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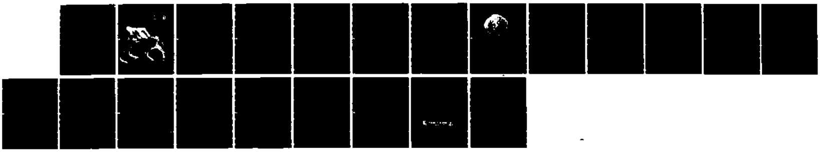

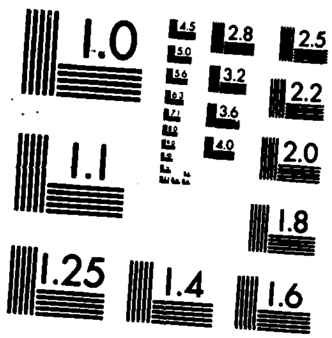

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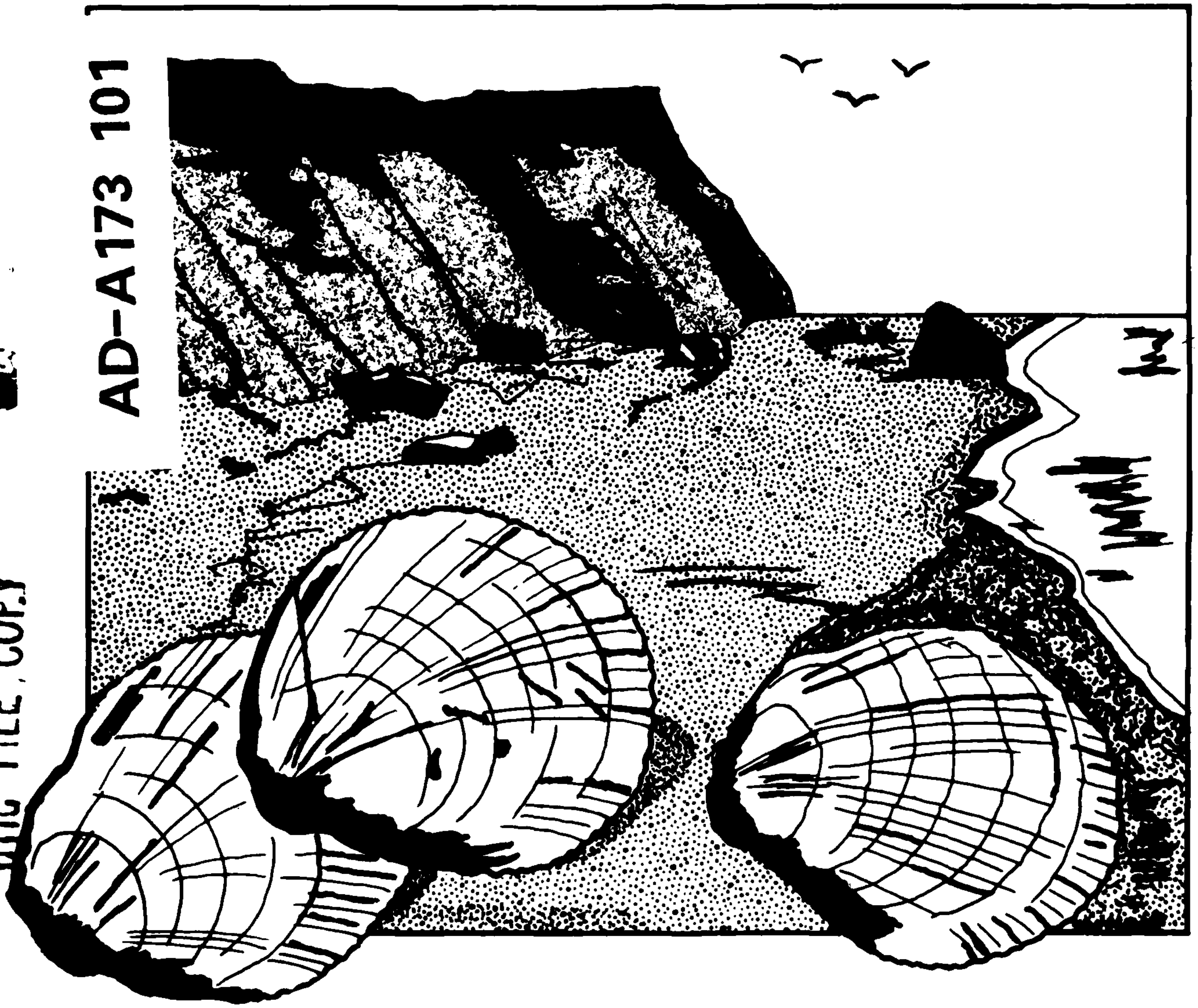
Biological Report 82(11.46)
April 1986

