M. James Allen and Alan J. Mearns

LIFE HISTORY OF THE DOVER SOLE

One of the few marine fishes in southern California with clearly identifiable health problems as a result of waste-water pollution is the Dover sole (*Microstomus pacificus*). Although Hagerman (1952) compiled life history information on commercial stocks of Dover sole in northern California, little information existed until recently on southern California populations. Many of the Project's laboratory and field studies have focused on this species; this is a summary of its life history that may help clarify its status with respect to wastewater effects.

DISTRIBUTION AND ABUNDANCE

The Dover sole is a relatively large (to 76 cm total length and 4.7 kg) pleuronectid flatfish that ranges from the Bering Sea in the north to San Cristobal Bay, Baja California, in the south. Although commercially important stocks occur from British Columbia to Santa Barbara, California, the best fishing grounds in California are near Eureka and Fort Bragg. Juvenile and adult Dover sole have been found at depths ranging from 9 to 1,189 m, although most of the commercial catch in northern California comes from a depth range of 82 to 823 m. Adults move into deeper water to spawn in the fall and winter, but movements of adults along the coast are not thought to be extensive. Individuals tagged in British Columbia, however, were found up to 204 km north and 680 km south of the tagging site (Westrheim and Morgan 1963).

In the Southern California Bight, commercially important stocks are found only near Santa Barbara (there is no legal commercial fishing south of Santa Barbara that affects this species). Since 1960, Dover sole catches in the Santa Barbara area have averaged 27,216 kg/yr, ranging from 9,687 to 94,746 kg; prior to 1959, the fishery was not important. The present Santa Barbara catch represents about 0.5 percent of the total California Dover sole catch per year, although it reached a high of 2.6 percent in 1962.

South of Santa Barbara, Dover sole are generally most abundant near deepwater municipal wastewater outfalls, where infaunal food organisms are abundant. In trawl surveys, Dover sole have been found at densities of up to 0.45 fish/sq m near the Whites Point outfall; the catch densities of the species

in other local coastal areas average about 0.02 fish/sq m (actual densities are probably higher). The average abundance of Dover sole near a new deepwater (60-m) outfall at Orange County increased above background levels within a year after discharge was initiated (Mearns et al. 1976).

ECOLOGICAL ROLE

Adult and juvenile Dover sole are important members of deep mud-bottom communities in southern California (Coastal Water Research Project 1973a; Mearns et al. 1976). At depths up to 200 m, the Dover sole is frequently found with the stripe- tail rockfish (*Sebastes saxicola*), Pacific sanddab (*Citharichthys sordius*), and plainfin midshipman (*Porichthys notatus*); at greater depths, the species is associated with the shortspine thornyhead (*Sebastolobus alascanus*) and sable-fish (*Anoplopoma fimbria*).

Although the Dover sole feeds to some extent on epifaunal organisms, such as echinoids, ophiuroids, gastropods, and crustaceans, the primary items in the diet of the species are infaunal organisms, such as bivalves, scaphopods, polychaetes, and echiurans. A closely related European species, the lemonsole (*Microstomus kitt*), is particularly efficient at extracting tubicolous polychaetes and snipping off clam siphons (Steven 1930): Dover sole show a similar hunting posture (body arched with head and tail raised) and presumably feed in a similar manner.

The Dover sole is the dominant polychaete-stalking flatfish in the Bight from 50 to at least 200 m. Its major competitors in this area include the hornyhead turbot (*Pleuronichthys verticalis*), curlfin sole (*Pleuronichthys decurrens*), English sole (*Parophrys vetulus*) , blackbelly eelpout (*Lycodopsis pacifica*) , and rex sole (*Glyptocephalus zachirus*).

Although it is an abundant species, we know of few Dover sole predators. Adults and juveniles are eaten by Pacific sleeper shark (*Somniosus pacificus*; Gotshall and Jow 1965) and the spiny dogfish (*Squalus acanthias*); the planktonic larvae are eaten by albacore (*Thunnus alalunga*). Whole Dover sole used as bait in a baited camera study (Coastal Water Research Project 1973b) were eaten by spiny dogfish, sablefish, and swell shark (*Cephaloacyllium ventriosum*) but not by other fishes attracted to the bait.

