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A PRELIMINARY EPIDEMIOLOGICAL ASSESSMENT OF THE POTENTIAL FOR DIARRHETIC SHELLFISH POISONING IN THE NORTHEAST UNITED STATES

E. Stamman, D. A. Segar, and P. G. Davis

SEAMOcean, Inc.
P.O. Box 1627
Wheaton, Maryland 20902

Rockville, Maryland
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UNITED STATES
DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary

National Oceanic and
Atmospheric Administration
Anthony J. Calio,
Administrator

National Ocean Service
Paul M. Wolff,
NOAA Assistant Administrator for
Ocean Services and
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Coastal and Estuarine Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
Rockville, Maryland

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1. INTRODUCTION

Acute gastroenteritis is a disease which potentially threatens consumers of shellfish. The disease is typically nonfatal and has a 1- to 3- day duration with primary symptoms of nausea, vomiting, diarrhea, and occasional fever. The cause of this disease is generally thought to be sewage-associated, human enteric viruses which have been discharged to the marine environment with sewage materials and then accumulated by filter-feeding bivalves.

However, there is another demonstrated cause of shellfish-borne gastroenteritis which does not involve a sewage-associated microbial pathogen and which is not widely known. This form of gastroenteritis, known as diarrhetic shellfish poisoning, is produced by a naturally occurring toxin. Certain species of the marine dinoflagellate Dinophysis produce this lipid-soluble toxin, which is consumed by shellfish during phytoplankton blooms of the toxin-producing species, and then accumulated in the shellfish hepatopancreas. When the whole shellfish body is then consumed by humans, the diarrhetic shellfish poisoning (DSP) syndrome occurs, with symptoms essentially identical to those of virus-caused gastroenteritis--typically diarrhea, nausea, vomiting, and abdominal cramps, with recovery taking approximately 3 days (Yasumoto et al., 1978). DSP is similar to paralytic shellfish poisoning (PSP), the cause of which also is a toxin-producing dinoflagellate (Gonyaulax spp.) ingested by shellfish and, subsequently, by humans.

DSP was only recently identified as a disease (Yasumoto et al., 1978). Between 1976 and 1981, 800 cases of gastroenteritis in Japan were attributed to diarrhetic shellfish poisoning. Mussels were found to be a frequent source of the disease, and the biotoxin apparently survives normal cooking processes (Yasumoto et al., 1978). Identical disease symptoms have also been noted among shellfish consumers in Europe, South America, and Southeast Asia.

Recently in the New York and New Jersey region, the reported incidence of gastroenteritis in humans due to the consumption of shellfish has risen dramatically. Prior to 1980, only sporadic cases were reported,

but the incidence increased to 31 cases during 1980, 210 cases in 1981, 1,332 cases during 1982, and 1,951 cases in 1983 (GAO, 1984). There was no known major increase in sewage effluent or sewage sludge disposal to the marine environment during this period, and the mechanisms for reporting shellfish-associated illnesses did not change. Therefore, it was thought the increase in shellfish-associated gastroenteritis probably was due either to an increase in the illegal harvesting of shellfish from sewage-polluted waters, or to an increase in diarrhetic shellfish poisoning. It is often difficult, or impossible, to ascertain the exact source of shellfish and, therefore, to determine if illegal havesting is the cause of the increase in shellfish-associated gastroenteritis. In addition, many of the shellfish consumed in the New York and New Jersey region are not harvested locally, but come from Rhode Island, Maryland, or other sources. Undoubtedly, sewage-contaminated shellfish account for some of the gastroenteritis cases, but it is thought possible that some proportion of the large increase in cases could be the result of DSP.

The increasing eutrophication of the New York and New Jersey coastal waters over the past two decades may be causing a shift in phytoplankton species towards certain dinoflagellates associated with DSP and PSP. Dinophysis fortii and D. acuminata are the two species of dinoflagellates which, thus far, have been linked to DSP, and at least one of these species has been observed in waters off New York and in other U.S. coastal waters. In addition, certain county health officials in New York have documented several possible cases of DSP (Freudenthal and Jijina, in press).

To date, there are apparently no published studies on DSP from researchers in the U.S., and Federal, state, and regional health and marine resource personnel are largely unaware of the potential problem. Knowledge of DSP comes primarily from studies performed in Japan and Europe (see references). However, there is no a priori reason that the problem could not be widespread and common throughout the world's coastal areas and that it could not occur in all waters in which the causative dinoflagellate species exist in sufficient densities to allow shellfish accumulation.

DSP presents several potential problems to marine resource managers and the general public. Since knowledge of the disease is not widespread and since the symptoms closely resemble gastroenteritis caused by sewage-associated viruses, attention in some cases may be focused erroneously on the control of sewage inputs or on the illegal harvesting of shellfish from closed areas. In contrast, the increasing potential for coastal eutrophication may lead to an increase in DSP, and the underlying cause may be ignored or not recognized. Routine monitoring for PSP is currently performed, and if a problem existed with DSP, it would be possible to continue or expand existing monitoring efforts to include DSP-causing dinoflagellates and their toxins. In addition, monitoring for DSP toxin may be possible within the context of a mussel watch program.

