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REVIEW OF ECOLOGY AND FISHERY OF THE OLYMPIA OYSTER, *OSTREA LURIDA* WITH ANNOTATED BIBLIOGRAPHY[1]

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ABSTRACT The Olympia oyster, *Ostrea lurida*, is a small bivalve mollusk species native to the western United States and Canada. It was commercially important in the late 19th century, and was cultured in Washington State until a near-collapse of the industry in the 1950s. Since then it has made a minor commercial comeback, but has been largely superseded by the introduced *Crassostrea gigas*. Most significant literature dates from prior to the collapse of the industry in the 1950s, and much of this is comprised of state or federal agency reports, or similar obscure literature formats. This document is divided into 2 parts; a review of all important literature to date on the distribution, biology, ecology, taxonomy, and commercial exploitation of *O. lurida;* and an annotated bibliography of known literature pertaining to *O. lurida*.

CLASSIFICATION

Phylum MOLLUSCA
Class BIVALVIA
Subclass PTERIOMORPHIA
Order OSTREOIDA
Superfamily OSTREACEA
Family OSTREIDAE
Ostrea lurida Carpenter, 1864
Ostrea conchaphila Carpenter, 1857, possible synonym
Preferred common name: Olympia oyster
Other common names: native oyster, California oyster, Yaquina oyster

IDENTIFICATION AND MORPHOLOGY

Ostrea lurida is a small oyster. Specimens in Bamfield Inlet on Vancouver Island may exceed 6 cm in shell height; those currently found in Humbolt Bay, CA, and the southwest Puget Sound, WA, rarely exceed 5 cm (Baker, unpubl. data); those in San Francisco Bay are usually much smaller (Townsend 1893, Edmondson 1923). The shells are roughly elliptical or circular in outline, and the longest axis is normally from the hinge to the ventral margin (Figs. 1 and 2). The lower, or attached valve (left valve) is not deeply cupped, in contrast to the genus *Crassostrea*. The internal volume of a market-sized *O. lurida* from the southwest Puget Sound is about 4 cubic cm (Westley 1961).

The shell of *O. lurida* is thin and not chalky, as are members of the genus *Crassostrea*. There is usually no external sculpture other than an irregular series of concentric lines and often a plicate ventral (opposite hinge) margin, but Stafford (1915) reported a small population of oysters on Campbell Island, British Columbia, with deep, narrow shells and frequently with radiating ridges, which he positively identified as *O. lurida,* and the *O. lurida* illustrated by McLachlan and Ayres (1979) have radial ridges. External shell color is usually gray, but may be blotched with purple (Carpenter 1864a, Hertlein 1959). Specimens from Humbolt Bay, CA, are usually brown (pers. obs.); a yellow, striped form identified by Carpenter as *expansa* can be found in southern California; a purple form identified by Carpenter as *lauticauda* is found in San Pedro Bay, CA (Hertlein 1959), and a white variety was reported by Stafford (1915) in Oyster Lagoon, in Blunden Harbor, British Columbia. According to Morris (1966), *lauticauda* is relatively elongate, while the rounder *expansa* is more likely to have a fluted or zigzag margin. There is no noticeable periostracum in mature specimens, but juveniles may have a thin yellowish periostracum (Baker, unpubl. data).

The interior of the shell is coated with a thin nacreous-like layer that quickly wears off in dead specimens (pers. obs.). This layer is greenish throughout most of the range (Kozloff 1973, 1974), but Stafford (1915) reports it as white in most of British Columbia. A form from San Quentin Bay, CA, and identified by Carpenter as *rufoides*, has reddish blotches on the interior of the shell, especially in the vicinity of the muscle scar (Hertlein 1959). The muscle scar is normally unpigmented or very slightly pigmented (Kozloff 1974). The shell is made of 2 main calcitic layers; an outer simple prismatic layer, and an inner foliated layer, in which the calcite crystals are organized in spirals that form stepped-growth pyramids (Watabe 1988).

On the inner margin of the shells on either side of, but not a part of, the hinge are a series of 2–12 tiny pits in the lower, or attached valve, and corresponding denticles on the upper valve. They are termed "chomata", with the pits being "catachomata" and the denticles being "anachomata" (Torigoe 1981). Some authors use the less precise term "crenulate" for these denticles (e.g., Quayle 1960) (Figs. 1 and 2).

The soft tissue is distinguished from sympatric (introduced) species in the genus *Crassostrea* by a lack of a promyal chamber, or an exhalent opening dorsal to the adductor muscle. Elsey (1935) includes good illustrations of the comparative anatomy of *O. lurida* and *Crassostrea gigas*. The gill ostia of *O. lurida* are 90–180 μm long and 45–60 μm wide, or about one-third larger than those of *C. gigas* (Elsey 1935). The diploid chromosome number is 20 (Ahmed and Sparks 1967). Cytological and other differences are discussed by Ahmed (1975).

FOSSIL RECORD

Arnold (1909) states that *O. lurida* is present in late Miocene deposits in central California, and Howard (1935) reports this species in Pliocene deposits. All other records are more recent. *O. lurida* is a fairly abundant fossil along most of its present range (Dall 1897, Arnold 1903, Filice 1958, Valentine 1959, 1960, Kvenvolden et al. 1979, Atwater et al. 1981, Clifton 1983, Miller and Morrison 1988), and is sometimes the dominant fossil.

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BAMFIELD INLET, VANCOUVER ISLAND, B.C.

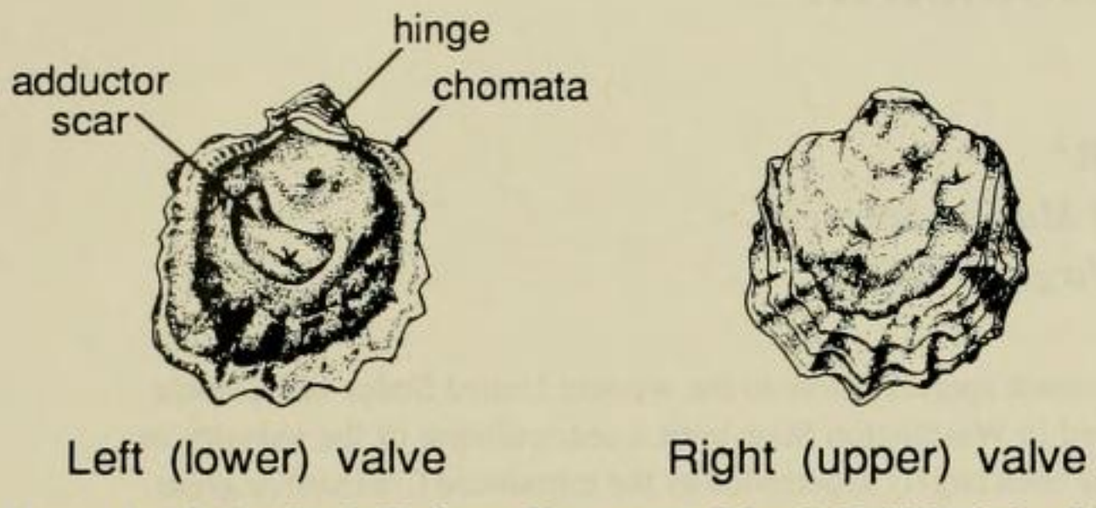

Figure 1. *O. lurida* shells from Vancouver Island, British Columbia, shown life size.

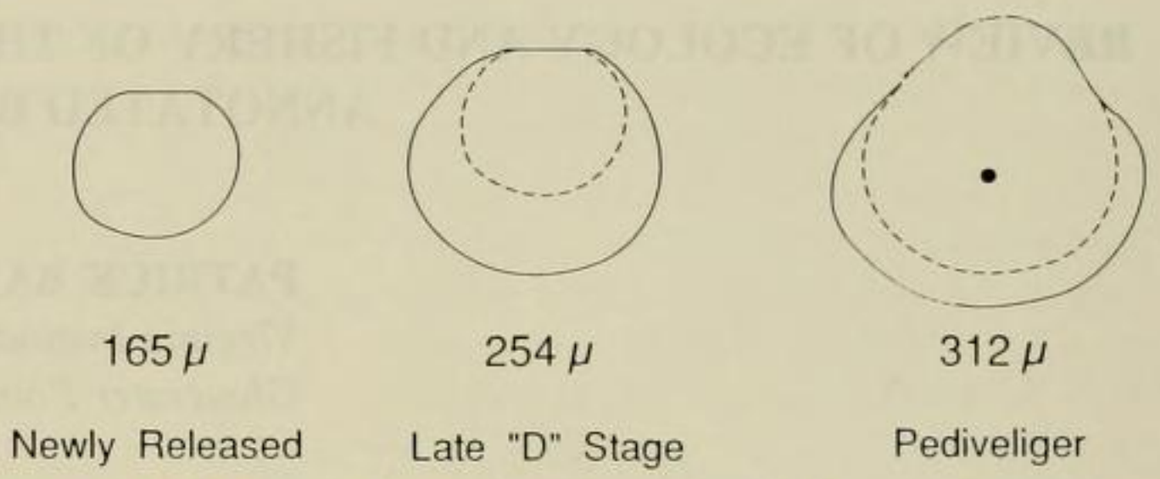

Figure 3. Outlines of *O. lurida* veliger larve at 3 stages of growth.

DISTRIBUTION

Although *O. lurida* is capable of living in full seawater, its distribution throughout the majority of its range is restricted to isolated bays and estuaries. The latitudinal extremes of the distribution are unclear. Dall (1914) states that the northernmost limit of *O. lurida* is Sitka, AK, and the southernmost limit is Cabo San Lucas, Baja California Sur (Mexico), but does not cite a reference for either locality. Paul and Feder (1976) state that this species is present in southeast Alaska, but do not name any localities.

In British Columbia, Stafford (1915) found *O. lurida* in a large number of inlets from Campbell Island south, and suspected that they were in many more. Quayle (1969) states that *O. lurida* is present in every small, shallow inlet in British Columbia. Large (commercially harvestable) populations of *O. lurida* on the inland waters, from north to south, have been reported in Hecate Channel by Campbell Island, Fish Egg Inlet, Blunden Harbor, Hardy Bay, Quadra Island, Malaspina Inlet, Oyster River, Comox Harbor, Pender Harbor, Deep Bay, Nanoose Bay, Oyster Harbor, Boundary Bay, and Ladysmith Harbor, Saltspring Island, and Portage Inlet, in Victoria (reported variously by Stafford 1915, Elsey 1933, and Quayle 1969). *O. lurida* larvae have been reported in abundance in Pendrell Sound and Hotham Sound (Bourne and Heritage 1979). From north to south on the outer coast of Vancouver Island, large populations of *O. lurida* have been reported in Quataino Sound, Esperanza Inlet, Nootka Sound, Toquart Harbor, Barkley Sound, and Sooke Harbor (Elsey 1933).

In Washington, *O. lurida* is found throughout the inland waters and in Willapa Bay (Galtsoff 1929) and possibly Grays Harbor (D. Tufts, Washington Dept. Fish. shellfish biologist, pers. comm.), along the outer coast. There are no records of *O. lurida* in Grays Harbor in the literature, however, so it must be regarded as uncommon there, at best. Past or present commercial quantities have been reported in Bellingham Bay and Samish Bay in northern Washington, Discovery Bay on the northeast corner of the Olympic Peninsula (Townsend 1893), Hoods Canal, all the inlets of the southwest Puget Sound, and Willapa Bay (Galtsoff 1929).

In Oregon, *O. lurida* has been reported in Netarts Bay, (Edmondson 1923, Dimick et al. 1941, Marriage 1954), Yaquina Bay (Fasten 1931, Dimick et al. 1941), and Coos Bay as an introduced species (Edmondson 1923, Carlton 1988, Carlton, pers. comm.), although *O. lurida* was abundant in Coos Bay within the last few thousand years (Dall 1897). Commercial quantities were found in Netarts Bay (Edmondson 1923) and Yaquina Bay (Fasten 1931, Dimick et al. 1941). *O. lurida* has apparently died out of Netarts Bay (L. Hansen, Whiskey Creek Oyster Farms, Netarts, OR, pers. comm.). It was introduced to Alsea Bay (Mix and Sprague 1970) and Winchester Bay (R. Sardiña, Winchester Aquaculture, Winchester Bay, OR, pers. comm.), with unknown results. There are no reports of *O. lurida* in any other Oregon estuaries.

In California, Galtsoff (1929) reported *O. lurida* as common on protected rocky reefs, but Bonnot (1935) did a survey of all California estuaries and bays, and found *O. lurida* absent in a number of bays north of Point Conception. *O. lurida* was present at that time in Humbolt Bay, Tomales Bay, San Francisco Bay, Elkhorn Slough in Monterrey Bay, and all bays and estuaries that Bonnot investigated south of Point Conception, including Mugu Lagoon, Alamitos Bay in San Pedro Bay, Anaheim Bay, Newport Bay, Mission Bay, San Diego Bay, and Tijuana Lagoon. *O. lurida* is reported as a major component of an Indian shell midden at Patrick's Point (Barner 1981), probably too far north of Humbolt Bay to have been carried from there, which may indicate the past abundance of *O. lurida* at Big Lagoon, just to the north. C. Johnson (Johnson Oyster Co., Inverness, CA, pers. comm.) reports that *O. lurida* are common but not abundant in Drakes Estero. Gilbert (1891) reported them in Bolsa Bay in Huntington Beach (which is now continuous with Anaheim Bay), and Coe (1932b) and Coe and Allen (1937) found them consistently at the Scripps Pier in Morro Bay. Turner et al. (1965) reported *O. lurida* in an intertidal survey off San Elijo Lagoon in San Diego County, but since they reported the size of "up to five inches," much larger than the normal size of *O. lurida*, this record is in doubt. On the other hand, because *O. lurida* has appeared in some southern California lagoons and estuaries after they were dredged to permit regular seawater exchange (see below), it is possible that there are marine populations nearby which supply recruits to coastal harbors.

ARCATA BAY, HUMBOLT BAY, CA

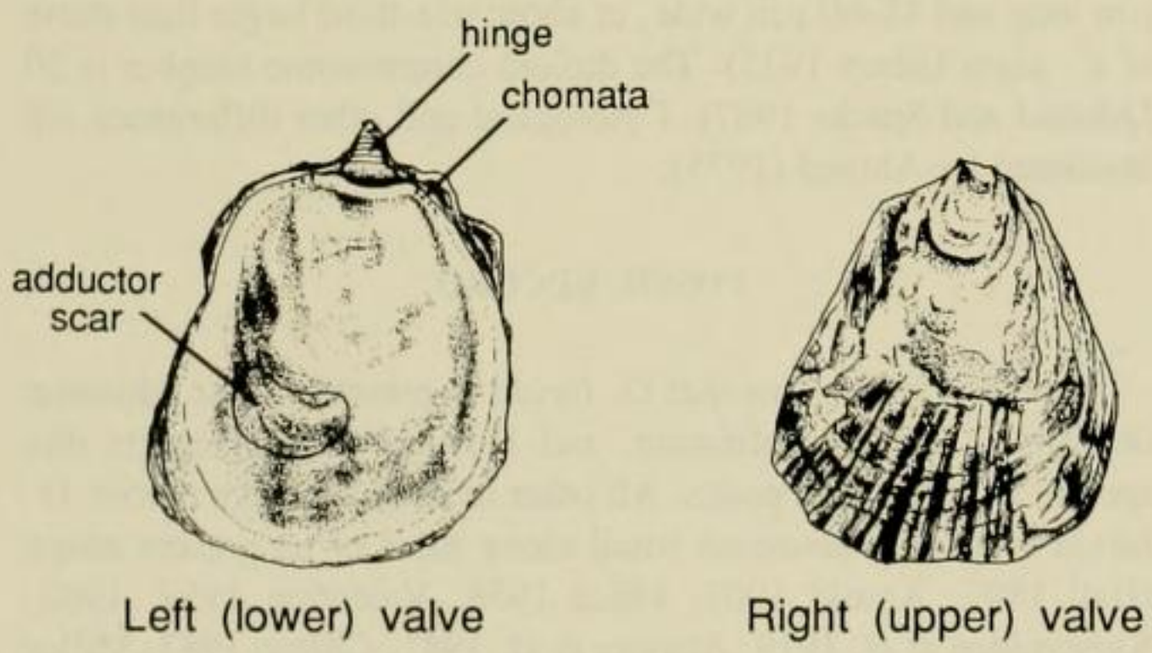

Figure 2. *O. lurida* shells from Humbolt Bay, CA, shown life size.

Commercial quantities of *O. lurida* have existed in Humbolt

Bay (Bonnot 1936), Tomales Bay (Barrett 1963), southern San Francisco Bay (Packard 1918), and Elkhorn Slough (Smith and MacKenzie 1948).

More recent surveys of many southern California lagoons and estuaries do not report *O. lurida* at some locations where they were formerly reported. This is the case with Elkhorn Slough (Browning 1972), Mugu Lagoon (Peterson 1975, Onuf 1987), Alamitos Bay (Reish 1963), Anaheim Bay (Reish et al. 1975), Mission Bay (Fry and Croker 1934), San Diego Bay (Browning and Speth 1973), and Tijuana Lagoon (Peterson 1975). Since the dredging and placement of riprap at the mouths of Agua Hedionda (Bradshaw et al. 1976) and Los Penasquitos Lagoons (Mudie et al. 1974), however, *O. lurida* has become established in both lagoons, where historically it was absent.

In Mexico, *O. lurida* has been reported in Bahia de San Quintin, in Baja California Norte (Keen 1962, Barnard 1970). The only other mention the author was able to find was the often-cited but unexplained mention of Cabo San Lucas in Baja California Sur by Dall (1914), which is at the extreme southern tip of the Baja peninsula. Keen (1958), however, reported no *O. lurida* on the Baja peninsula from Cedros Island south, but instead reported the morphologically very similar, but virtually unstudied, *Ostrea conchaphila* Carpenter, 1957. *O. conchaphila* is about the same size as *O. lurida* and differs from southern California varieties of *O. lurida* only in subtle differences that grade into *O. lurida* (Hertlein 1959). All Mexican records of *O. lurida* and *O. conchaphila* should probably be reviewed in this light.

O. lurida has been introduced to Japan (Hori 1933, Imai et al. 1954), and apparently it is established there, at least as a cultured species, because an introduction of *O. lurida* in 1970 to South Korea was made from Japan (Bae and Bae 1972). An attempt early in this century to introduce *O. lurida* to Hawaii failed (Brock 1960).

