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Aquaculture: Public Health, Regulatory and Management Aspects
Proceedings of the 6th U.S. Food and Drug Administration
Science Symposium on Aquaculture

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Paralytic Shellfish Poisoning in Shellfish Aquaculture
The State Regulatory Problem
Presented at the Sixth FDA Science Symposium
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by
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ABSTRACT

P.S.P. In Shellfish Aquaculture
The State Regulator Problem

Maine has a vigorous P.S.P. monitoring program designed to protect the public's health and to lessen the impact of P.S.P. on its valuable shellfish industry. The P.S.P. monitoring program is described as well as the ongoing research on the various parameters of the causative organism. The relationship of these studies to shellfish aquaculture is discussed as well as potential management in shellfish aquaculture around P.S.P.

Maine has a very valuable shellfish industry. For example, the landed value of the soft-shell clam in 1979 was approximately \$8,000,000 with a consumer value of about \$48,000,000. For the shellfish industry to remain viable, the public must have confidence in shellfish as to its safety as a food. The Department of Marine Resources is the state agency in Maine responsible for shellfish safety. Maine's Paralytic Shellfish Poisoning Monitoring Program has been described by Hurst and Gilfillan, "Paralytic Shellfish Poisoning In Maine"* (1977).

We began monitoring and closing for PSP in 1958 following a serious outbreak of PSP in nearby New Brunswick, Canada in 1957. Five monitoring stations were established in this eastern Maine area. Closures were made in portions of this area in 1958, 1959, 1961, 1964, 1969, 1970, and 1972 whenever scores exceeded 80 micrograms. This limited monitoring plan, coupled with up-to-date knowledge of the monitoring results in nearby Canada, has apparently given adequate public health protection in eastern Maine. Until 1972 no other areas were closed although our shellfish monitoring demonstrated occasional low PSP scores. Early in September 1972 it became evident that there were extremely toxic shellfish from Cape Ann, Massachusetts into western Maine. The aftermath of this discovery was the closure on September 15, 1972 from Cape Elizabeth to New Hampshire and the entire coast on September 17.

*John W. Hurst, Jr. and Edward S. Gilfillan, Paralytic Shellfish Poisoning in Maine. 10th. National Shellfish Sanitation Workshop, U.S. Dept. of Health, Education and Welfare, 1977.

Most of the coast, with the exception of Cape Elizabeth to New Hampshire, was reopened on September 30, 1972. Much of this area remained closed into 1973. 1973 did not require any closures other than the historical area in eastern Maine. 1974 was a year of high toxicity with a spring and summer peak. Inasmuch as we were without a precise sampling plan, 1974 was a year of multiple crises. Although hindsight demonstrated that while we were able to keep up with these crises, this method of PSP monitoring was not a responsible public health protection program. A lack of precise knowledge as to the areas which were toxic led to larger closed areas than were necessary in order to give adequate public health protection.

Late in 1974 we were able to obtain funds from the New England Regional Commission, NERCOM, Contract #10530699, to develop our monitoring plan. This permitted a greatly expanded PSP monitoring program to provide more precise information about distribution of PSP during an outbreak. One hundred nineteen monitoring stations were established. This monitoring program was initiated on April 1, 1975 and consisted of a series of 18 primary, 35 secondary and 63 tertiary sampling stations. These stations were established on the basis of previous historical data. Primary stations are sampled on a weekly basis throughout the danger period for PSP, that is, April through October. Primary sampling stations are those which in the past have been good indicators of the presence of PSP when it is present at a low level. Once PSP is identified at a primary sampling station, samples are taken at secondary and tertiary sampling locations. Secondary sampling locations are chosen on the basis of past results to be good indicators of what is expected to occur in given clam growing areas. Tertiary sampling stations are chosen to fill the gaps in these secondary sampling locations and further localize the distribution of PSP. In 1979, using the information derived from our sampling program, we were able for the first time, as a part of our management plan, to keep open a portion of the area, with the exception of mussels, which would have normally been closed for all shellfish for PSP. This entailed a heavy-handed sampling program. Although the growing area which we sampled intensively was relatively small, during the 55 day closure approximately 155 shellfish diggers harvested 17,050 bushels of soft-shelled clams with a landed value of \$426,250 and an estimated consumer value of \$2,770,625. Because of this obvious benefit to everyone concerned, we intend in the future to expand our ability to narrow down the areas which need to be closed for PSP. With this expanded monitoring program it is necessary to continually update the sampling stations and even sampling frequencies as conditions dictate. With experience and better knowledge, not only will it be possible to better define what areas need to be closed, but more importantly, what areas can safely remain open to harvesting.