TR EL-82-4

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

COMMON LITTLENECK CLAM



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)

COMMON LITTLENECK CLAM

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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

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
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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

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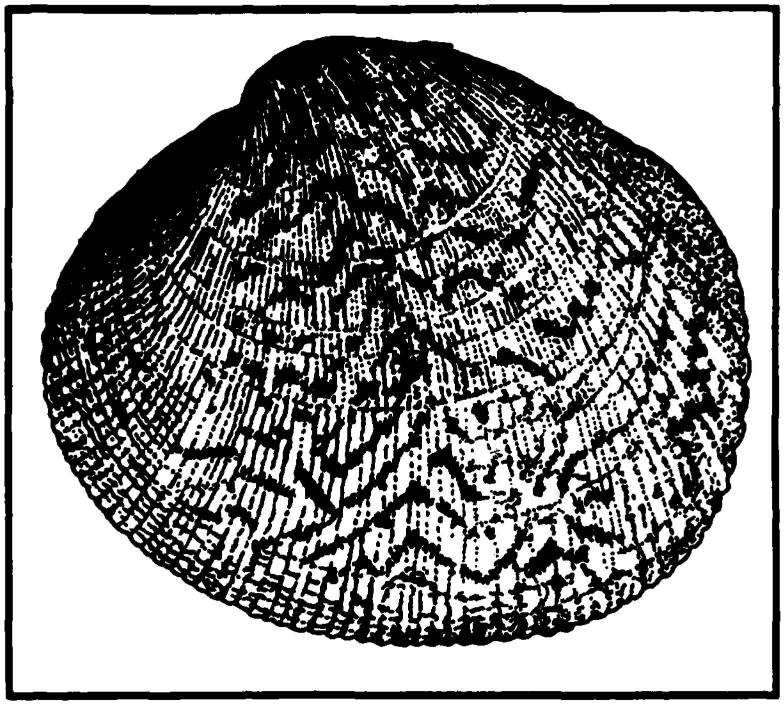

Figure 1. Common littleneck clam.

COMMON LITTLENECK CLAM

NOMENCLATURE/TAXONOMY/RANGE

Scientific name .... Protothaca staminea (Conrad)
Preferred common name .... Common littleneck clam (Figure 1)
Other common names .... Native littleneck clam, rock bay cockle, hardshell clam, Tomales Bay cockle, rock clam, ribbed carpet shell, steamer
Class .... Pelecypoda
Order .... Veneroida
Family .... Veneridae

Geographic range: Aleutian Islands, Alaska, south to Cape San Lucas, Baja California, Mexico; commercially abundant only north of Oregon. In California, the coastal waters near San Onofre, San Diego County (Figure 2), probably are the most productive area for clams in California (Frey 1971). Other concentrations are near Malibu Point and San Mateo Point south of San Clemente, California, and Bodega and Tomales Bays north of San Francisco. The clam is relatively scarce in northern California.

MORPHOLOGY/IDENTIFICATION AIDS

The following descriptions are extracted from Fitch (1953). The shell is oval and has inflated valves ornamented by well-defined, radiating ribs and less prominent, concentric ridges. Lunule (heart-shaped impression anterior to umbo) often is only faintly defined. The ventral margin is slightly crenulated. The pallial sinus (U-shaped indentation) extends

