Survival of Enteric Organisms in Sea Water

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THE increased use of ocean beaches and tidal areas for recreational activities and commercial shellfishing, coupled with the increased volume of sewage being discharged into the ocean and the heightened interest in general pollution control, has served to make the problem of salt water contamination acute. This is especially true in a coastal area such as California, which is experiencing a tremendous population growth.

Although the problem of controlling this contamination is basically an engineering one, a public health laboratory can be of real assistance in compiling and evaluating available information on the occurrence and survival of enteric organisms in sea water. Consequently, a review of the literature is reported by the division of laboratories of the California State Department of Public Health.

The reader's attention is called to two references which are of particular interest and value. These are Zobell's Marine Microbiology (*1*), a book which deals with the entire problem of micro-organisms in the sea, and Moore's comprehensive review on the contamination of ocean beaches (*2*).

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Some of the Early References

For more than half a century it has been known that sea water can be significantly contaminated by human wastes and that this contaminated water may be a factor in the transmission of enteric diseases either through the direct use of the water or indirectly through shellfish which have been exposed to it. The first study on this subject was reported in 1885 by Nicati and Rietsch (*3*), who were able to recover the cholera vibrio from the water of the old harbor at Marseilles during a cholera epidemic. In a series of laboratory experiments they showed that the survival of *Vibrio comma* varied in different waters. For example, the organism could be recovered from sterilized harbor water 81 days after inoculation, while in sterilized water from the open sea the survival time was reduced to 64 days. In polluted fresh water, however, the organism could not be recovered after 32 days.

In studying the Bay of Naples, de Giaxa (*4*) determined that enteric bacteria die off rapidly in the sea. In heat-sterilized sea water the typhoid bacillus and the cholera vibrio survived 25 and 36 days, respectively, while in raw sea water they persisted for only 9 and 4 days. He found that the total number of bacteria markedly affected the survival of the cholera bacillus; there was an inverse relationship between total bacterial count and survival time. He isolated a number of strains of marine bacteria which possessed definite antagonistic activity for the cholera bacillus and also for the nonenteric anthrax bacillus. De Giaxa concluded that water of the open sea could probably not be a means of spread of disease but that, in spite of the relatively rapid death rate in harbor water, such water might be infectious. He also indicated that fish and shellfish might be involved in disease transmission.

Fränkel (*5*), in a like manner, recovered cholera bacilli from the harbor at Duisberg, presumably after contamination of the water by the discharge from a ship on which cholera was present among the crew.

In connection with investigations on the contamination of shellfish and the possibilities of purifying them, a number of observers commented on the survival of enteric pathogens in sea water.

Conn (*6*) cited Burdoni, who showed that the typhoid bacillus would live in sea water for 14 days.

Foote (*7*) noted that, in raw brackish water with a salt content of 0.06 to 0.15 percent, the survival of typhoid organisms was a function of temperature, there being greater survival when the temperature was above freezing.

Reille (*8*) stated that, according to his experiments, sea water was favorable to the survival of typhoid bacteria.

Boyce and Herdman (*9*), on the other hand, claimed that typhoid bacilli will not flourish in clean sea water, and Klein (*10*) observed that sea water had a "powerful destructive action" on *Salmonella typhosa* but that survivors could be recovered even weeks after the collection of samples of heavily infected water.

Later, Winslow and Moxon (*11*), during a study of bathing beaches in New Haven Harbor, Conn., were able to recover large numbers of coliform bacteria. Although they did not discuss the factors which affected the coliform numbers, they did mention that tides and winds played a part in the distribution of bacteria. A combination of flood tide and onshore wind produced the least dispersion and the highest counts.

In a survey of sewage outfalls in Los Angeles, Knowlton (*12*) found that the coliform count decreased more rapidly than could be accounted for by dilution alone. After collecting samples with high coliform counts at bathing beaches distant from the outfall, he concluded, "These conditions lead me to believe that *B. coli* contamination may be caused by bathing only."

