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Biological Report 82(11.107)
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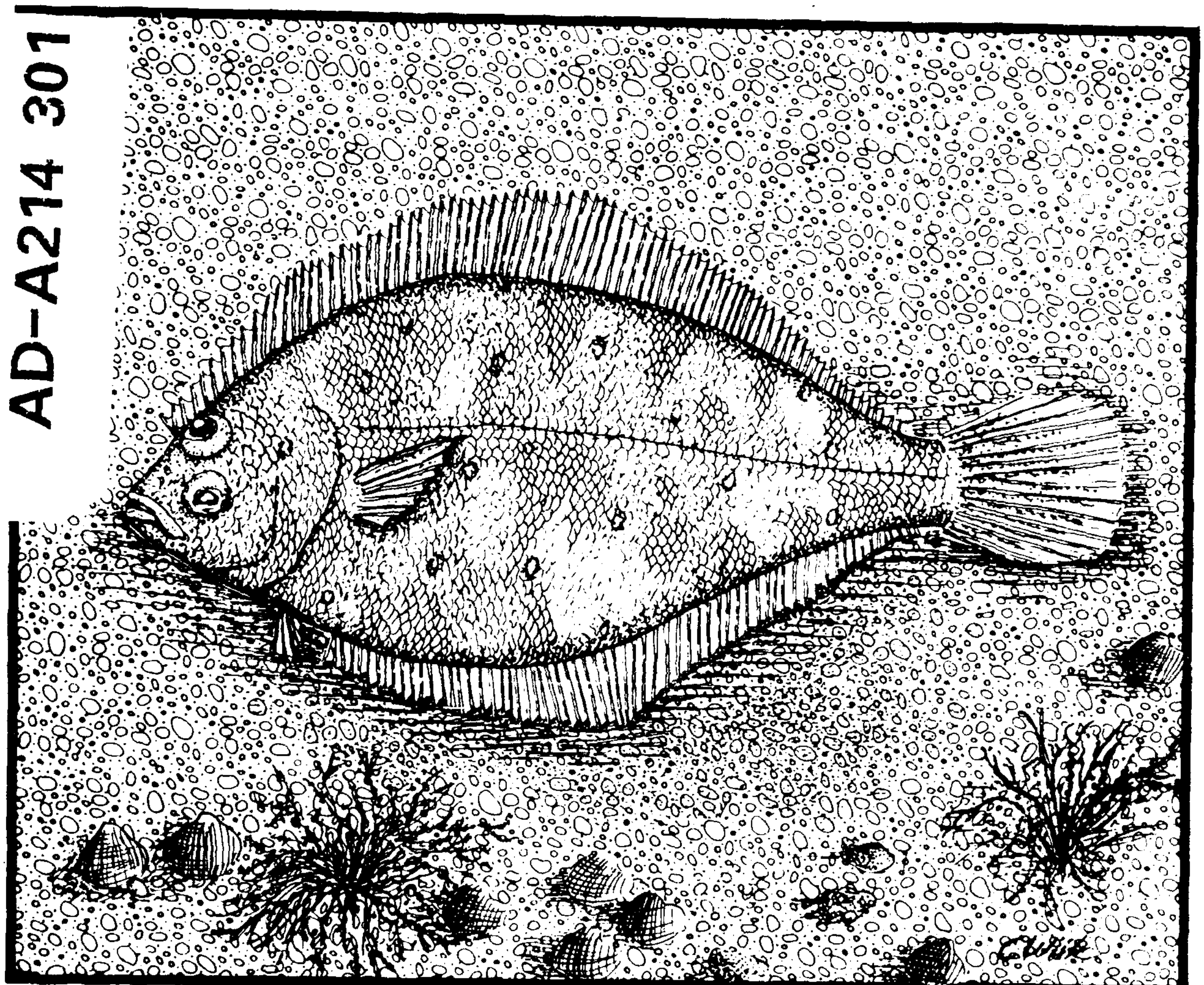

Fish and Wildlife Service
U.S. Department of the Interior

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 Southwest)

PACIFIC AND SPECKLED SANDDABS

by

Joseph P. Rackowski
Department of Fisheries and Wildlife
Oregon State University
Hatfield Marine Science Center
Newport, OR 97365

and

Ellen K. Pikitch
University of Washington
School of Fisheries
Fisheries Research Institute
Seattle, WA 98195

Project Officer
David Moran
U.S. Fish and Wildlife Service
National Wetlands Research Center
1010 Gause Boulevard
Slidell, LA 70458

Performed for

Coastal Ecology Group
U.S. Army Corps of Engineers
Waterways Experiment Station
Vicksburg, MS 39180

and

U.S. Department of the Interior
Fish and Wildlife Service
Research and Development
National Wetlands Research Center
Washington, DC 20240

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
National Wetlands Research Center
U.S. Fish and Wildlife Service
NASA-Slidell Computer Complex
1010 Gause Boulevard
Slidell, LA 70458

or

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

CONVERSION FACTORS

Metric to U.S. Customary

Multiply	*By*	*To Obtain*
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
meters (m)	0.5468	fathoms
kilometers (km)	0.6214	statute miles
kilometers (km)	0.5396	nautical miles
square meters (m^2)	10.76	square feet
square kilometers (km^2)	0.3861	square miles
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters (m^3)	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 (t)	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^2)	0.0929	square meters
square miles (mi^2)	2.590	square kilometers
acres	0.4047	hectares
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28350.0	milligrams
ounces (oz)	28.35	grams
pounds (lb)	0.4536	kilograms
pounds (lb)	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

CONTENTS

FIGURES

ACKNOWLEDGMENTS

We thank Susan Jurasz for preparing the illustrations of both species of sanddabs and for helping us to prepare the maps and graphs; and Ms. Joyce Underhill, California Department of Fish and Game, Long Beach, for providing unpublished commercial landings data. We also wish to thank Dr. William Pearcy, Oregon State University, Corvallis, Dr. David Stein, Oregon State University, Corvallis, and Mr. Larry Quirollo, California Department of Fish and Game, Eureka, for their critical review of an earlier draft of this profile. Ms. Theresa Ketchum assisted in typing the manuscript.

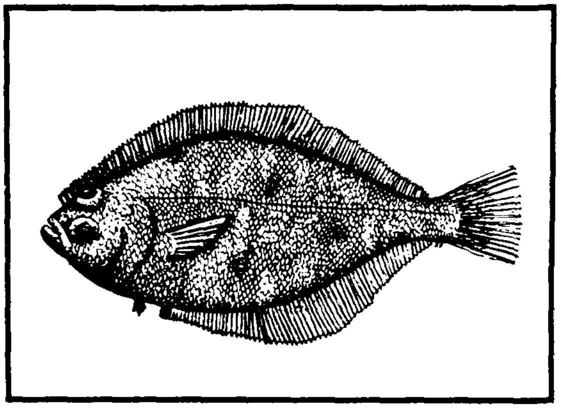

Figure 1. Pacific sanddab (Citharichthys sordidus), 36 cm (redrawn from Arora 1951).

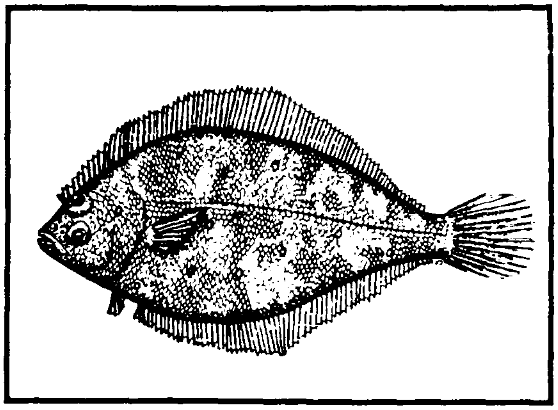

Figure 2. Speckled sanddab (Citharichthys stigmaeus), 14 cm (redrawn from Bane and Bane 1971).