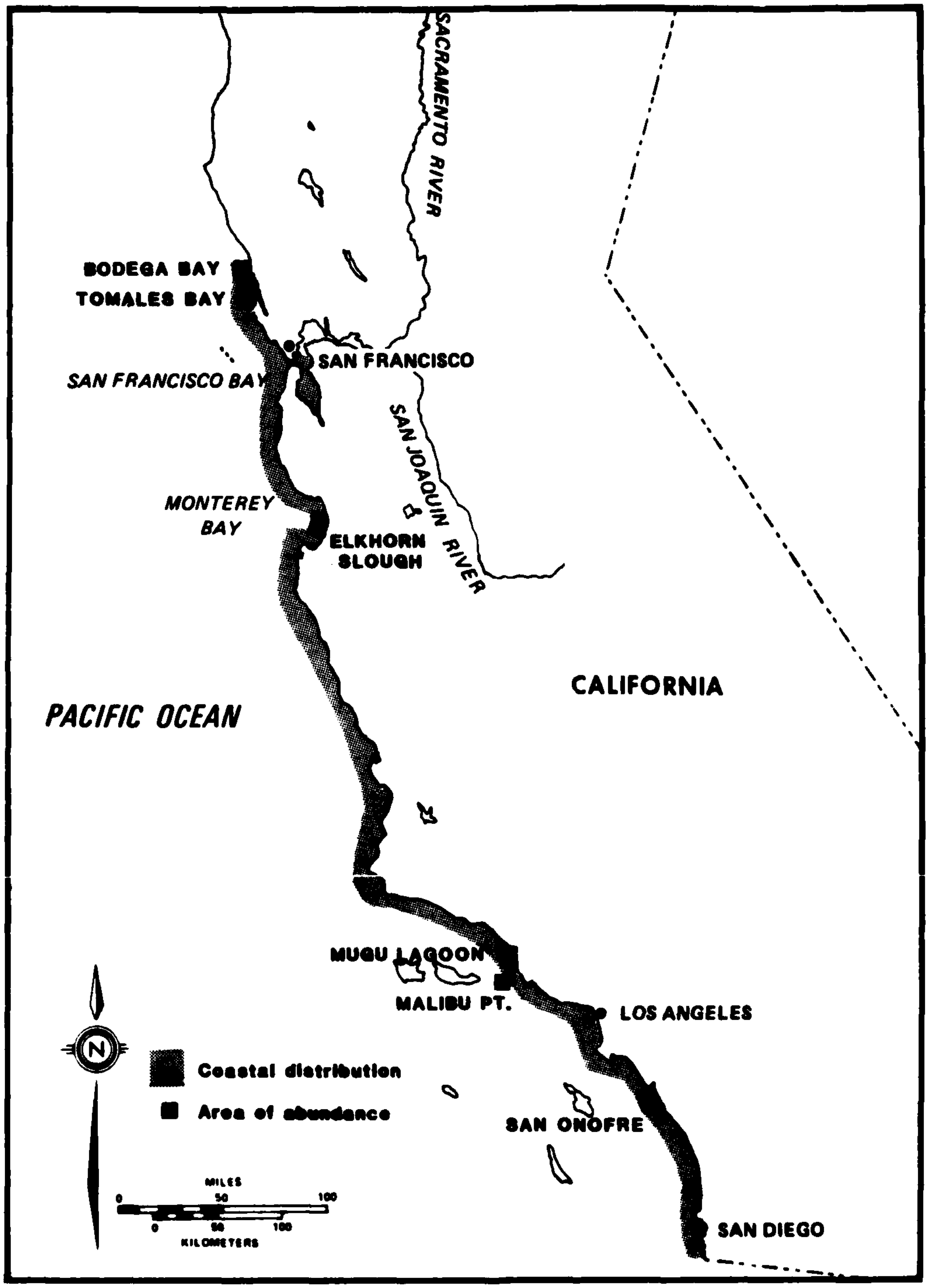

Figure 2. Distribution of the littleneck clam along the California coast. Greatest recorded abundance is at San Onofre, San Diego County (Frey 1971).

slightly more than half way to anterior adductor muscle. Color is highly variable: yellowish grey or grey if in sloughs and bays; often whitish with geometric patterns of wavy brown lines or blotches on sides of specimens along the open coast. The clam attains a length of 6.4 cm. It differs from chione clams (Chione spp.) and Japanese littleneck clams (Tapes japonica) in having a pallial sinus extending more than half way to the anterior adductor muscle, and from the rough-sided clam (Protothaca laciniata) and thin-shelled littleneck clam (P. tenerrima) in having radiating ribs more prominent than concentric ridges.

REASON FOR INCLUSION IN SERIES

The littleneck clam, relatively common in bays and estuaries and in cobble patches along the coast of California, supports an important sport shell fishery.

Because the littleneck clam lives in shallow bays with mud and sand bottoms, the habitat of this species in California is especially vulnerable to degradation because of harbor development, dredging, and pollution. For example, the waters of San Francisco Bay are so polluted in some areas that depuration is necessary before these and other clams can be eaten (Ritchie 1977).