Our PSP sampling program has documented how the different species of shellfish react to the poison (Fig. 3). This dramatic difference in accumulation of poison in the various species allows for at least some preplanning for our monitoring program in the spring. Mussels become toxic several weeks prior to the time that clams become poisonous, which allows for management of closures for species only. The mussel closure, in turn, forewarns the soft-shell clam industry of a potential closure, giving them

Fig. 1
Fig. 2

Fig. 3

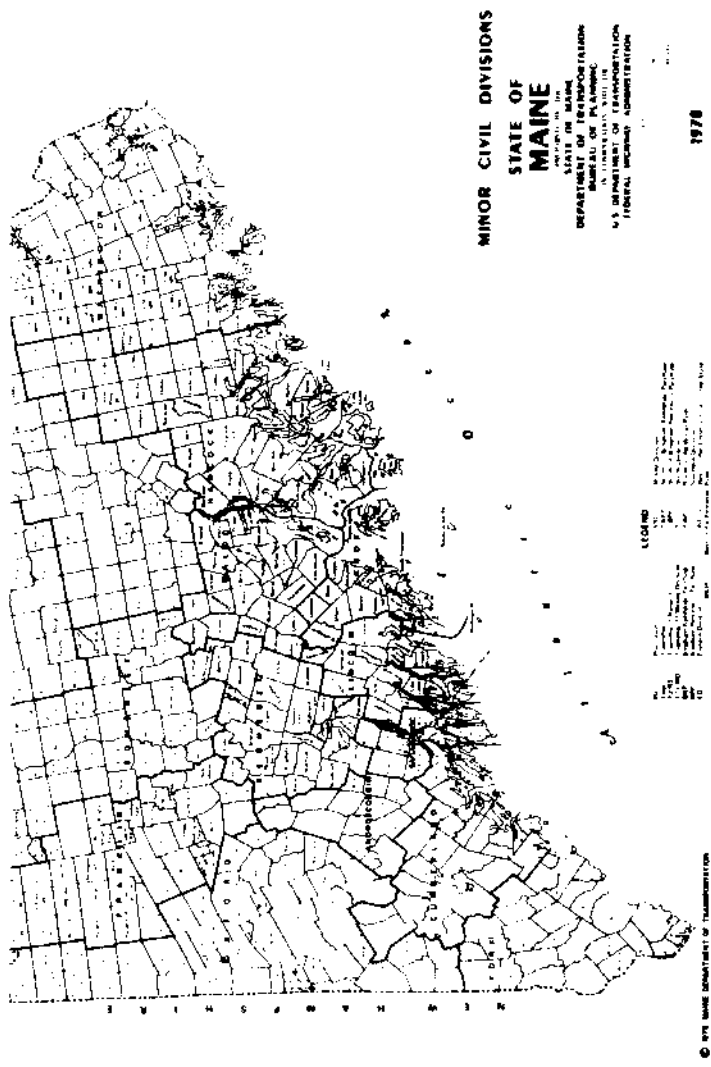


Figure 1. Coast of Maine.