The primary purpose of this study was to examine available data concerning shellfish-associated gastroenteritis outbreaks in the Northeast United States during the past several years and to determine whether these outbreaks included cases where the onset time of symptoms was less than 12 hours, indicating a possible DSP cause.

2. LITERATURE REVIEW

Several illnesses have been associated with the consumption of contaminated oysters, clams, and mussels for many years, but they did not become a public health concern in the U.S. until the early 20th century. These illnesses, which include typhoid fever, viral hepatitis, cholera, acute diarrheal disease or gastroenteritis, and paralytic and neurotoxic shellfish poisoning, can result in fever, constipation, nausea, abdominal discomfort, jaundice, dehydration, respiratory failure, and death (GAO, 1984).

Although not the most serious of these effects, acute gastroenteritis undoubtedly affects the most people. This disease is usually not fatal, persists for 1-3 days, and typically results in nausea, vomiting, diarrhea, and occasionally fever. The cause of this disease is generally thought to be sewage-associated human enteric viruses which have been discharged into the marine environment in sewage and which then are accumulated by filter-feeding bivalves.

In addition to illnesses caused by sewage-associated viruses and bacteria, a number of illnesses have been found to be caused by certain naturally occurring marine dinoflagellates. These rather recently discovered diseases include paralytic shellfish poisoning (PSP), which is caused by Gonyaulax species (N.B., proposals to change the taxonomic identification of some Gonyaulax species have been made) and other non-dinoflagellate species; neurotoxic shellfish poisoning (NSP), which is caused by Ptychodiscus brevis (Yasumoto, in press); and diarrhetic shellfish poisoning (DSP). This latter disease, DSP, is a recent discovery and is apparently not known to the majority of U.S. public health officials as a demonstrated cause of shellfish-associated gastroenteritis.

Diarrhetic shellfish poisoning was identified as a disease in Japan after 164 people contracted food poisoning from consumption of mussels and scallops (Yasumoto et al., 1978) in June-July of 1976 and 1977. Symptoms of the disease were diarrhea (experienced by 92% of those affected by the disease), nausea (80%), vomiting (79%), and abdominal pain (53%) (Yasumoto et al., 1978). Onset time of the symptoms after shellfish consumption ranged from 30 minutes in severe cases to a few hours in most cases. Only rarely did onset time exceed 12 hours. Recovery from symptoms usually occurred in three days. The Japanese investigators identified a dinoflagellate, Dinophysis fortii, as the causative agent of DSP and named the dinoflagellate-produced toxin dinophysistoxin (Yasumoto et al., 1980).

It was discovered that the dinoflagellate produced a lipid-soluble toxin which could be accumulated in the hepatopancreas organs of shellfish. When the shellfish is consumed by humans, the DSP syndrome results.

Yasumoto et al. tested the toxicity of various affected shellfish and discovered the hepatopancreas of the mussel was most toxic, with the gills also rather toxic. In scallops and oysters, the toxin was found only in the hepatopancreas. A method for routine assay of the toxin was devised which involves injecting the toxin extracted from the hepatopancreas into a 20 g mouse. The minimum dose of toxin required to kill a mouse within 24 hours was designated as one mouse unit (MU) (Yasumoto et al., 1980). Epidemiological data indicated that as small a dose as 12 MU of the toxin was sufficient to cause illness in a human (Yasumoto et al., 1978). The toxicity of the shellfish was expressed by the number of mouse units found in 1g of the hepatopancreas (MU/g). These investigators found that mussels were most toxic, scallops were slightly less toxic, and oysters were only mildly toxic. Although the toxin was not destroyed by normal cooking, the toxicity of scallops could be prevented by eliminating the hepatopancreas. Further, toxic mussels kept in a laboratory tank lost approximately half of their toxin within one week (Yasumoto et al., 1979).

To identify the causative agent, Yasumoto et al. (1980) correlated the time of phytoplankton species occurrence and cell densities in a given area with the occurrence of mussel toxicity. It was discovered that Dinophysis fortii was concentrated in the size fraction (40-95um) of phytoplankton that was found to be toxic, that its seasonal occurrence coincided with mussel toxicities, and that the numbers of D. fortii were found to be proportional to the toxicity levels found in the plankton samples. Further, toxin extracted from toxic mussels could not be differentiated from toxin extracted from a D. fortii rich phytoplankton sample using gel permeation chromatography and partition chromatography (Yasumoto et al., 1980).

As a result of these studies, a surveillance system was established in 1978 in Dinophysis-prone Japanese waters to monitor for shellfish toxicity. Unless the hepatopancreas can be removed, shellfish whose toxicity exceeds 0.05 MU/g hepatopancreas are not harvested for marketing. This monitoring of shellfish is necessary since, in Japanese waters, population densities of D. fortii as low as 200 cells/liter can induce shellfish toxicities capable of causing human illness (Yasumoto et al., 1980). This monitoring has undoubtedly helped reduced the incidence of DSP, which caused gastroenteritis in some 800 persons in Japan between 1976 and 1981.