The Japanese littleneck clam, apparently introduced with shipments of Pacific oyster seed, is rapidly replacing the common littleneck clam in San Francisco and Tomales Bays (Smith and Kato 1979; J.T. Carlston, William College, Mass., pers. comm.). A habitat suitability index model of the littleneck clam also has been prepared by the U.S. Fish and Wildlife Service (Rodnick and Li 1983).

LIFE HISTORY

Spawning

The sexes of the common littleneck clam are separate (Quayle 1943). The time of spawning varies throughout its range, depending largely on water temperature. Early studies in British Columbia report spawning in January (Fraser 1929) and in February and March (Fraser and Smith 1928). On Wood Island, British Columbia, the tubules of the ovary are filled with follicular cells in December and January (Quayle 1943). The growth of gametes reaches a peak in March and spawning begins in April. Few spawn later than September. The male spawning cycle parallels that of the female, but for unknown reasons lags behind that of the female by about 1 month. In British Columbia, most clams spawn in late spring but some may spawn off and on throughout the summer (Quayle and Bourne 1972).

In Alaska, spawning starts in mid-July when the water temperature is about 8° C (Glude 1978). In Prince William Sound, Alaska, spawning begins in late May to mid-June and continues into September (Nickerson 1977). In summer, water temperature fluctuations are unusually strong, so there may be two periods of high temperature and two corresponding spawning peaks. In a warmer than normal year, only one temperature and spawning peak may be expected.

In Mugu Lagoon, California, Peterson (1982) reported that June marks the beginning of the season of gamete release. He also observed that Protothaca's gonad weight declined sharply between June and December, indicating spawning between June and December. From studies conducted by Peterson and Quammen (1982), it appears that initial setting may occur as early as mid-April.

During spawning, the eggs and sperm are discharged through the siphon (Quayle and Bourne 1972) and mass fertilization takes place in the open water.

Eggs and Larval Stages

The embryos develop into a trochophore larval stage (60-80 μm) about 12 h after fertilization (Quayle and Bourne 1972). The veliger (straight-hinge stage) develops in the next 24 h. A ciliated velum develops and helps the larva swim and maintain itself in the upper part of the water column. Larvae feed on phytoplankton and are about 0.15 mm long after 1 week. The veligers develop an umbo (prodissoconch) and may reach a length of 0.26 to 0.28 mm in 2 weeks. Fraser (1929) found larvae up to 0.5 mm long in British Columbia. Prior to metamorphosis, the veligers develop a foot and an eye spot, move to the bottom, and search for a suitable surface on which to settle. Once a suitable surface is found, the larvae undergo metamorphosis and attach to the surface by secreting byssal threads. Depending on food supply and temperature, the planktonic larval stage generally lasts about 3 weeks (Quayle and Bourne 1972).

The larval stage is a critical one and breeding success or failure is frequently determined at this time (Quayle and Bourne 1972). Larvae are at the mercy of currents and may be carried away from settling areas and perish.

Postlarvae and Recruitment

Postlarvae are epifaunal and mortality may be high (Paul and Feder 1973). After settlement, mortality is highest during or at the end of the first year (Schmidt and Warme 1969). Highest mortality is in the winter.

In Mugu Lagoon, California, clams that had set in mid-April in sand were 7.6 mm long by mid-June whereas those in mud were 8.3 mm long by mid-June (Peterson 1982). Unlike the Washington clams, Saxidomus, which remain permanently at site of settlement, young littleneck clams can crawl, using their foot, to other areas.

The extent of annual recruitment of littleneck clams varies greatly between areas. Peterson (1975) found that Protothaca had the highest variance in numbers of all species collected in 10 sampling periods over a 3-year period, suggesting a high variability in recruitment. In sand, experimentally increased adult densities had no significant effect on recruitment, whereas in mud, high adult densities reduced recruitment up to 60%. In Prince William Sound, Alaska, the clam's northern limit, recruitment was erratic and there was little recruitment from 1967 to 1971, probably due to poor spawning conditions (Paul and Feder 1973; Paul et al. 1976a).

Maturity and Life-Span

The only data on maturity are from north Pacific populations. At Woods Island, Ladysmith Harbor, British Columbia, sexual differentiation was apparent when clams were 15 to 35 mm long or during their second or third year of life (Quayle 1943). Mature clams were usually 22 to 35 mm long. At Prince William Sound, Alaska, the youngest sexual mature clam was 3 years old and 13 mm long (Nickerson 1977). In British Columbia, Fraser and Smith (1928) found some mature 2-year-old clams; about one-half of the clams spawned for the first time at the end of the second year of life (25 mm long).