Survival in Sea Water

It is obvious from these earlier references that an appreciation of the problem existed long before there were adequate means for studying it. Conflicting reports on the effect of sea water on enteric micro-organisms pointed up the need for much additional work. Although subsequent studies did not all agree in their results, they have shown conclusively that there are factors present in sea water which decrease the survival of enteric organisms.

Trawinski (*13*), from his observations of the survival of various enteric pathogens in sea water and in the water from sewage outfalls, found that several members of the typhoid group survived for shorter time periods in the outfall water than in water from the open sea.

Burke and Baird (*14*) reported that fresh water bacteria could survive equally well in fresh or salt water.

Kořínek (*15*), after attempting to grow a number of fresh water and soil bacteria in media made with sea water, concluded that, although the micro-organisms could grow quite well on a sea water medium, in nature they have only a latent development in the sea.

The cholera vibrio was observed by Kiribayashi and Aida (*16*) to survive, on the average, for only 10 days in the water of Keelung Port, Formosa, but in the laboratory it survived longer.

In a series of carefully conducted experiments Beard and Meadowcraft (*17*) studied the survival of pure cultures of *S. typhosa* and *Escherichia coli*. The organisms were put into cells made essentially of a semipermeable membrane, and the cells were suspended in San Francisco Bay. After 35 days no typhoid bacilli and few coliforms could be recovered from the cells.

Experiments using laboratory cultures of the test micro-organisms are of questionable value since it has been shown that laboratory-propagated strains have a greater resistance than naturally occurring bacteria (*2*, *18*). The results of such experiments may, therefore, have little sanitary significance.

Zobell (*18*) avoided this objection by using sewage bacteria directly, without cultivating them in the laboratory. Comparing the survival of these bacteria in sea water and sewage-diluted sea water, he found that a concentration of 5 to 10 percent of sea water favored the survival of bacteria, whereas higher concentrations produced rapid killing. In 75 percent sea water the bacterial count was reduced to 39 percent of the original in 2 hours.

The general problems of the discharge of sewage into the Atlantic and Pacific Oceans have been discussed, respectively, by Weston (*19*) and Warren and Rawn (*20*). They indicated that enteric bacteria occur in significant numbers only in such places as tidal zones, harbors, and bays.

Zobell (*21*) confirmed these observations by finding coliform bacteria absent in 961 samples taken from the open sea but regularly present in samples from bays and estuaries. He attributed the die-off of coliform bacteria to the paucity of organic matter and the activity of predatory organisms, believing sea water itself, however, to be slightly toxic for *E. coli.*

Carpenter, Setter, and Weinberg (*22*) observed that sea water has considerable disinfecting properties on fresh sewage organisms. In their experiments an average of 80 percent of the organisms died in 30 minutes.

The Massachusetts Department of Public Health (*23*) and Weston and Edwards (*24*) have reported the results of an investigation made at the Lawrence Experiment Station. After mixing sewage with sea and tap water, at rates of 0.5, 1.0, and 1.5 percent, the total number of bacteria and number of coliforms were followed for 4 days. Both in the raw sewage and the sewage-tap water mixtures the bacterial count decreased slowly, but in the sewage-sea water mixture the decrease was very rapid. No coliforms survived beyond 4 days in the latter mixture.

During the course of examining the Santa Monica beaches, the California Department of Public Health (*25*) showed that marked coliform reductions occurred in samples of contaminated sea water held for 24 hours. At refrigerator temperatures, from 5 to 20 percent of the coliforms survived. At room temperature, however, only 1.0 to 2.5 percent of the original number of coliform bacteria could be recovered after 24 hours.

Stryszak (*26*), working in Poland with several *Salmonella* species, found that the waters of the Gulf of Gdansk(Danzig) produced a rapid kill when the temperature was between 5.5° and 18.5° C. Lower temperatures resulted in reduced kills.