REPRODUCTION AND LARVAL RECRUITMENT

We have no direct information on spawning in southern California Dover sole populations. However, spawning in northern California and Oregon populations occurs in deep water from November to March, and, when mature (at about 5 years), males are about 38 to 40 cm in length and females about 45 cm (Hagerman 1952). Fecundity is generally correlated with size, with smaller individuals of about 40 cm producing 40,000 to 50,000 eggs and larger individuals of 50 to 60 cm producing about 250,000 eggs.

The eggs are buoyant and the larvae planktonic. Planktonic larvae have been found up to 448 km offshore and as far south as 29°30'N (somewhat north of Guadalupe Island; Ahlstrom and Moser 1975), and can survive for several months in the plankton beyond the stage that most individuals settle out. Although larvae occur throughout the year, seasonal peaks of abundance (particularly from April to July) do occur (Figure 1). Larvae settle to the bottom when they are 40 to 50 mm in length (Figure 2); tiny Dover sole are abundant in otter trawl catches from February to July. The number of recruitments may vary from year to year, apparently depending upon the location of the major spawning populations and the direction of the currents subsequent to spawning. Spawning populations north of Point Conception may supply most of the larvae recruited into southern California populations, although the presence of small larvae (5 to 9 mm) in the Bight during April and May suggests that some local spawning does occur. Larvae surviving in the plankton for 9 months (which is probably not unusual) could be transported 3,500 km from the spawning site (assuming average California current velocities).

GROWTH

Although Dover sole are known to live for 15 to 20 years (Hageman 1952; Demory 1972a), specimens captured in local monitoring surveys are generally less than 8 years old. Older individuals may live in deep water, but the growth rate of southern California populations is lower than that of northern California populations. Six-year-old individuals taken south of Santa Barbara range from 24 to 31 cm in length whereas those from Santa Barbara north range from 29 to 39 cm in length. Southern California, being near the end of the geographic range of the Dover sole, apparently does not provide optimal conditions for growth in this species. Growth rates are generally higher in coastal populations than in those around islands (2 to 5 year coastal fish were twice the weight of Catalina fish); those living near the whites Point outfall have lower growth rates and larger liver-to-body-weight ratios than other populations off the mainland coast (Mearns and Harris 1975).

DISEASES AND ANOMALIES

The Dover sole is afflicted with a number of diseases and anomalies. These include fin erosion, tumors, missing tails (Demory 1972b), deformed caudal peduncles, bent fin rays, ambicoloration, and parasitism by nematodes (Hagerman 1952). Our studies have focused on fin erosion and tumor diseases because of the concern that wastewater pollution could be a cause. Our results are summarized elsewhere in this report and in last year's annual report.

CONCLUSIONS

Dover sole populations in southern California ate not of commercial importance, except near Santa Barbara, The species is nevertheless one of the most frequently occurring and abundant flatfishes in southern California at depths from 50 to 200 m and is therefore an important member of fish communities of the deeper portion of the mainland shelf. It shows obvious responses to wastewater discharge; populations near outfalls are generally more abundant, exhibit a higher prevalence of fin erosion disease, and show growth rates that are lower than those of other mainland coastal populations but higher than those of fish at Santa Catalina Island. Southern California populations may be largely the result of larval recruitment from spawning populations north of Point Conception, but this has yet to be confirmed. The fact that growth rates are lower in southern California than to the north suggests that southern California, which is near the southern end of the species' geographic range, may not have optimal conditions for producing and maintaining commercially important stocks of Dover sole.

REFERENCES

Ahlstrom, E.H., and H.G. Moser. 1975. Distributional atlas of fish larvae in the California current region: Flatfishes, 1955 through 1960. CalCOFI Atlas 23.

Coastal Water Research Project. 1973a. The ecology of the Southern California Bight: Implications for water quality management. TR 104, El Segundo, Calif.

