A REPORT ON KOREAN OYSTERS WITH EMPHASIS ON THE QUESTION OF IMPORTING *CRASSOSTREA GIGAS* SEED INTO THE UNITED STATES

Michael C. Mix
Department of General Science
Oregon State University

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A Report on Korean Oysters with Emphasis on the Question of Importing *Crassostrea gigas* Seed into the United States[1]

Michael C. Mix
Department of General Science
Oregon State University
Corvallis, Oregon

INTRODUCTION

I first became involved with the Korean seed oyster "situation" as a result of attending a meeting with members of the Oregon Cooperative Oyster Marketing Association (OCOMA) in Newport, Oregon, on December 1, 1975. Participants included all Oregon oyster producers and representatives from Oregon State University and the Oregon Department of Fish and Wildlife. The primary purpose of that meeting was to discuss whether or not OCOMA members should attempt to import seed oysters from the Republic of Korea in spite of a bilateral agreement between the United States and Korea which specifically prohibits the importation of live or fresh shucked oysters. Oregon oyster growers are particularly interested in obtaining Korean seed because it is 40% cheaper than the currently utilized Japanese seed; also, Japanese seed is becoming increasingly more difficult for U.S. oyster growers to obtain because of declining production and increased competition from other oyster growing countries.

There was considerable confusion about the basis for the U.S. prohibition of Korean seed oysters and references were made to "federal and state deals," "favoritism," "mysterious diseases," oyster drills, and efforts to reduce direct competition with developing aquaculture projects in the U.S. It was later determined (from an earlier [31 October 75] letter written by John B. Glude [Aquaculture Program Coordinator, National Marine Fisheries Service] to Robert Loeffel [Laboratory Director, Oregon Department of Fish and Wildlife]) that importation of live Korean oysters into the U.S. is prohibited on the basis that,

> "samples of [Korean] oysters examined at the National Marine Fisheries Service Laboratory at Oxford, Maryland, indicated the presence of [a] Haplosporidan [protozoan parasite] apparently of the genus *Minchinia*. This organism appears to be similar if not identical to the *Minchinia nelsoni* or *Minchinia costalis* which caused

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> extensive mortalities among the eastern oyster *Crassostrea virginica* during the late 1950's and through the 1960's. Although there is some evidence that the two east coast species of *Minchinia* do not infect *Crassostrea gigas* there is already evidence that the Korean [parasite] infects Pacific oysters. The potential danger of introducing the Korean *Minchinia* to oystering areas on the Pacific coast is obvious."

Mr. Glude indicated that the present embargo on importing live seed oysters or fresh shucked oysters would remain until the NMFS Oxford, Maryland, laboratory, after examining samples of oysters from Korea, had determined the significance of the *Minchinia* infection. Finally, Glude advised the State of Oregon to prohibit the importation of seed oysters from Korea until the cooperative research program between the U.S. (Oxford lab) and Korea was completed.

In subsequent conversations I have had with Oregon oyster growers and O.S.U. Marine Advisory Program (MAP) Agents, it was evident that there is a considerable amount of skepticism about the "disease basis" for prohibiting the importation of Korean seed oysters. Specifically, they are concerned (or in some cases, convinced) that complex politics are involved at both the federal and state level. Three issues were most frequently mentioned. First, some felt that there was a deal made between the two governments involving Korean access to north Pacific salmon stocks in return for their acceptance of the U.S. embargo on live oysters; and second, seed hatcheries associated with aquaculture projects in various states were being protected from competition. Third, some felt the real issue did not involve seed oysters at all, but that the agreement was initiated so the U.S. market would not be inundated with fresh Korean oysters. Such oysters could be sold at a considerably lower price and thus have a negative economic effect on U.S. oyster growers. Obviously, most Oregon oyster growers were concerned about such a prospect and suggested a solution in which the importation of seed oysters be allowed but the embargo remain on fresh marketable oysters.

At the OCOMA meeting, I indicated a willingness to examine seed and/or adult oysters from Korea and to review past studies as a potential first step in resolving the "disease issue." After approximately a year's hiatus, during which time I discussed the Korean oyster issue with several state and federal personnel (including scientists from the Oxford lab), permission was granted by the State of Oregon to allow delivery, to our laboratory,

of 7 kg of fresh adult oysters and 1 kg of seed oysters, from Korea, for histological examination.

The purpose of this report is to describe the results of our histological studies on the adult oysters and review previous studies associated with diseases and parasites of Korean oysters. Further, I was asked by OCOMA members and MAP personnel to provide, if possible, answers to the following two questions: what is the history of past studies conducted on Korean oysters; and, have similar studies been conducted on Japanese oysters? I would like to acknowledge the gracious assistance of personnel from the NMFS Oxford laboratory; their cooperation has been invaluable.