Ketchum and his colleagues (*27*), in the first of several papers from the Woods Hole Oceanographic Institute, concluded that coliform bacteria rapidly disappeared from normal sea water. This disappearance was more rapid than could be accounted for by such mechanical factors as dilution or sedimentation.

In a later paper from the Woods Hole laboratory (*28*), the bactericidal action of sea water was shown to be the most important factor in decreasing coliform counts. The total reduction was 99 percent.

Buck, Keefer, and Hatch (*29*) found that coliforms could persist in estuary water for longer than 200 days.

The North Sea has been examined by several investigators who recovered a number of pathogenic enteric bacteria (*30*). Buttiaux and Leurs (*31*), for example, found *Salmonella montevideo.* Their experimental work indicated that with 3 species of *Salmonella* there was more than 90 percent kill in spring water in 44 hours but that in sea water the number of survivors was greater.

As a result of studies similar to the ones mentioned, attention has turned to the reasons for the bactericidal effect of sea water and the quantitative determination of its importance. The explanations suggested by Waksman and Hotchkiss (*32*) for the low numbers of viable bacteria in water have been summarized as follows:

1. The presence in sea water of toxic substances which are destructive to bacteria under natural conditions.
2. The presence of bacteriophage in the water.
3. The adsorption of the bacteria by the sea bottom and their sedimentation.
4. The bactericidal effect of sunlight.
5. The consumption of the bacteria by protozoa and other small animal organisms.

6. The possible presence in the sea of inactive bacteria which are capable of developing only under more favorable conditions of temperature, aeration, and food supply.

7. The lack of sufficient nutriment in the water.

8. The antagonistic relations of other micro-organisms.

It will be convenient to discuss the more important of these categories separately.

Presence of Inorganic Salts

The most potentially toxic substances present in sea water, on the basis of concentration, are inorganic salts. The salinity of surface sea water is given by Zobell (*1*) as from 3.3 to 3.7 percent. Near river mouths and other areas of fresh water dilution, this concentration of salts may be appreciably reduced. In inland seas, it may be greater. The effect of high salt concentrations on fresh water or enteric bacteria may be due to differences in osmotic pressure or to the presence of specific inhibitory salt concentrations.

As early as 1890, de Freytag (*33*) investigated the effect of concentrated solutions of sodium chloride on a variety of bacteria. Unfortunately, he did not mention the salt concentrations used, nor did he compare the survival times with any fresh water controls. He found that, although the typhoid bacillus survived for longer than 5 months, the cholera bacillus died out within 6 to 8 hours.

After comparing the growth of several fresh water bacteria on media containing varying concentrations of sea water, Kořínek (*15*) concluded that the test organisms could grow quite well on a sea water medium. Furthermore, sea water exerted no marked autolytic effect.

Reporting on the extension of this work, Kořínek (*34*) noted that fresh water bacteria usually do not compete successfully in the sea with marine bacteria.

The survival of bacteria in an 0.85 percent saline solution and in distilled water was compared by Ballantyne (*35*), who showed that in either menstruum—in the absence of nutrients—micro-organisms, including *S. typhosa*, were able to survive up to 32 months.

Burke and Baird (*14*) assumed that the principal factor of difference in fresh water or salt water survival of bacteria was the concentration of sodium chloride. The results they obtained, however, did not support this assumption. Although no data are given in their report and the test micro-organisms are not identified, they claimed that fresh water bacteria survived in sea water nearly as long as in tap water. The length of survival depended on both temperature and the presence of organic matter. Nutrient broths prepared with 2 to 4 times the concentration of salt present in sea water permitted the extended survival of of fresh water bacteria. Sea salts other than sodium chloride did not affect viability. Thus, in general, these authors support the viewpoint that inorganic salts affect slightly, if at all, the survival of nonindigenous bacteria in the sea.

