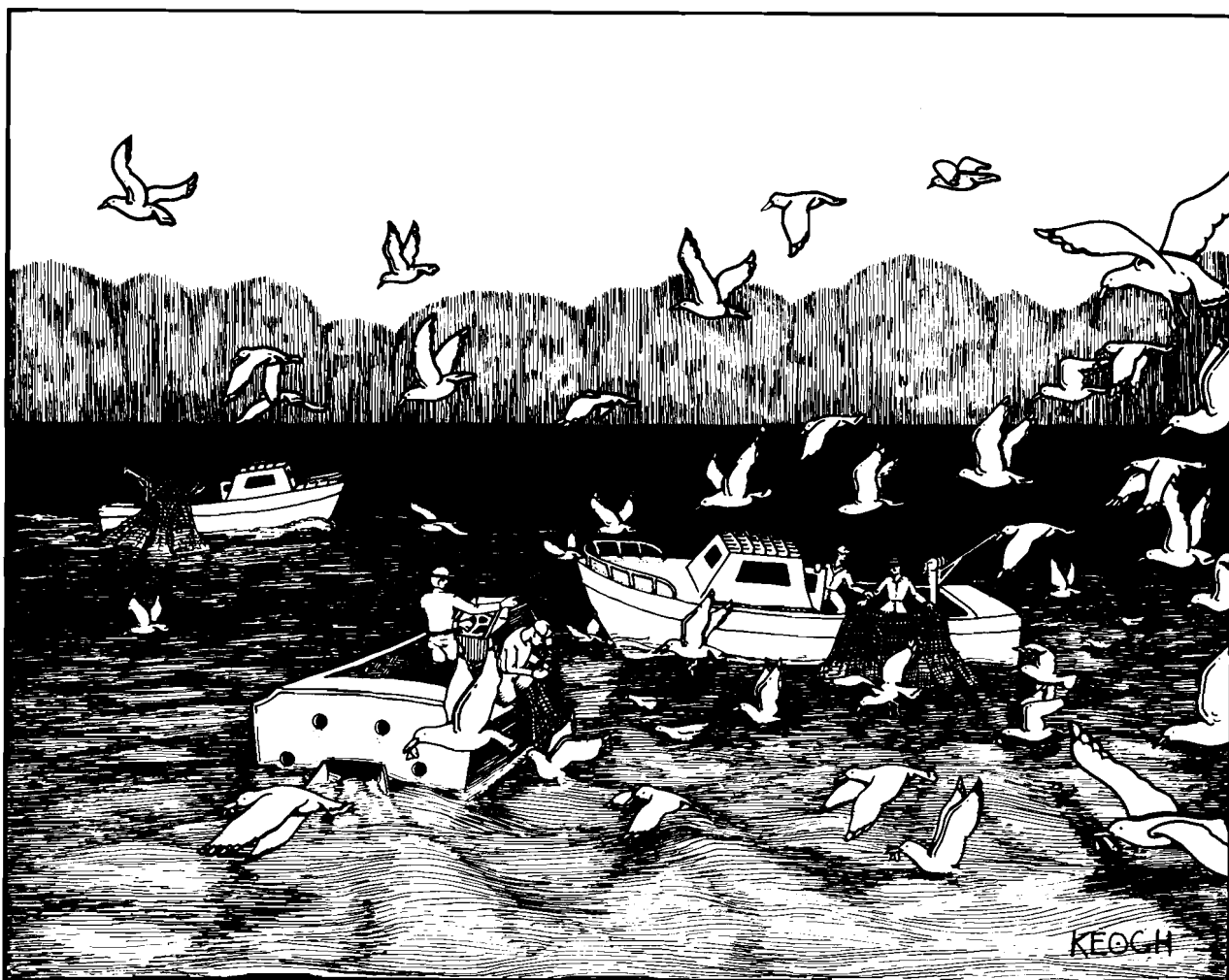


**Species Profiles: Life Histories and  
Environmental Requirements of Coastal Fishes  
and Invertebrates (Pacific Northwest)**

**PACIFIC HERRING**



**Fish and Wildlife Service  
U.S. Department of the Interior**

**Coastal Ecology Group  
Waterways Experiment Station  
U.S. Army Corps of Engineers**

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Species Profiles: Life Histories and Environmental Requirements  
of Coastal Fishes and Invertebrates (Pacific Northwest)

