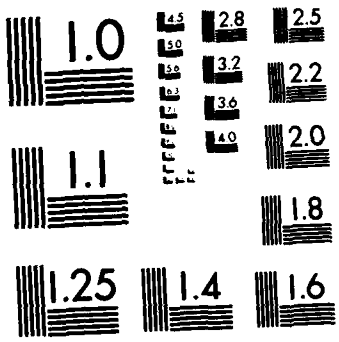
AD-A172 724 SPECIES PROFILES LIFE HISTORIES AND ENVIRONMENTAL 1/1
REQUIREMENTS OF COASTAL (U) CALIFORNIA COOPERATIVE
FISHERY RESEARCH UNIT ARCATA CA APR 86 FWS-82-11 50

UNCLASSIFIED F/G 8/1 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

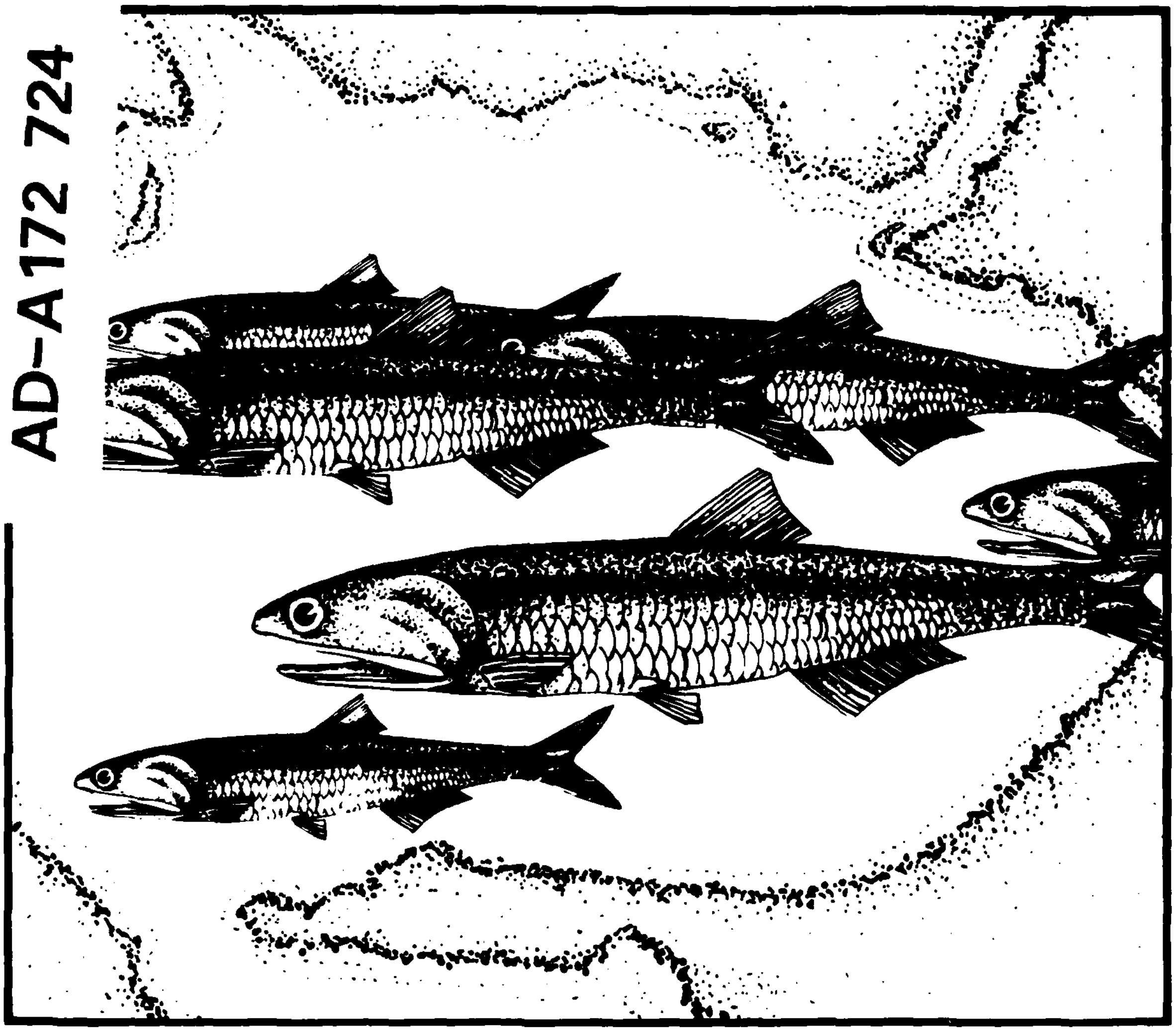
(12)

Biological Report 82(11.50)
April 1986

TR EL-82-4

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

NORTHERN ANCHOVY



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

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

Biological Report 82(11.50)
TR EL-82-4
April 1986

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

NORTHERN ANCHOVY

by

Stephen T. Kucas, Jr.
California Cooperative Fishery Research Unit
Humboldt State University
Arcata, CA 95521

Project Officer
John Parsons
National Coastal Ecosystems Team
U.S. Fish and Wildlife Service
1010 Gause Boulevard
Slidell, LA 70458

Performed for

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

and

National Coastal Ecosystems Team
Division of Biological Services
Research and Development
Fish and Wildlife Service
U.S. Department of the Interior
Washington, DC 20240

This series should be referenced as follows:

U.S. Fish and Wildlife Service. 1983-19__. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates. U.S. Fish Wildl. Serv. Biol. Rep. 82(11). U.S. Army Corps of Engineers, TR EL-82-4.