The life span of the littleneck clam varies among different locations. Their life span in years, their lengths, their location, and the authors are as follows: 13 years (62 mm), Porpoise Island, Alaska (Paul et al. 1976b); 10 years (54 to 63 mm), British Columbia, Canada (Fraser and Smith 1928; Quayle and Bourne 1972);

16 years (42 to 50 mm), Olson Bay, Prince William Sound, Alaska (Paul et al. 1976a); 15 years, Galena Bay, Prince William Sound, Alaska (Paul and Feder 1973; Nickerson 1977); and 7 years, Mugu Lagoon, California (Schmidt and Warme 1969).

GROWTH CHARACTERISTICS

Some scientists believe that littleneck clams can be accurately aged by counting the rings on the shell (see Figure 1). The rings are much closer together when growth slows in the winter because of low metabolism. Hughes and Clausen (1980), however, expressed caution about aging littleneck clams by shell rings. They observed excessive variation in ring patterns among specimens in the same population from Newport Bay, Oregon. Fraser and Smith (1928) also reported that any disturbance that interrupts growth can cause ring formation. Rings can be evaluated as an aging tool by marking the shell and then recovering the clams for examination at a later date (Paul and Feder 1973).

The growth of littleneck clams varies throughout its range. Growth curves are available for clam populations from Alaska, British Columbia, and California (Figure 3) and for an experimental plot in Oregon (Figure 4). In Prince William Sound, Alaska, clams reach the marketable length of 30 mm in 8 years (Feder and Paul 1973; Paul and Feder 1973), but at Porpoise Island, southeast Alaska, clams reach this length in 4 to 5 years (Paul et al. 1976b). In waters near Sidney, British Columbia, the range of length of the clams for each year of life was as follows: 1st year, 11-17 mm; 2nd year, 22-33 mm; 3rd year, 36-51 mm; 4th year, 37-51 mm; 5th year, 43-55 mm; 6th year, 44-57 mm; 7th year, 47-60 mm; 8th year, 49-61 mm; 9th year, 51-62 mm; and 10th year, 54-63 mm (Fraser and Smith 1928). The authors reported

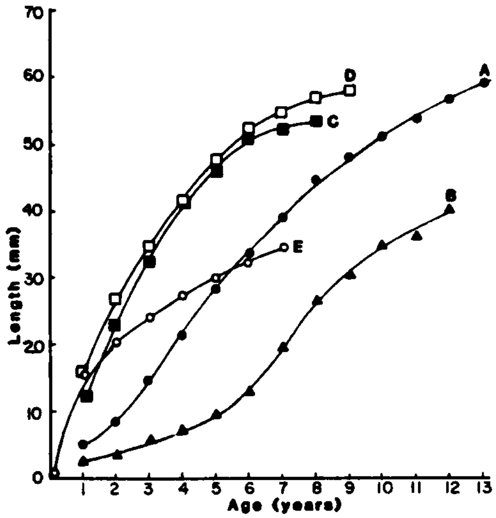

Figure 3. Ages and corresponding shell lengths (mm) of the common littleneck clam from (A) Porpoise Island, southeast Alaska; (B) Galena Bay, Prince William Sound, Alaska; (C) Victoria, British Columbia, Canada (Paul et al. 1976b); (D) Strait of Georgia, British Columbia, Canada (Quayle and Bourne 1972); and (E) Mugu Lagoon, California (Schmidt and Warme 1969).

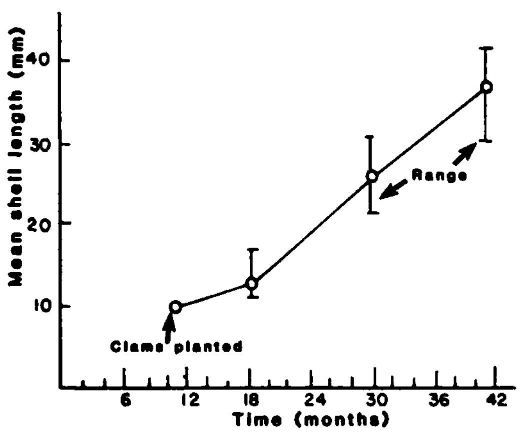

Figure 4. Growth curve of littleneck clams planted in an artificial substrate plot, Yaquina Bay, Oregon (Lukas 1973) over a period of 38 months (Sept. 30, 1970-April 12, 1973).

wide differences in growth rates among the years.