The larvae of *O. lurida* apparently tend to stay near their place of origin, since they are rarely, if ever, reported in near shore coastal plankton. This, plus the evidence that although *O. lurida* died out in prehistoric times in Coos Bay, OR (Dall 1897), and has only recently reappeared there (Carlton 1988), probably by human aid (L. Qualman, Qualman Oyster Farms, Charleston, OR, pers. comm), suggest that the rate of genetic exchange between coastal populations in Washington, Oregon, and northern California, is low. Table 1 shows distances between known coastal populations of *O. lurida* from Grays Harbor, WA, to the California-Mexico border, at about 1900, and Table 2 shows the same for after 1970.

TABLE 1.

Distances between known coastal bays and estuaries with Ostrea lurida; known distribution about 1900.

Bay or Estuary (North to South)	Distance to Next	Reference
Grays Harbor, WA	32 km	Galtsoff 1929
Willapa Bay, WA	172 km	Galtsoff 1923
Netarts Bay, OR	91 km	Edmondson 1923
Yaquina Bay, OR	431 km	Fasten 1931
Humbolt Bay, CA	325 km	Bonnot 1935
Tomales Bay, CA	30 km	Bonnot 1935
Drakes Estero, CA	50 km	C. Johnson, pers. comm.
San Francisco Bay, CA	136 km	Packard 1918
Elkhorn Slough, CA	460 km	Bonnot 1935
Mugu Lagoon, CA	91 km	Bonnot 1935
Alamitos Bay, CA	3 km	Bonnot 1935
Anaheim Bay, CA	5 km	Bonnot 1935
Bolsa Bay, CA	26 km	Gilbert 1891
Newport Bay, CA	102 km	Bonnot 1935
La Jolla Bay, CA	12 km	Coe 1932b
Mission Bay, CA	14 km	Bonnot 1935
San Diego Bay, CA	18 km	Bonnot 1935
Tijuana Lagoon	—	Bonnot 1935

HABITAT

O. lurida is moderately euryhaline, with about 80% survival at 15 ppt salinity for 49 days (Gibson 1974), although the lower limit of large populations in the southwest Puget Sound is about 23–24 ppt, average, for winter months (Hopkins 1937). Quayle (1941) states that populations in British Columbia are found near the mouths of small rivers in inlets. Coe (1932) and Coe and Allen (1937) reported them as a common fouling organism in full seawater in La Jolla Bay in California.

The northern limit is apparently set by temperature; *O. lurida* cannot withstand freezing (Davis 1955), and needs water of at least 12.5°C to reproduce (Hopkins 1937). Stafford (1915) was of the opinion that the northernmost populations of *O. lurida* persist only because they exist in sheltered inlets that warmed in the summer. It is not clear what the upper thermal limit is, but adults can withstand 30°C for a few hours (Hopkins 1937).

O. lurida is only rarely reported in benthic invertebrate surveys of water more than a few meters deep, although it is present in the main shipping channel, at a mean depth of over 10 m, in Isthmus Slough of Coos Bay, OR (Baker, unpubl. data), and the main beds in Yaquina Bay, OR were also in the main shipping channel (Fasten 1931, Dimick et al. 1941). Hopkins (1937) reported that this species prefers shallow subtidal areas or large tide pools, but individuals can be found at least 2 m above mean low water in the intertidal as well (Baker, unpubl. data).

O. lurida apparently requires hard substrate to settle on, but readily settles on very small pieces of hard substrate (Fasten 1931). This allows the species to form loose reefs in soft mud areas, and the largest populations occur in low intertidal or shallow subtidal mud areas of estuaries (Townsend 1893, Stafford 1915, Galtsoff 1929, Quayle 1941, 1960). Fairly large populations can also occur on rocky reefs (Stafford 1915, Bonnot 1935), and individuals or clusters are common on rocks in parts of the Puget

TABLE 2.

Distances between coastal bays and estuaries with Ostrea lurida; 1970 and later.

Bay or Estuary (North to South)	Distance to Next	Reference
Grays Harbor, WA	32 km	D. Tufts, pers. comm.
Willapa Bay, WA	152 km	D. Tufts, pers. comm.
Yaquina Bay, OR	263 km	Wachsmuth, 1979
Coos Bay, OR	120 km	Carlton, 1988
Humbolt Bay, CA	325 km	J. Carlton, pers. comm.
Tomales Bay, CA	30 km	C. Johnson, pers. comm.
Drakes Estero, CA	50 km	C. Johnson, pers. comm.
San Francisco Bay, CA	136 km	Bradford & Luoma, 1980
Newport Bay, CA	74 km	Human, 1970
Agua Hedionda Lagoon, CA	24 km	Bradshaw et al., 1976
Los Penasquitos Lagoon, CA	—	Mudie et al., 1974

Sound, WA (pers. obs.), in inlets of British Columbia (Quayle 1969), and in California (Galtsoff 1929, MacGinitie 1935, Barnard et al. 1959, Kozloff 1973). Kozloff (1973) also states that in parts of San Francisco Bay, *O. lurida* is a common fouling organism on pilings and floating piers.

LIFE HISTORY

O. lurida is a protandrous hermaphrodite. The gonads form at about 8 weeks after settlement, the spermatogonia are mature at five months, and the oogonia are mature at age six months. The sexual cycle after the initial male phase follows a female-male-recuperation stage cycle (Coe 1931a, 1932a, 1934). "Sperm balls" may function as spermatozeugmata when filtered from the water by a female (Strathmann 1987). The length of the male-female cycle varies with the individual, and may be interrupted at any stage by low temperature and carried on again when the temperature increases again (Coe 1931a). Hundreds of thousands of sperm balls may be released, each with about 2000 sperm (Coe 1931b), and the average number of larvae released during the female stage is about 250,000 (Hopkins 1936), but the number of eggs prior to fertilization has not been reported. Although the sexual stages may overlap, self-fertilization generally does not occur (Coe 1931b).

Spawning begins in California when the water temperature reaches 16°C in southern California, and lasts at least 7 months (Coe 1931a); in the southwest Puget Sound when the water temperature reaches 12.5–13°C, and lasts for about 6 months (Hopkins 1937, Santos et al. 1992b); and in Japan when the water temperature reaches 14°C (Imai et al. 1954). These temperatures are average daily temperatures taken in the main channel, and in the shallows water temperature may easily exceed that (pers. obs.). Santos et al. (1992b) reported that gametogenesis and spawning occurred at temperatures between 12 and 21°C in the laboratory, but while specimens at 12°C took 8 weeks from the beginning of gametogenesis to spawning, those at 21°C took only 2–3.5 weeks. Females at 18 and 21°C in this study produced significantly more larvae than those at lower temperatures. In British Columbia the spawning season lasts about 3 months (Stafford 1915). Two spawning/swarming peaks per year are common, if not typical (Hopkins 1937).

Eggs have been reported to be 90 μm (Elsey 1935) to 100–110 μm (Loosanoff and Davis 1963) in diameter at maturity. The larvae are brooded by the female about 10–12 days (Coe 1931a, Hopkins 1937, Strathmann 1987), and are gradually released in a process termed "swarming" by Stafford (1915), at about 180–185 μ in diameter (Stafford 1915, Hori 1933, Loosanoff and Davis 1963). Information on growth is included in Loosanoff and Davis (1963), and figures of larvae in various stages of growth are included in Hori (1933) and Loosanoff et al. (1966). The larvae spend from 21 days (pers. obs.) to 1 month (Hopkins 1937) to 6 to 8 weeks (Breese 1953) in the plankton, and settle at about 300 μm in diameter (Hori 1933, Hopkins 1937, Loosanoff and Davis 1963). They seem to prefer the undersides of objects (Hopkins 1935, 1937), although Bonnot (1937b) found that they would settle on upper or lower surfaces of concrete slats stacked several high with a narrow space in between, where it was dark. Although *O. lurida* larvae settle readily on concrete (Bonnot 1937b, Hopkins 1937), they will apparently not settle heavily on brush, as do larvae of *Crassostrea* species (Stevens 1928). Two setting peaks per year are typical (Bonnot 1937b, Hopkins 1937), but recruitment intensity is not necessarily in direct proportion to the magnitude of the spawning peaks (Hopkins 1937). The percent survival from recruitment to age 6 months for juveniles (spat) in southwest Puget Sound in the early 1950s averaged about 3%, with a 3% standard deviation (calculated from Woelke 1958).

O. lurida nears maximum size in about 4 years, growing relatively little after that (D. McMillin, Olympia Oyster Co, Shelton, WA, pers. comm.), but the growth rate of juveniles has not been studied. The present author has found fossil shells of individuals in Coos Bay, OR, with ten or more major hinge annuli, which may correspond to age in years.

PATHOLOGY AND POLLUTION

O. lurida is relatively disease-free, compared to other oyster species, although several virus-like lesions and several proliferative diseases have been reported at a low incidence (Mix 1976a, 1976b, Mix and Riley 1977). A haplosporidium (Mix and Sprague 1970) and a possibly pathogenic flagellate of the genus *Hexamita* (Stein and Denison 1959) have also been reported. None of these were correlated with significant mortalities in *O. lurida*, but Elston (1990) has incorrectly stated that *Hexamita* has been established as a disease-causing agent. A "microcell" disease described as *Mikrocytos mackini* that caused significant mortalities in *O. edulis* and *C. gigas* in British Columbia was discovered intermittently in *O. lurida* from Yaquina Bay, OR, in the winters of 1969 and 1970, but no mortality studies were done on it in *O. lurida* (Farley et al. 1988). Korringa (1976) makes reference to an unknown disease (not *Hexamita*) that occasionally destroys significant numbers of *O. lurida* in Washington.

Cardwell et al. (1979) suspected that blooms of the dinoflagellates *Gymnodinium splendens* and *Ceratium fusum* cause *O. lurida* mortalities, but D. McMillin (pers. comm.) reported good *O. lurida* survival, compared to *C. gigas*, during blooms of these dinoflagellates, which he had positively identified from photomicrographs taken during the bloom.

The only common internal macroparasite is an intestinal copepod, *Mytilicola orientalis* Mori, 1935, formerly called *M. ostreae*, introduced from Japan (Wilson 1938, Bernard 1969). The incidence of infection is low, ranging from 0 to 3% in San Francisco Bay, with no apparent effects (Bradley and Seibert 1978), and from 0 to 16% in the southwest Puget Sound, with a corresponding slight decrease in body weight (Odlaug 1946). *Odostomia* spp. (Gastropoda), which are ectoparasites, have been reported in high numbers in association with *O. lurida* (Strong 1928), but there is no evidence that *Odostomia* has a significant effect on the population.

The most serious form of pollution for *O. lurida* has been waste sulfite liquor from pulp mills. Studies in the southwest Puget Sound indicated high mortality at high concentrations of sulfites, and a lowering of body weight and reproductive success at lower quantities (Hopkins et al. 1935, McKernan et al. 1949, Odlaug 1949, Stein et al. 1959a, Gunter and McKee 1960). Oyster culturists in the area noted a total loss of *O. lurida* beds in inlets with pulp mills (Oakland Bay and Budd Inlet), and a general decline in the rest of the region (D. McMillin, pers. comm.).

Galtsoff (1929) suggested that untreated sewage dumped directly into Budd Inlet, in south Puget Sound, had killed the *O. lurida* there. Beck et al. (1966) review bacterial depuration in *O. lurida*. Clark et al. (1974) and Gibson (1974) found only minor effects of marine fuel contamination on *O. lurida*. Modin (1969),

reported high concentrations of organo-chloride pesticide residues washed into some California estuaries and taken up by *O. lurida*, but did not report on the effects on the oysters.

PREDATORS

Little study has been made of native invertebrate predators of *O. lurida*, because in commercial beds none are considered commercially significant. Several species of crabs, especially *Cancer productus* Randall, 1839, and *Cancer magister* Dana, 1852, can be serious pests on occasion in beds of relatively high salinity (Dimick et al. 1941, Quayle 1969, D. McMillin, pers. comm.), but rarely are in abundance near commercial beds. *Cancer gracilis* Dana, 1852, which is abundant over *O. lurida* beds, is capable of consuming adult *O. lurida* (Baker, 1988). The shore crab *Hemigrapsus oregonensis* (Dana, 1851) is thought to prey on juveniles (Dimick et al. 1941, Quayle 1969), but this has not been conclusively demonstrated. The large natacid snail *Polinices lewisii* (Gould, 1847) sometimes preys on adult *O. lurida*, and is regularly destroyed by oyster culturists, but it is not a major predator, in part because it seems incapable of penetrating dense *O. lurida* beds with its large, soft body and semi-burrowing mode of locomotion (Korringa 1976, D. McMillin, pers. comm.). The most serious native pests of adult *O. lurida* from the oyster culturists' viewpoint are several species of ducks (Aythyidae), including the white-winged scoter *Melanitta fusca* (Linné, 1758), the black scoter *Melanitta nigra* (Swainson, 1832), and the greater scaup *Aythya marila* (Linné, 1761), which are seasonally abundant predators (Galtsoff 1929, Sherwood 1931, D. McMillin, pers. comm.). In the Puget Sound, the starfish *Pisaster brevispinous* (Stimpson, 1857) can be a serious predator, but is not well-studied because it is easily controlled on diked beds (Galtsoff, 1929). Stingrays (*Myliobatus californica*) (Gill, 1865) are the most important oyster predator on soft bottoms in California (Townsend 1893, Roedel and Ripley 1950, Wicksten 1978), and leopard sharks *Triakis semifasciata* Girard, 1859, are also benthic bivalve predators in bays in California (Wicksten 1978).

Three introduced species have become serious predators on *O. lurida*. The Japanese oyster drill (a gastropod), *Ceratostoma inornatum* (Récluz, 1851) (formerly *Ocenebra japonica*), was introduced in the late 1920s to the Puget Sound, and was soon considered the most serious predator of *O. lurida* (Chapman and Banner 1949). It preys by boring through the shell of small or adult *O. lurida*, and can eat one oyster per week (Chew 1958, 1960). As serious, if not more so, is the flatworm *Pseudostylochus ostreophagus* Hyman, 1955, also introduced from Japan, which bores through the shell of juveniles, and can cause up to 90% mortality of juveniles (Woelke 1956b). *P. ostreophagus* is reported only from the Puget Sound in North America, but *C. inornatum* is also found in various harbors of the Strait of Georgia, Boundary Bay, and the Strait of Juan de Fuca in British Columbia, in various bays and inlets of the Puget Sound and in Willapa Bay in Washington, in Netarts Bay in Oregon, and in Tomales Bay and Morro Bay in California (Carlton 1979). The eastern oyster drill, *Urosalpinx cinerea* (Say, 1822), has been introduced in many areas of the West Coast, including all of the sites mentioned for *C. inornatum* except for Netarts Bay, OR, and Morro Bay, CA, and has also been introduced near Crescent, British Columbia (Sherwood 1931), and in Humbolt Bay, San Francisco Bay, Elkhorn Slough, and Newport Bay, all in California (Carlton 1979). In Washington, *U. cinerea* has either died out or become very rare, and is not considered a serious predator of *O. lurida* (D. McMillin, pers. comm.). Elsey (1933) reported that *U. cinerea* destroyed 10–20% of juvenile *O. lurida* in Boundary Bay, British Columbia, and Bonnot (1938) stated that *U. cinerea* was abundant enough in Tomales Bay, CA, to halt an attempt there to culture *O. lurida*. *U. cinerea* remains abundant in California (Carlton 1979).

The native analogs of the introduced drills, the thaids *Nucella lamellosa* (Gmelin, 1792) and *Acanthina spirata* (Blainville, 1832) are not considered significant predators of *O. lurida*. Although both are reported to be minor predators on *O. lurida* (Bonnot 1935, Dimick et al. 1941), Kincaid (1957) believes that *O. lurida* benefits from *Nucella* preying on barnacles and mussels growing on and competing with *O. lurida*.

The anomuran shrimps *Callianassa californiana* Dana, 1854, and *Upogebia pugettensis* (Dana, 1852) are not predators of *O. lurida*, but are considered serious pests by oyster culturists. These shrimp kill the oysters by smothering them with their burrowing activity, by making the grounds too soft, and by draining diked areas through their burrows (Stevens 1928, Bonnot 1935, Dimick 1941).

EPIBIONTS

O. lurida has the normal infestation of epizooans for a shell in the area, including; the barnacles *Balanus glandula* Darwin, 1854 and *Chthamalus dalli* Pilsbry, 1916 intertidally, and *Balanus crenatus* Bruguiére, 1789 subtidally (Baker, unpubl. data); the mussels *Mytilus galloprovincialis* and *M. trossulus* (both formerly called *M. edulis*) (Miller and Morrison 1988, Baker, unpubl. data); the boring sponge *Cliona celata* Grant, 1826 in areas of higher salinity (Bonnot 1935); the sponge *Halicondria* sp.; various bryozoans; and various small polychaetes, including *Polydora* sp., which bore into the shells (pers. obs.). Dimick et al. (1941) concluded that smothering by an unknown species of bryozoan and by the tube-dwelling amphipod *Corophium spinecorne* Stimpson, 1957 were major sources of *O. lurida* juvenile mortality in Yaquina Bay, OR. The slipper shell, or "cup," *Crepidula fornicata* Linnaeus, 1785, introduced from the Atlantic, is very abundant in the Puget Sound, and at one time was considered a serious pest, but McKernan et al. (1949) concluded that there was no evidence that these were significant competitors of *O. lurida*. At subtidal sites, or in the pools created by dikes in the southwest Puget Sound, the introduced compound ascidians *Botryllus* sp. and *Botrylloides* sp. can completely cover *O. lurida* (R. Sardiña, pers. comm., pers. obs.). Galtsoff (1932) and Barrett (1963) stated that the Pacific oyster, *C. gigas* (Thunberg, 1795), is a serious competitor, but throughout the majority of *O. lurida's* range this is not true, other than in the sense that culturists use former *O. lurida* beds to rear *C. gigas*. Oyster culturists, including Griffin (1941), report no evidence for superior competition by *C. gigas*, while Steele reported that *C. gigas* shells provide important hard substrate for *O. lurida*, and D. McMillin (Olympia Oyster Co., Shelton, WA, pers. comm.) believes that in its preferred habitat (see the section on habitat in this document) *O. lurida* out-competes *C. gigas*. In Humbolt Bay, *O. lurida* is considered to be a fouling pest on *C. gigas* (R. Sardiña, pers. comm.).