The major toxin responsible for DSP was isolated from mussels and named dinophysistoxin-1 (Yasumoto et al., 1981). However, further study of toxic shellfish and dinoflagellates has led to the isolation of several other known toxins and a limited understanding of the chemical changes these toxins undergo under certain environmental conditions. Murata et al., 1982, determined that dinophysistoxin-1 was 35(S)-methyl okadaic acid, $C_{45}H_{70}O_{13}$, and confirmed the presence of this toxin in Dinophysis fortii. A slightly different derivative of okadaic acid is one of the biotoxins produced by another dinoflagellate, Prorocentrum lima, which is associated with red tide events and which causes paralytic shellfish

poisoning. Yasumoto (in press) now lists eight toxins isolated from infested Japanese shellfish. Three are acidic toxins: okadaic acid, dinophysistoxin-1 (DTX1), and dinophysistoxin-3 (DTX3). DTX1 and DTX3 were the major toxins in both mussels and scallops, with okadaic acid found in Japanese mussels only in one month when D. fortii was scarce, but D. acuminata was relatively abundant. Five of the toxins are neutral polyether lactones and were named pectenotoxins (PTX1-5) after the family of scallops (Pectinidae) from which they were isolated (Yasumoto, in press).

Although DSP was first identified and intensively studied in Japan, this phenomenon has been identified as a significant health hazard in a number of other parts of the world. Similar gastrointestinal disturbances have been reported in the Netherlands (Kat, 1979, in press), Chile (Avaria 1979), Spain (Fraga et al., 1984), France (Lassus et al., in press; Marcaillou-Le Baut et al., in press), Sweden (Krogh et al., in press), Thailand (Sudara et al., 1984), and Norway (Dahl and Yndostad, in press).

In the Netherlands, the first described incidents of mussel-induced gastroenteritis occurred in July and August of 1961, and the causative agent was later identified as Dinophysis acuminata (Kat, in press). Another outbreak occurred in July 1971, which affected up to a hundred persons, and 25 consumers of mussels became ill in October 1976 (Kat 1979). These outbreaks of DSP occurred when blooms of D. acuminata exceeded 20,000 cells/l in the North Sea (Kat, in press). Kat also reports DSP in mussels from southwest Ireland during the summer of 1984, following a dense bloom (maximum 32,000 cells/l) of D. acuminata.

The first outbreak of DSP in Spain was recorded in August 1978, with other incidents occurring in August 1979, and September 1981, when 5,000 people became ill after mussel consumption (Fraga et al., 1984). Subsequent to this large outbreak in 1981, shellfish were monitored for DSP toxicity (Yasumoto et al., 1980). Because toxicity was detected by this monitoring in October 1982, September 1983, and November 1983, mussel consumption was prohibited before any illness could occur. These outbreaks have not been definitively associated with any one organism. Dinophysis acuminata, D. acuta, D. caudata, and D. rotundata are abundant in the affected waters in the summer, but no clear relationship between their abundance and mussel toxicity has been established. Although the occurrence of toxic mussels in November 1983 coincided with an increased concentration of D. acuta, the toxicity at other times seemed more closely associated with D. acuminata populations (Fraza et al., 1984).

Diarrhetic effects from shellfish consumption were noted in France in 1978 and 1981. However, it was not until diarrhetic outbreaks in 1983 and 1984 along the Normandy and Brittany coasts that the probable causative agent was identified as Dinophysis acuminata (Lassus et al., in press; Marcaillou-Le Baut et al., in press). French investigators have been unable to verify toxin production in that species, but a clear correlation was observed between toxicity levels in mussels (estimated

by mouse bioassay) and D. acuminata concentrations in the water column and shellfish viscera (Lassus et al., in press). As a result of these investigations, the French have established a June-to-August monitoring program which closes shellfish markets when D. acuminata is detected in concentrations as low as 200 cells/l (i.e., the threshold used by the Japanese in D. fortii monitoring) (Lassus et al., in press).

Although there had been an isolated report of mussel-related gastroenteritis in 1983, the first documented DSP phenomenon in Sweden occurred in October 1984 when 10 people became ill after consumption of mussels (Kroghet et al., in press). The outbreak followed a large dinoflagellate bloom that was dominated by Ceratium species, which are not reported to be toxic. Dinophysis species were also present in the bloom, with D. acuta occurring in concentrations of 1,000-23,000 cells/l, D. norvegica at a maximum of 20,000 cells/l, and D. acuminata at 1,000-9,000 cells/l. Although D. acuminata has been identified as the causative agent in several European DSP incidents (Kat, in press), the D. acuminata cell counts found in the Swedish bloom were normal for the waters (Krogh et al., in press) and mussel toxicity was not definitively linked to D. acuminata. Toxicity was demonstrated in the mussels by mouse bioassay and was calculated at more than 170 MU/kg soft mussel tissue (Krogh et al., in press). Swedish authoritites quarantined shellfish in early October 1984 and continued to ban the shellfish until April 1985. It was theorized (Krogh et al., in press) that the mussels' continued toxicity was due to their lowered metabolic activity (and, therefore, a lowered depuration rate) in the cool winter waters.