This profile should be cited as follows:

Kucas, S.T., Jr. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest)--northern anchovy. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.50). U.S. Army Corps of Engineers, TR EL-82-4. 11 pp.

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 planners, managers, engineers, and biologists with a brief sketch of the biological characteristics and environmental requirements of the species and to describe how populations 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:

Information Transfer Specialist
National Coastal Ecosystems Team
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 TABLE

Metric to U.S. Customary

Multiply	By	To Obtain
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
kilometers (km)	0.6214	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	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	1.8(°C) + 32	Fahrenheit degrees

U.S. Customary to Metric

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

CONTENTS

ACKNOWLEDGMENTS

Thanks to Rick Klingbeil, Joseph Lesh, and Jerry Spratt (California Department of Fish and Game) for reviewing the manuscript and to Thomas Hassler (California Cooperative Fishery Research Unit) for assisting in its preparation.

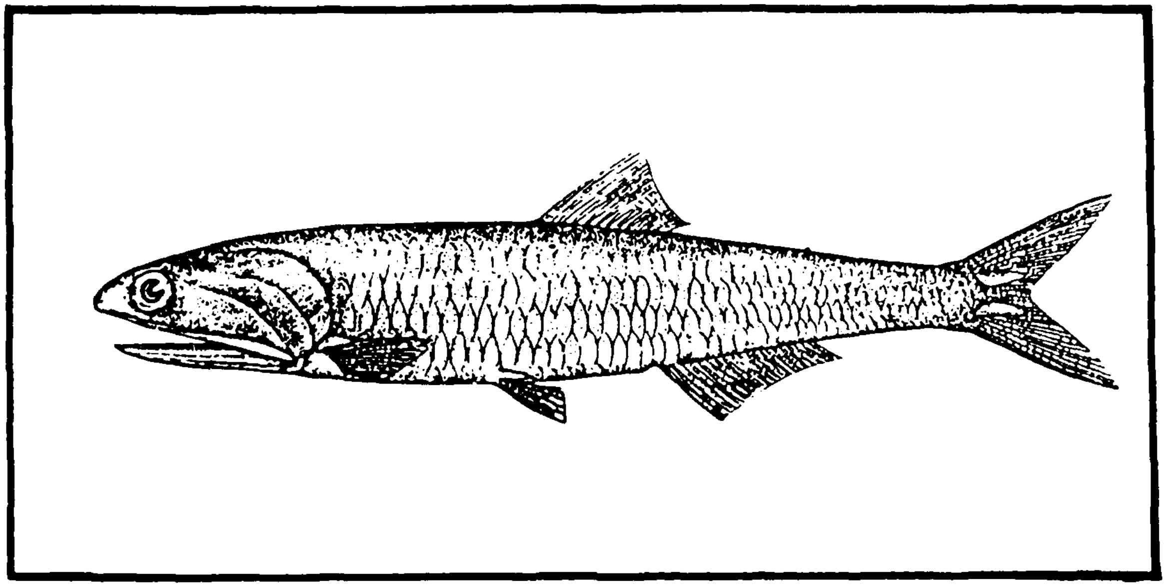


Figure 1. Northern anchovy.

NORTHERN ANCHOVY

NOMENCLATURE/TAXONOMY/RANGE

Scientific name . . . . . . *Engraulis mordax* (Girard)
Preferred common name . . . . Northern anchovy (Figure 1)
Other common names . . . . . Pinhead (applied to small fish)
Class . . . . Osteichthyes
Order . . . . Clupeiformes
Family. . . . . Engraulidae

Geographic range: Queen Charlotte Islands, British Columbia, south to Cape San Lucas, Baja California; center of abundance extends from Magdalena Bay, Mexico, to San Francisco, California (Ahlstrom 1966). Three populations are recognized: one from British Columbia to northern California, a second off southern California and the northern Baja California peninsula in Mexico, and a third off central and southern Baja California (Figure 2). Although the ranges of these populations overlap somewhat, each is genetically distinct (Vrooman and Smith 1971).

MORPHOLOGY/IDENTIFICATION AIDS[1]

Fin rays: dorsal 14-19, anal 19-26, pectoral 13-20; midlateral scales 41-50; gill rakers 28-41 and 37-45 on lower arch (number increases with size); gill rakers much longer than eye; pelvic fins abdominal; vertebrae 43-47. Body is long and slightly compressed. Head is anteriorly compressed and nearly twice as long as it is deep; snout protrudes and is pointed with large eye near the

[1]Largely extracted from Jordan and Evermann (1908) and Miller and Lea (1972).