HUMAN UTILIZATION

A major limitation to human utilization of *O. lurida* is its small size. It takes 1600–2000 shucked, raw *O. lurida* to fill one U.S. gallon, compared to 80–140 shucked *C. gigas* per gallon (McKee

1945), so *O. lurida* has been primarily a luxury item since the introduction of larger oysters to the Pacific coast of North America (Korringa 1976). Even at the high value of these oysters ($250 per gallon of shucked meats in 1988), the labor cost is considered too high for a hatchery based industry, such as that for *C. gigas* (Donaldson 1988). The ancient Amerinds, however, made extensive use of *O. lurida*, based on shell midden excavations (Dall 1897, Kidd 1961, Elsasser and Heizer 1966, Iwamota and Chew 1978, Barner 1981, R. Pullen, U.S.G.S., Coos Bay, OR, unpubl. data).

There is no record of commercial use of *O. lurida* in Alaska, and it is not at present considered to have commercial potential there (Wood 1973).

The commercial sale of *O. lurida* in historic times in British Columbia began in 1884, at an unspecified location (Quayle 1969). The harvest method was to rake together oysters at low tide on intertidal flats, apparently with no attempt to restock or manage the fishery (Stafford 1918), with the exception of Crescent Oyster Co., near Crescent, B.C., where a system of dikes were used to hold water at low tide (Sherwood 1931). This system is discussed for Washington state (below). Although many *O. lurida* harvest leases were taken out prior to World War II (Elsey 1933), there is no evidence that *O. lurida* in British Columbia became an important fishery. *Crassostrea virginica* (Gmelin, 1861) was cultured there starting in 1904 (Stafford 1917), and in the 1920s *C. gigas* was introduced and eventually became established (Quayle 1969). The success with these species probably distracted from attempts to manage *O. lurida*. By 1940, the *O. lurida* fishery had for all intents ceased (Quayle 1969), and in the British Columbia Department of Fisheries Oyster Bulletin (1950), Quayle remarked that no interest was shown in setting data published in the Bulletin for the previous year. There is no commercial fishery for *O. lurida* in British Columbia at present.

Washington has always been the center of the *O. lurida* industry. Large beds of *O. lurida* were discovered in Willapa Bay (then Shoalwater Bay) in 1850, and large shipments began that year to San Francisco, CA (Galtsoff 1929). By 1879 the regular trade to San Francisco had slowed (Barrett 1963), but the harvest continued to a high of 90,000 bushels in 1896, declining steadily thereafter (Galtsoff 1929), and completely ceasing by 1936 (Hopkins 1937). Figures by Ingersoll (1881) suggest a harvest high of 250,000 bushels in 1874. No attempts to manage the fishery were made in Willapa Bay (Galtsoff 1929). A similar trend befell the *O. lurida* beds in Samish Bay, in northern Washington. Harvesting began there about the same time as in Willapa Bay, and the population was effectively depleted in the 1890s (Steele 1964). An attempt was made a few years later to dike-culture *O. lurida* in Samish Bay, without success (Steele 1964).

The only significant culture of *O. lurida* took place in the southwest Puget Sound, WA, a network of narrow inlets with no major freshwater inputs. Populations in Budd Inlet were eradicated by 1891, apparently by pollution from the city and port of Olympia (Townsend 1893), but starting in about 1897 a system of dike culture was began in inlets nearby, particularly parts of Eld Inlet, Totten Inlet, and Oakland Bay (Woelke 1956a). It has been stated that the dikes are modelled after a system developed in France (Kincaid 1928), but they only vaguely resemble the dike/pond systems in France (Milne 1972, Korringa 1976). The dikes in Washington are made of concrete, and are designed to enclose about an acre of intertidal flat so that it retains several inches of water at all times (Galtsoff 1929). The dikes were plagued by settling and cracking (Hopkins 1937), and by the activities of burrowing anomuran shrimp (Stevens 1929), but apparently allowed better *O. lurida* survival and pest control (Galtsoff 1992). This system far exceeded any other bivalve culture efforts in North America for the period of 1890 to 1930 (Wallace 1966).

Oyster culturists either depended upon larvae from wild stocks for recruitment into the dikes, or purchased "seed" (shells with juveniles) from state owned beds in Oakland Bay, which they spread on the beds (Woelke 1956a). This allowed a fairly sustained yield at around 40,000 "sacks" (one sack equals 2 bushels, with about 2500 individuals per bushel) (Hopkins 1937) until about 1911, when most of the wild stocks were finally depleted. The industry in the southwest Puget Sound declined to about half that level, based entirely on cultivated *O. lurida*. The industry then persisted at that level until about 1927, when a large paper pulp mill on Oakland Bay went into operation, releasing sulfites either directly or indirectly into the inlet. Within several years *O. lurida* production in Oakland Bay was destroyed, including the "seed" beds, and overall production in the region began a slower decline. The pulp mill pollution was implicated in this decline (McKernan et al. 1949, Gunter and McKee 1960), although at about the same time 2 oyster predators were introduced from Japan; the gastropod *Ceratostoma inornatum* and the flatworm *Pseudostylochus ostreophagus*. *O. lurida* production declined steadily, so that by the late 1950s it had virtually ceased (Woelke 1956a). The pulp mill thought to be responsible shut down in 1956, but it was not until the early 1980s that *O. lurida* became commercially significant again (Kuons and Cardwell 1981, D. McMillin, pers. comm.). Now populations of the oyster thrive despite the introduced predators, and appear to be slowly gaining in commercial importance again in Eld Inlet, Totten Inlet, and Oakland Bay (Chew 1988).

O. lurida has been commercially harvested in Oregon from Netarts Bay, on a very small scale around the turn of the century and mainly for local consumption (Edmondson 1923), and from much larger beds in Yaquina Bay. The beds in Yaquina Bay were discovered in 1860, and were harvested steadily, without management, until largely depleted by 1930 (Fasten 1931). A series of experiments were made shortly after World War II in the culture of this species in Yaquina Bay (e.g., Breese 1953, Becker 1955), but today *O. lurida* is the least important species in shellfish culture in Yaquina Bay (Wachsmuth 1979). An attempt was made to introduce *O. lurida* to Coos Bay in 1914 (Edmondson 1923), without success (Galtsoff 1929). In 1987 an attempt was made to culture *O. lurida* in Winchester Bay, Oregon, but was abandoned within several years, although individuals continued to be brought in with *C. gigas* from Humbolt Bay, CA (R. Sardiña, pers. comm.).

Packard (1918), stated that *O. lurida* was commercially harvested from San Francisco Bay, in California, and Barret (1963) mentioned that it was harvested in 1859 from nearby Tomales Bay. In San Francisco Bay the shells of *O. lurida* were gathered for paving and for poultry feed, but Townsend (1893) considered this species a serious fouling pest on the introduced oyster *C. virginica*. In 1926 the *O. lurida* beds in Elkhorn Slough were heavily harvested, nearly wiping them out (Browning 1972), although small amounts were apparently taken in 1935 (Smith and MacKenzie 1948). In the early 1930s in Arcata Bay (the northern half of Humbolt Bay) several companies, in cooperation with the State of California and later Humbolt County, attempted to culture *O. lurida* there, using the dike system that was successful in the

southwest Puget Sound, WA. About 10 acres were eventually diked, and early results were encouraging (Bonnot 1936, 1937a, 1938), but very few oysters were actually marketed from there, and the various concerns soon lost interest in the project (Barrett 1963). At present there are large wild beds there that are marketed on a small scale (R. Sardiña, pers. comm.). Despite the abundance of *O. lurida* in some southern California inlets, it has apparently never been commercially harvested there.

There is no record known to this author of commercial harvest of either *O. lurida* or its sibling species, *O. conchaphila,* in Mexico.

With the exception of the introduced oyster drill, *C. inornatum,* and the flatworm *P. ostreophagus,* most of the major *O. lurida* predators can be controlled by shellfish culturists. Ducks are kept away by harassment (D. McMillin, pers. comm.), stingrays are kept out with low fences (Roedel and Ripley 1950), starfish are easily controlled in diked beds (Galtsoff 1929), and anomuran shrimp can be controlled chemically or with deep wooden dikes (Galtsoff 1929). While the oyster drill *Ceratostoma* and the flatworm *Pseudostylochus* seem beyond control, they have not prevented a strong recovery by *O. lurida* in the southwest Puget Sound.

TAXONOMY NOTE

Harry (1985) considers *O. lurida* to be a junior synonym of *Ostreola* (*Ostrea*) *conchaphila* (Carpenter 1857), which had formerly been considered a tropical sibling species to *O. lurida,* and sympatric with it in southern California and the Baja peninsula, Mexico (Hertlein 1959). Hertlein (1959) provides evidence that the 2 species grade into each other, and Abbott and Dance (1986) and Turgeon et al. (1988) have adopted Harry's revision. Harry's work was based only on adult shell and anatomy characteristics, however, and his generic reclassification, reminiscent of an attempted revision by Orton (1928), does not account for the genus *Tiostrea* (Chanley and Dinamani 1980), which is widely accepted in New Zealand and Chilé. Although the evidence is strong for the conclusion that *O. lurida* and *O. conchaphila* at least grade together where sympatric, more work should be done before accepting the generic revision. Because the name *O. lurida* has been used in several hundred scientific papers and fishery publications, compared to very few scientific papers and no fishery publications for *O. conchaphila,* the specific name *lurida* should be retained. This is in accordance with the provisions of Article 79c: suppression of unused senior synonyms, in the International Code of Zoological Nomenclature, 3rd ed., adopted by the 20th General Assembly of the International Union of Biological Sciences. Couch and Hassler (1989), Arakawa (1990), Brock (1990), and Banks et al. (1993) have retained the name *O. lurida.*

The presently favored form of discrimination between similar species is molecular examination of the genetic structure, either in the nucleus or the mitochondria. Some work on cellular DNA content has been done on *O. lurida* by Hinegardner (1974). Wilkins (1976) examined genetic variability at 2 loci within *O. lurida* and other bivalve species, and Buroker (1982) has compared allozyme variation in *O. lurida* and two other *Ostrea* species. Brock (1990) used *O. lurida* in a comparison of genetic distances between 3 oyster genera, while Banks et al. (1993) used *O. lurida* as an out group to compare genetic relatedness of 2 species of *Crassostrea.*

Ostrea Lurida ANNOTATED BIBLIOGRAPHY

Abbott, R. T. 1974. *American Seashells*. 2nd ed. Van Nostrad Reinhold Co., New York, 663 pp.

Abbott, R. T., & S. P. Dance. 1986. *Compendium of Seashells* (Revised Ed.). American Malacologists, Inc., Melbourne, Florida. 411 pp. [*In the main test *Ostrea lurida* is listed by that name on page 318, but in the revisions on page 411 it is listed as *Ostreola conchaphila,* after Harry (1985).]

Ahmed, M. 1975. Speciation in living oysters. *Adv. Mar. Biol.* 13:357–397. [*The author discusses ecological and cytological differences between *Ostrea* and *Crassostrea,* subspecies of *O. lurida,* and speciation of *O. lurida* and other commercial oyster species.]

Ahmed, M., & A. K. Sparks. 1967a. A preliminary study of chromosomes in two species of oysters (*Ostrea lurida* and *Crassostrea gigas*). *J.Fish. Res. Board Can.* 24(10):2155–2159. [*This and following articles by these authors state that the diploid chromosome number *Ostrea lurida* is 20.]

Ahmed, M. & A. K. Sparks. 1967b. Chromosomes of commercial bivalves in the Pacific Northwest. *Research in Fisheries of the University of Washington College of Fisheries* #240:38. [*See Ahmed and Sparks (1967a).]

Ahmed, M. & A. K. Sparks. 1968a. Chromosomes of oysters, clams, and mussels. (Abstract). *Proc. Natl. Shellfish. Assoc.* 58:10. [*See Ahmed and Sparks (1967a).]

Ahmed, M. & A. K. Sparks. 1968b. Chromosomes of oysters and mussels. *Research in Fisheries of the University of Washington College of Fisheries* #280:36–37. [*See Ahmed and Sparks (1967a).]

Aiken, D. 1990. Commercial aquaculture in Canada, and a glance at some prospects for the future. *J. World Aquacult. Soc.* 21(1):67–75. [*"*Ostrea lurida* . . . is highly regarded by oyster gourmets (but) it is a small, slow growing mollusc that is not cultured." Not entirely true; see main text.]

Allen Hancock Foundation, University of Southern California. 1963. An Oceanographic and Biological Survey of the Southern California Mainland Shelf. California State Water Quality Control Board Publication 27. 232 pp. [*The information regarding *Ostrea lurida* was taken directly from Bernard (1959).]

Aplin, J. A. 1967. Biological survey of San Francisco Bay 1963–1966. California Fish and Game Resources Operations MRO #67–4. 131 pp. [**Ostrea lurida* was found alive only once in 6 subtidal sites of central and southern San Francisco Bay, but in 3 of 7 intertidal sites.]

Arakawa, K. Y. 1990. Commercially important species of oysters in the world. *Mar. Behav. Physiol.* 17(1):1–13. [*Distribution, morphology, taxonomy, and commercial status of 10 species, including *Ostrea lurida,* are discussed briefly. Harry (1985) is acknowledged but not followed.]

Arnold, R. 1903. The paleontology and stratigraphy of the marine Pliocene and Pleistocene of San Pedro, California. *Calif. Acad. Sci. Mem.* 3. 420 pp. [**Ostrea lurida* is reported as living in San Pedro Bay (no specific location), and common in lower and recent Pleistocene deposits but absent in Pliocene deposits. *O. lurida* and *O. conchaphila* are listed in the Pleistocene at San Pablo Bay, *O. lurida* possibly at Los Angeles and San Juan Capistrano Pleistocene deposits, and *O. lurida* definitely in the Pleistocene but not the Pliocene of San Diego. Compare with Arnold (1909) and Howard (1935).]

Arnold, R. 1909. Paleontology of the Coalinga district, Fresno and King counties, California. United States Geologic Survey Bulletin 395. 173 pp. [**Ostrea lurida* is reported in the uppermost Miocene at 3 sites in the Etchegoin formation in the southwest hills of the San Joachim

Valley, central California, and in the Pliocene-lower Pleistocene in the Tulare formation in the same region. This bulletin is incorporated into the following reference by Arnold and Anderson (1910), with no new information on *O. lurida*. Compare with Arnold (1903) and Howard (1935).]

Arnold, R. & R. Anderson. 1910. Geology and oil resources of the Coalinga district, California. United States Geologic Survey Bulletin 398. 354 pp. [*See Arnold (1990).]

Atwater, B. F., B. E. Ross & J. F. Wehmiller. 1981. Stratigraphy of late Quaternary estuarine deposits and amino acid stereochemistry of oyster (*Ostrea lurida*) shells beneath San Francisco Bay, California. *Quat. Res.* 16(2):181–200. [*This article discusses the presence of large Pleistocene beds of *Ostrea lurida* beneath San Francisco Bay.]

Bae, G.-M. & P.-A. Bae. 1972. (Growth of transplanted Portugal and Olympia oysters in the Korean coastal waters.) *Bull. Korean Fish. Soc.* 5(1):17–22. (In Korean with English summary.) [**Ostrea lurida* was transplanted from Japan to estuarine waters with salinities of 24–32 ppt. Individuals grew well at temperatures of 16°C. and above.]

Baker, P. 1988. Predation on an introduced marine snail by native crabs. M.S. Thesis, University of Oregon, Eugene, Oregon. 58 pp. [*This includes a discussion of relative predation by 2 crabs, *Cancer gracilis* Dana 1864 and *Lophopanopeus bellus* (Stimpson, 1860), upon *Ostrea lurida* and other mollusks. *C. gracilis* seems as likely to eat the introduced oyster drill, *Ceratostoma inornatum*, as *O. lurida*.]

Banks, M. A., D. Hedgecock & C. Waters. 1993. Discrimination between closely related Pacific oyster species (*Crassostrea*) via mitochondrial DNA sequence coding for large subunit rRNA. *Mol. Mar. Biol. Biotechnol.* 2(3):129–136. [**Ostrea lurida* is used by the authors as an out group to compare genetic relatedness of 2 species of *Crassostrea*.]

Barnard, J. L. 1970. Benthic ecology of Bahia San Quintin, Baja California. Smithsonian Contributions to Zoology #44:60 pp. [**Ostrea lurida* is listed as present intertidally, but is apparently uncommon.]

Barnard, J. L., O. Hartman & G. F. Jones. 1959. Benthic biology of the mainland shelf of southern California. *In: Oceanic Survey of the Continental Shelf Area of Southern California*. pp. 265–429. California State Water Control Board Publication #20. [**Ostrea lurida* is reported as common in clusters on rocks in Newport Bay, in association with the barnacle *Chthamalus dalli* and various sessile polychaetes. This information is reprinted in Allan Hancock Foundation (1963) report to the California State Water Quality Control Board.]

Barner, D. C. 1981. Shell and archaeology: an analysis of shellfish procurement and utilization on the central Oregon coast. M.A. Thesis, Oregon State University, Corvallis, Oregon. 122 pp. [*This includes a summary of archaeological sites in Washington, Oregon and northern California with *Ostrea lurida* and other shellfish remains. *O. lurida* is a major component of a site at Willapa Bay, WA, and another near Patrick's Point, CA. See also Elsasser and Heizer (1966) and Kidd (1967).]

Barrett, E. M. 1963. The California oyster industry. California Fish and Game Bulletin 123. 103 pp. [*This is a careful and comprehensive study of the history of oyster harvest and culture in California, including a summary of *Ostrea lurida* harvest and culture, but is mainly concerned with other species of oysters.]

Beck, W. J., C. B. Kelly, J. C. Hoff & M. W. Presnell. 1966. Bacterial depuration studies on west coast shellfish. *Natl. Conf. Depur.* Kingston, Rhode Island. 10 pp. [**Escherichia coli* in *Ostrea lurida* is depurated to accepted standards within 48 hours in summer and autumn, but requires over 72 hours in winter.]

Becker, C. D. 1955. Larval setting and survival of young oysters, *Ostrea lurida* Carp., under laboratory conditions. M.S. Thesis, Oregon State College, Corvallis, Oregon. 97 pp. [*This was one of 5 M.S. theses about *Ostrea lurida* larval culture to come out of Oregon State College during this period. See also Breese (1953), Morris (1948), Pasquale (1953), and Warren (1951).]

