

# Puget Sound Pacific Whiting, *Merluccius productus*, Resource and Industry: An Overview

MARK PEDERSEN

## Introduction

There may be several aggregations of Pacific whiting, *Merluccius productus*, in Puget Sound, Wash., but only one currently supports a commercial fishery. This is the central Puget Sound population, which spawns locally in Port Susan (Fig. 1). It is distinct from the large oceanic population which spawns off Baja California and undergoes a long migration off Oregon, Washington, and British Columbia (Nelson, 1967). Utter and Hodgins (1971) have demonstrated the genetic isolation of these two populations.

The central Puget Sound population of Pacific whiting is of considerable importance. Previously unexploited, it became the object of an industrial-use trawl fishery in November 1965 (Hipkins, 1967). In 1983, 6,821 metric tons (t) were harvested from this stock, comprising 68 percent of the Puget Sound trawl landings and 15 percent of all groundfish landed commercially in Washington. Small groups of whiting occur in other areas of Puget Sound, although none has yet been commercially exploited. Whiting is also a major contributor to the recreational catch from fishing piers in Puget Sound, especially in August and September.

## Distribution

Pacific whiting is one of the most abundant species of groundfish in Puget Sound. Commercial quantities

of whiting are present in Saratoga Passage (Fig. 1) from September through December. During most years, about 70 percent (in numbers) of the catch in Saratoga Passage is comprised of adult fish. In some years, juveniles may dominate the catch, with the ratio of juveniles to adults increasing from south to north. Very few whiting in spawning condition have been observed in Saratoga Passage. These few were taken in or near Holmes Harbor during the late fall of 1982; however, there was not

enough evidence to indicate this might be a significant stock separate from that which spawns in Port Susan. Results from hydroacoustic surveys performed during fall daylight hours in Saratoga Passage suggested that whiting (mainly juveniles) were the major component of a medium-to-heavy density layer from 35 m to the bottom in water less than 73 m deep. In water deeper than 73 m, a mixture of juvenile and adult whiting occupied a heavy density layer from the bottom to 18 m off the bottom. Little is known of the vertical movements at night in Saratoga Passage.

The abundance of Pacific whiting declines in Saratoga Passage during December and January. About the same time a large aggregation begins to form in Port Susan. These circumstances suggest that whiting may use Saratoga Passage as a staging area to complete maturation prior to entering the Port Susan spawning ground.

During the fall, few adult fish have been observed in Port Susan, but scattered small schools of juveniles have been present. During late January, the percentage of adult fish in the whiting biomass begins to increase rapidly. About 95 percent of the whiting caught in Port Susan during this time have been maturing or mature adults (Kimura and Millikan, 1977). Night-time hydroacoustic surveys indicated dense schools of whiting 9-18 m thick from 4 to 7 m off the bottom in water depths of 110-145 m. During late February and March, schools of the same thickness have been observed hard on bottom, which may have been associated with spawning activi-

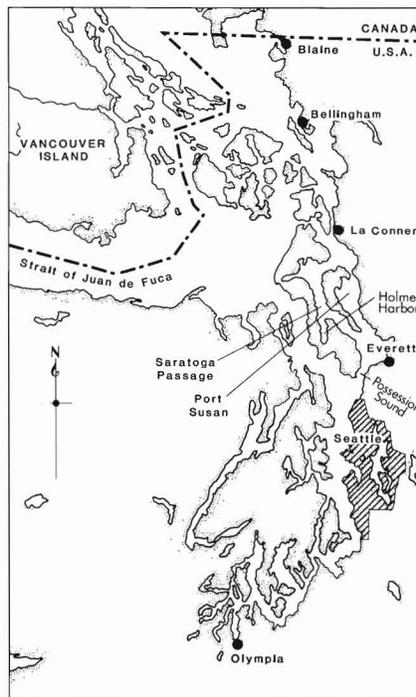


Figure 1.—Puget Sound and the Pacific whiting fishing grounds.

Mark Pedersen is with the Washington Department of Fisheries, 7600 Sand Point Way N.E., Bin C15700, Seattle WA 98115.

**Table 1.—Growth characteristics of Pacific whiting in Puget Sound, averaged from data collected 1965-74.**

Age	Males		Females	
	Average length (cm)	Average weight (g)	Average length (cm)	Average weight (g)
2	27.5	151.7	26.8	142.1
3	31.5	212.1	31.4	216.6
4	34.0	256.0	34.8	284.7
5	35.5	284.8	37.3	342.3
6	36.5	304.9	39.2	390.7
7	37.1	317.4	40.6	428.9
8	37.4	323.8	41.6	457.5
9	37.6	328.1	42.4	481.3
10	37.8	332.4	42.9	496.6

ty. During daylight hours in Port Susan, schools of whiting were more depressed, to about 40% of the nighttime thickness.