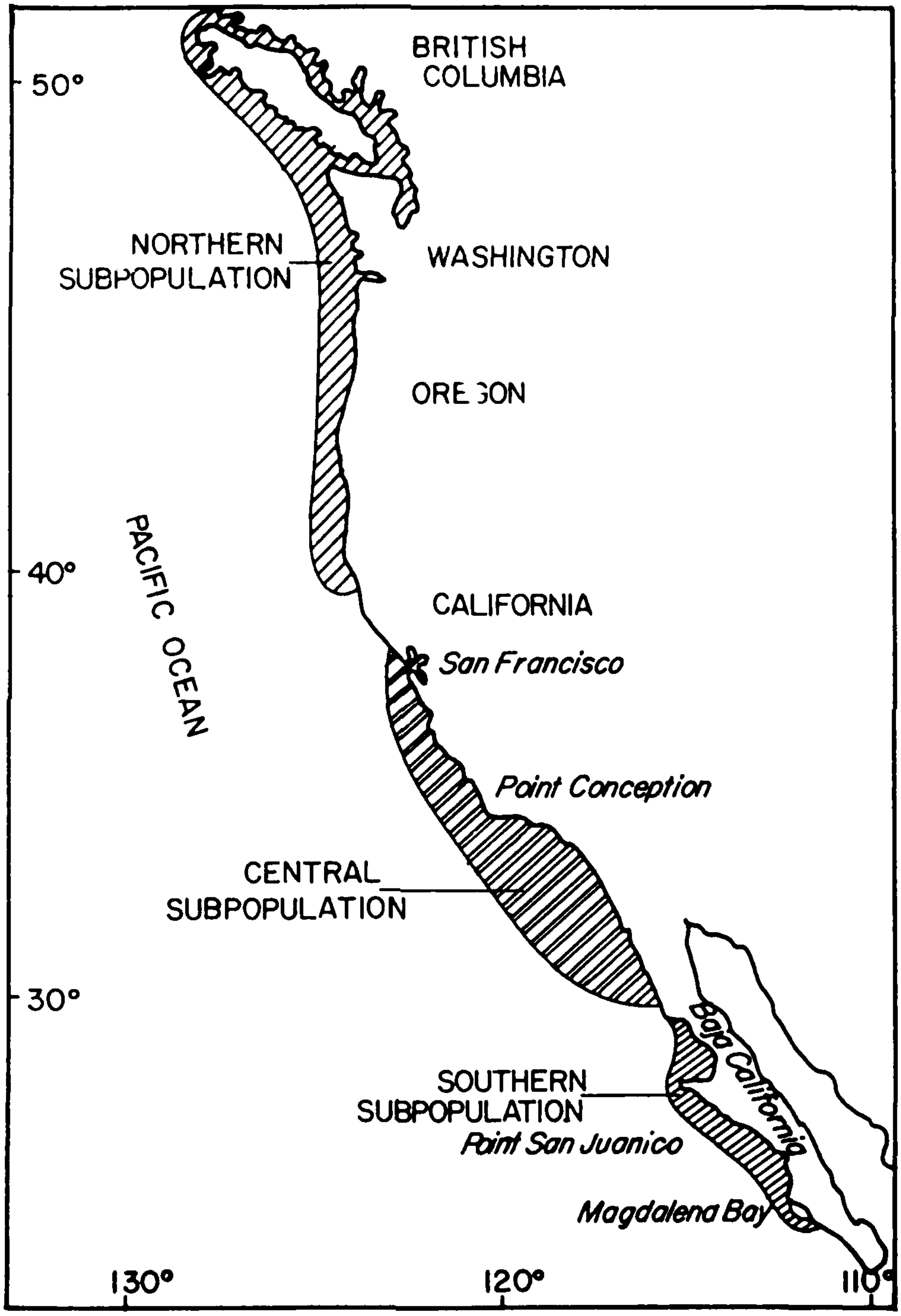


Figure 2. Distribution of northern anchovy (from Pacific Fishery Management Council 1978).

tip; gill openings extend under jaw into throat; mouth is subterminal with small teeth; maxillary extends beyond root of mandible; opercle is placed obliquely and deeper than it is long. Color in life: bluish above, silver on side and below; it is not translucent and has no silvery lateral band.

REASON FOR INCLUSION IN SERIES

The northern anchovy is abundant in the California Current and is ecologically and economically important in the coastal waters of southern California (Soule and Oguri 1972-1976; Mais 1974). Though it supports a sometimes thriving industrial fishery and a lucrative live-bait fishery, both yield much less profit than anchovy fisheries in other parts of the world (Baxter 1967). A sharp increase in the biomass of the northern anchovy off California in recent decades and a later decline in landings in the late 1970's have led to an intensive attempt by fishery agencies in California and Mexico to understand the biology and population dynamics of this species.

LIFE HISTORY

Spawning

Biological information about the northern anchovy was summarized by Baxter (1967). He reported that anchovy spawning, although recorded from British Columbia to a point below Magdalena Bay, Baja California, is heaviest between Point Conception, California, and Point San Juanico, Baja California. In waters north of Point Conception, spawning success has varied widely. Two major spawning areas are south of Point Conception. One is off southern California and northern Baja California, and the other is off central and southern Baja California (Ahlstrom 1956).