Cases of shellfish-associated gastroenteritis have been observed in the fall and early winter since 1968 along the southwest coast of Norway (Krogh et al., in press), but no etiologic agent was identified in these cases. In the autumn of 1984, several hundred people contracted DSP after consumption of mussels (Dahl and Yndestad, in press), and the mussels remained toxic until March 1985. Monitoring for Dinophysis species was begun during that autumn in an effort to establish a relationship between their occurrence and the toxicity of mussels. Although Dinophysis species reached relatively high concentrations (20,000-30,000 cells/l) in September-October 1984, Ceratium species (and other genera) far outnumbered Dinophysis species (Krogh and Yndestad, in press). Further, Dinophysis acuminata was found in substantially smaller quantities than D. acuta or D. norvegica. However, it is still possible that these low D. acuminata cell counts could have caused the DSP outbreaks since low cell counts of D. fortii were found to result in DSP in Japan (Yasumoto et al., 1980).

Several recent DSP studies (Dahl and Yndestad, in press; Krogh et al., in press) did not demonstrate that Dinophysis acuminata was the cause of the observed DSP symptoms. Indeed, Kat (in press) reported that D. acuta was suspected of producing DSP in mussels in Norway in 1971. D. acuta and Prorocentrum micans were found in the gut of mussels, and the mussel sample with the highest concentration of D. acuta in the gut produced the strongest DSP reaction in test rats. This finding (Kat, in

press), combined with the recent DSP outbreaks in Sweden and Norway where D. acuta was the dominant Dinophysis species in a large dinoflagellate bloom, would indicate D. acuta was the source of the toxin (Kat, in press). Guzman and Campodonico (1975) also implicated D. acuta as the cause of DSP-like gastroenteritis in Chile.

Yasumoto (in press) analyzed some of the toxic mussels from the Netherlands, France, and Sweden. Okadaic acid was identified as the principal toxin, which is the toxin that appears to coincide with D. acuminata accumulation. Dutch and Swedish mussels contained a minor component which chromatographically resembled the Japanese toxin DTX3, but was hydrolyzed to okadaic acid. None of the European mussels contained any of the pectenotoxins, PTX.

Yasumoto (in press) demonstrated the toxicity of okadaic acid from Japanese D. acuminata by injecting mice with a lipid fraction derived from plankton samples. He determined that approximately 40,000 cells could produce 1 MU of okadaic acid, which was confirmed in French samples of D. acuminata, even though there is some question whether the European and Japanese species of this dinoflagellate are the same (Yasumoto, in press). Yasumoto (in press) extracted okadaic acid as the principal toxin in Swedish mussels, which may have become toxic due to high densities of D. acuta. Other species are also suspected of producing okadaic acid or other toxins which can result in DSP in mussels. Sudara et al. (1984) have implicated D. caudata in DSP incidents in Thailand. Yasumoto (in press) has detected okadaic acid in D. mitra and Prorocentrum lima and an acid-neutral toxin in D. tripos, although most of these tests were run on wild specimen samples that contained numerous dinoflagellate species. Although definitive toxin verification would require tests run on cultured cells, and Dinophysis, thus far, has resisted culturing attempts, it is apparent that okadaic acid and its derivatives are produced in many species (Yasumoto, in press).

Although DSP has not been definitively documented in the U.S., Freudenthal and Jijina (in press) have reported a number of cases which are suggestive of DSP. One incident in August 1983, involved three people who consumed mussels from Maine waters and who experienced gastrointestinal symptoms (as well as symptoms resembling PSP) within 3 hours of consumption. These authors report that Maine mussel harvesting was closed in August 1983 because of an elevated toxin level in the mussels as determined by bioassay. Maine mussels are monitored daily by the Maine Department of Marine Resources by means of a mouse bioassay issued by the U.S. Food and Drug Administration (Wilson, personal communication). Although this bioassay is used to estimate the level of toxin present in shellfish, the test was designed to determine the presence of paralytic shellfish poisoning, PSP, which is caused in Maine waters by Gonyaulax tamarensis. This bioassay is not specific to any toxin and could reflect toxicity due to PSP, DSP, or any number of other causes.

Freudenthal and Jijina (in press) report a second episode in February 1983, involving a woman eating oysters and hard clams and becoming ill