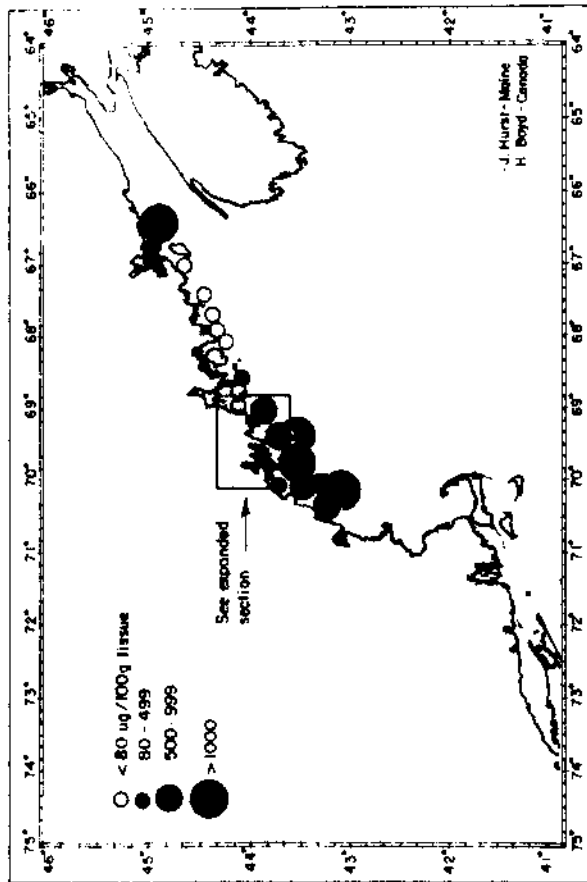


Figure 2. Location of PSP sampling areas showing degree of poison.

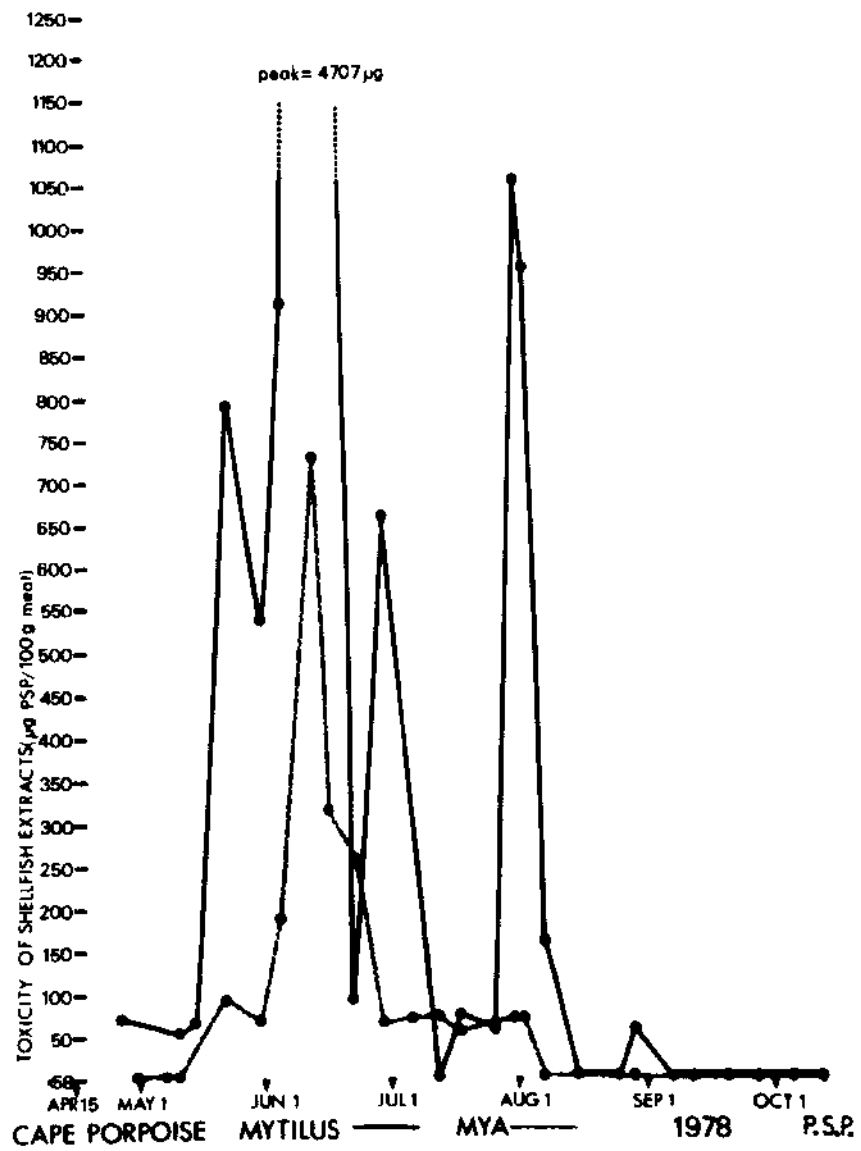


Figure 3. Variation in poison in species at Cape Porpoise.

time to locate alternate supplies of clams. In some years this has meant that we have only had to close for mussels because we have been able to demonstrate that clams were not becoming toxic. This has proved to be beneficial to the clam harvester and dealer because they are not put out of business because of a rise of poison only demonstrated in mussels. Prior to this expanded program, a rise of poison in one species has resulted in a closure for all species. I must point out, however, that when mussels become toxic, one must expand their sampling program to demonstrate that the other shellfish are not becoming toxic.