PACIFIC AND SPECKLED SANDDABS

NOMENCLATURE AND TAXONOMY

Scientific name ....Citharichthys sordidus Girard
Preferred common name ....Pacific sanddab (Figure 1)
Other common names ...Mottled sanddab, soft flounder
Scientific name ....Citharichthys stigmaeus Jordan and Gilbert
Preferred common name ....Speckled sanddab (Figure 2)
Other common names .....Catalina sanddab
Class ....Osteichthyes
Order ....Pleuronectiformes
Family ....Paralichthyidae

MORPHOLOGY AND IDENTIFICATION AIDS

In species of Citharichthys, the body is compressed, highly asymmetrical and colored only on the left side. The blind side is usually white or cream. The asymmetrical head is deep and blunt; both eyes are on the left side. Jaws are symmetrical and heavy with a median knob. The maxillary bone extends to the forward part of the lower eye. Pelvic fins are asymmetrical; fin of the eyed side is attached directly to the ventral ridge (Miller and Lea 1972; Hart 1973).

Pacific Sanddab

As the species name sordidus suggests, body and fin coloration on the eyed side is dull brown or tan and irregularly mottled with yellow and orange (Miller and Lea 1972; Hart 1973). The ridge between the eyes is concave; the lower eye is longer than the snout. Pectoral fin reaches to the middle of the eye when projected forward (Miller and Lea 1972). Gill rakers 15-16 on the lower section of the first anterior arch; dorsal rays 86-102, originating just anterior to the eye; anal rays 67-81, caudal rounded; scales ctenoid on eyed side, cycloid on blind side (Arora 1951; Eschmeyer et al. 1983). Lateral line scales 61-70; vertebrae 39-40; length to 16 inches (40 cm); weight to 2 pounds (Arora 1951; Roedel 1953; Miller and Lea 1972; Hart 1973).

Maximum reported total length (TL) 403 mm (Arora 1951; Chamberlain 1979).

Speckled Sanddab

Coloration is olive brown or tan with black speckling on the eyed side, and white to cream on blind side (Miller and Lea 1972; Hart 1973). Ridge between eyes flat to convex; pectoral fin, projected forward, falls short of the lower eye. Gill rakers 8-10 on the lower section of the first anterior arch; dorsal rays 75-97, first 2 or 3 rays anterior to upper eye (Batts 1964; Miller and Lea 1972). Anal rays 58-77, caudal rounded; scales imbricated, deciduous, ctenoid on both sides of the body. Vertebrae 34-39 (generally 36); lateral line straight, scales 52-58. Length to about 7 inches (17 cm); weight to about 1 pound (Miller and Lea 1972; Hart 1973; Wang 1981). Maximum reported length is 169 mm (Chamberlain 1979).

GEOGRAPHIC RANGE

Pacific Sanddab

Occurs along the Pacific coast from the Bering Sea to Cabo San Lucas, at the tip of Baja California (Wilimovsky 1954; Miller and Lea 1972; Hart 1973; Roedel 1948; Arora 1951). Most abundant along north central California, from Eureka to San Francisco, and fairly common in southern California (Figure 3). Pacific sanddabs occupy depths to 306 m, but are usually found at 18-275 m, and the optimum depth is 35-95 m (Hart 1973; Arora 1951; Roedel 1953; Fitch and Lavenberg 1971; Miller and Lea 1972). Pacific sanddabs tend to inhabit shallower depths at higher latitudes (Chamberlain 1979).

Speckled Sanddab

This species occurs along the Pacific coast from Montague Island, Alaska, to Magdalena Bay, Baja California (Wilimovsky 1954; Hart 1973; Townsend 1935; Miller and Lea 1972; Ford 1965); most abundant in nearshore waters along central and southern California (Figure 4). Speckled sanddabs inhabit depths extending from the intertidal zone to 366 m (Fitch and Lavenberg 1971; Hart 1973; Townsend 1935; Ford 1965).

REASON FOR INCLUSION IN THE SERIES

The Pacific sanddab is commercially important in California with demand often exceeding supply. Speckled sanddabs have little commercial importance because of their small size. Throughout the late 1970's and early 1980's sanddabs became increasingly important in the commercial fishery, in both pounds landed and dollar value of the catch.

Because sanddabs inhabit shallow, environmentally sensitive areas such as bays and estuaries, it is important to investigate the effects of pollutants and human interactions on their ecology.

LIFE HISTORY

In life history studies of the Citharichthys reviewed here, Arora (1951) provided the most complete review of the Pacific sanddab and Ford (1965) investigated the general biology, population dynamics, and behavior of the speckled sanddab. Reproduction of both species was studied by Chamberlain (1979). Ahlstrom et al. (1984) published detailed information on the development and distribution of sanddab larvae. Feeding ecology of the Pacific and speckled sanddabs was described by Hulberg and Oliver (1978) and Ambrose (1976).