In Mugu Lagoon, California, the growth rate of littleneck clams was consistently depressed at experimentally induced high intraspecific densities. In mud the clam's linear growth declined more than in sand as intraspecific density increased (Peterson 1982). In Alaska, clams at the higher tide levels had the best growth (Nickerson 1977). At Kiket Island, Washington, however, the best growth was near mean lower low water and less rapid at higher and lower tide levels. Growth was better on the north side of the island because of more stable water temperatures and salinities (Houghton 1977).

In British Columbia littleneck clams are 37 mm long in 3.5 to 4 years and 63 mm long in 10 years (Glude 1978). In the State of Washington, it takes 4 to 6 years for clams to reach commercial length (1.5 inches). In Oregon, clams planted on artificial substrate (Figure 4) were 37 mm long in 42 months (Lukas 1973). In California, clams reach legal size (1.5 inches) in 2 years (Frey 1971), although in Mugu Lagoon (Figure 3) it appears to take up to 7 years to reach legal size.

COMMERCIAL AND SPORT FISHERIES

Littleneck clams are of commercial importance only in British Columbia and Washington (Amos 1966). The U.S. catch on the west coast in 1963 produced 214,400 lb of meat worth $107,194. In British Columbia, the annual commercial landings ranged from 21,300 to 521,900 lb in 1951-1969 (Quayle and Bourne 1972). Clams are either dug with long-tined rakes or with a hydraulic clam dredge. As many as 2,500 clams per hour can be collected by a clam dredge in areas of high density (Nickerson 1977). The clams are marketed fresh for steaming as far south as San Francisco.

In California there was commercial digging prior to World War II, but now most of the beds have been overexploited and only sport clamming is permitted. San Francisco Bay is the only large area in California with sufficient clam abundance to support a commercial fishery (Ritchie 1977), but because of pollution, all clams from San Francisco Bay would have to be depurated before sale. Because of daily catch limit of 50 clams, a commercial fishery is unlikely to develop. Littleneck clams are not harvested in Prince William Sound or elsewhere in Alaska as a consequence of paralytic shellfish poison of PSP (Anonymous 1974). Eating shellfish that have consumed large amounts of the poison-producing microscopic dinoflagellate Gonyaulax catenella can cause serious illness (Nishitani and Chew 1983).

Sport clamming in California is done by hand with a rake or shovel (Frey 1971). Clam digging tends to be concentrated in the intertidal areas primarily during low tide. Fifty clams yield about 1.5 lb of edible meat.

The major problem of the sport clam fishery in California is the discharge of sewage and animal wastes into estuaries and nearshore marine waters (Ritchie 1977). Although there is a coastwide warning of the dangers of paralytic shellfish poison from May 1 to October 31, the poison is not a problem.

AQUACULTURE

Littleneck clams are not cultured on the west coast. Ritchie (1977) concluded that clam farming should be permitted in California only in those areas where no other endemic species of clams are present. Culture under these restrictions would involve some form of beach rehabilitation and/or the planting of hatchery-produced seed. In many areas, residents might object to using public lands for private benefit (Ritchie 1977). As a result of stringent State laws (e.g., 50 clam limit/day) and economic considerations, the potential for littleneck clam culture in California is low.

ECOLOGICAL ROLE

The littleneck clam is a suspension feeder, collecting everything in the plankton small enough to be ingested (Schmidt and Warme 1969). The size of particle ingested is controlled by the size of the mouth opening or the life stage. Clam postlarvae can feed only on particles under 10 µm in diameter, primarily benthic diatoms and perhaps sediment bacteria (Peterson 1982). Because most littleneck clams live in the intertidal zone, most feeding is at high tide.

Unlike many species of clams, littlenecks can move by using their foot (Peterson 1982) and reburrow (Quayle and Bourne 1972). Clams in heavily populated areas may move to less densely populated areas, and clams exposed by dredging can reburrow after dredging is completed. Over 88% of the clams less than legal size reburrowed in both "soft" and "hard" bottoms after exposure (Quayle and Bourne 1972). Feder and Paul (1973) demonstrated the littleneck's ability to reburrow through a mark and recapture study.