Bernard, F. R. 1969. The parasitic copepod *Mytilicola orientalis* in British Columbia bivalves. *J. Fish. Res. Board Can.* 26(1):13–25. [*This introduced species infests a number of bivalve hosts, including *Ostrea lurida*. See also Bradley and Seibert (1978) and Odlaug (1946).]

Bernard, F. R. 1983. Catalogue of the living Bivalvia of the eastern Pacific Ocean. Canadian Special Publication in Fishery and Aquatic Sciences 61, vii + 102 pp.

Bonnot, P. 1932. Commercial fishery notes: oyster growing in California. *Calif. Fish Game* 18(1):63–64. [*This and the following articles by Bonnot through 1939 deal mainly with an ultimately unsuccessful attempt to introduce *Ostrea lurida* dike culture to Humbolt Bay, California.]

Bonnot, P. 1935. The California oyster industry. *Calif. Fish Game* 21(1): 65–80. [*See also other articles by Bonnot (1932–1939).]

Bonnot, P. 1936. Report of the oyster investigations at Humbolt Bay for 1935. *Calif. Fish Game* 22(4):284–294. [*See also other articles by Bonnot (1932–1939).]

Bonnot, P. 1937a. Report on the California oyster industry for 1936. *Calif. Fish Game* 23(2):163–173. [*See also other articles by Bonnot (1932–1939).]

Bonnot, P. 1937b. Setting and survival of the Olympia oyster, *Ostrea lurida*, on upper and lower horizontal surfaces. *Calif. Fish Game* 23(3):224–228. [*See also other articles by Bonnot (1932–1939). This should be read in conjunction with Hopkins (1937).]

Bonnot, P. 1938. Report on the California oyster industry for 1937. *Calif. Fish Game* 24(2):191–195. [*See also other articles by Bonnot (1932–1939).]

Bonnot, P. 1939. Methods of collecting oyster spat. *Trans. Am. Fish. Soc.* 69:263–267. [*See also other articles by Bonnot (1932–1938).]

Bonnot, P. 1940. The edible bivalves of California. *Calif. Fish Game* 26(3):212–239. [*This gives a brief description of and range for *Ostrea lurida*.]

Bradford, W. L. & S. N. Luoma. 1980. Some perspectives on heavy metal concentrations in shellfish and sediment in San Francisco Bay, California. *In: Contaminants and Sediments*, Vol. 2. R. A. Baker (ed.). pp. 501–532. Ann Arbor Science Publishing, Inc. Ann Arbor, Michigan. [*As of 1979, all shellfish harvesting for human consumption in San Francisco Bay, including for *Ostrea lurida*, was prohibited because of bacterial contamination, but not because of heavy metals.]

Bradley, W. & A. E. Seibert, Jr. 1978. Infection of *Ostrea lurida* and *Mytilus edulis* by the parasitic copepod *Mytilicola orientalis* in San Francisco Bay, California. *Veliger* 21(1):131–134. [*This is the most recent discussion of this introduced parasite in *Ostrea lurida*. See also Bernard (1969) and Odlaug (1946).]

Bradshaw, J., B. M. Browning, K. Smith & J. W. Speth. 1976. The natural resources of Agua Hedionda Lagoon. California Department of Fish and Game Coastal Wetlands Series #16. 145 pp. [**Ostrea lurida* is found in low numbers on riprap in the dredged mouth of the lagoon. Compare to Mudie et al. (1974).]

Breese, W. P. 1953. Rearing of the native Pacific coast oyster larvae, *Ostrea lurida*, under controlled laboratory conditions. M.S. Thesis, Oregon State College, Corvallis, Oregon. 46 pp. [*This is the most thorough of the experiments during this period on *Ostrea lurida* larval culture, but modern methods make much of it obsolete. See also Becker (1955), Morris (1948), Pasquale (1953), and Warren (1951).]

Breese, W. P. 1969. Practical problems of phasing an oyster hatchery into production. (Abstract). *Proc. Natl. Shellfish. Assoc.* 60:13.

Breese, W. P. & W. Q. Wick. 1974. Oyster farming: culturing, harvesting, and processing a product of the Pacific Coast area. Oregon State University Sea Grant Marine Advisory Program, SG #13. 8 pp. [*A non-scientific brochure for the beginning oyster farmer. It is mentioned that *Ostrea lurida* is cultured in Yaquina Bay and Netarts Bay, in Oregon.]

Brock, V. E. 1960. The introduction of aquatic animals into Hawaiian waters. *Int. Rev. Gesamten Hydrobiol.* 45(4):463–480. [*Three thousand *Ostrea lurida* were imported to Manana, Oahu, in 1893, but did not survive.]

Brock, V. E. 1990. Intergenetic distances between *Ostrea*, *Crassostrea*, and *Saccostrea*, studied by means of crossed immunoelectrophoresis.

Mar. Ecol. Prog. Ser. 68(1–2):59–63. [**Ostrea lurida* was used, along with *O. edulis*, to compare genetic distances between the 3 genera. Harry (1985) was acknowledged but not followed.]

Browning, B. M. 1972. The natural resources of Elkhorn Slough: their present and future use. California Department of Fish and Game Coastal Wetland Series #4. 121 pp. [**Ostrea lurida* were once abundant in the slough, but in 1926 they were harvested heavily, and by the writing of this manuscript they were absent.]

Buroker, N. E. 1982. Allozyme variation in three nonsibling *Ostrea* species. *J. Shellfish Res.* 2(2):157–163. [*The proportions of polymorphic loci and genetic similarities between *Ostrea lurida*, *O. edulis*, and *O. permollis* were determined and compared.]

Buroker, N. E. 1983. Allozyme variation in three nonsibling *Ostrea* species. (Abstract.) *J. Shellfish Res.* 3(1):85. [*See Buroker (1982).]

Buroker, N. E. 1985. Evolutionary patterns in the family Ostreidae: larviparity versus oviparity. *J. Exp. Mar. Biol. Ecol.* 90(3):233–247. [*The author argues that *Ostrea* species, which are larviparous, experience greater variability within a species in genetic, environmental, and life history traits than do oviparous oysters, which have (according to this paper), longer planktonic periods. However, the reported environmental and life history traits reported for *Ostrea lurida* in Buroker's paper do not adequately reflect the important literature for this species, with the result that a partially fictitious oyster is described. If this is true for other oyster species used in this paper, the conclusions may be suspect.]

Burrell, J. B., Jr. 1985. Oyster culture. *In: Crustacean and Mollusks Aquaculture in the United States*. J. V. Humer and E. E. Brown (eds.). pp. 235–273. Avi Publishing Co., Westport, Connecticut. [*A brief description of *Ostrea lurida* dike culture, predators, and life history is given.]

Butler, P. A. 1971. Influences of pesticides on marine ecosystems. *Proc. R. Soc. Lond. Ser B Biol. Sci.* 177:321–329.

Cardwell, R. D., S. Olsen, M. I. Carr & E. W. Sanborn. 1979. Causes of oyster larvae mortality in South Puget Sound. National Oceanic and Atmospheric Administration Technical Memorandum ERL–NESA–39. 73 pp. [*Although this is mainly about the possible effects of dinoflagellates on *Crassostrea gigas*, on page 22 the authors state that they believe the dinoflagellates *Gymnodinium splendens* and *Ceratium fusum* to be responsible for heavy *Ostrea lurida* mortalities. This is in contrast to the opinion of D. McMillin (in main text).]

Carlton, J. T. 1979. History, biogeography, and ecology of the introduced invertebrates of the Pacific Coast of North America. Ph.D. Thesis, University of California, Davis, California. 904 pp. [*This is primarily about introduced invertebrates, and includes a review of the important literature regarding introduced oyster predators, including *Ceratostoma inornatum*, *Urosalpinx cinerea*, and *Pseudostylochus ostreophagus*. In addition, man-made changes that adversely affected native estuarine invertebrates such as *Ostrea lurida* are discussed.]

Carlton, J. T. 1988. Introduced marine and maritime invertebrates, plants and fish in Coos Bay, Oregon. Oregon Institute of Marine Biology, Charleston, Oregon. 66 pp. [**Ostrea lurida* is considered an introduced species in Coos Bay, because it was apparently absent for a period between early European settlement and sometime in the 1980s. This report is available from the Oregon Institute of Marine Biology.]

Carpenter, P. P. 1864a. Diagnoses de mollesques nouveaux provenent de Californie et faisant partie du musee de l'institution Smithsonienne. *J. Conchyliol.* XII, Series 3. 5:129–138. [*This contains the original description of *Ostrea lurida*. This article was reprinted on pages 295–317 in the Smithsonian Misc. Collections, Vol. X.]

Carpenter, P. P. 1864b. Supplementary report on the present state of our knowledge with regard to the mollusca of the west coast of North America. *Report of the British Association for the Advancement of Science for 1863:* 517–686. [*This is a discussion of works by other authors, and because Carpenter discusses each manuscript separately, and because most genera and species have been changed since then, it is very difficult to follow. *Ostrea lurida* is mentioned on pages 590, 591?, (on 599 as *O. edulis*?), 606, 615, 645, 646, and 666. This was reprinted in the Smithsonian Miscellaneous Collections, Vol. X, along with a number of other articles by Carpenter under the heading "The mollusks of western North America," pp. 1–446.]

Carpenter, P. P. 1872. The mollusks of western North America. Smithsonian Miscellaneous Collection #252. 325 pp. [*See Carpenter, 1864a, 1864b.]

Chapman, W. M. & A. H. Banner. 1949. Contributions to the life history of the Japanese oyster drill, *Tritonalia japonica*, with notes on other enemies of the Olympia oyster, *Ostrea lurida*. Washington Department of Fisheries Biological Report #49A:168–200. [*This is one of the important studies (see also Chew, 1960) on *Ceratostoma inornatum* (= *Tritonalia japonica*) as a predator on *Ostrea lurida*, and contains the best discussion of several other species of commercial oyster pest.]

Cheng, T. C. 1967. Marine mollusks as hosts for symbioses, with a review of known parasites of commercially important species. *Adv. Mar. Biol.* 5:1–424. [**Pseudostylochus ostreophagus* (a predator) and *Mytilicola orientalis* (a parasite) are reviewed, among others. See also Odlaug (1946) and Woelke (1957).]

Chew, K. K. 1960. Study of food preference and rate of feeding of Japanese oyster drill, *Ocinebra japonica* (Dunker). Fish and Wildlife Service Special Scientific Report—Fisheries #365. 27 pp. [*Along with Chapman and Banner (1949), this is the most important discussion of *Ceratostoma inornatum* as an *Ostrea lurida* predator. *Ocinebra* is an incorrect spelling of *Ocenebra*, and *Ocenebra japonica* is a synonym of *Ceratostoma inornatum*.]

Chew, K. K. 1988. Oyster aquaculture in the Pacific Northwest. *Proceedings of the 4th Alaska Aquaculture Conference*. Alaska Sea Grant Report 88–4. pp. 67–76. [*This briefly mentions that *O. lurida* production in Puget Sound, Washington, is slowly increasing.]

Chew, K. K. 1990. Global bivalve shellfish introductions. *World Aquacul.* 21(3):9–22. [*Included is a brief discussion of the decline of *Ostrea lurida* culture, in the context of *Crassostrea gigas* introductions.]

Chew, K. K. & Eisler, R. 1958. A preliminary study of the feeding habits of the Japanese oyster drill, *Ocinebra japonica*. *J. Fish. Res. Board Can.* 15(4):529–535. [*See Chew (1960).]

Chew, K. K., A. K. Sparks & S. C. Katkansky. 1964a. First record of *Mytilicola orientalis* Mori in the California mussel *Mytilus californianus* Conrad. *J. Fish. Res. Board Can.* 21(1):205–207. [**Mytilicola* infections were lower in *O. lurida* than in *M. californianus* and *M. edulis*.]

Chew, K. K., A. K. Sparks & S. C. Katkansky. 1964b. *Mytilicola* and other parasite infections in some bivalves. Research in Fisheries of the University of Washington School of Fisheries #166:60–63. [*This, along with works by Sparks et al., briefly mention some parasites in *Ostrea lurida* and other bivalves. See also Chew et al. (1964a).]

Clark, R. C., Jr., J. S. Finley & G. G. Gibson. 1974. Acute effects of outboard motor effluent on two marine shellfish. *Environ. Sci. Technol.* 8(12):1009–1013. [*This article concluded that this form of pollution had a greater effect on *Mytilus edulis* than on *Ostrea lurida*.]

Clifton, H. E. 1983. Discrimination between subtidal and intertidal facies in Pleistocene deposits, Willapa Bay, Washington. *J. Sediment. Petrol.* 53(2):353–369. [*Large deposits of Pleistocene *Ostrea lurida* shells aided in local sedimentary deposit identification.]

Coe, W. R. 1930. The life cycle of the California oyster (*Ostrea lurida*). *Anat. Rec.* 47:359. [*This, and the following articles by Coe (1931–1934), and Coe and Allen (1937) contain the most complete information on the natural history of *Ostrea lurida* in southern California.]

Coe, W. R. 1931a. Sexual rhythm of the California oyster (*Ostrea lurida*). *Science* 74(1914):247–249. [*See also Coe (1930–1934).]

Coe, W. R. 1931b. Spermatogenesis in the California oyster (*Ostrea lurida*). *Biol. Bull.* 61(3):309–315. [*See also Coe (1930–1934).]

Coe, W. R. 1932a. Development of the gonads and the sequence of the sexual phases in the California oyster (*Ostrea lurida*). Bulletin of the Scripps Institute of Oceanography, University of California, Technical Series 3(6):119–144. [*See also Coe (1930–1934).]

Coe, W. R. 1932b. Season of attachment and rate of growth of sedentary

marine organisms at the pier of the Scripps Institute of Oceanography, La Jolla, California. Bulletin of the Scripps Institute of Oceanography, University of California, Technical Series 3(3):37–86. [*See also Coe (1930–1934), Coe and Allen (1937).]

Coe, W. R. 1934. Alternation of sexuality in oysters. *American Naturalist* 68(1):1–16. [*See also Coe (1930–1934).]

Coe, W. R. & W. G. Allen. 1937. Growth of sedentary marine organisms on experimental blocks and plates for nine successive years. Bulletin of the Scripps Institute of Oceanography, Technical Series 4(4):101–136. [*See also Coe (1930–1934).]

Couch, D. & T. J. Hassler. 1989. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest)—Olympia oyster. U.S. Fish & Wildlife Service Biological Report 82(11.124), 8 pp. [*This is a summary of much of the important *O. lurida* literature.]

Dall, W. H. 1897. Editorial correspondence: Marshfield, Oregon (Coos Bay) Aug. 23, 1897. *Nautilus* 11(6):66. [*Dall mentions that *Ostrea lurida* is extinct in Coos Bay, Oregon, but is present in Indian shell middens. See also Carlton (1988).]

Dall, W. H. 1914. Notes on west American oysters. *Nautilus* 28(1):1–3. [*Carpenter's form *rufoides* of *Ostrea lurida* (1864) is long and thin and is found growing in currents, while the flattened form *expansa* (Carpenter, 1864a) is typical of specimens adhering to flat surfaces. See also Hertlein (1959).]

Dall, W. H. 1921. Summary of the marine shellbearing mollusks of the northwest coast of America, from San Diego, California, to the Polar Sea, mostly contained in the collection of the United States National Museum, with illustrations of hitherto unfigured species. United States National Museum Bulletin 112. 215 pp.

Davis, H. C. 1949. On cultivation of larvae *Ostrea lurida*. (Abstract). *Anat. Rec.* 105:111.

Davis, H. C. 1950a. On interspecific hybridization in *Ostrea*. *Science* 111(2889):522. [**Ostrea lurida* sperm will not fertilize or activate *Crassostrea virginica* eggs. See also Stafford (1913).]

Davis, H. C. 1950b. On the culture of oyster larvae in the laboratory. National Shellfisheries Association Addresses. June 1949:33–38. [*See also Davis (1961).]

Davis, H. C. 1955. Mortality of Olympia oysters at low temperatures. *Biol. Bull.* 105(3):404–405. [**Ostrea lurida* transplanted to Connecticut suffer 100% mortality in the winter, even when placed subtidally.]

Davis, H. C. & P. E. Chanley. 1955. Effects of some dissolved substances on bivalve larvae. *Proc. Natl. Shellfish. Assoc.* 46:59–74. [*This is a discussion of dissolved organic substances as nutrition.]

Di Girolamo, R. G. 1970a. The uptake, elimination, and effect of processing on the survival of poliovirus in west coast oysters. Ph.D. Thesis, University of Washington, Seattle, Washington. 178 pp. [*See Di Girolamo et al. (1970a, 1972, 1975).]

Di Girolamo, R. G. 1970b. The uptake, elimination, and effect of processing on the survival of poliovirus in west coast oysters. Dissertation Abstracts 31B:821. [*See Di Girolamo et al. (1970a, 1972, 1975).]

Di Girolamo, R. G., J. Liston, J. R. Matches & A. K. Sparks. 1969. Viral accumulation and elimination by Pacific Coast shellfish. Research in Fisheries of the University of Washington School of Fisheries #300:72–74. [*See Di Girolamo et al. (1970a, 1972, 1975).]

Di Girolamo, R. G., J. Liston & J. R. Matches. 1970a. Survival of poliovirus in chilled, frozen, and processed oysters. *Appl. Microbiol.* 20(1):5863. [*This discusses the uptake, presence, and elimination of poliovirus in *Ostrea lurida* and other oysters for human consumption. See also Di Girolamo et al. (1972, 1975).]

Di Girolamo, R. G., J. Liston, J. R. Matches & A. K. Sparks. 1970b. Survival of poliovirus in chilled, frozen, and processed oysters. Research in Fisheries of the University of Washington School of Fisheries #320:43–44. [*See Di Girolamo et al. (1970a, 1972, 1975).]

Di Girolamo, R. G., J. Liston & J. R. Matches. 1972. Effects of irradiation on the survival of virus in west coast oysters. *Appl. Microbiol.* 24(6):1005–1006. [*See also Di Girolamo et al. (1970a, 1975).]

Di Girolamo, R. G., J. Liston & J. R. Matches. 1975. Uptake and elimination of poliovirus in west coast oysters. *Appl. Microbiol.* 29(2):260–264. [*See also Di Girolamo et al. (1970a, 1972).]

