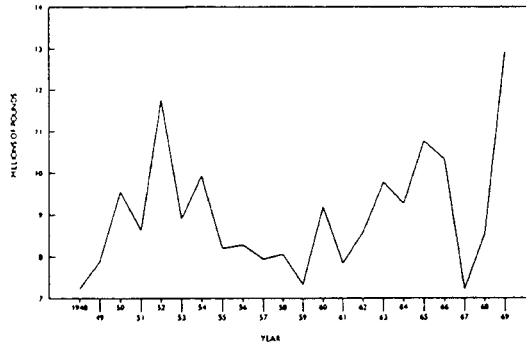


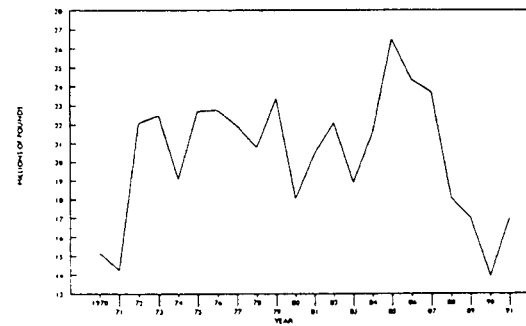
result of market demand during and following World War II and technological advances in fish handling and processing.

At the advent of trawling in the 1870's, Dover sole were inadvertently caught by lateen sailboats using paranzella nets. California's Dover sole fishery expanded from its beginning in San Francisco Bay to its present scope extending from Santa Barbara to the Oregon border. The developing trawl fishery experienced major changes in vessels and netting. Sailboats were replaced by steam, gasoline, then diesel-powered vessels. The original paranzella trawl net was supplanted by the more efficient otter trawl in the 1920's. By the 1980's, some trawl fishermen began to use roller or bobbin trawls to capture Dover sole and other deep-slope groundfish instead of more conventional trawls with rubber mudlines between the trawl doors and footrope to create a fish-herding mud cloud. A quick-freezing method, developed during World War II, hardened the soft flesh of the Dover sole to produce marketable fillets. This advance and the wartime demand for fish allowed trawlers to turn their attention to the large north coast population of Dover sole.

The directed Dover sole fishery began in 1943 when 28 tons were landed. Between 1944 and 1947, landings ranged from 62 tons to 1,400 tons. The fishery expanded to 3,600 tons in 1948, at which time Dover sole landing records were separated from nominal or unspecified sole landings, and rose further to 5,850 tons by 1952. Annual landings then remained stable at approximately 4,000 tons until 1969. From 1969 through 1989, landings have averaged 10,200 tons annually.



California commercial landings of Dover sole, 1948-1969.



California commercial landings of Dover sole, 1970-1991.

DOVER SOLE

History of the Fishery

The stature of Dover sole (*Microstomus pacificus*) has evolved from that of an undesirable by-product of bottom trawling prior to the 1940's to become the most abundant groundfish in statewide landings. This phenomenal rise was the

Actual historical catches of Dover sole were undoubtedly higher than reported landings due to at-sea discarding as a result of market-imposed landing limits. Dover sole from deep depths are often "jellied" (have flesh with a high water content) and consequently have reduced market appeal. Because Dover sole are typically captured jointly with other marketable groundfish, especially sablefish and thornyheads, trawling would often continue for co-occurring species, even after landing limits had been reached.

Commercial Dover sole landing limits were imposed coastwide in 1989 and 1990 by the Pacific Fishery Management Council as a trip limit on the aggregate poundage of Dover sole, thornyheads, and sablefish on board. Prior to that time, market demand and gear regulations, not resource availability nor quotas, were the dominant forces controlling statewide Dover sole landings. The intent of this regulation was to reduce the harvest of sablefish by restricting deep water trawl effort for the complex of Dover sole, thornyheads, and sablefish.