The monitoring plan also demonstrates that when there is a geographically widespread incidence of poison in mussels just below 80µg/100g, it is reasonable to question the advisability of having any of this area open to the harvesting of mussels. In mussels, 80µg/100g appears to be the threshold of a rapid rise of poison. We have noted a rise in mussels from 80µg/100g to 500µg/100g in a single day! Fortunately, this rapid rise is in reality not an instant thing; however, an up-to-date sampling program will give sufficient warning of what is going to take place (i.e., a widespread low level of poison). In the final analysis, mussel closures must be based upon the best available PSP monitoring data, on the State's ability to adequately monitor the harvest area, and on the overall value of the mussel resource in the area under consideration.

Maine has two distinct and separate areas in which PSP may be expected to occur. The first area in eastern Maine extends from the international border with Canada to the Machias River. The second area extends from Schoodic Point to New Hampshire. Between these two areas is an apparent PSP-free area. In addition to our shellfish monitoring program, we have demonstrated by our Gonyaulax cyst sampling program that this area is free of cysts. On either side of this area only low incidence of poison has been demonstrated. To date we have not explained satisfactorily the reasons for this area being toxin free, but undoubtedly it has to do with hydrographic and chemical conditions which are unfavorable for the growth of Gonyaulax. I conduct limited shellfish monitoring in this area to demonstrate that the shellfish continue to be safe. I am not going to become over confident in this area always being toxin free as I remember that until 1972, with the exception of Monhegan and Matinicus, there were no significant amounts of PSP south of our traditional eastern Maine area!

Fig. 4

Fig. 5

Additional information useful in decision making in evaluating of PSP in Maine has been derived from a F.D.A. contract (233-77-2314) to Bigelow Laboratory for Ocean Sciences entitled "Toward an Environmental Predictive Index for Toxic Dinoflagellate Blooms"* (1980). Although we have not yet been able to develop this index, we have made several important valuable advances in our understanding of the PSP phenomenon under this contract. This study has explored and given information on the following parameters:

- I. Patterns of intoxicification of shellfish in the Gulf of Maine coastal waters
- II. Taxonomy and life history aspects

Clarice M. Yentsch and John W. Hurst, Jr., Report of Investigations Toward an Environmental Predictive Index For Toxic Dinoflagellate Blooms. To Food and Drug Administration 1979.