Zobell and Feltham (*36*) in a discussion of marine bacteria mentioned that "the toxicity of sea water for nonmarine bacteria is due not only to its high salt concentration, but to some other factor as well," indicating that they considered the salts to exert some toxic effect.

In a later work Zobell (*18*) studied the survival of sewage bacteria in artificial and natural sea waters as well as in sodium chloride solutions. He showed that the death rates in the synthetic solutions were markedly different from those in the chemically similar sea water.

The Great Salt Lake in Utah obviously does not contain sea water, but its salt concentration of more than 25 percent makes it interesting in this connection.

Zobell and his associates, Anderson and Smith (*37*), in an attempt to grow *E. coli* on a lactose medium made with lake water, were unable to observe any gas production or to recover viable coliforms. They stated that the lake water would kill over 95 percent of the sewage bacteria in 1 minute.

Conflicting results, however, were obtained by Fraser and Argall (*38*), who claimed that *E. coli* was not rapidly killed and that the length of the survival time increased as the temperature decreased.

In summary, it would appear that the usual concentration of salts present in sea water may exert some bactericidal action, but that this toxicity factor is insufficient to account for the observed death rates or survival times.

Presence of Other Toxic Substances

The presence of other toxic substances has been stressed in recent years.

Zobell and Feltham (*36*) were among the first to make specific mention of the possible presence of such substances.

Waksman and Carey (*39*) spoke of "certain controlling factors" injurious to free bacterial development but made no attempt to characterize them.

Careful experimental work is described in an article by Zobell already cited (*18*). The test bacteria were submerged in the sea within Coors porous porcelain filter tubes impregnated with collodion. This semipermeable membrane permitted the passage of chemical substances from the sea water into the bacterial suspension but did not permit bacterial passage into the sea water. It was found that the death rate of sewage bacteria suspended in autoclaved sea water or sea water which had been passed through a Berkfeld filter was lower than that of bacteria in raw sea water.

A similar observation was made by Kiribayashi and Aida (*16*), who noted that cholera vibrios survived longer in boiled and sterilized sea water than in the untreated liquid.

Beard and Meadowcraft (*17*) concluded that the death rate of *E. coli* and *S. typhosa* was higher in unfiltered sea water than in filtered sea water.

Krassilnikov (*40*) found that a bactericidal factor also was present in the waters of the Black Sea. This factor was active against *E. coli* and was removed by passage of the water through a Seitz filter as well as by boiling or by heat sterilization, and its effect was overcome by the addition of organic matter. At a concentration of 0.1 percent of peptone it was completely absent.

The data of Ketchum, Carey, and Briggs (*27*) showed that there was a bactericidal principle in sea water which could be destroyed almost completely by autoclaving but only partially by boiling. This factor was not related in any simple way to the chemical composition of sea water. They suggested that the factor may be an antibiotic substance or an autolytic or degenerative product of the coliforms themselves.

In a continuation of this work, Vaccaro, Briggs, Carey, and Ketchum (*41*) determined that sea water treated by boiling, autoclaving, pasteurizing, and chlorinating had reduced bactericidal activity. The addition of organic matter also produced reduced activity although not as much as did sterilizing the sea water.

As part of an investigation of the viability of sewage bacteria with respect to shellfish purification, Sherwood (*42*) found that growth generally occurred in autoclaved sea water but not in raw sea water. By passing the treated water through sterile porcelain filters the effect of autoclaving was removed. Treated sea water which supported the growth of *E. coli* would not permit the persistence of heavy infections of *S. typhosa* or *Salmonella paratyphi* B.

De Balsac, Bertozzi, and Gaudin (*43*) observed that the bactericidal activity of sea water was independent of salinity, decreased with sample age until it disappeared after 8 to 10 days, was thermolabile, and persisted after passage of the water through a Chamberland filter.

It has clearly thus been established that sea water contains a potent toxic factor which is thermolabile. The isolation and identification of this factor has as yet to be accomplished.