RESULTS

1. Historical Background

To facilitate further discussion, I will first review the results of earlier studies conducted by personnel at the Oxford lab.

Japanese seed which is to be imported into the U.S., is checked yearly for the presence of external pests and predators during packing (February and March). With respect to histological studies for disease organisms in Japanese oysters, there are three aspects to consider. First, summer mortalities of common stocks of Pacific oysters (*Crassostrea gigas*) have occurred during the past several years in both Japan (Miagi area) and Puget Sound. Japanese scientists and personnel from the University of Washington have conducted extensive histological investigations in attempts to determine the exact cause of these mortalities. To date, the etiologic agent remains unknown but is thought to be a bacterium. It is the opinion of scientists involved in those studies that no [other?] disease organism is present in Japanese oysters and that they have been analyzed much more extensively than oysters from any other country including Korea. Second, in 1966-67, there was a special survey of adult and seed oysters, including histological examinations, from Japan, Taiwan and Korea. Results of those studies were presented in Manuscript Reports No. 67-6 to 67-12 (from the Oxford Laboratory) and distributed at the First Pacific Coast Oyster Mortality Workshop held in May, 1967, in Seattle, Washington. The following parasites and pathological conditions were found in Japanese oysters from the Sendai region of northern Japan and from the Hiroshima and Kumamoto areas: gregarine-like organisms, "focal necrosis" (thought possibly to be caused by a bacterial pathogen),

amoebiasis, larval stages of *Tylocephalum* (a cestode tapeworm) and an amoeboid parasite which was cytozoic (intracellular) in leucocytes and eggs. All of these, with the possible exception of focal necrosis, were considered to be nonpathogenic. No additional formal studies have been conducted on Japanese oysters since that time; however, Oxford personnel continue to occasionally examine small samples of Miagi oysters for disease organisms.

Korean oysters (seed) were first examined during the 1966-67 Far East study and the following parasites and pathological conditions were reported: a protistan egg parasite, gregarine-like organisms and *Hexamita* (a protozoan flagellate not presently considered to be a pathogen). The egg parasite was found exclusively as a cytozoic parasite in developing ova and presumably was a different species than the Japanese egg parasite.

Subsequently, a disease and parasite evaluation of seed and adult Pacific oysters, from the Chung Mu area of the Republic of Korea was undertaken by the Oxford laboratory. A total of 1,438 oysters from 6 sampling stations in the Hanson Island-Geoje Bay area were sampled over a 4-year period from May, 1971 to March, 1975. Of the 1,438 oysters examined, 4 (0.28%) were found to be infected with a haplosporidan parasite belonging to the genus *Minchinia*; these included 2 seed oysters from the Naegan growing area sampled May, 1971, 1 seed oyster from the Bup Dong area sampled October, 1973, and 1 adult oyster from the Eogu area sampled in March, 1975 (Kern, 1976). Kern (1976) felt that the continued presence of the haplosporidan indicated that it was enzootic to the Chung Mu area. He also pointed out that there was no evidence the parasite had been responsible for any major mortalities of oysters. From May, 1975 to April, 1976, Mr. Kern of the Oxford lab examined 763 oysters from Chubong and Naegan but did not find the *Minchinia* parasite.

In addition to *Minchinia*, the following parasites, disease organisms, unidentified organisms or pathological conditions were found during the four year investigation: ciliates, gregarine-like organisms, egg parasites, *Mytilicola* (a parasite copepod crustacean), epithelial gut lesions and "ovacystis" (viral inclusions in eggs). None of these have been associated with oyster mortalities.

2. O.S.U. Studies

On February 15, 1977, we received, at my lab, 7 kg of live adult oysters and 1 kg of oyster shells with attached spat, from Korea (area unknown). All

oysters were first examined grossly, then shucked, placed in fixative, processed in the usual way and microscopic slides were prepared for histological investigation. One hundred and seven normal adults were analyzed histologically along with 22 adults that were gaping when they arrived in our lab. We will analyze the spat samples during May or June, 1977 and the results will be forwarded at that time.

All adult oysters were "fat" and considered to be in prime market condition. Gross examination of the external shell revealed the following: a small number of tunicates and barnacles, calcareous tube worms, and a few small polychactes and nemerteans. A number of shells had small single holes in them and after microscopic examination, it was felt that such holes were the result of crab-oyster interaction. All adult oysters had mud blisters on the inner shell which were caused by *Polydora* sp. (mud worms).