## **PACIFIC HERRING**

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Vicksburg, MS 39180

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## **PREFACE**

This species profile is one of a series on coastal aquatic organisms, principally fish, of sport, commercial, or ecological importance. The profiles are designed to provide coastal managers, engineers, and biologists with a brief comprehensive sketch of the biological characteristics and environmental requirements of the species and to describe how populations of the species may be expected to react to environmental changes caused by coastal development. Each profile has sections on taxonomy, life history, ecological role, environmental requirements, and economic importance, if applicable. A three-ring binder is used for this series so that new profiles can be added as they are prepared. This project is jointly planned and financed by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service.

Suggestions or questions regarding this report should be directed to one of the following addresses.

Information Transfer Specialist  
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Slidell, LA 70458

or

U.S. Army Engineer Waterways Experiment Station  
Attention: WESER-C  
Post Office Box 631  
Vicksburg, MS 39180

# CONVERSION TABLE

## Metric to U.S. Customary

<i>Multiply</i>	<i>By</i>	<i>To Obtain</i>
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
meters	0.5468	fathoms
kilometers (km)	0.6214	statute miles
kilometers	0.5396	nautical miles
square meters (m <sup>2</sup> )	10.76	square feet
square kilometers (km <sup>2</sup> )	0.3861	square miles
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons
cubic meters (m <sup>3</sup> )	35.31	cubic feet
cubic meters	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (t)	2205.0	pounds
metric tons	1.102	short tons
kilocalories (kcal)	3.968	British thermal units
Celsius degrees (° C)	1.8 (° C) + 32	Fahrenheit degrees

## U.S. Customary to Metric

inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
statute miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet (ft <sup>2</sup> )	0.0929	square meters
square miles (mi <sup>2</sup> )	2.590	square kilometers
acres	0.4047	hectares
gallons (gal)	3.785	liters
cubic feet (ft <sup>3</sup> )	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28350.0	milligrams
ounces	28.35	grams
pounds (lb)	0.4536	kilograms
pounds	0.00045	metric tons
short tons (ton)	0.9072	metric tons
British thermal units (Btu)	0.2520	kilocalories
Fahrenheit degrees (° F)	0.5556 (° F - 32)	Celsius degrees

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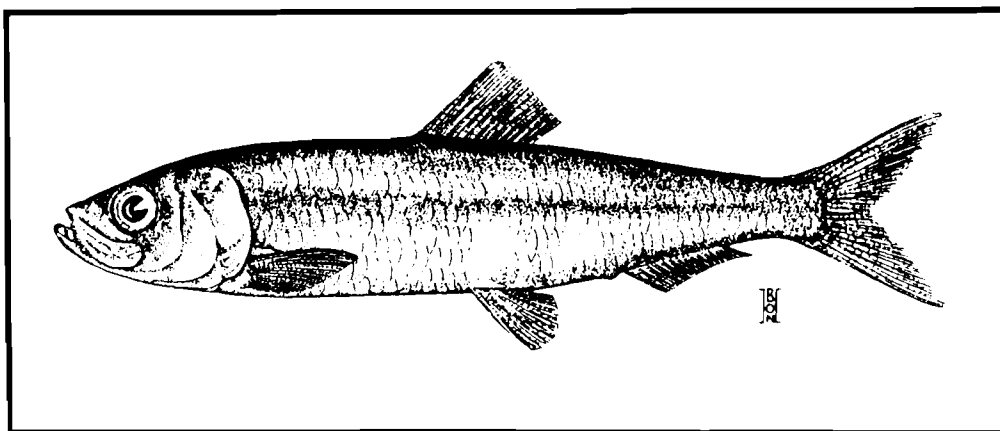


Figure 1. Pacific herring (from Hart 1973).

## PACIFIC HERRING

### NOMENCLATURE/TAXONOMY/RANGE

Scientific name . . . . . *Clupea harengus*  
*pallasi* (Valenciennes 1847)

Common name . . . . . Pacific herring

Class . . . . . Osteichthyes

Order . . . . . Clupeiformes

Family . . . . . Clupeidae

Geographic range: Geographic distribution of this subspecies extends from northern Baja California well into arctic Alaska and the U.S.S.R., Japan, and the Yellow Sea. It is commercially caught throughout most of its subarctic range.