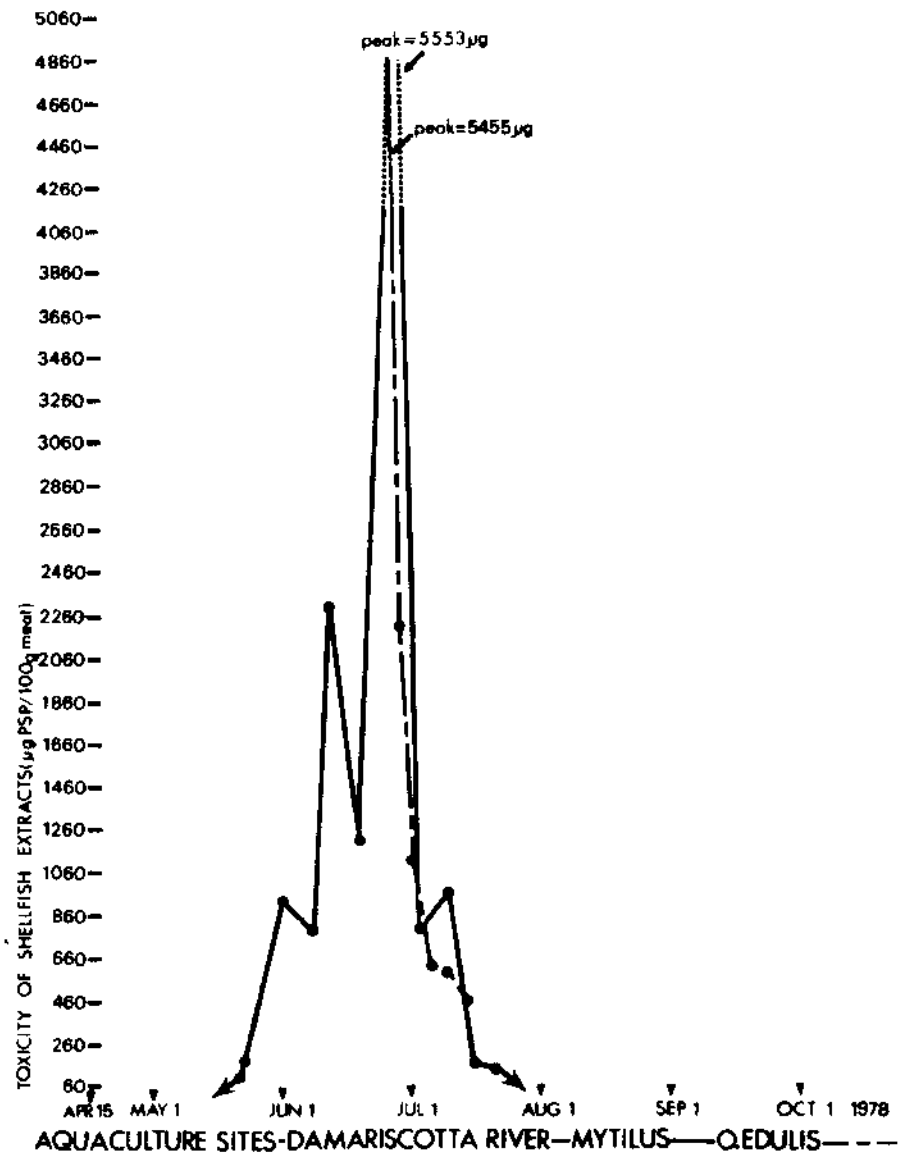


Figure 4. Degree of poison at aquaculture sites on Damariscotta River.

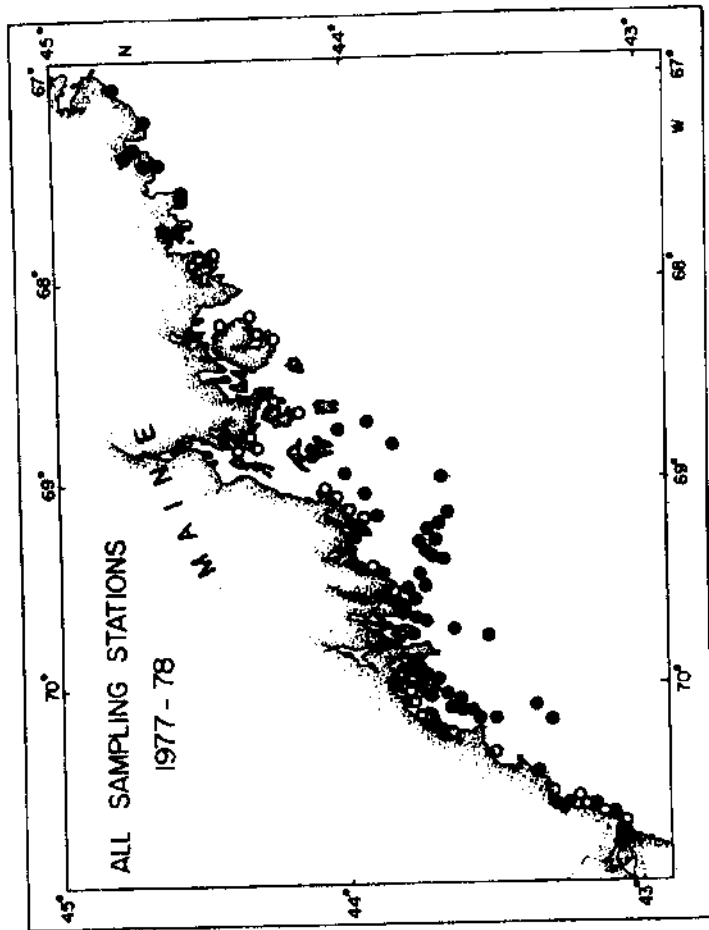


Figure 5. Cyst sampling stations - 1977-1978.