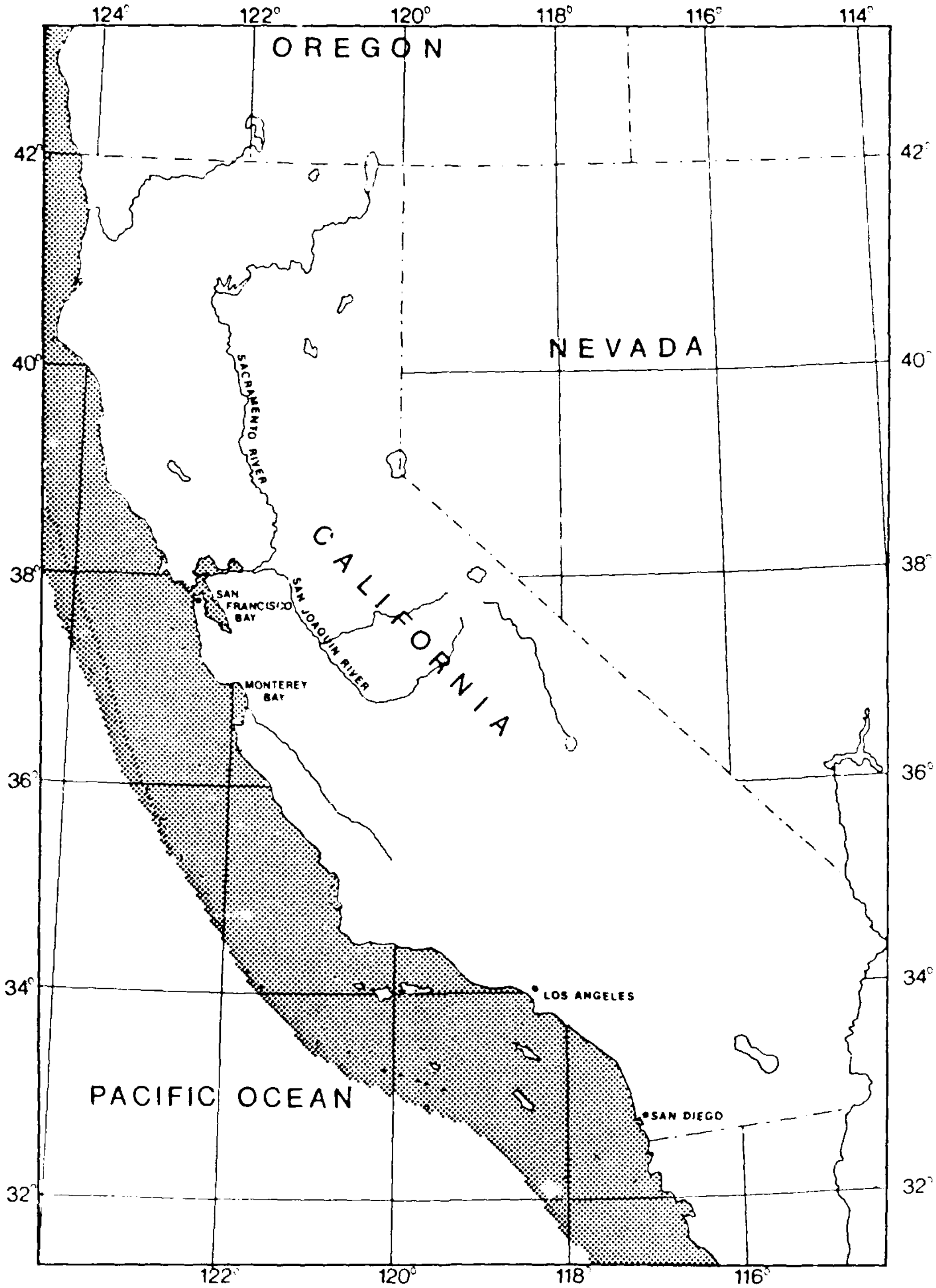

Figure 3. Geographic distribution of Pacific sanddab along the California coast.

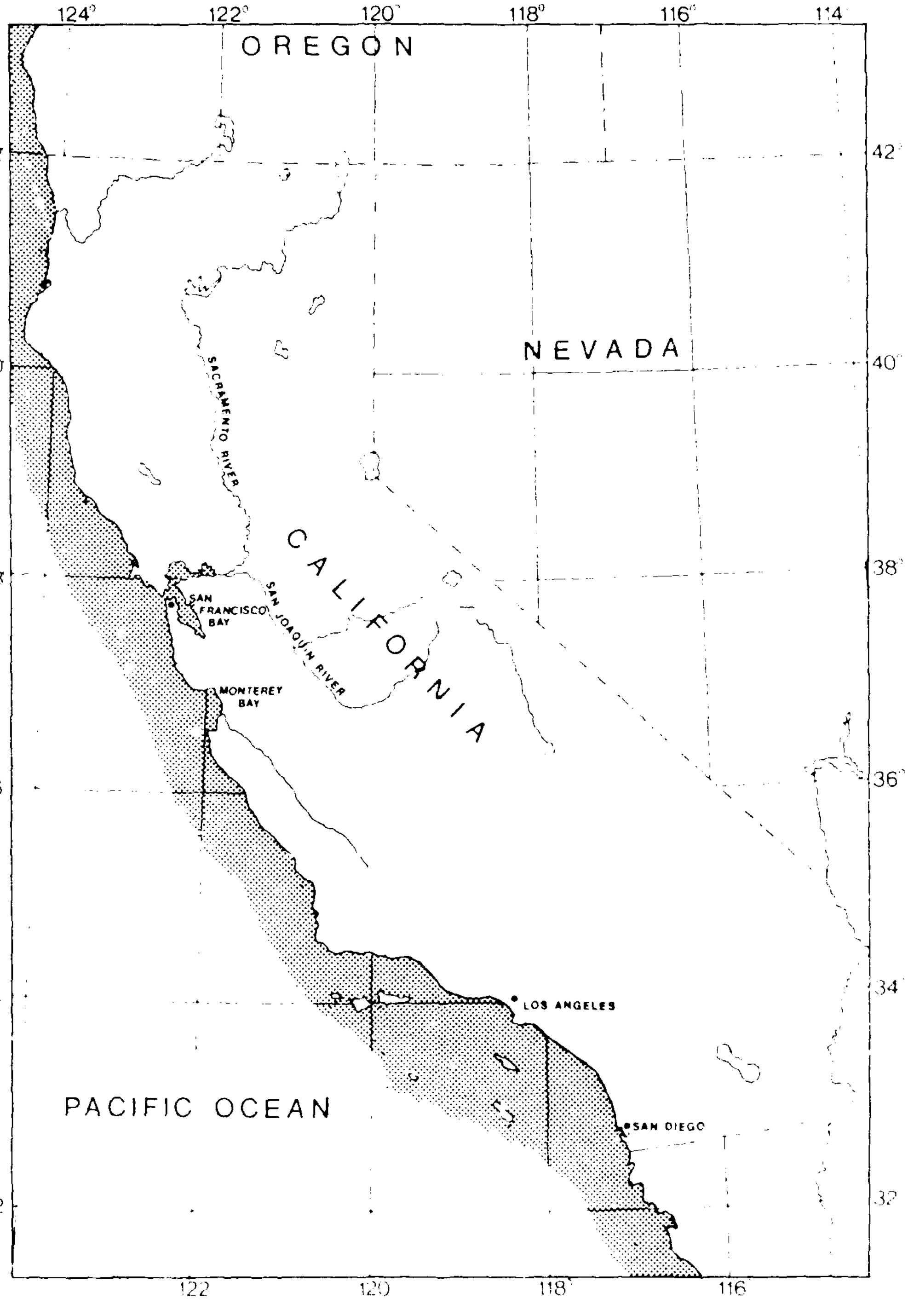

Figure 4. Geographic distribution of the speckled sanddab along the California coast.

Reproduction

Reproductive patterns of the two species of Citharichthys are similar. Differences in water temperature from year to year may influence the time of spawning (Chamberlain 1979; Ford 1965). Southern species of Citharichthys begin reproduction earlier and continue it longer than sanddabs in cooler northern waters (Chamberlain 1979). Adults spawn near bottom in bays and the open ocean, where water temperature is low. Vitellogenesis begins as early as February for both species of Citharichthys (Chamberlain 1979).

Spawning season in Pacific sanddabs, collected at depths of 35 to 90 m from Point Reyes to San Francisco, was determined from a series of observations of egg size (Arora 1951). The eggs were largest from July to September; most reached maximum size in August. Male development peaked during this same period. By October nearly all females were spent. Females matured at age 3, at an average of 190 mm TL (Arora 1951).

In specimens of speckled sanddabs of 91 to 148 mm (TL), from depths of 5 to 45 m, collected on the intercanyon shelf off southern California, Ford (1965) found that spawning began in April, when more than 50% of all eggs were mature, and ended in September. Spawning coincided with a sudden decline in bottom water temperature (from 15 to 10.5 °C) due to spring upwelling (Ford 1965). No mature eggs were found in sanddabs collected in October or December. Female speckled sanddabs matured at age 2, at an average length of 70 to 80 mm TL (Ford 1965). Spawning male and female speckled sanddabs congregated at the head of La Jolla Canyon during spring and summer. The collection of large numbers of recently fertilized eggs of sanddabs in surface net tows over the intercanyon shelf at 0800 to 0900 hours indicated that the fish spawned in early morning (Ford 1965).

Three distinct groups of egg maturity stages have been described for the two species of sanddabs reviewed here: stage I, immature; stage II, small, semi-opaque to large and granular; and stage III, mature. Arora (1951) and Ford (1965) both concluded that multiple spawnings per season occur because the three size groups of eggs are present simultaneously in mature females.

Eggs of west coast species of Citharichthys are spherical, translucent, similar in size, and contain one oil globule at maturity. Immature eggs may contain several oil globules of various sizes. The modal diameter of mature Pacific sanddab eggs was reported to be about 0.650 mm by Arora (1951). The average maximum diameter of Pacific sanddab eggs collected off Orange County in August was 0.845 mm (Chamberlain 1979). The largest speckled sanddab eggs averaged 0.448 mm in September, 0.540 mm in February, and 0.760 mm in May (Chamberlain 1979).