Dimick, R. E. & J. B. Long. 1939. Investigations of the native oyster in Yaquina Bay, Oregon, progress report 1, covering the period July 4 to September 15, 1939. Oregon Agricultural Experiment Station, Corvallis, Oregon, unpublished. [*This and the following paper are the most important descriptive studies on the natural history of *Ostrea lurida* in Oregon. The second paper (Dimick et al. 1941.) summarizes the first, and goes into detail on hydrographic conditions, natural history, and population parameters. They are available at the Oregon State Library.]

Dimick, R. E., G. England & J. B. Long. 1941. Native oyster investigations of Yaquina Bay, Oregon, progress report 2, covering the period July 4, 1939 to September 30, 1941. Oregon Agricultural Experiment Station, Corvallis, Oregon, unpublished. [*See Dimick and Long (1939).]

Donaldson, J. 1981. Hatchery rearing of the Olympia oyster. (Abstract). *J. Shellfish Res.* 1(1):131.

Donaldson, J. 1988. Overview of an operating oyster hatchery. Proceedings of the 4th Alaska Aquaculture Conference. Alaska Sea Grant Report 88–4. pp. 77–81. [*This article states that hatchery rearing of *O. lurida* is not cost-effective, given the present price of *O. lurida*.]

Edmondson, C. H. 1920. Edible Mollusca of the Oregon Coast. Bernice Bishop Museum Occasional Papers Vol. 7, No. 9:179–201. [**Ostrea lurida* was present in Yaquina and Netarts Bays, and in Coos Bay, where it had been introduced several years previously. Recruitment of *O. lurida* was reported in Coos Bay. This report also repeats the "old Indian story" that about 80 years previously (1840s), a large forest fire had lead to the extinction of *O. lurida* in Coos Bay.

Edmondson, C. H. 1923. Shellfish resources of the Northwest Coast of the United States. Appendix III to Report of the U.S. Commissioner of Fisheries for 1922, Bureau of Fisheries Doc. #920. 21 pp. [*This article is the best of the readily available early records of shellfish utilization on the Oregon coast, and should be read with Galtsoff (1929).]

Eisenberg, J. M. 1981. *A Collector's Guide to Seashells of the World*. McGraw Hill Book Co., New York. 239 pp. [**Ostrea luridais* listed as Figure 15 on page 157, but the accompanying photograph is not of *O. lurida*. Figure 14 is probably *O. lurida*.]

Elsasser, A. B. & R. F. Heizer. 1966. Excavation of two northwestern California sites. Report of the California Archaeological Survey #67: 1–151. [**Ostrea lurida* shells were found to be a major part of an Indian shell midden near Patrick's Point, indicating a past population of *O. lurida* in that area.]

Elsey, C. R. 1933. Oysters in British Columbia. *Bull. Biol. Board Can.* 34. 34 pp. [*Included is the best discussion of *Ostrea lurida* culture in British Columbia, with a map of commercial sites. Most work was done in Boundary Bay and Ladysmith Harbor. It is stated that the introduced drill *Urosalpinx cinerea* destroys 10–20% of juvenile *O. lurida* in Boundary Bay. *Saxidomus nuttalli* Conrad 1837 (butter clam) shells were preferred (by culturists) *O. lurida* cultch.]

Elsey, C. R. 1934. On the structure and function of the mantle and gills of *Ostrea gigs* (Thunberg) and of *Ostrea lurida* (Carpenter). Ph.D. Thesis, Rutgers University, New Jersey. 65 pp. (52 pages of unnumbered tables and figures). [*See Elsey (1935).]

Elsey, C. R. 1935. On the structure and function of the mantle and gill of *Ostrea lurida* and *Ostrea gigas*. *Trans. R. Soc. Can.* 48 (Section 5):131–160. [*This is a careful anatomical study of *O. lurida* and includes good illustrations. It is taken from Elsey (1934).]

Elston, R. A. 1990. *Mollusc Diseases: Guide for the Shellfish Farmer*. University of Washington Press, Seattle, WA. 73 pp. [*On page 24, the author states that *Hexamita* "has been established" as a disease-causing agent in *Ostrea lurida*, citing Stein and Denison (1959). See annotation under Stein and Denison (1959), however.]

Erickson, J. H. 1966. Bacteriological studies on commercial processing of Olympia oysters (*Ostrea lurida*). *In: 1965 Proceedings of the Northwest Shellfish Sanitation Research Planning Conference*. W. J. Beck & J. C. Hoff (eds.). pp. 23–31. U.S. Department of Health, Educa-

tion, and Welfare Public Health Service Publication 999–FP–6. [*This study shows how bacteria increases in processed *Ostrea lurida* stored at varying temperatures. See also Vasconcelos (1966a).]

Farley, C. A. 1978. Viruses and virus-like lesions in marine mollusks. *Mar. Fish. Rev.* 40(1):18–20. [*This and following articles mainly review previous literature, especially that of Mix et al. (1970–77) in reference to *Ostrea lurida*.]

Farley, C. A. 1985. Viral gametocyte hypertrophy in oysters. International Council for the Exploration of the Sea; Identification Leaflets for Diseases and Parasites of Fish and Shellfish #25. 4 pp. [*See Farley (1978).]

Farley, C. A. 1988. Mass mortalities and infectious lethal diseases in bivalve mollusks and associations with geographic transfers of populations. (Abstract). *J. Shellfish Res.* 7(3):554. [*Sarcoma epizootics cause "serious mortalities" in *Ostrea lurida* in Oregon.]

Farley, C. A. & A. K. Sparks. 1970. Proliferative diseases of hemocytes, epithelial cells, and connective tissue cells in mollusks. *Bibliogr. Haematol.* 36:610–617. [*See Farley (1978).]

Farley, C. A., P. H. Wolf & R. a. Elston. 1988. A long-term study of "microcell" disease in oysters with a description of a new genus, *Mikrocytos* (g.n.), and two new species, *Mikrocytos mackini* (sp.n.) and *Microcytos roughleyi* (sp.n.). *Fish. Bull.* 86(3):581–593. [**Mikrocytos mackini* is found in *Crassostrea gigas*, *Ostrea edulis*, and *O. lurida*, where it is found in vesicular connective tissue, and causes abscess-like inflammatory lesions. In *C. gigas* and *O. edulis* it can cause high mortalities in British Columbia, and although no mortality studies were done for *O. lurida*, the 2 February samples out of 2 years (1969–70) of monthly samples from Yaquina Bay, Oregon had 24% and 12% infection rates in *O. lurida*. In other months there were no "microcells," but neoplastic lesions and *Mytilicola orientalis* infections were frequent.]

Fasten, N. 1931. The Yaquina oyster beds of Oregon. *Am. Nat.* 45(700): 434–468. [*This article is not as exhaustive as Dimick (1939) and Dimick (1941), but is much easier to acquire. It discusses aspects of the harvest, pollution, and ecology of *Ostrea lurida* in Yaquina Bay.]

Filice, F. P. 1958. Invertebrates from the estuarine portion of San Francisco Bay and some factors influencing their distributions. *Wasmann J. Biol.* 1692);159–211. [*A very few living *Ostrea lurida* were found in San Pablo Bay, within San Francisco Bay (compare to Packard 1918b), intertidally to 6 m in depth. Salinities were 18.0–19.6 ppt.]

Fitch, J. E. 1953. Common marine bivalves of California. California Fish and Game Fish Bulletin #90. 102 pp. [*Although often cited, this contains only a brief paragraph on *Ostrea lurida*, and no new information.]

Freudenberg, W. 1934. Preliminary analysis of British Columbia oysters. Biological Board of Canada, Progress Reports of the Pacific Coast Stations #20:16–18. [*As of 1932, *Ostrea lurida* apparently was still taken commercially from Victoria and Crescent harbors, and Ladysmith and Nanoose Bays, in British Columbia.]

Galtsoff, P. S. 1929. Oyster industry of the Pacific coast of the United States. Appendix VIII to Report of the U.S. Commissioner of Fisheries for 1929, Bureau of Fisheries Doc. #1066:367–400. [*This is a comprehensive article on oyster culture of that period, and includes some information on enemies of *O. lurida* in the Puget Sound that is rarely reported elsewhere. It should be read in conjunction with Edmondson (1923).]

Galtsoff, P. S. 1932. Introduction of Japanese oysters into the United States. Bureau of Fisheries Fishery Circular #12. 16 pp. [*Galtsoff feared that *Crassostrea gigas* would become an important competitor of *Ostrea lurida* (contrast to Griffin 1941, and Steele 1957).]

Galtsoff, P. S. 1949. The oyster and oyster industry of the United States. U.S. Fish and Wildlife Service Fishery Leaflet 187. 10 pp. [*This updates Galtsoff (1929) with regard to the Pacific coast oyster industry.]

Galtsoff, P. S. 1964. The American Oyster. *Fish. Bull.* 64:1–480. [*Various aspects of *Ostrea lurida* reproduction and ecology are compared to those of *Crassostrea virginica*, but most of the document is about *C. virginica*.]

Gibson, G. G. 1974. Oyster mortality study summary report 1966–72. Fish Commission of Oregon, Management and Research Division: Newport, Oregon. 37 pp. [*This includes several studies of physiological tolerances of *Ostrea lurida*.]

Gilbert, C. H. 1891. Report upon certain investigations relating to the planting of oysters in southern California. *Bull. U.S. Comm. Fish.* 9:95–98. [*Along with Townsend (1893), this is one of the most important discussions of early *Ostrea lurida* distribution in southern California.]

Glude, J. B. 1948. Oyster investigation. Washington Department of Fisheries 1947 Annual Bulletin. pp. 17–20. [*This bulletin and other Washington Department of Fisheries publications contained brief mention of *Ostrea lurida* culture into the 1960s, tracking the decline and temporary collapse of the dike culture industry. See also Glude et al. (1946), Lindsay et al. (1948–1958), Westley (1959–1963), and Woelke (1956–1959).]

Glude, J. B. 1975. A summary report of Pacific coast oyster mortality investigations 1965–1972. Proceedings of the Third U.S.-Japan Meeting on Aquaculture, 1974. Special Publication of the Japanese Fishery Agency and the Japan Sea Regional Fisheries Research Laboratory: pp. 1–28. [*This article is mostly about *Crassostrea gigas* but briefly discusses the research to date on neoplastic disorders in *Ostrea lurida*.]

Glude, J. B., V. Tartar & R. Tollefson. 1946. Review of recent spawning and setting seasons. Washington Department of Fisheries Olympia Oyster Bulletin. 4 pp.

Gooding, D. & R. N. Ward. 1953. Shellfish research. Washington Department of Fisheries 62nd Annual Report. pp. 72–81. [*See Glude (1948).]

Grant, U. S., IV & H. R. Gale. 1931. Catalogue of the Marine Pliocene and Pleistocene Mollusca of California and Adjacent Regions. Memoirs of the San Diego Society of Natural History 1. 1036 pp.

Griffin, E. 1941. *Oysters Have Eyes, or The Travels of a Pacific Oyster*. Wilberilla Publishers, Seattle, Washington. 53 pp. [*This is mainly about *Crassostrea gigas* culture in Willapa Bay, Washington, and only briefly mentions *Ostrea lurida* exploitation (pp. 5–6). On page 43, Griffin states that the shells of *Crassostrea gigas* provide important settlement space for *O. lurida* juveniles. Contrast with Galtsoff (1932).]

Gunter, G. 1950. The generic status of living oysters and, the scientific names of the common American species. *Am. Mid. Nat.* 43(2):438–499. [*This discusses generic differences between *Crassostrea* and *Ostrea*.]

Gunter, G. & G. McKee. 1960. On oysters and sulfite waste liquor. Special Consultants' Report to the Washington Pollution Control Commission. 93 pp. [*This is a comprehensive report on all aspects of pulp mill pollution and oysters in the southwest Puget Sound, Washington, but relies heavily on other work, especially Hopkins et al. (1935), McKernan et al. (1949), Odlaug (1949), and Stein et al. (1959a). The biological conclusions are that pulp mill pollution is deleterious, if not outright toxic, to *Ostrea lurida*.]

Haderlie, E. C. & D. P. Abbott. 1980. Bivalvia. *In: Intertidal Invertebrates of California*. R. H. Morris, D. P. Abbott & E. C. Haderlie (eds.). pp. 355–411. Stanford University Press, Stanford, California. [*On page 364 is a short but excellent review of the natural history of *Ostrea lurida*.]

Harry, H. W. 1985. Synopsis of the supraspecific classification of living oysters (Bivalvia: Gryphaeidae and Ostreidae). *Veliger* 28(2):121–158. [*In this paper, Harry has revised most oyster taxonomy at the genus and species level. *Ostrea lurida* is declared a junior synonym of *Ostreola* (formerly *Ostrea*) *conchaphila* (Carpenter 1857), with a range of Alaska to Panama. The American Fisheries Society (Turgeon et al. 1988) and Abbott and Dance (1986) have adopted this revision, but authors of other recent publications have not.]

Harry, H. W. 1986. The relevancy of the generic concept to the geographic distribution of living oysters (Gryphaeidae and Ostreidae). *Am.*

Malacol. Bull. 4(2):157–162. [*The author presents an apparent correlation of oyster generic relatedness with geography, but this scheme depends on his own extensive generic revisions (Harry 1985).]

Hedgepeth, J. W. & S. Obrebski. 1981. Willapa Bay: a historical perspective and a rationale for research. Fish and Wildlife Service Biological Services Program AFWS/OBS–81/03. 60 pp. [*This article briefly records the history of *Ostrea lurida* harvests in Willapa Bay.]

Henderson, J. 1935. Fossil non-marine Mollusca of North America. Geological Society of America Special Papers #3. 313 pp. [*This work is a compilation of studies by other authors; in the case of *O. lurida*, Arnold (1909) and Arnold and Anderson (1910).]

Hertlein, L. G. 1959. Notes on California oysters. *Veliger* 2(1):5–10. [*Included is a discussion of *Ostrea lurida* and *O. conchaphila* in southern California. See also Dall (1914).]

Hinegardner, R. 1974. Cellular DNA content of the Mollusca. *Comp. Biochem. Physiol.* 47A(2):447–460. [*The cellular DNA of 110 mollusks, including *Ostrea lurida*, was measured. For *O. lurida*, the DNA content is 1.3 picograms per cell, near the median for mollusks.]

Hoff, J. C. & R. C. Becker. 1961. The accumulation and elimination of crude and clarified poliovirus suspensions by shellfish. *Am. J. Epidemiol.* 90(1):53–61. [**Ostrea lurida* depurated itself of filtered poliovirus to nondetectable levels within 96 hours but initially accumulates more of and takes longer to depurate itself of crude poliovirus. See also Di Girolamo et al. (1970a, 1972, 1975).]

Holmes, H. B. 1927. An investigation of sawdust pollution in relation to oysters in Yaquina Bay. U.S. Bureau of Fisheries, unpublished.

Holway, T. W. 1934. Some observations on the Pacific oyster "*Crassostrea gigas*" Thunberg and the native oyster "*Ostrea lurida*" Carpenter in Willapa Bay. M.S. Thesis, University of Washington, Seattle, Washington. 62 pp. [*The natural history of *Ostrea lurida* is discussed here.]

Hopkins, A. E. 1935a. Attachment of larvae of the Olympia oyster. *Ostrea lurida*, to plane surfaces. *Ecology* 16(1):82–87. [*This, and Hopkins (1936b, 1937), are the most important studies on the natural history and physiology of *Ostrea lurida* in the Puget Sound, and also contain information about oyster culture at that time.]

Hopkins, A. E. 1935b. Temperature and the shell movements of oysters. *Bull. U.S. Bur. Fish.* 47:1–14. [*See Hopkins (1935a).]

Hopkins, A. E. 1936a. Activity of the adductor muscle in oysters. *Physiol. Zool.* 9(4):498–507. [*See Hopkins (1935a).]

Hopkins, A. E. 1936b. Ecological observations on spawning and early larval development in the Olympia oyster (*Ostrea lurida*). *Ecology* 17(4):551–566. [*See Hopkins (1935a).]

Hopkins, A. E. 1936c. Pulsating blood vessels in the oyster. *Science* 83(2163):581. [*See Hopkins (1935a).]

Hopkins, A. E. 1936d. Pulsation of blood vessels in oysters, *Ostrea lurida* and *O. gigas*. *Biol. Bull.* 70(3):413–425. [*See Hopkins (1935a).]

Hopkins, A. E. 1937. Experimental observations on spawning, larval development, and setting in the Olympia oyster *Ostrea lurida*. *Bull. U.S. Bur. Fish.* 48:438–503. [*See Hopkins (1935a).]

Hopkins, A. E., P. S. Galtsoff & H. C. McMillin. 1935. Effects of pulp mill pollution on oysters. *Bull. U.S. Bur. Fish.* 47:125–162. [*This article is written as 3 separate articles within 1 document (by each of the 3 authors above), which are often referenced separately.]

Hori, J. 1933. On the development of the Olympia oyster, *Ostrea lurida* Carpenter, transplanted from the United States of Japan. *Bull. Jpn. Soc. Sci. Fish.* 1(6):269–276. [*This is a careful study of spawning and development of *Ostrea lurida*.]

Howard, P. J. 1935. Report on Buena Vista Hills, a portion of the Midway Sunset oil field. *Calif. Oil Fields* 20:5–22. [*Included are tables of common fossils of this area, in the southwest part of the San Joachim Valley, California. *Ostrea lurida* is common in both estuarine and marine deposits, apparently dating back to the early Pliocene.]

Human, V. L. 1971. The occurrence of *Urosalpinx cinerea* in Newport Bay. *Veliger* 13(3):299. [**Ostrea lurida* is present at Newport Bay, California, as small, scattered individuals.]

Hutchinson, E. N. & B. M. Brennan. 1936. Oyster culture: a natural resource revived. Published by the State of Washington Secretary of State. 14 pp.

Imai, T., S. Sakai, H. Okeda & T. Yoshida. 1954. Breeding of the Olympia oyster in tanks and culture experiments in Japanese waters. *Tohoku J. Agric. Res.* 5(1):13–25. [**Ostrea lurida* spawning under laboratory conditions and in the field in Japan is discussed.]

Ingersoll, E. 1881. *History and Present Condition of the Fisheries Industry: The Oyster Industry*. U.S. Government Printing Office, Washington, D.C. 250 pp. [**Ostrea lurida* is mentioned on pp. 201–202 as the Shoalwater Bay oyster. Commercial harvest in Shoalwater (Willapa) Bay began in 1850, climbed to 250,000 bushels in 1874, and declined to 15,000 bushels in 1880.]