### MORPHOLOGY/IDENTIFICATION AIDS

Body elongate, depth about 4-4.5 in standard length (SL), considerably compressed but variable. Head compressed; mouth terminal, moderate in size, directed moderately upward, lower jaw extending to point below eye; teeth lacking on jaws, ovate patch of fine teeth on vomer. Operculum without striae. Fins: dorsal

(1), 15-21; anal, 13-21; pectorals, about 17; pelvics, about 9, abdominal, each with fleshy appendage at base; caudal forked. Lateral line absent. Scales large, cycloid, 38 to 54 along midside, modified along midventral line with keels moderately developed anterior to pelvic fins and strongly developed between pelvic fins and anus. Vertebrae, 46 to 55. Gill rakers, 20 + 45. Color bluish green to olive on dorsal surface, shading to silvery on ventral surface, dusky on peritoneum. Length to 18 inches.

Recognition: Silvery, lacking black spots on sides of body. Also without spines or adipose fin, no scales or striae on head or gill cover, no modified scales on side of tail fin, no teeth on jaws, keels along midventral line only moderately developed (see Figure 1).

The above description is based entirely on the taxonomic accounts of the Pacific herring presented by Clemens and Wilby (1961); Miller and Lea (1972); and Hart (1973).

The elongate form of the larva is easily confused with other species. The posterior

position of the anus and the absence of an adipose fin separate clupeid larva from others including sand lance, stichaeid, and osmerid larvae.

## REASON FOR INCLUSION IN SERIES

The Pacific herring has a long history of exploitation for human consumption and reduction fisheries for animal feeds and as an item of trade. It also provides food for a wide variety of pelagic, intertidal, and avian predators. The Pacific herring is particularly susceptible to the influences of shoreline development because its spawning grounds are limited to rather specific intertidal and shallow subtidal locations. This and other life history characteristics also make it susceptible to overfishing. The larval stage is sometimes abundantly found in shallow, nearshore waters that are susceptible to shore-based environmental impacts.

## LIFE HISTORY

### *Spawning*

Pacific herring, *Clupea harengus pallasii*, spawn primarily on vegetation and substrates in intertidal or shallow subtidal waters (Hay 1985). Substrate spawning within the genus *Clupea* is unique to *C. harengus* and occurs in both the Pacific and Atlantic subspecies (Whitehead 1985). Spawning grounds of Pacific herring are typically in sheltered inlets, sounds, bays, and estuaries rather than along open coastlines (Haegele and Schweigert 1985a). Hay and Outram (1981) noted that the locations of spawning grounds were consistent from year to year. The general distribution and major spawning sites of Pacific herring in the Pacific Northwest are shown in Figure 2. Koons and Cardwell (1981) provided a detailed map of spawning sites in Puget Sound.

Within the range of the species, there is a latitudinal cline in spawn timing. Spawning may begin as early as October in California (J. Spratt, California Department of Fish and Game, Monterey; pers. comm.) and continue as

late as July in northern Alaska (Haegele and Schweigert 1985b). Spawning peaks in February and March in the Pacific Northwest. Regardless of the calendar month, spawning is apparently timed to coincide with "local spring" conditions (Ware 1985), a period of increasing plankton productivity.

Within a season, spawning occurs in "waves" of several days each separated by a little over 1 to several weeks. Larger fish within a stock tend to spawn first and smaller fish later (Hay 1986). In the actual spawning event, a rapid response in females is triggered by the presence of milt in the water column (Stacey and Hourston 1982). Thereafter, the behavior of males and females within the spawning school is simultaneous and nearly identical. Spawning waves are usually completed within 1 or 3 days and may occur either during the day or at night (Hay 1986). Stacey and Hourston (1982) provided an excellent detailed description and illustration of the spawning sequence.

### *Eggs and Larvae*

The eggs of Pacific herring adhere to vegetation and other solid substrates and may vary in density "from a few thinly scattered eggs to more than 20 layers" (Haegele and Schweigert 1985b). Densities are highest in the lower intertidal and upper subtidal zones. The fertilized eggs average 1.2-1.5 mm in diameter (Hart 1973); incubation time is about 2-3 weeks (Hay and Fulton 1983).