In summer, the fish disperse from the spring spawning grounds, and are commonly observed from piers near the surface along the shore, feeding on shrimps and small fishes.

### Biology

The length at which 50 percent of the fish are mature occurs at 29 cm and 31 cm for males and females, respectively. A very small proportion of fish mature at 2 years of age. The proportion of mature individuals increases rapidly with age, and nearly all fish are mature by 7 years of age. Females grow faster than males, and appear to live longer. Females have been recorded up to 73 cm in length and age 15 years, and males up to 45 cm and 11 years (based on examination of otoliths surfaces). However, most of the fish that occur in the fishery range between 4 and 9 years old, and 32 and 45 cm in length. Growth characteristics are shown in Table 1. In comparison with Canadian observations of length at age in the Strait of Georgia (McFarlane et al., 1983), the central Puget Sound whiting appeared to be 2-4 cm shorter at age for ages 3 years and older. At age 2, the data indicated Puget Sound fish were 2-4 cm larger than the Strait of Georgia fish. This observation, and

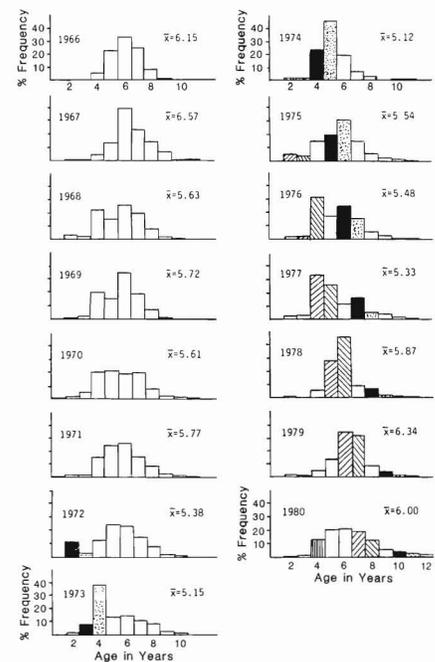
the fact that central Puget Sound whiting mature at a smaller size than do Strait of Georgia fish, may be related to stock response to several years of intensive commercial fishing in Puget Sound. Kimura et al. (1981) concluded that fish appear fully recruited to the exploitable population at age 6 or 7 years. The best estimate of the instantaneous rate of natural mortality ( $M$ ) is 0.65 (Kimura et al., 1981). Examination of age data has demonstrated that year-class strength can be quite variable (Fig. 2). The 1969, 1970, 1972, and 1973 year classes exhibited strong showings between 1972 and 1980.

### The Fishery

The Puget Sound commercial fishery is centered in Saratoga Passage from October through December and in Port Susan from January through June. Table 2 shows the harvest history for 1965-83. Millikan (1970) reviewed the first 5 years of the central Puget Sound fishery and examined some of the problems of interpreting catch per unit of effort (CPUE). Because fishing vessels vary in efficiency, average CPUE will be affected by which vessels fish during a year. Also, market conditions determine not only who fishes, but effort levels as well. Analyses of CPUE are also confounded because whiting may be tightly schooled during the fishery

**Table 2.—History of catch (t) and effort for the central Puget Sound whiting fishery, 1965-83.**

Season	Saratoga Passage		Port Susan		Combined	
	Catch	Trawl hours	Catch	Trawl hours	Catch	Trawl hours
1965-66	333.5	71	2,531.2	764	2,864.7	835
1966-67	1,025.4	279	3,728.9	973	4,755.6	1,252
1967-68	514.8	287	3,188.7	1,314	3,703.5	1,601
1968-69	763.9	320	3,468.3	1,049	4,232.3	1,369
1969-70	273.8	143	3,813.2	1,398	4,087.0	1,541
1970-71	182.7	62	3,365.2	2,241	3,547.9	2,303
1971-72		Negligible	1,895.4	1,506	1,895.4	1,506
1972-73		Negligible	1,122.4	731	1,122.4	731
1973-74		Negligible	2,284.7	1,071	2,284.7	1,071
1974-75	97.0	16	1,406.0	453	1,503.0	469
1975-76		Negligible	1,396.1	279	1,396.1	279
1976-77	360.2	24	1,244.4	231	1,604.6	255
1977-78	410.7	20	2,620.0	848	3,030.6	887
1978-79	115.2	6	4,362.6	764	4,477.8	770
1979-80		Negligible	4,490.1	569	4,490.1	569
1980-81	171.0	30	4,258.4	1,273	4,429.4	1,303
1981-82	1.2	2	4,618.1	1,007	4,619.3	1,009
1982-83	1,389.2	Unavailable	5,161.5	Unavailable	6,550.7	Unavailable



**Figure 2.—Age frequency of female Pacific whiting from Port Susan.**

and catch rates can be maintained by using echo sounders even when absolute abundance is low. When fishing effort is high, scattering of the schools may lower CPUE. Thus for this fishery, CPUE is not a useful statistic.