Iversen, E. S. 1968. *Farming the Edge of the Sea*. Fishing News Books Ltd., London, G.B. 301 pp. [**Ostrea lurida* dike culture is mentioned briefly.]

Iwamota, R. N. & K. K. Chew. 1978. Skokomish intertidal shellfish survey. Research in Fisheries of the University of Washington School of Fisheries #480:73. [**Ostrea lurida* is reported in Indian shell middens in northern Washington.]

Johnson, A. G., F. M. Utter & K. Noggol. 1972. Electrophoretic variants of aspartate aminotransferase and adductor muscle proteins in the native oyster (*Ostrea lurida*). *Anim. Blood Groups Biochem. Genet.* 3(2): 109–113.]

Jones, E. J. & A. K. Sparks. 1969. An unusual histopathological condition in *Ostrea lurida* from Yaquina Bay, Oregon. (Abstract). *Proc. Natl. Shellfish. Assoc.* 59:11.

Keen, A. M. 1937. *An Abridged Checklist and Bibliography of West North American Marine Mollusca*. Stanford University Press, Stanford, California. 84 pp. [*This is taken mainly from Dall (1921).]

Keen, A. M. 1944. Check list of California tertiary marine Mollusca. Geological Society of America, Special Paper #56. 280 pp. [*This is compiled from various other sources, such as Howard (1935). Over 30 fossil *Ostrea* species are listed.]

Keen, A. M. 1962. A new West Mexican subgenus and new species of Montacutidae (Mollusca: Pelecypoda), with a list of Mollusca from Bahia de San Quintin. *Pac. Nat.* 3(9):321–328. [*This includes mention of *Ostrea lurida* in Baja California (Mexico).]

Keep, J. 1891. Mollusks of the San Francisco markets. *Nautilus* 4(9):97–100. [*The "native, or Oregon oyster" was found in small numbers in seafood markets at this time, and the name suggest that they were taken from either Yaquina Bay (Oregon) or Willapa Bay (Washington).]

Keep, J., rev. by J. L. Baily, Jr. 1935. *West Coast Shells*. Stanford University Press, Stanford, California. 350 pp.

Kidd, R. S. 1967. The Martin site, southwestern Washington. *Tebiwa* 10:13–30. [**Ostrea lurida* shells make up about 70% of the shells of this American Indian food preparation midden on the west shore of Willapa Bay, Washington.]

Kincaid, T. B. 1928. Development of oyster industry in the Pacific. *Trans. Am. Fish. Soc.* 58:117–122. [*This briefly discusses the decline of the *Ostrea lurida* industry, and mentions that the dike system is copied from the French, but this statement could not be independently confirmed. See also Korringa (1976).]

Kincaid, T. B. 1951. *The Oyster Industry of Willapa Bay, Washington*. Calliostoma Co., Seattle, Washington. 45 pp. [*This non-technical publication includes a brief history of *Ostrea lurida* utilization in Willapa Bay, and a photograph of *O. lurida* larvae.]

Kincaid, T. B. 1957. *Local Races and Clines in the Marine Gastropod Thais lamellosa*. Calliostoma Co., Seattle, Washington. 75 pp. [**Nucella lamellosa* is not a significant predator on *Ostrea lurida*, but mainly consumes mussels and barnacles, potential competitors of the oyster (p. 33).]

Kolbe, E. R., M. J. English & J. R. Miner. 1979. Oyster production in the Pacific Northwest. Oregon Agricultural Experiment Station Technical Paper #5211.

Korringa, P. 1952. Recent advances in oyster biology. *Q. Rev. Biol.* 27(3):266–308 and 27(4):339–365. [*This article is printed in 2 parts in 2 issues of this journal. *Crassostrea* is called *Gryphaea*. "Recent"

means post-1940 for the most part, which was after the majority of the *Ostrea lurida* research, but there are occasional references to *O. lurida*.]

Korringa, P. 1976. *Farming the Flat Oysters of the Genus Ostrea*. Elsevier Scientific Publishing Co., New York. 238 pp. [*Most of 1 chapter is devoted to *Ostrea lurida* culture in Washington State. There is also a description of intertidal "parks" and holding ponds for the culture and harvest of *O. edulis* in France, from which the dike system in Washington may have evolved, in part.]

Kozloff, E. N. 1973. *Seashore Life of the Northern Pacific Coast*. University of Washington Press, Seattle, Washington, 370 pp. [*This is a popular, rather than scientific document. It states that *Ostrea lurida* is a common fouling organism in some parts of San Francisco Bay.]

Kozloff, E. N. 1974. *Keys to the Marine Invertebrates of Puget Sound, the San Juan Archipelago, and Adjacent Regions*. University of Washington Press, Seattle, Washington. 266 pp.

Kuons, R. R. & R. D. Cardwell. 1981. Significant areas for certain species of food fish and shellfish in Puget Sound. Washington Department of Fisheries Technical Report 59. 49 pp. [*This paper discusses present and potential *Ostrea lurida* culture areas.]

Kvenvolden, K. A., D. J. Blunt & H. E. Clifton. 1979. Amino acid racemization in quaternary shell deposits at Willapa Bay, Washington, USA. *Geochim. Cosmochim. Acta* 43(9):1505–1520.

Lindsay, C. E. 1948. Oyster investigations. Washington Department of Fisheries 1948 *Annual Report*. pp. 41–44. [*This bulletin and other Washington Department of Fisheries publications contained brief mention of *Ostrea lurida* culture into the 1960s, tracking the decline and temporary collapse of the dike culture industry. See also Glude et al. (1946), Lindsay et al. (1948–1958), Westley (1959–1963), and Woelke (1956–1959).]

Lindsay, C. E. & D. C. McMillin. 1948. Washington Department of Fisheries Puget Sound Oyster Bulletin, Series VII (1–12). [*This and following references for Lindsay et al. are series of short (1–10 pp.) mimeographs meant for circulation among oyster culturists and researchers. These present collected data on *Ostrea lurida* settlement and mortalities in the southwest Puget Sound, but rarely summarize or discuss it.]

Lindsay, C. E. & D. C. McMillin. 1949. Washington Department of Fisheries Puget Sound Oyster Bulletin, Series VIII (1–14). [*See Lindsay and McMillin (1948).]

Lindsay, C. E., D. C. McMillin, S. E. Sayce & H. E. Wiksten. 1950. Washington Department of Fisheries Puget Sound Oyster Bulletin, Series IX (1–14). [*See Lindsay and McMillin (1948).]

Lindsay, C. E. & S. E. Sayce. 1951. Washington Department of Fisheries Puget Sound Oyster Bulletin, Series X (1–16). [*See Lindsay and McMillin (1948).]

Lindsay, C. E., C. E. Woelke, R. E. Westley & H. E. Wiksten. 1952. Washington Department of Fisheries Puget Sound Oyster Bulletin, Series XI (1–14). [*See Lindsay and McMillin (1948).]

Lindsay, C. E., R. E. Westley & C. E. Woelke. 1953. Washington Department of Fisheries Puget Sound Oyster Bulletin, Series XII (1–4). [*See Lindsay and McMillin (1948).]

Lindsay, C. E., R. E. Westley & C. E. Woelke. 1954. Washington Department of Fisheries Puget Sound Oyster Bulletin, Series XIII (1–14). [*See Lindsay and McMillin (1948).]

Lindsay, C. E., R. E. Westley & C. E. Woelke. 1955. Washington Department of Fisheries Puget Sound Oyster Bulletin, Series XIV (1–11). [*See Lindsay and McMillan (1948).]

Lindsay, C. E., R. E. Westley & S. E. Sayce. 1958. Prediction of oyster setting in the State of Washington. *Proc. Natl. Shellfish. Assoc.* 49: 59–70. [*The authors describe methods used to predict the magnitude of *Ostrea lurida* settlement in the southwest Puget Sound. See also Lindsay and McMillin (1948).]

Lindsay, C. E., C. E. Woelke & R. E. Westley. 1956. Preliminary report on Olympia oyster survival experiment: Oakland Bay and North Bay, October 1953–March 1956. Washington Department of Fisheries Shellfish Lab. 7 pp. [*This reports on the effect of pulp mill pollution on *Ostrea lurida*.]

Loosanoff, V. L. & H. C. Davis. 1963. Rearing of bivalve mollusks. *Adv. Mar. Biol.* 1:1–136. [*Included here is a description of several stages of the larvae of *O. lurida*.]

Loosanoff, V. L., H. C. Davis & P. E. Chanley. 1966. Dimensions and shapes of larvae of some marine bivalve mollusks. *Malacologia* 4(2): 351–435. [*Included are pictures of *Ostrea lurida* larvae throughout development.]

Loosanoff, V. L. & R. R. Marak. 1951. Culturing lamellibranch larvae. *Anat. Rec.* 111:129–130.

MacGinitie, G. E. 1935. Ecological aspects of a California estuary. *Am. Mid. Nat.* 16(5):629–765. [**Ostrea lurida* was abundant in Elkhorn Slough on artifically-placed substrate, especially iron, to 8 km upstream from the mouth.]

MacGinitie, G. E. 1941. On the method of feeding of four pelecypods. *Biol. Bull.* 80(1):18–25. [*The author replaced part of 1 valve of 4 species of Pacific coast bivalves, including *Ostrea lurida*, with a glass plate, and observed the filter feeding mechanism. In all 4 species the feeding method was nearly identical.]

McKee, L. G. 1945. Planting and marketing oysters in the Pacific Northwest. U.S. Fish & Wildlife Service Fishery Leaflet 52. 6 pp. [*It takes 1600–2000 *Ostrea lurida* bodies to fill a gallon, compared to 80–140 *Crassostrea gigas* bodies.]

McKernan, D. L., V. Tartar & R. Tollefson. 1949. An investigation of the decline of the native oyster industry of Washington, with special reference to the effects of sulfite pulp mill waste on the Olympia oyster (*Ostrea lurida*). Washington Department of Fisheries Biological Report #49A:115–165. [*This was a critical pollution study for *O. lurida* in the southwest Puget Sound, and also contains a study on the effects of *Crepidula fornicata* on *Ostrea lurida*, and a discussion of other oyster pests.]

Mackin, J. G. 1971. Oyster culture and disease. *Proceedings of the First Annual Workshop, World Mariculture Society*. pp. 35–38. [*The author states that *Ostrea lurida* suffered heavy mortalities from a haplosporidium disease in southern Puget Sound, Washington, but does not cite a reference for this.]

McLachlan, D. H. & J. Ayers. 1979. *Fieldbook of Pacific Northwest Sea Creatures*. Naturegraph Publishers, Inc., Happy Camp, California. 208 pp. [*There is a color photograph of *Ostrea lurida* on page 123.]

Marchand, M. & F. Cabane. 1980. Hydrocarbures dans les moules et les huitres. *Rev. Int. Oceanogr. Méd.* 59:3–30. (In French with English summary).]

Marriage, L. D. 1954. The bay clams of Oregon: their economic importance, relative abundance, and general distribution. Oregon Fish Commission Contribution 20, 47 pp. [*In 1954, *Ostrea lurida* was apparently present but rare in Netarts Bay, present in Yaquina Bay, and absent in all other Oregon estuaries.]

Matthiessen, G. C. 1970. A review of oyster culture and the oyster industry in North America. Woods Hole Oceanographic Institute Contribution 2528, Woods Hole, Massachusetts. 55 pp. [*This reviews the status of the U.S. and Canada oyster industry, including *Ostrea lurida*, during the 1960s.]

Menzel, R. W. 1968. Chromosome number in nine families of marine pelecypod mollusks. *Nautilus* 82(2):45–50 and plates on pp. 53–58.

Miller, W., III & S. D. Morrison. 1988. Marginal marine Pleistocene fossils from near mouth of Mad River, northern California. *Proc. Calif. Acad. Sci.* 45(10):255–266. [*A well preserved late Pleistocene "oyster garden" contains, in decreasing order of frequency; *Ostrea lurida* in clumps on a mud bottom; the ectoparasitic gastropod *Odostomia nota* Dall and Bartsh, 1909; Balanus sp. (on *O. lurida* shells); the infaunal clam *Protothaca staminea* (Conrad, 1937); the snail *Bittium eschrichtii* (Middendorf, 1849); and 10 less common species of mollusks. Also common in *O. lurida* shells were bore holes of a polychaete, *Polydora* sp.; and a sponge, *Cliona* sp. A bryozoan, a brachyuran crab, seagrass, and fish bones were also preserved. Com-

plete with a sketch of the reconstructed community, this is one of the best estuarine ecological studies of an *Ostrea lurida* community.]

Milne, P. H. 1972. *Fish and Shellfish Farming in Coastal Waters*. Fishing News Books, London. 208 pp. [*The discussion here on intertidal oyster farming in France does not describe anything very similar to the dikes used for *O. lurida*.]

Mix, M. C. 1974. Diseases of shellfish in Yaquina Bay, Oregon. (Abstract). *Proc. Natl. Shellfish. Assoc.* 64:14. [*See Mix (1975a).]

Mix, M. C. 1975a. Proliferative characteristics of atypical cells in native oysters (*Ostrea lurida*) from Yaquina Bay, Oregon. *J. Invertebr. Pathol.* 26(3):289–298. [*This and following articles by Mix et al. deal mainly with neoplastic disorders of *O. lurida*, which do not seem to be significant on a population level. See also Jones and Sparks (1969), Farley and Sparks (1970), and Sparks (1970).]

Mix, M. C. 1975b. The neoplastic disease of Yaquina Bay mollusks. *In: The Cell Cycle in Malignancy and Immunity. Proceedings of the 13th Annual Hanford Biology Symposium*, J. C. Hampton (ed.). pp. 369–386. National Technical Information Service, Springfield, Virginia. [*See Mix (1975a).]

Mix, M. c. 1976a. A general model for leucocyte cell renewal in bivalve mollusks. *Mar. Fish. Rev.* 38(1):37–41. [*This includes a brief discussion of leucocyte genesis in *Ostrea lurida* and 2 photographs of leucocytes. See also Mix (1975a).]

Mix, M. C. 1976b. A review of the cellular proliferative disorders of oysters (*Ostrea lurida*) from Yaquina Bay, Oregon. *Prog. Exp. Tumor Res.* 20:275–282. [*See Mix (1975a).]

Mix, M. C., H. J. Pribble, R. T. Riley & S. P. Tomasovic. 1977. Neoplastic diseases in bivalve mollusks from Oregon with emphasis on research on proliferative disorders in Yaquina Bay oysters. *Ann. N.Y. Acad. Sci.* 298:356–373. [*This paper reports heavy mortalities of *Ostrea lurida* in the late 1950s and early 1960s in Yaquina Bay, Oregon, but concludes that neoplastic disorders are not responsible. This is contrary to the conclusions of Sparks et al. (1970).]

Mix, M. C. & R. T. Riley, 1977. A pericardial tumor in a native (Olympia) oyster, *Ostrea lurida*, from Yaquina Bay, Oregon. *J. Invertebr. Pathol.* 30(1):104–107. [*See Mix (1975a).]

Mix, M. C. & V. Sprague. 1970. Occurrence of a haplosporidium in native oysters (*Ostrea lurida*) from Yaquina Bay and Alsea Bay, Oregon. *J. Invertebr. Pathol.* 23(2):252–254. [**O. lurida* was introduced to Alsea Bay, Oregon, for this study.]

Modin, J. C. 1969. Pesticide concentrations in California bays and estuaries. Proceedings of the Symposium on Mollusca, Cochim, India, Part II. pp. 519–530. [*This reports on the concentrations of organochlorine pesticide residues (DDT, DDD, DDE) in the tissue of *Ostrea lurida* and *Crassostrea gigas* in 6 estuaries in 1967 and 1968. This does not state whether *O. lurida* was tested from all 6 estuaries. Pesticide levels were low in Humbolt Bay, Tomales Bay, and Drakes Estero (mostly less than 15 parts per billion), higher in San Francisco Bay and Morro Bay (mostly 30–100 ppb), and highest in Elkhorn Slough (mostly 150–400 ppb). The highest level was 920 parts per billion for a June 1967 sample in Elkhorn Slough.]

Moore, H. F. 1898. Oysters and methods of oyster culture. Report of the U.S. Commissioner of Fisheries for 1897. 263–340. [*This includes a short discussion of *Ostrea lurida* dike culture.]

Morris, P. A. 1966. *A Field Guide to Shells of the Pacific Coast and Hawaii, Including Shells of the Gulf of California*, 2nd ed. Houghton Mifflin Co., Boston. 297 pp. [*Reprinted 1980 as *Pacific Coast Shells*.]

Morris, R. W. 1948. Experiments of the larval culture of the native oyster, *Ostrea lurida* Carpenter, M.S. Thesis, Oregon State College, Corvallis, Oregon. 46 pp. [*This was the earliest of 5 M.S. theses on the culture of *Ostrea lurida* out of Oregon State College during this time period. See also Becker (1955), Breese (1953), Pasquale (1953), and Warren (1951).]

Mudie, P. J., B. M. Browning & J. W. Speth. 1974. The natural resources of Los Penasquitos Lagoon and recommendations for use and development. California Department of Fish and Game Coastal Wetlands Series #7: 96 pp. [*Prior to the dredging of the mouth, no marine shellfish existed in the lagoon, but within 1 year of dredging, at least 20 marine species, including *Ostrea lurida*, had become established. Compare to Bradshaw et al. (1976).]

Nelson, T. C. 1928. On the distribution of critical temperatures for spawning and for ciliary activity in bivalve Mollusca. *Science* 67(1730):220–221. [*This reviews *Ostrea lurida* research on the effects of temperature.]

Nightengale, H. W. 1936. *Red Tide Organisms: Their Occurrence and Influence on Marine Aquatic Animals with Special Reference to Shellfish in the Waters of the Pacific Coast*. The Argus Press, Seattle, Washington. 24 pp.

Nosho, T. 1989. Small scale oyster farming for plesure and profit. Washington Sea Grant Aquaculture Series WSG–AS 89–1, 12 pp. [*This contains a good description of the biology of *Ostrea lurida* in layman's terms, and mentions that it takes 300 to make a pint of shucked meat.]

Odlaug, T. O. 1946. The effect of the copepod, *Mytilicola orientalis*, upon the Olympia oyster, *O. lurida*. *Trans. Am. Microsc. Soc.* 65(4): 311–317. [*This is the most comprehensive discussion of this parasite in *Ostrea lurida*.]