with gastroenteritis after an unspecified period of time. A third reported incident involved two people suffering from gastroenteritis within five hours after consumption of steamed clams. The implicted clams were examined and D. norvegica was the dominant dinoflagellate species found in the clams. While these authors have proposed D. norvegica as another possible DSP-causing agent, this species has not been previously implicated in such incidents. The clams were tested for toxicity using a limited version of the Yasumoto mouse bioassay (Yasumoto et al., 1978) due to the small amount of implicated clam meat available and its deteriorating condition. Only 190 g of the clams were available, and all of this material was used to derive 5 ml of extract. Although the Yasumoto et al. (1978) procedure calls for extraction using only the hepatopancreas, the deteriorating condition of the shellfish meat prevented the time-comsuming dissection of the clams to isolate hepatopancreas tissues. Each of three mice were intraperitoneally injected with 1 ml of the extract (L. Miranda, Dept. of Pharmacognosy, University of Rhode Island, personal communication). Within 5 minutes, these mice displayed mild symptoms indicative of DSP, including convulsions, rapid breathing, difficulty in walking, and slow reflexes (Miranda, pers. comm.). However, all of these mice recovered within 6-8 hours. Since 2 ml of the extract were still available, a double dose was given to one mouse, which died within 29 hours. Although death occurred, this test was at double the usual dose, required more than the standard 24 hours for death to occur, and was administered to only one mouse instead of the usual three. Controls were run with Tween 80 which resulted in no symptoms, and a control was also run with presumed nontoxic soft shell clams. These clams were allowed to deteriorate to a degree similar to that of the implicated clams. A single dose of extract from these clams was injected and the mice also displayed symptoms similar to, although milder than, those evident in the original 3 test mice (Miranda, pers. comm.). Therefore, the symptoms obtained in the bioassay may have resulted from the poor quality of the clam meat and not dinoflagellate toxicity. The incidents reported by Freudenthal and Jijina illustrate the possible occurrence of DSP in U.S. waters. However, the inconclusive test results regarding these incidents prohibit definitive conclusions concerning the cause of the observed illnesses.

The University of Rhode Island Department of Pharmacognosy laboratory has also been conducting studies regarding the possible occurrence of DSP in Narragansett Bay (Miranda, pers. comm.). This lab, under the direction of Dr. Y. Shimizu, has received Sea Grant funds to survey the waters of the Bay for Dinophysis species and to test the indigenous shellfish for DSP toxicity. Three species (D. acuminata, D. tripos, and D. fortii) were observed in the Bay and a fourth species, D. acuta, is also suspected to occur (Miranda, pers. comm.). Blooms of D. acuminata were found in Narragansett Bay in June and September. However, no shellfish tested as toxic during these time periods. Although shellfish did display toxicity during May of two years, no Dinophysis were found concurrently, and toxicity may have been due to other physiological processes occurring in the shellfish during this time (Miranda, pers. comm.). It is interesting to note that these investigators conducted

toxicity bioassays on some Maine mussels which they received in May 1985. These mussels, which had been implicated in gastroenteritis illness in New York, proved lethal to mice in less than 24 hours. However, no Dinophysis species were found upon examination of the shellfish viscera, which may further strengthen the case for possible toxicity of shellfish in May that is unrelated to DSP (Miranda, pers. comm.).

The URI researchers did discover a bloom of D. acuminata in an experimental tank at the Marine Ecosystem Research Lab (MERL), which had been treated with very high concentrations of nitrate and phosphate (Miranda, pers. comm.). The dinoflagellates were collected from the tank and extracts from the cells proved toxic to mice. Although this lends additional credence to the possibility of DSP in U.S. waters, no evidence for its occurrence has been found in studies in Narragansett Bay. Miranda (pers. comm.) has stated that they have concluded Narragansett Bay is probably not a good candidate for DSP study because of its good mixing rate. This active flushing of the Bay would tend to break up dinoflagellate blooms and lessen their concentration as a shellfish food source.

Further work on DSP has been reported in the literature. Lassus et al. (in press) investigated the possible relationship of salinity and temperature with the occurrence of Dinophysis acuminata, either in blooms or at lower concentrations over a two-year period in France. They found that this dinoflagellate occurred over different geographical areas with a wide range of temperature/salinity conditions, and no relationship between Dinophysis and these hydrographic parameters was apparent.

Another aspect of the research that has received recent attention is the attempt to develop other bioassay techniques for the easy, rapid, and accurate assessment of shellfish toxicity. Yasumoto (in press) has proposed a suckling mouse assay which may improve sensitivity and specificity and may shorten analysis time to 4 hours. Since the test only requires 0.5 g of the shellfish digestive gland and has a minimum detection level of 5ng of okadaic acid, the procedure shows some promise as a useful tool for monitoring shellfish toxicity. Marcaillou-Le Baut et al. (in press) have compared bioassays using adult and infant mice and have concluded that neither test shows good reproducibility. They also found the infant mouse test difficult to use.

Other researchers are interested in whether shellfish might display a latent DSP-toxicity. Dr. Don Anderson (Woods Hole Oceanographic Institution, personal communication) is aware of latencies in some shellfish, including an incident where Irish mussels, which tested nontoxic in Ireland, tested toxic after shipment to England. It is possible that a nontoxic substance undergoes hydrolysis within the shellfish to produce a toxic substance (D. Anderson, pers. comm.), and this would further complicate monitoring of shellfish.

