SANITATION IN SEAFOOD PRODUCTION AND DISTRIBUTION

J. LISTON

Food Science, College of Fisheries
University of Washington, Seattle

The seafood industries are concerned with the harvesting and processing of a very wide range of marine animal products. Processes are extremely diverse and sometimes complex, involving most of the traditional methods of food preservation and some of the most modern techniques. The size of the individual production units varies from small one-man fishing boats through highly mechanized factory fishing vessels at sea and from family operated shellfish or fish house plants to large fish canneries and frozen prepared seafood operations on shore. This general diversity and unevenness within the industry is reflected in the varied approaches observable towards the problems of sanitation. These range from complete indifference to a keen appreciation of the necessity for a high level of sanitary control. As might be expected, more emphasis generally is placed upon good sanitation by the larger operators. However, the nature of the raw material and the processing operation also tend to influence the degree of emphasis.

No general program for sanitation in the fishing industry has ever been developed and the few rather limited studies which have been undertaken of scientific cleaning and sanitizing methods have been concentrated on specific sectors of the industry.

Public health requirements and maintenance of high quality in the product are two main stimuli toward good sanitation in a food operation. With the exception of molluscan shellfish (mainly mussels and oysters), seafoods never have presented a major public health problem in most Western countries, though the recent outbreak of Type E botulism from smoked fish and tuna may have altered the picture. This (formerly) healthy situation was probably a result of the general practice of keeping fish and fish products at low temperatures. The public health incentive to good sanitation was thus largely absent in fish operations. Again, quality in most fish products is primarily dependent on the extent to which endogenous bacterial growth may be inhibited. Typically, sanitation is concerned with the control of exogenous contamination which is of little concern to many fish processors and thus the other stimulus to good sanitation was also lacking.

Capture and Harvest

Uniquely among modern food industries, the seafood industry is based on a hunting economy. It is only in the case of the molluscan shellfisheries that a controlled system of culture and harvest directly analogous to agricultural methods on land exists. Marine fish and shellfish such as shrimp, crab and lobsters must, therefore, be located, captured and transported in fishing vessels to the processing plants. Sanitation procedures on board the vessel will obviously influence the bacteriological quality of the fish reaching the shore plant.

Fortunately, fish caught in unpolluted waters carry no bacteria of public health significance on their skin and other external surfaces and the flesh and internal organs are sterile. The natural flora of fish, exclusive of the intestine, consists principally of psychrophilic bacteria of the genera Pseudomonas, Achromobacter, and Vibrio plus a few eurythermic types such as Micrococcus. This has been confirmed by numerous investigations (see Table 1). The numbers of such organisms found on freshly caught fish range from about 10⁴ to 10⁵ per cm² of skin surface. In feeding fish, the intestine may contain very large numbers of bacteria, up to 10⁶ per g of gut content. Again most of these bacteria are gram negative psychrophilic types but potentially hazardous organisms such as Clostridium tetani and Cl. botulinum have been isolated from fish intestine (16, 20). The microflora of crustacean shellfish seems to be similar to that of fish (6). It is not generally recognized that the natural microflora of sessile shellfish such as oysters is also similar, for the most part, to that of free swimming fish (6). However, as is well known, these shellfish by their mode of feeding, tend to concentrate within them bacteria present in the surrounding water and since they are grown normally in inshore or brackish waters subject to considerable terrigenous contamination from land drainage and sometimes from sewage outfalls, they readily accumulate detectable numbers of coliform and other more dangerous enterobacteria such as Salmonellae.