Testes of mature Pacific and speckled sanddabs averaged 0.11% and 0.21%-0.36% respectively of fresh, wet body weight (Chamberlain 1979). Weight of fresh, wet ovaries were 1.0% to 4.4% of body weight for Pacific sanddab and 1.7% to 5.6% for speckled sanddab (Chamberlain 1979).

No fecundity estimates for Pacific sanddabs have been published. Ford (1965) reported that speckled sanddabs 50.0 to 67.5 mm TL contained only immature eggs of 0.03 to 0.15 mm, and fish larger than 78 mm TL had large numbers of mature or maturing eggs 0.35 to 0.77 mm in diameter. Estimated numbers of eggs spawned per season by speckled sanddabs were 4,200 at lengths of 85-90.5 mm, 12,100 at 109.5-110.5 mm, and 22,500 at greater than 129.0 mm TL (Ford 1965). Many post-spawning males and females of both species (which were sampled at various times during the spawning season) retained the bulk of the sperm or ovarian mass, suggesting that relatively small numbers of sperm and eggs are released throughout the spawning season, and multiple spawnings occur.

Early Development

Chamberlain (1979) published the most detailed description of Citharichthys eggs and embryos, and Ahlstrom et al. (1984), the best study of larval stages.

Larvae hatch at about 2.0 mm TL or less, and complete the yolk-sac stage of development at about 3.0 mm TL (Wang 1981). Paralichthid flatfish, including sanddabs, are usually sinistral; during metamorphosis the larvae transforms to a juvenile form with both eyes on the left side of the head and an asymmetrical pigmentation pattern (Ahlstrom et al. 1984). Timing of metamorphosis in flatfish is more closely related to environmental temperature and individual size than to age (Ahlstrom and Moser 1975). Citharichthys larvae longer than 5 mm can be identified on the basis of a combination of pigment characters, meristic counts, and location of capture (Ahlstrom et al. 1984; Ahlstrom and Moser 1975).

At about 5 mm TL, Pacific sanddabs develop two elongated, ornamental rays at the insertion of the dorsal fin and two corresponding rays from the pelvic fins (Figure 5). Speckled sanddabs develop no such rays during their development (Figure 6). Pacific sanddabs lose the rays during metamorphosis (Porter 1964). The meristic characteristics of adults are useful in identifying young Citharichthys (see summary of adult characteristics).

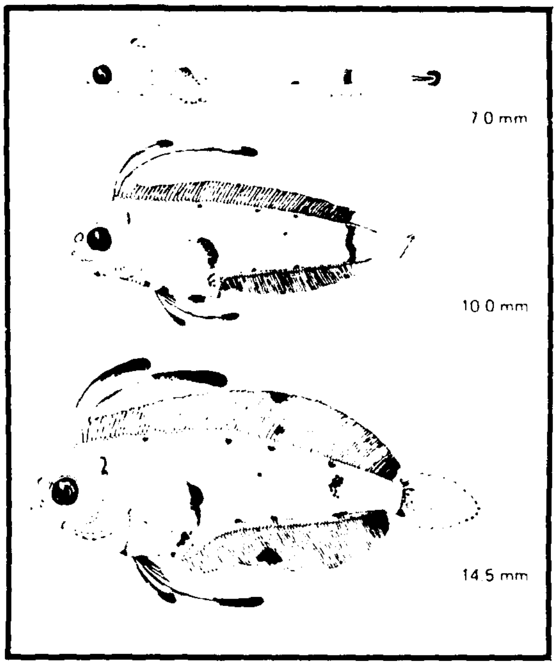

Figure 5. Larval development of the Pacific sanddab (Ahlstrom and Moser 1975).

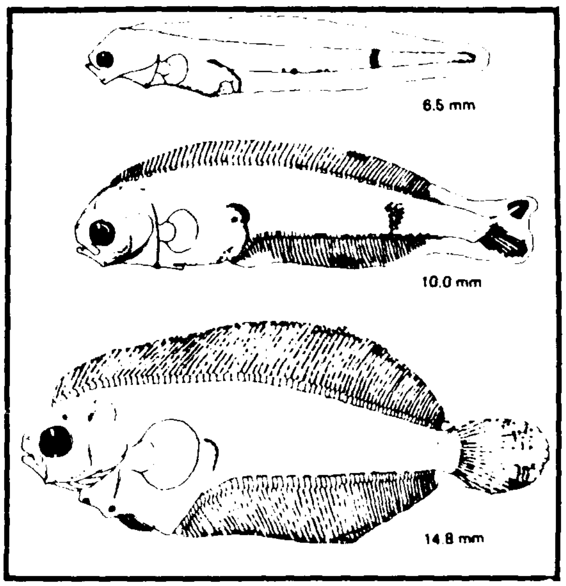

Figure 6. Larval development of the speckled sanddab (Ahlstrom and Moser 1975).

Larval Pacific sanddabs have groupings of melanophores along the dorsal, anal, caudal, and eyed-side pectoral fins, whereas speckled sanddab larvae lack melanin (Chamberlain 1979; Porter 1964). Pacific sanddabs lose much of the melanin during the late juvenile and early adult development stages, but this characteristic is useful in differentiating the juveniles of the two species. At about 28 mm standard length (SL), myotomes take on a W-shaped appearance. Pigmentation on the eyed side of Pacific sanddabs becomes more pronounced during growth from 110 to 120 mm SL.

Location of capture is important to the identification of sanddab larvae because of the differences in their distribution (Ahlstrom and Moser 1975). The geographic distributions of larval speckled and Pacific sanddabs overlap each other and also those of larval C. fragilis (gulf sanddab), and C. xanthostigma (longfin sanddab) in the southern portion of their range (Baja to southern California). Location of capture may often help to differentiate gulf and longfin sanddabs gathered from trawls north of their range.

Pelagic speckled sanddab larvae have been collected from close inshore to 320 km offshore (Berry and Perkins 1966); and pelagic larvae of Pacific sanddabs from close inshore (Berry and Perkins 1966) to 724 km offshore (Ahlstrom 1965). Juvenile Citharichthys usually inhabit the entire bathymetric range of the species, and may prefer the same substrate types as the adults (Chamberlain 1979). Ahlstrom (1959) reported sanddab larvae distributed between the surface and 88 m in depth. During spring, summer, and fall transformation and settling, speckled sanddabs of 25 to 75 mm TL were most abundant at depths of 15 to 25 m on the intercanyon shelf (Ford 1965). Larvae and juveniles move relatively short distances in search of prey, cover from predators, and more suitable temperature (Ahlstrom and Moser 1975; Chamberlain 1979; Ford 1965); in addition larvae are carried long distances by ocean currents.

Larvae of the four species of Citharichthys composed 87% of all flatfish larvae sampled during the California Cooperative Oceanic Fisheries Investigations (CALCOFI) between 1955 and 1960 (Ahlstrom and Moser 1975; Ahlstrom 1969). Eggs and larvae are planktonic, occurring along the entire CALCOFI sampling area, and were collected in large numbers from June to August. Loeb et al. (1983) reported that larval flatfish abundance peaked from October through November, primarily because large numbers of Pacific and speckled sanddabs were found in all nearshore regions.

GROWTH CHARACTERISTICS

Growth in sanddabs has been shown to be regulated by numerous factors: prey availability, population density, environmental temperature, salinity, and suitable habitat (Chamberlain 1979; Ford 1965; Ehrlich et al. 1979; Hulberg and Oliver 1978).