_____. 1973b. Baited camera observations of demersal fish. TM 207, El Segundo, Calif.

_____. 1975. Annual report. El Segundo, Calif. Demory, R.L. 1972a. Scales as a means of aging Dover sole (*Microstomus pacificus*). J. Fish. Res. Bd. Canada 29:1647-50.

_____. 1972b. Tailless Dover sole from off the Oregon coast. Calif. Dept. Fish Game 58(2);147-49.

Gotshall, D.W. , and T. Jow. 1965. Sleeper sharks (*Somniosus pacificus*) off Trinidad, California, with life history notes. Calif. Dept. Fish Game 51(4):294-98.

Hagerman, F.B. 1952. The biology of the Dover sole, *Microstomus pacificus* (Lockington). Calif. Dept. Fish & Game, Fish. Bull. 85.

Mearns, A.J., and L. Harris. 1975. Age, length, and weight relationships in southern California populations of Dover sole. TM 219, Coastal Water Research Project, El Segundo, Calif.

Mearns, A.J., M.J. Alien, L.S. Word, J.Q. Word, C.S. Greene, M.J. Sherwood, and B. Myers. 1976. Quantitative responses of demersal fish and benthic invertebrate communities to coastal municipal wastewater discharges. Final report, EPA Grant R801152.

Steven, G.A. 1930. Bottom fauna and food of fishes. J. Mar. Biol. Assoc. U.K. 16(3):677-706.

Westrheim, S.J., and A.R. Morgan. 1963. Results from tagging a spawning stock of Dover sole, *Microstomus pacificus*. Pac. Mar. Fish. Comm. Bull. 6:13-21.

Figure 1. Size distribution of Dover sole larvae taken in monthly midwater trawls off Southern California, 1960 to 1972 (unpublished data from University of Southern California, National Marine Fisheries Service, and Scripps Institution of Oceanography.

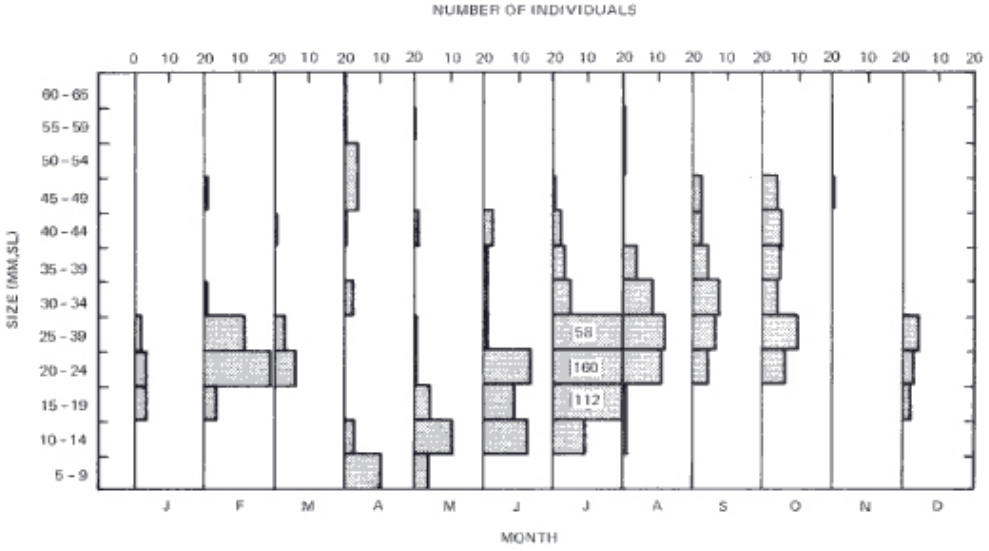

Figure 2. Size distribution of Dover sole captured by midwater trawl (Los Angeles County Museum of Natural history data, 1960 to 1969, 649 samples) and small-meshed otter trawl (Coastal Water Project data, 1972 to 1973, 346 samples) in the Southern California Bight.