In the winter, anchovies usually move to deeper water offshore, and in the spring they return to inshore shallow waters. Spawning is mostly within 60 mi of the coast, although it has been recorded up to 300 mi offshore. Anchovies stay near the bottom in the daytime and come to the surface at night. They spawn mostly at depths less than 10 m, at water temperatures of 12 to 15 °C (Ahlstrom 1959).

Although anchovies spawn throughout the year, particularly in the southern part of their range (Baxter 1967), most spawn in winter and spring (Stauffer and Parker 1980); however, spawning north of Point Conception peaks during the period from mid-June to mid-August (Hunter and Macewicz 1980).

Anchovies spawn several times a year; individual females may lay as many as 20,000 to 30,000 eggs a year (Hart 1973). During the peak spawning season, the fish appear to spawn about once a week (Hunter and Goldberg 1980). The eggs are pelagic and float passively in the upper layers of the ocean. Eggs have been collected (at 10 m depth) at water temperatures of 9.9 to 23.3 °C; more than 90% were taken at 13.0 to 17.5 °C.

The eggs of anchovies are ovoid (1.23 to 1.55 mm along the major axis and 0.65 to 0.82 mm along the minor axis), clear, and translucent. They hatch in 2 to 4 days, depending on water temperature (Bolin 1936).

Larval Stage

Newly hatched larvae are 2.5 to 3 mm long and weigh 0.0246 ± 0.0014 mg dry weight, of which 53% is yolk (Hunter 1977). The large and elongated yolk sac is absorbed in about 36 h. The larvae are elongated, transparent, and threadlike; olfactory and lateral line organs are well developed. After hatching, larvae are inactive and float motionless in the water except during short bursts of intense swimming at about 1-min intervals. The mouth is terminal in the early stages. Larvae about 10 mm long come to the surface at night to gulp air to inflate their swim bladder and thus conserve energy that would otherwise be required to maintain their position in the water column (Hunter and Sanchez 1976). Richardson (1981) hypothesized that these nightly vertical migrations cause southward and offshore transport of the larvae off California. Laboratory measurements indicated that schooling begins in larval anchovies when they are 11 to 12 mm standard length (SL). The onset of schooling is concurrent with an increase in patchiness of larvae in the sea (Hunter and Coyne 1982). Rapid structural and behavioral changes occur when the fish are 12-15 mm long. The lens retractor muscle becomes functional and the number of rods in the retina increases (O'Connell 1981). The young about 25 mm long resemble the adults.

In one study, survey cruises were made from the California-Oregon border to the southern tip of Baja California from 1949 to 1964 to determine the distribution and abundance of anchovy eggs and larvae (Ahlstrom 1967). Cruises were made about monthly from 1949 to 1960, and quarterly from 1961 to 1964. Of all larvae captured during surveys from 1951 to 1960, 96% were taken between Point Conception, California, and Magdalena Bay, Baja California. Most were collected from January to May and the fewest from August to October. Water temperatures (at 10 m depth) were 12 to 18 °C.

Juveniles

Little is known about the movement and habitat preference of juvenile anchovies. Tag returns have shown an interchange of fish between the central California, southern California, and northern Baja California fishing grounds, or between the central and southern subpopulations (Chavez et al. 1977). Most investigators maintain that both juveniles and adults move offshore in winter and return toward shore in spring. Changing wind patterns in fall, from northerly to southerly, could cause a shift in surface currents from southward to northward, a dampening of upwelling, and an onshore drift of surface waters (Wyatt et al. 1972). These factors may contribute to a northerly onshore movement of juveniles along the coast of California.

Maturity and Life Span

At least half of all female anchovies reach sexual maturity when about 96 mm long at the end of their first year of life (Hunter and Macewicz 1980); all anchovies are mature in their second year of life (age group I), according to the Pacific Fishery Management Council (PFMC 1978).

Anchovies are generally short-lived; fish more than 158 mm long and 4 years old are rare, but anchovies 229 mm long and 7 years old have been reported (Baxter 1967).

GROWTH CHARACTERISTICS

The age and growth rates of anchovies in central and southern California waters were first reported by Clark and Phillips (1952). The fish grew 92 mm SL in the first year of life; thereafter, successive annual increments (mm) in the second through fifth growing seasons were 28, 29, 13, and 4. Anchovies in southern California waters in the first year of life were generally smaller than those in central California waters (Spratt 1975).

COMMERCIAL AND BAIT FISHERIES

The northern anchovy in California supports a commercial fishery and a live-bait fishery. It has a wide range of uses: human food, bait (live or dead), feed for fish hatcheries and mink farms, and industrial fish meal and oil.