- A. Probing the occurrence of biological resting in the dinoflagellate, Gonyaulax excavata
 - B. Coexistence of toxic and nontoxic dinoflagellates resembling Gonyaulax tamerensis in New England coastal waters
- III. Patterns of distribution of Gonyaulax excavata
- A. Patterns of phytoplankton distribution: An apparent lunar tidal cycle of phytoplankton blooms and phytoplankton community succession in the Gulf of Maine
 - B. Distribution of Gonyaulax excavata resting cysts in the sediments of the Gulf of Maine
 - C. Patterns of resting cyst distribution
- IV. Mechanisms and conditions of intoxicification and dinoflagellate blooms
- A. Motile cells and cysts: two probable mechanisms of intoxicification of shellfish in New England waters
 - B. Dinoflagellate bloom initiation and perpetuation in the Damariscotta estuary
 - C. Current measurements and flow dynamics around Monhegan Island, Maine
- V. Physiology of nitrogen and toxins
- A. Light and nutrient limitation in Gonyaulax excavata: Nitrogen and carbon trace results
 - B. Toxicity and nucleic acid content of Gonyaulax excavata
 - C. Toxicity in resting cysts of the red-tide dinoflagellate Gonyaulax excavata from deeper water coastal sediments
 - D. Changes in toxicity of benthic resting cysts
- VI. Recent work with trace metals
- A. Iron in Maine coastal waters seasonal variation and its apparent correlation with a dinoflagellate bloom
 - B. Trace metal analysis by differential pulse ASV in water samples from the Gulf of Maine.

Shellfish aquaculture is expected to be an increasingly valuable addition to Maine's shellfish industry. As the aquaculturist evaluates potential locations for a new aquaculture enterprise, the occurrence of PSP is only one of the considerations that must be made in the selection of a growing area. The aquaculturist must investigate such parameters as site availability, distance from market, anticipated marketing practices and the overall environmental conditions of the growing area. It is entirely possible that the presence of PSP in an area may be an indication of a good growing area. The two species most favored by Maine aquaculturists are the blue mussel, Mytilus edulis, and the European flat oyster, Ostrea edulis. These two species will always become toxic during a Gonyaulax bloom! I have been fortunate in that early on I discovered that O. edulis becomes toxic. This oyster presents a very serious public health concern as it is consumed raw, thus a lower overall PSP level in this oyster may be expected to cause illness. I have no intention of finding out what this level is, however.

Shellfish aquaculture in Maine is centered in the Damariscotta River. This is due to the presence of the University of Maine's Darling Research

Fig. 6
Fig. 7

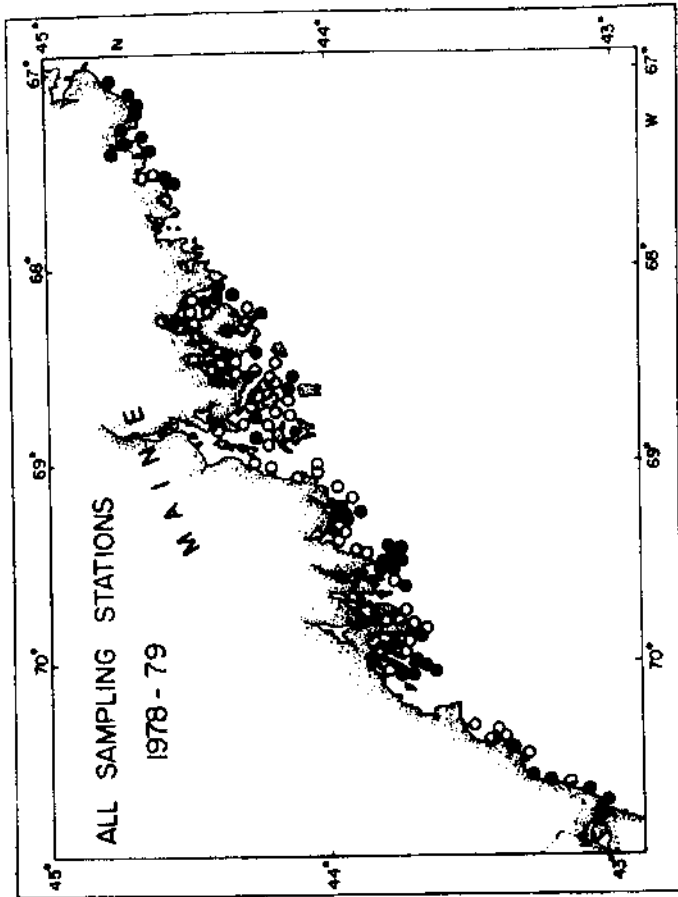


Figure 6. Cyst sampling stations - 1978-1979.