The port of Eureka has historically supported the largest Dover sole fishery, followed by Fort Bragg, Crescent City, San Francisco, and Monterey. The Morro Bay-Port San Luis area supported a very minor deep water trawl fishery until 1983 (annual landings of 50 tons), at which time a wintertime influx of trawlers from northern California and Oregon began targeting Dover sole. Good winter weather, an absence of market limits, and a relatively unexploited resource caused landings to rise dramatically. From 1983 to 1989, landings into Morro Bay and Port San Luis have averaged 1,760 tons.

Sport utilization of Dover sole is practically nonexistent. The depth distribution of Dover sole normally places them beyond most sport fishing activity, and Dover sole, because of their feeding habits, are not vulnerable to hook-and-line fishing.



Dover sole, *Microstomus pacificus*.

Status of Biological Knowledge

Dover sole occur from the Bering Sea to northern Baja California on mud bottoms at depths from 180 to 4,800 feet. Although early tagging experiments off Oregon and California suggested Dover sole move inshore in the summer, a more recent California Department of Fish and Game (CDFG) tagging study discovered that not all Dover sole participate in the summer inshore movement. In fact, most of the mature fish tagged and released in deep water were recovered in deep water regardless of season. Thus the CDFG tagging data indicate that two substocks may exist: one that migrates and one that does

not. Juvenile Dover sole settle on the continental shelf and gradually move down the slope over their lifetime, reaching the oxygen-minimum zone as they become sexually mature. Thus, fish composing the migratory substock may be younger than those composing the nonmigratory substock.

Fish size changes markedly with ocean depth. For example, the average weight of females increases from 0.61 pound in depths shallower than 1,500 feet, to 1.80 pounds in 1,500 to 3,300 feet, then to 2.46 pounds from 3,300 to 4,200 feet. The proportion of females also increases with depth, from two-thirds of the total biomass in shallow waters to over 90 percent at depths greater than 3300 feet.

Growth is rapid during the early years of life but decreases with age. Five-year-old Dover sole grow 0.65 inch per year, but, by 10 years of age, growth slows to 0.42 inch annually. Dover sole may attain an age of over 50 years and reach 30 inches in length. Fifty percent of Dover sole females 12.2 inches long are mature. The smallest mature Dover sole in 1987-1988 studies was six years old, whereas early studies reported mature five-year-old females.

Dover sole may spawn nine batches to release all eggs in a spawning season. Egg production is correlated with size. Fish of 0.55 pound produce 33,000 eggs, while 2.36-pound fish produce 54,000 eggs on average. The buoyant Dover sole eggs may experience a wide range of water temperatures, from 37 degrees F near the bottom to 59 degrees F at the sea surface. Thus, incubation time may vary from 10 days to one month. Larvae have a prolonged pelagic life of at least one year and are unusually large (one to two inches long) before settling to the bottom. Larvae have been found along the entire California coast, as far as 60 miles south of the U.S.-Mexico border and up to 280 miles offshore.

Dover sole feed commonly on polychaete worms, pelecypod and scaphopod mollusks, shrimp, and brittle stars. Only Pacific sleeper sharks and spiny dogfish are known to prey on Dover sole.

Status of Population

Population estimates of Dover sole in California waters are only available for limited geographic areas in central and northern California. In 1987 and 1988, the National Marine Fisheries Service (NMFS) conducted two surveys to assess the adult biomass of Dover sole in the area from Point Conception to Monterey Bay. The surveys found that 98 percent of the spawning biomass of Dover sole in central California waters live on the continental slope between 2,100 and 3,300 feet deep, an area characterized by low oxygen concentrations and very cold temperatures. Estimated biomass was 11,250 tons using one survey method and ranged from 15,400 to 18,700 tons using the other.

A Dover sole stock assessment using 1990 NMFS bottom trawl survey data and population modelling provided estimates of current biomass and yields for the area from Cape Mendocino, California to Cape Blanco, Oregon. Female spawning biomass was estimated to be 20,200 tons, with a likely range of 16,500 to 34,000 tons. Estimated maximum sustain-

able yield for the Eureka area is 3,000 to 4,100 tons. The stock in this area was in equilibrium and near the target biomass level that would provide maximum sustainable yield.

A quantitative assessment has not been conducted yet on the Dover sole population in central California between Monterey Bay and Cape Mendocino.

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