Records of the California commercial anchovy catch from 1916 to 1967 were summarized by Talbot (1973). The annual catch averaged about 325 metric tons (t) from 1916 to 1921; most of the fish were reduced to oil and meal. Enactment of restrictive laws in 1919 and 1921 made it impractical to continue to catch fish for reduction, and annual landings from 1922 to 1938 averaged only 145 t. In 1939 to 1946, annual average catches increased to 1,319 t, and then, as a result of declining sardine catches, the demand for anchovies for canning increased and the catch rose to 8,591 t by 1947. After 1947, more restrictions were placed on the anchovy fishery, and the landings dropped for the next 3 years; however, the boom was still to come. The collapse of the sardine fishery in California in 1952 resulted in a sharp increase in the anchovy catch to 39,000 t in 1953. Annual catches of over 15,000 t continued until 1958; consumer acceptance of canned anchovies then presumably dwindled, and the annual catch again declined to only 1,200 t annually from 1959 to 1965. Permits for the reduction of anchovies were again issued in 1966, and a record high catch of 143,000 t was reported in 1975.

The central subpopulation of anchovies off the coast of California and northern Baja California supports fisheries of both the United States and Mexico. The Institutio Nacional de Pesca and the California Department of Fish and Game have entered into an informal cooperative program to monitor the anchovy fishery (Chavez et al. 1977). Analysis of fish sampled from the Mexico-California landings has indicated major changes in age composition from 1977 to 1980 (Mais 1981). Before 1977, the catch was heavily dominated by fish of age groups I and II; some were even older. Since 1977, fish of age groups 0 and I have dominated catches, and older age groups have diminished. The optimum yield for the central California population for the 1981-82 fishing season was estimated to be 545,000 t (Stauffer and Charter 1982), as specified by the formula given in the Pacific Management Plan. According to Mais (1981), under the present high fishing pressure (and with production nearing 182,000 t per year), failures of two successive year classes could depress anchovy stocks to abnormally low levels.

The size of the anchovy population off California has changed over the last three decades. A marked increase in abundance coincided with a steady decrease in sardines in the same area. It has been estimated that anchovy spawning biomass increased from 640,000 t in 1951 to 5 to 8 million t in the mid-1960's (Smith 1972). The central subpopulation contributed about 78% of the total California biomass (Vrooman and Smith 1971). As judged by recent surveys of larval abundance, the biomass of adult fish in the central subpopulation may be as high as 2.7 million t (Stauffer and Charter 1982). These findings are difficult to interpret because of the conflicting data on mortality in the central subpopulation. Mortalities were estimated by Hanan (1981) to be 62% for annual mortality and 0.97% for instantaneous total mortality. He also indicated that instantaneous total mortality increased after 1976--an increase that coincided with a sharp decrease of older anchovies in the commercial catch and a decline in the total U.S. catch.

The commercial landings of anchovies, monitored by the California Department of Fish and Game, had an estimated ex-vessel value of $3.2 million in 1981 (PFMC 1983). More recent estimates have not been published.

Much of the value of the catch is due to landings for reduction. The ex-vessel price of anchovies varies considerably in response to changes in domestic and world markets for fish meal and other protein meals. Because of the great variability in fish meal demand, the anchovy ex-vessel price is expected to continue to fluctuate.

The live-bait fishery for anchovies has contributed 98% of the total live bait catch in California (Baxter 1967). The fishery is active at most coastal ports between San Francisco and San Diego, and expansion of this fishery to the north has been attempted (Waldvogel 1977). San Diego Harbor is the center of the live bait industry. Live-bait catches have fluctuated between 1,500 and 7,000 t annually, and sales were estimated to have been about $2.3 million per year (PFMC 1978).

ECOLOGICAL ROLE

The northern anchovy cannot be assigned to a single trophic level, largely because its diet consists of zooplankton, phytoplankton, and fish (Loukashkin 1970). Nonetheless, the anchovy in all life stages is planktophagous and it should be assigned to a low trophic level.

On the basis of observations in the field and in the laboratory, anchovies of all sizes are both filter feeders and particulate feeders, depending on the food available (Miller 1968). Anchovies probably feed chiefly during the day (Baxter 1967). Although the yolk sac is absorbed about 1.5 days after the fish hatch, laboratory observation has revealed that the larvae do not feed until about 2.5 days after hatching (Scura and Jerde 1977). Anchovy larvae longer than 7 mm "actually ate the greatest variety of food," according to Berner (1959). Stomach contents of fish 43 to 215 mm SL were 72% crustaceans in various developmental stages. Zooplankton other than crustaceans were second in abundance (11.5%), and indeterminate zooplanktonic remains and fleshy parts were third. The rest of the diet consisted of phytoplankton (6.6%) and foreign matter (0.6%) (Loukashkin 1970). Anchovies also sometimes eat their own eggs and larvae.

The chief competitor of the northern anchovy at all life stages is the Pacific sardine, Sardinops sagax (Baxter 1967). Competition begins in the larval stages and continues through life. Anchovies and sardines eat similar foods, and both species are most abundant between Point Conception, California, and Magdalena Bay, Baja California (Baxter 1967).

Essentially every predatory fish, bird, and mammal in the California Current eats anchovies. The PFMC (1978), in a summary of reports on anchovy predators, noted that anchovy eggs and larvae are the prey of an assortment of invertebrate and vertebrate planktivores, including adult anchovies. Duration of the planktonic life stage is only about 2 to 4 months, and mortality is high. Juvenile anchovies near shore are extremely vulnerable to piscivores--primarily bluefin tuna and albacore. Other predators are sharks, porpoises, seals, and birds. It has been estimated that adult anchovies taken annually by predators would compose about 73% of the spawning biomass if no fishing were done (PFMC 1978).