Epizoic growth on littleneck clams is rare; and Peterson (1982) stated that fouling organisms are either scraped off in reburrowing or are smothered. No epidemic disease has been found in littleneck clams (Quayle and Bourne 1972). Two species of tetraphyllidian cestodes were found in littleneck clams in Humboldt Bay, California, and littleneck clams often contained large numbers of larval tapeworms (Sparks and Chew 1966; Warner and Katkansky 1969). These parasites are killed by cooking and cannot infect humans even when alive.

The littleneck clam has many predators. In Mugu Lagoon, California, Peterson (1982) observed fatalities caused by the snail _Polinices reclusianus_ and the crab _Cancer anthonyi_. Littleneck clams make up 16% of the diet of the octopus _Octopus dofleini_ (Hartwick et al. 1981). The clams eaten were 15 to 70 mm long, but most were 40 to 50 mm long. The intensity of predation was related to distance between the den of the octopus and the gravel beaches where the clams lived.

Two carnivorous gastropods, _Forreria belcheri_ and _Shaskyus festivus_, prey on littleneck clams (Schmidt and Warme 1969). Sea stars (_Pycnopodia helianthoides_) prey on littleneck clams in Prince William Sound, Alaska (Paul and Feder 1975). The sea otter (_Enhydra lutris_) also is a major predator of clams (Feder and Paul, University of Alaska; pers. comm.). Other predators are polychaetes, fishes, and ducks (Quayle and Bourne 1972). Small fishes have been found to nip on the siphons of littleneck clams, reducing clam growth (Peterson and Quammen 1982).

In transplant experiments in Mugu Lagoon, California, the deep-dwelling bivalve _Sanguinolaria nuttallii_ has no discernible influence on the shallow-dwelling littleneck clam (Peterson and Andre 1980).

ENVIRONMENTAL REQUIREMENTS

Temperature and Salinity

Larval littleneck clams normally live in a relatively narrow range of temperature and salinity. Near Newport, Oregon, the optimum water temperature range is 10 to 15 °C and the optimum salinity range is 27 to 32 ppt (Phibbs 1971). Adult littleneck clams can withstand water temperatures from near freezing to 25 °C, and the salinity tolerance for adults ranges from about 20 ppt or less, to 30 ppt in Prince William Sound, Alaska (Glude 1978).

Substrate

Littleneck clams live in the coarse, sand to mud sediments of bays, sloughs and estuaries in California (Fitch 1953). On the open coast, they live in nearly any area where there are rocky points or reefs made up of small cobbles over coarse sand. In southeastern and south-central Alaska, littleneck clams are common on sandy gravel beaches. In some coastal waters of California, there are wide fluctuations in clam abundance because heavy runoff from creeks causes extensive sanding-in of cobble beaches which decimates clam habitat (Frey 1971). Littleneck clam populations in those areas that have undergone sanding-in may require as many as 5 years to recover (Frey 1971).

Littleneck clams live often on small beaches that exist in pockets on rocky shorelines, or in small patches of larger beaches (Fraser and Smith 1928). The best beaches for littleneck clams are those with coarse sand or fine gravel mixed with mud, stones, or shells. Apparently littleneck clams do poorly in fine sand.

Depth

Littleneck clams are most abundant in the lower part of the intertidal zone and subtidally to a depth of 3 m (Glude 1978). Maximum burrowing depth is about 15 cm. Quayle and Bourne (1972) observed littleneck clams from the lower three quarters of the intertidal zone down to a depth of 13 m. They stated that clams burrow down to a maximum depth of 16 cm. In Alaska, clams live in the 1.5 to 1.0 m tidal range (Paul et al. 1976a; Nickerson 1977).

Other Environmental Factors

Heavy metals have been concentrated in littleneck clams because long-lived sedentary animals commonly concentrate such contaminants. Littleneck clams are highly sensitive to copper which is used in antifouling boat paints (Roesijadi 1980a, 1980b). A 15% mortality of clams was reported at copper concentrations of 7 and 18 µg/l after 30 days of exposure. At 39 and 82 µg/l, mortality was 86% and 97%, respectively, after 30 days of exposure. Copper concentrates in the gills and disrupts regulation of cellular sodium and potassium.