3. INFORMATION COMPILATION ASSESSMENT

A number of state and local health authorities along the Northeast Atlantic coastline were requested to provide any information that they might have on possible incidents of DSP-caused gastroenteritis in their regions. The following authorities were contacted by mail for this information:

Dr. John Guzewich
New York State Department of Health
Bureau of Community Sanitation and Food Protection
Food Protection Section
Room 421, Tower Building
Albany, New York 12237

Dr. Mahfouz H. Laki
Director of Public Health
Suffolk County
Department of Health Services
225 Raybro Drive East
Hauppauge, New York 11788

Dr. Victor O. Sousa
First Deputy Commissioner
Westchester County Health Department
112 East Post Road
White Plains, New York 10601

Mr. Fred Siino
Associate Director
Community Health Services
75 Davis Street
Providence, Rhode Island 02908

Mr. Malcolm Shute
150 Washington
Department of Health Services
Shellfish Unit
Hartford, Connecticut 06107

Dr. John J. Dowling
Nassau County Department of Health
240 Old County Road
Mineola, New York 11501

Dr. Stephen Ridley
Massachusetts Department of Public Health
Massachusetts State Lab Institute
305 South Street
Jamaica Plain, Massachusetts 02130

Mr. Robert McCready
State of New Jersey
Department of Health
Communicable Disease Program
CN 360, Room 702
Trenton, New Jersey 08625

Specifically, these authorities were requested to supply from their files the following information:

1) the total number of shellfish-associated gastroenteritis cases for a given outbreak or year, and the number of cases with an identified etiology,

2) the reported incubation periods for each case without an identified etiology,

3) the symptoms reported for each case without an identified etiology,

4) the date of occurrence for each case without an identified etiology, and

5) the source of shellfish for each outbreak, if known.

3.1 Data Complilation

Data or data summaries were received from Mr. R. C. McCready, Public Health Rep. II, Department of Health, State of New Jersey; Mr. Malcolm C. Shute, Principal Sanitarian, Shellfish Unit, Department of Health Services, State of Connecticut; and Mr. John J. Guzewich, Chief, Food Protection Section, Department of Health, State of New York.

Mr. Ralph J. Timperi, Deputy Director, State Laboratory Institute, Department of Public Health, Commonwealth of Massachusetts, responded that their records had been reviewed but that no recorded information was found on outbreaks of shellfish-associated gastroenteritis. No reply was received from Suffolk County, N.Y.; Westchester County, N.Y.; or Rhode Island. The Department of Health, Nassau County, N.Y., responded that, although shellfish-related gastroenteritis data were available in their files, SEAMOcean personnel would have to travel to Nassau County and search through the files for the necessary information.

Information received from the three authorities providing data were assessed and the results of those analyses are presented in this report. Telephone inquiry was made regarding the status of Nassau County Department of Health files in an attempt to determine whether meaningful data could be compiled in a timeframe consistent with the scope of this contract. It was determined that the data within Nassau County files was unlikely to be obtainable and useful given the limited expenditure of time, money, and effort that could be made within the scope of the

contract. This conclusion was based upon information derived from discussions with County staff (A. Freudenthal, Nassau County Department of Health, personal communication), analysis of other authorities' data sets, and a realization of the difficulty involved in trying to sort through an unfamiliar filing system. It was further determined that Nassau County's data, at least for 1982, is most likely included in the information reported by the New York State Department of Health. Information derived from these reports regarding incidence of clam-associated gastroenteritis in Nassau County is, therefore, noted in the discussion of New York State data.

3.2 Data Assessment

Data and data summaries from the three health authorities supplying information were analyzed to determine whether the reported shellfish outbreaks could have been caused by DSP. Perhaps the most obvious differentiation in the symptomatologies of DSP-caused gastroenteritis and other shellfish-related illnesses is the short timeframe involved in the onset of symtoms in DSP cases. Onset of DSP-caused symptoms can begin at 30 minutes after shellfish consumption, with symptoms rarely beginning as late as 12 hours after consumption. Therefore, the time to onset of symptoms is used as the primary indication of whether a particular outbreak could have been caused by DSP.

State of New Jersey. Mr. R. C. McCready, Public Health Rep. II, Department of Health, State of New Jersey, responded to the inquiry. He reported that few shellfish-associated outbreaks of gastroenteritis had occurred in New Jersey since 1981 and that all such incidents had known etiological agents. He also sent data and data summaries on six separate shellfish-associated outbreaks of gastroenteritis from December 1982 to June 1984. An outbreak in December 1982, designated E-35-83 by the State, involved 25 people who contracted gastroenteritis and was statistically linked with consumption of raw clams at a business buffet. However, mean onset of symptoms was at 33 hours, which indicates that DSP was not the cause of the illness. Another outbreak in June 1984, designated E-275-84, involved 6 people who fell ill 2 days after consumption of raw clams at a restaurant. The length of the time period before onset of symptoms precluded a diagnosis of DSP, and a viral agent was hypothesized to have been responsible for the illnesses.