There is thus little or no intrinsic public health hazard associated with fish which can be controlled by good sanitation. Most fish in the North American fisheries are landed in uneviscerated condition; a notable exception is Pacific halibut. Therefore, the sporing anaerobes in the intestine cannot be disregarded at this point; though, of course, by contrast these organisms may be distributed over the surface...
TABLE 1. FLORA OF SEA FISH ACCORDING TO VARIOUS AUTHORS, AS SHOWN BY PERCENT ISOLATIONS IN THE VARIOUS GENERIC GROUPS

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reed and Spence (1929) Haddock</td>
<td>4</td>
<td>23+*</td>
<td>8</td>
<td>22</td>
<td>24</td>
<td>18</td>
</tr>
<tr>
<td>Stewart (1932) Haddock</td>
<td>22</td>
<td>57+</td>
<td>11</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Bedford (1933) Halibut</td>
<td>16</td>
<td>34+</td>
<td>30</td>
<td></td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Shewan (1938h) Herring</td>
<td>24</td>
<td>43+</td>
<td>13</td>
<td>11</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Thjøtte and Sømme (1938) Cod</td>
<td>14</td>
<td>48+</td>
<td>25</td>
<td>5</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Thjøtte and Sømme (1943) Misc. species</td>
<td>3</td>
<td>21+</td>
<td>6</td>
<td>4++d</td>
<td>2</td>
<td>64++ (chiefly Vibrio)</td>
</tr>
<tr>
<td>Wood (1940) Misc. species</td>
<td>48</td>
<td>19</td>
<td>17</td>
<td>7</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Aschehoug and Vesterhus (1943) Herring</td>
<td>17</td>
<td>25+</td>
<td>18</td>
<td>40</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Snow and Beard (1939) Salmon</td>
<td>13</td>
<td>54+</td>
<td>5</td>
<td>8</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>Dyer (1947) Cod</td>
<td>73</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Gianelli (1957) Porgy</td>
<td>53</td>
<td>21</td>
<td>7</td>
<td>6</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Liston (1957) Skate</td>
<td>3</td>
<td>19</td>
<td>9</td>
<td>65</td>
<td>4 (including Coryneb)</td>
<td></td>
</tr>
<tr>
<td>Liston (1957) Lemon sole</td>
<td>1</td>
<td>22</td>
<td>5</td>
<td>69</td>
<td>3 (including Coryne)</td>
<td></td>
</tr>
<tr>
<td>Georgala (1958) Cod</td>
<td>1</td>
<td>32</td>
<td>6</td>
<td>50</td>
<td>11 (including Coryne)</td>
<td></td>
</tr>
</tbody>
</table>

*Taken from Colwell (5).


*+ Probably includes organisms classed as Pseudomonas by current methods.

d++ Note that most of the bacteria in the Miscellaneous classification, should be added to Pseudomonas.

of iced fish by contact with intestinal material squeezed out under the pressure of fish and ice. The hazard associated with molluscan shellfish is well understood and an excellent control system to ensure the cleanliness of shellfish growing waters is in operation in the USA and many other countries of the world. The recent outbreaks of infectious hepatitis due to consumption of oysters harvested from polluted waters (8) serves to point up the need for continued close surveillance and indicates the possible emergence of a new problem associated with the transmission of viruses by foods. It would seem advisable that more information be obtained on the survival of virus particles in marine environments.

Once they are brought aboard the fishing vessel shrimp and fish are most commonly packed down in ice in the fish hold. Crabs and lobsters are transported live or, in a few cases, butchered and processed aboard the vessel (e.g., some Alaska King crab). Some small vessels operating day fisheries carry no ice while an increasing number of larger vessels freeze the fish at sea. This may be done using whole fish, as in the tuna industry, or after partially or completely processing the fish, as in the large factory trawlers operated by many European companies. Increasing use is being made in Pacific...
Coast fisheries of refrigerated sea water tanks in which fish may be held at 30 F, an optimum storage temperature.

Most fish boat holds are constructed of wood and conform to the shape of the hull. They are usually divided into pounds or pens which range along the side of the vessel separated from the central aisle by removable pen boards which fit into slotted stanchions. The entire area is very difficult to clean. The wooden walls and boards tend to become permeated by fish slime and bacteria which thus come to lie below the surface and cannot be effectively killed or dislodged. In most cases the fish boat holds are washed out between voyages but the methods used range from simple hosing down with water (often harbor water or sea water) to detergent and sanitizer treatments. An interesting study by Bureau of Commercial Fisheries personnel in this country confirmed the effectiveness as a sanitizing method of a simple procedure for continuous chlorination with sodium hypochlorite of the sea water used for washing down fish and fish holds (11). The method seemed to give very satisfactory results in terms of improved fish quality and general cleanliness of the vessel but unfortunately does not seem to have been very widely adopted by the fishing industry.