ENVIRONMENTAL REQUIREMENTS

Temperature

Anchovy larvae, juveniles, and adults have been observed at water temperatures ranging from about 8 to 25 °C. Eggs have been sampled at water temperatures of from 9.9 to 23.3 °C (Ahlstrom 1956). Water temperatures at a depth of 10 m were reported to be representative of the upper mixed layer where eggs thrived. Most eggs were taken when water temperatures were 13.0 to 17.5 °C. Anchovy larvae have been taken at water temperatures of 10.0 to 19.7 °C; but 95% were taken at 14.0 to 17.4 °C (Ahlstrom 1959). Most larvae live above the thermocline. Adult anchovies have been regularly observed at water temperatures of 12 to 20 °C (PFMC 1978); some anchovies apparently avoid high surface temperatures because they live in deeper water (Mais 1974). Anchovies usually spawn at water temperatures of 12 to 15 °C, which are typical during late winter (PFMC 1978).

Although data on water temperature and fish distribution are difficult to interpret, changes in water temperatures apparently affect the distribution of juvenile and adult anchovies. For example, when average water temperatures are lower than usual, adult anchovies are less abundant near shore, and juveniles dominate the catches there (Baxter 1967).

Depth

Adults avoid surface water during the day but move near the surface at night (Baxter 1967). Anchovy larvae tend to avoid water depths exceeding 48 m (Ahlstrom 1959). In contrast, Mais (1974) reported that adult anchovies are common at depths of 183 m or more during the day, but frequent the upper 73 m at night. Clearly, further investigation of the depth distribution of the northern anchovy and related environmental variations is needed.

Other Environmental Factors

Information about water quality requirements and preferences for the anchovy is scarce. Anchovies often congregate in areas of sewage outfalls, and periodic die-offs have been caused by oxygen deficiencies (PFMC 1978). Anchovies tend to move away from water deficient in oxygen and avoid high oxygen concentrations during plankton blooms. Weather may also exert an influence on water quality and anchovy distribution. Anchovies sometimes leave harbor waters just before heavy winter storms and high freshwater inflow. Attempts to interpret the effects of environmental variations (e.g., temperature, depth, and oxygen) on the distribution of anchovies have been inconclusive (Lasker and Smith 1977; Brewer and Smith 1982).

LITERATURE CITED

Ahlstrom, E.H. 1956. Eggs and larvae of anchovy, jack mackerel and Pacific mackerel. Calif. Coop. Oceanic Fish. Invest. Rep. April 1, 1956 to June 30, 1956:33-42.

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. 1966. Distribution and abundance of sardine and anchovy larvae in the California Current region of California, 1951-1964: a summary. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. 534:1-55.

Ahlstrom, E.H. 1967. Co-occurrence of sardine and anchovy larvae in the California Current region off California and Baja California. Calif. Coop. Oceanic Fish. Invest. Rep. 11:117-135.

Baxter, J.L. 1967. Summary of biological information on the northern anchovy Engraulis mordax Girard. Calif. Coop. Oceanic Fish. Invest. Rep. 11:110-116.

Berner, L. 1959. The food of larvae of the northern anchovy Engraulis mordax. Inter-Am. Trop. Tuna Comm. Bull. 4:3-15.

Bolin, R.L. 1936. Embryonic and early larval stage of the California anchovy. Calif. Dep. Fish Game Fish Bull. 22:314-321.

Brewer, G.D., and P.E. Smith. 1982. Northern anchovy and Pacific sardine spawning off southern California during 1978-1980: preliminary observations on the importance of the nearshore coastal region. Calif. Coop. Oceanic Fish. Invest. Rep. 23:160-171.

Chavez, H., S. Silva, and J.S. Sunada. 1977. The fishery for northern anchovy, Engraulis mordax, off California and Baja California in 1975. Calif. Coop. Oceanic Fish. Invest. Rep. 19:147-165.

Clark, F.N., and J.B. Phillips. 1952. The northern anchovy (Engraulis mordax) in the California fishery. Calif. Dep. Fish Game Fish Bull. 38:189-207.

Hanan, D. 1981. Update of the estimated mortality rate of Engraulis mordax in southern California. Calif. Dep. Fish Game Fish Bull. 67:62-64.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Can. Bull. 180. 740 pp.

Hunter, J.R. 1977. Behavior and survival of northern anchovy Engraulis mordax larvae. Calif.

Coop. Oceanic Fish. Invest. Rep. 19:138-146.

Hunter, J.R., and K.M. Coyne. 1982. The onset of schooling in northern anchovy larvae, Engraulis mordax. Calif. Coop. Oceanic Fish. Invest. Rep. 23:246-251.

Hunter, J.R., and S.R. Goldberg. 1980. Spawning incidence and batch fecundity in northern anchovy, Engraulis mordax. U.S. Natl. Mar. Fish. Serv. Fish. Bull. 77:641-652.

Hunter, J.R., and B. Macewicz. 1980. Sexual maturity, batch fecundity, spawning frequency, and temporal pattern of spawning for the northern anchovy, Engraulis mordax, during the 1979 spawning season. Calif. Coop. Oceanic Fish. Invest. Rep. 21:139-149.