The uptake of heavy metals in littleneck clams has been monitored in Elkhorn Slough, California (Graham 1972). Shell concentrations (ppm dry weight) were as follows: Ag, 5.8; Cd, 2.9; Cr, <5.7; Cu, 11.5; Mn, 16.8; Pb, <9.0; and Zn, 9.2. The quantities (ppm) in the clam meat were as follows: Ag, <1.0; Cd, 5.7; Cr, <1.5; Cu, 7.5; Mn, 11.5; Pb, 5.2; and Zn, 67.7. The quantities of heavy metals in the littleneck clam generally were lower than those in other shellfish in California. Crabs consumed more clams from oiled than from unoiled sand because clams do not burrow as deep in oiled sand (Pearson et al. 1981). Slow reburrowing in oiled sand also led to increased predation. Small clams are far more vulnerable to crab predation than large ones.

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15. Supplementary Notes

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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. Common littleneck clam (Protothaca staminea) supports an important sport fishery in the Pacific Southwest Region, but has no commercial importance. The species is distributed from Alaska to Baja, California. The egg develops into the trochophore stage 12 h after fertilization, and the planktonic larval stage lasts about 3 weeks. Adults usually mature in the second or third year of life. Mortality is greatest early in life. Intraspecific competition among adults is more evident in mud than in sand. Most littleneck clams live in the lower intertidal zone. Littleneck clams concentrate heavy metals and are highly sensitive to copper.

17. Document Analysis a. Descriptors

Life cycles
Fisheries
Sediments
Clams
Aquaculture
Feeding habits
Growth
Competition
Contaminants

b. Identifiers/Open-Ended Terms

Protothaca staminea
Environmental requirements
Ecological role
Common littleneck clam

c. COSATI Field/Group

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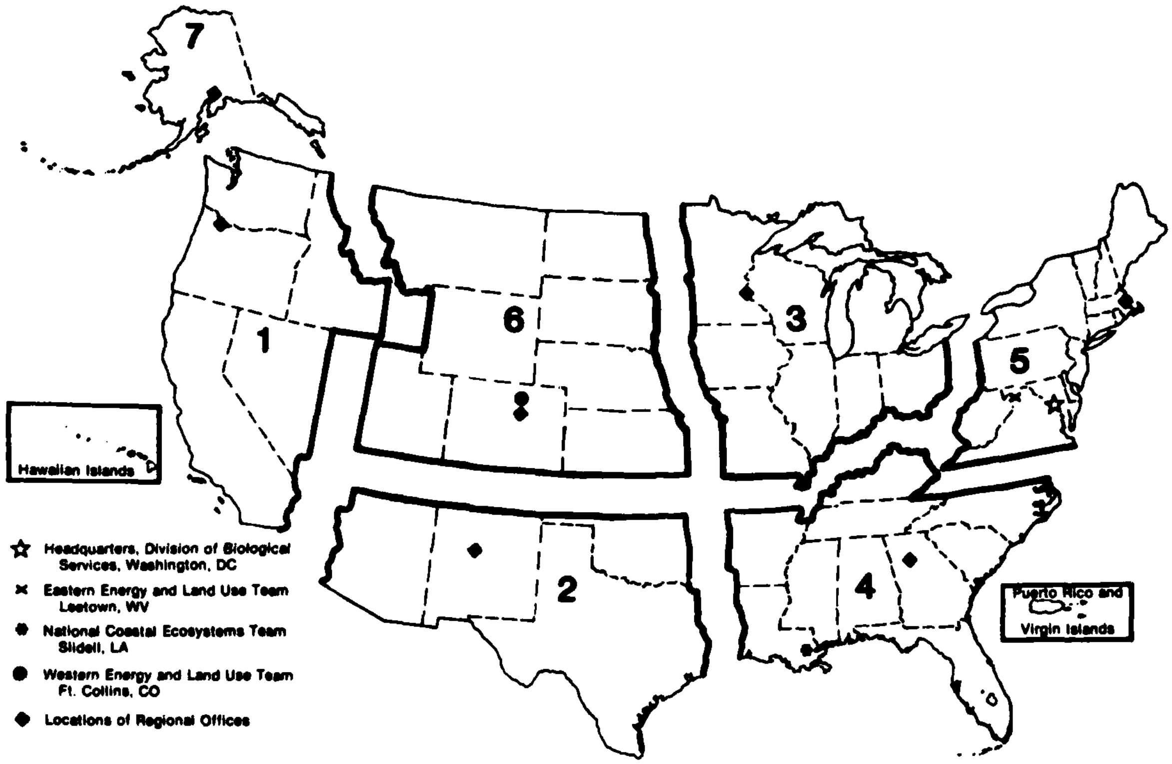

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