Presence of Bacteriophage

Numerous investigators have confirmed the presence in sewage of bacteriophages active against enteric bacteria.

As early as 1896 Hankin, cited by d'Herelle (*44*), noted the effects of bacteriophages.

Arloing, Sempé, and Chavanne (*45*), as a result of their experiences, believed that the disappearance of fresh water bacteria in the sea was due to the action of specific phages.

Guélin (*46*), who is one of the foremost students of bacteriophage and its sanitary significance in water, found that bacteriophages active against the coli-typhoid dysentery group were present in the port of Roscoff (France). The number of phages varied directly with the degree of sewage contamination. However, no conclusions were drawn as to the role these phages play in the destruction of enteric bacteria.

De Balsac and co-authors (*43*) believed that the bactericidal activity which they observed was not due to bacteriophages.

There are too few data available to be able to draw sound conclusions on the role played by bacteriophages in limiting the survival of enteric bacteria in sea water. The indications, however, are that the phages are not of the first order of importance.

Adsorption and Sedimentation

Russell (*47*) observed that the concentration of bacteria in the Gulf of Naples was highest in the bottom muds. Although he attributed this distribution to the growth and multiplication of indigenous bacteria, he showed that the mud could take up bacteria which derived from the mainland.

Rubentschik, Roisin, and Bieljansky (*48*) believed that the disappearance of coliforms introduced into the limans or salt lakes of the Odessa region, by drainage from sewage fields, was due primarily to the adsorption of the bacteria on muds. The adsorption capacity of ground sediments in the Chadjibey liman for *E. coli* was quite high. The shallowness of the lakes, particularly near the shore, and the tidal action were responsible for rapid mixing of sediments with the surface water. This in turn produced conditions favorable to adsorption of bacteria.

Waksman and Vartiovaara (*49*) also found that marine muds had marked adsorptive effects on bacteria. Sand, on the contrary, possessed slight adsorptive properties.

These results are in accord with accepted theories of the nature of soil. Clay and silt, which constitute a major portion of the mud, are electrically charged, and hence, are adsorptively active. Sand, however, not only has a larger particle size and, thus, has less relative surface area, but it is also electrically neutral.

According to the theory held by Dienert and Guillerd (*50*), sea water is neither antiseptic nor inimical to *E. coli*, but sewage discharged into the sea is purified by sedimentation as well as through the activity of predatory organisms.

In a careful study Weiss (*51*) determined the adsorptive effect of silt taken from rivers and estuaries. He showed that the degree of adsorption was a function of particle size and the physicochemical nature of the particle. The turbidity found in many natural waters was high enough to yield measurable adsorption of *E. coli*. The end result of this adsorption of bacteria by relatively heavy particles is an increase in the rate of bacterial removal by sedimentation. However, sea water generally reduced the adsorptive capacity of silts, and, furthermore, desorption may have taken place.

It may be concluded that adsorption and sedimentation of enteric organisms do occur, but they will be affected by the nature of the bottom deposits, the rate of desorption, and the rate of water movement, that is, the factors adversely affecting sedimentation. Adsorption and sedimentation do not, in themselves, affect the survival of bacteria but merely tend to remove the organisms from suspension and concentrate them in bottom deposits where they may continue an active existence.

Sunlight and Temperature

Although a considerable amount of information on the bactericidal effects of sunlight has been accumulated, there are few references dealing with this effect in sea water.

Gaarder and Spärck (*52*) have studied this phenomenon and considered it to play a significant part in the destruction of organisms in the sea. In all likelihood it is a contributing factor in bacterial destruction but of secondary importance only.

The effect of temperature has been mentioned in some of the references already cited.

Burke and Baird (*14*) found that fresh water bacteria inoculated into sea water survived longer at 20° to 22° C. than at 7° to 12° C.