The following organisms or pathological conditions were found in the 129 oysters examined histologically:

organism or condition	number of oysters
Egg parasite	
positive identification	2
tentative identification	2
Lesions of the gut and/or stomach epithelial surface	5
Minchinia sp.	0
Mytilicola sp.	0

I do not feel that any particular significance should be attached to the fact that we did not find any *Minchinia* sp. since only a single case (which I consider to be highly questionable) has been reported in an adult oyster. Too, because of its low prevalence (0.28%), the sample size may have been insufficient.

The relatively low number of oysters with the egg parasite may be misleading since there were only 6-10 oysters with distinguishable ova in our sample.

DISCUSSION

It must be emphasized that this project was not initiated or conducted in order to provide definitive disease data on which to base a decision on whether or not to import Korean oysters into Oregon waters. Rather, the purpose was to review the history and results of past studies, determine

precisely what diseases have been found in Korean oysters and establish whether or not there is sufficient reason, based on what is known, to prohibit the importation of Korean seed into Oregon waters.

Certainly, the available evidence dictates that extreme caution should be exercised before Korean seed oysters are imported and planted in U.S. waters. To illustrate the problems associated with importing foreign oysters into U.S. estuaries, a review of the pests, predators, disease organisms and less malevolent invertebrates introduced with Japanese seed may be useful at this point (from Light's Manual, 1975; Sinderman, 1970).

Pacific oysters, *C. gigas*, have been imported from Japan as seed stock and planted in waters of the Pacific coast states since the 1930's. The arrival of this species coincided with the decline in abundance of the native oyster, *Ostrea lurida*; however, it is still not clear whether or not these two events were related. The parasite copepod, *Mytilicola orientalis*, was described from the digestive tract of the Japanese oyster in 1935. This parasite was transferred to the U.S. west coast with early imports of seed oysters from Japan and is now common along the entire west coast. The Japanese oyster drill, *Ceratostoma inornatum* (formerly *Ocenebra japonica*), was also imported during early seed shipments and is now established in southern Puget Sound where it causes significant mortalities of young oysters. Two diseases, "multiple abscess bacterium" and "amoeboid organisms" have also apparently been introduced from Japan but their effects on west coast oysters are unknown. In addition, early shipments of oysters carried abundant epizoics, including sponges, cnidarians, polychaetes, mollusks, crustaceans, bryozoans, and other invertebrates; ironically, many of these species proliferated although the oysters never became established locally. Those species probably introduced with Japanese oysters include the polychaetes *Pseudopolydora kempi*, *P. paucibranchiata*, and *Spirorbis* sp.; the horn snail *Batillaria attramentaria*; the bivalves *Musculus senhousia*, *Lasaea* sp., and *Tapes japonica*; the nudibranchs *Okenia plana*, *Eubranchus misakiensis*, *Trinchesia* sp.; the amphipods *Corophium uenoi* and *Grandidierella japonica*; the isopod *Gnorimosphaeroma rayi*; the ectoproct *Victorella pavida*; and a few other invertebrates.

It is also interesting to note that extensive importations of adult and seed oysters (*Crassostrea virginica*) from the Atlantic coast during

the 1860's to 1910's, into central California bays, were responsible for the introduction of an equally impressive number of exotic invertebrates.

From these and other experiences involving the planting of foreign oysters into new areas, it is obvious that a certain risk exists with respect to introducing exotic, potentially dangerous, organisms into a new area.

More rigorous evaluations of Korean oysters have been and will be conducted than were or are conducted on Japanese seed oysters prior to their importation into U.S. waters. This is not particularly surprising when one considers how little was known about oyster diseases and parasites in the 1930's and how much is known today. Thus, the basic question is whether or not there is current justification for prohibiting the importation of Korean seed oysters based on their potential for introducing new diseases and parasites into U.S. waters. I will address only this aspect of the problem since it is beyond my expertise as an investigative reporter to delve into the putative politics involved in considering the importation of fresh marketable oysters.

According to Glude's letter, the presence of *Minchinia* sp. in Korean seed oysters necessitates prohibiting their importation into the U.S. Presumably, that is because 2 species of *Minchinia--M. costalis* (Wood and Andrews, 1962) and *M. nelsoni* (Haskin, Stauber and Mackin, 1966)--have been diagnosed as the etiologic agents responsible for the catastrophic oyster (*C. virginica*) mortalities that have ravaged the oyster industry along the middle Atlantic coast for the past 20 years (e.g. Andrews, 1966). However, there have already been several reports of finding haplosporidan species (which appear identical to the *Minchinia* sp.) in bivalve mollusks from the west coast (Taylor, 1966; Katkansky and Warner, 1970; Mix and Sprague, 1974; and Armstrong and Armstrong, 1974) and no mortality has been associated with these organisms although pathological lesions have been reported. Thus, it appears that haplosporidans may be endemic to many estuaries and bays along the west coast although little is known about their life cycles or potential for causing outbreaks of mortality. Virtually nothing is known about the Korean egg parasite or the condition known as ovacystis except that it exists in a certain low percentage of oysters.