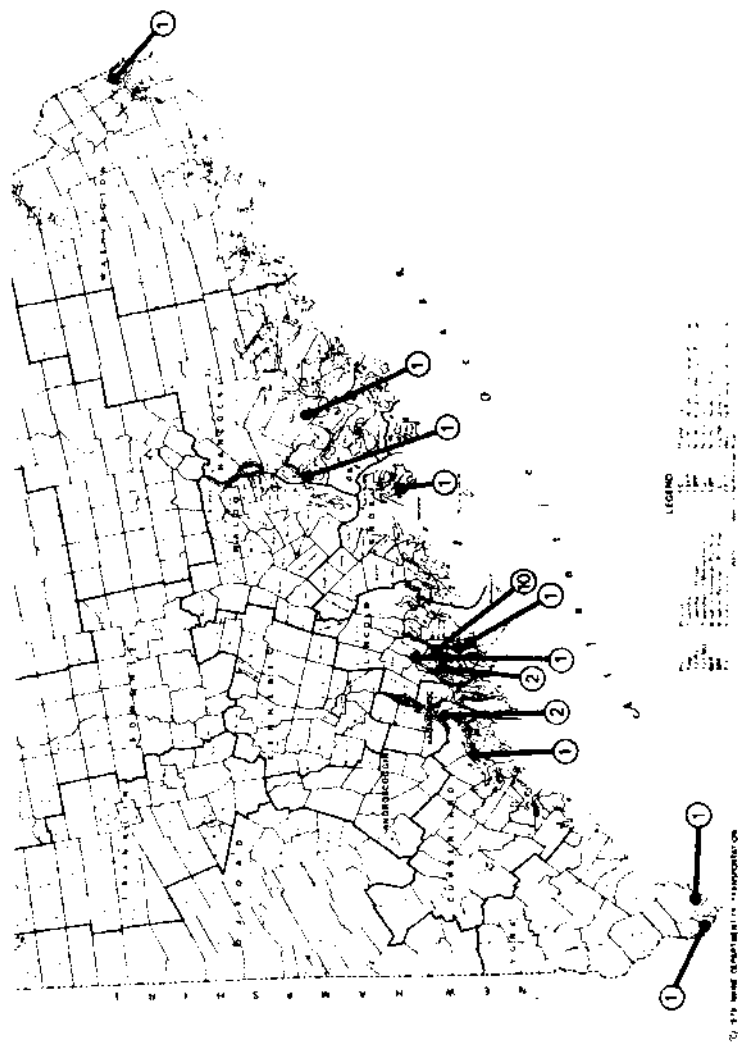


Figure 7. Locations of aquaculture sites.

Center on the river, which has promoted shellfish aquaculture. In respect to PSP, this centralized location of aquaculture is probably an unfortunate occurrence. This is because PSP can reasonably be expected to reoccur in the Damariscotta River every year. However, as aquaculture enterprises begin to expand into other areas it is reasonable to evaluate those areas for these enterprises to see how they shape up, paralytic shellfish poison-wise. As we evaluate the information available on PSP, it becomes increasingly evident that it is possible to utilize this information in the planning of new developments in shellfish aquaculture.

In the long run, the occurrence of PSP may work to the overall advantage of the aquaculture industry because it forces them to market their shellfish during periods when the overall quality is best. This is particularly true of mussels and European oysters; the quality of both species is poor during the months (May - October) when PSP may be expected to occur.

In conclusion, I anticipate an increasing awareness of PSP by the shellfish aquaculturists. Without a doubt, our increasing knowledge of the conditions which aggravate dinoflagellate blooms may be utilized by the shellfish aquaculturists and the Department of Marine Resources is developing a meaningful management plan for this potentially valuable addition to our shellfish resources.

REFERENCES

1. Hurst, John W. Jr. and Edward S. Gilfillan (1977) Paralytic Shellfish Poisoning in Maine. 10th. National Shellfish Sanitation Workshop, U.S. Department of Health, Education and Welfare.
2. Yentsch, Clarice M. and John W. Hurst, Jr. (1979) Report of Investigations Toward an Environmental Predictive Index For Toxic Dinoflagellate Blooms. To Food and Drug Administration.