Odlaug, T. O. 1949. Effects of stabilized and unstabilized waste sulphite liquor on the Olympia oyster, *O. lurida*. *Trans. Am. Microsc. Soc.* 68(2):163–182.]

Oldroyd, I. S. 1924. *The Marine Shells of the West Coast of North America. Pelecypoda and Brachiopoda*. Stanford University Press, Stanford, California. 247 pp. [*This book reproduces the mistakes of earlier authors, but it contains the first paragraph of Carpenter's hard-to-acquire original description (see also Palmer 1958).]

Oldroyd, I. S. 1925. Marine shells of Puget Sound and vicinity. *Publications of the Puget Sound Biological Station* 4:1–271. [*"Vicinity" includes to the Queen Charlotte Islands in northern British Columbia. This merely lists species collected by the author and others, with the sites collected. *Ostrea lurida* is reported at Blakely Island, in the San Juan Archipelago in Washington, and Van Dormop Creek on Vancouver Island, British Columbia, among other sites.]

Orcutt, C. R. 1922. Mollusks dredged from San Diego Bay. *Nautilus* 36(1):33–34. [**Ostrea lurida* makes up a major portion of the dredged shells.]

Orcutt, H. C. 1958. California oyster ground utilization plan. *Proc. Natl. Shellfish. Assoc.* 49:98–100. [**Ostrea lurida* is not regarded as having commercial significance in California by the California Department of Fish and Game (see also Barrett 1963), but beds of native oysters are protected from development nonetheless.]

Orton, J. H. 1928a. The dominant species of *Ostrea*. *Nature* 121(3044): 320–321. [*The author recognizes basic differences within the genus, and proposes breaking it up into *Monoeciostria* (*Ostrea*) and *Dieciostrea* (*Crassostrea, Saccostrea*), and renaming the species. *O. lurida* would become *M. vancouverensis*.]

Orton, J. H. 1928b. Transplantation of the European oyster. *Science* 67(1745):582–583. [*Includes a mention of the differences discussed in Orton (1928a).]

Packard, E. L. 1918a. A quantitative analysis of the molluscan fauna of San Francisco Bay. *Univ. Calif. Publ. Zool.* 18(13):299–336. [**Ostrea lurida* was reported at many stations, but dead material was included. It was reported living just outside the mouth of the bay, and on shells on all substrates in the bay except sand. *Ostrea elongata* referred to here is *Crassostrea virginica*.]

Packard, E. L. 1981b. Molluscan fauna from San Francisco Bay. *Univ. Calif. Publ. Zool.* 14(2):199–452. [*Despite the apparent journal volume discrepancy with Packard (1918a), this is the correct citation; Volume 14(1) was published in 1914, but 14(2) was not published until 1918, after Volumes 15–18 had been issued. This is a report of one of the voyages of the U.S. government research vessel *Albatross* in and about San Francisco Bay, and mainly reports distribution of the species in the bay. Living *Ostrea lurida* is reported throughout the southern part of the bay, north to Pt. Richmond, intertidally to 4 fathoms in depth. Dead shells were also found in the middle of San Pablo Bay, and

material (not specified as living or dead) were found between the mouth of the bay and the Farallon Islands, out to sea. The author also mentions that *Ostrea* is harvested commercially for human consumption in the southern part of the bay.]

Palmer, K. V. W. 1945. Molluscan types in the Carpenter Collection in the Redpath Museum. *Nautilus* 58(3):97–100. [*The type specimen of *Ostrea lurida*, from Shoalwater (Willapa) Bay, Washington, is in the Peter Redpath Museum, McGill University, Montreal, Canada. This was confirmed by personal communication from Ms. Susan Gabe, Curator, in 1991.]

Palmer, K. V. W. 1958. Type Specimens of Marine Mollusca Described by P. P. Carpenter from the West Coast (San Diego to British Columbia). *Geol. Soc. Am. Mem.* 76. 376 pp. [*This contains the second paragraph of Carpenter's original species description for *O. lurida* (see also Oldroyd 1924).]

Pasquale, N. 1953. Rearing of the native oyster larvae, *Ostrea lurida* Carp., in concrete and wooden tanks under controlled conditions. M.S. Thesis, Oregon State College, Corvallis, Oregon. 74 pp. [*See also Becker (1955), Breese (1953), Morris (1948), and Warren (1951).]

Paul, A. J. & H. M. Feder. 1976. Clam, mussel, and oyster resources of Alaska. *Univ. Alaska Inst. Mar. Sci. Rep.* 76–4:41 pp. [*This is an independent, if brief, confirmation of the existence of *O. lurida* in southeast Alaska. No sites given; *O. lurida* said to be present "but seldom encountered in dense aggregations there."]

Peters, E. C. 1988. Recent investigations on the disseminated sarcomas of marine bivalve mollusks. *Am. Fish. Soc. Spec. Publ.* 18:74–92. [*Review of Mix (1974–1976), Mix et al. (1970–1977), and Sparks (1970). This paper uses *Ostreola conchaphila* for *Ostrea lurida* (see Harry 1985).]

Phibbs, F. D. 1969. Larval culture of bivalve mollusks. (Abstract). *Proc. Natl. Shellfish. Assoc.* 59:12.

Phibbs, F. D. 1970. Laboratory hatching and rearing of Pacific coast clams and oysters. Completion report for period July 1976–June 1970. Fish Commission of Oregon for U.S. National Marine Fisheries Service. NOAA COM–75–10568. 43 pp. Available from National Technical Information Service. [*Only the first of 3 progress reports within this document contain any information about *Ostrea lurida*. It takes 13 days to reach a larval shell length of 250 μ at 16–20°C.]

Quayle, D. B. 1941. The edible mollusca of British Columbia. *Prov. British Columbia Rep. Comm. Fish.* 1940:75–87. [**Ostrea lurida* populations are reported to occur in inlets near the mouths of streams in British Columbia. This material is also found in Quayle (1960).]

Quayle, D. B. 1949. *British Columbia Department of Fisheries Oyster Bulletin* 1:1–12. [*These contain brief mention of *Ostrea lurida* settlement in British Columbia.]

Quayle, D. B. 1960. *The Intertidal Bivalves of British Columbia*. British Columbia Provincial Museum Handbook Series, #17. 104 pp. [*See Quayle (1941).]

Quayle, D. B. 1969. Pacific oyster culture in British Columbia. *Fish. Res. Board Can. Bull.* 169. 192 pp. [*There is a good discussion of the shell and anatomy of *Ostrea lurida* in the process of comparing it to *Crassostrea* in the first chapter.]

Ranson, G. 1950. La chambre promyaire et la classification zoologique des Ostreides. *J. Conchyliol.* 90:195–200. (In French). [**Ostrea* lacks a promyal chamber, *Crassostrea* has it.]

Ranson, G. 1960. Les prodissochonques (coquilles larvaires) des Ostreides vivants. *Bull. Inst. Oceanogr.* #1183. 41 pp. (In French).

Richard, G. P. 1988. Microbial purification of shellfish: a review of depuration and relaying. *J. Food Prot.* 51(3):218–251. [*Depuration is the process whereby edible shellfish rid themselves of contaminants, and relaying is the transport of these shellfish from contaminated growing areas to depuration sites. The *Ostrea lurida* material, on pages 231–233, is taken from Hoff and Becker (1961), Beck et al. (1966), and Di Girolamo et al. (1975).]

Ricketts, E. F. & J. Calvin, revised by J. W. Hedgepeth. 1952. *Between Pacific Tides*. Stanford University Press, Stanford, California. 516 pp. [*This includes a brief discussion of *Ostrea lurida* in the chapter entitled "Bay and estuary: rocky shores."]

Rosenfield, A. 1969. Oyster diseases in North America and some methods for their control. *In: Artificial Propagation of Commercially Valuable Shellfish*. K. S. Price, Jr. & D. L. Maurer (eds.). pp. 67–78. University of Delaware, Newark, Delaware. [*Mentions that *Hexamita* species are ubiquitous, but does not state that they are pathenogenic (see Stein and Denison 1959).]

Roughley, T. C. 1929. Monoecious oysters. *Nature* 124(3134):793. [**Ostrea* (now *Tiostrea*) *lutaria* and *O.* (now *Saccostrea*) *culcullata* are classified together as hermaphroditic oysters, along with *O. lurida*. This character is no longer a basis for taxonomic status, however.]

Santos, J. M., S. L. Downing & K. K. Chew. 1992a. The effects of water temperature on sexual development of adult Olympia oysters, *O. lurida*. (Abstract). *J. Shellfish Res.* 11(1):206–207. [*See Santos et al. (1992b).]

Santos, J. M., S. L. Downing & K. K. Chew. 1992b. The effects of water temperature on sexual development of adult Olympia oysters, *Ostrea lurida*. (Abstract). *J. Shellfish Res.* 11(2):556. [*The effects of water temperature on gametogenesis, spawning, and reproductive output are summarized. This is essentially the same abstract as Santos et al. (1992a), but with more complete results.]

Scofield, N. B. 1928. Oysters in California. *Calif. Fish Game* 14(3):203–240. [*The author mentions minor attempts to culture *Ostrea lurida* in California, but no localities are given. See Bonnot (1932–1938).]

Scofield, N. B. 1932. Commercial fishery notes: oyster growing in California. *Calif. Fish Game* 18(1):63–64. [*The initiation of *Ostrea lurida* culture experiments in Humbolt Bay is described (see also Bonnot 1932–1938), and earlier experiments are mentioned.]

Sherwood, H. P. 1931. The oyster industry of North America: a record of a brief tour of some of the centres on the Atlantic and Pacific coasts, and of a summer in Canada. *J. Cons.* 6(3):361–386. [*Non-scientific, but containing much historical information. This is one of the few references to the *Ostrea lurida* dikes near Crescent, B.C., and to the fact that oysters were sometimes transferred for "fattening." It also mentions that *Urosalpinx cinerea* were abundant at Crescent, as a result of *Crassostrea virginica* introductions, and that several species of ducks are major *O. lurida* predators.]

Sindermann, C. J. 1970. The role and control of diseases in mariculture. *In: Food- Drugs from the Sea Proceedings*, 1969. H. E. Youngken, Jr. (ed.). pp. 145–173. Marine Technology Society, Washington, D.C. [*See Mix (1975a) and Odlaug (1946).]

Sindermann, C. J. 1977. *Mytilicola* disease of oysters. pp. 215–216. *In: Disease Diagnosis and Control in North American Marine Aquaculture*. C. J. Sindermannn (eds.). Developments in Aquaculture and Fisheries Science 6. [*See Mix (1973s) and Odlaug (1946).]

Smith, A. G. & G. MacKenzie, Jr. 1948. The marine mollusks and brachipods of Monterrey Bay, California, and vicinity. *Proc. Calif. Acad. Sci.* 4th Ser, 26:147–245. [**Ostrea lurida* is reported as "fairly common" subtidally in Monterrey Bay, a full marine environment. The authors also report that *O. lurida* was harvested commercially on a small scale in Elkhorn Slough in 1935.]

Smith, L. S. 1955. Observations on the polyclad *Pseudostylochus ostreophagus*. University of Washington M.S. Thesis, Seattle, Washington. [*This is probably the major source of information for Woelke's paper (1956c).]

Smith, M. 1907. Annotated list of the Mollusca found in the vicinity of La Jolla, San Diego Co., Cal. *Nautilus* 21(5):55–59. [**O. lurida* found growing on stones in False Bay. See also Coe (1932b).]

Sparks, A. K. 1963. Survey of the Oyster Potential of Hawaii. *Hawaii Dep. Land Nat. Res. Div. Fish Game*. 44 pp. [*See Brock (1960).]

Sparks, A. K. 1970. Tumors and tumorlike conditions in invertebrates. *In: Invertebrate Pathology: Noncommunicable Diseases*. A. K. Sparks (ed.). pp. 271–371. Academic Press, New York. [*On pages 349–355 there is a discussion of neoplastic disease of *Ostrea lurida* in Yaquina Bay, Oregon, taken from Jones and Sparks (1969) and Farley and Sparks (1970).]

Sparks, A. K., K. K. Chew, S. C. Katkansky, D. E. Weitcamp, E. J. Robbins & L. Schwartz. 1967. Epizootics in experimental marine shellfish populations. Research in Fisheries of the University of Washington School of Fisheries #240:35–37. [*This and the following articles briefly discuss *Ostrea lurida* disease and parasites.]

Sparks, A. K., K. K. Chew, D. E. Weitcamp, E. J. Jones & L. Schwartz. 1968. Epizootics in experimental marine shellfish populations. Research in Fisheries of the University of Washington School of Fisheries #280:33–34.

Sparks, A. K., D. E. Weitcamp & E. J. Jones. 1970. Oyster mortality investigations. Research in Fisheries of the University of Washington School of Fisheries #320:26–27.

Stafford, J. 1912. Supplementary observations on the development of the Canadian oyster. *Am. Nat.* 46(1):29–40. [*This mentions that *Ostrea lurida* is found in large numbers in Nanoose Bay and Oyster Harbor. The eggs of *O. lurida* are larger than those of *Crassostrea.]

Stafford, J. 1913. Conservation of the oyster. Province of British Columbia Report of Commercial Fisheries, 1912. pp. 71–80. [*This is mostly about *Crassostrea virginica* in British Columbia, but Stafford also mentions that several attempts to crossbreed this species with *Ostrea lurida* failed. See also Davis (1950a).]

Stafford, J. 1914. The native oyster of British Columbia (*Ostrea lurida*, Carpenter). Province of British Columbia Report of Commercial Fisheries, 1913. pp. 79–102. [*This and the following articles by Stafford are exhaustive studies of *Ostrea lurida* in British Columbia, but much of the work is contradicted by Hopkins (1935a, 1936b, 1937). There are some good drawings of *O. lurida* larvae and juveniles in this article, and some internal anatomy drawings in the following article (1915), along with an extensive biogeographical study. The other articles contain some doubtful physiological studies and some harvest information.]

Stafford, J. 1915. The native oyster of British Columbia (*Ostrea lurida*, Carpenter). Province of British Columbia Report of Commercial Fisheries 1914. pp. 100–119. [*See Stafford (1914).]

Stafford, J. 1916. The native oyster of British Columbia (*Ostrea lurida*, Carpenter). Province of British Columbia Report of Commercial Fisheries 1915. pp. 141–160. [*See Stafford (1914).]

Stafford, J. 1917. The native oyster of British Columbia (*Ostrea lurida*, Carpenter). Province of British Columbia Report of Commercial Fisheries, 1916. pp. 88–120. [*See Stafford (1914).]

Stafford, J. 1918. The native oyster of British Columbia (*Ostrea lurida*, Carpenter). Province of British Columbia Report of Commercial Fisheries 1917. pp. 91–112. [*See Stafford (1914).]

Steele, E. N. 1957. *The Rise and Decline of the Olympia Oyster*. Fulco Publications, Elma, Washington. 126 pp. [*Despite some biases and writing style peculiarities, this is the best single reference for the history and cultivation of *O. lurida* in the southwest Puget Sound, the industry center. It goes into considerable depth on the politics of the Olympia oyster industry, and places most of the blame for the industry collapse in the 1950s on pulp mill pollution. Steele also believes that *Crassostrea gigas* poses no biological threat to *O. lurida* (contrast to Galtsoff 1932).]

Steele, E. N. 1964. *The Immigrant Oyster*. Warren's Quick Print, Olympia, Washington. 179 pp. [*In the short chapter entitled "Cultivation and harvesting of oysters" there is apparently the only reference to the fate (overharvesting) of the large *Ostrea lurida* beds in Samish Bay, northern Washington.]

Stein, J. E., G. M. Clark, J. G. Denison & R. E. Petersen. 1959a. The decline of the Olympia oysters (*O. lurida*) for the period of June 1957 through March 1959. Report of the Olympic Research Division, Rayonier, Inc., Shelton, Washington. 36 pp. [*This, Stein and Petersen (1959) and Stein et al. (1959b) are important studies for Gunter and McKee's paper (1960), but are unfortunately hard to come by. Rayonier, Inc., the owner of a large pulp mill, was the defendant in legal cases regarding pollution in the southwest Puget Sound.]

Stein, J. E. & J. G. Denison. 1959. *Hexamita* sp. and an infectious disease in the commercial oyster *Ostrea lurida*. *Proc. Natl. Shellfish. Assoc.* 50:67–81. [*Despite the title, there is no clear evidence presented here that *Hexamita* is a pathogen.]

Stein, J. E. & R. E. Petersen. 1959. A preliminary report on the setting of oyster larvae in spent sulfite liquor (SSL). Report of the Olympic Research Division, Rayonier, Inc., Shelton, Washington. 4 pp.

Stein, J. E., R. E. Petersen, J. G. Denison, G. M. Clark & I. E. Ellis. 1959b. The spawning of Olympia oysters (*Ostrea lurida*) kept in spent sulfite liquor (SSL). Report of the Olympic Research Division, Rayonier, Inc., Shelton, Washington. 14 pp.

Stevens, B. A. 1928. Callianassidae from the west coast of North America. *Publ. Puget Sound Biol. Stat.* 6:315–369. [*Pages 348–352 discuss the impacts of callianassid shrimp burrowing on *Ostrea lurida* beds. When oysters or shells are taken off the beds, the shrimp invade. They bury the oysters or drain the dikes through their burrows. This paper also mentions that *O. lurida* will not attach to wood, as will *Crassostrea.]

Stevens, B. A. 1929. Ecological observations on the Callianassidae of Puget Sound. *Ecology* 10(4):399–405. [*Burrowing anomuran shrimp make oyster beds too soft and undermine dikes. Taken from Stevens (1928).]

Strathmann, M. F. 1987. *Reproduction and Development of Marine Invertebrates of the Northern Pacific Coast*. University of Washington Press, Seattle, Washington. 670 pp. [*In the review of *O. lurida* reproduction on pages 329–330, the author suggests that "sperm balls" (Coe 1931b) function as spermatophores, to enhance fertilization success. She also states that the larval brooding period is about 10 days.]

Strong, A. M. 1928. Notes on microscopic shells from Newport Bay, California. *Nautilus* 42(1):1–4. [*In Newport Bay, *Ostrea lurida* is very abundant on all hard substrate, and is found in association with significant numbers of the ectoparasitic gastropod *Odostomia*.]

Tartar, V. 1949. Washington oysters. Washington Department of Fisheries circular. 5 pp. [*This includes a brief description of *Ostrea lurida* and *Crassostrea gigas*, from an aquaculture viewpoint.]