Hunter, J.R., and C. Sanchez. 1976. Diel changes in swim bladder inflation of the larvae of the northern anchovy, Engraulis mordax. U.S. Natl. Mar. Fish. Serv. Fish. Bull. 74:847-855.

Jordan, D.S., and B.W. Evermann. 1908. American food and game fishes. Doubleday, Page and Company, New York. 572 pp.

Lasker, R., and P.E. Smith. 1977. Estimation of the effects of environmental variations on the eggs and larvae of the northern anchovy. Calif. Coop. Oceanic Fish. Invest. Rep. 19:128-137.

Loukashkin, A.S. 1970. On the diet and feeding behavior of the northern anchovy, Engraulis mordax (Girard). Proc. Calif. Acad. Sci. 37:419-458.

Mais, K.F. 1974. Pelagic fish surveys in the California Current. Calif. Dep. Fish Game Fish Bull. 162. 72 pp.

Mais, K.F. 1981. Age-composition changes in the anchovy, Engraulis mordax, central population. Calif. Coop. Oceanic Fish. Invest. Rep. 22:82-87.

Miller, D.J., and R.N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dep. Fish Game Fish Bull. 157. 249 pp.

Miller, R.C. 1968. California Academy of Sciences (agency reports). Calif. Coop. Oceanic Fish. Invest. Rep. 12:10.

O'Connell, C.P. 1981. Estimation by histological methods of the percent of starving larvae of the northern anchovy (Engraulis mordax) in the sea. Pages 357-360 in R. Lasker and K. Sherman, eds. The early life history of fish: recent studies. The second ICES Symposium, Woods Hole, 2-5 April 1979. Rapp. P.-V. Reun. Cons. Int. Explor. Mer 178. 605 pp.

Pacific Fishery Management Council. 1978. Northern anchovy fishery management plan. Federal Register 43(141), Book 2:31655-31879.

Pacific Fishery Management Council. 1983. Northern anchovy fishery management plan. Fourth draft revision. FMP Amendment No. 5.

Richardson, S.L. 1981. Spawning biomass and early life of northern anchovy, Engraulis mordax, in the northern subpopulation off Oregon and Washington. U.S. Natl. Mar. Fish. Serv. Fish. Bull. 78:855-876.

Scura, E.D., and C.W. Jerde. 1977. Various species of phytoplankton as food for larval northern anchovy, Engraulis mordax, and relative nutritional value of the dinoflagellates Gymnodinium spledens and Gonyaulax polyedra. U.S. Natl. Mar. Fish. Serv. Fish. Bull. 75:577-584.

Smith, P.E. 1972. The increase in spawning biomass of northern anchovy, Engraulis mordax. U.S. Natl. Mar. Fish. Serv. Fish. Bull. 70:849-874.

Soule, D.F., and M. Oguri, eds. 1972-1976. Marine studies of San Pedro Bay, California, parts 1-12. Allan Hancock Foundation, University of Southern California, Los Angeles.

Spratt, J.D. 1975. Growth rates of the northern anchovy Engraulis mordax in southern California waters, calculated from otoliths. Calif. Fish Game 61:116-126.

Stauffer, G.D., and R.L. Charter. 1982. The northern anchovy spawning biomass for the 1981-82 California fishing season. Calif. Coop. Oceanic Fish. Invest. Rep. 23:15-19.

Stauffer, G.D., and K.R. Parker. 1980. Estimate of the spawning biomass of the northern anchovy central subpopulation for the 1978-79 fishing season. Calif. Coop. Oceanic Fish. Invest. Rep. 21:12-16.

Talbot, G.B. 1973. The California sardine-anchovy fisheries. Trans. Am. Fish. Soc. 102:178-187.

Vrooman, A.M., and P.E. Smith. 1971. Biomass of the subpopulations of the northern anchovy Engraulis mordax Girard. Calif. Coop. Oceanic Fish. Invest. Rep. 15:49-51.

Waldvogel, J.B. 1977. Age, maturity and distribution of northern anchovy, Engraulis mordax, in Humboldt Bay, California. M.S. Thesis. Humboldt State University, Arcata, Calif. 36 pp.

Wyatt, B., W.V. Burt, and J.B. Pattullo. 1972. Surface currents off Oregon as determined from drift bottle returns. J. Phys. Oceanogr. 2:286-293.

AD-A172724

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. Biol. Rep. 82(11.50)*		3. Recipient's Accession No.

4. Title and Subtitle
Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Southwest)--Northern Anchovy

5. Report Date
April 1986

6.

7. Author(s)
Stephen T. Kucas, Jr.

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
California Cooperative Fishery Research Unit
Humboldt State University
Arcata, CA 95521

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address
National Coastal Ecosystems Team
Fish and Wildlife Service
U.S. Department of the Interior
Washington, DC 20240

U.S. Army Corps of Engineers
Waterways Experiment Station
P.O. Box 631
Vicksburg, MS 39180

13. Type of Report & Period Covered

14.