At hatching, Pacific herring larvae "depend on endowed yolk to survive" (Lasker 1985). Yolk-sac larvae move actively in the wild (Westerhagen and Rosenthal 1979). Acuity of the larval eye is low (the minimum separable angle is about 3 to 4 degrees in larvae <12 mm long) but is sufficient in larvae 10-12 mm long to detect prey at short distances (Blaxter and Jones 1967). The yolk-sac stage is generally completed within a week; after that, condition factor (weight/volume) begins to increase, coinciding with the onset of feeding (Westerhagen and Rosenthal 1979).

Larval distribution depends on local current patterns (Eldridge 1977) but may be modified

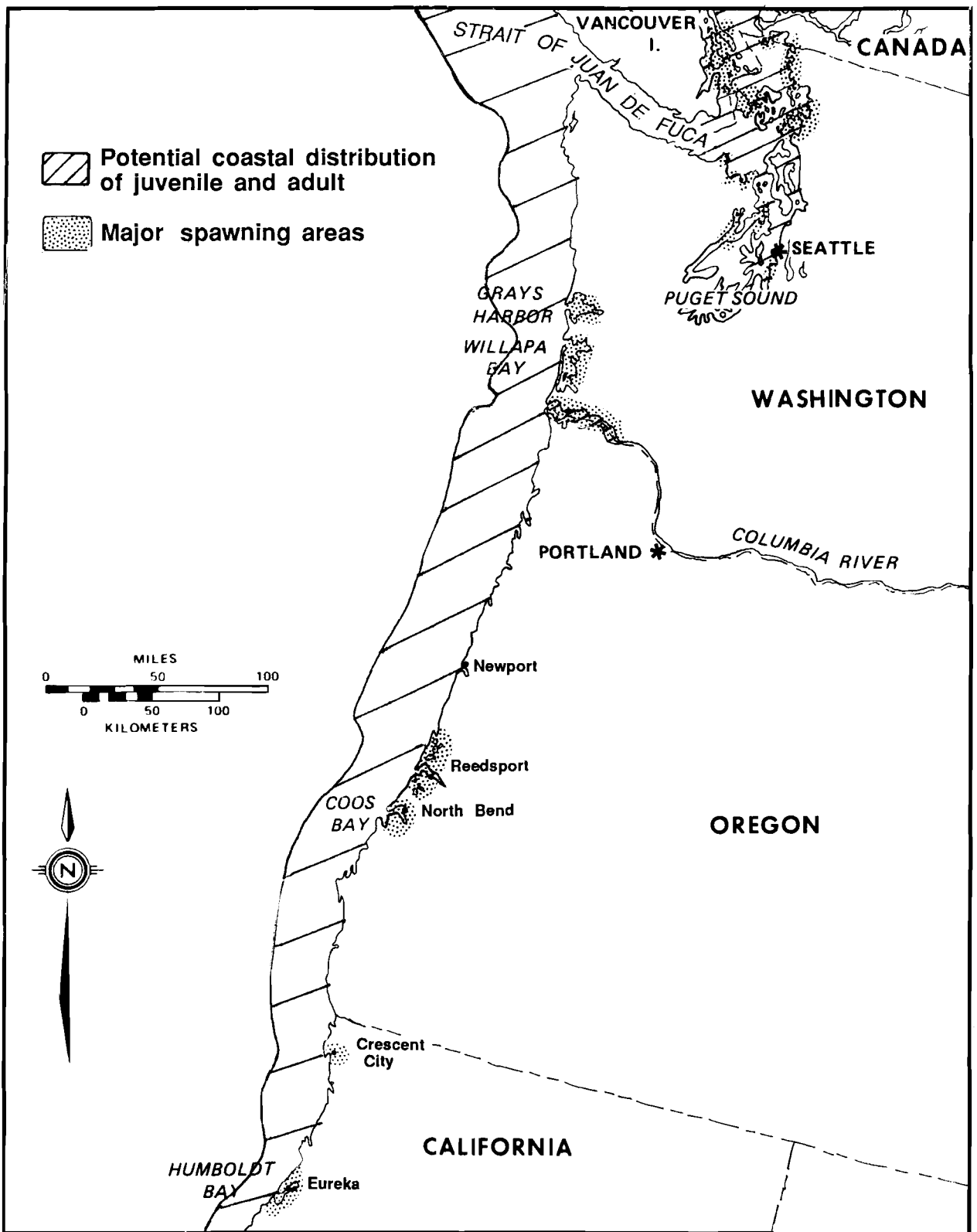


Figure 2. Distribution of the Pacific herring in the Pacific Northwest Region. Shaded areas show known spawning grounds.

by daily vertical migrations--down by day, up by night (Hourston and Haegele 1980). Survival in these early stages therefore depends on stable current patterns that promote larval retention in areas favorable to feeding and growth (Stevenson 1962).