Good sanitary conditions in fishing vessel holds can be achieved most readily by the use of lining materials such as aluminum or plastic faced boards which provide cleanable surfaces rather than wooden boards which are essentially uncleanable. Most modern European fishing vessels are being fitted with aluminum fish holds but they are not yet a common feature of North American vessels which tend to be smaller and wood hulled.

The bacteriological quality of the ice or brine used to cool fish on board fishing vessels also has sanitary significance. Fresh ice made from water of good quality normally carries few bacteria but large populations accumulate in ice in contact with fish (9). The reuse of ice is an undesirable and insanitary procedure. However, this is a very minor problem in practice. Refrigerated brine or sea water tanks also develop high populations of bacteria but these are almost exclusively psychrophilic types derived from the fish. A number of attempts have been made to control bacterial populations in brine tanks both on ships and on shore by the use of ultra violet germicidal lamps. These have met with variable success. The numbers of bacteria in the brine are reduced by the method but there is no effect on the development of bacteria on the fish itself (2). A variety of preservative chemicals have been proposed for incorporation in ice or brine to reduce bacterial growth (19). However, none has proved to be satisfactory in practice though tetracycline antibiotics, particularly Aureomycin (chlortetracycline) and Terramycin (oxytetracycline) have been used with some success particularly in Canada (27). As might be expected, such aids to preservation are most effective when applied under clean conditions and are in no way a substitute for an effective sanitation program.

Another shipboard sanitation problem which is well recognized is the danger of contamination of the catch by bilge water. Most fish holds are so constructed that this rarely happens.

There is surprisingly little information available concerning the extent of shipboard contamination of fish by bacteria of public health significance. That some contamination does occur, however, may be inferred from the observations of Spencer and Georgala (26) (reproduced in Table 2), and the repeated isolation of Erysipelothrix rhusiopathiae from the fish market but not from fish sampled aseptically at sea (23).

### PRIMARY PROCESSING

The unloading of fish from the vessel and its primary processing through such operations as heading, evisceration and steaking or filleting involves a great deal of direct handling of the product. This is true also of the primary processing operations applied to shellfish which include shucking of oysters and clams, shelling of shrimp and picking of crabmeat. Moreover, because of the somewhat erratic supply of raw products to the processing plants most incoming seafoods and often primary processed materials are subject to variable intervals of buffer storage in a variety of containers or storage rooms. Since the duration of an average fishing voyage may range from a few days to several weeks fish arriving at the processing establishment are likely to represent a wide range of quality including relatively high count fish caught early in the voyage and lightly contaminated fish caught shortly before arrival in port. These fish are usually sorted into storage areas according to species, size or some similar criterion, so that fresh and less than fresh fish are often mixed.
indiscriminately. Moreover, as fish pass along the processing line spoilage bacteria may be transferred from longer stored to fresh fish and subsequently to fillets or steaks of both types. Under these conditions there are numerous opportunities for contamination of the seafood by bacteria of human origin. Again there is remarkably little information on the real extent of such contamination in practice, except in the case of oysters where under poor sanitary conditions very high levels of fecal bacteria have been detected in the shucked meats. In one study of filleted fish 38% of the fillets carried fecal \textit{E. coli} which may have been present on the landed fish and 30% carried coagulase-positive staphylococci which are certainly absent from freshly caught fish (25). Early studies in USA indicated that fish fillets may be contaminated by coliform bacteria (9).

The sources of contamination during primary processing are numerous. The baskets, boxes or conveyors used to transfer fish from ship to shore may provide an initial source of contamination which can be supplemented by storage bins or boxes. Where such containers are made of wood the danger of contamination is particularly great. The extensive studies by Spencer (24, 25) on the cleanliness of fillet boxes clearly indicate the extreme difficulty involved in cleaning and sanitizing wooden surfaces contaminated by fish slime and experiments in our laboratories and by other workers have confirmed this (15).