Waksman and Carey (*53*), in studying the effect of storage of sea water on bacterial multiplication, noted that temperature had a marked effect on changes in numbers of bacteria. As the temperature increased to an optimum, the rate of multiplication also increased.

Fraser and Argall (*38*) reported that in waters of the Great Salt Lake few *E. coli* survived for longer than 8 hours at summer temperature; however, at 6° C. approximately 50 percent survived a 24-hour exposure.

Ballantyne (*35*), in his work with physiological saline, found that *S. typhosa* also survived longer at low temperatures.

In spite of the conflicting reports on the effect of temperature on bacteria in sea water, there is no reason to believe that its effect will be materially different than it is in fresh water or any other aqueous system. Unfortunately, such information is equally conflicting, so that, in any given environment at ordinary temperatures, it is impossible to predict the effect of temperature changes other than to say that the tendency for increased survival is greater at lower temperatures.

Aeration and Food Supply

The dissolved oxygen concentration, which is a function of temperature, pressure, salinity, and biological activity, may be used to measure the degree of water aeration.

The only information available on the relationship between micro-organisms and oxygen content in natural sea water is the observation by Buttiaux and Leurs (*31*) that oxygenation of sea water did not affect the survival of *Salmonella typhimurium*.

Waksman and Carey (*53*) showed clearly that in stored sea water the oxygen content affected bacterial multiplication.

Zobell and Anderson (*54*) attributed this increase in numbers to the effect on the solid surface of the container, rather than to oxygen tension.

Under most circumstances survival, and more especially reproduction, of bacteria is associated with available nutrient materials.

Russell (*47*) found that multiplication of bacteria was quite marked in marine muds which are relatively rich in organic matter. He did not comment on the survival of bacteria in waters containing different concentrations of organic matter.

Burke and Baird (*14*) believed that the presence of organic matter in sea water would increase the survival time of nonmarine bacteria.

Waksman and Carey (*39*), in their investigation of the decomposition of organic matter in the sea, concluded that sea water contains enough organic substances in true solution to support an extensive population of bacteria. They did not indicate whether they believed that enteric bacteria or fresh water bacteria could thrive in such an environment.

In another study, Waksman and Vartiovaara (*49*) showed again that rapid and considerable increases in bacterial numbers took place following adsorption of parent bacteria on marine muds. The neutralizing effect of organic matter on the bactericidal principle in sea water has already been mentioned (*40*, *41*).

Steininger (*30*) found that at ebb tide the concentration of protein in the standing water of tidal pools was sufficient to provide favorable conditions for the multiplication of *S. paratyphi* B.

An unsigned editorial in the *American Journal of Public Health* (*55*) commented on the destruction of the bactericidal principle in sea water by autoclaving but not by boiling (*27*) and suggested that instead of being an antibiotic substance this principle was, in fact, not a toxicity but a starvation problem. Thus, chemical compounds present, but unavailable as nutrients to coliform bacteria, were decomposed by the elevated temperature of the autoclave (but not by boiling) and produced products "which enable the coliform bacteria to maintain themselves more efficiently" (*55*).

It should not be concluded that under all circumstances the chance of survival or of reproduction of the enteric bacteria is improved by the presence of organic matter. In the event that there is sufficient organic matter present to support growth, a competition between enteric organisms and saprophytes indigenous to either the fresh water or marine habitat would follow. Generally, the enteric organisms would be unequal to the competition. If we consider that the total number of bacteria in the sea is a direct function of the concentration of organic matter, it follows that there will be more competitors of the enteric bacteria as more organic substances occur and that these other organisms, either directly or indirectly, will reduce the growth and survival of the fecal bacteria. This has been shown by de Giaxa (*4*) and Kořínek (*34*).

Antibiotics and Animal Predators

De Giaxa (*4*) was the first to report the existence in the sea of bacteria antagonistic to *V. comma*. After growing these unidentified organisms in mixed culture with *V. comma*, he was unable to produce an experimental infection in animals. Pure cultures of the vibrio were, on the other hand, quite infectious.