Torigoe, K. 1981. Oysters in Japan. *Journal of Science of the Hiroshima University*, Series B, Division 1, 29(2):291–419.]

Townsend, C. H. 1893. Report of observations representing the oyster resources and oyster fishery of the Pacific Coast of the United States. *Report of the U.S. Commissioner of Fisheries* for 1889 to 1891. pp. 343–372. [*Passing mention is made to *Ostrea lurida* in San Francisco Bay, but as an "utterly worthless" species compared to *Crassostrea virginica*.]

Townsend, C. H. 1896. The transplanting of eastern oyster to Willapa Bay, Washington with notes on the native oyster industry. *Report of the U.S. Commissioner of Fisheries* for 1895. pp. 193–202. [*This is mainly about the introduction of *Crassostrea virginica*, but mention is made of "culture" of *Ostrea lurida* in Willapa Bay, apparently by replanting juveniles collected from natural beds.]

Turgeon, D. D., A. E. Bogan, E. V. Coan, W. K. Emerson, W. G. Lyons, W. L. Pratt, C. F. E. Roper, A. Scheltema, F. G. Thompson & J. D. Williams. 1988. *Names of Mollusks*. American Fisheries Society Special Publication 16. 227 pp. [*On page 28, *Ostrea lurida* is listed as *Ostreola conchaphila*, after Harry (1985).]

Valentine, J. W. 1959. Pleistocene molluscan notes II. Faunule from Huntington Beach Mesa, Calif. *Nautilus* 73(2):51–57.

Valentine, J. W. 1960. Pleistocene molluscan notes 3. Rocky coast faunule, Bahia San Quintin, Mexico. *Nautilus* 74(1):18–23.

Vasconcelos, G. J. 1966a. Bacteriological studies on commercial processing of Olympia oysters (*Ostrea lurida*). *In: 1965 Proceedings of the Northwest Shellfish Sanitation Research Planning Conference*. (W. J. Beck & J. C. Hoff (eds.). pp. 15–22. U.S. Department of Health, Education, and Welfare, Public Health Services Publication 999–FP–6. [*This study shows how bacterial levels vary during processing of *Ostrea lurida*. See also Ericksen (1966).]

Vasconcelos, G. J. 1966b. Storage studies on Olympia oyster shellstock (*Ostrea lurida*). *In: Proceedings of the Northwest Shellfish Sanitation Research Planning Conference*. W. J. Beck & J. C. Hoff (eds.). pp. 32–42. U.S. Department of Health, Education, and Welfare Public

Health Services Publication 999–FP–6. [*This study shows how fecal coliform levels in *Ostrea lurida* stored out of water rise over time.]

Wachsmuth, L. J. 1979. Comparisons of seven types of oysters grown in Yaquina Bay, Oregon, from an oyster farmer's point of view. (Abstract). *Proc. Natl. Shellfish. Assoc.* 69:206. [*This oyster culturist considers *Ostrea lurida* the least valuable of the 7 oyster species and subspecies.]

Wallace, D. H. 1966. Oysters in the estuarine environment. *Am. Fish. Soc. Spec. Publ.* 3:68–73. [*Included is a brief discussion of Ostrea lurida culture from 1890–1930, and states that it far exceeded any other North American molluscan culture efforts at that time. This also briefly discusses reasons for the industry decline.]

Warren, C. E. 1951. The flagellate *Bodo lens* (O. F. Muller) as food for larvae of the native Pacific coast oyster. M.S. Thesis, Oregon State College Corvallis, Oregon. 120 pp. [*See also Becker (1955), Breese (1953), Morris (1948), and Pasquale (1953).]

Weitcamp, D. E., E. J. Jones & A. K. Sparks. 1969. Oyster mortality investigations. *Research in Fisheries of the University of Washington School of Fisheries* #300:49–50.

Westley, R. E. 1959a. Olympia and Pacific oyster condition factor data, State of Washington 1954–1958. *Wash. Dep. Fish. Shellfish Lab.* 5 pp. [*See Westley (1959b).]

Westley, R. E. 1959b. Olympia oyster reproduction in south Puget Sound 1942–1958. *Wash. Dep. Fish. Olympia Oyster Probl. Bull.* 5. 12 pp. [*This and other Washington Department of Fisheries bulletins by Westley continue work began by Woelke. Westley later changed the focus of this bulletin to condition data. In that regard only Westley (1959c) is of any real interest. See also Glude et al. (1946), Lindsay et al. (1948–1958), Westley (1959–1963), and Woelke (1956–1959).]

Westley, R. E. 1960a. Oyster condition factor data. *Wash. Dep. Fish. Shellfish Lab.* 7 pp. [*See Westley (1959b).]

Westley, R. E. 1960b. Summary Olympia oyster reproduction in south Puget Sound–1962. *Wash. Dep. Fish. Olympia Oyster Probl. Bull.* 5, Appendix. 5 pp. [*See Westley (1959b).]

Westley, R. E. 1961a. Olympia oyster reproduction in south Puget Sound. *Wash. Dep. Fish. Olympia Oyster Probl. Bull.* 5, Appendix #2. 5 pp. [*See Westley (1959b).]

Westley, R. E. 1961b. Oyster condition factor data Appendix II–1962. *Wash. Dep. Fish. Shellfish Lab.* 7 pp. [*See Westley (1959b).]

Westley, R. E. 1961c. Selection and evaluation of a method for quantitative measurement of oyster condition. *Proc. Natl. Shellfish. Assoc.* 50:145–149. [*Oyster condition is based on the relationship of shell volume and dry weight. See also Westley (1959b).]

Westley, R. E. 1962a. Oyster condition index data Appendix III–1961. *Wash. Dep. Fish. Shellfish Lab.* 8 pp. [*See Westley (1959b).]

Westley, R. E. 1962b. Summary Olympia oyster reproduction in south Puget Sound–1961. *Wash. Dep. Fish. Olympia Oyster Probl. Bull.* 5, Appendix #3. 4 pp. [*See Westley (1959b).]

Westley, R. E. 1963a. Oyster condition index data Appendix IV–1962. *Wash. Dep. Fish. Shellfish Lab.* 6 pp. [*See Westley (1959b).]

Westley, R. E. 1963b. Summary of Olympia Oyster reproduction in south Puget Sound–1962. *Wash. Dep. Fish. Olympia Oyster Probl. Bull.* 5, Appendix #4. 4 pp. [*See Westley (1959b).]

Wicksten, M. K. 1978. Checklist of marine mollusks at Coyote Point Parks, San Francisco Bay, California. *Veliger* 21(1):127–130. [**Ostrea lurida* is only mentioned as a member of the fauna here, but the author states that the major large predators on soft substrate bivalves are the bat ray *Myliobatus californica* and the leopard shark *Triakis semifasciata*. The former is probably the "stringray" mentioned by Townsend (1893).]

Wilbur, K. M. & C. M. Yonge. 1964. *Physiology of Mollusca*. Vol. I. Academic Press, New York. 473 pp. [*The material in here on *Ostrea lurida* is taken from Yonge (1960).]

Wilkins, N. P. 1976. Genetic variability in marine Bivalvia: implications and applications in molluscan aquaculture. *10th Eur. Symp. Mar. Biol.* 1975. 1:549–563. [*AAT I and AAT II loci in *Ostrea lurida* were examined for variability. This is far fewer than were examined for most other bivalve species, and probably cannot be used to infer anything about variability in *Ostrea lurida*.]

Williamson, M. B. 1892. An annotated list of the shells of San Pedro Bay and vicinity with a description of two new species described by W. H. Dall. *U.S. Natl. Museum Proc.* 15:179–220.]

Woelke, C. E. 1954. A newly identified oyster predator. *Wash. Dep. Fish. Res. Pap.* 1:50–51. [*See Woelke (1956c).]

Woelke, C. E. 1956a. Statistical review of the Puget Sound Olympia oyster industry 1897–1955. *Wash. Dep. Fish. Olympia Oyster Probl. Bull.* 1. 4 pp. [*This is the first of a short series of bulletins initially on *Ostrea lurida* settlement and survival in the southwest Puget Sound, but terminated by Westley less than a decade later. This first bulletin is a good summary of the industry in the region, but later bulletins merely report data. See also Glude et al. (1946), Lindsay et al. (1948–1958), Westley (1959–1963), and Woelke (1956–1959).]

Woelke, C. E. 1956b. Adult Olympia oyster mortalities 1929–1956. *Wash. Dep. Fish. Olympia Oyster Probl. Bull.* 2. 2 pp. [*See Woelke (1956a).]

Woelke, C. E. 1956c. The flatworm *Pseudostylochus ostreophagus* Hyman, a predator of oysters. *Proc. Natl. Shellfish. Assoc.* 47:62–67. [*This is the most important publication on the flatworm *P. ostreophagus*, documenting drilling of and predation on *Ostrea lurida* juveniles. Probably at least partly taken from Smith (1955).]

Woelke, C. E. 1958a. Olympia oyster spat survival 1946–1957. *Wash. Dep. Fish. Olympia Oyster Probl. Bull.* 3. 20 pp. [*See Woelke (1956a).]

Woelke, C. E. 1958b. Growth of Olympia oysters. *Wash. Dep. Fish. Olympia Oyster Probl. Bull.* 4. 13 pp. [*See Woelke (1956a).]

Woelke, C. E. 1958c. The effects of spent sulphite waste liquor on the development of eggs and larvae of two marine molluscs and three of their food organisms. *Wash. Dep. Fish. Shellfish Lab.* 17 pp. [*See also Odlaug (1949) and Gunter and McKee (1960).]

Woelke, C. E. 1959. Preliminary report on laboratory studies on the relationship between fresh sulphite waste liquor and the reproductive cycle of the Olympia oyster, *Ostrea lurida*. *Wash. Dep. Fish. Shellfish Lab.* 26 pp. [*See also Odlaug (1949) and Gunter and McKee (1960).]

Woelke, C. E. 1960. Preliminary report of laboratory studies on the relationship between fresh sulfite waste liquor and the reproductive cycle of the Olympia oyster, *Ostrea lurida*. *Wash. Dep. Fish. Res. Bull.* #6:107–148. [*See also Odlaug (1949) and Gunter and McKee (1960).]

Yocum, H. B. & E. R. Edge. 1929. The Pelecypoda of the Coos Bay region, Oregon. *Nautilus* 43(2):49–51. [*This includes a mention of *Ostrea lurida*, but it does not say they were alive, and may refer either to ancient shells or recently introduced oysters (see Edmondson 1920).]

Yonge, C. M. 1960. *Oysters*. Collins Press, London. 209 pp. [*References are made throughout to the biology and culture of *O. lurida*.]

SUBJECT INDEX

1937b, 1939, 1940; Bradford & Luoma 1980; Bradley & Seibert 1978; Bradshaw et al. 1976; Browning 1972; Carlton 1979; Coe 1930, 1931a, 1931b, 1932a, 1932b; Filice 1958; Fitch 1953; Galtsoff 1929; Gilbert 1891; Hertlein 1959; Howard 1935; Human 1971; Kozloff 1973; MacGinitie 1935; Modin 1969; Mudie et al. 1974; Orcutt 1922; Orcutt 1958; Packard 1918a, 1981b; Ricketts et al. 1952; Scofield 1928, 1932; Smith 1907; Smith & MacKenzie 1948; Strong 1928; Townsend 1893; Valentine 1959

Culture and Harvest, Adults: Aiken 1990; Barrett 1963; Bonnot 1935, 1936, 1937a, 1938, 1939; Breese and Wick 1974; Burrell 1985; Chew 1988, 1990; Couch & Hassler 1989; Dimick & Long 1939; Dimick et al. 1941; Edmondson 1920, 1923; Elsey 1933; Fasten 1931; Galtsoff 1929, 1949; Gibson 1974; Glude 1947; Glude et al. 1946; Hedgepeth & Obrebski 1981; Holway 1934; Hutchinson & Brennan 1936; Imai et al. 1954; Ingersoll 1881; Iversen 1968; Keep 1891; Kincaid 1928; Kincaid 1951; Kolbe et al. 1979; Korringa 1976; Lindsay 1948; Lindsay et al. 1948, 1949, 1950, 1951, 1952, 1953, 1954, 1955, 1958; Matthiessen 1970; Moore 1898; Nosho 1989; Orcutt 1958; Quayle 1960, 1969; Scofield 1932; Sherwood, 1931; Stafford 1917, 1918; Steele 1957; Tartar 1949; Townsend 1893, 1896; Wachsmuth 1979; Wallace 1966; Westley 1959b, 1960b, 1961a, 1962b, 1963b; Woelke 1956a, 1956b, 1958a, 1958b; Yonge 1960

Culture, Larvae: Becker 1955; Breese 1953, 1969; Davis 1949, 1950b; Davis & Chanley 1955; Donaldson 1981, 1988; Imai et al. 1954; Loosanoff & Davis 1963; Loosanoff & Marak 1951; Morris 1948; Pasquale 1953; Phibbs 1969, 1970; Warren 1951

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Ecology: Chapman & Banner 1949; Couch & Hassler 1989; Coe 1931a, 1932b; Coe & Allen 1937; Dimick et al. 1941; Fasten 1931; Filice, 1958; Galtsoff 1932; Griffin 1941; Hopkins 1936b, 1937; Kozloff 1973; Miller & Morrison 1988; Ricketts et al. 1952; Stafford 1916; Stevens 1928, 1929; Strong 1928

Enemies: Baker 1988; Barret 1963; Bernard 1969; Bradley & Seibert 1978; Carlton, 1979; Chapman & Banner 1949; Cheng 1967; Chew 1960; Chew & Eisler 1958; Chew et al. 1964a, 1964b; Dimick et al. 1941; Elsey 1933; Galtsoff 1964; Gibson 1974; Human 1971; Kincaid 1957; Korringa 1976; McKernan et al. 1949; Odlaug 1946; Sindermann 1977; Smith 1955; Sparks et al. 1967, 1968; Stein & Denison 1959; Stevens 1928, 1929; Strong 1928; Wicksten 1978; Woelke 1954, 1956b, 1956c, 1958a

Fossil: Arnold 1903, 1909; Arnodl & Anderson 1910; Atwater et al. 1981; Barner 1981; Clifton 1983; Dall 1897; Elsasser & Heizer 1966; Grant & Gale 1931; Howard 1935; Iwamoto & Chew 1978; Keen 1944; Kidd 1967; Kvenvolden et al. 1979; Miller & Morrison 1988; Valentine 1959, 1960

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Introductions: Bae & Bae 1972; Brock 1960; Carlton 1988; Davis 1955; Edmondson 1920, 1923; Galtsoff 1929; Hori 1933; Imai et al. 1954; Sparks 1963

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Oregon: Breese & Wick 1974; Carlton 1988; Dall 1897; Dimick & Long 1939; Dimick et al. 1941; Edmondson 1920, 1923; Farley *el* MI, 1988; Fasten 1931; Galtsoff 1929; Gibson 1974; Holmes 1927; Kolbe et al. 1979; Marriage 1954; Mix 1974, 1975a, 1975b, 1976b; Mix et al. 1977; Mix & Riley 1977; Mix & Sprague 1970; Wachsmuth 1979; Yocom & Edge 1929

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Reproduction: see *Histology, Spawning and Development*

Settlement and Growth: Becker 1955; Bonnot 1937b, 1939; Coe 1930, 1932b; Coe & Allen 1937; Couch & Hassler 1989; Dimick et al. 1941; Glude et al. 1946; Gooding & Ward 1953; Hopkins 1934a, 1936b, 1937; Imai et al. 1954; Lindsay et al. 1958; Quayle 1949; Stafford 1914, 1915, 1917; Stein & Petersen 1959; Westley 1959b, 1960b, 1961a, 1962b, 1963b

Spawning and Development: Breese 1953; Coe 1930, 1931a, 1931b, 1932a; Couch & Hassler 1989; Davis 1950b; Galtsoff 1964; Glude et al. 1946; Hopkins 1936b, 1937; Hori 1933; Imai et al. 1954; Korringa 1952; Nelson 1928; Phibbs 1970; Ranson 1960; Santos et al. 1992a, 1992b; Stafford 1912, 1914, 1915; Stein et al. 1959b; Strathmann 1987; Tartar 1949; Woelke 1959, 1960; Yonge 1960

Taxonomy and Genetics: Abbott 1974; Abbott & Dance 1986; Ahmed 1975; Ahmed & Sparks 1967a, 1967b, 1968a, 1968b; Arakawa 1990; Banks et al. 1993; Brock 1990; Buroker 1982, 1985; Carpenter 1864a, 1864b, 1872; Dall 1914; Davis 1949, 1950a; Eisenberg 1981; Gunter 1950; Harry 1985; Hertlein 1959; Hinegardner 1974; Keep & Baily 1935; Menzel 1968; Moore 1899; Morris 1966; Oldroyd 1924; Orton 1928a, 1928b; Palmer 1945, 1958; Ranson 1950; Roughley 1929; Stafford 1916, Turgeon et al. 1988; Wilkins 1976; Williamson 1892

Washington: Baker 1988; Cardwell et al. 1979; Chapman & Banner 1949; Chew 1988; Chew et al. 1964a; Couch & Hassler 1989; Edmondson 1922; Galtsoff 1929, 1932; Glude 1947; Glude et al. 1946; Gooding & Ward 1953; Griffin 1941; Gunter & McKee 1960; Hedgepeth & Obrebski 1981; Holway 1934; Hopkins 1935a, 1936b, 1937; Hopkins et al. 1935; Kincaid 1928, 1951; Kolbe et al. 1979; Korringa 1952, 1976; Kozloff 1973, 1974; Kuons & Cardwell 1981; Kvenvolden 1979; Lindsay 1948; Lindsay et al. 1948, 1949, 1950, 1951, 1952, 1953, 1954, 1955, 1956, 1958; McKernan et al. 1949; McLachlan & Ayres 1979; Matthiessen 1970; Moore 1898; Odlaug 1946, 1949; Oldroyd 1925; Sherwood 1931; Smith 1955; Sparks et al. 1970; Steele 1957, 1964; Stein et al. 1959a, 1959b; Stein & Denison 1959; Stein & Petersen 1959; Stevens 1928, 1929; Tartar 1949; Townsend 1896; Wallace 1966; Westley 1959a, 1959b, 1960a, 1960b, 1961a, 1961b, 1961c, 1962a, 1962b, 1963a, 1963b; Woelke 1954, 1956a, 1956b, 1956c, 1958a, 1958b, 1958c, 1959, 1960; Yonge 1960