The butchering of fish and shellfish is still essentially a manual operation in most plants, though recently some mechanization has been introduced by a few firms. Notable exceptions are provided by the salmon canning industry in which the Iron Chink cannery introduced in the early part of this century efficiently eviscerates and trims fish completely mechanically. Also the peeling of shrimp largely is effected by machines nowadays.

A number of studies have been made on the bacteriology of the butchering process but these have been concerned primarily with psychrophilic spoilage bacteria (3, 4). The flesh of fish stored for only a few days in ice or brine is essentially sterile. Consequently any contamination of the fillet must be exogenous in the sense that the bacteria are transferred from the skin slime to the flesh surface via knives, filleting boards, gloves, etc. Essentially continuous sanitation procedures are necessary to reduce contamination at this stage. Unfortunately many smaller and older fish filleting plants include many untreated wooden surfaces which never can be completely sterilized. More modern plants make extensive use of metal (usually stainless steel) in the construction of tables and conveying lines but the wooden board still is the only generally acceptable support for the actual filleting operation. Because incoming fish carry more or less heavy loads of bacteria into the plant the primary processing lines show a rapid build-up of bacterial contamination (4, 26). Recent studies in the Pacific Northwest provide confirmation of the earlier reports and reveal that fish may pass through a brief period at the point of filleting where they are essentially sterile and indicate quite clearly the source and nature of subsequent contamination which includes fillet boards, knives, gloves, hand rinse water, etc.

Copious amounts of cold water are used in most fish filleting operations and this serves to depress bacterial contamination somewhat in most plants. An increasing number of plants are adopting in-plant chlorination. Usually a final concentration of about 5 ppm chlorine is maintained. This level of chlorine has no deleterious effect on the fish but effectively reduces the bacterial populations. Processors using in-plant chlorination will usually use an increased level of chlorine for clean-up purposes.

The disposal of waste from primary processing operations in fish plants has produced problems in the past. Most seafood plants are built close to the ocean. In earlier times most of the gurry was dumped directly into the sea. This is still done in the case of plants situated in remote areas such as Alaskan salmon canneries and South (West) African pilchard canneries. In such plants, sea water often is used for washing the fish and trouble has developed where the intake for this water was situated so that it received water from the gurry dumping area.

Processing plants situated in less remote areas usually have little trouble disposing of the waste since there is a ready market for such material as animal feeding stuff. For example, in the Pacific Northwest much of the waste is purchased and used by mink farmers. Nevertheless, waste must be disposed of quickly (or frozen) since it rapidly decays and can create a public nuisance as well as a source of undesirable contaminants for incoming fish.

### Secondary Processing

**Canning.**

Except that the primary processing referred to above constitutes an integral part of most fish canning operations and, therefore, introduces its attendant problems to the situation, fish canneries are faced with sanitation problems similar to those found in establishments canning other foods. Due to the very serious consequences which may result from poor sanitation in canned food preparation, fish canners are more aware of the need for good sanitary control than their colleagues in the fresh and frozen fish field. Moreover, the National Canners Association and the major can companies are engaged in
edcational and technical assistance programs which serve constantly to emphasize the principles and practices of scientific cleaning and sanitation. In addition some states (e.g., California) operate an active program of regulation and inspection of canning operations and since canned goods generally enter interstate markets, plants and products also are subject to Federal Food and Drug Administration surveillance. Current problems in canned seafood products are, in general, less a product of poor sanitation practices than of the nature of the raw material leading to difficulties such as struvite (magnesium ammonium phosphate) formation in various products.

Frozen and Precooked Frozen Products.

A very high proportion of seafoods is now retail- ed as frozen or frozen precooked products, i.e., fish, molluscs and crustaceae.

In the case of frozen but uncooked seafoods such as “green” shrimp, fillets, fish portions, etc., there are few additional sanitation problems beyond the primary processing stage. Sometimes dips are used on seafoods destined for freezing. These can be a source of contamination unless they are changed quite frequently. Packaging materials generally are quite free from bacteria but there is opportunity for contamination of the product from the hands of personnel engaged in packaging. This is of more significance in the case of precooked products.