Most age and growth studies conducted on Pacific and speckled sanddabs have been based on the scale method of age determination. Females of both species grow faster and attain larger sizes than males (Chamberlain 1979; Ford 1965; Villadolid 1927). In the Pacific sanddab, the growth rate is faster and the life span (8-10 years) is longer than in the speckled sanddab (3-4 years) (Arora 1951; Ford 1965).

Pacific sanddabs grow rapidly from July to November (Arora 1951). Average total lengths of Pacific sanddabs at ages I to IV (males and females combined) are 95, 148, 192, and 226 mm. Corresponding average weights are 6.6, 27.8, 69.3, and 116.5 g (Arora 1951). Throughout development, weight increased at a rate slightly higher than the cube of the length (Arora 1951). After the fourth year, females grew faster than males; at the end of the seventh year, males averaged 246 mm, and females, 274 mm TL (Arora 1951). Villadolid (1927) reported similar growth rates for Pacific sanddabs collected off San Francisco and Monterey.

Arora (1951) determined the age composition and length-weight relation for Pacific sanddabs from 150 fish collected near the Farallon Islands, off the northern California coast; and Chamberlain (1979) collected length and weight data for this species in trawl surveys off southern California.

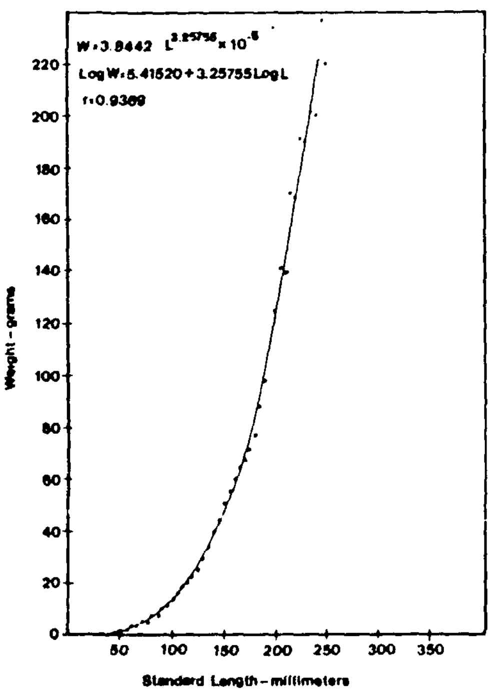

Figure 7. Length-weight relationship with fitted curve for Pacific sanddab (Chamberlain 1979).

Arora's (1951) length-weight equation ($\log W = 5.59 + 3.26 \log L$) was similar to Chamberlain's equation (Figure 7). The two equations have different Y intercept values, however, because Arora used total length measurements and Chamberlain measured standard length. Both researchers determined that standard length increases 84 mm for every 100-mm increase in total length.

Ford (1965) examined 50 speckled sanddabs, 50-148 mm TL, to estimate length-at-age. Growth rates are typical of most fish; there is a very rapid increase in length during the first year (Ford 1965). Seasonal variation in growth is similar to that in Pacific sanddabs: most rapid growth is during summer and early fall. At the end of the first year, speckled sanddabs attain 55%-60% of the median total length and 13%-18% of the median weight attained at the end of the third year (Ford 1965). Total length ranges (millimeters) for groups 0-III were 25-75, 76-105, 106-120, and 121-150. Estimated mean total lengths at the end of the first, second, and third year were 66.5, 93.8, and 111.0 mm for males and 69.0, 99.6, and 126.6 mm for females (Ford 1965). Growth rate decreased at a median total length of 70 mm. Differences between the sexes in total length and median dry weight near the end of the third year of life were about 16 mm and 1.9 g for speckled sanddabs (Ford 1965).

Ford (1965) used total length measurements in relating dry and wet weight to length in speckled sanddabs: $\log_{10}$ Dry Wt(g)= -6.2753 + 3.2953 $\log_{10}$ TL; and $\log_{10}$ Wet Wt(g)= -5.5750 + 3.2953 $\log_{10}$ TL. These equations are similar to the length-weight relation developed by Chamberlain (1979)(Figure 8). Once again, the method of measurement is responsible for the differences in coefficients.

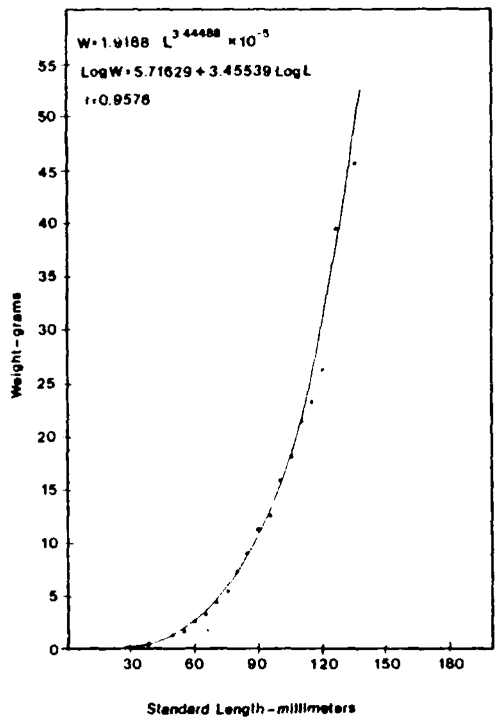

Figure 8. Length-weight relationship with fitted curve for speckled sanddab (Chamberlain 1979).

MIGRATION AND MOVEMENT OF ADULTS

Adult Citharichthys are not highly migratory (Chamberlain 1979). Movement of adult sanddabs is influenced by prey availability (Hulberg and Oliver 1978; Cailliet et al. 1978), seasonal temperature fluctuations (Ehrlich et al. 1979; Stephens et al. 1973; Ford 1965), and substrate type (Feder et al. 1974; Ambrose 1976).

Population densities and age composition of speckled sanddabs on the intercanyon shelf, off La Jolla, CA, were relatively stable, reflecting the constancy of the bathymetric distribution and abundance over a sampling period averaging 30 days. Distribution was not greatly affected by short-term, diel variations in environmental conditions (Ford 1965).

The abundance of speckled sanddabs peaked in King Harbor, Redondo Beach, CA, from winter through early summer, when bottom temperatures were low (Ehrlich et al. 1979). After summer and fall breakdown of thermal stratification, the numbers of speckled sanddabs decreased in King and Los Angeles Harbors (Ehrlich et al. 1979; Stephens et al. 1973).

Water temperature fluctuations, pollution, and human interference increase stress on inner harbor sanddab populations by causing increased rates of infection, parasitism, and higher mortality (Ehrlich et al. 1979; Stephens et al. 1973). Due to the instability of inner harbor environments which may force fish to move seaward into other waters, the occurrence of subpopulations of sanddabs in inner harbor waters is unlikely (Ehrlich et al. 1979; Chamberlain 1979; Stephens et al. 1973 ; Taylor 1957).

ECOLOGICAL ROLE

Food and Feeding

Larval Citharichthys have been described as planktonic by several authors (Ahlstrom and Moser 1975; Fitch and Lavenberg 1971). Postlarvae eat zooplankton and adults eat a wide variety of small pelagic fish, cephalopods, crustaceans, and marine worms (Hogue and Carey 1982; Hulberg and Oliver 1978; Ambrose 1976; Fitch and Lavenberg 1971; Ford 1965).

Marine fish larvae feed on many kinds of organisms but copepod nauplii appear to predominate in their diets (Houde and Taniguchi 1979). Larval survival and growth rate and the length of the larval period depend on concentrations of food organisms, but during the larval period marine fish are also most vulnerable to predation (Houde and Schekter 1980).