### *Juveniles and Adults*

Larval Pacific herring metamorphose 2 to 3 months after hatching (Hourston and Haegele 1980; Hay 1985) and begin to school when they reach lengths of 25-40 mm (Hart 1973). During the first summer after having been spawned, juveniles gather in large schools and remain primarily in inshore waters (Hay 1985; Stocker et al. 1985). Juveniles may gather after their first summer and move offshore until maturation (Stocker et al. 1985) or they may remain inshore until their first spawning (Hay 1985). First-year juveniles that move offshore live mainly in waters with depths of 150-200 m. Schools of immature fish (second and third year) are found in areas with depths of 100-150 m (Hourston and Haegele 1980). These offshore "juvenile schools" appear to remain separated from offshore schools of adults (Haist and Stocker 1985). Age at first maturity is generally 2-5 years but increases with increasing latitude (Hay 1985) and decreases with increasing exploitation (Ware 1985).

Not all stocks of Pacific herring make this extensive offshore migration. Many small resident populations remain in coastal inlets and bays (Stevenson 1955). Some stocks migrate offshore in the spring after spawning and return from their offshore feeding grounds to inshore waters during the late fall and early winter of each year. The large schools of adults may arrive inshore weeks or even months before the spawning season (Hourston 1980). The move from inshore "holding" areas to spawning sites may simply be from deep water to the adjacent shallows (Hardwick 1973) or may cover long distances in a short time. On the west coast of Vancouver Island, BC, a tagged herring moved 150 km in 6 days (Haegele and Schweigert 1985b). Migratory and non-migratory stocks may mix while both are inshore but apparently separate before spawning (Hay 1985).

### *GSI and Fecundity*

The gonadosomatic index (GSI) is an expression of gonadal weight as a percentage of total body weight. It has been found to provide "a sensitive and quantifiable estimate of maturity" for Pacific herring (Hay and Outram 1981). Since much of the fishery for Pacific herring is for their eggs, or roe, such an index can be extremely useful in correctly timing the fishery to maximize egg yield. The seasonal pattern of gonadal development for male and female Pacific herring from the lower eastern coast of Vancouver Island, BC (adjacent to Puget Sound, WA) is shown in Figure 3. GSI is lowest in the months after spawning and then begins to increase sharply in the fall. Large herring attain a higher maximum GSI than do the smaller adults (Hay 1985). The GSI of female Pacific herring during the spawning season was estimated at 29% (Gunderson and Dygert 1988).

Males begin gonadal development earlier, develop faster, and reach a lower maximum GSI than females (Hay and Outram 1981). Hay (1986) wrote that the "energy investment of

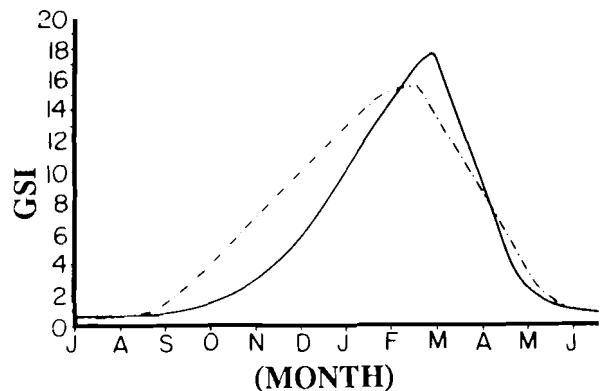


Figure 3. Seasonal pattern of gonadosomatic index (GSI = gonad weight + whole body weight X 100%) in a resident stock of Pacific herring (adapted from Hay and Outram 1981). Solid line is females; dashed line is males. The pattern shown here may not be the same for migratory stocks. Most populations have a maximum GSI above 25%.