The enormous expansion over the past few years in precooked or convenience frozen foods has affected the seafood industry profoundly. Large quantities of fish and shellfish now are retailed in precooked form. These include crabmeat (a traditional item), shrimp, fishsticks, prepared portions, fish and chips, fish dinners and prepared fish dishes of various kinds. The sudden increase in production of these items has introduced a new dimension of hazard to a section of the fish industry which previously had produced only raw products subject to the protective effect of home cooking before consumption. Moreover, new and potentially more hazardous food ingredients such as egg, milk powders, etc., have been introduced into seafood processing in the form of breading and batter mixes.

A number of studies have been made of the bacteriology of prepared frozen seafood products and it is clear that contamination of the raw material can and does occur during preparation and processing (17, 18). During the last ten years or so, there has been a very marked improvement in the final bacteriological quality of such foods. This is undoubtedly due to a variety of factors, such as: increasing experience and sophistication on the part of processors; technical advances in equipment design and operation; the efforts of trade bodies such as the NAFFEM; and of the state and federal regulatory agencies. Our own studies have convinced us that the bacteriological problem in precooked frozen seafoods is primarily one of sanitation and hygiene (14). The raw materials are, in most cases, of good bacteriological quality. The build-up of organisms of public health significance occurs only in the course of handling. Such bacteria are obviously derived principally from operating personnel. This is illustrated in Tables 3 and 4. The data derived from the studies on batter are particularly illustrative of the importance of extrinsic factors in controlling contamination.

### Table 3. Effect of Processing on Bacteria of Public-Health Significance

<table>
<thead>
<tr>
<th>Stages of processing</th>
<th>Coliforms</th>
<th>Enterococci</th>
<th>Hemolytic streptococci</th>
<th>Coagulase-positive staphylococci</th>
<th>Sporulating anaerobes</th>
<th>Salmonella-Sheigella group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$&lt;1$</td>
<td>$&lt;10$</td>
<td>$10^{2}$</td>
<td>$10^{3}$</td>
<td>$&lt;1$</td>
<td>$&lt;10$</td>
</tr>
<tr>
<td>A</td>
<td>6</td>
<td>27</td>
<td>41</td>
<td>13</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>6</td>
<td>12</td>
<td>41</td>
<td>3</td>
<td>39</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>10</td>
<td>42</td>
<td>29</td>
<td>17</td>
<td>11</td>
</tr>
<tr>
<td>D</td>
<td>47</td>
<td>29</td>
<td>14</td>
<td>6</td>
<td>3</td>
<td>22</td>
</tr>
</tbody>
</table>

*Taken from Raj and Liston (17).

*A = raw blocks (15), B = raw sticks, (32), C = battered and breaded sticks (101), D = precooked sticks (63). The figures in parentheses indicate the number of samples tested.*

**TRADITIONAL SECONDARY PROCESSING**

The traditional preservative processes—pickling, salting and smoking—are of decreasing significance in the North American seafood industry but are still major factors in the seafood industries of many other countries of the world.

Sanitary control in such operations is often minimal since it is widely and erroneously believed that the processes themselves are sufficiently bactericidal to
control any public health risk. Though it is doubtful that poor sanitation practices were entirely to blame, the recent tragic outbreaks of botulism caused by smoked fish demonstrate the nature of the fallacy.

Earlier work has shown that organisms of public health significance may accumulate and persist in brines and on the surface of salted fish (1).

An important reason for emphasizing better sanitation in traditional fish processing is the reduction in the severity of the processes which are used today. Indeed regimens of salting and smoke curing now are used which serve principally to flavor rather than to preserve the product.

**NEW PROCESSES**

New processes being applied to seafoods or in prospect for them include freeze drying and radiation pasteurization.

Little is yet known concerning the specific problems of freeze drying though a commercially successful freeze-dry shrimp operation has been running for some time in this country. It seems apparent that sanitary control of the primary processing operations would be of most importance here.