Morphological adaptations such as long symmetrical jaws, sharp teeth, and long serrated gill rakers allow sanddabs to grasp and hold animals while swimming in midwater (Pearcy and Hancock 1978; Alexander 1974). Significantly greater stomach fullness in Pacific sanddabs collected at dawn in trawl samples (versus samples collected from trawls at other times) suggests that the fish are nocturnal feeders (Hopkins and Hancock 1980).

Young and Mearns (1980), in work on the flow of pollutants through the marine food web, assigned sanddabs to primary and secondary carnivore trophic positions. Hulberg and Oliver (1978) showed that euphausid and mysid crustaceans accounted for most of the number and volume of crustaceans eaten by adult Pacific sanddabs of 85 to 211 mm SL. The polychaetes eaten by sanddabs were almost exclusively species that feed at the sediment surface (e.g., Nothria elegans, Amaeana occidentalis, and Magelona sacculata). Tentacles of A. occidentalis were eaten more frequently than the entire animal. Juvenile rockfishes (Sebastes spp.) and razor clams (Siliqua spp.) were also found in stomachs of Pacific sanddabs. Habits of the prey suggest Pacific sanddabs are opportunistic feeders and poor diggers (Hulberg and Oliver 1978).

Cross et al. (1985) reported that the proportion of crustaceans decreased and the proportion of polychaetes increased in the Pacific sanddab diet, along an increasing pollution gradient of municipal wastewater on the mainland shelf near Los Angeles, CA. In the same study, speckled sanddabs fed primarily on benthic, epibenthic, and nektonic crustaceans.

Juvenile speckled sanddabs, shorter than 75 mm, fed on copepods, amphipods, cumaceans and mysids; adults (76 mm and larger) relied less on these forms and seemed to concentrate on the larger decapods, mollusks, and small fish (Ford 1965). Speckled sanddab prey consisted primarily of crustaceans (61%); the major taxa, in order of importance, were Amphipoda, Decapoda, Mysidacea, Cumacea, Copepoda, and Isopoda (Ford 1965). In concurrence, Ambrose (1976) found amphipod and mysid crustaceans to be the most important prey for speckled sanddabs at seaward stations of Elkhorn Slough, CA. When speckled sanddabs fed at inner slough stations they ate polychaetes, bivalve siphons, decapods, and (to a lesser extent) fish.

Speckled sanddabs had the second highest mean trophic diversity among all species sampled (0.51, on a scale of 0-1), at stations where it occurred (Ambrose 1976). Speckled sanddabs were generalized feeders at seaward of Elkhorn Slough, and much more specialized feeders at inner slough stations where they fed on one species of mysid, Acanthomysis davisii (Cailliet 1977; Ambrose 1976). Speckled sanddabs rely on sight for feeding and pick food cleanly from the bottom, without much extraneous material (Ford 1965). These fish take advantage of normally unavailable infauna dislodged from sand by the digging rays Urolophus halleri and Myliobatis californica. Since speckled sanddabs reach densities of up to $1/m^2$ over sand, they may increase the mortality rates of infaunal prey disturbed by digging rays (VanBlaricom 1982). Poor visibility and substrate type at some inner slough stations may have affected speckled sanddab feeding habits (Ambrose 1976). Food types at inner slough areas did not appear to be a limiting factor (Ambrose 1976).

Species Association

In southern California, Pacific sanddabs are found in associations with Dover sole, Microstomus *pacificus*, plainfin midshipman, *Porichthys notatus*, pink seaperch, *Zalembius rosaceus*, and shortspine combfish, *Zaniolepis frenata* (Chamberlain 1979; Stephens et al. 1973).

Larval Pacific sanddabs are preyed on by albacore (*Thunnus alalunga*), salmon (*Oncorhynchus* spp.), chub mackerel (*Scomber japonicus*), and invertebrates such as medusae and ctenophores (Fitch and Lavenberg 1971)

In southern California, speckled sanddabs are found in associations in shallow water with California tonguefish, *Symphurus atricauda*; hornyhead turbot, *Pleuronichthys verticalis*; and English sole, *Parophrys vetulus* (Chamberlain 1979; Stephens et al. 1973; Ford 1965).

Juveniles and adults of both species are preyed on by larger fish such as the California halibut, *Paralichthys californicus* (Ford 1965).

ENVIRONMENTAL REQUIREMENTS

Substrate

Both species of sanddabs reviewed here have similar preferences for sandy bottom areas along the California coast (Hulberg and Oliver 1978; Hart 1973; Ambrose 1976; Cailliet et al. 1978; Ford 1965). Chamberlain (1979) collected sanddab specimens from fine sand and sandy-mud containing broken shell material. Feder et al. (1974) reported Pacific sanddabs to be dominant in deep sand or sandy-mud areas. Speckled sanddabs prefer irregularities and foreign objects in their habitat, resulting in their higher densities around rock pilings, pier pilings, and canyons (Feder et al. 1974; Ford 1965). Ford (1965) determined that speckled sanddabs tolerated sediments having a wide range of grain sizes and that grain size had no effect on the quantity of suitable food organisms available to speckled sanddabs. Ambrose (1976) reported substrate and turbidity to be the most likely factors limiting the movement of speckled sanddabs in Elkhorn Slough.

Temperature

Ehrlich et al. (1979) estimated a temperature range of 8-13 °C for efficient growth, in a laboratory study of speckled sanddabs from King Harbor. Although only limited information is available on the effects of temperature on sanddab physiology , it is generally expected that temperature affects oocyte maturation, time of spawning, larval development, adult and larval movement into different habitats, food availability, and growth rate.

Densities of juvenile and adult speckled sanddabs were higher at depths greater than 15 m, where temperatures were lower and relatively stable, than at depths less than 15 m. Speckled sanddabs seemed to favor a temperature range of 10.0 to 20.5 °C, over a depth range extending to 45 m (Ford 1965).

Vegetation

Information concerning the specific vegetation requirements for sanddabs was not found in the literature. Larvae, postlarvae, and young juvenile sanddabs may increase survival by inhabiting vegetated areas where protection from predators is available and prey organisms are more highly concentrated as compared with open areas.

Salinity

Chamberlain (1979) estimated the specific gravity of fresh eggs of speckled sanddabs to be demersal at 1.025. As the salinity increases to 1.045, sanddab eggs become planktonic. Eggs of both species hatch in salt water. Salinity requirements for juveniles and adults were not found in the literature.

Dissolved Oxygen

Explicit physiological requirements for dissolved oxygen were not found in the literature.

Contaminants

Livers of Pacific sanddabs collected near sewage outfalls had higher levels of DDTs, PCBs, PCB metabolites, copper, and zinc than did a control site. Concentrations of DDT metabolites and cadmium were sometimes higher at the control site, but that site may be exposed to some contamination. Gonads of Pacific sanddabs had higher concentrations of DDT, PCBs, and zinc near the sewage outfalls relative to the control site; there was not a similar trend for copper and cadmium (Brown et al. 1986).

COMMERCIAL AND RECREATIONAL IMPORTANCE

Commercial Fishery

The two species of Citharichthys discussed here are taken incidentally with other bottom fish in commercial fisheries (Frey 1971). The Pacific sanddab ranked second in abundance among fish species collected in trawl surveys conducted from 1969-1972 by the Southern California Coastal Water Research Project (1973). During trawl surveys conducted on Santa Monica Bay over a 6 year period, Carlisle (1969) found speckled sanddabs to be the most abundant species sampled.

Because of their small size, speckled sanddabs are usually discarded at sea or ground up for use in fish meal. In the Los Angeles area, speckled sanddabs obtained from a commercial hook-and-line fishery, were sold in local markets until the late 1940's (Anon. 1949).