From three to fourteen vessels have participated annually since the inception of the fishery. Vessels range in

length from 15.2 to 26.6 m, and from 39 to 112 gross tons. Most vessels utilize variations of pelagic trawls with telemetry, although a few vessels have utilized bottom trawls with moderate success. Fishing occurs during the day only in Saratoga Passage, and both day and night in Port Susan. Vessels land every day or every other day. Most of the harvest has been landed at Everett, Wash., but until 1983 between 10 and 30 percent were landed at LaConner, Wash. Landings now occur at Bellingham and Blaine in addition to Everett. The average price per metric ton to fisherman has gradually increased from \$22 to \$61 over the years. Since 1981, vessels with refrigerated holds have entered the fishery to supply whiting to be processed for human consumption. These vessels land daily.

### Processing

Through 1980, the primary utilization of the central Puget Sound whiting resource was for industrial purposes. Between 450 and 800 t annually were sold as animal food, specifically for use as a major component in production of fish food pellets for salmonids. The bulk of the landings, however, was reduced to fish meal via a dry press method. Much of this meal was also used in making food for fish hatcheries in the Pacific Northwest, as well as being incorporated into food for chickens and swine in California.

In the spring of 1981, a market developed for human utilization of whiting that began to compete with industrial users. Over 900 t were landed for human food in 1981 and twice that was landed in the spring of 1982. Vessels with refrigerated holds would unload daily at Everett, and fish were trucked to the processing plant where they were headed and gutted by machine, washed, sealed, packaged, and frozen. The product was marketed in packages of various weights and distributed primarily in the Southern States. This process yielded about 50 percent food product and most of the remainder was rendered. During the 1983-84 season, all land-

ings were sold to fish companies for human food.

There are currently four major buyers (all food fish companies), and more companies are becoming interested. Competition for the limited resource in Puget Sound is now acute, as the demand exceeds the supply by more than twofold.

### Management

Because the resource of Pacific whiting in Puget Sound is of considerable importance, the Washington Department of Fisheries makes a substantial effort to assess its condition, monitor the fisheries, and implement management actions to prevent overharvest.

During the 1960's, the whiting resource assessment surveys in Port Susan were among the first on the west coast to employ hydroacoustic equipment to estimate absolute abundance. This was a period of rapid technical development, and considerable improvement was made in both equipment and methodology. For example, the hydroacoustic data from the 1969-70 surveys were analyzed with an analog integrator (which converted fish echo signals directly into fish densities). In 1971, a more versatile and accurate digital integrator was developed, and all subsequent data have been processed using this method of integration. Also, from 1969 through 1972, trawl catch densities (volume swept method) were used to scale acoustic output to give absolute or real density values. This method made the unrealistic assumption that trawl efficiency was 100 percent; in addition, the number of data points was often limited. In 1974, a fully calibrated echo sounding system became available, making it possible to obtain abundance estimates based entirely on acoustic measurements (Thorne, 1974). In 1975, acoustic densities based on net haul data were compared with densities determined from calibration measurements, and this resulted in an acoustic target value of -37 decibels per kilogram of whiting (Thorne, 1975). This standard value was used to calculate subse-

quent population estimates until 1983. Target values now vary depending on the size composition in schools of fish as determined from trawl hauls.

Thorne (1975) summarized hydroacoustic survey results in Port Susan from 1971 to 1975. Surveys were conducted from February through April with most of the effort occurring in March. Estimates of whiting abundance for the period range from a low of 8,000 t in 1971 to a high of 28,200 t in 1974, with no apparent trends. This fluctuation is due to variability in geographic scope between years and inadequate trawling to verify species composition of acoustic sign.

The first attempt at a comprehensive assessment of the central Puget Sound whiting population was by Kimura and Millikan (1977). Their report examined the 10 years of biological data collected during the 1965-74 seasons, and they presented a stock assessment which utilized yield per recruit and generalized production models. The best estimate of maximum sustainable yield (MSY) from this report was 3,600 t as derived from the generalized production model.