Radiation pasteurization using gamma radiation from Cobalt 60 presently is being studied very intensively. Many early studies indicated the suitability of seafoods for this kind of process and the more recent studies have amply confirmed these findings. Sanitation problems associated with radiation pasteurization again are mainly confined to the primary processing operation. It is important that good control of contamination be exercised here since the radiation process results in a sharp reduction of the natural microflora. Recent studies in our laboratory have indicated that under comparable conditions staphylococci will grow out in irradiated fish but not in unirradiated (21). Thus, the desirable restrictive influence of the natural microflora toward certain pathogens, at least, is minimized. Another possible consequence of poor sanitation in plants operating the process could be a build up of radiation resistant bacteria. Of course, it is proposed that radiation pasteurized fish be held at temperatures below those at which potential pathogens can grow, so that it is only in the event of mishandling that contaminant organisms could or would grow out.

**DISTRIBUTION AND RETAIL**

Seafoods are widely regarded as highly perishable food products and the necessity for rapid and expeditious distribution of wet fish is well known. Nevertheless, the handling of many fish products in retail trade leaves a great deal to be desired. Frozen fish products share the common fate of frozen foods being occasionally subject to widely fluctuating temperatures of storage which sometimes reach above the melting point. However, it is the unprocessed or traditionally processed seafood which suffers the greatest indignity. These items are generally tucked away in a corner of the meat counter where they

---

**Table 4. Batter Samples Before and After Reconstitution**

<table>
<thead>
<tr>
<th>Count per gram</th>
<th>Total counts</th>
<th>Enterococci</th>
<th>Coliforms</th>
<th>E. coli</th>
<th>Hemolytic streptococci</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20°C</td>
<td>35°C</td>
<td>I</td>
<td>II</td>
<td>I</td>
</tr>
<tr>
<td>&lt; 1</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&lt; 10</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10³</td>
<td></td>
<td></td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10⁴</td>
<td></td>
<td></td>
<td>20</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>10⁵</td>
<td></td>
<td></td>
<td>0</td>
<td>58</td>
<td>0</td>
</tr>
<tr>
<td>10⁶</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10⁷</td>
<td></td>
<td></td>
<td>0</td>
<td>54</td>
<td>0</td>
</tr>
</tbody>
</table>

*Taken from Ray and Liston (17).
*I = dehydrated batter mix (10 samples). Showed no incidence of coagulase-positive staphylococci, sporing anaerobes, and Salmonella-Shigella group.
*II = reconstituted batter from the line (33 samples). Showed 100% incidence of coagulase-positive staphylococci, 50% incidence of sporing anaerobes, and none of Salmonella-Shigella group.
lie exposed to temperatures which often are too high. Though such temperatures may effectively inhibit the growth of dangerous mesophiles, they do not sufficiently depress the growth rate of psychrophilic bacteria which abound on fish.

This brief survey of some of the sanitation problems of the seafood industry obviously is not intended to be comprehensive. The industry is too large and too diversified to be adequately dealt with in a single short paper. However, the author hopes that sufficient material has been covered to enable the reader to obtain some idea of the peculiar and yet often familiar nature of the sanitation problems which exist in the fishing industry.

It is noteworthy that, despite the strictures which have in the past been (rightly) laid on the fishing industry for poor sanitation practices, the record of fish as a safe food is even yet (recent botulism notwithstanding) unsurpassed by most other products. At the same time it is encouraging to record that the industry as a whole is moving toward a better appreciation of the need for good sanitation practices. An acceleration of this could be achieved through the advice and active assistance of qualified sanitarians of local, state and national agencies. It is doubtful that a true appreciation of the nature and role of bacteria in causing spoilage of seafoods or even the real nature of the bacterial hazards to the public health resulting from poor sanitation practices is really widespread among fishing industry personnel. Certainly there is a very poor understanding of the principles and practice of modern cleaning and sanitation systems. Dissemination of accurate information at the grass roots level by education of actual plant operators is greatly needed in the industry. This can be carried out most effectively by trained sanitarians in close and constant contact with the food industries.

ACKNOWLEDGMENT

I am grateful to Dr. Wayne Tretsven of the Bureau of Commercial Fisheries, Seattle, Washington, for allowing me to utilize some of his unpublished data on filleting operations in the Pacific Northwest.

REFERENCES