Most Pacific sanddabs are harvested commercially by bottom

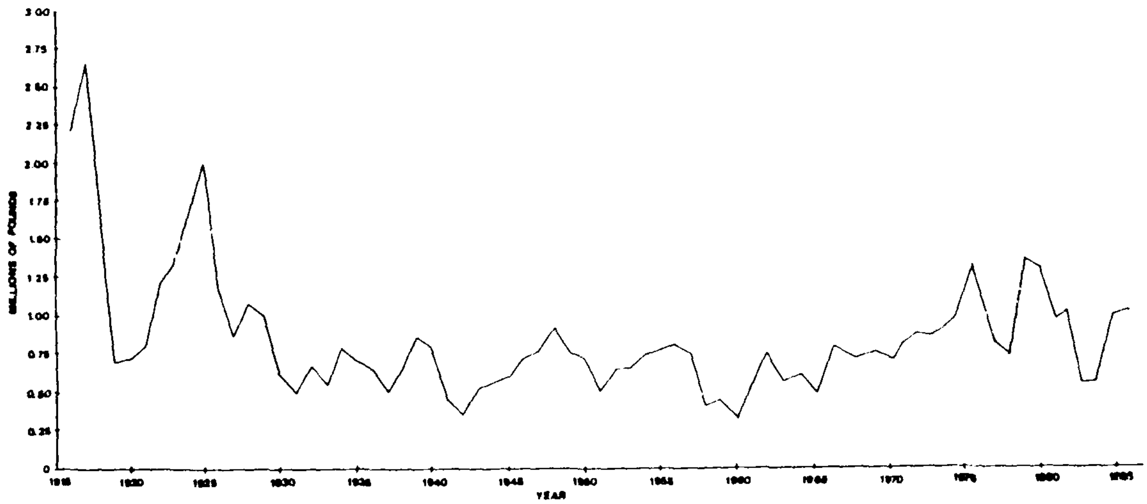

Figure 9. Commercial landings of sanddabs, 1915 - 1986 (Frey 1971: Joyce Underhill, California Department of Fish and Game, Long Beach, CA: pers. comm.).

fishermen using otter trawls (Fitch and Lavenberg 1971). The commercial Pacific sanddab catch is landed almost entirely from the ports of Eureka, San Francisco, and Monterey (Fitch and Lavenberg 1971; Anon. 1949). Before 1938, San Francisco landings amounted to more than 95% of the total commercial catch. Highest landings to date were in 1917 when more than 2 million pounds were taken (Anon. 1949). Landings then declined (Figure 9), rose to 2 million pounds in 1925, and averaged about 500,000 pounds from 1930-1970 (Arora 1951, Anon. 1949). Commercial landings from 1970-1986, averaged over 900,000 pounds (Figure 9), indicating an increased demand for this species (Joyce Underhill, California Department of Fish and Game, Long Beach, CA; pers. comm.). Price quotations from the Fisherman's Marketing Association in April 1987, indicated that commercial fish buyers were paying $0.37 per pound for Pacific sanddabs.

Sport Fishery

Sanddabs are caught by sport fishermen with hook-and-line. Wire in the form of a hoop, around which several hooks are fastened, is baited with squid, fish, shrimp, or clams and lowered to a point close to the bottom (Fitch and Lavenberg 1971). Sandy bottom areas with consistently good fishing include the horseshoe kelp area west of Los Angeles Harbor and areas offshore from La Jolla, Newport Beach, Avalon, San Pedro, Malibu, Goleta, Pismo Beach, Pacific Grove, Moss Landing, and Capitola (Chamberlain 1979; Fitch and Lavenberg 1971). Fitch and Lavenberg (1975) noted that speckled sanddabs make interesting additions to aquaria.

LITERATURE CITED

Ahlstrom, E.H. 1959. Vertical distribution of pelagic fish eggs and larvae off California and Baja California. U.S. Fish Wildl. Serv. Fish. Bull. 60:107-146.

Ahlstrom, E.H. 1965. Kinds and abundances of fishes in the California current region based on egg and larval surveys. Calif. Coop. Oceanic Fish. Invest. Rep. 10:31-52.

Ahlstrom, E.H. 1969. Mesopelagic and bathypelagic fishes in the California current region. Calif. Coop. Oceanic Fish. Invest. Rep. 13:39-44.

Ahlstrom, E.H., and H.G. Moser. 1975. Distributional atlas of fish larvae in the California Current region: flatfishes, 1955 through 1960. Calif. Coop. Oceanic Fish. Invest. Rep. Atlas No. 23. 207 pp.

Ahlstrom, E.H., K. Amaoka, D.A. Hensley, H.G. Moser, and B.Y. Sumida. 1984. Pleuronectiformes: Development. Pages 640-670 in H.G. Moser, W.J. Richards, D.M. Cohen, M. P. Fahay, A.W. Kendall, Jr., and S. L. Richardson, eds. Ontogeny and systematics of fishes. American Association of Ichthyologists and Herpetologists Special Publication 1. 760 pp.

Alexander, R.M. 1974. Functional design in fishes. The Anchor Press, Tiptree Essex. 160 pp.

Ambrose, D.A. 1976. The distribution, abundance, and feeding ecology of four species of flatfish in the vicinity of Elkhorn Slough, California. M.S. Thesis, San Jose State University. 121 pp.

Anonymous. 1949. The commercial fish catch of California for the year 1947 with a historical review 1916-1947. Calif. Dep. Fish Game. Fish. Bull. No. 80. 87 pp.

Arora, H.L. 1951. An investigation of the California sand dab, Citharichthys sordidus (Girard). Calif. Fish Game 37:3-42.

Bane, G.W., and A.W. Bane. 1971. Pages 124-126 in Bay fishes of Northern California. Mariscos Publications, Southampton and New York.

Batts, B.S. 1964. Lepidology of adult pleuronectiform fishes of Puget Sound, Washington. Copeia 1964 (4):666-673.

Berry, F.H., and H.C. Perkins. 1966. Survey of pelagic fishes of the California current area. U.S. Fish Wild. Serv. Fish. Bull. 65:625-682.

Brown, D.A., R.W. Gossett, G.P. Hershelman, C.F. Ward, A.M. Westcott, and J.N. Cross. 1986. Municipal wastewater contamination in Southern California, U.S.A., Bight. Part I. Metal and organic contaminants in sediments and organisms. Mar. Environ. Res. 18:291-310.

Cailliet, G. M. 1977. Several approaches to the feeding ecology of fishes. Pages 1-13 in C.A. Simenstad and S.J. Lipovsky, eds. Gutshop '76 fish food habits studies. Proc. First Pac. Northwest Tech. Workshop, October 13-15, 1976. University of Washington Press, Seattle.

Cailliet, G., B.S. Antrim, and D.S. Ambrose. 1978. Trophic spectrum analysis of fishes in Elkhorn Slough and nearby waters. Pages 118-128 in C.A. Simenstad and S.J. Lipovsky, eds. Gutshop '78 fish food habits studies. Proc. Second Pac. Northwest Tech. Workshop, October 10-13, 1978, University of Washington Press, Seattle.

Carlisle, J.G., Jr. 1969. Results of a six year trawl study in an area of heavy waste discharge: Santa Monica Bay, California. Calif. Fish Game 55:26-46.

Chamberlain, D.W. 1979. Histology of the reproductive systems and comparison of selected morphological characters in four Eastern Pacific species of Citharichthys (Pisces: Bothidae). Ph.D. Dissertation. University of Southern California, Los Angeles, CA. 297 pp.

Cross, N.J., J. Roney, and G.S. Kleppel. 1985. Fish food habits along a pollution gradient. Calif. Fish Game 71:28-39.