It is my judgment that the U.S. embargo on Korean seed oysters is certainly justified based on the presence of the haplosporidan (*Minchinia* sp.) and the egg parasite. There are, however, many questions and issues

that require resolution. I will address this point in the last section. It seems unfortunate that the cooperative program, involving the examination of Korean oysters by the Oxford lab, has apparently been terminated. As I understand it, the purpose of the program was to identify indigenous parasites and diseases, of Korean oysters, evaluate the problems associated with such organisms and eventually, to determine whether or not Korean spat could be introduced into the U.S. and under what conditions. Unless such a cooperative program is reestablished it may never be possible to evaluate the future potential for importing Korean seed oysters.

RECOMMENDATIONS

1. Clearly, it is imperative that the cooperative Korean-U.S. program be reestablished. It simply will not be possible to resolve the problems associated with diseases and parasites unless there is a mutual exchange of material and information.
2. I feel strongly that additional personnel and laboratories must be involved in future studies of the samples and especially the analyses of the problems. Although personnel at the Oxford lab are highly qualified to identify disease organisms, they cannot be expected to have detailed knowledge about the unique problems, potential and characteristics of each U.S. growing area. To illustrate this point, I will consider the *Minchinia* sp. parasite that has been found in Korean oysters and is the basis for the current embargo on Korean seed oysters.

First a review of the facts: 1) *Minchinia* sp. have been responsible for catastrophic oyster mortalities on the east coast; 2) a *Minchinia* sp. has been found in 0.28% of the Korean oysters examined; 3) nothing is known about the life cycle of the Korean *Minchinia* sp.; 4) available data indicates the Korean *Minchinia* sp. has never been associated with oyster mortalities; 5) with a single (suspect) exception, the Korean *Minchinia* sp. has apparently never been found in the tissues of an adult oyster (Kern, 1976 reported the presence of a single plasmodium, within a hemocyte, in the stomach epithelium). This suggests that oysters may have the cellular defense mechanisms to control the *Minchinia* sp. and 6) no one knows the species of any of the various west coast or Korean *Minchinia*.

Thus, the critical question: is the simple presence of an organism, not itself known to cause mortality or pathological lesions, that belongs to a genus containing members which cause severe oyster mortalities,

sufficient reason to invoke an embargo? In my judgment, guilt by association (organisms of the same genus) is not sufficient reason to invoke a permanent embargo; certainly, it is cause for caution.

Some additional facts relevant to Oregon: the available evidence suggests that haplosporidans (thought to be *Minchinia* sp.) are endemic in all Oregon bays in which oysters are grown commercially (Tillamook, Yaquina, Coos) (Mix and Sprague, 1974, Oregon Fish Commission technical reports); we (Mix, Pribble and Sprague, unpublished research) found haplosporidans in tissues of young oysters (less than 1 year old) (*Ostrea lurida*) but not in oysters beyond that age. Based on the presence of necrotic plasmodiam in those oysters, we concluded that oysters possess the cellular immune mechanisms necessary to eliminate this disease organism when it is encountered; the Oregon haplosporidan has never been associated with oyster mortalities, in spite of being present in extremely dense oyster populations--a condition normally favorable for rapid disease transmission; the haplosporidan was never found in oysters from the commercial growing areas; *Minchinia* sp. are thought to tolerate only high salinity water; and Oregon oysters are grown in very low to mid-salinity waters.

Again, it is my judgment that the prohibition on importing Korean seed oysters is, at the present time, reasonable. However, there is no *a priori* reason to assume that the presence of plasmodial stages in 4 of 1,438 oysters is indicative of impending mortality at some future time in some distant estuary. The Oregon oyster industry and Oregon bays and estuaries differ significantly from those of the east coast and Korea. Thus, I feel it is both reasonable and important that representatives, scientists, and personnel from the state fish commissions from the various affected states (those wishing to import Korean seed) be involved in the evaluation of information and the final decision-making processes.

3. I would suggest that personnel who might represent the various states be identified and/or recommended by the appropriate state agency responsible for regulating shellfish and that this be done as expeditiously as possible. Certainly, there is already enough information available on Korean seed oysters to consider convening a meeting in the near future to evaluate the problems. Perhaps such a meeting could be held in Seattle with representatives from California, Oregon, Washington and the Oxford

laboratory attending. It seems obvious that if some action is not taken soon, problems related to the importation of Korean seed oysters will remain unresolved and the frustration of oyster growers unable to obtain reasonably-priced seed in the future may lead to some undesirable consequences.

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