Four outbreaks, designated E-329-83, E-331-83, E-332-83, and E-341-83, were reported between April 20 and May 14, 1983, and involved a total of 76 people who became ill at private functions. Attack rates in all cases indicated that the illness derived from consumption of raw clams which were traced back to a single supplier and shipper. Originating from a depuration plant in England, the clams were taken from the market. Mean onset times in three of the outbreaks (E-329-83, E-331-83, and E-341-83) were from 36-48 hours (36, 48, and 40 hours, respectively), which ruled out DSP as the cause. Analysis did not indicate a bacterial etiological agent and affected persons were encouraged to receive immune serum globulin injections to preclude complication with Hepatitis A. The fourth outbreak, E-332-83, was not

investigated until almost a month after the illnesses had occurred. Most of the people interviewed (6 out of 10) reported an onset time of 36-47 hours, similar to those reported in the other three outbreaks. Onset times for the remaining four cases may have been 12 hours or less. However, this cannot be verified from the data obtained from DOH, New Jersey. Further, the clams from the E-332-83 incident were traced to the same supplier implicated in the three other outbreaks already identified as unrelated to DSP. This compilation of evidence supports a conclusion that faulty data reporting was probably responsible for the contradictory and confusing onset time data reported in the one incident (E-332-83). As reported by the N.J. State Health Department, data regarding mean onset times associated with these shellfish-associated gastroenteritis outbreaks indicate that these incidents were not caused by the dinoflagellate toxins in the consumed clams.

State of Connecticut. Mr. Malcolm C. Shute, Principal Sanitarian, Shellfish Unit, Environmental Health Section, Department of Health Services, State of Connecticut, responded to the inquiry. He submitted data summaries on 12 shellfish-related outbreaks from 1968 to 1978. Although etiology was not determined in most of the cases, it is apparent that DSP was not involved in at least 11 of these cases. The etiology for most of the cases was listed as an "undetermined non-bacterial gastroenteritis" that was caused by suspected "sewage poisoning." The suspected or verified etiology and the mean onset time to symptoms for these outbreaks were presented as follows:

Date	Number Ill	Onset Time	Etiology
1968	12	Mean onset 38.9 hrs.	Undetermined
1975	14	Mean onset 36 hrs.	Vibrio
1977a	1	Onset approx. 1 month	Hepatitis
1977b	23	Mean onset 35 hrs.	Suspected viral or Vibrio
1978a(Apr. 26)	4	Mean onset 39 hrs	Suspected "sewage poisoning"
1978b(May 20)	17	Onset not given, but shellfish consumed previous day*	Suspected "sewage poisoning"
1978c(May 16)	23	Onset 12-36 hrs.*	Suspected "sewage poisoning"
1978d(May 29)	6	Mean onset 48 hrs.	Suspected "sewage poisoning"
1978e(May 27)	4	Mean onset 30 hrs.	Suspected "sewage poisoning"
1978f(May 30)	2	Onset not given, but clams eaten May 28-29	No other information
1978g(May 28)	10	Mean onset 37 hrs.	Suspected "sewage poisoning"
1978 (Suspected Outbreak)	2	No other information	No other information

Most of the reported cases were not DSP-related, as evidenced by the onset times to symptoms that ranged from one case where the earliest onset time was 12 hours and onset times extended to 36 hours, to most cases where the mean onset time ranged from 30 to 48 hours. Because of the incomplete data reported, there is a possibility that DSP could be the causative agent in perhaps 1-2 of the cases (marked with an asterisk in the above data summary), but other circumstantial evidence (shellfish source in common with other non-DSP outbreaks) makes this highly unlikely.

New York State. John J. Guzewich, Chief, Food Protection Section, Bureau of Community Sanitation and Food Protection, Department of Health, State of New York, responded to the inquiry. Mr. Guzewich refused our request for specific data citing the very large expenditure of time that would be required to query approximately 12 local health offices across his state to derive the requested information. However, he did supply two helpful documents prepared by the Department of Health: "A Review of Foodborne Disease Outbreaks Reported in New York State in 1982" (N.Y. State Dept. of Health, 1983b, hereafter referred to as the "Review Report") and "Clam Associated Enteric Illness in New York State, May-September 1982, A Preliminary Report" (N.Y. State Dept. of Health, 1983a, referred to as the "Preliminary Report").

The "Preliminary Report" (1983a) summarized clam-associated gastroenteritis outbreaks in 1982. A single food service establishment furnished clams which resulted in 234 people becoming ill. Although no etiologic agent was identified, the mean incubation time was 41 hours, indicating causes other than DSP.

The "Preliminary Report" focused on 22 outbreaks of clam-related enteric illness that occurred in upstate New York in May-September 1982. Although no etiologic agent was identified for this series of illnesses, a viral agent was hypothesized by the State to be the cause. In the light of this probable viral etiology, it is interesting to note that clams in 20 out of the 22 outbreaks were documented or suspected to have originated in Rhode Island. The State investigators of these incidents were aware of DSP, but concluded that DSP was unlikely in these outbreaks because the incubation period was between 12 and 72 hours in 84% of the 347 persons who became ill and reported an onset time (443 people were affected in the incidents and 387 were interviewed). Only 2% of those stating an onset time reported symptoms from 0-12 hours after consumption. Further, the cumulative profile of the incidence of gastrointestinal symptoms does not fit the profile reported by Yasumoto et al. (1978) for DSP incidence. In these New York cases, the percent frequency of symptoms for those affected were diarrhea, 82.7%; abdominal cramps, 58.4%; nausea, 51.9%; vomiting, 27.8%; and fever, 18.6%. These frequencies can be compared with those reported (Yasumoto et al., 1978) for DSP: diarrhea, 92%; nausea, 80%; vomiting, 79%; and abdominal cramps, 53%. While there is no report that such a symptom profile is definitive for DSP, a very high incidence of diarrhea and vomiting is