15. Supplementary Notes
*U.S. Army Corps of Engineers Report No. TR EL-82-4

16. Abstract (Limit: 200 words)

Species profiles are literature summaries of the taxonomy, morphology, distribution, life history, and environmental requirements of coastal aquatic species. They are prepared to assist in environmental impact assessment. The northern anchovy (Engraulis mordax) generally is found in coastal waters. It moves offshore in winter and returns inshore in spring. Although anchovies spawn throughout the year, most spawn in winter and spring. Few northern anchovies live longer than 7 years. Commercial catches (1916-82) for California ranged from 27 to 143,000 t. Anchovies are primarily planktophagous in all life stages; their diet consists of zooplankton, phytoplankton, and fish. Anchovy have been collected at water temperatures of 8 to 25 °C. Keywords:

17. Document Analysis a. Descriptors
Feeding habits,
Growth,
Estuaries,
Fishes.

b. Identifiers/Open Ended Terms

Northern anchovy	Spawning
Engraulis mordax	Life history
Commercial fishery	Habitat requirements

c. COSATI Field/Group

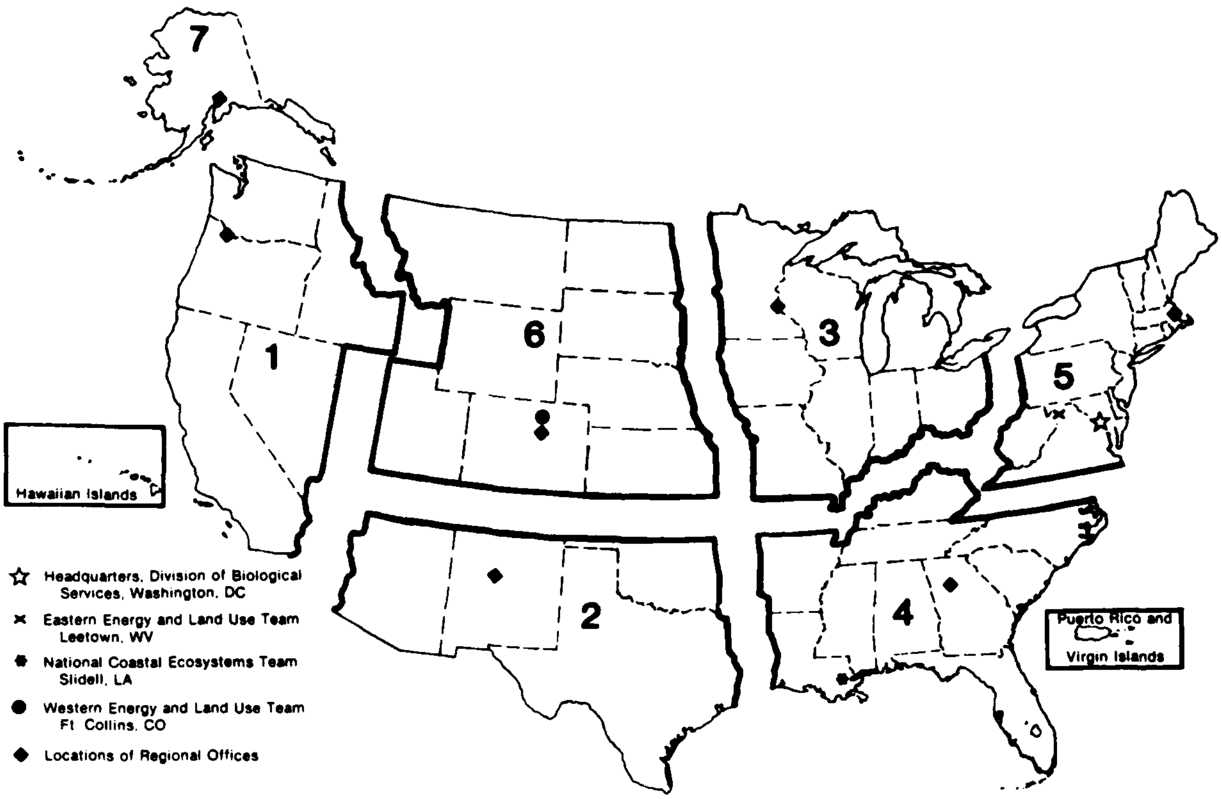
18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Unlimited release	Unclassified	11
	20. Security Class (This Page)	22. Price
	Unclassified	

(See ANSI-Z39.18)

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

U.S.G.P.O. 1986/661-638

12



REGION 1
Regional Director
U.S. Fish and Wildlife Service
Lloyd Five Hundred Building, Suite 1692
500 N.E. Multnomah Street
Portland, Oregon 97232

REGION 2
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 1306
Albuquerque, New Mexico 87103

REGION 3
Regional Director
U.S. Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

REGION 4
Regional Director
U.S. Fish and Wildlife Service
Richard B. Russell Building
75 Spring Street, S.W.
Atlanta, Georgia 30303

REGION 5
Regional Director
U.S. Fish and Wildlife Service
One Gateway Center
Newton Corner, Massachusetts 02158

REGION 6
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 25486
Denver Federal Center
Denver, Colorado 80225

REGION 7
Regional Director
U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503

END

11-86

DTIC