Kiribayashi and Aida (*16*) assumed that the toxic principle in sea water was associated with the presence of saprophytic micro-organisms.

Zobell (*18*) and Waksman and Hotchkiss (*32*) observed the bactericidal action of sea water. Waksman and Hotchkiss did not attribute this action to a chemical factor. They found that the toxic agent did not interfere with the decomposition of organic matter as measured by oxygen uptake. Since the reduction in the number of bacteria was not accompanied by a decrease in oxygen consumption, they concluded that other living organisms, namely protozoa and other nannoplankton, were responsible for the reduction.

This point of view was held also by Stryszak (*26*), who believed that the effect of low temperatures on the increased survival of *Salmonella enteriditis*, *S. typhosa*, and *S. paratyphi* B was due to the thermal inactivation of predatory protozoa rather than to any more direct temperature effect. Similarly, when the concentration of organic matter increased, the population of saprophytes and animal predators did the same. From this effect Stryszak inferred that the predators were most important in the elimination of enteric pathogens from the sea.

Rosenfeld and Zobell (*56*), in comparing the bactericidal properties of sea water and cultures of antagonistic marine bacteria, found that both the sea water and the cultures suffered losses in activity after filtration through bacteria-proof filters and that both were, on the whole, active against the same organisms. Most of the antibiotic-producing bacteria belonged to the genera *Bacillus* and *Micrococcus*. Although antibiotic activity against *Proteus* sp., *S. typhimurium*, and *Shigella paradysenteriae* was not shown, activity against several gram-positive bacteria was demonstrated. It was concluded that the bactericidal activity of sea water "may be at least partially due to an autochthonous flora of antibiotic-producing organisms" (*56*).

Vaccaro and co-workers (*41*) believed that a normal population of marine bacteria was a necessary condition for bactericidal activity of sea water. They said:

". . . the preponderance of evidence thus points toward an antibiotic action, but it can not be stated categorically that all other possibilities have been excluded. The character of the activity is such that it suggests that the bactericidal substance is present in very small concentration."

Ketchum, Ayers, and Vaccaro (*28*) completed a study of a tidal estuary with a mathematical analysis of the factors contributing to the decrease in coliform counts and showed that bactericidal action was considerably more significant than either dilution or predation. Unevaluated factors were from 3 to 7 times as effective as dilution but were not as effective as bactericidal action in reducing counts.

From the foregoing it may be concluded that the single most important factor in reducing the number of enteric bacteria in sea water is a biological one and most likely is the result of the production of antibiotic substances by marine bacteria.

Summary and Conclusions

From a review of the literature on the survival of enteric organisms in sea water, it is apparent that these organisms can create a health hazard in estuaries, bays, and especially beaches. The rate of disappearance of the fecal bacteria is greater than that which would be expected from dilution alone. A number of factors are implicated. These include the production by marine bacteria of unidentified, heat-labile antibiotic substances; and adsorption and sedimentation, predation, and competition for the limited food supply. The net result is a partial or complete disinfection or self-purification of sea water. Nevertheless, this bacterial destruction should not be relied on as the sole protection offered to users of sea water.

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CDC Course in Epidemiology for Nurses

A 3-week course in communicable disease control is offered by the Communicable Disease Center, Public Health Service, Atlanta, Ga., to public health nurses and instructors in communicable disease nursing, beginning May 6, 1956.

The course, designed to increase the technical knowledge and skills of nurses in the prevention and control of communicable diseases, will emphasize epidemiological principles and techniques.

To a limited number of students, field experience under supervision may be available following the completion of the course, May 26.

For further information and for application forms, those interested should write to the director of public health nursing in a State health department or to the Chief, Nursing Section, Epidemiology Branch, Communicable Disease Center, Public Health Service, 50 Seventh Street, N. E., Atlanta, Ga.