typical of DSP. In addition to this summer series of outbreaks, the New York State Department of Health's "Review Report" analyzed a large number of gastroenteritis outbreaks associated with clam or oyster consumption during December 1982. Over a three week period, 659 people (231 incidents) became ill after clam consumption, and 230 people (54 incidents) became ill after consuming raw oysters. Once again, State officials concluded that there was a probable viral etiology for both summer and winter outbreaks. This probable etiology was based upon blood analysis of victims from seven different incidents (four summer and three winter). Greater than 50% of the paired blood samples (acute and convalescent sera) from four of the seven incidents revealed a fourfold, or greater, difference in Norwalk antibody titer between the acute and convalescent sera. Hepatitis resulted in 10 victims of the shellfish-related summer illnesses, and Immune Serum Globulin injection was recommended for all winter victims and may have prevented any further hepatitis cases. Most of the implicated oysters were traced to a harvester in a closed Massachusetts river, and most of the implicated clams appear to have originated in Long Island waters. DSP was not implicated since incubation periods of between 24 and 38 hours were reported for these cases.

Although Nassau County did not respond with data or data summaries, information from the County on clam-associated incidents of gastroenteritis in 1982 is included in the New York State Department of Health reports. The department listed all clam-related incidents reported in Nassau County in 1982 as having a confirmed viral etiology (N.Y. State Dept. of Health, 1983b). However, all incidents of clam-related illness reported in the "Review Report" for Nassau County occurred in December of 1982. In contrast, the "Preliminary Report" (N.Y. State Dept. of Health, 1983a) states that Nassau County reported 40 people ill in 9 incidents of clam-associated gastroenteritis during the first six months of 1982. Although the "Review Report" lists one incident with 11 people ill from an unknown food and caused by a suspected viral etiological agent in February 1982 (which could account for some of the unexplained incidents), there appears to be a substantial number of gastroenteritis incidences which have not been accounted for in the "Review Report." If these earlier Nassau incidents did indeed occur, they also fail to appear in a June 1984 GAO report entitled "Problems in Protecting Consumers from Illegally Harvested Shellfish" (General Accounting Office, 1984). However, the information found in that report was obviously taken from the New York "Review Report" or was received from the same source.

4. SUMMARY AND RECOMMENDATIONS

It is clear from the literature review that Diarrhetic Shellfish Poisoning presents a significant, although sporadic, threat to public health among people who eat shellfish in certain areas of the world. Shellfish monitoring in DSP-prone regions appears to be an effective deterrent to gastroenteritis caused by ingestion of affected shellfish and precludes the necessity of monitoring for all the various individual phytoplankton species that might cause DSP.

While a potential for DSP certainly exists in the United States, there is no definitive evidence that any DSP cases have occurred as a result of shellfish consumption in this country. It is possible that this illness has occurred in the U.S., but that non-reporting of the illness by affected individuals and incomplete data reporting of documented, shellfish-associated illness have prevented its identification in this country. Further, because information regarding DSP has only recently become widely available, many U.S. public health officials may have assumed that most cases of shellfish-associated gastroenteritis are caused by suspected "sewage poisoning."

Nonetheless, dinoglagellates capable of causing DSP are found in U.S. waters and, if DSP has not been reported as the cause of shellfish-associated illness in this country, one must ask why. There is some speculation that the species of dinoflagellates that are found in the U.S. may be a different variety than those species causing DSP in other countries (D. Anderson, pers. comm.). Since researchers are still unable to culture Dinophysis species, definitive proof of toxin production in any given strain of dinoflagellate is still unobtainable. Another possible reason why there has been no DSP reported in the U.S. may be that mussels are the shellfish most often associated with DSP. Although growing, mussel consumption in the U.S. lags far behind their consumption in other countries. It is also possible that conditions in U.S. water or markets are such that chemical changes do not occur to change nontoxic substances into the toxic substances involved in DSP (D. Anderson, pers. comm.).

Despite the lack of evidence of DSP occurrence in the U.S., there is no reason to believe that DSP could not occur in U.S. shellfish. However, it would appear premature to expend scarce marine pollution research funds in DSP-specific research or in monitoring of water for DSP-causing dinoflagellates without definitive evidence that DSP has occurred in the U.S. Routine shellfish toxicity monitoring will continue to be employed to protect consumers from other shellfish-associated illnesses and will provide a measure of protection against DSP.

Incomplete data reporting is one of the primary reasons that cases of shellfish-associated gastroenteritis cannot be positively, or negatively, attributed to DSP. Therefore, NOAA should request all local and state health authorities to report onset time data as precisely and accurately as possible when investigating reports of these illnesses. Further, if such cases of gastroenteritis are reported with onset time to symptoms of less than 12 hours, immediate steps should be taken to analyze the implicated shellfish according to standard procedures (Yasumoto, in press) in DSP investigations.

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