Ehrlich, K.F., J.S. Stephens, G. Muszynski, and J.M. Hood. 1979. Thermal behavior of the speckled sanddab, Citharichthys stigmaeus: laboratory and field investigations. U.S. Natl. Mar. Fish. Serv. Fish. Bull. 76(4):867-872.

Eschmeyer, W.N., E.S. Herald, and H. Hammann. 1983. Lefteye Flounders: Family Bothidae. Pages 283-286 in R.G. Peterson, ed. The Peterson field guide series: a field guide to the Pacific coast fishes of North America from the Gulf of Alaska to Baja California. Houghton Mifflin Co., Boston. 336 pp.

Feder, H.M., C.H. Turner, and C. Limbaugh. 1974. Observations on fishes associated with kelp beds in Southern California. Calif. Dep. Fish Game, Fish Bull. 160. 144 pp.

Fitch, J.E., and R.J. Lavenberg. 1971. Pages 41-43 in Marine food and game fishes of California. University of California Press, Berkeley.

Fitch, J.E., and R.J. Lavenberg. 1975. Pages 32-34 in Tidepool and nearshore fishes of California. University of California Press, Berkeley.

Ford, R.R. 1965. Distribution, population dynamics and behavior of a bothid flatfish, Citharichthys stigmaeus. Ph.D. Dissertation. University of California, San Diego. 243 pp.

Frey, H.W. (ed). 1971. California living marine resources and their utilization. California Department of Fish and Game. 148 pp.

Hart, J.L. 1973. Pages 596-599 in Pacific fishes of Canada. Fish. Res. Board Canada. Bull. 180.

Hopkins, J.A., and M.K. Hancock. 1980. Diel feeding pattern and prey of the Pacific sanddab, Citharichthys sordidus. Am. Zool. 20(4):950.

Hogue, E.W., and A.G. Carey, Jr. 1982. Feeding ecology of 0-age flatfishes at a nursery ground on the Oregon coast. U.S. Natl. Mar. Fish Serv. Fish. Bull. 80(3): 555-565.

Houde, E.D., and R.C. Schekter. 1980. Feeding by marine fish larvae: development and functional responses. Environ. Biol. Fishes 5:315-334.

Houde, E.D., and A.K. Taniguchi. 1979. Laboratory culture of marine fish larvae and their role in marine environmental research. Pages 176-205 in F.S. Jacoff, ed. Advances in marine environmental research. Proc. of a symp., Environ. Res. Lab., U.S. Environmental Protection Agency, Narrangansett, R.I. Rep. No. EPA-600/9-79-035.

Hulberg, L.W., and J.S. Oliver. 1978. Prey availability and the diets of two co-occurring flatfish. Pages 29-36 in C.A. Simenstad and S.J. Lipovsky, eds. Gutshop '78 fish food habits studies. Proc. Second Pac. Northwest Tech. Workshop, October 10-13, 1978. University of Washington Press, Seattle.

Loeb, V.J., P.E. Smith, and H.G. Moser. 1983. Geographical and seasonal patterns of larval fish species structure in the California current area, 1975. Calif. Coop. Oceanic Fish. Invest. Rep. 24: 132-151.

Miller, D.J., and R.N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dep. Fish Game. Fish Bull. 157. 235 pp.

Pearcy, W.G., and D. Hancock. 1978. Feeding habits of Dover sole, Microstomus pacificus; rex sole, Glyptocephalus zachirus; slender sole, Lyopsetta exilis; and Pacific sanddab, Citharichthys sordidus, in a region of diverse sediments and bathymetry off Oregon. U.S. Natl. Mar. Fish. Serv. Fish. Bull. 76(3):641-651.

Porter, P.E. 1964. Notes on fecundity, spawning and early life history of Petrale sole (Eopsetta jordani), with descriptions of flatfish larvae collected in the Pacific Ocean off Humboldt Bay, California. M.S. Thesis. Humboldt State College. 124 pp.

Roedel, P.M. 1948. Common marine fishes of California. Calif. Fish Game Bull. No. 68. 150 pp.

Roedel, P.M. 1953. Common ocean fishes of the California Coast. Calif. Fish Game Bull. No. 91. 184 pp.

Southern California Coastal Water Research Project. 1973. The ecology of the Southern California Bight: implications for water quality management. Three-year report of the SCCWRP. 531 pp.

Stephens, J.S., Jr., D. Gardiner, and C. Terry. 1973. The demersal fish populations of San Pedro Bay. Pages 147-166 in D.F. Soule and M. Oguri, eds. Marine Studies of San Pedro Bay, California. Part II, Biological Investigations. Allan Hancock Foundation and University of Southern Calif., Los Angeles.

Taylor, F.H.C. 1957. Variations and populations of four species of Pacific Coast flatfish. Ph.D. Dissertation. University of California, Los Angeles. 351 pp.

Townsend, L.D. 1935. Notes on Citharichthys sordidus and C. stigmaeus with an extension of range. Copeia 1935 (4):193.

VanBlaricom, G.R. 1982. Experimental analyses of structural regulation in a marine sand community exposed to oceanic swell. Ecol. Monogr. 52:283-306.

Villadolid, D.V. 1927. The flatfishes (Heterosomata) of the

Pacific Coast of the United States. Ph.D. Dissertation. Stanford University, 332 pp.

Wang, Johnson C.S. 1981. Taxonomy of the early life stages of fishes -- fishes of the Sacramento-San Joaquin Estuary and Moss Landing Harbor - Elkhorn Slough, California. Ecological Analysts, Inc., Concord, CA. 168 pp.

Wilimovsky, N.J. 1954. List of the fishes of Alaska. Stanford Ichthyol. Bull. 4:279-294.

Young, D.R., and A.J. Mearns. 1980. Pollutant flow through the marine food web; progress report to the Chemical Threats to Man and the Environment Program, National Science Foundation, Washington, DC. Nat. Tech. Info. Serv., PB82-158502, Springfield, VA. 131 pp.

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7. Author(s)
Joseph P. Rackowski[1] and Ellen K. Pikitch[2]

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

[1]Department of Fisheries and Wildlife
Oregon State University
Hatfield Marine Science Center
Newport, Oregon 97365

[2]Fisheries Research Institute
School of Fisheries
University of Washington
Seattle, WA 98195

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16. Abstract (Limit: 200 words)

Species profiles are literature summaries of taxonomy, morphology, range, growth characteristics, ecology, life history, and commercial importance of coastal species. Pacific sanddab, Citharichthys sordidus, and speckled sanddab, Citharichthys stigmaeus, are common along the California coast from the intertidal zone to depths of 306 m. Pacific sanddabs spawn from July to September and speckled sanddabs, from April to September. Eggs and larvae are common throughout the range of the species. Average life span is 8-10 years in Pacific sanddabs and 3-4 years in speckled sanddabs. Females of both species live longer than males. Female Pacific sanddabs attain sexual maturity at age 3 and female speckled sanddabs, at age 2. Postlarvae feed on zooplankton; adults eat a variety of crustaceans and fish. Both species prefer sandy bottoms. The speckled sanddab was the most abundant species caught in trawl surveys off southern California. Commercial catch statistics lump both species under sanddabs. Average annual landings, 1930-70, were 500,000 pounds and from 1971-86, landings rose to 900,000 pounds. Commercial fish buyers paid $0.37 per pound for sanddabs in April, 1987.

17. Document Analysis a. Descriptors

Fishes
Flatfishes
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Growth
Life cycles
Salinity
Temperature

b. Identifiers/Open-Ended Terms

Pacific sanddab
Citharichthys sordidus
Life history spawning
Ecology
Speckled sanddab
Citharichthys stigmaeus
Commercial and recreational importance
Habitat requirements

c. COSATI Field/Group

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