During the period 1971-76, catch levels moderated, and there was no apparent need for further assessment. However, in the 1978-79 period, landings exceeded 3,600 t, and another stock assessment was performed by Kimura et al. (1981). Virtual population analysis indicated that the 4,200 t average annual catch taken during the 1966-69 seasons represented a heavy exploitation rate, from a population biomass of about 10,300 t. Hydroacoustic estimates of biomass fluctuated greatly over the years, but the 1979 and 1980 surveys indicated population biomasses of 10,400 and 12,200 t, respectively. A new MSY estimate of about 4,500 t was derived from this latest stock assessment.

Because examination of age and length compositions indicated no strong year classes entering the fishery in 1980, and because hydroacoustic biomass estimates and fishery modeling indicated the population was being fully utilized, it appeared that a

conservative policy on future harvest was justified.

Under existing stock conditions, it was determined that an appropriate rate of exploitation would be 33 percent of the estimated biomass (Kimura et al., 1981). This rate would be used to determine the annual acceptable biological catch (ABC). Under this approach, the appropriate harvest during the 1979-80 season would have been about 4,050 t.

An estimated 4,500 t were taken, representing an exploitation rate of 37 percent. The fishery was closed by emergency regulation on 10 May 1980. The harvest guideline was not reached in 1981 and the fishery ceased naturally. The fishery was closed 3 April 1982 when the harvest reached the projected 4,626 t ABC. During 1983, the fishery was closed on 24 February when the apparent ABC was attained. More fish entered the grounds in March and the fishery was reopened for 4 days.

At this point, there is little data to support a theory that all whiting in Saratoga Passage are a distinct stock

from those in Port Susan. For this reason, and because it is anticipated that very intense fishing pressure on whiting will occur as they concentrate in Port Susan, it is appropriate to continue to consider the fish in Saratoga Pass, Possession Sound, and Port Susan as one stock. The harvest guideline of one-third of the peak acoustic biomass of whiting in Port Susan will remain. The peak whiting biomass will be determined by averaging the acoustic estimates obtained between mid-February and mid-April and adding the cumulative seasonal catch (including that from Saratoga Passage). Fishing may be suspended prior to that time if catches exceed one-third of the most recent biomass estimates.

In the future, research should focus on improvement and standardization of hydroacoustic survey techniques; delineation of the central Puget Sound population and other groups of whiting in Puget Sound; and a better understanding of the biological parameters and population dynamics of this important resource.

## Literature Cited

- Hipkins, F. W. 1967. Midwater trawl, telemetry gear prove value on Puget Sound hake. *Natl. Fisherman* 47(10):10B-11B, 15 B.
- Kimura, D. K., and A. E. Millikan. 1977. Assessment of the population of Pacific hake (*Merluccius productus*) in Puget Sound, Washington. *Wash. Dep. Fish. Tech. Rep.* 35, 46 p.
- \_\_\_\_\_, N. A. Lemberg, and M. G. Pedersen. 1981. Status of the central Puget Sound hake population in 1980. *Wash. Dep. Fish. Tech. Rep.* 62, 30 p.
- McFarlane, G. A., W. Shaw, and R. J. Beamish. 1983. Observations on the biology and distribution of Pacific hake, walleye pollock, and spiny dogfish in the Strait of Georgia, February 20-May 2, and July 3, 1981. *Can. MS Rep. Fish. Aquat. Sci.* 1722, 109 p.
- Millikan, A. E. 1970. The Puget Sound hake fishery, past, present and future. *Wash. Dep. Fish. Tech. Rep.* 5, p. 1-15.
- Nelson, M. O. 1967. Availability of Pacific hake (*Merluccius productus*) related to the harvesting process. *FAO Conf. on Fish Behavior in Relation to Fishing Techniques and Tactics*, Bergen, Norway, 10/19-27/67, Experience Paper, FR:FB/67/E/34. 26 p.
- Thorne, R. E. 1974. Acoustic survey of hake in Port Susan and vicinity during 1974. *Final Rep. Serv. Contr.* 573, *Wash. Dep. of Fish.*, 8 p.
- \_\_\_\_\_. 1975. Acoustic survey of hake in Port Susan and vicinity during 1975. *Spec. Rep. Serv. Contr.* 629, *Wash. Dep. Fish.*, 6 p.
- Utter, F. M., and H. O. Hodgins. 1971. Biochemical polymorphism in the Pacific hake (*Merluccius productus*). *Cons. Perm. Int. Explor. Mer. Rapp. P.-V. Reun.* 161, p. 87-89.